Bowral Sewage Treatment Plant Upgrade

Review of Environmental Factors

Report number ISR18138

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For Wingecarribee Shire Council

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Cover photo: PWA, August 2018.

Declaration

This Review of Environmental Factors (REF) has been prepared by Public Works Advisory, Department of Regional NSW on behalf of Wingecarribee Shire Council. The report presents the assessment of potential impacts that may result from activities associated with the proposal to upgrade Bowral Sewage Treatment Plant located on the border of Bowral and Burradoo in the NSW Southern Highlands (the Proposal).

Wingecarribee Shire Council is a public authority and a determining authority as defined in the *Environmental Planning & Assessment Act 1979* (EP&A Act). The Proposal satisfies the definition of an activity under the Act, and as such Wingecarribee Shire Council must assess and consider the environmental impacts of the proposal before determining whether to proceed.

This REF has been prepared in accordance with Sections 5.5 and 5.7 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and Clause 228 of the *Environmental Planning and Assessment Regulation 2000* (EP&A Reg). This REF provides a true and fair assessment of the proposed activity in relation to its likely effects on the environment. It addresses to the fullest extent possible all matters affecting or likely to affect the environment as a result of the proposed activity.

On the basis of the information presented in this REF it is concluded that:

(1) the proposed activity is not likely to have a significant impact on the environment. An Environmental Impact Statement is not required.

(2) the proposed activity is not likely to significantly affect threatened species, populations, ecological communities, or critical habitat. A Species Impact Statement (SIS) is not required.

(3) the proposed activity is not likely to affect or being carried out on any Commonwealth land, or significantly affect any matters of national environmental significance.

Subject to implementation of the measures to avoid, minimise or manage environmental impacts listed in this REF, the proposed activity is recommended to proceed.

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Designation	Environmental Scientist
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Designation	Principal Scientist
Organisation	Public Works Advisory, Department of Regional NSW
Signature	
Date	29/09/2021

Verification and Determination

Verifier

I have examined this REF and the Declaration by Michelle Moodley and Kristen Parmeter (the authors) and accept the report on behalf of Wingecarribee Shire Council.

Name	
Designation	
Organisation	
Signature	

Determination

I determine that the activity is approved and may proceed.

Name	
Designation	
Organisation	
Signature	

Executive Summary

The towns of Bowral and Burradoo are located in the Southern Highlands, within the Wingecarribee Shire Council (WSC) Local Government Area (LGA), approximately 130 km south west of Sydney. Bowral Sewage Treatment Plant (STP), is located off 217 Burradoo Road, in proximity to the Burradoo railway station (Lot 2 DP 1119953 and Lot 278 DP 914555).

Bowral STP receives sewage from Bowral, East Bowral and Burradoo through a combination of gravity sewers and sewage pump stations (SPS). The STP was last upgraded in 2006 however the design capacity has since been exceeded and a further upgrade is required to meet current and future demands. The STP upgrade will also aim to improve process and operational performance and provide treatment infrastructure to meet environmental objectives from regulators such as the Environmental Protection Agency (EPA).

A Concept Design Report prepared by Public Works Advisory (PWA) in 2018 investigated options to establish the best way to upgrade and amplify the Bowral STP process units. The options centred around Intermittently Decanted Extended Aeration (IDEA) style bioreactors, while continuous flow bioreactors and Membrane bioreactors (MBRs) were considered but not detailed in any options investigations. A Design Development Report was prepared by Hunter H_2O in 2021 which discussed three secondary treatment options including:

- Retaining and derating the existing IDEA, and constructing a second large IDEA, a new decant balance tank and converting a sludge lagoon to an aerobic digester. Break point chlorination was replaced by more advanced denitrifying IDEA bioreactors, including anoxic zones, mixed liquor recycle (MLR) pumping and carbon dosing.
- Utilising the existing IDEA as an aerobic digester, then constructing two new advanced denitrification IDEA bioreactors and decant balance tank as a single structure.
- A Four Stage Bardenpho (FSB) Option which involved utilising the existing IDEA as an aerobic digester, then constructing new FSB continuous flow bioreactors and associated clarifiers.

Based on the comparisons undertaken in the Hunter H_2O Design Development Report and other supporting documentation, WSC elected to proceed with the FSB Option. Some modifications were subsequently made during further development of the design in order to meet water quality objectives and improve treatment system control and processes.

Scope of Works

The proposed STP augmentation comprises the following new or upgraded components. A copy of the design drawings are provided in Appendix B.

- New inlet works - incorporating two mechanical band screens and a manual bypass screen, sewage flow monitoring, a vortex style grit removal tank and an odour control system (with a biofilter and an activated carbon filter).
- New lift pump station – including three influent pumps to transfer flows to the bioreactors and two bypass (solids contact) pumps.
- A new Storm Detention Pond (SDP1) - located at the site of the current Pasveers, including two storm return pumps, a return rising main to the screened sewage channel and an overflow to the existing Storm Detention Pond (SDP2).

- Upgrade of the existing SDP2 - including replacement storm return pumps and modifications to the existing return rising main to the screened sewage channel.
- A new bioreactor splitter box.
- Two new bioreactors - designed as FSB but able to be operated as Modified Ludzack-Ettinger (MLE).
- A new bioreactor (diffused air) aeration supply system.
- Two new secondary clarifiers.
- Two new Return Activated Sludge (RAS) pumps.
- A new scum pump station - accepting scum from the two clarifiers and delivering it to the aerobic digester or bioreactors.
- A new filter feed pump station delivering flows to the tertiary filters.
- An Emergency Storage Tank (EST) - modifying the existing catch/balance pond to store overflows from the filter feed pump station and a new emergency return pump station.
- Tertiary filters - including a new feed splitter with filter bypass weir and pre flocculation tanks, an alum dosing point, four deep bed, dual media filter cells, an air scour system including blowers, a clean backwash and a dirty backwash tank (both with pumps).
- A new UV system - including three in-channel UV banks.
- Upgrade of the Reclaimed Effluent (RE) system.
- A new Waste Activated Sludge (WAS) pumping and thickening system - including a WAS pump, gravity thickener with centre drive and scraper and Thickened WAS (TWAS) pump.
- An aerobic digester - incorporating the existing IDEA bioreactor and existing IDEA surface aerators, and relocation of the existing WAS pump to act as the new Digested WAS (DWAS) pump.
- A new mechanical dewatering facility - consisting of a single dewatering train to start (but designed to accommodate a future second dewatering train). This facility will include a new dewatering feed tank, a polymer make-up, storage, dosing and dilution system, dosing pumps, dewatering feed pumps, a polymer dosing point to each feed line, a screw press dewatering unit, a slewing, inclined biosolids conveyor delivering biosolids to a truck trailer and a bunded truck trailer hard stand with awning.
- Retention of the existing biosolids hardstand.
- Potential retention of at least one sludge lagoon as emergency liquid sludge storage.
- A Foul Water Pump Station (FWPS).
- A caustic storage and dosing system.
- A new alum storage and dosing facility.
- Site provision for future carbon storage and dosing (if required).
- Site provision for photovoltaic/solar power supply (subject to budgetary availability of funds or receipt of subsequent NSW government grant funding for such public infrastructure projects).

Planning Framework

The proposed Bowral STP upgrade works are permissible without consent pursuant to clauses 106(1), and 106(2)) of *State Environmental Planning Policy (Infrastructure) 2007 (SEPP Infrastructure).* Clauses 106(1) and 106(2) allows development for the purpose of sewage treatment plants by or on behalf of a public authority to proceed without consent on land in a prescribed zone. Prescribed zones are defined in clause 105 and include SP2 Infrastructure.

This Review of Environmental Factors (REF) has been prepared in accordance with Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to fully assess the potential environmental impacts associated with the proposal in accordance with sections 5.5 and 5.7 of the EP&A Act and clause 228 of the *Environmental Planning and Assessment Regulation 2000*. WSC would be the proponent and determining authority for the works.

Approvals

A number of approvals would be required to undertake the proposed Bowral STP upgrade works, including:

- Variation to the Environment Protection Licence (EPL) under Section 58 of the *Protection of the Environment Operations Act* 1997;
- Approval to provide sewerage services and to operate an effluent reuse scheme under Section 60 of the *Local Government Act* 1993; and
- Potentially an Aquifer Interference Licence (if more than 3ML of groundwater is likely to be extracted per annum during construction works) under Section 91 of the *Water Management Act* 2000. If dewatering of less than 3ML is required for the Proposal, a water access licence exemption for aquifer interference activities taking 3ML or less of groundwater per year should be lodged with DPIE- Water (NRAR).

Summary of Potential Environmental Impacts

A number of short-term construction impacts associated with noise, dust, traffic, and waste management are predicted. It has been assessed that these impacts can be managed to avoid or minimise impacts to the environment through the implementation of appropriate mitigation measures.

The proposal would not significantly affect any historic heritage, Aboriginal heritage sites, listed threatened species, fauna populations or communities provided appropriate mitigation measures are implemented.

The upgrade works would improve the operational reliability of the STP, increase the treatment capacity to meet current and future population demand and provide treatment infrastructure to meet required regulatory objectives.

Conclusion and Recommendations

On the basis of the information presented in this REF it is concluded that by adopting the safeguards identified in this assessment it is unlikely that there would be significant adverse environmental impacts associated with the proposed Bowral STP upgrade works. Therefore, an Environmental Impact Statement would not be required.

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List of Abbreviations

ADWF	Average Dry Weather Flows
AHD	Australian Height Datum
BC Act	*Biodiversity Conservation Act 2016*
BOD	Biological Oxygen Demand
CEMP	Construction Environmental Management Plan
COD	Chemical Oxygen Demand
DIA	Discharge Impact Assessment
DFTF	Design Full Treatment Flow
DSTF	Design Storm Treatment Flow
DIA	Discharge Impact Assessment
DPIE	Department of Planning, Industry & Environment
EES	NSW Environment, Energy and Science
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	Environmental Planning And Assessment Regulation 2000
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FSB	Four Stage Bardenpho
FWPS	Foul Water Pump Station
IDEA	Intermittently Decanted Extended Aeration
LEP	Local Environmental Plan
LGA	Local Government Area
LRV	Log Removal Values
ML	Mixed Liquor
MLE	Modified Ludzak Ettinger
MLR	Mixed Liquor Recycle
MLSS	Mixed Liquor Suspended Solids
NorBE	Neutral or Beneficial Effect on water quality
OEMP	Operation Environmental Management Plan

PDWF	Peak Dry Weather Flow
POEO Act	*Protection of The Environment Operations Act 1997*
PWA	Public Works Advisory
RAS	Return activated sludge
SEPP	State Environmental Planning Policy
STP	Sewage Treatment Plant
SWMP	Soil And Water Management Plan
TMP	Traffic Management Plan
WAS	Waste Activated Sludge
WM Act	*Water Management Act 2000*
WMP	Waste Management Plan
WSC	Wingecarribee Shire Council

1. Introduction

1.1 Background

The towns of Bowral and Burradoo are located in the Southern Highlands within the Wingecarribee Shire Council (WSC) Local Government Area (LGA) approximately 130 km south west of Sydney.

The Bowral Sewage Treatment Plant (STP) is located off 217 Burradoo Road (Lot 2 DP 1119953 and Lot 278 DP 914555). The STP receives sewage from the Bowral, East Bowral and Burradoo gravity network and Sewage Pump Stations (SPS).

The STP was last upgraded in 2006 and utilises the intermittently decanted extended aeration (IDEA) activated sludge (AS) process for secondary treatment of the sewage influent. The secondary treated effluent is filtered and disinfected prior to discharge to the Mittagong Rivulet. The current STP has a design capacity of 14,600 EP.

Bowral STP is being upgraded to meet future demands within the catchment, as the current design capacity has been exceeded. The upgrade will improve process and operational performance and provide treatment infrastructure to meet environmental objectives from regulators such as the NSW Environment Protection Authority (EPA).

The effluent quality of the Bowral STP meets current NSW EPA licence obligations. Sampling of the Wingecarribee River upstream and downstream of the discharge point indicates that there is no deterioration in the water quality with respect to the pollutants discharged by the plant.

A location map and aerial view of Bowral STP is provided in Figure 1-1 and Figure 1-2.

Figure 1-1 Bowral STP Location Map

Source: SIX Maps, accessed March 2018

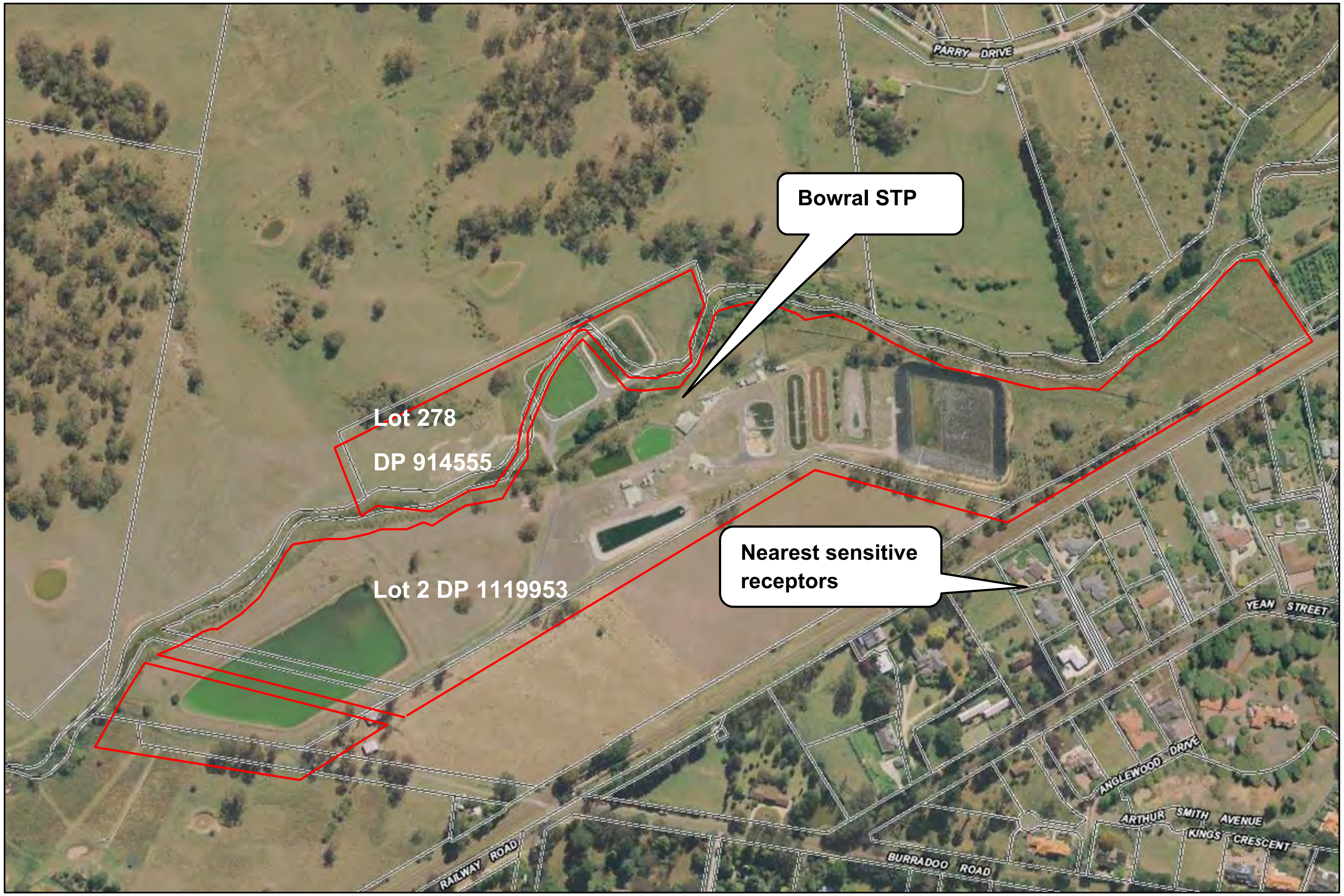

Figure 1-2: Aerial view of Bowral STP (outlined) and nearest sensitive receptors

Source: SIX Maps, accessed August 2018

1.2 Proposal Objectives

The main objectives of the proposed Bowral STP upgrade are to:

- provide capacity to 21,000 EP for future development and projected population increase demands within the catchment, as the current design capacity has already been exceeded,
- improve process and operational performance, and
- provide treatment infrastructure to meet EPA and other environmental and water quality requirements.

1.3 Summary of Works

The proposed STP augmentation comprises the following new or upgraded components:

- New inlet works - incorporating two mechanical band screens and a manual bypass screen, sewage flow monitoring, a vortex style grit removal tank and an odour control system (with a biofilter and an activated carbon filter).
- New lift pump station – including three influent pumps to transfer flows to the bioreactors and two bypass (solids contact) pumps.
- A new Storm Detention Pond (SDP1) - located at the site of the current Pasveers, including two storm return pumps, a return rising main to the screened sewage channel and an overflow to the existing Storm Detention Pond (SDP2).
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- A new UV system - including three in-channel UV banks.
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- A new Waste Activated Sludge (WAS) pumping and thickening system - including a WAS pump, gravity thickener with centre drive and scraper and Thickened WAS (TWAS) pump.
- An aerobic digester - incorporating the existing IDEA bioreactor and existing IDEA surface aerators, and relocation of the existing WAS pump to act as the new Digested WAS (DWAS) pump.
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- Retention of the existing biosolids hardstand.
- Potential retention of at least one sludge lagoon as emergency liquid sludge storage.
- A Foul Water Pump Station (FWPS).
- A caustic storage and dosing system.
- A new alum storage and dosing facility.
- Site provision for future carbon storage and dosing (if required).
- Site provision for photovoltaic/solar power supply (subject to budgetary availability of funds or receipt of subsequent NSW government grant funding for such public infrastructure projects).

A copy of the designs for the proposal are provided in Appendix B.

WSC are also proposing to upgrade the existing Bowral STP intake main as part of a separate package of works. This will be assessed as an addendum to this REF.

1.4 Land Ownership

The proposed works are located on land (Lot 2 DP 1119953 and Lot 278 DP 914555) owned by WSC.

2. Statutory Framework and Development Controls

This section presents the statutory planning and strategic policy context for the proposal.

2.1 Environmental Planning Instruments

2.1.1 Wingecarribee Local Environmental Plan 2010

The Bowral STP is located within the Wingecarribee LGA. The *Wingecarribee Local Environmental Plan 2010 (LEP)* identifies the land use zones relevant to the site. The Bowral STP site is zoned SP2 Sewerage System as shown in Figure 2-1. The objectives of this zone are:

- To provide for infrastructure and related uses.
- To prevent development that is not compatible with or that may detract from the provision of infrastructure.
- To ensure that the scale and character of infrastructure is compatible with the landscape setting and built form of surrounding development.

Development for the purpose of Sewage Systems is permissible with consent in this zone.

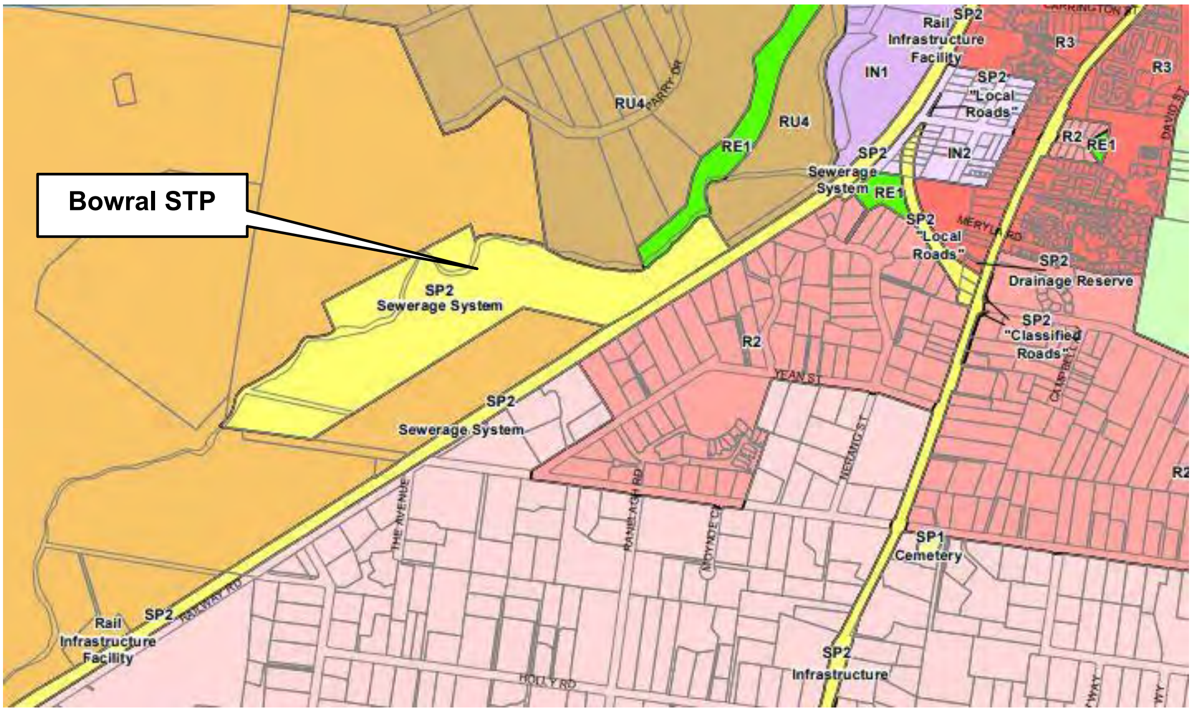


Figure 2-1 Extract from the Wingecarribee LEP Zoning Map (Tile 007G)

It is noted that Clause 5.12(1) of the Wingecarribee LEP 2010 also states that the LEP does not restrict or prohibit, or enable the restriction or prohibition of, the carrying out of any development, by or on behalf of a public authority, that is permitted to be carried out with or without development consent, or that is exempt development, under *State Environmental Planning Policy (Infrastructure) 2007*. The applicability of *State Environmental Planning Policy (Infrastructure) 2007* to the proposed development is detailed in Section 2.1.2 below.

Under the Wingecarribee LEP 2010, the site is identified as having the following values, constraints, or risks:

Natural Resources and Sensitivities

Mittagong Rivulet bisects the STP site and this area is identified as Riparian Land Category 2 - Aquatic and Terrestrial Habitat according to the LEP Natural Resources and Sensitivity Map. This mapping also identifies unnamed drainage lines, classified as Category 3 - Bank Stability and Water Quality Sensitivity, that traverse the northern and western boundaries of the Bowral STP (see Figure 2-2). Clause 7.5 of the LEP requires a consent authority to consider impacts to riparian lands before determining a development application. It is noted that the proposal does not require development consent and therefore these provisions do not apply. Nevertheless, an assessment of the impact on water quality and riparian lands, as well as proposed mitigation measures, are provided in Sections 5.6 and 5.8.

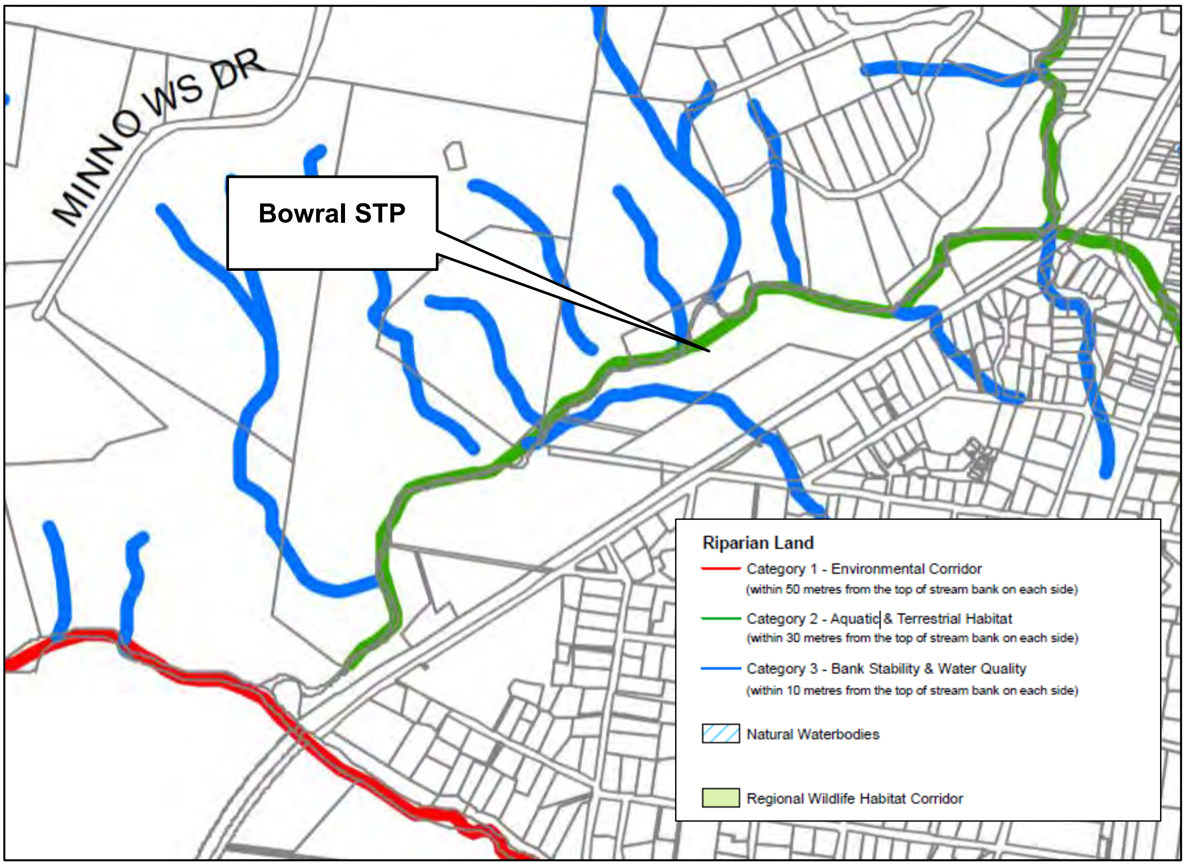


Figure 2-2 Bowral STP Natural Resources Sensitivity Map

Source: Wingecarribee LEP (2010) Natural Resources Sensitivity Map (Tile 007D)

Flood Planning

The Flood Planning Map made under the Wingecarribee LEP identifies the Bowral STP as being located in a flood prone area (see Figure 2-3). An assessment of the impact on flood planning, as well as proposed mitigation measures, are provided in Section 5.6.

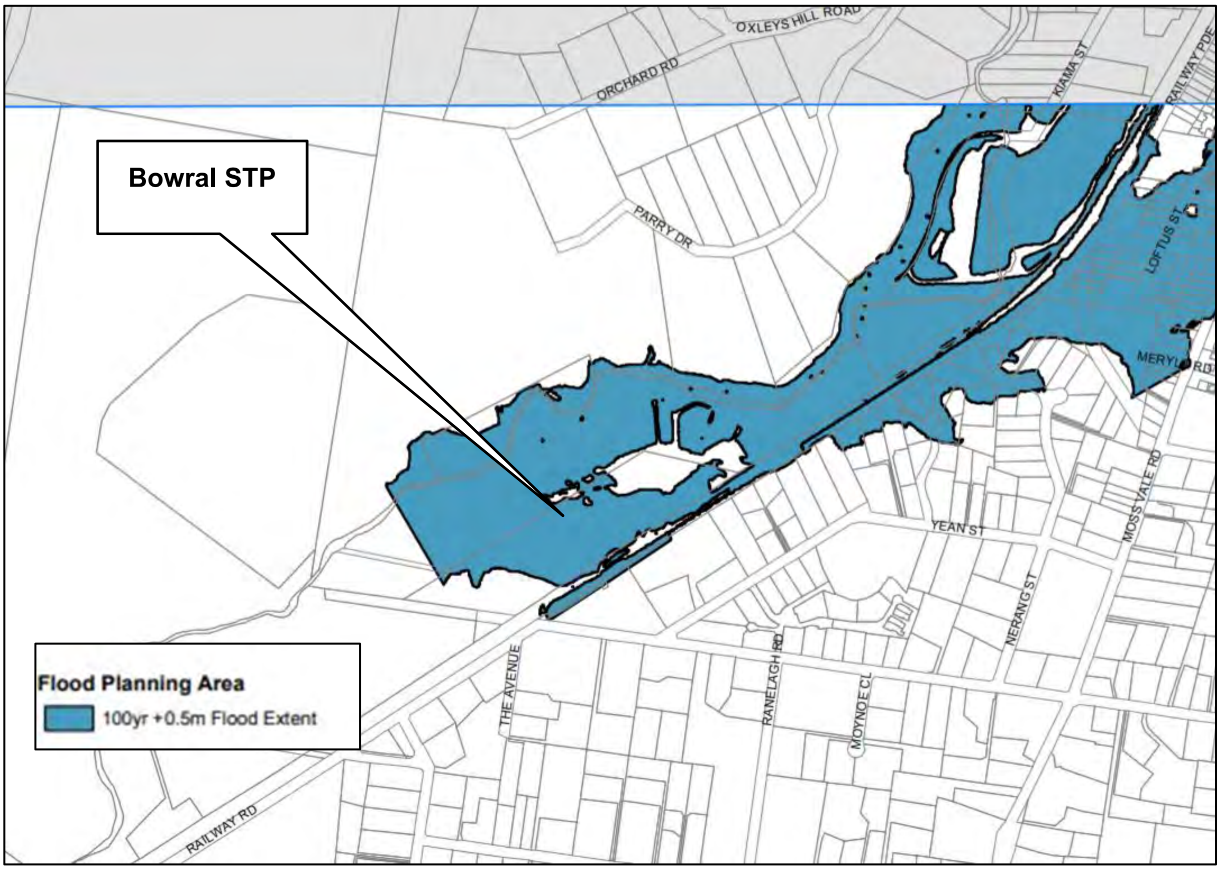


Figure 2-3 Bowral STP Flood Planning Map

Source: Wingecarribee LEP (2010) Flood Planning Map (Tile 007E)

2.1.2 State Environmental Planning Policy SEPP (Infrastructure) 2007

State Environmental Planning Policy (Infrastructure) 2007 (SEPP (Infrastructure) 2007 aims to assist in the effective delivery of public infrastructure throughout the State by improving certainty and regulatory efficiency through a consistent planning assessment and approvals regime for public infrastructure and services across NSW. The SEPP provides clear definition of environmental assessment and approval process for public infrastructure and services facilities.

Clauses 106(1) and 106(2) of SEPP (Infrastructure) 2007 allows development for the purpose of sewage treatment plants by or on behalf of a public authority to proceed without consent on land in a prescribed zone. Prescribed zones are defined in clause 105 and include SP2 Infrastructure.

2.1.3 State Environment Planning Policy No 33 - Hazardous and Offensive Development

State Environment Planning Policy (SEPP 33) Hazardous and Offensive Development applies to any proposal that falls under the definition of "potentially hazardous (or offensive) industry" and aims to ensure that proposals are adequately assessed in relation to potential off-site risk. Although this SEPP only applies to proposals that are assessed under Part 4 of the EP&A Act, it has been considered in relation to the STP upgrade in Section 5.13 .

2.1.4 State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011

The Bowral STP site is located within the Warragamba sub-catchment, the largest of Sydney's five drinking water catchments (see Figure 2-4). The works are therefore subject to the provisions of the *State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011* (Drinking Water SEPP). The aims of the Drinking Water SEPP are:

(a) to provide for healthy water catchments that would deliver high quality water while permitting development that is compatible with that goal, and

(b) to provide that a consent authority must not grant consent to a proposed development unless it is satisfied that the proposed development would have a neutral or beneficial effect on water quality, and

(c) to support the maintenance or achievement of the water quality objectives for the Sydney drinking water catchment.

Clause 9 of the SEPP specifies that any development or activity proposed to be undertaken in the Sydney drinking water catchment must incorporate WaterNSW's current recommended practices and standards or demonstrate how the practices and performance standards proposed to be adopted will achieve outcomes not less than those achieved by WaterNSW's recommended practices and standards. The current recommended practice which is considered most relevant for this proposal is the application of:

- *Developments in the Sydney Drinking Water Catchment – Water Quality Information Requirements,* (WaterNSW, September 2020),
- *Neutral or Beneficial Effect on Water Quality Assessment Guideline 2015* (WaterNSW, 2015a),
- *Managing Urban Stormwater: Soils and Construction Volume 1, Fourth Edition*, March 2004 ("Blue Book", Vol. 1), and
- *Guideline for the Preparation of Environmental Management Plans*, (DPINR, 2004).

The recommended practices and standards relevant to the development are discussed in Section 2.3.

Clause 12 of the SEPP specifies that a public authority must, before it carries out any activity to which Part 5 of the EP&A Act applies, consider whether the activity would have a neutral or beneficial effect on water quality.

WSC has consulted with WaterNSW and the EPA, and the above recommended practices and standards have been considered as the part of the STP upgrade design development process. A Discharge Impact Assessment including a Neutral or Beneficial Effect (NorBE) assessment has been prepared for the proposal to consider the effect on water quality (Manly Hydraulics Laboratory (MHL), 2021). A copy of the report is provided in Appendix E.

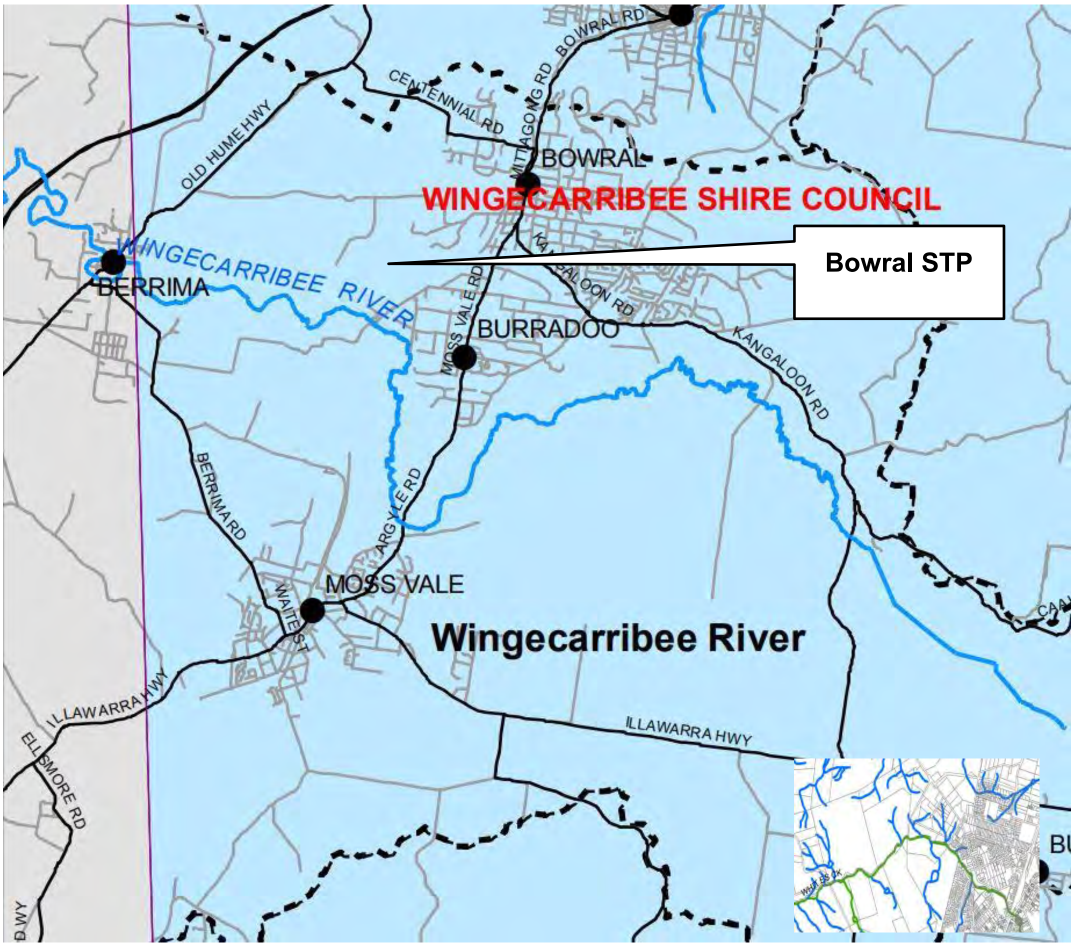


Figure 2-4 Extract from the Sydney Drinking Water Catchment Map (Tile 015)

2.1.5 State Environmental Planning Policy (Koala Habitat Protection) 2021

State Environmental Planning Policy (Koala Habitat Protection) 2021 (SEPP (Koala Habitat Protection)) seeks to encourage the proper conservation and management of areas that provide habitat for Koalas. Schedule 1 of SEPP (Koala Habitat Protection) identifies Wingecarribee as an LGA to which this planning instrument applies. It is noted that SEPP (Koala Habitat Protection) does not apply to proposals assessed under Part 5 of the EP&A Act, however consideration of this SEPP has been undertaken as part of the REF.

Vegetation removal would be limited to planted grass only. Accordingly, the proposed works would not be considered to affect any Koala populations or their habitat areas, and therefore a Plan of Management for the conservation and management of areas of Koala habitat is not required to be prepared as part of the current proposal.

2.2 Relevant Legislation

2.2.1 Environmental Planning and Assessment Act 1979

The applicable environmental planning instrument for the works is SEPP (Infrastructure) 2007, which provides the permissibility for the proposed development (refer to Section 2.1.2). As the SEPP removes the need for development consent, these works would be assessed under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). WSC is the proponent and the determining authority for the proposal.

This REF has been prepared in accordance with Section 5.5 of the EP&A Act, which requires that the proponent take into account to the fullest extent possible all matters affecting or likely to affect the environment due to the proposed activity.

Consideration of the factors listed under Clause 228 of the *Environmental Planning and Assessment Regulation 2000* (EP&A Reg) has been used to assist in assessing the significance of the project, and is provided in Appendix A.

2.2.2 Protection of the Environment Operations Act 1997

The NSW Environment Protection Authority (EPA) is responsible for the administration of the Protection of the Environment Operations Act 1997 (POEO Act). The POEO Act regulates air, noise, land and water pollution.

It is a requirement under Schedule 1 of the POEO Act that treatment plants, pumping stations, overflow structures and reticulation systems within a sewerage scheme that has a capacity that exceeds 750 kL/day or approximately 2,500 EP load, involving the discharge or likely discharge of wastes or by-products to land or waters, are subject to licencing by the NSW EPA. The existing Bowral Sewerage Scheme operates under Environment Protection Licence (EPL) No. 1749 granted to WSC by the EPA under the POEO Act.

As the activity is both scheduled under the POEO Act and being undertaken by a Public Authority, the EPA would be the Appropriate Regulatory Authority in relation to environmental pollution matters. The EPA has advised that the licence would need to be revised for the upgraded STP.

The proposed works would necessitate a variation to the existing EPL to account for the increased capacity and modifications to the treatment facilities. When applying for an EPL, NSW EPA would normally need to be informed of the treatment capacity, the expected effluent standard and details of any proposed environmental monitoring program. Once the treatment plant is constructed, Council would be able to apply for a variation to their existing licence.

Section 120 of the POEO Act states that it is an offence to pollute waters without a licence. Any operational discharges from the Bowral STP would be licenced under the EPL. The construction works can proceed without causing water pollution and a licence under s120 of the POEO Act would therefore not be required.

Other relevant provisions of the POEO Act that the Proposal would need to comply with include:

Section 115 – It is an offence to dispose of waste in a manner that harms or is likely to harm the environment.

Section 116 – It is an offence to cause any substance to leak, spill or otherwise escape (whether or not from a container) in a manner that harms or is likely to harm the environment

Section 124 - The occupier of any premises who operates any plant in or on those premises in such a manner as to cause air pollution from those premises is guilty of an offence if the air pollution so caused, or any part of the air pollution so caused, is caused by the occupier's failure (a) to maintain the plant in an efficient condition, or (b) to operate the plant in a proper and efficient manner.

Section 129 - The occupier of any premises at which scheduled activities are carried on under the authority conferred by a licence must not cause or permit the emission of any offensive odour from the premises to which the licence applies.

Section 139 – The occupier of any premises who operates any plant (other than control equipment) at those premises in such a manner as to cause the emission of noise from those premises is guilty of an offence if the noise so caused, or any part of it, is caused by the occupier's failure: (a) to maintain the plant in an efficient condition, or (b) to operate the plant in a proper and efficient manner.

Section 167 – The occupier of any premises must maintain any control equipment installed at the premises in an efficient condition. The occupier of any premises must operate any control equipment installed at the premises in a proper and efficient manner.

2.2.3 Protection of the Environment Operations (Waste) Regulation 2014 (NSW)

The *Protection of the Environment Operations (Waste) Regulation 2014* sets out the provisions with regards to non-licensed waste activities and non-licensed waste transporting, in relation to the way in which waste must be stored, transported, and the reporting and record-keeping requirements. The decommissioning of existing STP components and the disposal of other construction waste would be required to comply with this regulation.

2.2.4 Local Government Act 1993 (NSW)

Section 60 of the *Local Government Act 1993* states that a Council must seek approval from the Department, Planning, Industry and Environment - Water (DPIE – Water) to provide for sewage from its area to be discharged, treated or supplied to any person.

A section 60 approval is required for the proposed upgrade of the Bowral STP. WSC has liaised with DPIE - Water with regard to this approval and provided all relevant design information for their consideration.

2.2.5 National Parks and Wildlife Act 1974 (NSW)

The *National Parks and Wildlife Act 1974* (NPW Act) provides for the statutory protection of Aboriginal cultural heritage places, objects and features. Part 6 of the NPW Act provides specific protection for Aboriginal objects and declared Aboriginal places by establishing offences of harm. It is a defence against prosecution for unintentionally harming Aboriginal Objects if due diligence had been exercised to determine that no Aboriginal object would be harmed, or the harm or desecration was authorised by an Aboriginal heritage impact permit (AHIP).

A search of the Aboriginal Heritage Information Management Systems (AHIMS) database did not identify any previously recorded Aboriginal sites or places in or near the STP site. *The Due*

Diligence Code of Practice for the Protection of Aboriginal Objects in NSW (OEH, 2010) has been considered in assessing the likelihood of encountering items of Aboriginal cultural heritage during the construction works. It is considered that further archaeological investigations and/or an Aboriginal Heritage Impact Permit are not required and that the works can proceed with caution and in accordance with the mitigation measures in this REF (see Section 5.11).

2.2.6 Water Management Act 2000 (NSW)

The objects of the *Water Management Act 2000* (WM Act) are to provide for the sustainable and integrated management of the water sources of the state for the benefit of both present and future generations.

Section 91(F) of the WM Act states that an aquifer interference activity cannot be carried out without, or otherwise than as authorised by, an aquifer interference approval. However, extracting less than 3ML of groundwater per annum is exempt from requiring an aquifer interference licence.

Geotechnical investigations undertaken for the proposed upgrade works indicated that groundwater was encountered at approximate depths of 2.9m – 5.7m.

If more than 3ML of groundwater dewatering is required during construction works, an aquifer interference approval would be required for the works. If dewatering of less than 3ML is required for the proposal, a water access licence exemption for aquifer interference activities taking 3ML or less of groundwater per year should be lodged with DPIE- Water (NRAR). Refer to Section 5.7.

The proposed upgrade would not require any other approvals under the WM Act.

2.2.7 Biodiversity Conservation Act 2016 (NSW)

The Biodiversity Conservation Act 2016 (BC Act) protects species of threatened flora and fauna, endangered populations and endangered ecological communities and their habitats in NSW. It also lists Key Threatening Process that adversely affects threatened species, populations or ecological communities or that may cause species, populations or ecological communities that are not threatened to become threatened.

Amongst other matters, offences are established for damage to habitats of threatened species or threatened ecological communities. Defences to those offences include that the act was necessary for the carrying out of a development consent within the meaning of the EP&A Act. Part 4 of the *Biodiversity Conservation Act 2016* sets out provisions for threatened species and threatened ecological communities and introduces a new biodiversity assessment method (BAM), a new biodiversity offset scheme (BOS) and an expanded biodiversity certification program.

The proposal would not have a significant impact on any threatened flora and fauna species, populations or communities, or their habitats as listed under the BC Act (see Section 5.7).

2.2.8 Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) provides for Commonwealth involvement in development assessment and approval in circumstances where there exist ‘matters of national environmental significance’. Matters of national environmental significance include:

- World heritage properties
- National heritage places
- Wetlands of international importance
- Nationally threatened species and ecological communities
- Migratory species
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mining)
- A water resource, in relation to coal seam gas development and large coal mining development

No matters of national environmental significance would be significantly impacted by the proposal, as the works would be confined within areas previously disturbed by the existing STP facilities (see Section 5.7).

2.2.9 Fisheries Management Act 1994 (NSW)

The objects of *the Fisheries Management Act 1994* (FM Act) are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. In particular, the objects of this Act include:

- to conserve fish stocks and key fish habitats, and
- to conserve threatened species, populations and ecological communities of fish and marine vegetation, and
- to promote ecologically sustainable development, including the conservation of biological diversity.

The FM Act includes schedules of threatened aquatic species, populations and ecological communities, which must be considered in accordance with Section 5A of the EP&A Act. The STP is located adjacent to Mittagong Rivulet (also known as Mittagong Creek), with the riparian area along Mittagong Rivulet identified as Key Fish Habitat (see Figure 5-14). It is noted that the proposed works do not require clearing of this riparian vegetation. Furthermore, the works do not involve dredging, reclamation or blocking of fish passage and therefore a permit under the FM Act is not required.

2.3 Relevant Policies and Guidelines

2.3.1 Licensing Guidelines for Sewage Treatment Plants (EPA, 2003)

These guidelines have been prepared by the EPA to help licensees in non-metropolitan areas, generally local councils and other water authorities, understand the process for licensing whole sewage treatment systems. The upgrade works would be consistent with these guidelines.

The guideline is largely concerned with reducing overflows from sewerage systems. The Bowral STP upgrade design has been based upon the review of the existing and future sewer catchment and ensuring that the plant has sufficient capacity and emergency storage to avoid any discharges to the environment.

2.3.2 Technical Framework: Assessment and Management of Odour from Stationary Sources in NSW (DECCW, 2006)

The framework adopts odour performance criteria, which are based on a sliding scale relating to the population density of an area, as the response to an odour impact, can vary significantly over a given population. The criteria assumes that within a densely populated area there would be a greater potential for individuals within the community to be ‘annoyed’ by a given odour event (see Table 2-1 below).

Table 2-1 Odour Unit Criteria and Population Density

Population of Affected Community	Criteria (OU)
Urban (>~2000) and/or schools and hospitals	2
~ 500	3
~ 125	4
~ 30	5
~ 10	6
Rural single residence (≤ 2)	7

Source: Department of Environment, Climate Change and Water Technical framework: assessment and management of odour from stationary sources in NSW November 2006

An odour assessment of the proposed works to the Bowral STP has been undertaken in accordance with the technical framework and is discussed in more detail in Section 5.5.2.

2.3.3 Australian National Water Quality Management Strategy (ANZECC & ARMCANZ 2000)

The primary objective of the *Australian National Water Quality Management Strategy* is based on ecologically sustainable development of water resources. The main objective of the Guidelines for fresh and marine water quality is intended to support this overall objective: to provide an authoritative guide for setting water quality objectives required to sustain current or likely future environmental values for natural and semi-natural water resources in Australia and New Zealand. It is recognised that a nationally consistent approach to water quality management is underpinned by the development of high-status guidelines which can provide guidance when issues arise.

The Guidelines are intended to provide government, industry, consultants and community groups with a sound set of tools that enable the assessment and management of ambient water quality in a wide range of water resource types, and according to designated environmental values, which are:

- Aquatic ecosystems;
- Primary industries (irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods);
- Recreation and aesthetics;
- Drinking water;

- Industrial water (no water quality guidelines are provided for this environmental value);
- Cultural and spiritual values.

The guidelines provide certainty that there would be no significant impact on water resource values if the guidelines are achieved.

An initial classification of the catchment area and receiving waters, based on the ANZECC 2000 Guidelines, indicates that the catchment fits into the “Aquatic Systems - South East Australia – Upland River, Slightly-Moderately disturbed systems” (see Section 5.6).

The proposed Bowral STP upgrade works would allow the STP to provide satisfactory treatment for the peak load while producing effluent that meets EPA discharge requirements (see Section 5.6 for further discussion).

2.3.4 Developments in the Sydney Drinking Water Catchment – Water Quality Information Requirements, (WaterNSW, September 2020)

The development site is located within Sydney’s drinking water catchment. Developments in the *Sydney Drinking Water Catchment – Water Quality Information Requirements* (Water NSW, September 2020) describes the information required as part of a development application to demonstrate that a proposal can achieve a neutral or beneficial effect on water quality (NorBE). It describes the different reports and modelling that is required to be included with a development application, and how they vary for different types and scales of development.

WaterNSW is responsible for ensuring that the declared Sydney catchment area and water management works in such areas are managed and protected to promote water quality, the protection of public health and public safety, and the protection of the environment, and the management of bulk water across the State. WaterNSW has a statutory function to protect and enhance the quality of water in the catchment.

Development applications in the Sydney drinking water catchment should include a water cycle management study (WCMS) or equivalent information depending upon the development to help council and WaterNSW assess whether the development will have a NorBE on water quality.

The proposal is permitted without development consent under SEPP (Infrastructure) 2007, therefore a WCMS is not required to support a development application. However, in consultation with WaterNSW and the NSW EPA, a Discharge Impact Assessment (DIA) has been prepared by MHL (2021) (refer to Appendix E) to model the current and projected post-STP upgrade concentrations of contaminants at locations downstream of the STP effluent discharge point and assess the likely future water quality impacts of the proposed STP upgrade. A NorBE analysis has been undertaken for several STP upgrade treatment scenarios as a component of the DIA.

2.3.5 Neutral or Beneficial Effect on Water Quality Assessment Guideline 2015 (WaterNSW, 2015a),

The *NorBE Guideline* (WaterNSW, 2015a) provides advice about the meaning of the neutral or beneficial effect, how to show it, and how to assess an application against the NorBE test.

A neutral or beneficial effect on water quality means development that:

- has no identifiable impact on water quality, or

- will contain any water quality impact on the development site and stop it from reaching any watercourse, waterbody or drainage depression on the site, or
- will transfer any water quality impact outside the site where it is treated and disposed of to standards approved by the consent authority.

Councils and WaterNSW use the NorBE test to assess development applications in the Sydney drinking water catchment. For activities carried out under Part 5 of the EP&A Act, public authorities are required to consider whether the activity would have a neutral or beneficial effect on water quality before they carry out that activity.

As mentioned in Section 2.1.4 and 2.3.4, a NorBE assessment has been prepared for the proposed upgraded STP. This assessment forms part of the DIA which is provided in Appendix E.

2.4 Summary of Statutory Approvals

The following table provides a summary of the statutory approvals required for the proposal.

Table 2-2 Summary of Approvals and Requirements

Agency	Requirements	Reference
Wingecarribee Shire Council	Project determination	Part 5 of EP&A Act
EPA	Variation to EPL No. 1749	Section 58 of POEO Act
DPIE - Water	Approval to provide sewerage services	Section 60 of LG Act
	Aquifer Interference Licence (if more than 3ML of groundwater is likely to be extracted per annum during construction works). Alternately, a water access licence exemption should be lodged with DPIE- Water (NRAR) for aquifer interference activities taking 3ML or less of groundwater per year.	Section 91 of WM Act

2.5 Agency Consultation

Relevant government agencies were consulted prior to (provided directly to WSC) and during the preparation of the REF. A list of those agencies that were contacted and a summary of their responses is provided in Table 2-3 below. Copies of the responses received are contained in Appendix C.

Table 2-3 Agency Consultation

Agency	Summary of Comments	Where Addressed in REF
EPA 19 September 2018 (letter)	**Environmental Requirements for Assessment of STP Upgrades** • The Environmental Assessment (EA) for the upgrade of Bowral STP must follow the approach prescribed in the ANZECC 2000 National Water Quality Guidelines. • The guidelines recommend defining the downstream uses of water and determining the necessary water quality needed to support those uses.	Refer to Sections 2.3.3 and 5.6
	• As the proposal represents a significant risk to environmental values, it is appropriate that a comprehensive assessment is undertaken that quantitatively identifies the impact on the relevant indicators for the various environmental values.	A Discharge Impact Assessment (DIA) has been prepared for the proposal. Refer to Section 5.6 and Appendix E
	The EPA requests that the following specific topics be addressed as part of the Options Study for Moss Vale STP and the Concept Design EA for the proposed upgrade of Bowral STP. • A description of the Wingecarribee River and Medway Rivulet including flow regimes, geomorphology, land use, riverine vegetation and aquatic ecology. • A description of the uses of water from the River and Rivulet (type and amount) including industrial, agricultural, recreational, drinking water and ecosystem. • Assignment of an appropriate level of protection under the ANZECC 2000 Guidelines.	Section 5.6
	• A description of the health of the rivers and whether environmental values are being achieved using indicators of water quality such as physical and chemical stressors, toxicants, and aquatic health applying quantitative biological measurements.	Section 5.6

Agency	Summary of Comments	Where Addressed in REF
	• Describe the current state of the waterway (e.g. whether NSW WQOs are being achieved) and specific human uses (e.g. exact location of drinking water offtake), sensitive ecosystems or species conservation values.	
	• An estimation must be made of the level and extent of river(s) impacted by the STP discharge through loads discharged, measured levels of pollutant concentrations and changes to stream health. • Note also that the potential toxicity effects in the Wingecarribee River due to aluminium levels from flocculant dosing should be examined.	A DIA has been prepared for the proposal. Refer to Section 5.6 and Appendix E.
	• Describe the relative contribution of the STP under dry and wet weather to flow, nutrient loads and concentrations in the river(s) and catchment.	Section 4.1 and 5.6
	• Consider as to whether the upgraded STP would have a neutral or beneficial effect on water quality in the Wingecarribee River and further downstream (Sydney Catchment Drinking Water SEPP 2011). • Describe the methods used to define NorBE including baseline conditions and projected conditions commensurate with the project timeframe. o Note that pollutant loads calculated under licence requirements for the load-based licensing scheme are subject to significant variance due to the limited number of samples required and large variability in flowrates during wet weather conditions. The EPA recommends that an intensive sampling program be used to accurately define typical loads under average dry weather conditions to be used in the NorBE assessment.	A DIA including a NorBE test has been prepared for the proposal. Refer to Section 5.6 and Appendix E

Agency	Summary of Comments	Where Addressed in REF
	Receiving environment and background conditions • Describe existing surface and groundwater quality. An assessment needs to be undertaken for any waters likely to be affected by the proposal. • State the ambient Water Quality Objectives and environmental values for the receiving waters relevant to the proposal. These refer to the community's agreed environmental values and human uses endorsed by the NSW Government as goals for ambient waters. Where groundwater may be impacted the assessment should identify appropriate groundwater environmental values. • State the indicators and associated trigger values or criteria for the identified environmental values. Indicators should be selected that are relevant to the issues in the waterway, as well as potential pollutants from the activity. • Describe the current state of the waterway (e.g. whether NSW WQOs are being achieved) and specific human uses (e.g. exact location of drinking water offtake), sensitive ecosystems or species conservation values. • State any locally specific objectives, criteria or targets which have been endorsed by the NSW Government.	Refer to Section 5.6
	Where site-specific studies are proposed to tailor the trigger values to reflect local conditions, and the results are to be used for regulatory purposes (e.g. to assess whether a licensed discharge impacts on environmental values), then prior agreement from the EPA on the approach and study design must be obtained.	A DIA has been prepared for the proposal. Refer to Section 5.6 and Appendix E

<table>
<tr><th>Agency</th><th>Summary of Comments</th><th>Where Addressed in REF</th></tr>
<tr><td></td><td>Describe Proposal
Describe the proposal including the location of discharges, volumes and water quality of all discharge streams.
Identify and estimate the quality and quantity of all pollutants that may be introduced into the water cycle by source and discharge point, including residual discharges after mitigation measures are implemented. This should be undertaken for construction and operational phases.
The Assessment should demonstrate that all practical options to avoid discharge have been assessed and mitigation measures employed to minimise environmental impact where discharge is necessary.</td><td>Refer to Section 4</td></tr>
<tr><td></td><td>Impact Assessment - predict impacts and environmental outcomes
Describe the nature and degree of impact that any proposed discharges would have on the receiving environment.</td><td>Section 5.6</td></tr>
<tr><td></td><td>Assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes. Demonstrate how the proposal would be designed and operated to:
protect the NSW WQOs for receiving waters where they are currently being achieved; and
contribute towards achievement of the NSW WQOs over time where they are not currently being achieved.
The proposal should demonstrate how wastewater discharged to waterways would ensure the ANZECC Guidelines water quality criteria for relevant chemical and non-chemical parameters are met at the edge of the initial mixing zone of the discharge, and that any impacts in the initial mixing zone are demonstrated to be reversible. The proposal should</td><td>Section 5.6</td></tr>
</table>

Agency	Summary of Comments	Where Addressed in REF
	also avoid direct discharge impacts on ecologically significant areas and sensitive ecosystems.	
	If a mixing zone is proposed, the EPA must be consulted early in the development of any mixing zone proposal. The EPA would advise the applicant under what conditions a mixing zone would and would not be acceptable, as well as the information and modelling requirements for assessment. EPA recommends the project demonstrates that the area within the mixing zone would not contain: • contaminants in concentrations that cause acute toxicity to aquatic life. • substances that can bio-accumulate. • contaminants in concentrations that settle to form harmful deposits (also in the far field). • substances in concentrations that produce problematic colour, odour, turbidity or undesirable aesthetic impacts (also in the far field). • substances in concentrations which encourage undesirable aquatic life or result in the dominance of nuisance species. The proposal should provide a rationale, along with relevant calculations, modelling or monitoring, (depending on the nature and scale of the proposal) supporting the predicted outcomes. The degree of investigation should reflect the risk presented by the activity.	Noted A DIA has been prepared for the proposal. Refer to Section 5.6 and Appendix E
	Outline how total water cycle considerations are to be addressed showing total water balances for the development. Include water requirements (quantity, quality and source(s)) and proposed storm and wastewater disposal, including type, volumes, proposed treatment and management methods and re-use options.	Water balance not considered necessary due to minimal water requirements.
	Assess impacts on groundwater and groundwater dependent ecosystems.	Section 5.6 and 5.8.2

Agency	Summary of Comments	Where Addressed in REF
	Management and Mitigation Measures Provide rationale as to why the proposed discharge method represents the best environmental outcome and what measures can be taken to reduce the environmental impact.	Section 3.3.4
	Describe how stormwater would be managed both during construction and operation.	Refer to Section 5.7.1 and 5.7.2
	Describe wastewater treatment measures that are appropriate to the type and volume of wastewater and are based on a hierarchy of avoiding generation of wastewater; capturing all contaminated water (including stormwater) on the site; reusing/recycling wastewater; and treating any unavoidable discharge from the site to meet specified water quality requirements	Refer to Section 4
	Pollution Reduction Programs (PRP) The PRPs require that the Moss Vale/Bowral STP must be upgraded by the end of 2020. The upgrades should be undertaken with the objective of meeting the following: • appropriate ANZECC environmental values for downstream river health and water quality objectives assessed on a site-specific assessment. • mass load discharges to meet considerations for neutral and beneficial water quality under the 2011 Sydney Drinking Water SEPP; and • pollutant concentrations expected from reasonable and feasible contemporary treatment technology. Contemporary technology is considered by the EPA to be that which produces the equivalent effluent quality to a membrane bioreactor STP. The licensee must upgrade Bowral/Moss Vale STPs to meet effluent performance criteria agreed with the EPA by the due date - 31 December 2020.	The requirement for the STP upgrades to be completed by the end of 2020, is not achievable. The program does not allow for delays or additional investigations works
WaterNSW	**State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011**	Section 2.1.4

Agency	Summary of Comments	Where Addressed in REF
19 September 2018 (letter)	• Any upgrades must not result in a reduction in the quality of water in receiving waterways. Wherever the quality of water in receiving waterways is currently less than satisfactory WaterNSW considers the aim should be an improvement in water quality. • Clause 12 of the SEPP states that a public authority, must, before it carries out any activity to which Part 5 of the Act applies, consider whether the activity would have a neutral or beneficial effect on water quality.	The proposed STP upgrade design would achieve improved discharge water quality to that of the existing STP. Discussion with EPA and WaterNSW has been undertaken by WSC in relation to STP upgrade design and discharge quality requirements. A NorBE assessment has been prepared for the proposal as part of the DIA to consider water quality effects (provided in Appendix E)
WaterNSW 16 October 2015 (letter)	**NorBE Assessment Requirements:** • Predicted design wastewater loading which is: o based on projected population growth over the project life which should include planned subdivisions and any new industries o considers average and peak wastewater flows for dry and wet weather conditions o incorporates any infiltrations via old reticulation systems	Section 2.3.3 and 3.2 A NorBE assessment has been prepared for the proposal to consider water quality impacts (provided in Appendix E)
	• Details on the design and capacity of proposed augmented STP including the key design standards and expected performance of the augmented STPs.	Section 4.1 and 4.2

Agency	Summary of Comments	Where Addressed in REF
	• Predicted effluent quality for 50, 90 and 100 percentile concentrations for total suspended solids (TSS), BOD, TP, TN and pathogens.	Section 5.7 NB. DIA prepared for the proposal- Predicted effluent quality distributions were generated between the 50th and 98th percentiles 100th percentile design values are not available. BOD was analysed but omitted from the results due to the majority of results falling below the 2mg/L reading limit.
	• A NorBE water quality assessment for dry, average and wet weather conditions based on 50 and 90 percentile pollutant concentrations in effluent and should include o estimates and comparison of pollutant loading and pollutant concentrations of TSS, BOD, TP, TN and pathogens for the following two scenarios: ▪ pre-upgrade or baseline effluent quantity and quality (pollutant concentrations) as per current EPL at the licence discharge point, and ▪ post-upgrade effluent quantity and quality at the discharge point	A DIA including a NorBE assessment has been prepared for the proposal noting WaterNSW comments to consider water quality impacts (provided in -Appendix E) Assessment has been completed for TN, TP, TSS, and BOD between 50th and 98th percentiles. This has been done for both dry (typical) and wet weather conditions. Both current and projected concentrations and loads have been calculated at the discharge point. Predictions of volumes of discharges have been calculated. Frequency is

Agency	Summary of Comments	Where Addressed in REF
	o detailed hydraulic and water quality modelling and assessment for dry, average and wet weather conditions including: ▪ predictions for volume and frequency of effluent discharges, including untreated wastewater releases ▪ predictions for changes to flows in the discharging water body ▪ impacts of discharges on water quality during low, medium and high river flows, particularly of: ▪ high effluent concentrations of pollutants (TSS, BOD, TP, TN and pathogens), and ▪ partially and primary treated effluent when wastewater flows exceed the capacity of the plant ▪ impacts on aquatic flora and fauna and geomorphology of the discharging water body, and o options for addressing the management of sewage which exceeds the capacity of the plant.	incorporated through the cumulative distribution of concentrations and loads. Expected flows have been projected based on design EP values. Completed for TN, TP, TSS, and BOD at two downstream locations (mixing zone, and far field). No analysis done for stormwater discharges due to pond exceedance. Data not available to determine concentrations of discharging effluent. Outcomes of interim macroinvertebrate monitoring data is provided in Section 5.8 A copy of the interim analysis report of is provided in Appendix H. Management of excess inflows have been incorporated into new inlet works design. Refer to Section 4.2.1. Provided during meeting with EPA in October 2019 and subsequently sent to WaterNSW for comment.

Agency	Summary of Comments	Where Addressed in REF
	• Proposed monitoring program including location of proposed monitoring points upstream and downstream of the discharge point.	
WaterNSW 2 October 2018 (letter)	**STP Design** • In consideration of the project population ground for determination of the design capacity of the augmented STP, the increased density of development including the proportion of multiple and multi-unit dwellings (including boarding houses) within the catchment area should be considered.	Considered as part of the IWCM (see Section 3.2)
	• The proposed raw sewage detention pond and emergency storage pond should have sufficient capacity to prevent any overflow of raw sewage.	Section 4.1
	• Provision for power supply back-up in the event of a power failure at a pumping station or at the STP.	Section 4.2.20
	NorBE water quality assessment • Pre- and post-upgrade pollutant loading for 100 percentile pollutant concentrations in effluent	Refer to Section1.1 ,2.3.3 and 5.6 NorBE has been considered for the Proposal. A DIA including a NorBE test has been prepared for the proposal to assess pre and post-upgrade pollutant loading.
	Detailed Hydraulic and Water Quality Modelling Assessment • impacts of effluent discharges on water quality on receiving waters during extended dry climactic conditions • the potential for total wastewater loading exceeding the projected wastewater loading for the design scenario	Refer to Section1.1 ,2.3.3 and 5.6 A DIA including water quality modelling has been prepared for the proposal (provided in Appendix E)

Agency	Summary of Comments	Where Addressed in REF
	• the potential for overflow of raw sewage from the failure of any sewage pumps within the plant • the potential for overflow of raw sewage from the storm detention pond and/or overflow from the sludge lagoons. • potential for flood inundation of any elements of the STP and impacts on water quality in particular, inundation of the raw sewage storm detention pond and proposed chemical storage area	
	Conceptual Construction Environmental Management plan (CEMP) incorporating a Conceptual Soil & Water Management Plan (SWMP) for the construction phase of the project.	Refer to Section 4.3.4, 6.1and 6.2
OEH (now Environment, Energy and Science (EES)) 2 October 2018 (letter)	<u>Biodiversity</u> There are mapped areas of Southern Highlands Shale Woodland (SHSW) threatened ecological community, listed as critically endangered under the *NSW Biodiversity Conservation (BC) Act 2016* and *Commonwealth Environment Protection & Biodiversity Conservation (EPBC) Act 1999,* immediately north of the subject site. SHSW may also occur on site, as the extent of the EEC may not be wholly evident from the mapping. The Mittagong Rivulet watercourse bisecting the site is also identified on the Biodiversity Values Map supporting the BC Act 2016. As such, you may also wish to consider a vegetation management plan (VMP) and associated works to improve the resilience and functioning of the Mittagong Rivulet riparian corridor.	Section 5.8
	It is noted that a Biodiversity Development Assessment Report (BDAR) and biodiversity offsets are not required for Part 5 activities under Section 7.8 of the BC Act, unless there is likely to be a significant impact on threatened species and you elect not to prepare a Species Impact Statement (SIS). If a BDAR or SIS is not required, we recommend that you consider measures to offset any impacts on biodiversity.	Noted

Agency	Summary of Comments	Where Addressed in REF
	Aboriginal cultural heritage An assessment of impacts on Aboriginal cultural heritage values should also be undertaken. If Aboriginal objects are to be harmed, including any archaeological test excavation required as part of this assessment, an Aboriginal Heritage Impact Permit (AHIP) under the National Parks & Wildlife Act 1974. A known Aboriginal cultural heritage site is also located within the vicinity of the STP. Although there are no identified Aboriginal objects on AHIMS within the site itself, its location adjacent to the riparian corridor and the presence of a known site nearby indicates sensitivity for Aboriginal cultural heritage values.	Section 5.11
	Flooding It is recommended that Wingecarribee Shire Council be consulted with regard to floodplain risk management as the approval authority and custodian of the most up-to-date flood information, namely the Burradoo BU2 Flood Risk Management Plan (FRSMP). The REF assessment should ensure that the design implications of flood events greater than the 1% Annual Exceedance Probability (AEP) and up to the probable maximum flood (PMF) are considered. This is to ensure that operation of the STP during flood events is not compromised, so that inundation of critical components does not lead to failure and longer term shutdowns.	Refer to Section 5.6
DPI – Fisheries 26 November 2018 (letter)	The REF should include:	
	• Location of works (including topographic map and photos).	Refer to Section 1.1 and 5.2
	• Name of adjacent waterway(s).	Section 5.6
	• Description of works to be undertaken.	Section 4
	• Investigations into the options for the reduction in volume of discharge, including beneficial reuse of the treated effluent	Section 3.3.4, 4.2.12 and 5.7.2

Agency	Summary of Comments	Where Addressed in REF
	• Description and condition of aquatic habitats (watercourses, wetlands) located on the site and downstream of the site in Mittagong Creek. In particular, description of the aquatic and riparian habitat conditions at and adjacent to proposed STP site and waterway discharge site – particularly extent and condition of riparian vegetation, water depth, and permanence of water flow and snags (large woody debris).	Refer to Section 5.6 and 5.8
	• Analysis of any interactions of the proposed works with aquatic and riparian environments. In particular details of any impacts on aquatic habitats and riparian areas associated with pipeline crossings of waterways and proposed construction methods	N/A. Waterway crossings are not proposed
	• Safeguards to mitigate any impacts upon aquatic environments and riparian habitats.	Section 5.6.3,5.7.3 and 5.8.3
	• Potential impacts on any aquatic threatened species, populations and ecological communities listed under the Fisheries Management Act 1994 and safeguards to mitigate any potential impacts.	Section 2.2.9
	• Safeguards to mitigate any impacts upon water quality (including impacts downstream in Mittagong Rivulet and on any aquatic threatened species, populations and ecological communities. This should include details of proposed storage of excess inflows of untreated effluent, provisions for power and equipment failures and treatment of effluent, proposed erosion and sediment controls for works, and details of proposed baseline, outfall and downstream water quality monitoring following any discharges of treated and untreated effluent. Monitoring of water discharges should include sampling of estrogen, as there is increasing evidence that estrogen adversely affects the health of fish.	Refer to Section 3.3 and 5.6 A Discharge Impact Assessment including discharges water quality modelling has been prepared for the proposal. Estrogen sampling analysis found that the concentrations of estrogenic endocrine-disrupting chemicals (EDCs) are relatively low and the risk of seeing estrogenically mediated effects in receiving waters is minimal (A copy of the report is provided in Appendix E).

Agency	Summary of Comments	Where Addressed in REF
	• Details of proposed revegetation of adjacent riparian buffer areas.	Disturbance of riparian buffer areas is not envisaged
NSW Health	No comment received	
DPIE – Water	Requirements with regards to the STP upgrade are covered by the process to gain approval under Section 60 of the Local Government Act 1993.	Section 2.2.4

3. Need for the Project and Option Evaluation

This section reviews the existing sewerage infrastructure at the Bowral STP, provides the context for the proposed works and describes the option evaluation process. It has been summarised from the *Bowral Sewage Treatment Plant (STP) Upgrade Draft Concept Design Report* (PWA, January 2019) and the *Bowral Sewage Treatment Plant Upgrade Detailed Design Report* (Hunter H_2O, June 2021).

3.1 Existing Infrastructure and Operation

Raw sewage enters the plant via two gravity mains and DN450 RC gravity main. The existing STP consists of the following systems.

- Inlet works with mechanical screening
- Two x 2,000 EP Pasveer Channel reactors
- One x 10,600 EP IDEA reactor
- Effluent catch/balance pond
- Liquid alum and caustic storage and dosing systems
- Two effluent cloth filtration units
- Artificial ultra-violet (UV) open channel type disinfection system
- Two sludge stabilisation lagoons
- Sludge drying beds (used as drying beds and also used to allow 'Geobags' to drain)

The current STP us currently operating at close to its design load.

The STP operates under EPL 1749. The current effluent quality limits under EPL No 1749 are listed in Table 3-1. Non-conformances at the Bowral STP have been related to high flows or concentrations received at the plant. The latest being in 2014 where Total Nitrogen (TN) exceedance occurred which has been an ongoing issue over the years. The upgraded plant has been designed to provide a more consistent and reliable effluent quality.

Table 3-1: NSW EPA effluent limits for Bowral STP

Parameter	Current EPA Licence 50 %ile (mg/L)	Current EPA Licence 90 %ile (mg/L)	Current Effluent 50 %ile (mg/L)	Current Effluent 90 %ile (mg/L)
TSS	10	15	4	8
Ammonia Nitrogen	-	2	0.6	1.3
TN	7.5	10.0	5.6	6.8
TP	0.3	0.5	0.13	0.25
BOD	5	10	2.0	4

3.1.1 Sewage Lift Pump Station

The existing raw sewage pump lift pump station consists wet well with 3 pumps and transfer flows to the inlet works.

3.1.2 Inlet Works

The existing inlet works has a mechanical step screen, but no grit removal system. The inlet works is designed for a flow equivalent to a load of 14,530 EP

Excess storm flows to the plant are currently bypassed upstream of the mechanical screening system to the storm detention pond. This has resulted in the excessive deposition of solids in the subsequent unit processes which has been very difficult to remove, requiring excessive cleaning input from the plant operators. The volatile nature of the solids has also resulted in the production of odours from the decomposition of the solids in the storm detention pond.

3.1.3 Intermittently Decanted Extended Aeration (IDEA) Reactor

The Bowral STP has an existing IDEA reactor with a design capacity of 10,600 EP.

3.1.4 Pasveer Channels

Pasveer Channels comprising 2 x 2000 EP ditch style bioreactors which operate in parallel with the IDEA Reactor.

3.1.5 Chemical phosphorous removal

Two stage alum dosing is currently employed at Bowral STP. The inert chemical from the secondary dosing stage is flocculated and captured in the downstream effluent catch/balance tank.

3.1.6 pH (Alkalinity) Correction

Liquid caustic is currently being dosed into the inlet works with the dose rate flow paced with the inlet flow meter.

3.1.7 Effluent Catch Balance Tanks

The existing catch balance pond at Bowral has a very long hydraulic retention time (HRT) and is therefore highly susceptible to algae formation. It has also been found by the plant operators to be very difficult to de-sludge. Automatic cleaning means have been found to be unsuccessful and the ponds are manually cleaned by the plant operators. Inflow to the plant is diverted to the storm detention ponds during catch balance cleaning events. Significant catch balance tank downtime is required to convert the pond to a configuration that is of reduced HRT and that is easier to de-sludge.

3.1.8 Cloth Filtration System

The plant currently has 2 cloth media filters with a combined capacity of 150 L/s. Filtered effluent currently discharges into a channel type UV disinfection system.

3.1.9 UV Disinfection

Filtered effluent is currently disinfected to reduce faecal coliforms levels from 10^6 fcu/100mL to less than 200 fcu/100mL, prior to discharge. The existing UV system, which is older than 10 years, is designed to provide full treatment for flows up to 55 L/s and partial treatment for flows up to 129 L/s.

3.1.10 Bio-solids Management

The waste activated sludge (WAS) produced by the secondary treatment process at Bowral STP is currently stabilised via 2 x 5.5 ML sludge lagoons and dried on drying beds. Stabilised, dewatered bio-solids is routinely tested for Stabilisation and Contaminant Grade and transferred off-site.

Stabilised sludge is occasionally dewatered on-site using Geobags or with a centrifuge that is brought onto site when required.

An aerial view of the Bowral STP site showing the existing STP layout is provided below in Figure 3-1.

Figure 3-1 Aerial view of the existing Bowral STP site.

Source: SIX Maps, accessed August 2021

3.2 Basis of Design (Population and Loadings)

3.2.1 Load Projections

The urban population of Bowral based on the year 2016 Census (ABS, 2016) was 12,949 people. The equivalent population (EP) load would likely exceed the existing 14,600 EP design load of Bowral STP when the non-residential load is taken to account.

The projected EP load for the STP is presented in Table 3-2, as calculated in an Integrated Water Cycle Management Options Review Paper (IWCM) that was undertaken by Public Works Advisory (PWA) in 2017. Table 3-2 indicates that the total load to the plant exceeded the design load of the STP in the year 2016. An ultimate population of up to 21,000 EP has been adopted for the proposed upgrade, being the adopted IWCM loads plus an allowance of 10% rounded up to the nearest 1,000 EP.

Table 3-2 Equivalent Populations (EP) Projections (IWCM, 2017)

Source	2016	2031	2046
Total EP	14,842	16,914	18,692

3.2.2 Biological loading

Values derived from Council sampling and as presented in the IWCM are considered as standard level values that are an appropriate basis for design (see Table 3-3).

Table 3-3: Design Biological Load

Parameter	Value
Hydraulic loading	220 L/EP/day
Biochemical Oxygen Demand (BOD5)	60 g/EP/day
Suspended Solids (SS)Total	60 g/EP/day
Total Nitrogen (TN)	12.5 g/EP/day
Total Phosphorus (TP)	3 g/EP/day

3.2.3 Hydraulic Loading

The design basis for the hydraulic load is presented in Table 2-3. The hydraulic loading design has been calculated based on the design EP loading, the current collection and transfer system performance and the requirements for treatment to meet the EPA quality requirements for the STP EPL.

Table 3-4: Design Hydraulic Loads

Flow	Factor	Flow rate
ADWF		53 L/s
DDWF (design dry weather flow)	4.5 x ADWF	160 L/s
DWWF (design wet weather flow)	7 x ADWF	374 L/s
PWWF (peak wet weather flow)	10 x ADWF	535 L/s

3.3 Option Evaluation

The following information is taken from the *Bowral Sewage Treatment Plant Upgrade Detailed Design Report* prepared by Hunter H_20 (2021) for the proposal.

3.3.1 Preliminary Design

The Bowral STP was last upgraded in 2006 to a nominal design capacity of 14,600 EP. The urban population of Bowral in 2016 was approximately 12,500 EP, with an estimated total STP load (including non-residential loads) as high as 15,500 EP. Therefore, the current load on Bowral STP exceeds the design load.

Therefore, WSC are required amplify and intends to upgrade the Bowral STP to increase the capacity to 21,000 EP, being the projected ultimate population, and to improve performance over time to meet treated effluent discharge quality requirements.

In 2017, PWA prepared *an Integrated Water Cycle Management Options Review Paper* which provided a modified version the GHD (2015) upgrade strategy.

3.3.2 Concept Design

In 2018, PWA prepared a *Concept Design Report* (CDR). This assessment comprised of an options investigation to identify the best way to upgrade and amplify the various Bowral STP process units centred around constructing an additional IDEA style bioreactor. The upgrade strategy proposed including :

- Dual catch ponds that drain completely and include solids removal systems.
- Future break point chlorination for TN removal (NorBE), plus de-chlorination.
- Conversion of one existing Pasveer bioreactor to an additional storm detention pond.
- Conversion of one sludge lagoon to an aerobic digester with decant thickening.
- Provision of permanent mechanical dewatering facilities.

3.3.3 Detailed Design

In 2019, WSC called for quotations for the Detailed Design of the Bowral STP upgrade which was intended to be in keeping with the Concept Design Report prepared by PWA. A *Design Development Report* was subsequently prepared by Hunter H_2O (June 2021) (Provided in Appendix F). This report discussed three secondary treatment options, including:

- PWA Option (modified) – This was similar to the preferred option outlined in the CDR. This included retaining the existing IDEA, derating it, constructing a second large IDEA, constructing a new decant balance tank and converting a sludge lagoon to an aerobic digester. Break point chlorination was replaced by more advanced denitrifying IDEA bioreactors, including anoxic zones, mixed liquor recycle (MLR) pumping and carbon dosing.

- H_2O Option – This option involved utilising the existing IDEA as an aerobic digester, then constructing two new advanced denitrification IDEA bioreactors and decant balance tank as a single structure.
- MLE/FSB Option – This option involved utilising the existing IDEA as an aerobic digester, then constructing new Four Stage Bardenpho (FSB) continuous flow bioreactors and associated clarifiers (including the provision for future carbon dosing).

As part of the detailed design process for the STP upgrade, a *Discharge impact Assessment* (MHL, 2021) carried out a comparison of the effluent discharge capabilities for multiple plant type treatment performance scenarios, including IDEA, MLE and FSB type treatment plants, to assess their compliance with the default ANZECC guidelines (shown in Table 3-5 below). The modelling of the nutrient removal capabilities for the various treatment processes indicated that a reduction in the concentrations of contaminants in the receiving waters and a relative improvement in water quality in the receiving waters would be achieved through the MLE and FSB type plants at full design load (also refer to Section 5.7). Based on the performance scenario modelling, the MLE/FSB Option with the FSB plant initially operating under MLE configuration, with subsequent conversion to FSB operation, was identified as the preferred treatment plant type for the STP upgrade detailed design.

Some modifications were made during further development of the design. The most significant design changes included:

- The solids removal performance of the disk (cloth) filters, even after upgrading and amplification, was considered inadequate in consideration of future water quality objectives. A decision was made to replace the existing disk filters with deep bed, dual media filters.
- The option to use the existing IDEA decanter for digester thickening was analysed in detail. It was found to require a slow decant lowering speed of around 1 mm per minute. This was considered too difficult to control introducing higher levels of risk. A decision was made to adopt pre-thickening using a picket fence gravity thickener.
- A channel type UV system was adopted (in lieu of an in-pipe system) for improved hydraulics and control.
- A manual SDP washdown system was added for cleaning of the storm ponds after use.

The selected MLE/FSB STP upgrade option is described in detail in Section 4.2. Designs are provided in Appendix B.

Table 3-5 Modelled Effluent Discharge Capabilities for IDEA, MLE and FSB plant type scenarios

	IDEA with Cloth Filters		Continuous (MLE) Type Plant with Carbon Dosing and Cloth Filters		Four Stage Bardenpho (FSB) Type Plant with Carbon Dosing and Cloth Filters		PQL (Practical quantitation limits)
	50%ile	90%ile	50%ile	90%ile	50%ile	90%ile	
BOD (mg/L)	<2	3	<2	3	<2	3	2
TSS (mg/L)	5	10	5	10	5	10	3
TN (mg/L)	7	10	5	7	3	5	0.3
TP (mg/L)	0.2	0.5	0.1	0.3	0.1	0.3	0.02

(Source: Discharge Impact Assessment. MHL, 2021)

3.3.4 Treated Effluent Management Options

Options for effluent management are considered to be limited. Accordingly, it is proposed to continue the current practice of treated effluent discharge to Mittagong Rivulet. The current STP is a modern standard activated sludge based plant and has been proven to provide a very good level of treatment. The augmented plant would improve treatment performance and aim to meet EPA requirements. Therefore it is predicted that impacts on receiving waters due to continued discharge would be limited. Council is continuing to investigate recycled water opportunities and implement where it is of a benefit to the community, however these are unlikely to significantly change the volume of effluent to the environment.

3.4 Preferred Option and Justification

The 'do nothing' option is not feasible as it would not achieve the objectives of the proposal and would not meet current or future population capacity or future water quality requirements. The Bowral STP is currently operating at design capacity, therefore the STP requires upgrading as soon as possible.

The preferred MLE/FSB Option involves utilising the existing IDEA as an aerobic digester, then constructing new FSB continuous flow bioreactors and associated clarifiers. The design includes the two new bioreactors designed as FSB, which are also able to initially be operated under the Modified Ludzak Ettinger (MLE) configuration.

The main advantages to the preferred MLE/FSB Option include:

- The MLE/FSB plant is unlikely to have significant adverse environmental impacts on the existing quality of the receiving waters. With significant improvements achieved in the reduction of TN contamination downstream compared to an IDEA type plant.
- It better manages the risk of achieving future effluent quality requirements, less risk of sunken assets.
- It is capital cost neutral.
- It is simpler to operate and control (no time sequencing and fewer set points).

- It would be identical to the style of STP for the proposed Moss Vale STP Upgrade where similarly stringent effluent quality projections are expected. This commonality provides operator mobility and familiarity advantages.
- It provides equal or better wet weather treatment capacity and performance.

It is considered that the MLE/FSB type treatment system would provide an effective and robust outcome for the proposed Bowral STP Upgrade. The detailed design has evolved from a number of iterations And it is considered that HunterH_20's design development process has replicated an assessment of options. The thoroughness of and the design development and the designers experience in the upgrade of other STPs has led to a design which would provide adequate treatment so that effluent discharges do not have significant impacts on the environment (receiving waters). The design also future proofs the STP for potential further upgrades (and minimises the risk of 'sunken assets' in future augmentations).

Table 3-6 below provides an overview of the justification and decisioning process undertaken as part of the Bowral STP design development for the selected continuous MLE/FSB type treatment plant.

Table 3-6 STP Treatment Process Design Development and Justification

STP Treatment Type/Design Component	STP Design Development and Justification
Intermittent vs Continuous Treatment Process	• IDEA technology was originally the preferred upgrade approach. (as per the PWA Concept Design Report, 2018). Part of the reason of this approach was that WSC are familiar with their operation and comfortable with the maintenance requirements. They can also be operated in a storm mode to better cater for infiltration events. • The continuous process is able to achieve superior total nitrogen performance - it can be configured to meet the expected future (ultimate) nitrogen limit, whereas the intermittent process is very unlikely be able to achieve this limit. • Allowance was made to provide a solids contact mode within the continuous process to give comparable wet weather treatment capacity to the IDEA process. • Initial cost estimates of both technologies were found to be of comparative magnitude.
Conventional Continuous vs MBR	• Minimal difference in nitrogen removal performance - reactor can maintain the same configuration, it is only the solids separation approach that changes. • Minimal difference in phosphorus removal performance (assuming that other similar conventional filtration is provided for the conventional activated sludge system) • Cost savings associated with smaller reactor footprint is offset by the ongoing costs for membrane replacements, cleaning systems, reduced aeration efficiency, etc. • The operational complexity of an MBR plant is significantly greater than intermittent and conventional processes - increasing both operational and maintenance demands. • It is both cost and operationally prohibitive to provide membrane capacity above peak full treatment flow (3 x ADWF). The wet weather treatment capacity is therefore at least half of the continuous and intermittent processes, leading to a reduction in storm storage capacity and an increase in overflow of non-treated effluent.

	• There are minimal-effluent reuse drivers at the treatment plant to take advantage of the disinfection log credits offered by the membrane technology.
Issues with Breakpoint Chlorination (Chlorination/Dechlorination)	The original concept design by PWA suggested chlorination/ dechlorination of effluent as a means to minimise effluent nitrogen concentrations. However, the design development report by Hunter H_2O identified a number of issues with this approach, a summary is provided below: • Requires nitrogen to be present as ammonia - well operated activated sludge systems typically achieve less than 1 mg/L. • Although theoretically possible to 'detune' the activated sludge process, it is unstable and can drive poor settleability and generation of nitrogen radicals. • The mass of chlorine required to achieve breakpoint chlorination is approximately 7 x the incoming concentration. Such high doses are costly and increase the risk of forming chlorinate radicals. • An equivalent dechlorination dose is required, further increasing cost and is difficult to control, given the small margin of error available. • Biological nitrogen removal within the activated sludge process avoids these issues and presents a more stable, cost effective and environmentally superior approach.
Add on Nitration Filters	• The adopted continuous process configuration is able to achieve very low nitrogen concentrations and meet future effluent discharge requirements. A large part of residual nitrogen is a result of un biodegradable soluble nitrogen that cannot easily be removed (advanced treatment techniques with a high capital cost are required). • A liquid carbon/COD dose to the dual media filters may be used to further denitrify nitrate coming from the secondary process, however nitrate concentrations are expected to be minimal (especially if a carbon dose is applied to the secondary anoxic cell of the reactor) • Items to note with this approach: - Removal is facilitated by bacteria growing within the filter media - encouraging this growth decreases filter run times; - Each time a backwash occurs, the bacteria achieving the removal are flushed from the system and need to re-establish;

	- There is a risk that dosing excess carbon into the effluent stream will result in breaches of the final BOD requirements. • A carbon dose could be considered in the future, however has not been considered at this stage given the quality of effluent from the adopted continuous process and the risk of exceeding effluent COD/BOD requirements. • Nitrogen filters are not well proven in Australia, and their inclusion would be a risk to Council.
Mechanical Band Screens (instead of a step screen)	The Concept Design Report (PWA, 2018) suggested a single step mechanical screen. The developed design includes two band Screens (in duty/standby configuration - each sized for PWWF). The band screens will have 5 mm perforations which will perform better than the 5 mm one dimensional step screen slots suggested in the Concept Design Report. Therefore, screening performance is superior.
Dual Media Tertiary Filters (instead of cloth filters)	The STP currently has two cloth media disk filters - which Council finds operationally difficult with regard to biofouling leading to ineffective backwashing and shortening cloth media life. The Concept Design Report suggested providing an additional cloth filter to reduce the suspended solids (and phosphorus captured in the filters) solids) before effluent is disinfected with the UV unit. Dual media filters are significantly superior to cloth filters, particularly with regard to solids and phosphorus removal. Dual media filters are designed to result in at least half the effluent TSS of the upgraded cloth filters, with reflective improvements total phosphorus (TP) removal. Although the initial capital cost of installing dual media filters is greater than cloth filters, the long term operational /maintenance benefits and risk of needing to replace the older cloth filters in time, the long term financial outcome would be nearer to breakeven.

4. Proposal Description

This section provides a detailed description of the infrastructure to be provided for the Bowral STP including relevant details relating to construction and operation of the proposed works.

4.1 Design Considerations

Environment Protection Licence (EPL)

Under the POEA Act 1997, Council would need to apply to vary the existing licence EPL No 1749 before commencing construction. The application to vary the EPL would need to include details of the treatment capacity, the expected effluent standard and details of any proposed environmental monitoring program.

Discharge Volumes

The 2016 and predicted future dry weather discharge volumes of treated effluent from the STP is shown in Table 4-1. Wet weather discharge will vary according to the weather and amount of infiltration into the collection system. On average, it would be typical that wet weather would add 10% volume to the amount of effluent released.

Table 4-1 Discharge volumes from Bowral STP

	2016	2021	2026	2031	2036	2041	2046
Bowral STP (EP)	14,842	15,817	16,425	16,914	17,486	18,078	18,692
ADWF (ML/d) EPA Monitoring Point 1	3.562	3.796	3.942	4.059	4.197	4.339	4.486

Treated Effluent Discharge Quality

The STP is located in the declared drinking water catchment which is regulated by the Sydney Drinking Water Catchment SEPP (see Section 2.1.4). Under the SEPP, developments proposed by a public authority within the drinking water catchment that are permissible without development consent should consider the neutral or beneficial effect on the water quality (NorBE) and incorporate (as far as practical) current recommended practices or performance standards endorsed or published by WaterNSW related to water quality.

To meet EPA water quality requirements, the upgraded STP must absorb some of the impact of new developments in the catchment area by removing additional pollutants/nutrients due to the increased load. The population is predicted to increase by 40% from the current load to the ultimate design horizon in 2046 at the Bowral STP. This means that the new works would be required to:

- have no identifiable impact on the receiving water quality, or
- contain any water quality impact on the site and stop it from reaching any watercourse, waterbody or drainage depression on the site, or
- transfer any water quality impact outside the site where it is treated and disposed of, to standards approved by EPA.

WSC has undertaken ongoing consultation with the EPA and WaterNSW to determine what baseline is required and realistic effluent standards for the upgraded STP. WaterNSW have indicated that the baseline condition targets for NorBE should be the 2007 year loads from the Catchment Report prepared by PWA in 2007 when the Bowral STP was first commissioned and that this would be the basis for suggested licence conditions. As a result, the reduction factor would not be as per the normal NorBE guidelines approach, but rather to maintain the discharge loads as per the 2007 baseline.

Based on the comparisons undertaken in the Design Development Report (HunterH_2O,2021) and other supporting documentation, including the DIA; WSC elected to proceed with the MLE/ FSB Option, with the FSB plant initially operating under MLE configuration and subsequent conversion to FSB operation. This design option was preferred over the IDEA type plant, as it is more able to meet the required treated effluent discharge requirements. This is further discussed in Section 5.7.

STP Upgrade EPL Conditions

WSC proposed EPA Licence effluent discharge concentrations and load limits for the upgraded STP to the EPA (WSC, 30 June 2021), to ensure reasonable limits are implemented that protect the environment and drinking water catchment, while facilitating the practical operation of the STP. These proposed limits are shown in Table 4-2 and Table 4-4, respectively.

The suggested licence concentration limits for the proposed upgraded Bowral STP are commensurate with licence limits for other sewage treatment plants that discharge into the Sydney drinking water catchment. The concentration limits allow for wet weather, operational, maintenance and other unforeseen events. As the load limits would be used to limit the annual amount of nutrients entering the catchment, it was suggested that the concentration limits are limited to 90%ile to ensure compliant operation. The average load from the 2007 catchment report (PWA, 2007), current licence loads and 2021 annual return loads are summarised below in Table 4-3. It is suggested that the new loads are rounded from these figures where practical for the new EPL.

Table 4-2 Suggested new EPL Effluent Discharge Licence Concentration Limits

Pollutant	Unit of Measure	90%ile	100%ile
Ammonia	mg/L	2	
BOD	mg/L	15	
E.coli	Colony forming units per 100 millilitres	200 (80 percentile)	
Nitrogen (total) (TN)	mg/L	10	
pH	-		6.5 – 8.5
Phosphorus (total) (TP)	mg/L	0.5	
Total Suspended Solids	mg/L	15	

Table 4-3 Average effluent discharge loads from the 2007 catchment report, current licence loads and 2021 annual return loads

Source	Nitrogen (kg)	Phosphorus (kg)	BOD (kg)	Total Suspended Solids (kg)
Current Licence loads	27,500	1,650	11,000	11,000
2021 annual return loads #	5,294	427	5,294	11,210
2007 catchment report loads (average)	9,790	365	2,646	5,689

 # Noting that 2021 was considered an extremely 'wet year'

Table 4-4 Suggested new EPL Effluent Discharge Licence Load Limits

Source	Nitrogen (kg)	Phosphorus (kg)	BOD (kg)	Total Suspended Solids (kg)
50 percentile load and flow	10,000	300*	3,500**	6,000

*At 0.2 mg/L at full load
**At the 2 mg/L detection limit at design load

4.2 Description of the Proposed Works

The proposed upgrade works at the Bowral STP would include the following:

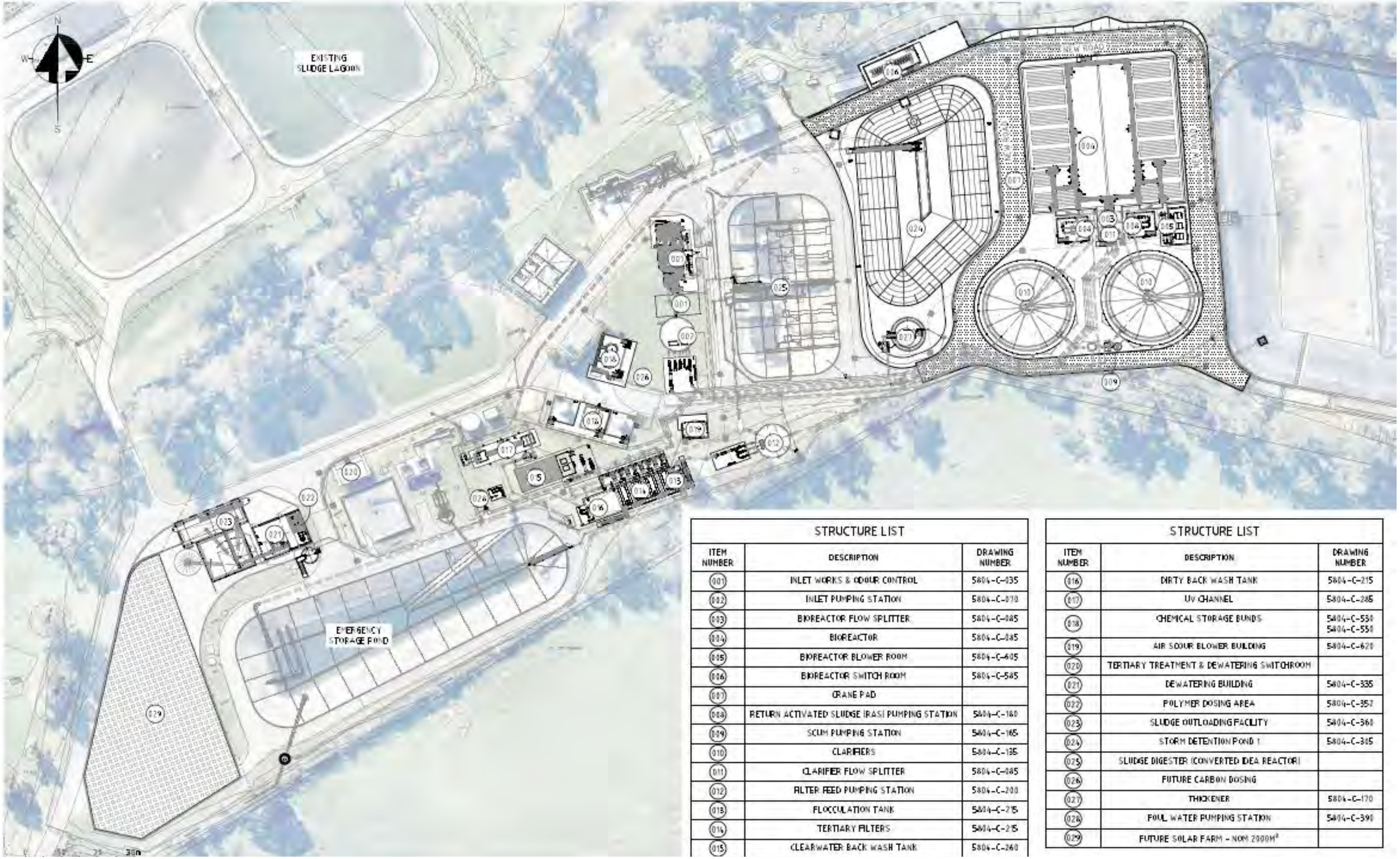
- A new inlet works and new lift pump station
- Odour control system servicing the inlet works and inlet lift pump station
- A new storm detention pond (SDP1) located at the site of the current Pasveers,
- Upgrade of The existing storm detention pond (SDP2)

- A new bioreactor splitter box
- Two (2) new bioreactors designed as FSB but able to be operated as MLE.
- A new bioreactor aeration supply system
- Two new secondary clarifiers each sized for up to 3 ADWF (FSB mode) or 3.75 ADWF (MLE mode)
- A new scum pump station, with a single scum pump (duty only)
- A new filter feed pump station
- An emergency storage tank (EST) system
- Tertiary filtration system
- A new UV disinfection system to replace the existing UV system.
- An upgraded reclaimed effluent (RE) system for onsite reuse.
- A new Waste Activated Sludge pumping and thickening system
- An aerobic digester
- A new mechanical dewatering facility
- Retain the existing biosolids hardstand as a backup or if truck movements are temporarily halted.
- Retain at least one sludge lagoon as emergency liquid sludge storage.
- A foul water pump station (FWPS)
- An alkalinity storage and dosing system
- A new alum storage and dosing facility
- A new chlorine storage and dosing facility
- Site provision for future carbon storage and dosing (sucrose solution used for sizing).
- Site provision for future recycled water treatment system.
- Site provision for photovoltaic/solar power supply (subject to budgetary availability of funds or receipt of subsequent NSW government grant funding for such public infrastructure projects).

A description of the main components of the upgraded STP is detailed below.

The STP site layout, proposed upgrade works layout, process flow diagram and photographic view of the site are provided in Figure 4-1, Figure 4-2 and Figure 4-3, respectively.

Plans are provided in Appendix B and the Detailed Design Report is provided in Appendix F.



STRUCTURE LIST		
ITEM NUMBER	DESCRIPTION	DRAWING NUMBER
001	INLET WORKS & ODOUR CONTROL	5804-C-035
002	INLET PUMPING STATION	5804-C-070
003	BIOREACTOR FLOW SPLITTER	5804-C-085
004	BIOREACTOR	5804-C-085
005	BIOREACTOR BLOWER ROOM	5804-C-605
006	BIOREACTOR SWITCH ROOM	5804-C-585
007	CRANE PAD	
008	RETURN ACTIVATED SLUDGE (RAS) PUMPING STATION	5804-C-180
009	SCUM PUMPING STATION	5804-C-165
010	CLARIFIERS	5804-C-135
011	CLARIFIER FLOW SPLITTER	5804-C-085
012	FILTER FEED PUMPING STATION	5804-C-200
013	FLOCCULATION TANK	5804-C-215
014	TERTIARY FILTERS	5804-C-215
015	CLEARWATER BACK WASH TANK	5804-C-260

STRUCTURE LIST		
ITEM NUMBER	DESCRIPTION	DRAWING NUMBER
016	DIRTY BACK WASH TANK	5804-C-215
017	UV CHANNEL	5804-C-285
018	CHEMICAL STORAGE BUNDS	5804-C-530 5804-C-550
019	AIR SCOUR BLOWER BUILDING	5804-C-620
020	TERTIARY TREATMENT & DEWATERING SWITCHROOM	
021	DEWATERING BUILDING	5804-C-335
022	POLYMER DOSING AREA	5804-C-352
023	SLUDGE OUTLOADING FACILITY	5804-C-360
024	STORM DETENTION POND 1	5804-C-305
025	SLUDGE DIGESTER (CONVERTED IDEA REACTOR)	
026	FUTURE CARBON DOSING	
027	THICKENER	5804-C-170
028	FOUL WATER PUMPING STATION	5804-C-390
029	FUTURE SOLAR FARM - NOM 2000M²	

Figure 4-1 Bowral STP Upgrade Proposed Site Layout

Source: Hunter H_2O, 2021

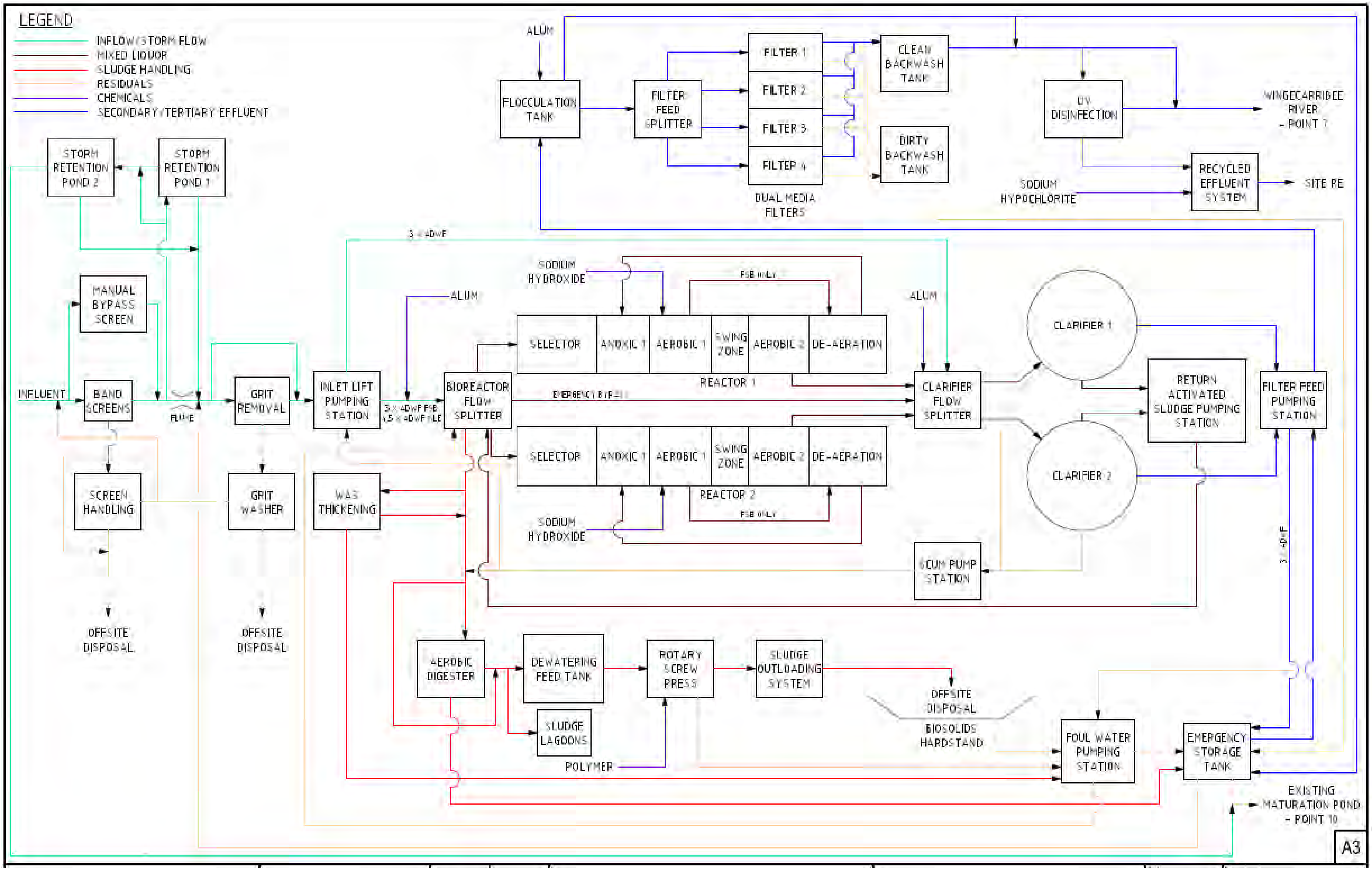


Figure 4-2 Bowral STP Upgrade Process Flow Diagram

Source: Hunter H_2O, 2021

Figure 4-3 Aerial view of the existing Bowral STP site

Source: WSC, 2008.

4.2.1 Inlet Works and Odour Control System

A new inlet works is proposed and would be sized for the equivalent PWWF at 21,000 EP.

The proposed inlet works would include:

- Two mechanical band screens (duty/duty) each sized for 13 ADWF.
- A bypass channel fitted with a manual screen sized for 13 ADWF.
- Appropriate screen washing and dewatering.
- Screened sewage flow monitoring.
- An overflow to the new storm detention pond No 1 (SDP1) for flows above 7.5 ADWF.
- A single vortex style grit tank sized for 7.5 ADWF.
- A grit sparge and extraction system (pumped).
- A single fluidised bed classifier for grit washing and dewatering.

An odour control system would also be installed to service the inlet works and inlet lift pump station, including extraction fans, a biofilter and an activated carbon filter.

4.2.2 Sewage Lift Pump Station

Screened and degritted sewage would flow from the inlet works to the lift pump station. There are three influent pumps and two bypass pumps in the lift pump station. The influent pumps deliver degritted sewage up to the Design Full Treatment Flow (DFTF) (set by operator) to the bioreactor splitter. There it is mixed with foul water and RAS before flowing to the bioreactors. The influent flow is monitored. The influent is fully treated through the bioreactors and clarifiers.

The new lift pump station would consist of:

- A new wet well.
- Three influent pumps in duty/assist/standby configuration, each sized for 1.5 ADWF. These can be operated as duty/assist/assist under the MLE configuration.
- Two bypass (solids contact) pumps in duty/assist configuration, each sized for 1.5 ADWF.

4.2.3 Storm Detention Ponds

Screened sewage in excess of Design Storm Treatment Flow (DSTF) would overflow a weir in the screened sewage channel of the inlet works and gravitate to storm detention pond 1 (SDP1). The operator can also shut down the lift pump station to undertake rare maintenance items (e.g. to repair or clean out splitter boxes, the filter feed pump station, etc). The storm detention ponds would provide many days of storage at average flow, allowing such repairs or maintenance to be undertaken. Stored storm sewage would be returned to the inlet works when conditions allow (e.g. wet weather flows subside).

A new storm detention pond (SDP1) would be constructed at the site of the current Pasveers, consisting of;

- An inlet receiving overflows from the screened sewage channel upstream of the grit tank.

- Two storm return pumps in duty/assist configuration. Each return pump is sized for 1.5 ADWF.
- A return rising main to the screened sewage channel.
- An overflow to SDP2.

The existing storm detention pond (SDP2) would be upgraded to include:

- The existing return pump wet well with hydraulic connection to SDP2.
- Replacement of storm return pumps (duty/assist) each sized for 1.5 ADWF.
- Modifications to the existing return rising main to the screened sewage channel.
- New overflow pipework directing excess flows to overflow of the existing Emergency Storage Tank.

4.2.4 Bioreactor Splitter

Influent from the lift pump station would be delivered to the feed chamber of the bioreactor splitter. Alum would be dosed to the influent main allowing adequate mixing time before reaching the feed chamber. The foul water from the foul water pump station (FWPS) would also be delivered to the feed chamber, where it mixes with the dosed influent. This mixture is split two ways using weirs before falling into to a combined feed and RAS chamber. Feed to either bioreactor can be isolated manually using stop boards at these weirs.

The new bioreactor splitter box would consist of consist:

- A bioreactor feed splitter, accepting influent from the lift pump station plus foul water from the FWPS. The feed splitter splits this mixture between the two bioreactors.
- A Mixed Liquor (ML) splitter accepting ML from the two bioreactors and splitting it to the two clarifiers. A high level switch inhibits the lift pump station (PS) should one clarifier be taken out of service without the maximum flow being reduced.
- A second (optional) alum dosing point to the ML splitter.
- A solids contact splitter box splitting the bypass flow between the two clarifiers. It mixes with the ML, providing solids contact, before gravitating to each clarifier.
- An alum dosing point to the common ML gravity main to the ML splitter. Mixing will occur in this gravity main, the ML splitter box and the ML gravity mains to the clarifiers.
- A RAS splitter accepting flows from the two RAS pump stations and splitting it to the two bioreactors. This mixes with the feed before gravitating to each bioreactor.
- An emergency overflow (alarmed) of RAS and feed directly to the bypass splitter and on to the clarifiers if one bioreactor is out of service and the operator has not capped the feed flow.

4.2.5 MLE/FSB Bioreactors and aeration system

Two (2) new bioreactors would be installed, designed as FSB but able to be operated as MLE. Each bioreactor is designed to accept 1.5 ADWF (FSB mode) or 2.25 ADWF (MLE mode).

There are two bioreactors which would be in duty/duty configuration. It may be possible to treat sewage in one bioreactor, particularly in summer, or under Current loading conditions, but this is not recommended unless it is necessary for maintenance. The ability to effectively treat sewage using a single bioreactor reduces as the connected load increases or temperature decreases.

The bioreactors would be designed to be operated in two process configurations:

- The Modified Ludzac Ettinger (MLE) configuration (anoxic-aerobic).
- The Four Stage Bardenpho (FSB) configuration (anoxic-aerobic-anoxic-aerobic).

The FSB configuration is capable of achieving a lower effluent TN concentration than the MLE configuration. It requires a larger unaerated mass fraction (adding a second anoxic zone). This means that the operating sludge age and mixed liquor suspended solids (MLSS) increases. This increase in MLSS decreases the DFTF capacity. This is why the bioreactors are rated for a DFTF of 4.5 ADWF under MLE mode and 3.0 ADWF under FSB mode.

Under the MLE mode, the secondary anoxic zone is aerated. Therefore, the primary aerobic, secondary anoxic and secondary aerobic zones become one, larger, primary aerobic zone. The MLR is drawn from the secondary aerobic zone (via the de-aeration zone) as this is where the nitrate concentration is at its highest, reducing the MLR pumping rate required.

Each of the bioreactors includes the following:

- A selector zone fed with dosed feed and RAS, complete with a mixer (duty only).
- A primary anoxic zone accepting flows from the selector and the MLR. This zone includes three mixers (duty/duty/duty) and an Oxygen Reduction Potential (ORP) element.
- Provision for a future carbon dosing point to the primary anoxic zone.
- A primary aerobic zone that accepts flows from the primary anoxic zone. This zone includes removable aeration diffuser grids, two dissolved oxygen (DO) elements and two aeration control valves.
- An alkalinity dosing point to the primary aeration zone. This zone will also contain a combined temperature and pH element.
- A secondary anoxic zone that accepts flows from the primary aerobic zone. This can be aerated (MLE) or mixed (FSB). It will include two mixers (duty/duty) plus removable aeration grids.
- Provision for a future carbon dosing point to the secondary anoxic zone.
- A secondary aerobic zone that accepts flows from the secondary anoxic zone. This zone will include a removable aeration grid plus a DO element and an aeration control valve (which also controls air to the secondary anoxic zone when aerated).
- A de-aeration zone that accepts flows from the primary aerobic zone (FSB) or secondary aerobic zone (MLE). Stop boards are used to select the flow path. This zone is fitted with a mixer (duty only) but should remain aerobic under most conditions.
- Three (3) MLR pumps in duty/assist/assist configuration pumping ML from the de-aeration zone to the primary anoxic zone.
- A ML outlet weir from the secondary aerobic zone to the ML splitter.

A new bioreactor aeration supply system would also be installed to maintain optimum dissolved oxygen in the aerobic zones of the bioreactors, comprising:

- Three blowers in duty/assist/standby configuration.
- Acoustic enclosures for each blower.
- A new blower building with ventilated cooling.

4.2.6 Secondary Clarifiers

There would be two secondary clarifiers in duty/duty configuration. Each clarifier can be isolated at the clarifier splitter (ML and bypass) and taken out of service for maintenance. Peak Dry Weather Flow (PDWF) can be accommodated with one clarifier out of service provided the sludge age and MLSS is reduced (e.g. MLE mode or FSB mode in summer). The RAS pumping system can be used to drain most of the contents of the clarifier and pump it back to the bioreactors.

Two new secondary clarifiers would be installed, each sized for up to 3 ADWF (FSB mode) or 3.75 ADWF (MLE mode). Each clarifier consists of:

- ML feed pipes.
- An energy dissipating inlet (EDI) and feed / flocculation well.
- A rotating sludge and scum scraper with peripheral drive.
- Self-flushing scum boxes intermittently delivering scum to the scum pump station.
- Out board effluent launders.
- Stamford baffles to deflect any momentum currents away from the effluent weirs.
- An effluent pipe to the filter feed pump station (via a common main)
- Two RAS pumps in duty/standby configuration. These extract RAS from the central floor of the clarifier and deliver to a common rising main to the RAS splitter. The RAS flow from each clarifier is individually monitored and controlled to ensure a perfect RAS split.

4.2.7 Scum Pump Station

A new scum pump station is required to capture scum and foam and prevent it entering the secondary effluent and to extract scum from the clarifiers and deliver it to the digester or lift pump station

The new scum pump station, with a single scum pump (duty only) would be installed to accept scum from the two clarifiers and deliver it to the aerobic digester or bioreactors (via the lift pump station).

4.2.8 Filter Feed Pump Station

The filter feed pump station system would shed wet weather flows in excess of DFTF, control filter feed flows to DFTF, monitor filter feed flows and detect filter bypasses, deliver secondary effluent to the filters and prevent overflow of the UV facilities.

Secondary effluent would flow under gravity from the clarifiers to the filter feed pump station (FFPS). Emergency storage return flows could also be pumped directly to the filter feed pump station as an option.

A new filter feed pump station would be installed, including:

- Three filter feed pumps in duty/assist/standby configuration delivering flows up to 3 ADWF to the tertiary filters.
- An overflow from the filter feed pump station to the Emergency Storage Tank (EST).
- An optional return pipe from the EST.

4.2.9 Emergency Storage Tank

Partially or fully treated secondary effluent in excess of the filter DFTF would overflow a weir in the filter feed pump station and would gravitate to the EST (old catch/balance pond). The overflow threshold is controlled by the filter feed pump station. The EST accept and store all secondary effluent flows as required occasionally due to poor effluent quality or overflows.

An EST system would be installed consisting of;

- The existing catch/balance pond to store overflows from the filter feed pump station (typically flows in excess of 3 ADWF and below 7.5 ADWF).
- Benching and a sump to allow the EST it to be fully drained between events.
- A new emergency return pump station with a single return pump (duty only) sized for 1.5 ADWF.
- An existing overflow to the existing effluent lagoon.
- A rising main returning stored effluent to the inlet works or back to the filter feed pump station.

4.2.10 Tertiary Filtration System

The tertiary filtration system would remove chemical precipitants from tertiary phosphorus polishing and polish suspended solids, BOD and total nitrogen from the secondary effluent. Secondary effluent from the filter feed pump station would be pumped to the filters via the filter feed splitter. Alum can be dosed (optional) to the flocculation tank in the filter feed splitter to trim phosphorus from the effluent. These alum precipitants, plus the solids in the secondary effluent, are removed in the filters. The filters would be deep bed, dual media, constant level, constant rate filters.

Tertiary filters would be installed, comprising:

- A new rising main from the filter feed pump station.
- A new feed splitter including a filter bypass and 2 pre flocculation tanks. The filter bypass can be directed to the EST or the UV facility.
- Two vertical shaft flocculation mixers within the flocculation tanks (1 per tank)
- An alum dosing point to the flocculation tank.
- Four deep bed, dual media filter cells.
- An air scour system including duty/standby blowers (housed in a separate blower building)
- A clean backwash tank and duty/standby pumps.
- A return main from the clean backwash tank to the filter cells.

- A dirty backwash tank and duty/standby pumps.
- An overflow from the dirty backwash tank to the EST.
- A new dirty backwash rising main from the dirty backwash tank to the FWPS.

4.2.11 UV Disinfection System

The UV system feed consists of tertiary effluent from the filters and secondary effluent (filter bypass) from the filter feed overflow (if the manual valve on the overflow line to the EST is closed). This is mixed before entering the UV receival pit. UV disinfection utilises UV light in a tight bandwidth to damage the DNA of pathogens so that they cannot reproduce. The ultraviolet (UV) disinfection system would de-activate pathogens and meet effluent F-Coli licence limits and assist in the disinfection of reclaimed effluent (RE) used around the STP.

A new UV disinfection system would be installed to replace the existing UV system. This would consist of:

- A UV receival pit with UV transmissivity analyser and a high level switch. The high level switch inhibits the filter feed pumps if the receival pit is in danger of overflowing.
- A UV transmissivity element.
- Three in-channel UV banks in duty/assist/assist configuration (including space for a future bank).
- A modulating effluent penstock for level control.
- A manual UV channel bypass.

4.2.12 Effluent Reuse System

Treated effluent would be utilised on-site as wash water for the mechanical screening system, general cleaning of STP infrastructure, for irrigating the grounds and for fire protection within the STP. Currently, the effluent from the UV unit is pumped to the 35kL reuse storage tank. The effluent for the new system would also go to this tank from the UV unit.

An upgraded reclaimed effluent (RE) system would be installed for onsite reuse, consisting of:

- Relocation of the RE lift pump (duty only) to downstream of the new UV system.
- The existing RE storage tank with backup potable water supply.
- A replacement, amplified RE pumping system (proprietary) to service the increased RE pressure and flow requirements (particularly dewatering).
- A chlorine dosing point to the RE tank feed line.
- A separate storm clean pump (duty only) proving high flow, high pressure disinfected effluent for wash down of the SPDs. This does not pass through the RE tank and does not receive chlorination.

4.2.13 Waste Activated Sludge pumping and thickening system

Waste Activated Sludge (WAS) would be drawn from the bioreactors and pumped to the WAS thickener. Thickened WAS (TWAS) is drawn from the thickener and pumped to the aerobic digester for stabilisation. The purpose of the Waste Activated Sludge (WAS) thickening system is to control the sludge age of the biomass in the bioreactors to optimise process performance and to prevent the mixed liquor suspended solids (MLSS) getting too high and compromising capacity.

A new WAS pumping and thickening system would be installed consisting of:

- A new WAS pumping system with a duty only WAS pump drawing from the ML splitter or the RAS splitter. This delivers WAS to the thickener or thickener bypass directly to the aerobic digester.
- A picket fence style gravity thickener with centre drive and scraper.
- A supernatant gravity line from the thickener to the FWPS.
- A duty only Thickened WAS (TWAS) pump, drawing TWAS from the centre well of the thickener and pumping it to the digester at a known thickness.

4.2.14 Aerobic Digester

The old IDEA bioreactor would be re-used as an aerobic digester. The aerobic digester would stabilise activated sludge biosolids so they are suitable for re-use, reduce the dry mass of biosolids to reduce transport and disposal costs and remove nitrogen from the recycled supernatant, reducing the TN in the effluent.

TWAS from the thickener and scum from the clarifiers would be pumped to the aerobic digester. WAS can also be pumped directly to the digester if the overflow thickener is being bypassed for maintenance.

An aerobic digester would be installed comprising:

- New TWAS and scum feed pipes to join the existing feed manifold at one end of the digester.
- A bypass line to divert TWAS (or WAS) plus scum around the digester to the dewatering feed tank or to the existing sludge lagoons.
- The existing IDEA bioreactor.
- The existing IDEA surface aerators in duty/duty/duty/duty configuration. Aeration should be adequate with one or even two aerators out of service.
- Overflow pipework, delivering flow to the EST
- Retention of existing instrumentation.
- Relocation of the existing WAS pump to act as the new Digested WAS (DWAS) pump. DWAS is pumped from the digester during dewatering periods, but only while the digester is aerating.

4.2.15 Dewatering Facility

The sludge dewatering facility would dewater biosolids to reduce transport and disposal costs and convey biosolids to out loading system. A new mechanical dewatering facility consisting of a single dewatering train at commissioning but designed to accommodate a second dewatering train operating in parallel in the future.

The dewatering facility would include:

- A new dewatering feed tank, complete with mixer/aerator

- A polymer make-up, storage, dosing and dilution system. Dosing pumps in duty/duty configuration (duty/standby at commissioning).
- Dewatering feed pumps in duty/duty configuration (duty/standby at commissioning).
- A polymer dosing point to each feed line.
- Two screw press dewatering units in duty/duty configuration (duty only at commissioning). Dewatering can be accommodated with the use of only one unit by extending the dewatering period each week.
- A filtrate collection system delivering filtrate to the FWPS.
- A duty only, horizontal, biosolids cross-conveyor.
- A slewing, inclined biosolids conveyor delivering biosolids to a truck trailer (default).
- A building including acoustic insulation and ventilation.
- A bunded truck trailer hard stand.
- An awning over the truck trailer hard stand.

4.2.16 Foul Water Pump Station

A new Foul Water Pump Station (FWPS) would be required to collect various foul water streams generated throughout the plant, collect contaminated stormwater from areas around the plant and return foul water to the bioreactors for treatment.

- The foul water pump station (FWPS) would consist of:
  - A new pump station wet well.
  - Two new foul water pumps (duty/standby).
  - A new filter backwash main connection.
  - A new thickener supernatant connection.
  - A new dewatering filtrate connection.
  - Contaminated stormwater and washwater connections from various hardstands.
  - A new foul water main to the bioreactor feed splitter.
  - A stormwater overflow to the EST.

4.2.17 Caustic Storage and Dosing System

A new caustic storage and dosing system is required to store chemicals used for alkalinity and pH correction, to accept chemical deliveries and to dose alkalinity to the bioreactors to prevent alkalinity loss and pH suppression.

A caustic storage and dosing system would be installed, including:

- New caustic storage tanks, cross connected and used for alkalinity storage (based on 25% sodium hydroxide).
- Two new caustic dosing pumps (duty/duty), one dosing to the primary aerobic zone of each bioreactor.
- The existing unloading and bunded storage areas.

4.2.18 Alum Storage and Dosing System

Biological treatment removes some phosphorus from sewage. However, some 70% of sewage phosphorus remains in biologically treated secondary effluent. The new alum storage and dosing system would be required to store alum, used for phosphorus precipitation (soluble phosphorus removal), accept alum deliveries and to dose alum to remove phosphorus.

The new alum storage and dosing facility would comprise:

- Two new alum storage tanks.
- Two new (duty/standby) alum dosing pumps to dose to the bioreactor feed splitter (via the influent rising main).
- Two new (duty/standby) alum dosing pumps dosing to the ML splitter box (via the common ML gravity main) or the filter feed.
- A new storage bund and tanker delivery area.

4.2.19 Chlorine Storage and Dosing System

The new chlorine storage and dosing system would provide additional disinfection of the reclaimed effluent (RE) plant. It would assist in the prevention of bacterial and algal growth in the RE system and store the chemical used for RE chlorination

The new chlorine storage and dosing facility would consist of:

- Intermediate bulk container (IBC) storage (duty/standby).
- A new chlorine dosing pump (duty only), dosing to the feed to the existing RE storage tank.

4.2.20 Power Supply

An upgrade to the STP power supply would be required to meet the increased load requirements and large quantity of new drives and instruments for the new plant.

A new 1000kVA pad mount substation, new main switchroom, new main switchboard MCC-1001 and new tertiary treatment switchboard MCC-2001 (installed in the existing tertiary treatment switchroom) have been included in the design.

The existing 500kVA transformer is insufficient for the upgraded power demand and would need to be replaced as part of the proposal. It would be decommissioned and removed at the end of the works, once the new switchroom and power supply are in place and all existing equipment that would remain in service has been repowered from the new supply.

The power supply upgrade, temporary power supply and decommissioning of the existing power supply would be coordinated with WSC to minimise disruption and ensure there is no interruption to operations during the STP upgrade. The existing standby generator at the site would form part of the upgraded power supply network to supply power to the STP during extended power outages.

The design has allowed site provision for photovoltaic/solar power supply, however construction will be subject to budgetary availability of funds or receipt of subsequent NSW government grant funding for such public infrastructure projects.

4.2.21 Electrical Systems

A new switchroom would be constructed as part of the upgrade works and will house the main switchboard. The switchroom would be sized to house a back-to-back main switchboard located in the centre of the room, allowing sufficient spare space in the room for future extension of the main switchboard by one tier, and spare wall space for future use by WSC.

Two (2) new switchboards would be constructed as part of the upgrade works. These include:

- MCC-1001 Main Switchboard, housed in the new main switchroom.
- MCC-2001 Tertiary Treatment Switchboard, housed in the existing tertiary treatment switchroom.

4.2.22 Control Network and Communications

The Bowral STP control system architecture will use an Ethernet network topology. There are 2 plant PLCs as noted above. The plant PLCs will directly control all STP field and process equipment, and a ClearSCADA SCADA system communicating with the plant PLCs will provide the operator interface for the plant.

SCADA workstations are installed in the administration building control room, the main switchroom and the tertiary treatment switchroom buildings for operator access.

A single mode fibre optic cable network would be established for the STP upgrade. Fibres would run between major plant areas to communications panels installed in each area, arranged in a ring to provide redundant network paths in the event of a communications failure. The communications panels will house the fibre optic termination modules as well as any communications and network hardware required for that area.

The plant control system Ethernet network has been designed to provide PLC control and communication to all plant control equipment and instrumentation, and segregation (by physical separation) between the process & PLC control (CONTROL) networks and operations management level (SCADA) networks. A firewall and a corporate network switch (existing) have been included in the design to control communications and provide an interface between the corporate network and the local Control and SCADA networks. The SCADA network would use a ring topology, utilising the single mode fibre optic network to connect and provide SCADA communications to all areas.

Two ClearSCADA system would be used for the site. ClearSCADA rack mounted servers will be installed in the switchroom and will communicate with the plant PLCs via the SCADA Ethernet network.

Three ClearSCADA Client desktop workstations would be provided and installed in the administration building to provide the operator interface to the plant control system.

4.3 Construction Issues

4.3.1 Construction Methodology

The exact construction methodology would be determined by the successful contractor. A general construction rationale is outlined below:

- Implement appropriate temporary drainage, site run-off and other construction environmental control measures at the site that are necessary for the construction of the plant augmentation.
- Undertake earthworks to achieve requisite design levels.
- Construct treatment facilities and associated works (roads, pipelines etc.) within the proposed new plant.
- Commissioning of new treatment facilities with diversion of influent sewage to the new inlet works.
- Restoration of the overall STP site, including topsoiling and grassing to design level/grades to include surface drainage of stormwater, would be undertaken.

Delivery of the proposed construction works whilst maintaining effective operation of the existing STP presents unique challenges and associated risks. Effective management of these risks would be required to successfully complete the Proposal. The *Bowral STP Upgrade Detailed Design Report* prepared by HunterH_2O (2021) incorporates a high level staging plan, allowing construction and commissioning of the STP whilst providing continued operation and effective interfacing with existing infrastructure (refer to Appendix F). However, the staging plan and interface strategy must be developed further by the construction contractor to ensure effective implementation.

The staging plan included in the detailed design report (HunterH_2O, 2021) has been grouped into a number of logical phases to facilitate construction and transition to the upgraded treatment process. The phases include;

1. Phase 1 – Site establishment
2. Phase 2 – Decommission Eastern sludge lagoon and drying beds
3. Phase 3 – Construct Stage 1 infrastructure (capable of treating commissioning loads)
4. Phase 4 – Pre Commission new infrastructure
5. Phase 5 – Cutover to new treatment processes
6. Phase 6 – Decommission redundant assets
7. Phase 7 – Construct Stage 2 infrastructure
8. Phase 8 – Commission Stage 2 infrastructure and decommission northern sludge lagoons
9. Phase 9 – Finalise earth works, roads, drainage, site fencing, landscaping etc.
10. Phase 10 – Demobilisation.

The construction contract is to specify that a detailed, staged construction plan needs to be developed, approved by WSC and implemented, taking into account the following requirements:

- The existing treatment facilities are to be kept (either full or partially) operational, until such time as appropriate new treatment units are commissioned within the proposed plant upgrade works; and
- Any waste or contaminated products (sewage, bio-solids, contaminated soil, etc.) are to be appropriately managed either within the STP site or transported to a suitable approved landfill disposal site.

4.3.2 Construction Equipment and Compound

The types of equipment likely to be required for the construction work would include the following:

- Truck mounted auger
- Backhoe
- Air compressor
- Dewatering equipment (e.g. pumps, filters)
- Excavator / Rock breaker
- Crane
- Concrete agitators and pumps
- Water trucks
- Rollers
- Dump trucks

Geotechnical investigations have identified that all excavations would be within the soil mantle and should be readily achievable using conventional earth moving equipment such as small dozers and hydraulic excavators; however, a rock breaker may also be required if bedrock is encountered. Groundwater dewatering should be managed through the implementation of appropriate pumps, settling, treating and filtering techniques during the construction works and disposed of in a manner to prevent groundwater and surface water quality impacts.

The contractor would establish a compound area to accommodate construction facilities for the duration of the construction period. The compound area would accommodate the following facilities:

- Vehicle parking;
- Site office;
- Amenities;
- Stockpiles; and
- Fuel storage.

4.3.3 Construction Timeframe

The construction works are predicted to take approximately 18 months.

The Interim Construction Noise Guidelines (DECC 2009) outlines recommended standard construction working hours as:

- Monday to Friday 7am to 6pm
- Saturdays 8am to 1pm
- No work on Sundays or public holidays.

The construction would comply with these recommended hours.

4.3.4 Construction Environmental Management Plan

The proposed works would be undertaken in accordance with a Construction Environmental Management Plan (CEMP) prepared by the construction contractor and approved by WSC prior to the commencement of works.

The CEMP would incorporate site specific management plans and would reflect all the mitigation measures identified in this REF, additional mitigation measures identified as a result of the contractor's risk assessment and construction methodology, and any conditions of the project consent and other licences/approvals.

4.4 Operational Issues

An Operation and Maintenance Manual for the upgraded Bowral STP would be developed to detail all maintenance and monitoring requirements for the operation of the plant.

Operational and maintenance of the STP are important to maintain effective and efficient sewerage system operations and reduce operations and maintenance costs. An ongoing program of systematic inspections, preventative maintenance and equipment overhaul is required to ensure operational efficiency to achieve adequate service life, and to minimise odours, leakages and overflows.

The Bowral STP operation would require the services of an operator(s) competent in undertaking routine operation, maintenance and process monitoring tasks.

Relevant occupational health and safety practices would be adhered to during operation of the STP, as required to meet the NSW *Work Health and Safety Act 2001* and the *Work Health and Safety Regulation 2001*.

WHS requirements for STPs and related infrastructure are predominantly concerned with providing safe access for Operators, prevention of injury from slips, trips and falls, procedures and equipment for confined spaces and requirement for handling of hazardous materials.

Handrails, platforms, stairs and/or safety chains are required to provide safe access and working conditions in circumstances where work is at height or there is potential for falling off or into structures. Appropriate fencing is required within the STP site to prevent unintentional or unauthorised entry.

Design of the proposed plant upgrade would incorporate relevant safety provisions to meet current WHS requirements, including the completion of Safety in Design checklists that outline potential safety issues and how they have been addressed in plant design.

4.4.1 Operations Environmental Management Plan

The STP Operational Environmental Management Plan (OEMP) would be updated to include the operational mitigation measures detailed in this REF, any conditions of the project consent and other licences/approvals to ensure adequate safeguards are in place and routinely monitored. The consent and licence conditions would prevail over the proposed mitigation measures where there is an inconsistency. This would avoid environmental impacts during the operation of the augmented STP.

4.4.2 Monitoring

Monitoring would be undertaken in accordance with the EPL issued by EPA. This would include process monitoring and recycled water quality monitoring (prior to discharge).

5. Environmental Assessment

This section identifies and characterises the likely potential impacts associated with the construction and operational phases of the project. Where considered necessary, feasible mitigation measures are identified. Environmental management procedures based on these mitigation measures are outlined in Section 6.

5.1 Assessment Methodology

The key objectives of this assessment are to:

- Identify those facets of the environment likely to be affected by the Proposal during both construction and operation;
- Identify the sensitivity of the site;
- Identify and characterise the associated impacts; and
- Identify and evaluate feasible mitigation measures for the identified impacts.

Environmental issues of relevance to the proposal include:

- Water Quality;
- Air Quality;
- Noise and Vibration;
- Traffic and Access;
- Waste Management;
- Chemical Management and Public Health;
- Flora and Fauna;
- Soils and Geology;
- Location and Land Use;
- Bushfire;
- Heritage;
- Greenhouse Gas Emissions; and
- Visual Amenity

5.2 Location and Land Use

The Bowral STP is located in the suburb of Burradoo in the NSW Southern Highlands, approximately 150 km south of Sydney. The STP is located off 217 Burradoo Road, Bowral (Lot 2 DP 1119953 and Lot 278 DP 914555) and is zoned as SP2 Sewerage Systems.

The existing STP site is located on cleared and disturbed area on the banks of Mittagong Rivulet (see Figure 5-1). The STP site is fenced. Surrounding land to the north, west and south is zoned for environmental management while land to the north east, and east is zoned for primary production and public recreation. To the south-west and south of the site are private properties (grazing paddocks). Burradoo Station and railway and the residential area of Burradoo is located approximately 50m south and south-east of the site.

Figure 5-1 Bowral STP Locality Map

Source: Google Maps, Accessed 21 November 2018

5.2.1 Construction Impacts

The construction works may result in some minor disruptions to the Burradoo residential area, users of Burradoo Road and the Burradoo railway Station to the south east of the site. The proposed upgrade works would be located wholly within the STP site and whilst some impacts to surrounding land users may arise through increased noise, dust and traffic, these impacts are not expected to significantly or adversely affect the use of the surrounding land. Potential noise, traffic and dust impacts are discussed further in Sections 5.3, 5.4 and 5.5 below.

All construction activities would be carried out with due diligence, duty of care and best management practices. This would be documented in the project specific CEMP.

5.2.2 Operational Impacts

The upgrade works to the existing STP site would be consistent with current land use and zoning (SP2) of the site.

During the operation of the upgraded STP, minimal impacts to surrounding land uses are anticipated, with any impacts, such as noise and odour, likely to be similar to those from the existing STP operations. Such impacts are discussed further in Sections 5.3 and 5.5

The upgraded STP will provide a positive, long term benefit to the community through improved sewage management and treatment services providing increased opportunities for development of the surrounding land.

5.2.3 Mitigation

Construction

- The surrounding community is to be consulted with regards to the construction works, predicted program and any access requirements.
- Areas disturbed during construction would be restored to their pre-construction condition.
- Best management construction impacts are to be documented in a project specific CEMP.

Operation

- An OEMP for the upgraded Bowral STP is to be developed and is to include specific measures to respond and investigate operational complaints.

5.3 Noise and Vibration

The nearest sensitive receptors are the two residential properties at 47 and 46 Yean Street, Burradoo, approximately 50 m to the south of STP site (see Figure 1-2).

No background noise monitoring has occurred as part of this REF. However, given the rural /residential nature of the surrounding area, background noise levels at the nearest noise receptors are predicted to be 40 dB(A) (using Figure 2.2 of the Noise Guide for Local Government (DECCW, 2010) as a guide).

5.3.1 Construction Impacts

During standard working hours, noise goals in the *Interim Construction Noise Guidelines (DECC, 2009a)* (ICNG) are 10 dB(A) above the Recorded Background Level (RBL) with a maximum of 75 dB(A) with respite periods. Outside standard working hours, the noise management level is 5 dB(A) above the background level. The construction noise level objective would therefore be 50 dB(A) during standard working hours.

Noise impacts were estimated based on the *Interim Construction Noise Guideline* and *AS 2436 Guide to Noise and Vibration on Construction, Demolition and Maintenance sites* for the construction equipment likely to be used during construction (listed in Table 5-1 below). The sound pressure levels of this equipment and the likely sound pressure levels at 50 m and 100 m from the source are also shown in Table 5-1. The maximum predicted noise levels at the closest residences located 50 m from the construction works, and in surrounding rural areas during construction would exceed the recommended noise affected level of 50 dB(A), but would not exceed the highly affected noise level of 75 dB(A), above which there may be strong community reaction to noise (DECCW, 2009). It should be noted that these calculations assume flat ground surfaces and do not account for propagating effects such as ground conditions, atmospheric absorption or weather.

Nevertheless, it is recommended that any appropriate and practical measures be implemented to mitigate noise impacts during construction (see Section 5.3.3).

Table 5-1 Estimated Construction Noise Levels

Equipment	A-weighted sound power levels (mid-point dB)	Sound Pressure Level dB at 50m	Sound Pressure Level dB at 100m
Hand tools (electric)	102	57	51
Excavator	107	62	56
Bobcat	104	59	53
Air compressor	101	56	50
Dump truck	117	72	66
Crane	104	59	53
Concrete agitator truck	109	64	58
Light commercial vehicle	106	61	55
Rock breaker	118	73	67
Generator	99	54	48

Construction Vibration

British Standard (BS) 6472 – 2008, Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz) is recognised as the preferred standard for assessing the 'human comfort criteria. There is no Australian Standard that sets criteria for the assessment of building damage caused by vibration. Guidance of limiting vibration values is attained from Reference to *German Standard DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of vibration on structures*. Table 5-2 provides a summary of the relevant vibration criteria.

Table 5-2: Summary of Relevant Vibration Criteria

Human comfort intermittent vibration limits (BS 6472-2008)			
Receiver Type	**Time of Day**	**Preferred Value**	**Recommended Max**
Residential	Day	0.2 m$^{-s1.75}$	0.4 m$^{-s1.75}$
Guideline values for short term vibration on structures (DIN 4150-3: 1999)			
Receiver Type	**1 Hz to 10 Hz**	**10 Hz to 50 Hz**	**50 Hz to 100 Hz**
Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	20mm/s	20 – 40 mm/s	40 – 50 mm/s
Dwellings and buildings of similar design and/or occupancy.	5 mm/s	5 – 15 mm/s	15 – 20 mm/s

The equipment used during construction would produce levels of vibration that are unlikely to exceed the above criteria. However, the Contractor will be required to develop a Construction and Vibration Management Plan to confirm these findings.

5.3.2 Operational Impacts

Based on similar treatment processes at other STPs, the main source of noise would be from the new mechanical equipment particularly the aeration blowers associated with the new MLE/FSB plant and various pumps. No formal noise assessment was undertaken as part of the REF.

The *Noise Policy for Industry (NPfI)* (EPA, 2017) replaced the *NSW Industrial Noise Policy (NSW EPA, 2000)*. It contains the relevant noise criteria for operational noise and is designed to assist industry and authorities ensure that potential noise impacts associated with industrial projects are managed effectively. The policy sets out the procedure to determine the project noise trigger levels relevant to a particular industrial development, which is a level that, if exceeded, would indicate a potential noise impact on the community, and so 'trigger' a management response; for example, further investigation of mitigation measures.

The project noise trigger level is the lower (that is, the more stringent) value of the project intrusiveness noise level and project amenity noise level. The project intrusiveness noise level aims to protect against significant changes in noise levels, whilst the project amenity noise level seeks to protect against cumulative noise impacts from industry and maintain amenity for particular land uses. Applying the most stringent requirement as the project noise trigger level ensures that intrusive noise is limited and amenity is protected. It ensures that no single industry can unacceptably change the noise level of an area.

Typically, the intrusiveness level would inform the project noise trigger level in areas with little industry (and/or ambient noise levels), whereas the amenity level would inform the project noise trigger level in areas with higher existing background noise levels.

The recommended intrusive and amenity noise levels relevant to the sensitive receivers surrounding the STP are listed in Table 5-3.

Table 5-3 Intrusiveness and Amenity Noise Levels

Receiver	Time of Day	Intrusiveness Noise Level $LA_{eq,15min}$ dB(A)	Amenity Noise Level LA_{eq}, dB(A)	Recommended Noise Mgmt Level LA_{eq}, dB(A)
Residential – Rural (approx. 50 m to the south)	Day (7am – 6pm)	45	50	50
	Evening (6pm – 10pm)	40	45	45
	Night (10pm – 7am)	40	40	40

Based on the operation of similar mechanical equipment at other STPs, it is anticipated that noise levels from the mechanical plant would not exceed 75 dB (A) mean sound pressure level at 1 m distance. Mechanical equipment would be designed to ensure that noise at the STP boundaries does not exceed ambient noise levels by 5dB. Blowers would be housed within a blower room and/or within acoustically designed enclosures to minimise noise.

It is predicted that noise levels from the upgraded plant would be below the recommended day, evening and night noise management levels (as shown in Table 5 3 above). It is noted however, that these calculations assume flat ground surfaces and do not account for propagating effects such as ground conditions, atmospheric absorption or weather. Therefore, during detailed design, the Contractor would be required to verify operational noise emissions to demonstrate that selected plant and equipment complies with NPfI requirements at the nearby sensitive receptors listed in Table 5 3.

During operation, vibration from the operation of the STP would not be discernible at the boundary of the site.

5.3.3 Mitigation

Construction

- The Contractor would prepare a Noise and Vibration Management Plan (NVMP) as part of the CEMP. The NVMP would address site specific issues, taking into consideration EPA's *Interim Construction Noise Guideline* (in particular Tables 4 – 10) and *Assessing Vibration: A Technical Guideline* (in particular mitigation measures in Section 3).
- Works would be undertaken during normal work hours i.e. 7am to 6pm Monday to Friday; 8am to 1pm Saturdays. No work would be undertaken on Sundays, Public Holidays or

outside these work hours without notification to affected community and EPA. Notification would provide the following details:

  - The locations and types of surrounding receivers likely to be affected;
  - The nature of the proposed works;
  - The noise characteristics of any powered equipment likely to be used;
  - Measures to be taken to reduce noise emissions; and
  - Any other information EPA may request.

- All reasonable practical steps shall be undertaken to reduce noise and vibration from the site.
- Community notification would be undertaken where work is likely to cause vibration or offensive noise to adjoining or nearby residents.

Operation

- Operational noise emissions would be verified to demonstrate selected plant and equipment complies with NPfI requirements at the nearest sensitive receptor. This would be achieved through post-compliance monitoring to validate the noise emissions and to identify the need for additional mitigation measures.
- Council is to implement a community complaints management program, including complaints hotline and response management procedure.

5.4 Traffic and Access

Burradoo has a small population with generally low traffic volumes. The STP site is accessible only from Burradoo Road via a level rail crossing near Burradoo Station. The STP access road is used only by vehicles accessing the STP and a few local residents. Traffic flow along the access road is low.

Burradoo Road is a sealed two-way road off Moss Vale Road leading to the Burradoo Railway Station and commuter car park. Railway Road intersects with Burradoo Road at the railway station / STP access road. Both Burradoo Road and Railway Road are anticipated to have low to moderate traffic volumes with vehicles typically travelling at low to moderate speeds. Moss Vale Road is the main road connecting Burradoo to the south west and Bowral CBD to the north. Traffic volumes along this road are expected to be moderate with vehicles travelling at moderate speeds

5.4.1 Construction Impacts

Increased traffic levels are expected during the construction of the STP. Construction vehicles and staff would enter the STP site via the access road off Burradoo Road. The construction workforce would vary according to the work being carried out, the construction method and contractor's program, however indicative average numbers during construction would be 15 - 20 employees (based on the construction of a similar sized STP).

It is estimated that the construction of the STP would involve an average of approximately 5 truck movements per day plus additional traffic associated with the movement of construction employees. Particular operations may require more frequent heavy vehicle movements (e.g. concreting operations) which would require deliveries of large quantities of materials, in addition to chemical delivery trucks. Passage and parking setup for heavy vehicles would be detailed in the CEMP.

The construction contractor would be required to prepare a Traffic Management Plan (TMP) for the construction works. It is recommended that the Contractor liaises with ARTC in relation to accessing the railway corridor during the works and that management measures for heavy vehicles crossing the railway line is included in the TMP. The TMP would be developed in accordance with the *RTA's Traffic Control at Work Sites Manual, Issued July 2018,* and *Australian Standard 1742.3 - 2009 Traffic Control for Works on Roads.* Provided this plan is suitably prepared and implemented, increased traffic arising from construction is not predicted to have a significant impact on local traffic flow or result in significant additional loads upon the existing road network. Construction traffic is most likely to impact those members of the community accessing the railway station and/or continuing onto Railway Road from Burradoo Road (including those commuting to/from Oxley College). These impacts are however expected to be minor with vehicles moving to and from the site throughout the day and queues of traffic unlikely. Any traffic or access impacts resulting from construction vehicles accessing the STP site would be minor, localised and short-term. The affected community would be notified in advance of the proposed construction work program and advised of any issues such as access to individual properties.

The condition of the STP access road and Burradoo Road, including the railway corridor crossing, in the vicinity of the STP should be assessed prior to construction and augmented if required, including the provision of any erosion and sedimentation controls, to withstanding the anticipated heavy vehicle movements during construction. Once construction has been completed, a reassessment of the road conditions would be undertaken and any damage rectified.

5.4.2 Operational Impacts

During operation of the upgraded STP, access to the site and vehicle movements would be consistent with current operations. Heavy vehicles would continue to access the STP for maintenance and bulk chemical deliveries, and maintenance personnel will continue to access the site to undertake routine operational and maintenance works. Access to the site during the operation of the STP would not be excessive and therefore no adverse impacts are expected.

5.4.3 Mitigation

Construction

- Prior to the commencement of works, existing onsite access tracks that would be used by heavy vehicles would be assessed for adequacy and augmented where necessary. Appropriate drainage would be provided for any unsealed tracks utilised during the works to ensure that vehicle movements do not cause erosion and sedimentation of the nearby waterway.
- Prior to the commencement of works, the contractor would prepare a dilapidation report for Burradoo Road, the railway corridor crossing at Burradoo Station and the STP access road to identify areas of existing damage.
- The contractor would prepare a Traffic Management Plan as part of the CEMP, to be reviewed by WSC prior to commencement of works. The Traffic Management Plan would

include measures to minimise traffic impacts, avoid congestion in the vicinity of Burradoo railway Station, ensure public safety and would be prepared in accordance with:

- *RTA's Traffic Control at Work Sites Manual, Issued July 2018, and*
- *Australian Standard 1742.3 - 2009 Traffic Control for Works on Roads.*

- The contractor must liaise with ARTC in relation to accessing the railway corridor during the works and management measures for heavy vehicles crossings of the railway line must be included in the TMP.
- Any disturbance to landowners due to vehicle movements and noise would be minimised by adhering to the working hours outlined in Section 4.3.3.
- The contractor would ensure access to properties are not impacted.
- Any temporary access tracks required for the works would be located to minimise disturbance to the existing environment. Following completion of the works the temporary tracks would be removed, topsoil provided and re-grassed. Existing tracks would be restored to their condition prior to works.
- Construction vehicles would comply with the speed limits set for the roads accessing the site.
- A dedicated vehicle wash down area would be established on site.
- All vehicles transporting spoil would be covered and filled to maximum capacity to minimise vehicle movements.
- All roads, kerbs, gutters and footpaths damaged as a result of construction are to be restored to their pre-construction condition.
- All sealed roads would be kept clean and free of dust and mud at all times. Where material is tracked onto sealed roads at any time, it would be removed immediately so that road pavements are kept safe and trafficable.

5.5 Air Quality

Information from this section has been extrapolated from the Bowral STP Odour Impact Assessment (SLR, 2021). A copy of the assessment is provided in Appendix G.

The nearest active Automatic Weather Station (AWS) collecting data operated by the Bureau of Meteorology (BoM) suitable for use in a quantitative air dispersion modelling study is located at Moss Vale, approximately 4 km southeast of the Bowral STP. Long term wind data (2001 – 2018) recorded by the Moss Vale AWS are presented as wind roses in Figure 5-2. Figure 5-2 indicates that winds at Moss Vale AWS are predominantly of moderate strength (between 5.3 m/s and 8.0 m/s). Calm wind conditions were predicted to occur approximately 6.4% of the time over the 17-year period reviewed. The seasonal wind roses show that typically:

- In summer, winds predominantly blow from the north-northeast and northeast with a very low frequency of winds from the northwest and west quadrants. On average, calm winds are experienced 3.3% of the time during summer.
- In autumn, winds predominantly blow from the west, with the lowest frequency of winds from the northwest and southwest. On average, calm winds are experienced 9.7% of the time during

- In winter, winds predominantly blow from the west quadrant, with the lowest frequency of winds from the northeast and southeast quadrants. On average, calm winds are experienced 7.9% of the time during winter.
- In spring, winds predominantly blow from the west and north-northeast. On average, calm winds were experienced 4.7% of the time during spring.

Three odour complaints have received since 2018 and have all been related to operation of the sludge lagoons.

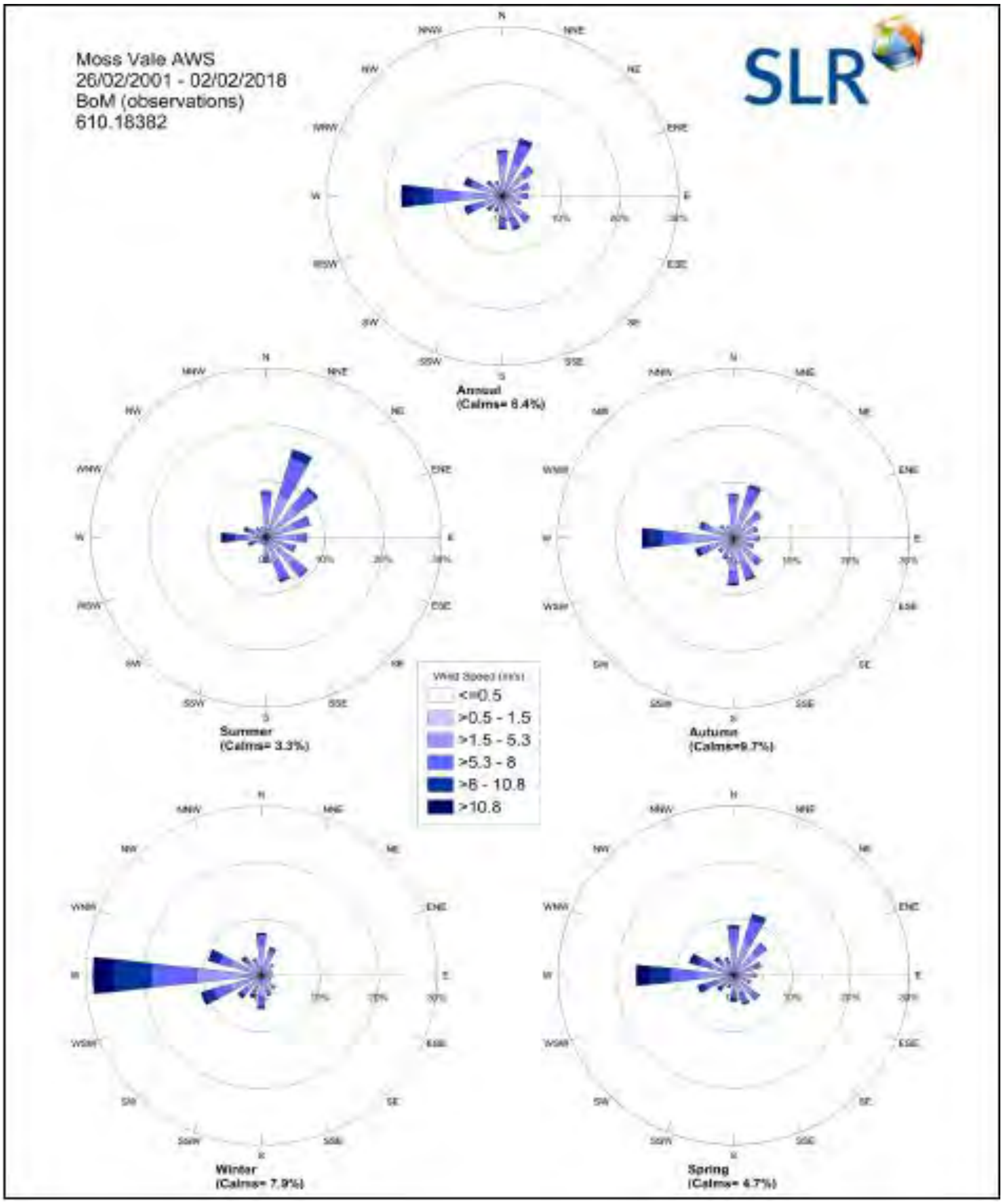


Figure 5-2 Rose of Wind Direction Vs Wind Speed for Moss Vale AWS (2001 -2018)

Source: SLR, Bowral Sewage Treatment Plant Upgrade Odour Impact Assessment, April 2021

5.5.1 Construction Impacts

It is not anticipated that an increase in odour emission levels would occur during STP upgrade construction works as a staging plan has been developed, allowing construction and commissioning of the STP whilst providing continued operation and effective interfacing with existing STP infrastructure.

The main impact to air quality during construction is expected to arise from the generation of airborne localised dust associated with earthworks. This is not anticipated to cause notable adverse environmental impacts unless the weather is particularly windy. Dust suppression methods, including the use of water carts, would be applied on windy days to prevent dust being transported off site.

Local air quality may be affected by emissions from construction traffic. However, these emissions would occur only intermittently, and are expected to be minor and temporary. It would be unlikely that they would contribute to a permanent detectable reduction in local air quality.

Some minor odour impacts may occur during the final commissioning stage of the new STP works, during the decommissioning process for some of the existing STP infrastructure components. However, odour impacts would be minor and short term in nature.

Overall, with the implementation of the recommended mitigation measures in Section 5.5.3, potential air quality impacts during construction works are considered minor and unlikely to be significant.

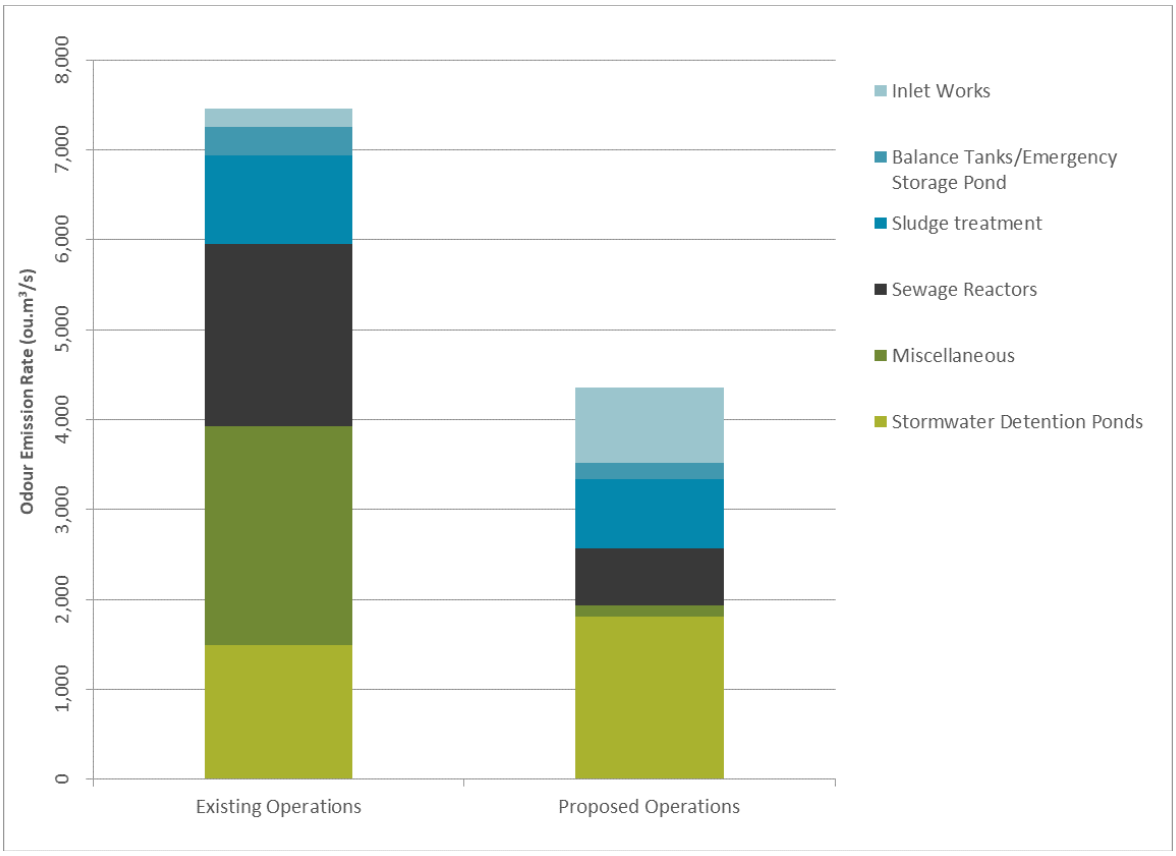
5.5.2 Operational Impacts

The potential odour sources from the proposed Bowral STP include:

- Inlet works
- Stormwater detention ponds
- Sludge Digester
- Bioreactor
- Clarifiers
- Catch/balance tanks and Emergency Storage
- Sludge dewatering building
- Other (smaller) miscellaneous sources – i.e. Flocculation tanks, Dual media filters, Clear water backwash tank, Dirty water backwash tank, Sludge loadout facility.

The SLR Odour Impact Assessment (OIA) modelling used conservative odour emission rates, which were undertaken based on the footprint area (m^2) of the odour source structures. The contribution of each of the identified sources to overall emissions from the existing and proposed operations has been illustrated in Figure 5-3. It should be noted that the stormwater detention ponds (emergency storage) emissions contribution shown in Figure 5-3 would not occur during normal operation of the upgraded STP, as the odour emission rates only apply when the stormwater detention ponds are in operation during infrequent high inflow bypass events (anticipated to be 15 - 20 days per year). In addition, it is noted that as part of the upgraded STP operational process, sewage would be screened prior to being transferred to the stormwater detention ponds. Therefore, the risk of odour impacts would be further reduced as less solids would be deposited in the stormwater detention ponds after a high rainfall (bypass) event.

Figure 5-4 illustrates the location of the surrounding sensitive receptors in relation to the Bowral STP. Predicted concentrations of odour were assessed at each of these receptors, for the normal and emergency storage operational scenarios modelled.



Note - Peak to mean ratio not included

Note 2 – The increase in inlet works odour emission rates from the existing to the proposed operations are predominantly due to the conservative odour emission rates adopted for the proposed inlet works.

Note 3 – 'Miscellaneous' items in the existing operation sources including sludge lagoons (to be decommissioned as part of the proposed STP upgrade). Reduction in sludge odour associated with the lagoons and drying beds would contribute to the reduction in miscellaneous odour emissions during operation of the upgraded STP). For the proposed operation 'miscellaneous items comprise smaller odour sources including flocculation tanks; dual media filters; clear water backwash tank, dirty water backwash tank and the sludge loadout facility.

Note 4 – The increase in Stormwater Detention Ponds emission rates during Proposed Operations is associated with the increased total footprint (m²) of the odour source structures, as the STP upgrade design would include an additional storm detention pond. The storm detention ponds emissions contributions would not occur during normal STP operations and would only occur when the storm ponds are in operation approximately 20 days per year or less, during infrequent high rainfall events.

Figure 5-3 Source odour emission contributions

Source: SLR, April 2021

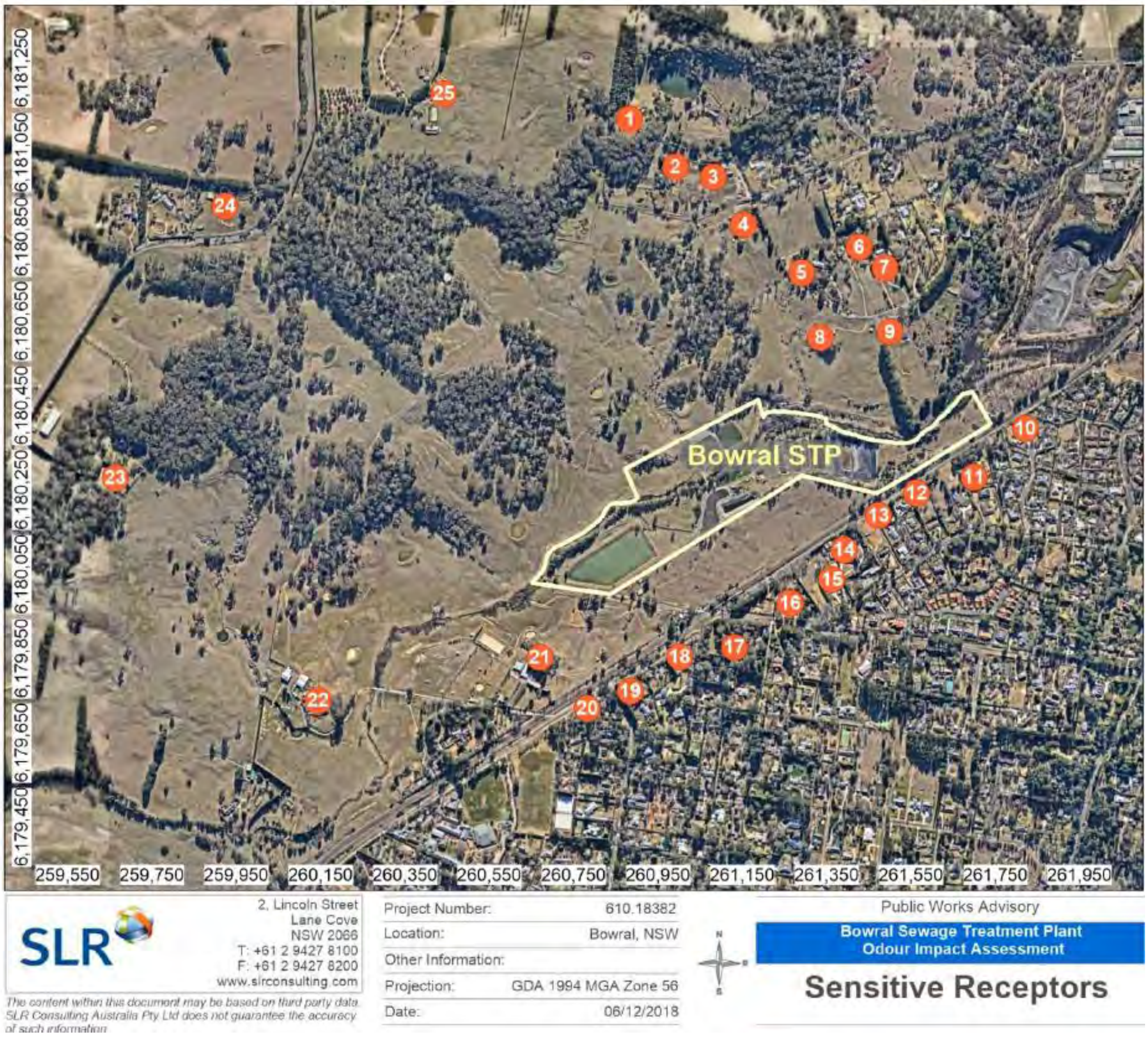


Figure 5-4 Location of Identified Sensitive Receptors

Source: SLR, 2021

As illustrated in Figure 5-5, the area predicted to be affected by the existing and proposed operations, including the emergency storage (stormwater detention ponds) at the Bowral STP (i.e. the area within the 2 ou contour line) is 0.48 km^2 and 0.21 km^2 respectively. It is noted that as a conservative measure, these areas include the total area occupied by the Bowral STP (approximately 0.18 km^2). Dispersion modelling was performed to predict worst-case impacts associated with the existing and proposed operations at the Bowral STP.

Based on 2016 ABS Census data, it is estimated that a population of approximately 32 people may be affected by the existing operations at the Bowral STP. It is predicted that the affected population would decrease to 5 people as a result of the proposed STP upgrade.

Therefore, the following odour impact assessment criteria (expressed as the 99th percentile for a nose response average, i.e. 1-second average) were adopted for the OIA, whereby odour concentration is measured in terms of odour units (ou):

- 5 ou for the assessment of odour impacts due to existing normal operations and existing operations with emergency storage; and

- 6.0 ou for the assessment of odour impacts due to proposed STP upgrade normal operations and proposed operations with emergency storage.

Criteria for operations with emergency storage were applied to normal operations as well in order to provide conservative results.

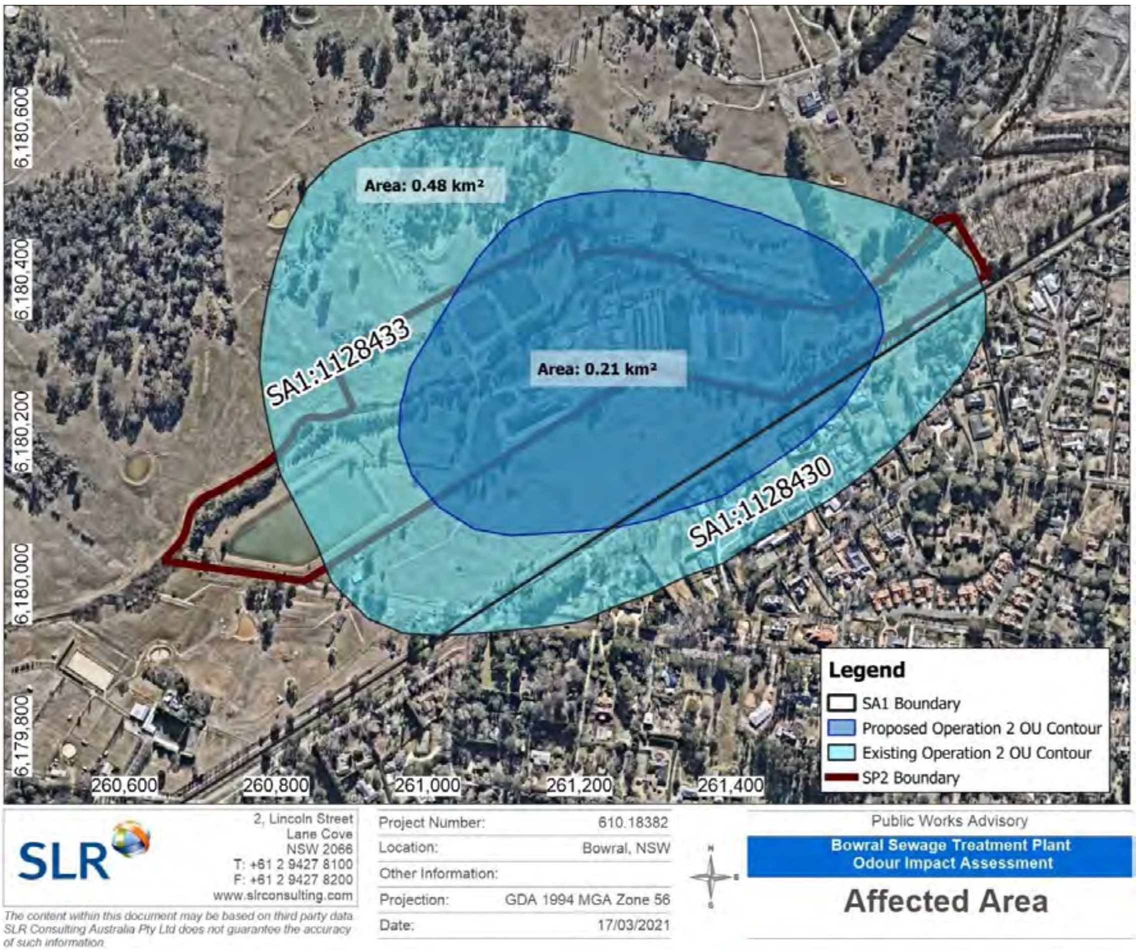


Figure 5-5 Affected area for Odour Modelling (atmospheric dispersion modelling)

Source: SLR, 2021

Atmospheric dispersion modelling was undertaken to assess potential odour impacts associated with both the normal operation and also during infrequent operation of the emergency storage (stormwater detention ponds) of the existing and upgraded STP. As noted above, the stormwater detention ponds do not form part of the normal operation of the STP and are only in use during rare high rainfall events, whereby sewage inflows to the STP are screened to remove solid material and then transferred to the stormwater detention ponds for temporary storage prior to treatment.

The dispersion modelling indicated that the predicted odour concentrations at all surrounding sensitive receptors would result in a significant decrease in the 99th percentile 1-hour average odour concentrations for proposed normal operations as compared to existing normal operations. The results indicate that after the upgrade, the predicted 99th percentile odour concentrations, which range between 0.1 ou and 1.0 ou would be in compliance with the adopted OIA criterion of 6 ou at all of the sensitive receptors modelled.

The predicted 1-hour average 99th percentile odour concentrations for the existing and proposed normal STP operations are shown as contour plots in Figure 5-6 and Figure 5-7, respectively. It is noted that odour contour plots do not reflect odour concentrations occurring at any particular instant in time, but rather show a compilation of the predicted 99th percentile (88th highest) odour concentrations at all locations downwind, taking into account all combinations of meteorological conditions modelled across the modelling period.

Overall, the atmospheric dispersion modelling for the upgraded STP indicates that odour concentrations are predicted to decrease by an average of 62 % across the sensitive receptors under normal operations and 40 % for operations with emergency storage after the proposed STP upgrade. The total odour emissions from the proposed operations is estimated to be 10,014 ou.m^3/s which is approximately 42 % lower than the emissions estimated for the existing operations.

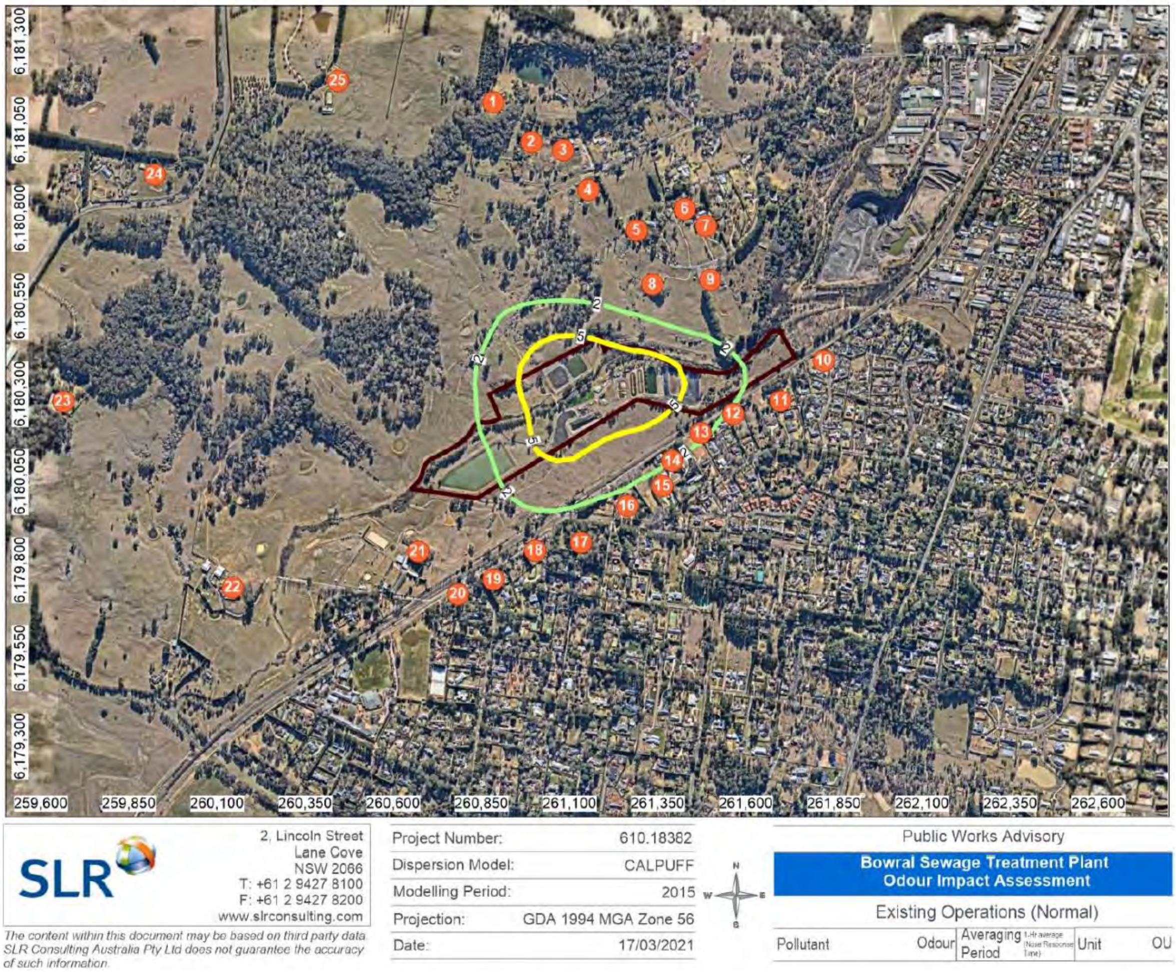


Figure 5-6 Predicted 99th Percentile (Nose Response Time) Odour Concentrations (ou) – Existing Normal Operations

Source: SLR, 2021

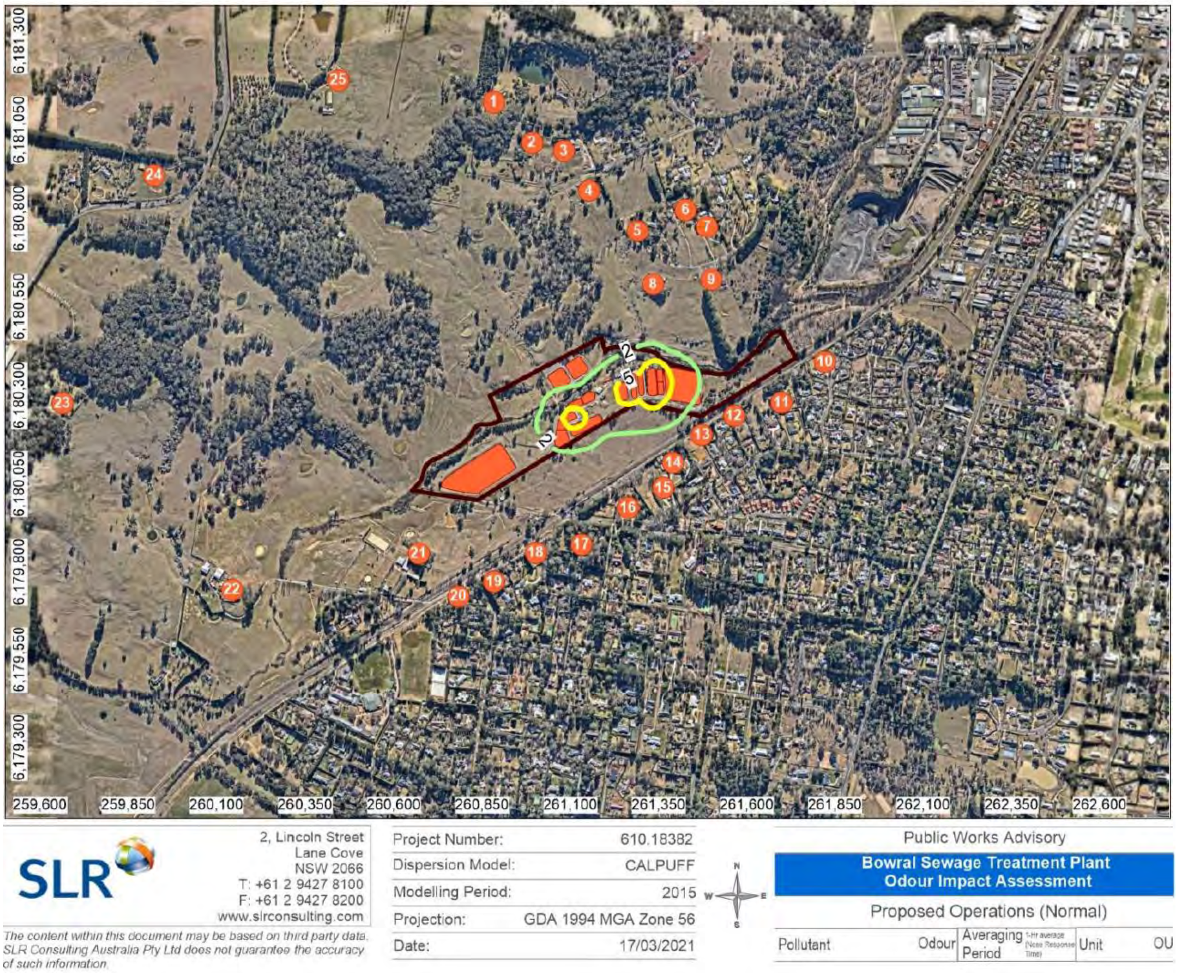


Figure 5-7 Predicted 99th Percentile (Nose Response Time) Odour Concentrations (ou) – Proposed Normal Operations

Source: SLR, 2021

Odour concentrations at all nearby sensitive receptors are predicted to be below the adopted OIA criterion of 6 ou (nose response time) for the proposed STP upgrade design. The standard odour design criteria adopted during the engineering design stage for an expanding STP (at the boundary of the SP2 lot) recommended by the *NSW Best Practice Odour Guideline - Sewerage systems including sewage treatment plants, water recycling facilities, sewage reticulation systems and sewer mining* (DoP NSW, 2010) (Odour Guideline) is the achievement of a 2 ou odour assessment criterion. The odour emissions modelling predicted that the upgraded Bowral STP would only exceed the 2 ou odour design criterion during the infrequent operation of the emergency storage, as modelling of the proposed normal operations shows the STP is in compliance with the recommended guidelines of less than 2 ou, with an average of 1.3 ou for normal operations and an average of 2.9 ou for operations with emergency storage across all boundary receptors.

Based on the modelling results, the following conclusions were drawn:

- The modelling of odour emissions from all identified sources associated with the proposed operations at the upgraded Bowral STP showed that predicted 99th percentile odour concentrations at all nearby sensitive receptors are predicted to be below the adopted OIA criterion of 6 ou (nose response time) as a result of the STP upgrade. Based on the modelling predictions, the proposed upgrades would result in a 55 % to 69 % decrease (compared to the existing normal operations) and a 31 % to 50 % decrease (compared to existing operations with emergency storage) in the 99th percentile odour concentrations at the nearby sensitive receptors for the respective scenarios.

- The proposed STP upgrade would not achieve the 2.0 ou odour design criterion (at the boundary of the SP2 lot) recommended by the relevant Odour Guideline published by NSW Department of Planning (2010). However, this risk would only occur during the infrequent operation of the emergency storage (stormwater detention ponds), in the circumstance of rare high rainfall events and not during normal STP operation.

Compliance with the 2 ou Odour Guideline criterion at the plant boundary during operation of the storm detention ponds would be unlikely without significant additional plant odour controls. However, the STP design engineers have confirmed that this is not feasible considering the proximity of the SP2 lot boundary from the treatment processes. Furthermore, the design of the proposed works has included reasonable and practical methods to address and mitigate potential odour issues which may occur during the infrequent operation of the storm detention ponds, including enclosing the inlet works and the lift pump station, inclusion of an odour control unit and efficient wash down water for cleaning the storm detention ponds after a storm event, which would significantly reduce potential for odour emissions. However, the STP upgrade, as designed, would achieve a significant improvement in odour performance compared to the existing STP with good margins to the assessment criteria (a reduction from 3.5 ou based on the existing STP normal operation to 2.2 ou post-upgrade for the maximum sensitive receptor, compared to the OIA criterion of 6 ou).

It should be noted that the odour emission levels which exceed the Odour Guideline compliance threshold of 2 ou would not occur during normal daily operation of the upgraded STP and only apply during the rare occurrence where the stormwater detention ponds are in operation, and therefore would only potentially occur during infrequent high rainfall events. In addition, as part of the upgraded STP design treatment process, sewage would be screened prior to being transferred to the stormwater detention ponds. As such, unlike the existing STP, the risk of odour emissions would be further reduced during operation of the upgraded STP as less solids would be deposited in the stormwater detention ponds after a high rainfall event. Furthermore, the three odour complaints received since 2018 have all been related to operation of the sludge lagoons which would be decommissioned as part of the plant upgrade. When considered on conjunction, the OIA odour emissions results, the infrequent use of the stormwater detention ponds and the upgraded sewage screening design suggest a low risk in relation to odour impacts during daily, standard operation of the upgraded STP.

Management measures to further reduce the potential for odour emissions are provided in Section 5.5.3.

5.5.3 Mitigation

Construction

- Further reductions in the odour concentrations at the boundary could potentially be achieved through physical controls including tree breaks which may redirect wind flows, aid dispersion and remove dust.
- Construction vehicles and equipment would be suitably serviced prior to commencement of construction activities and all necessary maintenance undertaken during the construction period to meet EPA air quality requirements.
- The excessive use of vehicles and powered construction equipment would be avoided to minimise emissions.
- All construction machinery would be turned off when not in use to minimise emissions.
- Construction contractors would monitor dust generation potential.
- Dust suppression methods including the use of water carts would be applied where required (i.e. on windy days when earthworks and vehicle movements are generating dust).
- Any stockpiled spoil/fill would be protected to minimise dust generation to avoid sediment moving offsite.
- Vehicles transporting spoil from the sites would be covered.
- Complaints monitoring is recommended whereby any complaint received during the construction works should be investigated as soon as possible so that effective appraisal of the complaint can be carried out by subjective assessment.

Operation

- An Odour Management Plan (OMP) should be adopted for the Bowral STP as part of the OEMP. The OMP should outline the management structure and strategies for odour performance during the operation of the STP. The OMP should be developed as per the recommendations of the Odour Guideline and should include procedures for complaints registering and investigation.
- The SDP will have efficient wash down water for cleaning after a storm event, significantly reducing odour.
- Complaints monitoring is recommended whereby any complaint should be investigated as soon as possible so that effective appraisal of the complaint can be carried out by subjective assessment. Where odour complaints are verified, engineering, and operational or other odour reduction measures should be implemented.

5.6 Soils and Geology

The following information on geology, topography and soils has been taken from the *Bowral Sewage Treatment Plant Geotechnical Investigation Report* (PWA, October 2018b).

The geotechnical investigation comprised the drilling of ten (10) boreholes to depths ranging from 2m to 6m.

Soils and Geology

The Wollongong 1:250,000 Geological Series Sheet SI 56-9 (Second Edition, 1966), indicates that the site is underlain by a sequence of sedimentary rocks of Liverpool Sub-Group of the Wianamatta Group. The sequence is Triassic in age and consists of shale with some sandstone beds.

The geotechnical investigation confirmed that the STP site is located within shale and associated residual soils. Also, minor alluvial sediments, associated with flood plain of Mittagong Rivulet, and fill, associated with the construction of the existing structures, mantle the residual deposits.

Topography

The existing sludge lagoons (No. 1 and 2) and sludge drying area are located on the northern bank of the creek, where the original trickling filter plant used to be located. Immediately to the north and north-west of the sludge lagoons/drying area, the topography rises at a moderately steep gradient.

The proposed sludge dewatering area, access road and structures associated with sludge stabilisation options are to be located on the northern bank of the creek.

The majority of the existing STP structures are located on the southern bank of the creek. This part of the site is generally bordered by Mittagong Rivulet to the north, private properties (grazing paddocks) to the south-west and south, and the main southern railway to the east/southeast.

5.6.1 Construction Impacts

Erosion and Sediment Control

Earthworks and general ground disturbances associated with the construction works could result in sediment and other materials leaving the site via wind or water movement. Aspects of the proposal identified as potentially impacting on water quality includes:

- transportation of imported fill to the site;
- decommissioning and removal of redundant treatment units;
- excavation for foundations site levelling and pipework / conduits;
- stockpiling of excess spoil; and
- general construction waste entering drainage lines.

The contractor would establish appropriate controls to stabilise active work sites and prevent or minimise the likelihood of erosion, and the risk of discharging sediment-laden water into adjacent Mittagong Rivulet and other unnamed natural drainage lines that run to the north east of the STP site. It would be necessary to retain these controls until a vegetative cover had been re-established.

The proposed upgrade works would be staged to keep the existing STP components operational during construction.

5.6.2 Operational Impacts

The STP site would be appropriately remediated and landscaped post construction, including topsoiling and grassing to design level/grades, which would significantly reduce the potential for soil erosion from occurring. The plant would include pits and stormwater drainage to manage run-off and mitigate soil erosion onsite. Roadways around the treatment facilities would be graded towards stormwater drainage.

5.6.3 Mitigation

Construction

- A detailed Soil and Water Management Plan (SWMP) shall be prepared as part of the CEMP. The SWMP would describe the site-specific measures to be implemented for all works areas, in accordance with the guidelines outlined in the 2004 Landcom publication *Managing Urban Stormwater: Soils and Construction*, 4th edition ("The Blue Book") and *Volume 2a Installation of Services*. The SWMP would need to be site specific and would need to address the following issues to prevent erosion, sediment loss and water quality impacts:
  - Identification of site specific sediment and erosion control measures wherever erosion is likely to occur.
  - Identification of any environmentally sensitive areas on or near construction sites to ensure runoff is diverted away from sensitive areas.
  - Requirements for vegetation clearing to be kept to a minimum.
  - Retention of all surface runoff on-site and where possible stormwater from off site would be diverted around the construction site.
  - Backfilling and stabilising of trenches once pipelines or other underground services are installed.
  - Location of construction compounds (at least 50m from any the drainage line).
  - Location and management of stockpiles, such as locating stockpiles away from the drainage line near the works areas.
  - Regular inspection of all erosion and sediment controls, especially when rain is expected and directly after any rain events.
- All areas where ground disturbance has occurred would be stabilised following completion of works to ensure there is no erosion hazard and restored to their pre-construction condition. This would involve, where required, reshaping the ground surface, covering it with topsoil excavated from the site and re-establishing an appropriate vegetation cover.
- Any excess spoil would either be spread across the ground in nearby areas in such a manner as to avoid creating an erosion hazard or removed off site for disposal in accordance with relevant WSC and EES requirements.

5.7 Water Quality

Water Quality

Catchment Water Quality

Bowral STP discharges treated effluent into Wingecarribee River where it is joined by the Mittagong Rivulet, which is located within Sydney's drinking water catchment. Wingecarribee River is a tributary of the Wollondilly River, which flows into Warragamba Dam and forms part of the Sydney drinking water catchment. The Sydney drinking water catchment collects and stores up to 2.6 million megalitres of water to supply Sydney, the Blue Mountains, the Illawarra, the Southern Highlands and parts of the Shoalhaven area. The Catchment includes the entire catchment area upstream of Warragamba Dam, including the Coxs, Kowmung, Nattai, Wollondilly and Wingecarribee River sub-catchments and their tributaries. The major water supply catchments (Upper Nepean, Shoalhaven, Warragamba, Blue Mountains and Woronora) are further divided into 27 minor sub-catchments, with Bowral STP located within the Wingecarribee River sub-catchment of the Warragamba catchment.

Catchment audits undertaken by WaterNSW (formally the Sydney Catchment Authority) have identified the STPs at Bowral (EPL 1749), Moss Vale (EPL 1731) and Mittagong (EPL 10362) as requiring significant upgrades in the short to medium term due to capacity issues. The audit recommended that priority should be given to upgrading these STPs.

The Wingecarribee sub-catchment, including Wingecarribee Reservoir, has also been impacted by high nutrient loads associated with dairy effluent and ongoing adverse impacts resulting from an incident in 1998 when the peat island in the reservoir separated from Wingecarribee Swamp. The area is also under development pressure with the largest number of development applications submitted in the audit period of any LGA across the Catchment. The Wingecarribee River at Berrima also experienced poor water quality across a range of parameters during the audit period.

Upstream Water Quality

The following information has been taken from the *Discharge Impact Assessment for the Bowral Sewerage Scheme* (DIA) (Manly Hydraulics Laboratory (MHL), 2021). A copy of the report is provided in Appendix E

Upstream water monitoring on the Wingecarribee River (Point 11) is required as part of the EPA licence conditions. Point 11 is located approximately 25 m upstream of the location where the effluent from Bowral STP enters the Wingecarribee River (as shown in Figure 5-9).

Trend analysis was carried out for the water quality parameters monitoring data upstream of the STP (MHL, 2021). Linear temporal trends in the data anomalies were assessed over two time periods: the calendar years 2013-2019 and 2017-2019. Two time periods were chosen to explore the stability of any trends over time. The 5% level of significance was used to compare the slope of the trend lines with a slope of zero (i.e. no change over time).

Trends in river water quality parameters at Point 11 are shown in Table 5-4. For most variables, the temporal trends are not statistically different from zero (at the 5% level).

- BOD concentrations are increasing, although the slope is only just significantly different from zero.
- Both ammonia and pH have decreasing concentrations.

- Prior to 2017, many ammonia concentrations were at the limit of reading. This is the likely reason for the significant slope of the ammonia regression line.

The analysis was repeated using data from 2017-2019 and, with the exception of alkalinity, the results are consistent with those from the longer term. It was unclear why the trend in alkalinity changed markedly over time.

Table 5-4 Temporal trends in contaminant concentrations upstream of Bowral STP (at Point 11)

Variable	2013-2019		t-calc	2017-2019	
	Slope (concentration change)	significance	t-crit= +/-1.98	Slope (concentration change)	significance
BOD	↑	SIG	1.98	↓	NSD
TSS	↑	NSD	0.16	↑	NSD
Conductivity	↑	NSD	1.79	↑	NSD
Ammonia	↓	SIG	-7.18	↓	NSD
Nitrite	↓	NSD	-0.01	↑	NSD
Nitrate	↓	NSD	-0.54	↑	NSD
Oxidised nitrogen	↓	NSD	-0.54	↑	NSD
Total nitrogen	↓	NSD	-1.57	↓	NSD
Total phosphorus	↑	NSD	0.52	↑	SIG
pH	↓	SIG	-3.24	↓	SIG
Oil and grease	Insufficient data above limit of reading for reliable statistics				
Faecal coliforms	↑	NSD	0.11	↑	NSD
Alkalinity	↑	NSD	1.96	↓	SIG

Source: MHL, 2021
Arrows pointing up indicate an increasing trend over the time period.
Arrows pointing down indicate a decreasing trend over the time period.
NSD = the slope of the linear trend line is not statistically different from a slope of zero at the 5% level of significance.
SIG = the slope of the linear trend line is statistically different from a slope of zero at the 5% level of significance.

Analysis of upstream water quality monitoring data at Point 11 and at the STP discharge point (Point 7) was also undertaken as part of the DIA. The results below in Table 5-5 indicate that the concentrations of substances discharged from Point 11 are significantly lower than the concentrations of substances discharged from the STP. This is generally consistent with expectations. Two exceptions were total suspended solids and faecal coliforms. Upstream faecal coliform concentrations substantially greater than the STP concentrations is unusual. This result suggests one or more upstream source(s) of faecal contamination, although corresponding elevated concentrations of nutrients (not observed) would also be expected.

Table 5-5 Comparison of water monitoring data from STP and Point 11

Variable	Averages		t-calc	Results	
	STP	Point 11	t-crit = +/-1.98	Difference	Significance
BOD	2.32	1.26	7.49	STP > Point 11	SIG
TSS	4.50	23.97	-25.18	Point 11 > STP	SIG
Conductivity.	54.59	16.92	54.81	STP > Point 11	SIG
Ammonia	0.70	0.07	15.72	STP > Point 11	SIG
Nitrite	0.18	0.01	10.66	STP > Point 11	SIG
Nitrate	3.66	0.17	33.93	STP > Point 11	SIG
Oxidised nitrogen	3.77	0.18	34.90	STP > Point 11	SIG
Total nitrogen	5.73	1.10	40.93	STP > Point 11	SIG
Total phosphorus	0.17	0.07	13.06	STP > Point 11	SIG
pH	7.43	7.25	10.60	STP > Point 11	SIG
Oil and grease	Insufficient data above limit of reading				
Faecal coliforms (log10)	0.92	2.28	-19.19	Point 11 > STP	SIG
Alkalinity	61.72	30.28	27.38	STP > Point 11	SIG

Source: MHK, 2021
There are only very limited data for oil and grease that are above the limit of reading. Therefore, the results are not reliable.
NSD = the two means are not statistically different at the 5% level of significance.
SIG = the two means are statistically different at the 5% level of significance.

Mittagong Rivulet

Treated effluent from the Bowral STP is discharged into the Wingecarribee River where it is joined by the Mittagong Rivulet (also known as Mittagong Creek). Mittagong Rivulet bisects the STP site and flows into Wingecarribee River approximately 1.1 km downstream of the STP (see Figure 5-8).

Figure 5-8 Mittagong Rivulet (also known as Mittagong Creek)

Source: PWA, October 2018

Council's ongoing instream testing indicates that the Wingecarribee River is impacted by development, agriculture, STP releases and other factors. This provides a good estimation of the actual loads released and the background and impact of the releases at the EPA testing points, with Council's testing including dry and wet results. An initial classification of the receiving waters, based on the ANZECC 2000 Guidelines, indicates that the catchment fits into the "Aquatic Systems - South East Australia – Upland River, Slightly-Moderately disturbed systems". The associated low risk trigger levels provided for this classification as listed in Table 3.3.3 of this guideline are provided in Table 5-6, together with water quality monitoring data for Wingecarribee River in the vicinity of the STP (see Figure 5-9).

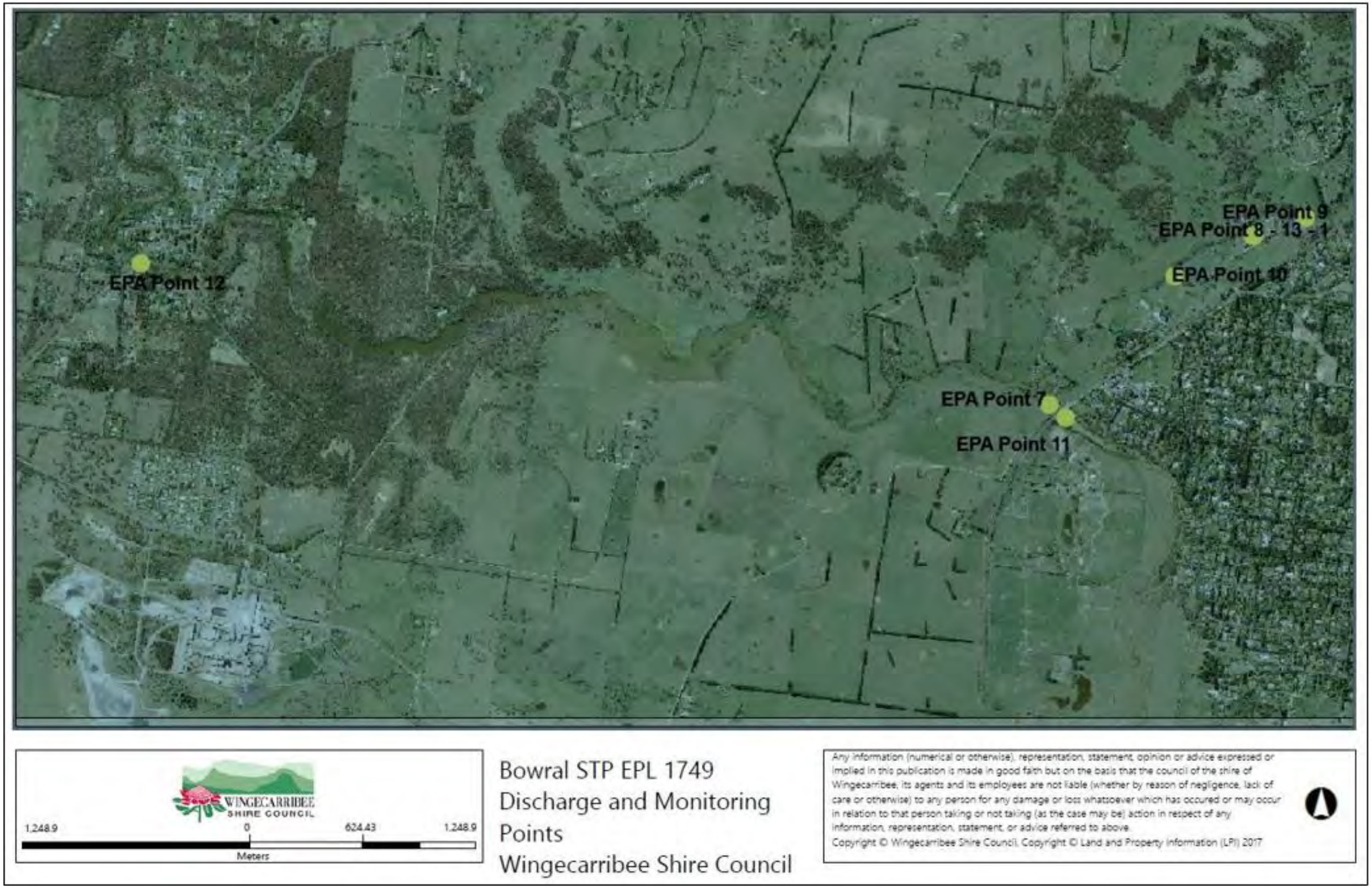


Figure 5-9 Bowral STP Discharge and Monitoring Points

Table 5-6 Comparison of ANZECC Low Risk Trigger Values and Wingecarribee River Upstream and Downstream Water Quality with STP Discharges

Bowral STP (Fortnightly Testing 2013 - 2018)				
Parameter	**ANZECC Default Trigger Value**	**Upstream EPA Monitoring Point 11 Wingecarribee River**	**Downstream EPA Monitoring Point 12 Wingecarribee River**	**STP EPA Monitoring Point 1**
Total Phosphorus	20 µg/L	85µg/L (90%ile) 58µg/L (50%ile)	82µg/L (90%ile) 42µg/L (50%ile)	249µg/L (90%ile) 100µg/L (50%ile)
Total Nitrogen	250 µg/L	1632µg/L (90%ile) 980µg/L (50%ile)	1431µg/L (90%ile) 1000µg/L (50%ile)	6800µg/L (90%ile) 5600µg/L (50%ile)
NOx	15	505µg/L (90%ile) 50µg/L (50%ile)	420 (90%ile) 140 (50%ile)	5146 (90%ile) 3700 (50%ile)
Ammonium NH_4	13	94µg/L (90%ile) 50µg/L (50%ile)	100 (90%ile) 50 (50%ile)	1300 (90%ile) 600 (50%ile)
Chlorophyll –a	NA µg/L	No testing results		
Turbidity	2-25 NTU	No testing results		
DO	90-110%	No testing results		
pH	6.5 – 7.5	7.4 (90%ile) 7.3 (50%ile)	7.8 (90%ile) 7.6 (50%ile)	7.6 (90%ile) 7.4 (50%ile)
Salinity	30-350 µg/L	No testing results		
FC		-	510 (90%ile) 97 (50%ile)	70 (90%ile) 6 (50%ile)
Aluminium	27-150µg/L pH>6.5	No testing results		

Source: WSC, 2019

Being located downstream of the urban area of Moss Vale, upstream water quality in Wingecarribee River is already well above the low risk trigger values for all the assessed parameters except for pH. The Total Phosphorus (TP) instream quality is around three times the trigger level prior to receiving STP releases (see Table 5-6). The Total Nitrogen (TN) instream quality is around 3-4 times the trigger level prior to receiving STP releases.

Downstream Catchment

The Bowral STP discharges on average 3.6 ML/d (ADWF) into Wingecarribee River. It is noted that the effluent quality from the Bowral STP is on average better than the current EPA limits because the plant inflow is less than the design capacity and because of operator vigilance and dedication.

Based on the assessment of the water quality information (from Council's monitoring data 2013-2018), it was found that:

- Phosphorus in the STP discharge from the Bowral STP does not have any impact on the instream quality of the Wingecarribee River with downstream values being lower than upstream values.
- Nitrogen based impacts are slight at Bowral for Total Nitrogen (TN) and ammonia but higher for nitrogen oxides (nitrate and nitrites). High TN may be due to fertilizers and animal waste generated between the sampling points upstream and downstream of the STP discharge)

Mittagong Rivulet joins the Wingecarribee River approximately 1.1 km downstream of the Bowral STP. The estimated average flow in Mittagong Rivulet is 3 ML/day (Egis, 2002).

The Mittagong Rivulet is subject to the Water Sharing Plan for *the Greater Metropolitan Region, Unregulated River Water Sources 2011* and lies within the Lower Wingecarribee River Management Zone. Water access licences (WAL) from the Lower Wingecarribee River Management Zone total 1,072 ML/yr.

The MHL Discharge Impact Assessment (2021) carried out analysis of downstream water quality parameter data at Point 12, which is located on the Wingecarribee River at Berrima Weir, about 5 km downstream of the location where the effluent from Bowral STP enters the river (refer to Figure 5-9) . It is noted that the distance between the STP discharge point and Berrima Weir is relatively long. Consequently, time and distance travelled, diffuse sources, and other (unknown) point sources, may confound the analysis results.

Trend analysis was also carried out for the water quality parameters monitoring data downstream of the STP (MHL, 2021). Linear temporal trends were assessed over two time periods for the calendar years 2013-2019 and 2017-2019. The significance (at the 5% level) of the slope of the linear regression line is given in Table 5-7 for the two time periods 2013-2019 and 2017-2019. The analysis results presented in Table 5-7 are summarised below:

- Results for the period 2013-19 are consistent with the results for the 2017-19 period.
- Prior to 2017, many results for ammonia were below the limit of reading. This is likely the reason for the significant slope of the regression line.
- The last 3 data points for nitrate are high. Although there is no justification to change them, their removal from this analysis results in a change in the slope of the trend line. Hence, these results should be treated with some caution.
- Total nitrogen shows a significant decreasing trend, although the impact of ammonia (as noted above) may be the reason for the significance of this trend.
- The significant decreasing trend in pH using the 2017-19 data is a result of the single low reading at the end of the data set.

- There is a significant decreasing trend in faecal coliforms. While the trend remains in the 2017-19 data, the slope of the regression line is not significantly different from a slope of zero.

Table 5-7 Temporal trends in contaminant concentrations downstream of Bowral STP (at Point 12)

Variable	2013-2019		t-calc	2017-2019	
	slope	significance	t-crit= +/-1.98	slope	significance
BOD	↑	NSD	0.48	↓	NSD
TSS	↓	SIG	-2.01	↓	NSD
Conductivity	↑	SIG	4.05	↑	SIG
Ammonia	↓	SIG	-7.33	↓	NSD
Nitrite	↓	NSD	-0.60	↑	NSD
Nitrate	↑	NSD	1.29	↑	NSD
Oxidised nitrogen	↑	NSD	1.21	↑	NSD
Total nitrogen	↓	SIG	-2.12	↓	NSD
Total phosphorus	↓	NSD	-1.63	↓	NSD
pH	↑	NSD	0.31	↓	SIG
Oil and grease	Insufficient data above limit of reading				
Faecal coliforms	↓	SIG	-2.72	↓	NSD
Alkalinity	↑	SIG	3.84	↓	NSD

Source: MHL, 2021
Arrows pointing up indicate an increasing trend over the time period.
Arrows pointing down indicate a decreasing trend over the time period.
NSD = the slope of the linear trend line is not statistically different from a slope of zero at the 5% level of significance.
SIG = the slope of the linear trend line is statistically different from a slope of zero at the 5% level of significance.

Existing STP Impacts on River Water Quality

The Discharge Impact Assessment (MHL, 2021) prepared for the proposal estimated the current impact of the STP on the receiving waterways using historic data collected between 2013 and 2019. Background or upstream concentrations were compared with effluent data as well as downstream data to determine how the STP effluent impacted each measured analyte.

Based on the results of the data analysis, the following key observations were made:

- Concentrations of suspended solids in the STP are less than those in the river. This is a result of the high level of sewage treatment.
- Ion concentrations (total dissolved solids/conductivity) show a significant difference among days, among sites and in the interaction term. Ions discharged from the STP are generally greater than concentrations in the river.

- Concentrations of some metals (aluminium, manganese and iron) are less in the STP than in the river. This may suggest an upstream source of metals.
- Concentrations of zinc are greater in the STP than in the river. The first reading of the day consistently showed the highest concentration of zinc. This is likely due to lower dilution factors overnight (off-peak), therefore indicating a higher concentration of zinc.
- Nutrient concentrations from the STP discharges exceeded those observed in the river.
- Concentrations of indicator bacteria were generally less in the STP discharges than in the river waters. This may suggest that input from farm animals is a substantial contributor to the bacterial quality of the river.

The DIA carried out an Analysis of Variance (ANOVA) to determine statistically significant differences among data from the STP, Point 11 (upstream) and Point 12 (5 km downstream).

In general, analysis concluded that there is no statistically significant difference between the data from points 11 and 12. Concentrations from both of these locations are significantly less than those from the STP discharge location, as expected. Of note, concentrations of total suspended solids (TSS) and faecal coliforms in the effluent are significantly less than the concentrations in the river. The high level of sewage treatment results in very low concentrations of TSS being discharged to the Wingecarribee River. These results also suggest a source of faecal contamination upstream of the discharge location.

Overall, the analysis results indicate that, 5 km downstream from the STP discharge location, there is (in general) no statistically significant difference between the upstream and downstream water quality parameter data. That is, the influence of the STP discharges at the downstream location cannot be isolated.

University of Newcastle carried out analysis of xenoestrogens in effluent samples taken from several WSC-operated STPs including Bowral STP in 2020. The results of the analysis indicate that concentrations of estrogenic endocrine-disrupting chemicals found in the effluent samples are relatively low and the risk of seeing estrogenically mediated effects in receiving waters is minimal. A copy of the report is provided in Appendix E.

Groundwater

Groundwater was intersected at boreholes mainly in the eastern section of the site near the proposed inlet works, sludge digester, storm detention pond 1, crane pad and bioreactor and bioreactor switchroom works (PWA, 2018b) and during subsequent geotechnical investigation at the STP site at the proposed location of the inlet works at 2.5 m depth, but not observed during auger drilling within any of the remaining boreholes advanced as part of this investigation (D& N Geotechnical, 2021). Standpipe Piezometers were installed at the proposed location of the filter feed pumping station (MW102) and the proposed inlet works (MW105). The standing water level was measured on Monday, 12 April 2021 as 1.25 m below ground level at the filter feed pumping station location and 2.73 m below ground level at the location of the new inlet works (D& N Geotechnical, 2021).

Flooding

The Bowral STP site is within the 1 in 100 year flood level as shown in Figure 5-10. Topography of the site is relatively flat, sloping gently from north to south making the majority of the lower areas prone to flooding. It is noted that the finish level of all in-ground tanks will be located above the flood level.

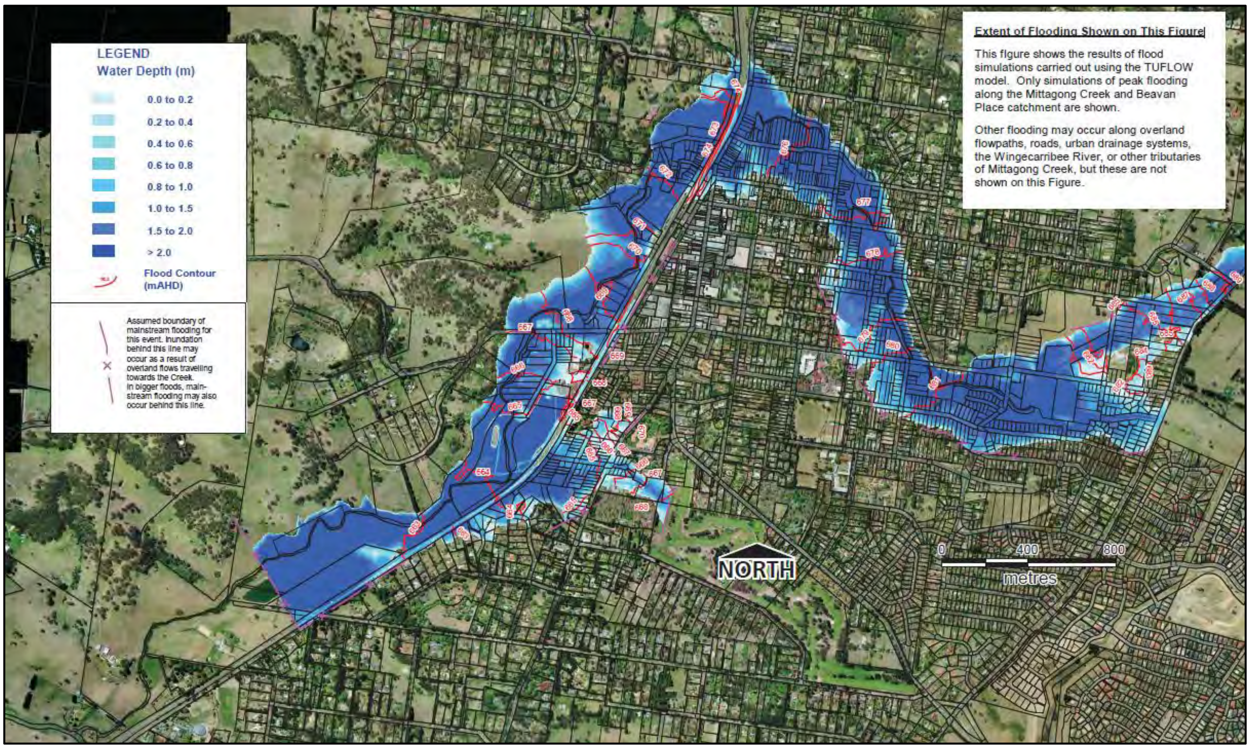


Figure 5-10 Mittagong Rivulet Flood Contours

Source: Bewsher Consulting Pty Ltd and Wingecarribee Council, 2018

5.7.1 Construction Impacts

Groundwater

The geotechnical investigation undertaken for the proposed upgrade works indicated that groundwater was encountered at approximate depths of 1.25 -5.7m, therefore, groundwater should be managed during the construction of the proposed STP upgrade works to prevent groundwater and surface water quality impacts.

If groundwater is encountered during the works, dewatering, settling, treating and filtering techniques would be required to be implemented. If it is anticipated that more than 3 ML of groundwater would be extracted in the course of construction works, an aquifer interference approval would be required from DPIE - Water prior to the commencement of construction works. However, it is anticipated that less than 3 ML of groundwater in total would be extracted during the works. As such, it is recommended that the volume of water extracted during the course of the works each day should be recorded and an aquifer interference activity exemption should be lodged through DPIE - Water (NRAR) by the construction contractor on behalf of the proponent (Further information on groundwater aquifer exemption requirements is available at https://www.dpie.nsw.gov.au/nrar/how-to-apply/water-licences/Groundwater).

Given the implementation of the recommended mitigation measures detailed in Section 5.7.3 the impacts during construction are unlikely to be significant.

Overall, given the proper implementation of mitigation measures provided below the impacts on water quality during construction is not considered to be significant.

Spill Management

Accidental spillage of fuels, hydraulic fluids and lubricating oils used in the operation of construction equipment could result in the release of hydrocarbons and metals which may be transported to nearby watercourses. The significance of the impact would depend on the type of fuel or oil used, the quantity spilt, the prevailing weather conditions and rate of flow of the watercourse. Several mitigation measures are recommended below to manage and mitigate potential spill incidents.

5.7.2 Operational Impacts

Stormwater

The finish level of all in-ground tanks proposed would be located above flood levels at least and above the natural surface level 100 mm to avoid overland run-off. Stormwater would be managed through the onsite stormwater system and adverse water quality impacts are not predicted

Groundwater

There is limited potential for the STP to impact groundwater. The proposed storm detention ponds would have a HDPE lining to prevent wastewater seepage into groundwater during operation. Provided there are no significant overflows or spills no adverse impact to groundwater quality are predicted.

Effluent Discharge

Following upgrade works, treated effluent produced at the STP would continue to be discharged to the Wingecarribee River where it is joined by the Mittagong Rivulet as per the current arrangement. The upgrade of the Bowral STP has been designed to meet the NSW EPA licence conditions and WaterNSW NorBE requirements for discharges into Sydney's drinking water catchment (see Section 4.1 for the effluent quality design targets).

The upgraded plant is expected to provide a more consistent and reliable effluent quality as well as an improved effluent quality.

The results of discharged effluent contaminant concentration modelling indicate that MLE and FSB plant type options would result in downstream contaminant concentrations at equal or lower levels than the existing STP.

MHL's DIA analysis results (such as the results shown in Table 5-8) were based on using cloth filters for tertiary treatment, rather than dual media filters. However, it should be noted that as the STP detailed design developed, it was determined that dual media tertiary filters would provide a better effluent quality outcome than cloth filters for tertiary treatment (especially for TSS and TP) and as a result, better discharge effluent contaminant concentrations than the results from the modelling shown in Table 5-8.

Table 5-8 Downstream Contaminant Concentrations at DS 1 and DS 2 locations (at full design load of 18,692 EP)

	Concentrations (mg/L)					
	TSS		TN		TP	
ANZECC	25		0.25		0.02	
Background (50%ile)	N/A		2.0		0.10	
	50%	90%	50%	90%	50%	90%
DS-1						
Existing	11	44	4.5	6.4	0.12	0.21
IDEA	11	42	5.6	8.8	0.16	0.41
MLE	11	41	4.3	6.2	0.09	0.25
FSB	11	42	2.9	4.4	0.10	0.24
DS-2						
Existing	17	65	3.8	5.7	0.12	0.17
IDEA	18	64	4.2	7.3	0.13	0.30
MLE	17	63	3.7	5.3	0.10	0.18*
FSB	18	64	2.8	4.0	0.10	0.18*

(Source: Discharge Impact Assessment. MHL, 2021)

NB: Cells shaded green indicate an improvement on existing conditions

Results are based on the use of cloth filters for tertiary treatment as opposed to the selected STP design comprising dual media filters for tertiary treatment .

** 90%ile for TP at DS-2 (MLE and FSB) are within the error of the model results – so, likely not different from the existing conditions*

DS1 – located close to the STP discharge point into the Wingecarribee River

DS2 – located approximately 5 km downstream from the STP discharge point into the Wingecarribee River

In general, the STP upgrade would result in increased plant treatment capacity and ultimate improved secondary and tertiary treatment processes that provide a greater ability to treat increased future flows, thereby ensuring the plant is able to consistently meet (and generally better) the EPL requirements following the capacity increase including BOD and Suspended Solids.

Furthermore, the upgrade would incorporate improved wet weather handling facilities and a proposed filtration and dosing system which would provide for the removal of additional nutrients and would ultimately improve the treated effluent quality.

Improved disinfection (incorporating upgraded UV disinfection) would ensure that E. Coli levels in the treated effluent would be less than 200 CFU/100mL (80 percentile). This would result in an overall improved water quality outcome, and therefore would provide an increased ability to meet the objectives of the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000) with regards to environmental values of water namely, aquatic ecosystems, recreation and aesthetics.

ANZECC Guidelines Water Quality Modelling

A discussed in Section 4.1, modelling undertaken as part of the DIA by MHL (2021) (refer to Appendix E) aimed to (i) estimate the concentrations of contaminants in the waters downstream of the discharge locations and their compliance with the default ANZECC guidelines, and (ii) assess compliance of each of three STP upgrade treatment options scenarios (IDEA, MLE, FSB) with standard NorBE requirements. The scenarios were defined by the projected 50% and 90%ile values for total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP) based on the use of cloth filters for tertiary treatment, rather than dual media filters which are anticipated to result in lower contaminant concentrations to that of the modelling results.

A summary of the modelled concentrations of the contaminants for each treatment scenario post STP upgrade for the upstream water monitoring location (DS1) and for the downstream location (DS-2) (for the 50% and 90%ile values) is provided in Table 5-8. It was found that in all modelling scenarios cases, the 50%ile background (i.e. upstream) concentration already lies close to or above the relevant ANZECC guideline. The implication is that it will be (almost) impossible to meet the ANZECC guidelines.

The STP concentration for TSS would not change for the different treatment scenarios. The patterns at both DS1 and DS2 are similar. Concentrations at DS2 are less than those at DS1, as expected due to the additional dilution achieved farther downstream.

Downstream concentrations of TSS are substantially greater than the STP concentrations. The reason for this is because the upstream concentrations of TSS are relatively high (and almost double the ANZECC guideline). With increasing distance downstream, effluent from the STP (with relatively low TSS concentrations) mixes with the higher upstream concentrations. Therefore, the concentrations at DS2 exceed those at DS1. However, TSS may not be a good indicator of impacts from the STP discharges because other sources of TSS (such as bank erosion) would also contribute to elevated levels of suspended solids.

The modelling found that downstream nutrient concentrations would be greatest for IDEA, then for MLE and the lowest concentrations would be from FSB. (Note, STP concentrations of TP are the same for MLE and FSB, hence their downstream results are the same). Again, the upstream concentrations are well in excess of the ANZECC guidelines (up to about a factor of 2) and the simulated concentrations are likewise in excess of the ANZECC guidelines.

For most contaminants, the upstream concentrations exceeded the ANZECC guidelines. This resulted in the downstream concentrations generally exceeding the ANZECC guidelines. This may suggest that the default ANZECC guidelines are not appropriate for this region.

NorBE Assessment

The Neutral or Beneficial Effects (NorBE) is an assessment tool used to determine the likely impact of a development on Sydney's drinking water catchment. Developments and activities carried out by public authorities are required to consider and aim to have a 'neutral or beneficial effect' on water quality in the catchment.

There are two major components to meeting NorBE, including:

- Does the model indicate at least a 10% 'improvement' in pollutant loads for total suspended solids, total phosphorus and total nitrogen?
- Are the post-development cumulative probability pollutant concentration curves for total phosphorus and total nitrogen between the 50th and 98th percentiles equal to or less than the pre-development curves?

However, it should be noted that the NorBE assessment '10% improvement' component is not considered realistic for the Bowral STP upgrade as the STP has been subject to ongoing pollutant load improvements over the years; and as discussed in Section 4.1, WaterNSW consider that the 2007 year catchment report data (PWA, 2007) which was taken shortly after the previous STP upgrade is considered a more suitable NorBE baseline to compare the proposed STP upgrade against.

The NorBE associated with each of the STP upgrade treatment type scenarios was undertaken as part of the DIA, noting that MHL modelling scenarios and the results below are indicative only; as the detailed design has resulted in some changed parameters and, although the DIA modelling was based on normal NorBE assessment, it was based on reductions of existing discharge concentrations rather than the 2007 baseline data. A copy of the NorBE Assessment is provided in Appendix E.

The NorBE makes generic references to impacts on 'water quality'. However, there is only specific reference to TN and TP for the NorBE concentration requirements and to TSS, TN and TP for the NorBE annual load requirements. The 'tipping point' is described as the concentration of contaminants in the effluent at which the NorBE requirements are just met.

The annual loads together with the tipping point concentrations for the Bowral STP at the future upgrade design capacity are shown in Table 5-9. The 50%ile tipping point values for TSS lies below the practical quantitation limits (PQLs). Therefore, it may not be possible to demonstrate using data, that these NorBE requirements are actually met.

Table 5-9. Bowral (EP=18,692): NorBE annual loads and concentrations for the existing data and for the 'tipping point'

	Annual loads		Concentrations			
	Existing	Tipping point	Existing		Tipping point	
			50%	90%	50%	90%
	kg/year	kg/year	mg/L	mg/L	mg/L	mg/L
TSS	6,670	6,110	4.0	8.2	2.6	5.7
TN	6,530	6,380	4.75	6.44	3.24	4.34
TP	220	215	0.135	0.244	0.101	0.182

Source: MHL.2021

Exceedance plots comparing simulations of the three treatment type scenarios with the existing concentrations for Bowral (EP = 18,692) are shown in Figure 5-11 with key results are summarised below in Table 5-10 and Figure 5-11. Ticks in the table indicate that the contaminant meets the NorBE concentration requirement for that scenario. Crosses indicate that the contaminant do not meet the NorBE concentration requirement for that scenario. Table cells labelled 'marginal' indicate scenarios that are close to meeting the NorBE concentration requirement, noting that the DIA results were based on using cloth filters for tertiary treatment rather dual media filters, which would provide a better outcome with respect to meeting the NorBE concentration requirements.

TP exceeds the NorBE concentration requirement for the MLE and FSB scenarios when the probability of exceedance is <0.20 (i.e. greater than the 80%ile).

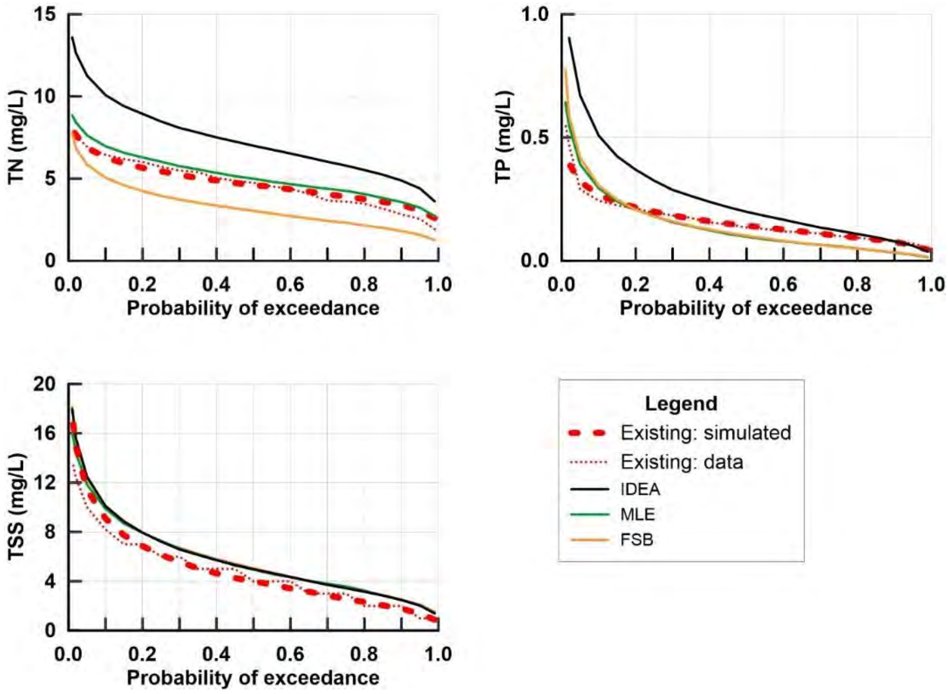


Figure 5-11 Bowral exceedance plots (EP=18,692) for concentrations simulated from the three scenarios and under existing conditions

Source: MHL.2021

Table 5-10 Bowral (EP=18,692): NorBE concentrations for three treatment type scenarios (with the 10% improvement based on existing loads)

	Scenario treatment type		
	IDEA	MLE	FSB
TN	×	marginal	✓
TP	×	marginal	marginal

Source: MHL, 2021

Note:
TSS is at the detection level therefore it is not possible to achieve NorBE
Cells shaded pink indicate a failure of the NorBE conditions, while cells shaded green indicate that the relevant NorBE conditions are met. Cells that are unshaded fail the relevant NorBE condition although the value is within about 10% of the NorBE criteria.

MHL's DIA was based on using cloth filters for tertiary treatment not dual media filters, which would provide a better outcome an results are based on existing loads rather than 2007 baseline data .

Annual loads were also estimated by averaging the annual loads for each of the 5 years the comprise the simulation period and multiplied by 1.1. The results are provided in Table 5-11. The scaled annual loads for TSS are close to the existing loads, almost complying with the NorBE load requirement. The FSB and MLE loads for TP almost comply with the NorBE annual load requirement.

Table 5-11 Bowral (EP=18,692): NorBE annual loads

Annual load		Scenario treatment type		
(kg/year)	Existing	IDEA	MLE	FSB
TN	6,530	13,830	9,980	6,120
TP	220	480	280	260

Source: MHL, 2021

Cells shaded pink indicate a failure of the NorBE conditions, while cells shaded green indicate that the relevant NorBE conditions are met. Cells that are unshaded fail the relevant NorBE condition although the value is within about 10% of the NorBE criteria.

It should be noted that the NorBE to water quality has been considered, as required, in relation to the proposed STP upgrade, and the FSB treatment type has been selected with an aim to meet NorBE requirements, as it comes closest to meeting NorBE. However, if it is possible to add the benefit of the existing sewage treatment processes (particularly for TSS) with the FSB process, it may be possible to meet the NorBE requirements. It is stressed that NorBE does not define 'pre-development' conditions.

For some contaminants (particularly TSS) the existing concentrations are less than those proposed by one (or more) scenario. In general, this means that the NorBE concentration and/or load requirements would not be met. The 50%ile tipping point values for TSS often lay below the PQL. Therefore, it may not be possible to confirm with data, that the NorBE requirement is met.

The 'tipping point' concentrations are substantially less than the existing concentrations to ensure that the NorBE load requirement is simultaneously met. Compliance with NorBE is usually governed by the annual loads, rather than by the concentrations. Furthermore, based on WaterNSW and EPA consultation, the baseline condition targets for NorBE are the Catchment Report loads data from 2007 (PWA, 2007) when the Bowral STP was first commissioned and is the basis for suggested licence conditions, rather than the existing loads which were modelling in the DIA. It is anticipated that post-upgrade the STP discharge loads would meet NorBE requirements and EPL conditions based on discharge loads as per the 2007 baseline data.

Overall, despite the increased capacity, the proposed upgrade of the Bowral STP is predicted to result in an overall positive impact on water quality and reduce the contribution of pollutant levels to the Wingecarribee River system, resulting in downstream contaminant concentrations at equal or lower levels than the existing STP. Based on the improved water quality outcomes overall to meet EPA licence requirements, no adverse impacts to downstream water users is expected.

Recycled Water Reuse

Treated effluent would be utilised on-site as wash water for the mechanical screening system, general cleaning of infrastructure and for irrigating the grounds within the STP. Currently, the effluent from the UV unit is pumped to the 35kL reuse storage tank. The effluent produced by the new system will continue to go to this tank from the UV unit.

In addition, the Chevalier College fields and grounds, the Oxley College fields, Eridge Park and the Bowral golf course have been identified as future potential users of recycled water will be further investigated by Council. Any changes to the current reuse scheme would be subject to further investigation and assessment.

Provided the recycled water reuse scheme operates in accordance with all best practice guidelines, management plans and within licence limits, no adverse impacts to surface or groundwaters are predicted.

5.7.3 Mitigation

Construction

- The CEMP would incorporate a pollution incident response management plan that defines appropriate procedures for notification of pollution incidents to the required authorities in accordance with s. 147 to 153 of the POEO Act and requires response actions to be implemented in order to address any risks such as incidents posed to the environment, property or surrounding communities.
- Any disposal of wastewater or fluids generated as part of construction works would be undertaken in a manner that does not cause water pollution. The CEMP would document an appropriate offsite disposal facility for treatment and disposal.
- A site-specific spill management plan would be prepared and include the following requirements:
  - Emergency spill kits are to be kept at the site (vehicle kits).
  - Refueling of machinery to be undertaken in a dedicated area within the construction compound appropriately protected as outlined in the spill management plan.
  - Any chemicals and fuels are to be stored in a bunded area at least 50 metres from any drainage line.
  - Any hazardous materials stored on site would be stored in the compounds and within impervious and bunded enclosures capable of storing 110% of the volume of material stored there.
  - Workers would be trained in the spill management plan and the use of the spill kits.
- Where less than 3 ML of groundwater is extracted during the works. The volume of water extracted during should be recorded daily and an aquifer interference activity exemption should be lodged through DPIE - Water (NRAR) by the construction contractor on behalf of the proponent on the completion of works (Further information is available at https://www.dpie.nsw.gov.au/nrar/how-to-apply/water-licences/Groundwater). If more than 3 ML of groundwater is anticipated to extracted during the works, an aquifer interference approval would be required from DPIE- Water prior to the commencement of works.
- Mitigation measures to manage groundwater (which as indicated in the geotechnical investigations will be encountered during construction) would be incorporated into the CEMP, including:
  - Dewatering techniques during excavation;

- Measures to ensure groundwater quality is not impacted during construction;
- Techniques to settle, treat or filter groundwater encountered during excavation works i.e. diverting groundwater through baffle tanks or filter membranes; and appropriate treatment and monitoring regimes when groundwater flows come to the surface, including disposal of groundwater in such a way as to prevent adverse impacts (such as erosion and water pollution). Groundwater should not be discharged to a waterway during construction.

Operation

- The existing EPA licence is to be amended and the STP operated in accordance with EPA licence conditions. Monitoring of effluent discharge will be undertaken in accordance with the licence requirements.
- Routine maintenance of the STP is to be undertaken in accordance with the Operations and Maintenance manual prepared for the plant.
- The STP Operation Environmental Management Plan (OEMP) would be updated to detail appropriate actions in the event of equipment or power failure. The OEMP would be periodically reviewed to assess the efficacy of all management procedures. Identified shortcomings would be remedied to ensure these continue to be effective.
- Appropriate signage is to be maintained where chemicals are stored.
- The community would be notified of any incident with the potential to result in public health impacts.

5.8 Flora and Fauna

The Bowral STP site is predominantly cleared of vegetation and is subject to routine maintenance such as slashing and mowing. The vegetation on site consists of landscape trees and shrubs and grass lawn (see Figure 4-3).

In response to consultation regarding this project, EES has advised that:

- individuals of Paddys River Box (*Eucalyptus macarthurii*) trees, listed as endangered under the BC Act and EPBC Act, have been recorded on the subject site adjacent to the existing detention ponds,
- mapped areas of Southern Highlands Shale Woodland (SHSW) ecological community, listed as endangered under the BC Act and critically endangered under the EPBC Act, exist immediately to the north of the site. SHSW may also occur on site, as the extent of the EEC may not be wholly evident from the mapping (see Figure 5-12)
- Mittagong Rivulet is identified on the Biodiversity Values Map supporting the BC Act (see Figure 5-13).

Treated effluent from the STP is discharged into Mittagong Rivulet, which is identified as Riparian Land Category 2 - Aquatic and Terrestrial Habitat according to the Wingecarribee LEP 2010 Natural Resources and Sensitivity Map (see Figure 2-2).

The Department of Primary Industries (Fisheries) identifies Mittagong Rivulet as Key Fish Habitat (see Figure 5-14).

A search of EES' Atlas of NSW Wildlife indicates 28 threatened species protected under the *Biodiversity Conservation Act 2016* have previously been recorded within a 10km x 10km radius of the site, including 5 threatened flora species, 18 threatened bird species and 5 mammal species. An EPBC Act Protected Matters Report for a 10km by 10km area surrounding the site identified 5 listed threatened ecological communities, 47 listed threatened species and 15 listed migratory species that may or are likely to occur, or have habitat, in the area. These search results are provided in Appendix D.

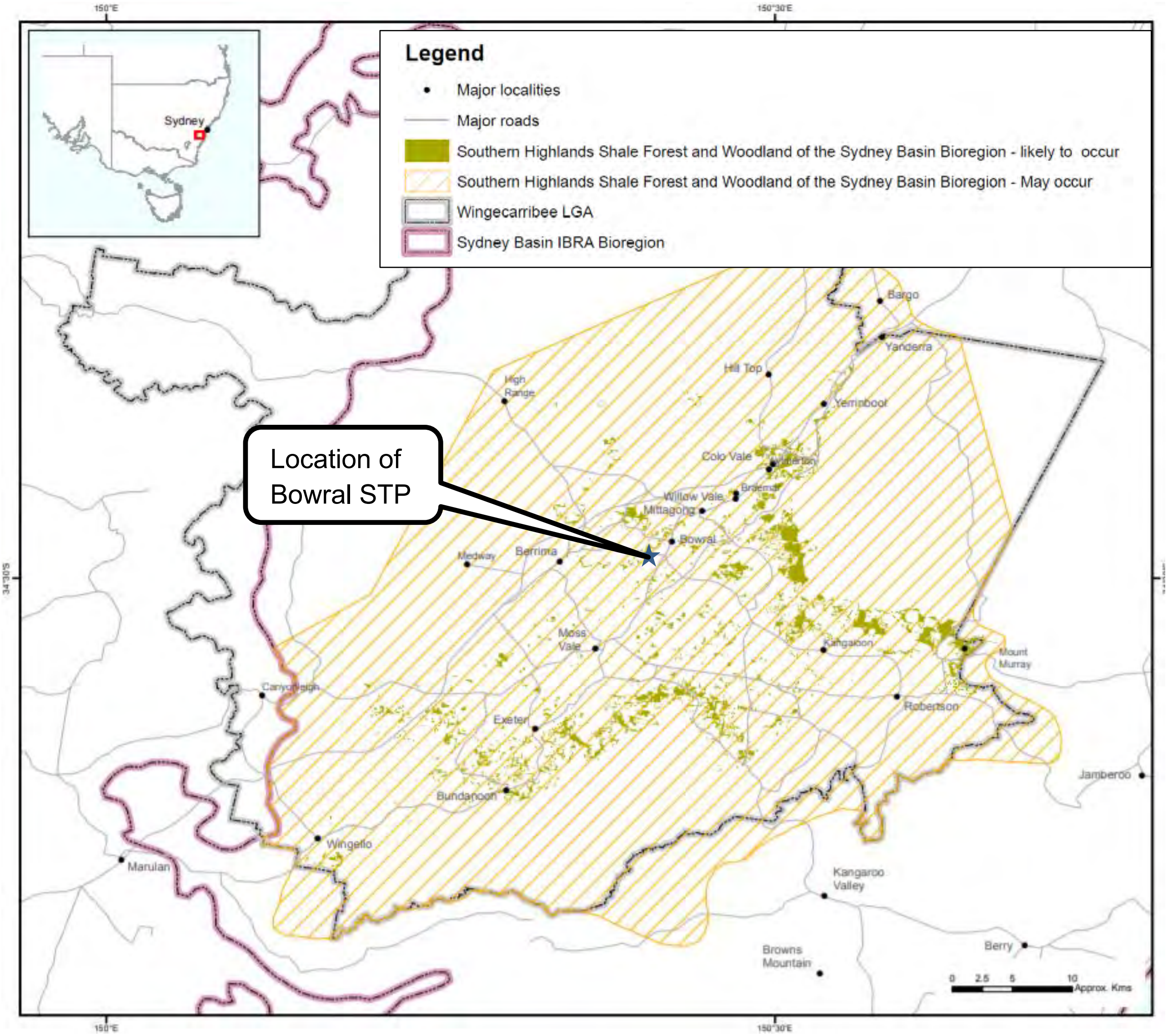


Figure 5-12 Southern Highlands Shale Forest and Woodland of the Sydney Basin Bioregion Map Extract

Source: Department of Environment and Energy, March 2017

Figure 5-13 Biodiversity Values Map Extract

Source: Biodiversity Values Map and Threshold Tool, accessed January 2019

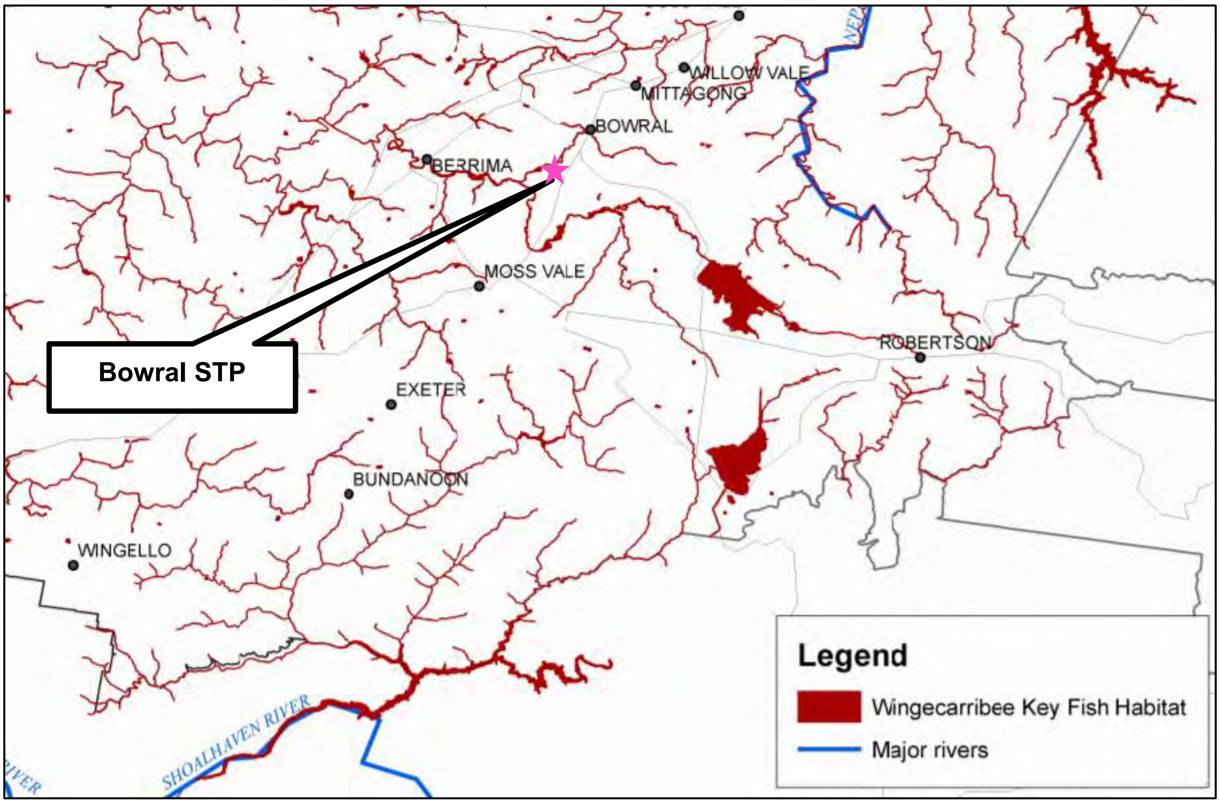


Figure 5-14 Wingecarribee Key Fish Habitat Map Extract

Source: Key Fish Habitat Maps, Department of Primary Industries, accessed January 2019

Overall the area of the site to be affected by the upgrade works has very limited habitat potential due to its highly disturbed nature. None of the threatened flora species or communities listed as occurring within a 10km radius of the site are anticipated to be utilising the site for primary habitat.

5.8.1 Construction Impacts

The proposed works would require very minor vegetation removal, this comprising a small section of planted grass surrounding existing infrastructure at the STP site. The works associated with the STP upgrade occur within the highly and/previously disturbed cleared areas of the site. Given the disturbed nature and the high proportion of cleared areas, the site is considered to have limited habitat value and therefore construction works are not anticipated to impact significantly on any fauna habitat of conservation value.

The proposal is not anticipated to impact on any Matters of National Environmental Significance listed under the EPBC Act or threatened species, populations and endangered ecological communities, or their habitats, which are listed under NSW *Biodiversity Conservation Act 2016*.

The area for development is located entirely within the existing STP site which has been disturbed previously for the construction of existing STP infrastructure. Accordingly, the works are not anticipated to impact adversely on any areas of Southern Highlands Shale Woodland, Paddys River Box (*Eucalyptus macarthurii*) and Mittagong Rivulet.

No instream works are proposed as part of the STP upgrade and provided appropriate sediment and erosion controls are implemented, there is limited potential for the construction works to impact the aquatic environment.

Overall, any impacts on flora and fauna as a result of the proposal are considered to be negligible.

5.8.2 Operational Impacts

The operation of the STP is not expected to result in any impact to terrestrial biodiversity. Given the improved and more reliable effluent quality, no adverse impacts (when compared to the operation of the existing STP) are predicted.

A 2-year macroinvertebrate water monitoring program of the Wingecarribee River is currently being undertaken by Sydney Water Monitoring Services to determine the ecological impact of the Bowral STP discharges on the receiving waterway. It should be noted that the macroinvertebrate study is being conducted over several years and therefore the complete analytical results are not yet available.

The Macroinvertebrate sampling undertaken to date has been carried out at two sites (shown in Figure 5-15) which are located upstream and downstream of the Bowral STP discharge point. Macroinvertebrate analysis is used as a primary indicator for biodiversity and ecological health of riverine systems, as the presence or absence of macroinvertebrates is a result of their exposure to changing water quality over periods of time.

The *MHL – Southern Highlands Interim Biological Monitoring Report Bowral STP* (Sydney Water Monitoring Services, 2021) included interim macroinvertebrate monitoring data and provided the below interpretation of analytical results.

Taxa Richness across both sampling sites has fluctuated seasonally, there is a consistent trend of a slightly higher taxa richness at the upstream site, although the differences between sites are not significant and could be due to natural variation in the sampling habitat. Both upstream and downstream sites have community assemblages dominated by pollution tolerant taxa indicative of impacted waterways (including *Acarina, Atyidae, Corixidae, Coenagrionidae, Chironomidae (sub families Chironominae and Orthocladiinae)* and *Leptoceridae)*.

The number of Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa across both sampling sites has fluctuated seasonally, there is a consistent trend of a slightly higher number at the upstream site in autumn with quite a distinct difference in the spring sampling occasion. Overall there were seven EPT families collected over the three sampling occasions. Four taxa were only found at the upstream site, while one taxa was only found at the downstream site. The rest of the taxa were found at both sites. *Leptoceridae* were by far the most populous and consistently present EPT taxa, the rest of the taxa were found in low numbers and often in only one sampling season.

Although EPT taxa are thought to be more sensitive to organic pollution than some other taxa, within some families there are genera which are quite tolerant to pollution. EPT and other taxa diversity-based indices are influenced by several natural factors other than pollution. These include stream size, substrate variability, current, water temperature, food resources and life cycles. The large rainfall event in May 2021 which occurred prior to sampling may have contributed to the lower levels of taxa richness and EPT collected that season.

Stream Invertebrate Grade Number Average Level – National scores (SIGNAL 2) scores were similar at both the upstream and downstream sites across all three sampling seasons. Plotting of the results indicated that both sites represent agricultural or urban impacted waterways with similar levels of impact. The results were consistent with the surrounding land use of the catchment and showed that both sites have been subject to similar levels of agricultural/urban pollution impacts.

Stream Invertebrate Grade Number Average Level – Sydney Family (SIGNAL SF) results were very similar between the upstream and downstream sites and remained consistent across seasons and were indicative of natural water quality. This indicates that water quality at both upstream and downstream sites have been impacted by mild organic pollution.

Australian River Assessment System (AUSRIVAS) results indicated that both upstream and downstream sites were of a similar ecological condition. The AUSRIVAS OE50 index scores displayed similar levels at both upstream and downstream sites, with the upstream remaining slightly higher than the downstream site across seasons. The index scores for both sites fell within Band C, except for the upstream site in spring which fell into Band B. AUSRIVAS Band C is indicative of a severely impacted system, while Band B is indicative of a moderately impacted system. The fact that the upstream and downstream sites displayed values in Band C and lower Band B indicate that both sites are under a similar amount of impact.

The results of all biotic indices indicated the waterway is moderately impacted by pollution both upstream and downstream of the Bowral STP discharge point. This is consistent with land use in the wider catchment, which is dominated by agricultural and urban land use, both of which have been shown to have adverse impacts on aquatic ecosystems. There was a consistent trend throughout the results where the upstream site was in slightly better condition than the downstream, although the difference was minor and may be due to natural variation and site-specific features. The upstream sampling site comprises a slightly thicker surrounding of riparian vegetation along with increased amount of emergent macrophyte within the stream edge. These environmental variables may assist in decreasing the amount of nutrients and urban run-off entering the creek and provide better habitat diversity for macroinvertebrates. The downstream sampling site is located downstream not only of the STP effluent discharge point, but also of a busy roadway and railway bridge which passes directly over the river. These impervious surfaces leading right up to the river may increase the amount of urban runoff entering the river at this point, as impervious surfaces have been found to increase the amount of urban run-off entering urban waterways.

The differences between the upstream and downstream sampling sites could be due to natural variation in site specific habitat and/or characteristics. The results of the macroinvertebrate analyses undertaken to date have indicated that there has been no clear impact on macroinvertebrate communities that can be specifically attributed to the Bowral STP discharges.

A copy of the Bowral STP interim biological monitoring report is provided in Appendix H.

Figure 5-15 Location of macroinvertebrate sampling sites upstream (BOW US) and downstream (BOW DS) of the Bowral STP site.

Source: Sydney Water Monitoring Services, 2021

Based on the disturbed nature of the STP site and above interim macroinvertebrate study results, no significant impacts to aquatic flora and fauna are predicted during operation of the upgraded STP subject to the implementation of the mitigation measures provided in Section 5.8.3.

5.8.3 Mitigation

Construction

- Appropriate hygiene strategies are to be identified and implemented during the construction phase of the development to minimise the infestation and spread of noxious weeds as a result of the works.
- Vegetation disturbance /clearing should be limited to those shown on plans and within the works footprint. No other vegetation is to be impacted by the works without further environmental assessment.
- Vehicles and machinery would utilise existing tracks and cleared areas where possible to access the site during construction.

Operation

- Consideration should be given to a vegetation management plan (VMP) and associated works to improve the resilience and functioning of the Mittagong Rivulet riparian corridor.
- The works area should be monitored for the spread of weeds.

5.9 Bushfire

A small section of the STP site, located north of the existing aerobic sludge digester is identified as a bush fire prone land (Vegetation Buffer) on the Bushfire Prone Land Map, certified by the NSW Rural Fire Services, (refer to Figure 5-16).

1 **Vegetation Category 1**
0 **Vegetation Buffer**

Figure 5-16 Bowral STP located within a Bushfire Prone Land
Source: NSW DPE Planning Portal, accessed October 2018

5.9.1 Construction Impacts

The design of the aboveground upgrade works at the STP should take into consideration the potential bushfire risk at the site, in accordance with the relevant principles of the RFS publication *Planning for Bushfire Protection 2019.*

Construction works at the site are not anticipated to pose a bushfire risk. Any fire risks associated with works (such as welding) should be incorporated into safe work method statements or similar.

5.9.2 Operational Impacts

The proposed works would not hinder the fire fighting vehicular access to the STP facilities and any adjoining scrub / forest boundaries. The ability of fire fighting appliances to defend assets within the site and respond to fires that may threaten the STP from surrounding areas would be improved post construction as a result of the upgraded internal roads.

5.9.3 Mitigation Measures

Construction

- Design of the aboveground upgrade works at the STP should take into consideration the potential bushfire risk at the site, in accordance with the relevant principles of the RFS publication *Planning for Bushfire Protection 2019*.
- Construction staff to be made aware of the location of the proposed works in bushfire prone land and the potential for bushfire risk.
- No hot works to be undertaken on Total Fire Ban days.

Operation

- Relevant District Brigades (Burradoo/Bowral) would be issued with key access to the STP site, to be used only in an emergency situation.

5.10 Waste Management

5.10.1 Construction Impacts

STP Construction

Excess building materials would be generated from the construction work including miscellaneous wastes associated with packaging and transport of plant and equipment and various other manufactured items forming part of the upgrade works. These would be recycled or reused where possible or where this was not possible, disposed of at Council's landfill site.

The potential to encounter contaminated soils due to past use of the site as STP would need to be determined through a contaminated soil assessment. If the site is determined to be contaminated a detailed site investigation would be required to determine if the site poses an unacceptable risk to human health or the environment. A remediation action plan may then be required following EPA NSW Guidelines including *Guidelines for consultants reporting on contaminated sites* and (EPA NSW 2011) *Planning Guidelines SEPP 55 - Remediation of Land.*

Excess cut of material may be produced from the construction of the pre-aeration tank, reuse storage tank and storm detention pond. The cut would be used for fill/foundations and creation of the embankments where possible. The reuse surplus spoil would need to comply with the EPA's *Resource Recovery Exemption and Resource Recovery Order for Excavated Natural Material* or disposed in accordance with the *Waste Classification Guidelines* (EPA, 2014). The long-term onsite storage of surplus spoil would be seeded to minimise the likelihood of it being transported offsite through wind or water action, and sediment control measures would be put in place. This would be undertaken in accordance with the relevant management measures identified in the soil and erosion control plan to prevent mobilisation of material and subsequent impacts on water quality.

Decommissioning of Existing Pasveer Channels

The existing Pasveer Channels are to be decommissioned as part of the STP upgrade works. Demolition waste may be processed into engineered material and, if it complies with the EPA *Resource Recovery Order and Resource Recovery Exemption* for recovered aggregate, reused as backfill material on-site. Alternatively, the material would be disposed to a licensed landfill in accordance with its waste classification.

5.10.2 Operational Impacts

Waste solids generated within Bowral STP would include:

- Screenings and grit from the inlet works; and
- Stabilised bio-solids.

Screenings and grit from the inlet works would be disposed of as per current practices.

Sludge generated from the sewage treatment process would be stabilised to achieve stabilisation Grade B as defined in the EPA's Biosolids Guidelines (NSW EPA, 1997). Stabilised sludge is currently dewatered via sludge drying beds and dewatered sludge is stored on site. Post-upgrade a new mechanical dewatering facility fed from an aerobic digester consisting of a single dewatering train would deliver biosolids to a bunded truck trailer hard stand area for disposal. However, one sludge lagoon would be retained as emergency liquid sludge storage.

5.10.3 Mitigation

Construction

- The contractor or Council is to carry out a contaminated soil test prior to construction. If the site is determined to be contaminated, a detailed site investigation would be required to determine if the site poses an unacceptable risk to human health or the environment. A remediation action plan may then be required following EPA NSW Guidelines including Guidelines for consultants reporting on contaminated sites and (EPA NSW 2011) Planning Guidelines SEPP 55 - Remediation of Land.
- A Waste Management Plan (WMP) would be prepared as part of the CEMP by the construction contractor for the management of waste generated during construction works. The WMP must be prepared in accordance with the applicable waste management provisions of the *Protection of the Environment Operations Act 1997* and the *Protection of the Environment Operations (Regulation) 2014.* The WMP would follow the resource management hierarchy principles embodied in the *Waste Avoidance and Resource Recovery Act 2001* and the *NSW Government Resource Efficiency Policy 2014*. It would include, but not necessarily be limited to, the following:
  - Non-recyclable waste and containers would be regularly collected and disposed of at a licensed landfill or other disposal site in the area. Waste oil would be sent to approved recyclers.
  - The worksite would be left tidy and rubbish free each day prior to leaving site and at the completion of construction.

    - Transportation of waste must be done in a manner that avoids the waste spilling, leaking or otherwise escaping from the vehicle or plant used to transport the waste. Waste would be transported to a place that can lawfully receive that waste.

- No batched concrete mixing plants would be established in the works areas. Any required concrete would be mixed off-site and transported to the construction areas.
- Following completion of the works, excess concrete would be removed off-site for recycling.
- All waste removed from the site would be classified and disposed of appropriately, and all non-recyclable waste would be disposed of at an appropriate licensed waste disposal facility.
- If any contaminated material is encountered during earthworks, work shall cease, the site secured, and a safe work method statement(s) and appropriate practices implemented. Any contaminated material would be classified first and then stored, transported and disposed of in accordance with EPA requirements at an EPA licensed waste facility.
- If practicable, surplus excavated materials/fill would be reused onsite as part of rehabilitation and restoration works. Any surplus spoil disposed of in this manner would be seeded to minimise the likelihood of it being transported offsite through wind or water action.
- Test demolition waste that is to be reused as backfill onsite to ensure compliance with the relevant EPA Resource Recovery Order and Resource Recovery Exemption. Alternatively, dispose of the material to a licensed landfill in accordance with its waste classification.

Operation

- Biosolids would be managed in accordance with a Biosolids Management Plan to be prepared for the augmented STP.
- Biosolids management would be consistent with the EPA's *Environmental Guidelines: Use and Disposal of Biosolids Products* (EPA, 1997).
- Land application of biosolids (if proposed) would be controlled to prevent any off-site migration.

5.11 Heritage

A search of the Aboriginal Heritage Information Management System did not identify any Aboriginal sites or places within 200m of the STP site, being Lot 2 DP 1119953 and Lot 278 DP 914555 (refer to Appendix D).

The site is located within 200m of Mittagong Rivulet however the site has been previously disturbed for the construction of the existing STP, access roads and site levelling.

There are no State or local heritage listings that apply to the STP site.

5.11.1 Construction Impacts

All of the previously recorded Aboriginal sites are located outside the STP site boundary. Works would be contained to the STP site and therefore will not cause harm to previously recorded Aboriginal heritage sites or places.

The Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW (DECCW, 2010) has been used in assessing the likelihood of encountering items of Aboriginal cultural heritage during the construction works. It is considered that further archaeological investigations and/or an Aboriginal Heritage Impact Permit are not required and that the proposed development can proceed with caution. This is due to the previous disturbance and filling of the site, noting that the area within the existing boundary fence of the STP site has previously been subject to both above ground and below ground disturbance and the proposed STP components would be constructed within previously disturbed areas of the site. In the event that any Aboriginal heritage items are found during the proposed development, proposed development should cease and safeguards listed below would be applied.

5.11.2 Operational Impacts

No impacts are predicted.

5.11.3 Mitigation

- As part of an induction, in the unlikely event that any historical relics or sites are identified workers should be aware of their responsibilities under the provisions of the *Heritage Act 1977*. In this event all works must cease and the area be protected until a qualified archaeologist inspects the site and provides management advice in consultation with Heritage NSW.
- As part of an induction, in the unlikely event that any unknown Aboriginal objects are uncovered during proposed works, all workers and sub-contractors should be aware of their responsibilities under the provisions of the NPW Act (including the penalties under the ancillary provisions) and *Heritage Act 1977*. In this event all works must cease and the area where Aboriginal objects are uncovered is protected until a qualified archaeologist and representatives of registered Aboriginal parties are contacted and can inspect and assess the area to determine its significance.

5.12 Greenhouse Gases Emissions

Existing Greenhouse Gas Emissions (GHG) from the STP are related to current energy usage, with this energy generated from conventional fuel sources. The current half hourly peak day demand varies between 60-200 kW.

An upgrade to the plant power supply would be required to meet the increased load requirements and new instruments required for the new plant. To meet the increase power demands, a new 1000kVA pad mount substation, new main switchroom and two switchboards would be required for the proposal.

It is noted that the provision of photovoltaic/solar power supply for the STP will be considered by WSC subject to budgetary availability of funds or receipt of subsequent NSW government grant funding for public infrastructure projects.

5.12.1 Construction Impacts

No significant emissions of GHGs are anticipated during construction. Construction vehicle movements and the use of fuel powered construction equipment may emit GHGs (mainly CO_2). However, the quantity and duration of use of vehicles, plant and equipment for construction works would be limited, and therefore the works are not considered to have a significant impact on state or national GHG emission levels.

5.12.2 Operational Impacts

During operation of the upgraded Bowral STP, energy consumed onsite is likely to increase due to the provision of new treatment facilities, in particular, pumps, UV unit associated facilities, air blower and switch room. The new 1000kVA substation would meet the upgraded STP's power demands and allow capacity for future upgrades when required.

5.12.3 Mitigation

Construction

- Burning matter of any kind would not be permitted on site.
- Reduce the number of traffic movements required.
- Energy efficiency requirements would be included in the site environmental induction.

Operation

- Energy efficient equipment or functions would be used where possible for the operation of the STP.
- STP lighting to be minimised where possible.
- STP equipment and machinery would be suitably serviced and maintained during the operation of the STP.

5.13 Chemical Management and Public Health

5.13.1 Operational Impacts

As alum and caustic soda dosing is proposed at the upgraded STP for wastewater treatment, chemical spills may occur, resulting in offsite impacts. In order to avoid these impacts, liquid alum and caustic soda would be stored in two new bulk storage tanks within bunded areas. The existing bunded alum storage area would be converted to an additional caustic soda storage area. The bunded areas would also contain dosing pumps, sump pump, safety shower and eyewash facilities. The bunds would have a minimum storage volume of 110% of the total chemical volume stored.

The design features of the proposed storage tanks are noted in Section 4.2.17 and 4.2.18. These design features for chemical storage and handling facilities would reduce the likelihood of any offsite impacts. Procedures would be implemented to ensure that any chemical spills are cleaned up without any discharges to surface water.

Other chemicals that may be used at the STP include:

- cleaning chemicals;
- fuel and lubricant for machinery; and
- herbicides for onsite weed management.

All chemicals would be handled in accordance with the manufacturer's recommendations and Safety Data Sheets (previously called Material Safety Data Sheets). Safety Data Sheets would be available on site at all times. The risks associated with chemical management and use at the plant are considered low. No off-site impacts in regard to the use or handling of chemicals are anticipated to occur. Emergency response plans and procedures would be incorporated into the OEMP.

5.13.2 Mitigation

Operation

- The STP is to operate in accordance with EPA licence conditions including any chemical storage limits or other requirements.
- Routine maintenance of the STP is to be undertaken in accordance with the Operations and Maintenance manual prepared for the plant.
- The transport and handling of any chemicals used in the operation of the STP would be undertaken in accordance with all relevant SafeWork NSW guidelines.
- Notification to the EPA in accordance with Part 5.7 of the POEO Act is to be undertaken where a pollution incident occurs in the course of an activity so that material harm to the environment is caused or threatened.
- Liquid chemical storage and filling areas would be located in bunded areas designed to accommodate 110% of the total capacity delivered and are to include appropriately designed drainage and safety equipment.
- Storage tanks would be regularly inspected and maintained to ensure their integrity. Plant personnel would be trained for proper and safe operation of these facilities.
- Specific requirements for the management of chemicals associated with the STP would be detailed in the STP OEMP.
- All hazardous substances are to be listed in a register together with the relevant Safety Data Sheets. Employees are to have access to this register at all times.
- Fuel and lubricants for machinery maintenance are to be stored and managed appropriately.
- Appropriate signage is to be maintained where chemicals are stored.
- The community would be notified of any incident with the potential to result in public health impact.

5.14 Visual Amenity

All of the proposed upgrade works would be located within the boundary of STP site. In general, the STP site it is not visible to the general public from the access road and surrounding areas as it is situated within a large property within a rural setting, some distance from the town centre (see Figure 5-17). However, the STP site is visible from several private residences to the north of the STP which are located on higher ground.

Figure 5-17 General Public view of Bowral STP from the Burradoo Road level crossing

5.14.1 Construction Impacts

The main visual impacts during the construction period would be from equipment and vehicles used during construction works and a temporary site perimeter fence, stockpiling and site compound. Visual impacts resulting from construction would be short term and would be negligible due to the limited visibility of the site to surrounding residents and the general public.

5.14.2 Operational Impacts

The STP upgrade would result in the construction of new sewage treatment infrastructure which would be located wholly within the existing fenced STP site. However, several new structures would be constructed above the existing ground level including the bioreactors and filters and various components of the treatment system would be relocated within the STP site. The new facilities would be consistent with the existing sewage treatment infrastructure landscape at the site and it is considered that the changed location of the treatment units or their elevation above ground would not adversely impact on the visual aesthetics of the development.

Overall, given the limited visibility of the site to the general public, the proposed STP upgrade would have a negligible impact on the visible aesthetics of the area.

5.14.3 Mitigation

- Council would undertake landscaping following construction using native species endemic to the local area.

6.0 Environmental Management

6.1 Construction Environmental Management Plan

Preparation of a Construction Environmental Management Plan (CEMP) is mandatory for all projects undertaken by or on behalf of government agencies or where funding is being provided by the government.

The CEMP would be developed to ensure that appropriate environmental management practices are followed during a project's construction and/or operation. Wingecarribee Shire Council (WSC) would review the CEMP for this proposal, which should include the following elements, as described in the Guideline for the Preparation of Environmental Management Plans (DIPNR, 2004):

Table 6-1 Construction Environmental Management Plan Structure

Background	Introduction to the document Description of the proposal and project details The context for the CEMP in regard to the overall project The CEMP objectives The contractor's environmental policy
Environmental Management	Environmental management structure of the organisation and specific team responsibilities with respect to the CEMP and its implementation Approval and licensing requirements relevant to the project Reporting requirements Environmental training Emergency contacts and response
Implementation	A project specific risk assessment A detailed list of environmental management safeguards and controls CEMP sub plans for specific environmental controls A detailed schedule assigning responsibility to each environmental management activity and control
Monitor and Review	Environmental monitoring Environmental auditing Corrective action CEMP review and document control procedures

The CEMP would include a risk assessment which ensures that the safeguards identified in this REF, as well as any others that are considered relevant, are effectively translated into actual construction techniques and environmental management activities, controls, and monitoring/verification to prevent or minimise environmental impacts. The CEMP should also identify the requirements for compliance with relevant legislation and any other regulatory requirements to ensure environmental safeguards described throughout this REF are implemented. The environmental management objectives and supporting actions presented in this section are intended to assist in this process.

The following details the environmental objectives during construction and the proposed mitigation to be included in the CEMP. This list is not definitive, and additional measures detailed as part of the determination of the project and conditions of any other approvals must also be included. Operational safeguards are also included.

6.2 Environmental Management Measures

Implementation of the mitigation measures outlined below would be undertaken during several phases of the project. These phases comprise:

- Detailed design – refinement of the design details
- Pre-construction – prior to the contractor arriving on site to carry out the works
- Construction – during construction phase
- Operation – post construction

6.2.1 Location and Land Use

Objective

- Minimise impacts to surrounding land users during construction and operation

Actions

Action/Phase	Responsibility
Pre-construction	
The surrounding community is to be consulted with regards to the construction works, predicted program and any access requirements.	WSC
Best management construction impacts are to be documented in a project specific CEMP.	Contractor
Construction	
Areas disturbed during construction would be restored to their pre-construction condition.	Contractor
Operation	
An OEMP for the upgraded Bowral STP is to be developed and is to include specific measures to respond and investigate operational complaints.	WSC

6.2.2 Noise and Vibration

Objective

- Compliance with relevant recommendations specified in the Interim Construction Noise Guideline (DECC, 2009).
- Avoidance/minimisation of noise impacts on nearby sensitive noise receivers.

Actions

Action/Phase	Responsibility
Construction	
The Contractor would prepare a Noise and Vibration Management Plan (NVMP) as part of the CEMP. The NVMP would address site specific issues, taking into consideration EPA's Interim Construction Noise Guideline (in particular Tables 4 – 10) and Assessing Vibration: A Technical Guideline (in particular mitigation measures in Section 3).	Contractor
Works would be undertaken during normal work hours i.e. 7am to 6pm Monday to Friday; 8am to 1pm Saturdays. No work would be undertaken on Sundays, Public Holidays or outside these work hours without notification to affected community and EPA. Notification would provide the following details: - The locations and types of surrounding receivers likely to be affected; - The nature of the proposed works; - The noise characteristics of any powered equipment likely to be used; - Measures to be taken to reduce noise emissions; and - Any other information EPA may request.	Contractor
All reasonable practical steps shall be undertaken to reduce noise and vibration from the site.	Contractor
Community notification would be undertaken where work is likely to cause vibration or offensive noise to adjoining or nearby residents.	Contractor
Operation	
Operational noise emissions would be verified to demonstrate selected plant and equipment complies with NPfI requirements at the nearest sensitive receptor. This would be achieved through post-compliance monitoring to validate the noise emissions and to identify the need for additional mitigation measures.	Contractor
Council is to implement a community complaints management program, including complaints hotline and response management procedure.	WSC

6.2.3 Traffic and Access

Objective

- Ensure that construction vehicles do not cause excessive inconvenience to road and pedestrian users.
- Ensure the safety of road users and construction personnel for the duration of the works.
- Minimise the pollution impacts resulting from the use of vehicles during construction.

Actions

Action/Phase	Responsibility
Pre-construction	
Prior to the commencement of works, existing onsite access tracks that would be used by heavy vehicles would be assessed for adequacy and augmented where necessary. Appropriate drainage would be provided for any unsealed tracks utilised during the works to ensure that vehicle movements do not cause erosion and sedimentation of the nearby waterway.	WSC /Contractor
Prior to the commencement of works, the contractor would prepare a dilapidation report for Burradoo Road, the railway corridor crossing at Burradoo Station and the STP access road to identify areas of existing damage.	WSC /Contractor
Construction	
The contractor would prepare a Traffic Management Plan as part of the CEMP, to be reviewed by WSC prior to commencement of works. The Traffic Management Plan would include measures to minimise traffic impacts, avoid congestion in the vicinity of Burradoo railway Station, ensure public safety and would be prepared in accordance with: - *RTA's Traffic Control at Work Sites Manual, Issued July 2018, and* - *Australian Standard 1742.3 - 2009 Traffic Control for Works on Roads.*	Contractor
The contractor must liaise with ARTC in relation to accessing the railway corridor during the works and management measures for heavy vehicles crossings of the railway line must be included in the TMP.	Contractor
Any disturbance to landowners due to vehicle movements and noise would be minimised by adhering to the working hours outlined in Section 4.3.3.	Contractor
The contractor would ensure access to properties are not impacted.	Contractor
Any temporary access tracks required for the works would be located to minimise disturbance to the existing environment. Following completion of the works the temporary tracks would be removed, topsoil provided and re-grassed. Existing tracks would be restored to their condition prior to works.	Contractor

Action/Phase	Responsibility
Construction vehicles would comply with the speed limits set for the roads accessing the site.	Contractor
A dedicated vehicle wash down area would be established on site.	Contractor
All vehicles transporting spoil would be covered and filled to maximum capacity to minimise vehicle movements.	Contractor
All roads, kerbs, gutters and footpaths damaged as a result of construction are to be restored to their pre-construction condition.	Contractor
All sealed roads would be kept clean and free of dust and mud at all times. Where material is tracked onto sealed roads at any time, it would be removed immediately so that road pavements are kept safe and trafficable.	

6.2.4 Air Quality

Objective

- Avoidance/minimisation of off-site dust nuisance to neighbouring residences and the community.
- Minimisation of air quality impacts resulting from sewage treatment operation, machinery and vehicle emissions.

Actions

Action/Phase	Responsibility
Design	
Further reductions in the odour concentrations at the boundary could potentially be achieved through physical controls including tree breaks which may redirect wind flows, aid dispersion and remove dust.	WSC
Pre-construction	
Construction vehicles and equipment would be suitably serviced prior to commencement of construction activities and all necessary maintenance undertaken during the construction period to meet EPA air quality requirements.	Contractor
Construction	
The excessive use of vehicles and powered construction equipment would be avoided to minimise emissions.	Contractor
All construction machinery would be turned off when not in use to minimise emissions.	Contractor

Action/Phase	Responsibility
Construction contractors would monitor dust generation potential.	Contractor
Dust suppression methods including the use of water carts would be applied where required (i.e. on windy days when earthworks and vehicle movements are generating dust).	Contractor
Any stockpiled spoil/fill would be protected to minimise dust generation to avoid sediment moving offsite.	Contractor
Vehicles transporting spoil from the sites would be covered.	Contractor
Complaints monitoring is recommended whereby any complaint received during the construction works should be investigated as soon as possible so that effective appraisal of the complaint can be carried out by subjective assessment.	Contractor
Operation	
An Odour Management Plan (OMP) should be adopted for the Bowral STP as part of the OEMP. The OMP should outline the management structure and strategies for odour performance during the operation of the STP. The OMP should be developed as per the recommendations of the Odour Guideline and should include procedures for complaints registering and investigation.	WSC
The SDP will have efficient wash down water for cleaning after a storm event, significantly reducing odour.	WSC
Complaints monitoring is recommended whereby any complaint should be investigated as soon as possible so that effective appraisal of the complaint can be carried out by subjective assessment. Where odour complaints are verified, engineering, and operational or other odour reduction measures should be implemented.	WSC

6.2.5 Water Quality and Erosion and Sediment Control

Objective

- To effectively manage sediment and erosion control during the construction stage of the project.
- Prevention/minimisation of impacts to the waterways during the construction works.

Actions

Action/Phase	Responsibility
Pre-construction & Construction	
Where less than 3 ML of groundwater is extracted during the works. The volume of water extracted during should be recorded daily and an aquifer interference activity exemption should be lodged through DPIE - Water	Contractor

Action/Phase	Responsibility
(NRAR) by the construction contractor on behalf of the proponent on the completion of works (Further information is available at https://www.dpie.nsw.gov.au/nrar/how-to-apply/water-licences/Groundwater). If more than 3 ML of groundwater is anticipated to extracted during the works, an aquifer interference approval would be required from DPIE- Water prior to the commencement of works.	
A detailed Soil and Water Management Plan (SWMP) shall be prepared as part of the CEMP. The SWMP would describe the site-specific measures to be implemented for all works areas, in accordance with the guidelines outlined in the 2004 Landcom publication *Managing Urban Stormwater: Soils and Construction*, 4th edition ("The Blue Book") and *Volume 2a Installation of Services*. The SWMP would need to be site specific and would need to address the following issues to prevent erosion, sediment loss and water quality impacts: - Identification of site specific sediment and erosion control measures wherever erosion is likely to occur. - Identification of any environmentally sensitive areas on or near construction sites to ensure runoff is diverted away from sensitive areas. - Requirements for vegetation clearing to be kept to a minimum. - Retention of all surface runoff on-site and where possible stormwater from off site would be diverted around the construction site. - Backfilling and stabilising of trenches once pipelines or other underground services are installed. - Location of construction compounds (at least 50m from any the drainage line). - Location and management of stockpiles, such as locating stockpiles away from the drainage line near the works areas. - Regular inspection of all erosion and sediment controls, especially when rain is expected and directly after any rain events.	Contractor
All areas where ground disturbance has occurred would be stabilised following completion of works to ensure there is no erosion hazard and restored to their pre-construction condition. This would involve, where required, reshaping the ground surface, covering it with topsoil excavated from the site and re-establishing an appropriate vegetation cover.	Contractor
Any excess spoil would either be spread across the ground in nearby areas in such a manner as to avoid creating an erosion hazard or removed off site for disposal in accordance with relevant WSC and EES requirements.	Contractor

Action/Phase	Responsibility
The CEMP would incorporate a pollution incident response management plan that defines appropriate procedures for notification of pollution incidents to the required authorities in accordance with s. 147 to 153 of the POEO Act and requires response actions to be implemented in order to address any risks such as incidents posed to the environment, property or surrounding communities.	Contractor
Any disposal of wastewater or fluids generated as part of construction works would be undertaken in a manner that does not cause water pollution. The CEMP would document an appropriate offsite disposal facility for treatment and disposal.	Contractor
A site-specific spill management plan would be prepared and include the following requirements: - Emergency spill kits are to be kept at the site (vehicle kits). - Refueling of machinery to be undertaken in a dedicated area within the construction compound appropriately protected as outlined in the spill management plan. - Any chemicals and fuels are to be stored in a bunded area at least 50 metres from any drainage line. - Any hazardous materials stored on site would be stored in the compounds and within impervious and bunded enclosures capable of storing 110% of the volume of material stored there. - Workers would be trained in the spill management plan and the use of the spill kits.	Contractor
Mitigation measures to manage groundwater (which as indicated in the geotechnical investigations will be encountered during construction) would be incorporated into the CEMP, including: - Dewatering techniques during excavation; - Measures to ensure groundwater quality is not impacted during construction; - Techniques to settle, treat or filter groundwater encountered during excavation works i.e. diverting groundwater through baffle tanks or filter membranes; and appropriate treatment and monitoring regimes when groundwater flows come to the surface, including disposal of groundwater in such a way as to prevent adverse impacts (such as erosion and water pollution). Groundwater should not be discharged to a waterway during construction.	Contractor
Operation	

Action/Phase	Responsibility
The existing EPA licence is to be amended and the STP operated in accordance with EPA licence conditions. Monitoring of effluent discharge will be undertaken in accordance with the licence requirements.	WSC
Routine maintenance of the STP is to be undertaken in accordance with the Operations and Maintenance manual prepared for the plant.	WSC
The STP Operation Environmental Management Plan (OEMP) would be updated to detail appropriate actions in the event of equipment or power failure. The OEMP would be periodically reviewed to assess the efficacy of all management procedures. Identified shortcomings would be remedied to ensure these continue to be effective.	WSC
Appropriate signage is to be maintained where chemicals are stored.	WSC
The community would be notified of any incident with the potential to result in public health impacts.	WSC

6.2.6 Flora and Fauna

Objective

- Avoidance/minimisation of impacts to flora and fauna
- Minimise clearing of vegetation
- Avoid weed invasion

Actions

Action/Phase	Responsibility
Construction	
Appropriate hygiene strategies are to be identified and implemented during the construction phase of the development to minimise the infestation and spread of noxious weeds as a result of the works.	Contractor
Vegetation disturbance /clearing should be limited to those shown on plans and within the works footprint. No other vegetation is to be impacted by the works without further environmental assessment.	Contractor
Vehicles and machinery would utilise existing tracks and cleared areas where possible to access the site during construction.	Contractor
Operation	
Consideration should be given to a vegetation management plan (VMP) and associated works to improve the resilience and functioning of the Mittagong Rivulet riparian corridor.	WSC
The works area should be monitored for the spread of weeds.	WSC

6.2.7 Bushfire

Objective

- Minimise potential harm of a bushfire to people and property during construction and operation of the Bowral STP.

Actions

Action/Phase	Responsibility
Pre- Construction	
Design of the aboveground upgrade works at the STP should take into consideration the potential bushfire risk at the site, in accordance with the relevant principles of the RFS publication *Planning for Bushfire Protection 2019*.	WSC
Construction	
Construction staff to be made aware of the location of the proposed works in bushfire prone land and the potential for bushfire risk.	Contractor
No hot works to be undertaken on Total Fire Ban days.	Contractor
Operation	
Relevant District Brigades (Burradoo/Bowral) would be issued with key access to the STP site, to be used only in an emergency situation.	WSC

6.2.8 Waste Management

Objective

- Compliance the provisions of the Protection of the Environment Operations (Waste) Regulation 2014.
- Maximise reuse/recycling of waste material and minimise waste disposed of to landfill.

Actions

Action/Phase	Responsibility
Construction	
The contractor or Council is to carry out a contaminated soil test prior to construction. If the site is determined to be contaminated, a detailed site investigation would be required to determine if the site poses an unacceptable risk to human health or the environment. A remediation action plan may then be required following EPA NSW Guidelines including Guidelines for consultants reporting on contaminated sites and (EPA NSW 2011) Planning Guidelines SEPP 55 - Remediation of Land.	Contractor / WSC

Action/Phase	Responsibility
A Waste Management Plan (WMP) would be prepared as part of the CEMP by the construction contractor for the management of waste generated during construction works. The WMP must be prepared in accordance with the applicable waste management provisions of the *Protection of the Environment Operations Act 1997* and the *Protection of the Environment Operations (Regulation) 2014.* The WMP would follow the resource management hierarchy principles embodied in the *Waste Avoidance and Resource Recovery Act 2001* and the *NSW Government Resource Efficiency Policy 2014*. It would include, but not necessarily be limited to, the following: - Non-recyclable waste and containers would be regularly collected and disposed of at a licensed landfill or other disposal site in the area. Waste oil would be sent to approved recyclers. - The worksite would be left tidy and rubbish free each day prior to leaving site and at the completion of construction. - Transportation of waste must be done in a manner that avoids the waste spilling, leaking or otherwise escaping from the vehicle or plant used to transport the waste. Waste would be transported to a place that can lawfully receive that waste.	Contractor
No batched concrete mixing plants would be established in the works areas. Any required concrete would be mixed off-site and transported to the construction areas.	Contractor
Following completion of the works, excess concrete would be removed off-site for recycling.	Contractor
All waste removed from the site would be classified and disposed of appropriately, and all non-recyclable waste would be disposed of at an appropriate licensed waste disposal facility.	Contractor
If any contaminated material is encountered during earthworks, work shall cease, the site secured, and a safe work method statement(s) and appropriate practices implemented. Any contaminated material would be classified first and then stored, transported and disposed of in accordance with EPA requirements at an EPA licensed waste facility.	Contractor
If practicable, surplus excavated materials/fill would be reused onsite as part of rehabilitation and restoration works. Any surplus spoil disposed of in this manner would be seeded to minimise the likelihood of it being transported offsite through wind or water action.	Contractor
Test demolition waste that is to be reused as backfill onsite to ensure compliance with the relevant EPA Resource Recovery Order and Resource Recovery Exemption. Alternatively, dispose of the material to a licensed landfill in accordance with its waste classification.	WSC
Operation	

Action/Phase	Responsibility
Biosolids would be managed in accordance with a Biosolids Management Plan to be prepared for the augmented STP.	WSC
Biosolids management would be consistent with the EPA's *Environmental Guidelines: Use and Disposal of Biosolids Products* (EPA, 1997).	WSC
Land application of biosolids (if proposed) would be controlled to prevent any off-site migration.	WSC

6.2.9 Heritage

Objective

- Minimise potential impacts to items and places of historic and Aboriginal cultural heritage due to the works

Actions

Action/Phase	Responsibility
Construction	
As part of an induction, in the unlikely event that any historical relics or sites are identified workers should be aware of their responsibilities under the provisions of the *Heritage Act 1977*. In this event all works must cease and the area be protected until a qualified archaeologist inspects the site and provides management advice in consultation with Heritage NSW.	Contractor
As part of an induction, in the unlikely event that any unknown Aboriginal objects are uncovered during proposed works, all workers and sub-contractors should be aware of their responsibilities under the provisions of the NPW Act (including the penalties under the ancillary provisions) and *Heritage Act 1977*. In this event all works must cease and the area where Aboriginal objects are uncovered is protected until a qualified archaeologist and representatives of registered Aboriginal parties are contacted and can inspect and assess the area to determine its significance.	Contractor

6.2.10 Greenhouse gases

Objective

- Minimise greenhouse gases emissions associated with the proposed works

Action/Phase	Responsibility
Construction	
Burning matter of any kind would not be permitted on site.	Contractor

Action/Phase	Responsibility
Reduce the number of traffic movements required.	Contractor
Energy efficiency requirements would be included in the site environmental induction.	Contractor/WSC
Operation	
Energy efficient equipment or functions would be used where possible for the operation of the STP.	WSC
STP lighting to be minimised where possible.	WSC
STP equipment and machinery would be suitably serviced and maintained during the operation of the STP.	WSC

6.2.11 Chemical Management and Public Health

Objective

- Minimise public health risks due to use of chemicals and operation of the STP.

Actions

Action/Phase	Responsibility
Operation	
The STP is to operate in accordance with EPA licence conditions including any chemical storage limits or other requirements.	WSC
Routine maintenance of the STP is to be undertaken in accordance with the Operations and Maintenance manual prepared for the plant.	WSC
The transport and handling of any chemicals used in the operation of the STP would be undertaken in accordance with all relevant SafeWork NSW guidelines.	WSC
Notification to the EPA in accordance with Part 5.7 of the POEO Act is to be undertaken where a pollution incident occurs in the course of an activity so that material harm to the environment is caused or threatened.	WSC
Liquid chemical storage and filling areas would be located in bunded areas designed to accommodate 110% of the total capacity delivered and are to include appropriately designed drainage and safety equipment.	WSC

Action/Phase	Responsibility
Storage tanks would be regularly inspected and maintained to ensure their integrity. Plant personnel would be trained for proper and safe operation of these facilities.	WSC
Specific requirements for the management of chemicals associated with the STP would be detailed in the STP OEMP.	WSC
All hazardous substances are to be listed in a register together with the relevant Safety Data Sheets. Employees are to have access to this register at all times.	WSC
Fuel and lubricants for machinery maintenance are to be stored and managed appropriately.	WSC
Appropriate signage is to be maintained where chemicals are stored.	WSC
The community would be notified of any incident with the potential to result in public health impact.	WSC

6.2.12 Visual Amenity

Objective

- Protect the visual amenity of the locality for neighbouring land users and the local community.

Actions

Action/Phase	Responsibility
Construction	
Council would undertake landscaping following construction using native species endemic to the local area.	WSC

7.0 Conclusions

The upgrade of the Bowral STP is required to increase the plant's capacity during the peak loads period and improve effluent discharge quality, in compliance with EPA requirements. Wingecarribee Shire Council are proposing to upgrade the STP in stages to accommodate peak loads up to year 2046 to 21,000 EP and to overcome operational issues identified at the plant.

The proposed works would involve new inlet works, new pump stations, new storm detention pond, two new bioreactors, new clarifiers, new emergency storage tank, tertiary filters, upgrade of the UV disinfection system, aerobic digester, dewatering facilities, chemical dosing facilities and reclaimed effluent on site reuse system. The upgrade would provide improved STP treatment infrastructure to ensure that the EPA's requirements for treated effluent discharge, noise and odour are met.

Whilst a number of short term impacts associated with the construction of the proposed STP upgrade works such as noise, dust, traffic and hazardous materials/waste management are predicted, it has been assessed that these can be adequately managed through the implementation of appropriate mitigation measures

The operation of the upgraded plant would ensure that the treatment capacity is sufficient for present and future peak loads while producing effluent that meets the EPA's discharge requirements.

Pursuant to the provisions of the *Environmental Planning and Assessment Act 1979*, and *Environmental Planning and Assessment Regulation 2000*, an environmental assessment of the proposed Bowral STP Upgrade has been undertaken. Consideration has been given to the likely impact of the activity on the environment, having regard to all relevant factors. On the basis of the information presented in this REF it is concluded that by adopting the safeguards identified in this assessment it is unlikely that there would be significant adverse environmental impacts associated with the proposed works.

8.0 References

DECC (2009) *Interim Construction Noise Guidelines*

DECCW (2009) *Waste Classification Guidelines – Part 1 Classifying Waste*

DECCW (2010) *Due Diligence Code of Practice for the Protection of Aboriginal Objects* in NSW

Department of Planning (2010) *NSW Best Practice Odour Guideline - Sewerage systems including sewage treatment plants, water recycling facilities, sewage reticulation systems and sewer mining*

D & N Geotechnical (2021) *Bowral Sewage Treatment Plant Geotechnical Investigation Report.*

Environment Protection Authority (1997) *Environmental Guidelines: Use and Disposal of Biosolids Products (reprinted, 2000)*

Environment Protection Authority (2017) *Noise Policy for Industry*

HunterH$_2$0 (2021) *Bowral Sewage Treatment Plant Upgrade Detailed Design Report*

Landcom (2004) *Managing Urban Stormwater: Soils and Construction, 4th Edition (The Blue Book)*

Manly Hydraulics Laboratory (2021) *Discharge Impact Assessment for the Bowral Sewerage Scheme.*

Public Works Advisory (formerly NSW Department of Commerce) (2008*)* *Assessment of Proposed Sewage Treatment Upgrade Projects within the Sydney Catchment*. Report No. WS070015

Public Works Advisory (2018) *Wingecarribee Shire Council Integrated Water Cycle Management Options Review Paper*

Public Works Advisory (2018b) *Bowral Sewage Treatment Plant Geotechnical Investigation Report* .

Public Works Advisory (2019) *Bowral Sewage Treatment Plant (STP) Upgrade Concept Design Report*

SLR Consulting (2021) *Bowral Sewage Treatment Plant Upgrade - Odour Impact Assessment*

Sydney Water Monitoring Services (2021) *MHL – Southern Highlands Interim Biological Monitoring Report Bowral STP*

Appendix A – Consideration of Clause 228

Clause 228 of the EP&A Regulation 2000 stipulates, for purposes of Part 5 of the Act, the factors that must be taken into account when consideration is being given to the likely impact of an activity on the environment.

A determining authority is only required to consider the following matters where an EIS has been prepared for a Part 5 activity under the EP&A Act. However, the following information is provided to assist determining authorities in making determinations consistent with those made for an activity requiring preparation of an EIS.

The various factors and findings following environmental assessment are presented below.

***(a) any environmental impact on a* community**

There is the potential for some temporary noise, visual, and local traffic impacts during the construction works. Mitigation measures would be implemented to minimise these impacts.

Positive impact to the community is predicted post construction with the improved sewerage service.

(b) any transformation of a locality

The works would be constructed on the site of the existing plant. All disturbance to ground surfaces during construction would be rehabilitated post construction.

(c) any environmental impact on the ecosystems of the locality

The proposal would have minimal impact on the ecosystems of the locality.

(d) any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality

No impacts identified.

(e) any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations

No impacts identified.

(f) any impact on the habitat of protected animals (within the meaning of the Biodiversity Conservation Act 2016)

The proposal would have minimal impact on habitat of protected fauna within the meaning of the *Biodiversity Conservation Act 2016)*

(g) any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air

The proposed activity would not have any significant impact on any animal, plant or other form of life listed under the *Biodiversity Conservation Act 2016* or the E*nvironment Protection and Biodiversity Act 1999*, given the proper implementation of mitigation measure provided in Section 5.8.3.

(h) any long-term effects on the environment

Potential positive long term effect on the environment through improved sewage treatment and discharge of consistently high quality treated effluent in accordance with EPA licence conditions and consideration of NorBE requirements.

(i) any degradation of the quality of the environment

Temporary degradation may occur during construction due to the construction works. The quality of effluent discharge into the environment will be more consistent.

(j) any risk to the safety of the environment

No impacts anticipated

(k) any reduction in the range of beneficial uses of the environment,

No impacts anticipated

(l) any pollution of the environment,

The reliability of the quality of discharges would be more consistent when compared to the existing situation. The discharges would continue to meet EPA licence conditions.

(m) any environmental problems associated with the disposal of waste

Safeguards would be implemented to prevent any impacts associated with the handling and disposal of waste materials.

(n) any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply

None identified.

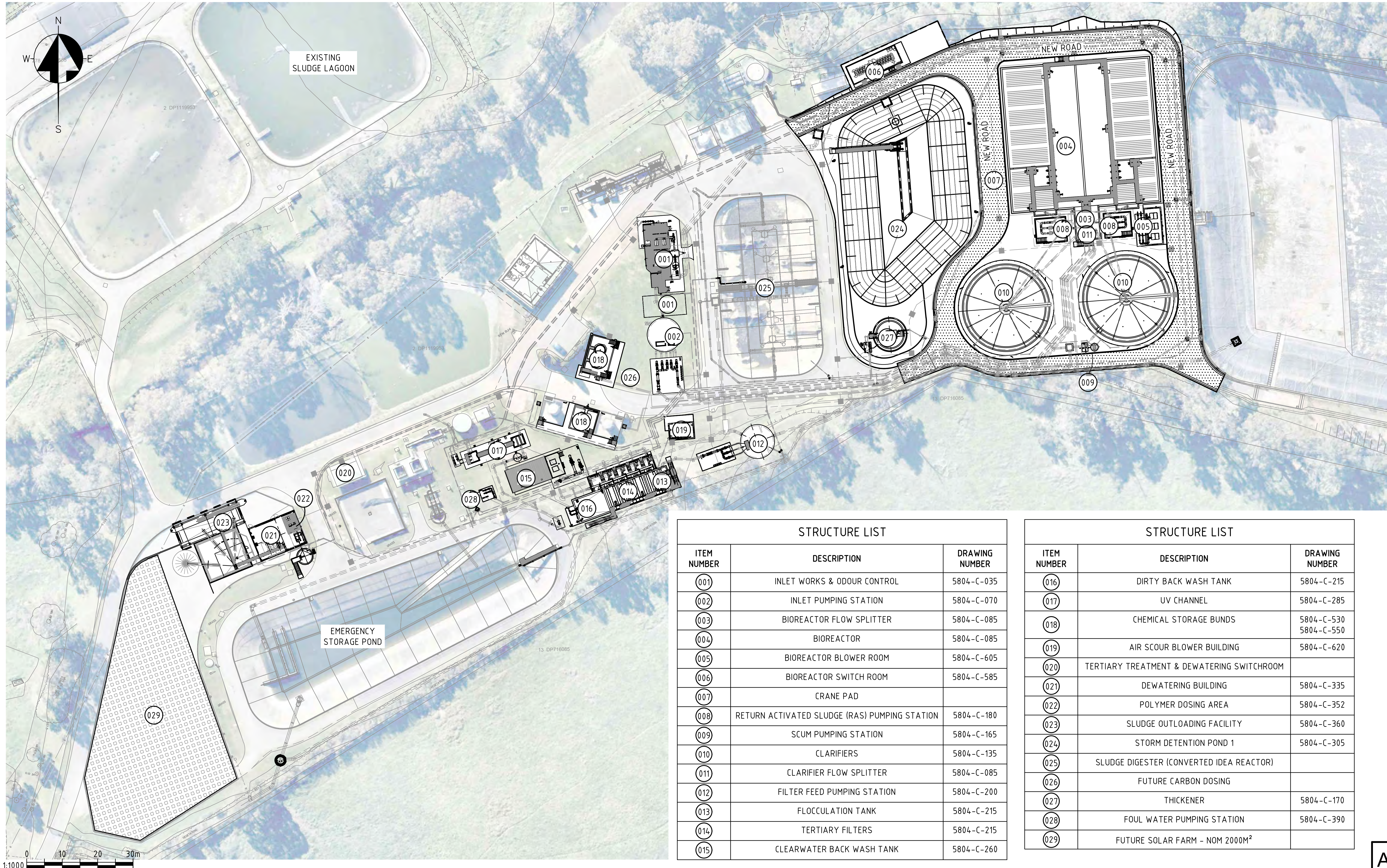
(o) any cumulative environmental effect with other existing or likely future activities

The proposal has been designed in consideration of population projections for the Bowral and Burradoo areas.

(p) any impact on coastal processes and coastal hazards, including those under projected climate change conditions.

None identified.

Appendix B – Plans



STRUCTURE LIST

ITEM NUMBER	DESCRIPTION	DRAWING NUMBER
001	INLET WORKS & ODOUR CONTROL	5804-C-035
002	INLET PUMPING STATION	5804-C-070
003	BIOREACTOR FLOW SPLITTER	5804-C-085
004	BIOREACTOR	5804-C-085
005	BIOREACTOR BLOWER ROOM	5804-C-605
006	BIOREACTOR SWITCH ROOM	5804-C-585
007	CRANE PAD	
008	RETURN ACTIVATED SLUDGE (RAS) PUMPING STATION	5804-C-180
009	SCUM PUMPING STATION	5804-C-165
010	CLARIFIERS	5804-C-135
011	CLARIFIER FLOW SPLITTER	5804-C-085
012	FILTER FEED PUMPING STATION	5804-C-200
013	FLOCCULATION TANK	5804-C-215
014	TERTIARY FILTERS	5804-C-215
015	CLEARWATER BACK WASH TANK	5804-C-260

STRUCTURE LIST

ITEM NUMBER	DESCRIPTION	DRAWING NUMBER
016	DIRTY BACK WASH TANK	5804-C-215
017	UV CHANNEL	5804-C-285
018	CHEMICAL STORAGE BUNDS	5804-C-530 5804-C-550
019	AIR SCOUR BLOWER BUILDING	5804-C-620
020	TERTIARY TREATMENT & DEWATERING SWITCHROOM	
021	DEWATERING BUILDING	5804-C-335
022	POLYMER DOSING AREA	5804-C-352
023	SLUDGE OUTLOADING FACILITY	5804-C-360
024	STORM DETENTION POND 1	5804-C-305
025	SLUDGE DIGESTER (CONVERTED IDEA REACTOR)	
026	FUTURE CARBON DOSING	
027	THICKENER	5804-C-170
028	FOUL WATER PUMPING STATION	5804-C-390
029	FUTURE SOLAR FARM - NOM 2000M²	

A3

AMENDMENTS

Ver	Date	Description	Drawn
D	06/08/21	TENDER ISSUE	TJS
C	04/06/21	PRELIMINARY	TJS
B	26/03/21	PRELIMINARY	TJS
A	26/02/21	PRELIMINARY	TJS

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Drawn CT | Checked
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HORIZONTAL
Co-ordinate System -
BM Adopted -
East - North -

VERTICAL
Datum -
BM Adopted -
Reduced Level -

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE

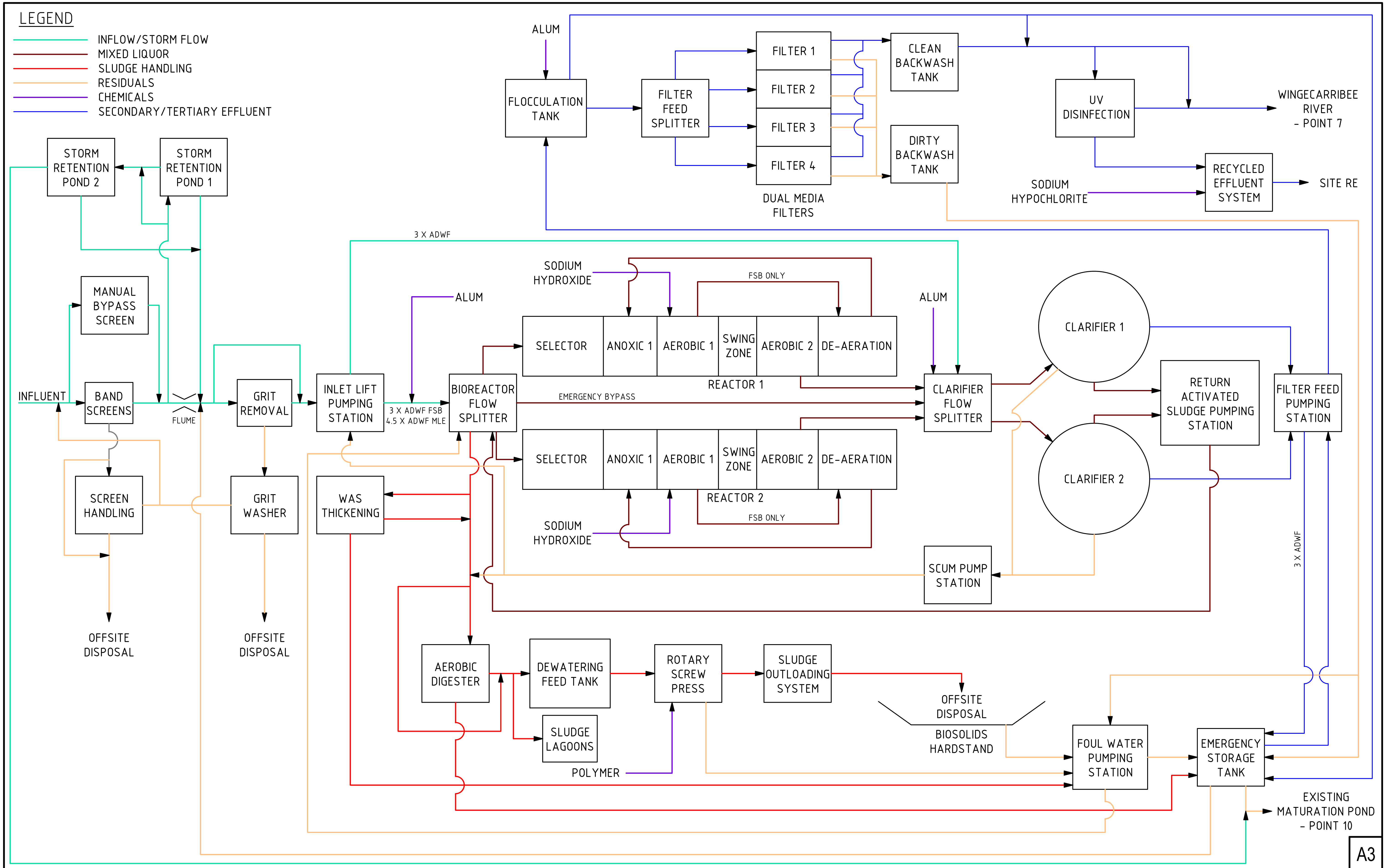
SITE ARRANGEMENT

Scale 1:1000 at A3

Document No 5804- C - 010

Status **PRELIMINARY**

Version D



AMENDMENTS

Ver	Date	Description	Drawn
C	21/09/21	REVISED TENDER ISSUE	RR
B	10/08/21	TENDER	RR
A	01/09/20	DRAFT	MA

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Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
PROCESS FLOW DIAGRAM

Scale: N.T.S. at A3	Document No: **5804- P - 006**
Status: **TENDER**	Version: **C**

Plot Date: 21/09/21 - 20:19 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-006 - PROCESS FLOW DIAGRAM.dwg

Appendix C – Consultation Responses

NSW GOVERNMENT | Department of Primary Industries

Our Ref: C18/456

5 November 2018

Kristen Parmeter
Environmental Scientist
NSW Public Works
Level 14 – McKell Building
2-24 Rawson Place
SYDNEY NSW 2000

Dear Ms Parmeter

Subject: Bowral Sewage Scheme Upgrade – Review of Environmental Factors

Thank you for your letter dated 25 September 2018 seeking comment on the above proposed works from DPI Fisheries, a division of NSW Department of Primary Industries.

DPI Fisheries is responsible for ensuring that fish stocks are conserved and that there is no net loss of key fish habitats upon which they depend. To achieve this, DPI Fisheries ensures that developments comply with the requirements of the ***Fisheries Management Act 1994*** (namely the aquatic habitat protection and threatened species conservation provisions in Parts 7 and 7A of the Act, respectively), and the associated ***Policy and Guidelines for Aquatic Habitat Management and Fish Conservation (1999)***. In addition, DPI Fisheries is responsible for ensuring the sustainable management of commercial, recreational and Aboriginal cultural fishing, aquaculture and marine protected areas within NSW.

Initial Comments

DPI Fisheries welcomes the proposed upgrade to improve the quality of water currently being discharged from the Sewage Treatment Plant. The Department also encourages improvements in sustainable and efficient use of water resources and ask that the REF explores the options for increasing the beneficial reuse of the treated effluent (eg: for irrigation, playing fields, etc) with an aim to achieve a reduction in the discharge of reclaimed water to the surrounding waterways.

As the plant upgrade is designed for increased volumes and discharge over time, the REF will need to consider the impacts on the aquatic environment both at outfall and downstream impacts. A water quality monitoring program should be designed and implemented to demonstrate that the NorBe water quality objective is being met following the upgrade works.

Environmental Assessment Requirements

DPI Fisheries advises that the REF for the proposed development should include information on the following:

- Location of works (including topographic map and photos).
- Name of adjacent waterway(s).
- Description of works to be undertaken.
- Investigations into the options for the reduction in volume of discharge, including beneficial reuse of the treated effluent
- Description and condition of aquatic habitats (watercourses, wetlands) located on the site and downstream of the site in Mittagong Creek. In particular, description of the aquatic and riparian habitat conditions at and adjacent to proposed STP site and waterway discharge site – particularly extent and condition of riparian vegetation, water depth, and permanence of water flow and snags (large woody debris).
- Analysis of any interactions of the proposed works with aquatic and riparian environments. In particular details of any impacts on aquatic habitats and riparian areas associated with pipeline crossings of waterways and proposed construction methods.
- Safeguards to mitigate any impacts upon aquatic environments and riparian habitats.
- Potential impacts on any aquatic threatened species, populations and ecological communities listed under the ***Fisheries Management Act 1994*** and safeguards to mitigate any potential impacts***.***
- Safeguards to mitigate any impacts upon water quality (including impacts downstream in Mittagong Creek and on any aquatic threatened species, populations and ecological communities. This should include details of proposed storage of excess inflows of untreated effluent, provisions for power and equipment failures and treatment of effluent, proposed erosion and sediment controls for works, and details of proposed baseline, outfall and downstream water quality monitoring following any discharges of treated and untreated effluent. Monitoring of water discharges should include sampling of estrogen, as there is increasing evidence that estrogen adversely affects the health of fish.
- Details of proposed revegetation of adjacent riparian buffer areas.

Once the REF has been prepared for the proposal could you please forward a copy to this office for our review and further comment.

DPI Fisheries Approvals

<u>Dredging and reclamation</u>. Any dredging or reclamation in a waterway (below the high bank) (e.g. pipeline crossings) will require approval from DPI Fisheries. If the works are authorised by a public authority (e.g. NSW Public Works), the public authority is required under section 199 of the ***Fisheries Management Act 1994*** to consult with DPI Fisheries and take into account any issues raised prior to approving the dredging/excavation and reclamation works in a waterway.

<u>Removal or movement of Large Woody Debris (snags) or boulders</u>. Works that involve removal or movement of large woody debris or snags require approval from DPI Fisheries. Because of its significance as fish habitat, the removal of large woody debris from NSW rivers and streams has been listed as a Key Threatening Process for several threatened fish species under Schedule 6 of the ***Fisheries Management Act***.

For further detailed advice on DPI Fisheries aquatic habitat requirements, please refer to the Department's Policy and Guidelines for Fish Habitat Conservation and Management (2013 Update) available on our website www.dpi.nsw.gov.au.

If you require any further information, please do not hesitate to contact me on

Yours sincerely

Jillian Reynolds
Fisheries Manager
Coastal Systems - South

NSW Department of Primary Industries | 4 Woollamia Road | T: (02) 4428 3400
DPI Fisheries | PO Box 97 | F: (02) 4441 8961
Aquatic Ecosystems | Huskisson NSW 2540 | www.dpi.nsw.gov.au/fisheries

Office of Environment & Heritage

NSW GOVERNMENT

Date:	2 October 2018
Your reference:	Bowral STP
Our reference:	DOC18/733625
Contact:	Calvin Houlison 4224 4179

Kristen Parmeter
Environment Scientist
Public Works Advisory
PO Box N408
Grosvenor Place NSW 1220
E-mail: kristen.parmeter@finance.nsw.gov.au

Dear Ms Parmeter

RE: Bowral Sewage Treatment Plant Augmentation Review of Environmental Factors (REF)

Thank you for referring the abovementioned proposal for proposed augmentation works to the Bowral sewage treatment plant (STP) at Burradoo Road, Bowral. We understand the proposal is permissible without consent under the State Environmental Planning Policy (Infrastructure) 2007 as a Part 5 activity, and that our assessment requirements for the Review of Environmental Factors (REF) are sought.

In summary, we suggest the REF include an assessment of the potential impacts on biodiversity, including threatened species, populations, ecological communities, or their habitats likely to occur on or near the subject site. There are recorded individuals of Paddys River Box (*Eucalyptus macarthurii*) trees, listed as endangered under the NSW Biodiversity Conservation (BC) Act 2016 and Commonwealth Environment Protection & Biodiversity Conservation (EPBC) Act 1999, on the subject site adjacent to the existing detention ponds.

There are mapped areas of Southern Highlands Shale Woodland (SHSW) ecological community, listed as endangered under the NSW Biodiversity Conservation (BC) Act 2016 and critically endangered under the Commonwealth Environment Protection & Biodiversity Conservation (EPBC) Act 1999, immediately north of the subject site. SHSW may also occur on site, as the extent of the EEC may not be wholly evident from the mapping.

The Mittagong Creek watercourse is also identified on the Biodiversity Values Map supporting the BC Act 2016. As such, you may also wish to consider a vegetation management plan (VMP) and associated works to improve the resilience and functioning of the Mittagong Creek riparian corridor. We note that a Biodiversity Development Assessment Report (BDAR) and biodiversity offsets are not required for Part 5 activities under Section 7.8 of the BC Act, unless there is likely to be a significant impact on threatened species and you elect not to prepare a Species Impact Statement (SIS). If a BDAR or SIS is not required, we recommend that you consider measures to offset any impacts on biodiversity.

An assessment of impacts on Aboriginal cultural heritage values should also be undertaken. If Aboriginal objects are to be harmed, including any archaeological test excavation required as part of this assessment, an Aboriginal Heritage Impact Permit (AHIP) under the National Parks & Wildlife Act 1974. Although there are no identified Aboriginal objects on AHIMS within the site or immediate surrounds, the site location of the STP adjacent to the riparian corridor is of particular sensitivity for Aboriginal cultural values.

Finally, we recommend that Wingecarribee Shire Council be consulted with regard to floodplain risk management as the approval authority and custodian of the most up-to-date flood information, namely the Burradoo BU2 Flood Risk Management Plan. The REF assessment should ensure that the design implications of flood events greater than the 1% Annual Exceedance Probability (AEP) and up to the probable maximum flood (PMF) are considered. This is to ensure that operation of the STP during flood events is not compromised, so that inundation of critical components does not lead to failure and longer term shutdowns.

Our suggested requirements for Aboriginal cultural heritage, flooding and biodiversity are detailed at Attachment A.

Please contact me on 4224 4179 or via e-mail calvin.houlison@environment.nsw.gov.au should you have any further queries.

Yours sincerely

CALVIN HOULISON
A/ Senior Team Leader
Planning (Illawarra), South East Branch
Conservation & Regional Delivery

Attachment A: OEH suggested assessment requirements for Bowral STP augmentation works REF
Attachment B: Relevant guidance material

ATTACHMENT A: OEH SUGGESTED ASSESSMENT REQUIREMENTS FOR BOWRAL SEWAGE TREATMENT PLANT AUGMENTATION WORKS REVIEW OF ENVIRONMENTAL FACTORS

1. Aboriginal Cultural Heritage

The REF should contain:

1. A description of the Aboriginal objects and declared Aboriginal places located within the area of the proposal.
2. A description of the cultural heritage values, including the significance of the Aboriginal objects and declared Aboriginal places, that exist across the whole area that will be affected by the proposal, and the significance of these values for the Aboriginal people who have a cultural association with the land.
3. A description of any consultation with Aboriginal people regarding the proposal and the significance of any Aboriginal cultural heritage values identified through that consultation. The OEH advises that the proponent may utilise the OEH's *Aboriginal Consultation Requirements for Proponents 2010* as best practice guidelines for such consultation (these OEH requirements for consultation must be followed if the proposal requires an Aboriginal Heritage Impact Permit or the Aboriginal heritage assessment requires archaeological testing).
4. The views of those Aboriginal people regarding the likely impact of the proposal on their cultural heritage. If any submissions have been received as a part of the consultation requirements, then the report must include a copy of each submission and your response.
5. A description of the actual or likely harm posed to the Aboriginal objects or declared Aboriginal places from the proposal, with reference to the cultural heritage values identified.
6. A description of any practical measures that may be taken to protect and conserve those Aboriginal objects or declared Aboriginal places.
7. A description of any practical measures that may be taken to avoid or mitigate any actual or likely harm, alternatives to harm or, if this is not possible, to manage (minimise) harm.

In addressing these requirements, the proponent must refer to the following documents:

a) *Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW* (OEH, 2010) - www.environment.nsw.gov.au/resources/cultureheritage/ddcop/10798ddcop.pdf. These guidelines identify a process that could be used to prepare Aboriginal cultural heritage assessments for activities assessed under Part 5 of the *Environmental Planning and Assessment Act 1979*.

b) *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (OEH, 2010) - www.environment.nsw.gov.au/licences/consultation.htm. This document further explains the consultation requirements that are set out in clause 80C of the National Parks and Wildlife Regulation 2009. The process set out in this document must be followed and documented in the REF if the proposal requires an Aboriginal Heritage Impact Permit or the Aboriginal heritage assessment requires archaeological testing.

c) *Code of Practice for the Archaeological Investigation of Aboriginal Objects in New South Wales* (OEH, 2010) - www.environment.nsw.gov.au/licences/archinvestigations.htm. The process described in this Code should be followed and documented where the assessment of Aboriginal cultural heritage requires a archaeological testing to be undertaken.

Notes:

- An Aboriginal Site Impact Recording Form (http://www.environment.nsw.gov.au/licences/DECCAHIMSSiteRecordingForm.htm) must be completed and submitted to the Aboriginal Heritage Information Management System (AHIMS) Registrar, for each AHIMS site that is harmed through archaeological investigations required or permitted through these environmental assessment requirements.
- Under Section 89A of the *National Parks and Wildlife Act* 1974, it is an offence for a person not to notify OEH of the location of any Aboriginal object the person becomes aware of, not already recorded on the Aboriginal Heritage Information Management System (AHIMS). An AHIMS Site Recording Form should be completed and submitted to the AHIMS Registrar (http://www.environment.nsw.gov.au/contact/AHIMSRegistrar.htm), for each Aboriginal site found during investigations.

2. Flooding

The REF should include an assessment of the following referring to the relevant guidelines in Attachment 2:

1. Whether the proposal is consistent with the Burradoo BU2 floodplain risk management plan.
2. Whether the proposal is compatible with the flood hazard of the land.
3. Whether the proposal will significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties.
4. Whether the proposal will significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.
5. Whether the proposal incorporates appropriate measures to manage risk to life from flood.
6. Whether the proposal is likely to result in unsustainable social and economic costs to the community as a consequence of flooding.
7. The implications of flooding over the full range of potential flooding, including the probable maximum flood, should be considered as set out in the NSW Government Floodplain Development Manual. This should include the provision of:
    a. Full details of the flood assessment and modelling undertaken in determining any design flood levels (if applicable), including the 1 in 100 year flood levels.
    b. A sensitivity assessment of the potential impacts of an increase in rainfall intensity and runoff (10%, 20% and 30%) and sea level rise on the flood behaviour for the 1 in 100 year design flood if applicable.
8. All site drainage, stormwater quality devices and erosion / sedimentation control measures should be identified and the onsite treatment of stormwater and effluent runoff and predicted stormwater discharge quality from the proposal should be detailed.

3. Biodiversity

The REF should include a detailed biodiversity assessment, including assessment of impacts on threatened biodiversity, native vegetation and habitat. The REF must assess the impact of the proposed activity on biodiversity values to determine if the proposed development is “likely to significantly affect threatened species” for the purposes of the Biodiversity Conservation Act 2016 (in particular Sections 7.2, 7.3 and 7.8) (BC Act), as follows:

a. The REF must determine whether the proposed activity is likely to have a significant impact based on ‘*the test for determining whether proposed development likely to significant affect threatened species or ecological communities’* in Section 7.3 of the BC Act and supporting Threatened Species Test of Significance Guidelines (OEH, 2018).

b. Where there is reasonable doubt regarding potential impacts, or where information is not available, then a significant impact upon biodiversity should be considered likely when applying the test in Section 7.3 of the BC Act. Where it is concluded that there is no significant impact, the REF must justify how the conclusion has been reached.

Activity resulting in a significant impact

Where the activity is considered “likely to significantly affect threatened species” under Section 7.8 of the BC Act, a species impact statement is required unless the proponent elects to prepare a BDAR.

If an SIS is prepared, the following requirements will apply:

- The proposed SIS must be set out in accordance with the requirements as set out in Clause 7.6 of the Biodiversity Conservation Regulation 2017.
- The proponent must also seek and comply with the Office of Environment and Heritage Chief Executive’s requirements for SIS preparation.

If a BDAR is prepared, the following requirements will apply:

- Biodiversity impacts related to the proposal are to be assessed in accordance with the Biodiversity Assessment Method and documented in a Biodiversity Development Assessment Report (BDAR). The BDAR must include information in the form detailed in the *Biodiversity Conservation Act 2016* (s6.12), Biodiversity Conservation Regulation 2017 (s6.8) and the BAM.
- The BDAR must document the application of the avoid, minimise and offset hierarchy including assessing all direct, indirect and prescribed impacts in accordance with the Biodiversity Assessment Method.
- The BDAR must include details of the measures proposed to address the offset obligation as follows:
  - The total number and classes of biodiversity credits required to be retired for the proposal.
  - The number and classes of like-for-like biodiversity credits proposed to be retired.
  - The number and classes of biodiversity credits proposed to be retired in accordance with the variation rules.
  - Any proposal to fund a biodiversity conservation action.
  - Any proposal to make a payment to the Biodiversity Conservation Fund.
- If seeking approval to use the variation rules, the BDAR must contain details of the reasonable steps that have been taken to obtain requisite like-for-like biodiversity credits.

The BDAR must be prepared by a person accredited to apply the Biodiversity Assessment Method under s6.10 of the *Biodiversity Conservation Act 2016*.

Activity not resulting in a significant impact

Where a threatened species assessment is prepared to support a conclusion of “no significant impact” under Section 7.8 of the BC Act, the REF must include a field survey of the site, conducted and documented in accordance with the relevant guidelines. including:

- Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna – Amphibians (DECCW, 2009)
- Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities - Working Draft (DEC, 2004)
- Threatened Species Test of Significance Guidelines (OEH, 2018)

The approach should also reference the field survey methods and assessment information on the OEH website including the Bionet Atlas, Threatened Species Profile and Bionet Vegetation Classification (see Attachment 2).

The proposal must be designed to avoid and minimise impacts on biodiversity to the fullest extent possible and offset remaining direct and indirect biodiversity impacts. Where impacts cannot be avoided, measures to offset impacts should be considered.

Commonwealth Matters of National Environmental Significance

For the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999,* the REF should identify any relevant Matters of National Environmental Significance (MNES) and whether the proposal has been referred to the Commonwealth or already determined to be a controlled action.

ATTACHMENT B: RELEVANT GUIDANCE MATERIAL

Title	*Web address*
Relevant Legislation	
Commonwealth Environment Protection and Biodiversity Conservation Act 1999	http://www.austlii.edu.au/au/legis/cth/consol_act/epabca1999588/
Floodplain Development Manual	http://www.environment.nsw.gov.au/floodplains/manual.htm
Environmental Planning and Assessment Act 1979	http://www.legislation.nsw.gov.au/maintop/view/inforce/act+203+1979+cd+0+N
Fisheries Management Act 1994	http://www.legislation.nsw.gov.au/maintop/view/inforce/act+38+1994+cd+0+N
Marine Parks Act 1997	http://www.legislation.nsw.gov.au/maintop/view/inforce/act+64+1997+cd+0+N
National Parks and Wildlife Act 1974	http://www.legislation.nsw.gov.au/maintop/view/inforce/act+80+1974+cd+0+N
Protection of the Environment Operations Act 1997	http://www.legislation.nsw.gov.au/maintop/view/inforce/act+156+1997+cd+0+N
Biodiversity Conservation Act 2016	https://www.legislation.nsw.gov.au/~/view/act/2016/63
Biodiversity Conservation Regulation 2017	https://www.legislation.nsw.gov.au/~/view/regulation/2017/432
Biodiversity Conservation (Savings and Transitional) Regulation 2017	https://www.legislation.nsw.gov.au/~/view/regulation/2017/433
Water Management Act 2000	http://www.legislation.nsw.gov.au/maintop/view/inforce/act+92+2000+cd+0+N
Aboriginal Cultural Heritage	
Aboriginal Cultural Heritage Consultation Requirements for Proponents (DECCW, 2010)	http://www.environment.nsw.gov.au/licences/consultation.htm
Code of Practice for the Archaeological Investigation of Aboriginal Objects in New South Wales (DECCW, 2010)	http://www.environment.nsw.gov.au/licences/archinvestigations.htm
Aboriginal Site Impact Recording Form	http://www.environment.nsw.gov.au/licences/DECCAHIMSSiteRecordingForm.htm
Aboriginal Heritage Information Management System (AHIMS) Registrar	http://www.environment.nsw.gov.au/contact/AHIMSRegistrar.htm
Biodiversity	
Biodiversity Assessment Method (OEH 2017)	http://www.environment.nsw.gov.au/resources/bcact/biodiversity-assessment-method-170206.pdf
Biodiversity Assessment Calculator	https://www.lmbc.nsw.gov.au/bamcalc

Threatened Species Test of Significance Guidelines (OEH, 2018)	https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Threatened-species/threatened-species-test-significance-guidelines-170634.pdf
Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna -Amphibians (DECCW, 2009)	http://www.environment.nsw.gov.au/resources/threatenedspecies/09213amphibians.pdf
Field Survey Methods	http://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/about-threatened-species/surveys-and-assessments/field-survey-methods
Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft (DEC, 2004)	http://www.environment.nsw.gov.au/resources/nature/TBSAGuidelinesDraft.pdf
OEH Threatened Species website	http://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species
Atlas of NSW Wildlife	http://www.environment.nsw.gov.au/wildlifeatlas/about.htm
BioNet Vegetation Classification (NSW Vegetation Classification System)	http://www.environment.nsw.gov.au/research/Visclassification.htm
PlantNET	http://plantnet.rbgsyd.nsw.gov.au/
Online Zoological Collections of Australian Museums	http://www.ozcam.org/
Principles for the use of biodiversity offsets in NSW	http://www.environment.nsw.gov.au/biodivoffsets/oehoffsetprincip.htm

Flooding and Coastal Erosion

Floodplain development manual	https://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-manual
Climate Change Impacts and Risk Management	http://www.environment.gov.au/climate-change

DOC18/709414-01

Ms Kristen Parmeter
Public Works Advisory
PO Box N408
GROSVENOR PLACE NSW 1220

Email: kristen.parmeter@finance.nsw.gov.au

Dear Ms Parmenter

Request for Environmental Requirements for Amplification of Bowral Sewage Treatment Plant

The Environment Protection Authority (EPA) refers to Public Works Advisory's (PWA) letter dated 21 September 2018 concerning the proposed amplification of Bowral Sewage Treatment Plant (STP). The letter contains a list of improvements to be made to the STP to cater for increasing population growth in the Bowral area. PWA has requested that the EPA provide Environmental Assessment Requirements for a Review of Environmental Factors (REF) for the project. The REF is being undertaken on behalf of Wingecarribee Shire Council (WSC) who is the project's proponent.

The EPA has provided WSC with its Environmental Assessment requirements in a letter dated 19 September 2018 (EPA Ref: DOC18/597501). A copy of the letter is attached for your reference.

In relation to the proposed works in PWA's letter, the EPA expects that if implemented, there will be some improvement in the quality of effluent and downstream water quality in the Wingecarribee River. However, no mention is made of how the proposed technology and process modifications have been chosen to deliver the water quality needed to meet downstream uses and protection of aquatic ecosystems. This question should be fully addressed in the Environmental Assessment of the project.

The EPA refers you to its letter of 19 September 2018 where consideration of environmental values under the ANZECC National Water Quality Guidelines (and NORBE considerations) is discussed in detail. The NSW Government has adopted the approach outlined in the ANZECC guidelines to maintaining and improving water quality, and to give guidance on the level of assessment needed to determine ambient water quality and river health.

PWA's letter also states that: *"The works are permissible without consent under State Environmental Planning Policy (Infrastructure) 2007 and therefore a REF is being prepared in accordance with the provisions of Part 5 of the Environmental Planning and Assessment Act 1979 and clause 228 of the Environmental Planning and Assessment Regulation 2000. WSC would be the determining authority for the proposal."*

Under Part 5 of the EP&A Act, WSC would be a determining authority for the proposal. The EPA has a role as an approval authority through the necessary modification of the Environment Protection Licence 1749 to allow the works to become operational.

Given the importance, complexity, likely high levels of community interest (both local and consumers of SWC drinking water), cost and long-term nature of the works, the EPA encourages public consultation on the project.

If you have questions regarding the above, please phone Andrew Couldridge on (02) 4224 4100.

Yours sincerely

31/10/18

PETER BLOEM
Manager Regional Operations Illawarra
<u>Environment Protection Authority</u>

Attachment: DOC18/597501

NSW EPA

DOC18/597501

Mr Barry Paul
Wingecarribee Shire Council
PO Box 141
MOSS VALE NSW 2577

Dear Mr Paul

Environmental Assessment Requirements and Draft Pollution Reduction Programs for Upgrade of Moss Vale and Bowral Sewage Treatment Plants

The Environment Protection Authority (EPA) refers to the meeting held between Wingecarribee Shire Council (WSC), WaterNSW and the EPA at Moss Vale on 31 July 2018.

The meeting was held for Council to provide an update on the program for upgrade of Bowral, Moss Vale and Mittagong Sewage Treatment Plants (STPs).

Stace Lewer (Manager Assets, WSC) gave a presentation on the planning process for upgrade of the STPs. He said that WSC is currently undertaking an application process for Section 60 approval under the *Local Government Act 1993*. This is a 3 step process and involves an Options Study, Concept Design & Environmental Impact Assessment, and a Detailed Design for upgrade of the STPs.

Moss Vale and Mittagong STPs are in the Options Study Stage and Bowral STP is undergoing Concept Design managed by NSW Public Works Advisory Service. WSC said that Environmental Assessment (EA) including consideration of NorBE and water quality impacts would be undertaken as part of the detailed design process for the STPs.

Environmental Requirements for Assessment of STP Upgrades

The Department of Industry guidance for Section 60 Approvals states that Options Studies "should include preliminary consideration of environmental and all other regulatory requirements relevant to the options". The EPA has provided its general and specific requirements for the EA of the Bowral STP Concept Design and Moss Vale STP Options Study in the attachments to this letter **(Attachment 1).**

The attached EA requirements were prepared in accordance with the EPA's policy "Operational Guidance on Water Pollution Regulation, August 2016". The adoption of the policy for the STP upgrades is in accordance with recommendations contained in the NSW Auditor's report "Regulation of water pollution in drinking water catchments and illegal disposal of solid waste, June 2018".

The EPA requests that Council provide the EPA's assessment requirement for Bowral STP to Public Works Advisory for their consideration. The EPA is available to meet with WSC and Public Works as necessary to discuss requirements for the upgrades.

The EPA will address the requirements for the upgrade of Mittagong STP in a detailed separate letter due to the need for more intensive assessment of environmental impacts.

The EPA requests that Council provide the final draft of the Option reports for Moss Vale and Mittagong STPs to the EPA for its consideration.

Notices requiring upgrade of Sewage Treatment Plants

The EPA has drafted the attached Pollution Reduction Programs (PRP) for the upgrade of Bowral and Moss Vale STPs **(Attachment 2).** The draft PRP proposes a completion date by the end of 2020.

After consideration of the environmental impact assessments required to be undertaken for the projects, the EPA may attach specific performance objectives for upgrade in the PRP's.

The PRP's formalise the STP upgrade process on the licence and provide a response to recommendations made in the NSW 2016 Sydney Drinking Water Catchment Audit for upgrade of STP's in the Wingecarribee sub-catchment.

The EPA request that WSC review the PRP's and provide any comment by 19 October 2018.

If you have questions regarding the above, please phone the contact officer on (02) 4224 4100.

Yours sincerely

19/09/18

PETER BLOEM
Manager Regional Operations Illawarra
<u>Environment Protection Authority</u>

Attatchment 1 & 2

Contact officer: Andrew Couldridge
(02) 4224 4100

cc: Mr Malcom Hughes
WaterNSW
Level 14, 169 Macquarie Street
PARRAMATTA NSW 2124

ATTACHMENT 1

Specific Considerations for Environmental Assessment of Moss Vale and Bowral STP Upgrades

The Environmental Assessment (EA) for the upgrade of Moss Vale and Bowral STPs must follow the approach prescribed in the ANZECC 2000 National Water Quality Guidelines. The guidelines recommend defining the downstream uses of water and determining the necessary water quality needed to support those uses. An appropriate level of treatment and means of disposal and/or re-use can then be determined taking consideration of downstream uses as well as reasonable, feasible and practical measures available to complete the upgrades.

As the proposal represents a significant risk to environmental values, it is appropriate that a comprehensive assessment is undertaken that quantitatively identifies the impact on the relevant indicators for the various environmental values.

The EPA requests that the following specific topics be addressed as part of the Options Study for Moss Vale STP and the Concept Design EA for the proposed upgrade of Bowral STP.

- A description of the Wingecarribee River and Medway Rivulet including flow regimes, geomorphology, land use, riverine vegetation and aquatic ecology.
- A description of the uses of water from the River and Rivulet (type and amount) including industrial, agricultural, recreational, drinking water and ecosystem.
- Assignment of an appropriate level of protection under the ANZECC 2000 Guidelines.

- A description of the health of the rivers and whether environmental values are being achieved using indicators of water quality such as physical and chemical stressors, toxicants, and aquatic health applying quantitative biological measurements.
- An estimation must be made of the level and extent of river(s) impacted by the STP discharge through loads discharged, measured levels of pollutant concentrations and changes to stream health.
- Note also that the potential toxicity effects in the Wingecarribee River due to aluminium levels from flocculant dosing should be examined.

- Describe the relative contribution of the STP under dry and wet weather to flow, nutrient loads and concentrations in the river(s) and catchment.
- Consider as to whether the upgraded STP would have a neutral or beneficial effect on water quality in the Wingecarribee River and further downstream (Sydney Catchment Drinking Water SEPP 2011).
- Describe the methods used to define NorBE including baseline conditions and projected conditions commensurate with the project timeframe.
    - Note that pollutant loads calculated under licence requirements for the load based licensing scheme are subject to significant variance due to the limited number of samples required and large variability in flowrates during wet weather conditions. The EPA recommends that an intensive sampling program be used to accurately define typical loads under average dry weather conditions to be used in the NorBE assessment.

General Considerations for Environmental Assessment of STP Upgrades

Receiving environment and background conditions

1. Describe existing surface and groundwater quality. An assessment needs to be undertaken for any waters likely to be affected by the proposal.

2. State the ambient Water Quality Objectives and environmental values for the receiving waters relevant to the proposal. These refer to the community's agreed environmental values and human uses endorsed by the NSW Government as goals for ambient waters. Where groundwater may be impacted the assessment should identify appropriate groundwater environmental values.

3. State the indicators and associated trigger values or criteria for the identified environmental values. This information should be sourced from the ANZECC Guidelines for Fresh and Marine Water Quality:
(http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality). Indicators should be selected that are relevant to the issues in the waterway, as well as potential pollutants from the activity.

   Where site-specific studies are proposed to tailor the trigger values to reflect local conditions, and the results are to be used for regulatory purposes (e.g. to assess whether a licensed discharge impacts on environmental values), then prior agreement from the EPA on the approach and study design must be obtained.

4. Describe the current state of the waterway (e.g. whether NSW WQOs are being achieved) and specific human uses (e.g. exact location of drinking water offtake), sensitive ecosystems or species conservation values.

5. State any locally specific objectives, criteria or targets which have been endorsed by the NSW Government.

Describe Proposal

6. Describe the proposal including the location of discharges, volumes and water quality of all discharge streams.

7. Identify and estimate the quality and quantity of all pollutants that may be introduced into the water cycle by source and discharge point, including residual discharges after mitigation measures are implemented. This should be undertaken for construction and operational phases.

8. The Assessment should demonstrate that all practical options to avoid discharge have been assessed and mitigation measures employed to minimise environmental impact where discharge is necessary.

Impact Assessment – predict impacts and environmental outcomes

9. Describe the nature and degree of impact that any proposed discharges will have on the receiving environment.

10. Assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes. Demonstrate how the proposal will be designed and operated to:
    - protect the NSW WQOs for receiving waters where they are currently being achieved; and
    - contribute towards achievement of the NSW WQOs over time where they are not currently being achieved.

11. The proposal should demonstrate how wastewater discharged to waterways will ensure the ANZECC Guidelines water quality criteria for relevant chemical and non-chemical parameters are met at the edge of the initial mixing zone of the discharge, and that any impacts in the initial mixing zone are demonstrated to be reversible. The proposal should also avoid direct discharge impacts on ecologically significant areas and sensitive ecosystems.

12. If a mixing zone is proposed, the EPA must be consulted early in the development of any mixing zone proposal. The EPA will advise the applicant under what conditions a mixing zone will and will not be acceptable, as well as the information and modelling requirements for assessment.

13. EPA recommends the project demonstrates that the area within the mixing zone will not contain:
    - contaminants in concentrations that cause acute toxicity to aquatic life.
    - substances that can bio-accumulate.
    - contaminants in concentrations that settle to form harmful deposits (also in the far field).
    - substances in concentrations that produce problematic colour, odour, turbidity or undesirable aesthetic impacts (also in the far field).
    - substances in concentrations which encourage undesirable aquatic life or result in the dominance of nuisance species.

14. The proposal should provide a rationale, along with relevant calculations, modelling or monitoring, (depending on the nature and scale of the proposal) supporting the predicted outcomes. The degree of investigation should reflect the risk presented by the activity.

15. Assess impacts on groundwater and groundwater dependent ecosystems.

16. Outline how total water cycle considerations are to be addressed showing total water balances for the development. Include water requirements (quantity, quality and source(s)) and proposed storm and wastewater disposal, including type, volumes, proposed treatment and management methods and re-use options.

Management and Mitigation Measures

17. Provide rationale as to why the proposed discharge method represents the best environmental outcome and what measures can be taken to reduce the environmental impact.

18. Describe how stormwater will be managed both during construction and operation.

19. Describe wastewater treatment measures that are appropriate to the type and volume of wastewater and are based on a hierarchy of avoiding generation of wastewater; capturing all contaminated water (including stormwater) on the site; reusing/recycling wastewater; and treating any unavoidable discharge from the site to meet specified water quality requirements.

ATTACHMENT 2

DRAFT POLLUTION REDUCTION PROGRAMS FOR BOWRAL AND MOSS VALE

SEWAGE TREATMENT PLANTS

Background

The 2016 Sydney Drinking Water Catchment Audit report was prepared for the Minister for Primary Industries by consultants Alluvium/Eco Logical. The Audit assessed catchment health during the period 1 July 2013 to 30 June 2016. The Audit report was tabled in Parliament on 8 August 2017.

The Audit recommended action where it found a worsening trend for multiple water quality indicators. In relation to discharges from sewage treatment plants in the catchment, the Auditor made the following recommendation:

> "*Sewerage infrastructure*: There is evidence that some sewage treatments plants are now at capacity and continued investment in sewerage infrastructure is required to keep risks to inflow water quality at an acceptable level. Priority should be given to upgrading the Moss Vale and Mittagong Sewage Treatment Plants (STPs), then Bowral and Berrima STPs."

The EPA regulates STPs in the catchment area and the load of nutrients discharged to Lake Burragorang. The EPA is concerned about the effect of increasing loads on the lake and increased risks of algal bloom (such as occurred in 2007).

The STPs identified in the Audit report as being over capacity and contributing to catchment nutrient loads include Bowral, Moss Vale STPs, Mittagong and Berrima STPs.

The Audit report states that the stream with the worst water quality over the audit period was Gibbergunyah Creek (at site E203) downstream of the discharge from Mittagong STP. Wingecarribee River at Berrima downstream of Bowral STP had the equal second most problematic water quality (at Site E332).

In response to the audit findings, the EPA has attached Pollution Reduction Programs (PRPs) requiring upgrade of the STP under most pressure. These include the Bowral and Moss Vale due to population growth and age. Mittagong is approaching its design capacity and discharges to the ecologically sensitive Nattai River. Berrima is an old plant however due to its relatively small size and small population growth, has not been included as a priority for upgrade at this time.

The PRPs require that the Bowral and Moss Vale STPs must be upgraded by the end of 2020. The upgrades should be undertaken with the objective of meeting the following:

- appropriate ANZECC environmental values for downstream river health and water quality objectives assessed on a site-specific assessment.
- mass load discharges to meet considerations for neutral and beneficial water quality under the 2011 Sydney Drinking Water SEPP; and
- pollutant concentrations expected from reasonable and feasible contemporary treatment technology. Contemporary technology is considered by the EPA to be that which produces the equivalent effluent quality to a membrane bioreactor STP.

Pollution Reduction Program

Upgrade of Bowral/Moss Vale STPs

The licensee must upgrade Bowral/Moss Vale STPs to meet effluent performance criteria agreed with the EPA by the due date.

Due Date: 31 December 2020.

Note: Effluent performance criteria for the upgraded STP will be based on an assessment of environmental impact of the STP and consideration of practical measures to control pollution as described in Section 45 of the Protection of the Environment Operations Act 1997. The EPA will attach performance criteria to this PRP following consideration of options studies in the environmental impact statement prepared for the upgrade of the STP. The performance criteria are unlikely to be the same as concentration and load limits on the current licence.

DOC18/597501

Mr Barry Paul
Wingecarribee Shire Council
PO Box 141
MOSS VALE NSW 2577

Dear Mr Paul

Environmental Assessment Requirements and Draft Pollution Reduction Programs for Upgrade of Moss Vale and Bowral Sewage Treatment Plants

The Environment Protection Authority (EPA) refers to the meeting held between Wingecarribee Shire Council (WSC), WaterNSW and the EPA at Moss Vale on 31 July 2018.

The meeting was held for Council to provide an update on the program for upgrade of Bowral, Moss Vale and Mittagong Sewage Treatment Plants (STPs).

Stace Lewer (Manager Assets, WSC) gave a presentation on the planning process for upgrade of the STPs. He said that WSC is currently undertaking an application process for Section 60 approval under the *Local Government Act 1993*. This is a 3 step process and involves an Options Study, Concept Design & Environmental Impact Assessment, and a Detailed Design for upgrade of the STPs.

Moss Vale and Mittagong STPs are in the Options Study Stage and Bowral STP is undergoing Concept Design managed by NSW Public Works Advisory Service. WSC said that Environmental Assessment (EA) including consideration of NorBE and water quality impacts would be undertaken as part of the detailed design process for the STPs.

Environmental Requirements for Assessment of STP Upgrades

The Department of Industry guidance for Section 60 Approvals states that Options Studies "should include preliminary consideration of environmental and all other regulatory requirements relevant to the options". The EPA has provided its general and specific requirements for the EA of the Bowral STP Concept Design and Moss Vale STP Options Study in the attachments to this letter **(Attachment 1).**

The attached EA requirements were prepared in accordance with the EPA's policy "Operational Guidance on Water Pollution Regulation, August 2016". The adoption of the policy for the STP upgrades is in accordance with recommendations contained in the NSW Auditor's report "Regulation of water pollution in drinking water catchments and illegal disposal of solid waste, June 2018".

The EPA requests that Council provide the EPA's assessment requirement for Bowral STP to Public Works Advisory for their consideration. The EPA is available to meet with WSC and Public Works as necessary to discuss requirements for the upgrades.

The EPA will address the requirements for the upgrade of Mittagong STP in a detailed separate letter due to the need for more intensive assessment of environmental impacts.

The EPA requests that Council provide the final draft of the Option reports for Moss Vale and Mittagong STPs to the EPA for its consideration.

Notices requiring upgrade of Sewage Treatment Plants

The EPA has drafted the attached Pollution Reduction Programs (PRP) for the upgrade of Bowral and Moss Vale STPs **(Attachment 2).** The draft PRP proposes a completion date by the end of 2020.

After consideration of the environmental impact assessments required to be undertaken for the projects, the EPA may attach specific performance objectives for upgrade in the PRP's.

The PRP's formalise the STP upgrade process on the licence and provide a response to recommendations made in the NSW 2016 Sydney Drinking Water Catchment Audit for upgrade of STP's in the Wingecarribee sub-catchment.

The EPA request that WSC review the PRP's and provide any comment by 19 October 2018.

If you have questions regarding the above, please phone the contact officer on (02) 4224 4100.

Yours sincerely

19/09/18

PETER BLOEM
Manager Regional Operations Illawarra
<u>Environment Protection Authority</u>

Attatchment 1 & 2

Contact officer: Andrew Couldridge
(02) 4224 4100

cc: Mr Malcom Hughes
WaterNSW
Level 14, 169 Macquarie Street
PARRAMATTA NSW 2124

ATTACHMENT 1

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Pollution Reduction Program

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Due Date: 31 December 2020.

Note: Effluent performance criteria for the upgraded STP will be based on an assessment of environmental impact of the STP and consideration of practical measures to control pollution as described in Section 45 of the Protection of the Environment Operations Act 1997. The EPA will attach performance criteria to this PRP following consideration of options studies in the environmental impact statement prepared for the upgrade of the STP. The performance criteria are unlikely to be the same as concentration and load limits on the current licence.

PO Box 398, Parramatta NSW 2124
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Parramatta NSW 2150
www.waternsw.com.au
ABN 21 147 934 787

2 October 2018

Contact: *Girja Sharma*
Telephone: *98652501*
Our ref: D2018/107668

Kristen Parmeter
Environmental Scientist
Environment & Sustainability
NSW Public Works Advisory
PO Box N408, Grosvenor Place
Sydney NSW 2000

Dear Ms Parmeter

Subject: Upgrade of Bowral Sewage Treatment Plant

Thank you for notifying WaterNSW that NSW Public Works Advisory has been engaged by Wingecarribee Shire Council (WSC) to prepare a Review of Environmental Factors (REF) for augmentation of the Bowral sewage treatment plant (STP) and seeking comments on the proposal for inclusion in the environmental impact assessment.

WaterNSW provided advice to WSC in relation to the upgrade of Council's STPs (Ref D2018/102620; dated 19 September 2018) and specific advice on undertaking a neutral or beneficial effect on water assessment for upgrades (Ref. D2015/106347; dated October 2015).

In addition to requirements contained in the above letters, WaterNSW considers that the REF should also consider the following project specific details:

- STP design
  - the population growth for the projected design capacity of the augmented STP should also consider the increased number of higher density developments such as multi dwellings, and boarding houses
  - the proposed storm detention pond and emergency storage pond should have sufficient capacity to prevent any overflow of raw sewage
  - provision for hiring the power generation unit in the event of power failure for pumping station or at the STP.
- NorBE water quality assessment
  - pre and post augmentation pollutant loading for 100%-ile pollutant concentrations in effluent
- Detailed hydraulic and water quality modelling and assessment
  - impacts of effluent discharges on water quality of receiving waters during extended dry climatic conditions
  - the potential of the total wastewater loading exceeding the projected wastewater loading for the design scenario
  - the potential overflow of raw sewage from the failure of sewage pumping station/s
  - the potential overflow of raw sewage from the emergency storage pond/s and sludge lagoons (if part of upgraded system design) during extended wet weather
  - flood inundation of any elements of the STP and impacts on water quality in particular inundation of the emergency storage pond

- Conceptual Construction Environmental Management Plan (EMP) including a Soil and Water Management Plan for all construction activities associated with the upgrade of sewage network, pump station, and STP
- Conceptual Operational EMP for the augmented sewage system.

WaterNSW is happy to continue to engage with NSW Public Works Advisory, as the preparation of the environmental impact assessment of this upgrade proceeds.

If you wish to discuss further, please contact Girja Sharma on 98652501.

Yours sincerely

MALCOLM HUGHES
Manager Catchment Protection

PO Box 323, Penrith NSW 2751
Level 4, 2-6 Station Street,
Penrith NSW 2750
Ph: 1300 722 468
www.waternsw.com.au
ABN 21 147 934 787

Our Reference:D2015/106347

Mr Bob Lewis
Manager Projects & Contracts
Wingecarribee Shire Council
DX 4961
BOWRAL 2576

Dear Mr Lewis

Subject: Wingecarribee Shire Council Sewerage Treatment Plants Augmentation

I refer to the meeting held on 1 September 2015 between Wingecarribee Shire Council (WSC) and other key stakeholders including the Environment Protection Authority (EPA), NSW DPI Water and WaterNSW to discuss WSC's proposal for the augmentation of the Moss Vale, Bowral and Mittagong Sewerage Treatment Plants (STPs). WaterNSW also attended an initial stakeholder meeting along with the EPA on 18 September 2014.

WaterNSW's position is that any development or activity within the Sydney drinking water catchment should only be approved if the carrying out of the proposed development or activity would have a neutral or beneficial effect (NorBE) on water quality.

At the 1 September 2015 meeting, WSC asked WaterNSW to provide the requirements for a NorBE water quality assessment as part of the preparation of an environmental assessment for the augmentation of WSC's STPs. WSC also asked whether a joint NorBE assessment can be undertaken for the Bowral and Moss Vale STPs, both of which discharge to the Wingecarribee River, and for a response regarding a Bubble Licence Concept. WaterNSW provides the following information in response to these matters.

<u>NorBE Assessment Requirements</u>

WaterNSW considers that the environmental assessment for the augmentation of each STP should address but not be limited to the following matters:

1. Predicted design wastewater loading which is:
    - based on projected population growth over the project life which should include planned subdivisions and any new industries
    - considers average and peak wastewater flows for dry and wet weather conditions
    - incorporates any infiltrations via old reticulation systems

2. Details on the design and capacity of proposed augmented sewerage treatment plants including the key design standards and expected performance of the augmented STPs.

3. Predicted effluent quality for 50, 90 and 100 percentile concentrations for total suspended solids (TSS), BOD, TP, TN and pathogens.

4. A NorBE water quality assessment for dry, average and wet weather conditions based on 50 and 90 percentile pollutant concentrations in effluent and should include
   - estimates and comparison of pollutant loading and pollutant concentrations of TSS, BOD, TP, TN and pathogens for the following two scenarios:
     - pre-augmentation or baseline effluent quantity and quality (pollutant concentrations) as per current EPL at the licence discharge point, and
     - post-augmentation effluent quantity and quality at the discharge point
   - detailed hydraulic and water quality modelling and assessment for dry, average and wet weather conditions including:
     - predictions for volume and frequency of effluent discharges, including untreated wastewater releases
     - predictions for changes to flows in the discharging water body
     - impacts of discharges on water quality during low, medium and high river flows, particularly of:
       - high effluent concentrations of pollutants (TSS, BOD, TP, TN and pathogens), and
       - partially and primary treated effluent when wastewater flows exceed the capacity of the plant
     - impacts on aquatic flora and fauna and geomorphology of the discharging water body, and
   - options for addressing the management of sewage which exceeds the capacity of the plant.

5. Proposed monitoring program including location of proposed monitoring points upstream and downstream of the discharge point.

Joint NorBE Assessment for Moss Vale and Bowral STPs

The NorBE Water Quality Assessment Guideline 2015 defines NorBE. Central to the definition is the concept of the site. The site is the land on which the development or activity is to be carried out. The guideline states that pollutant loads or concentrations for each pollutant leaving a site are measured at the site boundary, or at the point where the pollutant enters a drainage depression, waterbody or watercourse. In this case the NorBE criteria is therefore satisfied if there is a neutral or beneficial effect on water quality where the effluent is discharged into Mittagong Rivulet or Whites Creek. WaterNSW therefore does not support the concept of a joint NorBE assessment. A separate NorBE water quality assessment should be prepared for each STP at the discharge point and water quality impact assessment immediately downstream of the discharge point.

Bubble Licence Concept

WaterNSW is not a regulator and therefore Council should seek advice from the EPA in this regard.

WaterNSW would like to continue to be involved as a stakeholder in the upgrade of the STPs; review of the environmental assessment documentation and provide comments. If you have any questions regarding above comments please contact Dr Girja Sharma, Team Leader Assessments, on 47242459.

Yours sincerely

Malcolm Hughes

MALCOLM HUGHES
Senior Manager Planning & Environment

16/10/15

Kristen Parmeter

From: Larry Greentree <larry.greentree@dpi.nsw.gov.au>
Sent: Tuesday, 2 October 2018 9:17 AM
To: Kristen Parmeter
Subject: Re: FW: Bowral Sewage Treatment Plant Augmentation - Review of Environmental Factors (REF) consultation letter
Attachments: image002.png

Dear Kristen,

Thank you for seeking our advice on requirements for the REF on Bowral STP Augmentation.

Firstly, I have forwarded your email to our Water Referrals group (which can be contacted via email at water.referrals@dpi.nsw.gov.au) for separate response - this Water Referrals group will advise on the broad Department of Industry Water requirements for any environmental impact assessments being considered.

From the perspective of Water Utilities group within DOI Water, our requirements covered by the Section 60 approval process (ie approval under Section 60 of the Local Government Act 1993). Relevant information on the Section 60 approval process can be found on our web site at https://www.industry.nsw.gov.au/water/water-utilities/regulatory-assessments/s60-approval-water-sewage-treatment-works

Regards,

Larry Greentree
Principal Technical Assessor, Water & Sewerage
Water Utilities
Lands & Water Division | Water
NSW Department of Industry
Level 10, 10 Valentine Avenue, Parramatta NSW 2150
Locked Bag 5123, Parramatta NSW 2124
T: 02-9842 8493 | M: 0422 396 707
E: larry.greentree@dpi.nsw.gov.au
W: www.water.nsw.gov.au | www.water.nsw.gov.au

Read the DPI Strategic Plan and watch our video

On Wed, Sep 26, 2018 at 11:51 AM Kristen Parmeter <kristen.parmeter@finance.nsw.gov.au> wrote:

> Dear Mr Greentree,
>
> Please find attached a copy of a consultation letter issued to Department of Industry - Water as part of the environmental impact assessment being carried out in relation to a proposal to upgrade to the existing Bowral Sewage Treatment Plant.

I have been provided with your contact details by Wingecarribee Shire Council and am therefore forwarding a copy to you, as you may be best-placed to respond on behalf of DoI – Water in relation to any comments/ requirements for the proposal. However, please let me know if this letter should be referred to a colleague at DoI - Water and I will refer the letter to them.

Please don't hesitate to contact me should you have any questions, or require further information regarding the proposal.

Thanks and kind regards,

Kristen Parmeter
Environmental Scientist, PWA Environment & Sustainability

Public Works Advisory| Department of Finance, Services and Innovation
p 02 9240 8803 **m** 0436 697 139
e kristen.parmeter@finance.nsw.gov.au | www.publicworksadvisory.nsw.gov.au
Level 4, 66 Harrington Street, The Rocks, NSW, 2000

From: Kristen Parmeter
Sent: Friday, 21 September 2018 4:51 PM
To: 'water.enquiries@dpi.nsw.gov.au' <water.enquiries@dpi.nsw.gov.au>
Subject: Bowral Sewage Treatment Plant Augmentation - Review of Environmental Factors (REF) consultation letter

Dear Sir/Madam,

Wingecarribee Shire Council proposing to upgrade the existing Bowral Sewage Treatment Plant (STP) and Public Works Advisory have been engaged to prepare a Review of Environmental Factors (REF) for the proposal.

The purpose of the attached letter is to invite the Department of Industry - Water to provide comments on the proposal and to identify matters to assist in the environmental planning and delivery of the project.

If you have any comments on the proposal, it would be appreciated if you could provide a response prior to 12 October 2018 to Kristen Parmeter at:

Public Works Advisory

PO Box N408,

Grosvenor Place NSW 1220

Email: kristen.parmeter@finance.nsw.gov.au

Phone: 02 9240 8803

If you require any further information at this stage regarding the project, please free to contact me.

Kind regards

Kristen Parmeter
Environmental Scientist, PWA Environment & Sustainability

Public Works Advisory| Department of Finance, Services and Innovation
p 02 9240 8803 **m** 0436 697 139
e kristen.parmeter@finance.nsw.gov.au | www.publicworksadvisory.nsw.gov.au
Level 4, 66 Harrington Street, The Rocks, NSW, 2000

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Appendix D – AHIMS and Flora and Fauna Search Results

AHIMS Web Services (AWS)
Search Result

Purchase Order/Reference : Bowral STP 1

Client Service ID : 606661

Public Works Advisory

Date: 15 July 2021

66 Harrington Street
Sydney New South Wales 2000

Attention: Kristen Parmeter

Email: kristen.parmeter@finance.nsw.gov.au

Dear Sir or Madam:

AHIMS Web Service search for the following area at Lot : 2, DP:DP1119953 with a Buffer of 200 meters, conducted by Kristen Parmeter on 15 July 2021.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.

A search of the Office of the Environment and Heritage AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

0	**Aboriginal sites are recorded in or near the above location.**
0	**Aboriginal places have been declared in or near the above location. ***

If your search shows Aboriginal sites or places what should you do?

- You must do an extensive search if AHIMS has shown that there are Aboriginal sites or places recorded in the search area.
- If you are checking AHIMS as a part of your due diligence, refer to the next steps of the Due Diligence Code of practice.
- You can get further information about Aboriginal places by looking at the gazettal notice that declared it. Aboriginal places gazetted after 2001 are available on the NSW Government Gazette (http://www.nsw.gov.au/gazette) website. Gazettal notices published prior to 2001 can be obtained from Office of Environment and Heritage's Aboriginal Heritage Information Unit upon request

Important information about your AHIMS search

- The information derived from the AHIMS search is only to be used for the purpose for which it was requested. It is not be made available to the public.
- AHIMS records information about Aboriginal sites that have been provided to Office of Environment and Heritage and Aboriginal places that have been declared by the Minister;
- Information recorded on AHIMS may vary in its accuracy and may not be up to date .Location details are recorded as grid references and it is important to note that there may be errors or omissions in these recordings,
- Some parts of New South Wales have not been investigated in detail and there may be fewer records of Aboriginal sites in those areas. These areas may contain Aboriginal sites which are not recorded on AHIMS.
- Aboriginal objects are protected under the National Parks and Wildlife Act 1974 even if they are not recorded as a site on AHIMS.
- This search can form part of your due diligence and remains valid for 12 months.

AHIMS Web Services (AWS)
Search Result

Purchase Order/Reference : Bowral STP AHIMS 2

Client Service ID : 607393

Public Works Advisory
66 Harrington Street
Sydney New South Wales 2000
Attention: Kristen Parmeter
Email: kristen.parmeter@finance.nsw.gov.au

Date: 19 July 2021

Dear Sir or Madam:

AHIMS Web Service search for the following area at Lot : 278, DP:DP914555 with a Buffer of 200 meters, conducted by Kristen Parmeter on 19 July 2021.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.

A search of the Office of the Environment and Heritage AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

0	**Aboriginal sites are recorded in or near the above location.**
0	**Aboriginal places have been declared in or near the above location. ***

If your search shows Aboriginal sites or places what should you do?

- You must do an extensive search if AHIMS has shown that there are Aboriginal sites or places recorded in the search area.
- If you are checking AHIMS as a part of your due diligence, refer to the next steps of the Due Diligence Code of practice.
- You can get further information about Aboriginal places by looking at the gazettal notice that declared it. Aboriginal places gazetted after 2001 are available on the NSW Government Gazette (http://www.nsw.gov.au/gazette) website. Gazettal notices published prior to 2001 can be obtained from Office of Environment and Heritage's Aboriginal Heritage Information Unit upon request

Important information about your AHIMS search

- The information derived from the AHIMS search is only to be used for the purpose for which it was requested. It is not be made available to the public.
- AHIMS records information about Aboriginal sites that have been provided to Office of Environment and Heritage and Aboriginal places that have been declared by the Minister;
- Information recorded on AHIMS may vary in its accuracy and may not be up to date .Location details are recorded as grid references and it is important to note that there may be errors or omissions in these recordings,
- Some parts of New South Wales have not been investigated in detail and there may be fewer records of Aboriginal sites in those areas. These areas may contain Aboriginal sites which are not recorded on AHIMS.
- Aboriginal objects are protected under the National Parks and Wildlife Act 1974 even if they are not recorded as a site on AHIMS.
- This search can form part of your due diligence and remains valid for 12 months.

Australian Government

Department of Agriculture, Water and the Environment

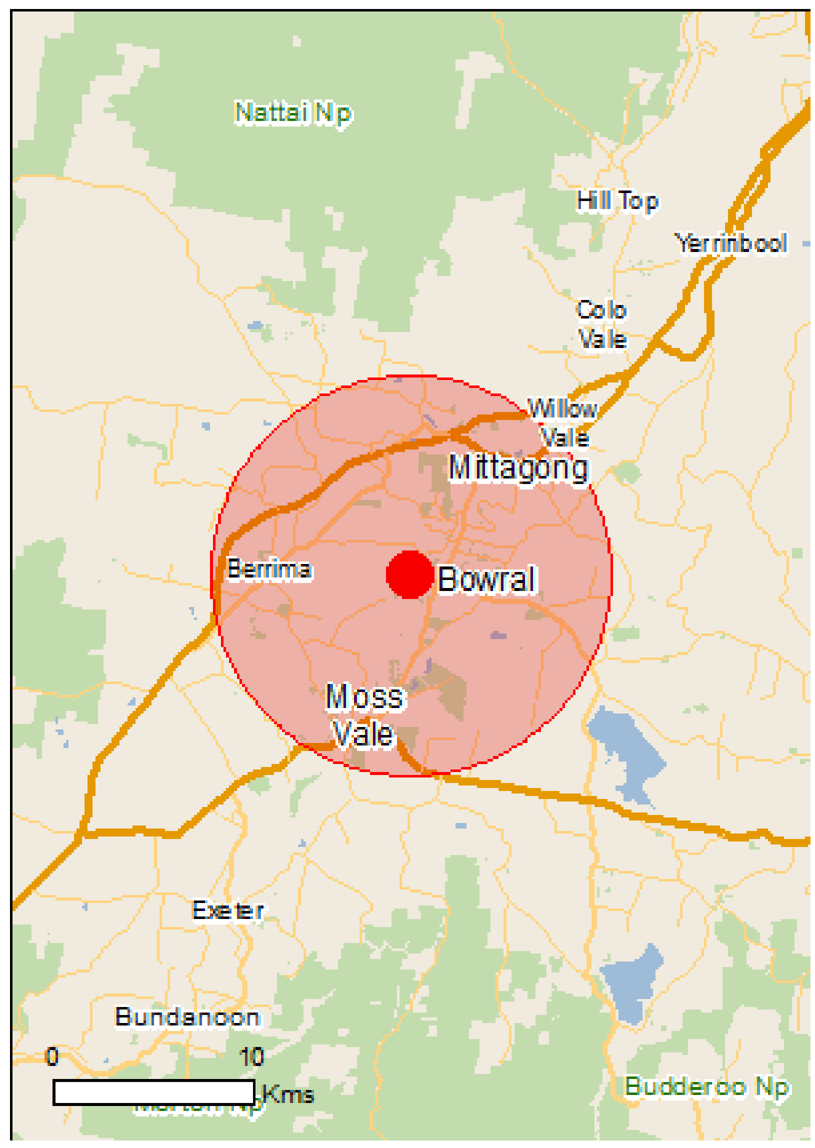
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

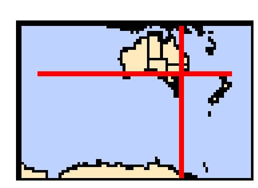
Report created: 29/09/21 17:23:07



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2015

Coordinates

Buffer: 10.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	7
Listed Threatened Species:	56
Listed Migratory Species:	15

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	5
Commonwealth Heritage Places:	None
Listed Marine Species:	20
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Regional Forest Agreements:	1
Invasive Species:	42
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coastal Upland Swamps in the Sydney Basin Bioregion	Endangered	Community may occur within area
Natural Temperate Grassland of the South Eastern Highlands	Critically Endangered	Community likely to occur within area
Robertson Rainforest in the Sydney Basin Bioregion	Critically Endangered	Community likely to occur within area
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	Critically Endangered	Community may occur within area
Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion	Critically Endangered	Community likely to occur within area
Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion	Endangered	Community likely to occur within area
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within

Name	Status	Type of Presence
		area
Polytelis swainsonii Superb Parrot [738]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area
Fish		
Macquaria australasica Macquarie Perch [66632]	Endangered	Species or species habitat known to occur within area
Prototroctes maraena Australian Grayling [26179]	Vulnerable	Species or species habitat may occur within area
Frogs		
Heleioporus australiacus Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat may occur within area
Litoria littlejohni Littlejohn's Tree Frog, Heath Frog [64733]	Vulnerable	Species or species habitat may occur within area
Mixophyes balbus Stuttering Frog, Southern Barred Frog (in Victoria) [1942]	Vulnerable	Species or species habitat may occur within area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat known to occur within area
Isoodon obesulus obesulus Southern Brown Bandicoot (eastern), Southern Brown Bandicoot (south-eastern) [68050]	Endangered	Species or species habitat likely to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat known to occur within area
Petrogale penicillata Brush-tailed Rock-wallaby [225]	Vulnerable	Species or species habitat likely to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus Long-nosed Potoroo (SE Mainland) [66645]	Vulnerable	Species or species habitat likely to occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat likely to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Plants		
Acacia bynoeana Bynoe's Wattle, Tiny Wattle [8575]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Acacia pubescens Downy Wattle, Hairy Stemmed Wattle [18800]	Vulnerable	Species or species habitat likely to occur within area
Boronia deanei Deane's Boronia [8397]	Vulnerable	Species or species habitat likely to occur within area
Caladenia tessellata Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat may occur within area
Commersonia prostrata Dwarf Kerrawang [87152]	Endangered	Species or species habitat likely to occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat likely to occur within area
Eucalyptus aggregata Black Gum [20890]	Vulnerable	Species or species habitat known to occur within area
Eucalyptus macarthurii Camden Woollybutt, Paddys River Box [7827]	Endangered	Species or species habitat known to occur within area
Genoplesium baueri Yellow Gnat-orchid, Bauer's Midge Orchid, Brittle Midge Orchid [7528]	Endangered	Species or species habitat may occur within area
Gentiana wingecarribiensis Wingecarribee Gentian [18033]	Endangered	Species or species habitat may occur within area
Grevillea raybrownii [65665]	Vulnerable	Species or species habitat known to occur within area
Haloragis exalata subsp. exalata Wingless Raspwort, Square Raspwort [24636]	Vulnerable	Species or species habitat may occur within area
Helichrysum calvertianum [5702]	Vulnerable	Species or species habitat known to occur within area
Kunzea cambagei [11420]	Vulnerable	Species or species habitat known to occur within area
Leucochrysum albicans subsp. tricolor Hoary Sunray, Grassland Paper-daisy [89104]	Endangered	Species or species habitat may occur within area
Persicaria elatior Knotweed, Tall Knotweed [5831]	Vulnerable	Species or species habitat may occur within area
Persoonia acerosa Needle Geebung [7232]	Vulnerable	Species or species habitat likely to occur within area
Persoonia glaucescens Mittagong Geebung [12770]	Vulnerable	Species or species habitat known to occur within area
Persoonia hirsuta Hairy Geebung, Hairy Persoonia [19006]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Persoonia mollis subsp. revoluta [56094]	Vulnerable	Species or species habitat known to occur within area
Phyllota humifusa Dwarf Phyllota [10133]	Vulnerable	Species or species habitat known to occur within area
Pomaderris brunnea Rufous Pomaderris, Brown Pomaderris [16845]	Vulnerable	Species or species habitat likely to occur within area
Pomaderris cotoneaster Cotoneaster Pomaderris [2043]	Endangered	Species or species habitat may occur within area
Prasophyllum affine Jervis Bay Leek Orchid, Culburra Leek-orchid, Kinghorn Point Leek-orchid [2210]	Endangered	Species or species habitat may occur within area
Prasophyllum fuscum Tawny Leek-orchid, Slaty Leek-orchid [19455]	Vulnerable	Species or species habitat may occur within area
Rhizanthella slateri Eastern Underground Orchid [11768]	Endangered	Species or species habitat may occur within area
Rhodamnia rubescens Scrub Turpentine, Brown Malletwood [15763]	Critically Endangered	Species or species habitat may occur within area
Thelymitra kangaloonica Kangaloon Sun Orchid [81861]	Critically Endangered	Species or species habitat likely to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat likely to occur within area
Xerochrysum palustre Swamp Everlasting, Swamp Paper Daisy [76215]	Vulnerable	Species or species habitat likely to occur within area
Zieria murphyi Velvet Zieria [4634]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Hoplocephalus bungaroides Broad-headed Snake [1182]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Breeding known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Commonwealth Land - Australian Postal Commission
Commonwealth Land - Australian Telecommunications Commission
Commonwealth Land - Commonwealth Trading Bank of Australia
Commonwealth Land - Telstra Corporation Limited

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Breeding known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Cecil Hoskins	NSW

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
Southern RFA	New South Wales

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Alauda arvensis Skylark [656]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Pycnonotus jocosus Red-whiskered Bulbul [631]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat may occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Chrysanthemoides monilifera		
Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Cytisus scoparius		
Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Eichhornia crassipes		
Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista linifolia		
Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista monspessulana		
Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana		
Broom [67538]		Species or species habitat may occur within area
Nassella neesiana		
Chilean Needle grass [67699]		Species or species habitat likely to occur within area
Nassella trichotoma		
Serrated Tussock, Yass River Tussock, Yass Tussock, Nassella Tussock (NZ) [18884]		Species or species habitat likely to occur within area
Opuntia spp.		
Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata		
Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate		
Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla		
Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii		
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis		
Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Ulex europaeus		
Gorse, Furze [7693]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-34.49138 150.39841

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- -Office of Environment and Heritage, New South Wales
- -Department of Environment and Primary Industries, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment, Water and Natural Resources, South Australia
- -Department of Land and Resource Management, Northern Territory
- -Department of Environmental and Heritage Protection, Queensland
- -Department of Parks and Wildlife, Western Australia
- -Environment and Planning Directorate, ACT
- -Birdlife Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -South Australian Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums
- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- Forestry Corporation, NSW
- -Geoscience Australia
- -CSIRO
- -Australian Tropical Herbarium, Cairns
- -eBird Australia
- -Australian Government – Australian Antarctic Data Centre
- -Museum and Art Gallery of the Northern Territory
- -Australian Government National Environmental Science Program
- -Australian Institute of Marine Science
- -Reef Life Survey Australia
- -American Museum of Natural History
- -Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
- -Tasmanian Museum and Art Gallery, Hobart, Tasmania
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Data from the BioNet Atlas website, which holds records from a number of custodians. The data are only indicative and cannot be considered a comprehensive inventory, and may contain errors and omissions. Species listed under the Sensitive Species Data Policy may have their locations denatured (^ rounded to 0.1°C; ^^ rounded to 0.01°C. Copyright the State of NSW through the Department of Planning, Industry and Environment. Search criteria : Public Report of all Valid Records of Threatened (listed on BC Act 2016) or Commonwealth listed Entities in selected area [North: -34.44 West: 150.34 East: 150.44 South: -34.54] returned a total of 921 records of 31 species.

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Kingdom	Class	Family	Species Code	Scientific Name	Exotic	Common Name	NSW status	Comm. status	Records	Info
Animalia	Aves	Anatidae	0216	*Oxyura australis*		Blue-billed Duck	V,P		7	
Animalia	Aves	Anatidae	0214	*Stictonetta naevosa*		Freckled Duck	V,P		3	
Animalia	Aves	Apodidae	0334	*Hirundapus caudacutus*		White-throated Needletail	P	V,C,J,K	2	
Animalia	Aves	Ardeidae	0197	*Botaurus poiciloptilus*		Australasian Bittern	E1,P	E	6	
Animalia	Aves	Accipitridae	0226	*Haliaeetus leucogaster*		White-bellied Sea-Eagle	V,P		1	
Animalia	Aves	Accipitridae	0225	*Hieraaetus morphnoides*		Little Eagle	V,P		6	
Animalia	Aves	Rostratulidae	0170	*Rostratula australis*		Australian Painted Snipe	E1,P	E	1	
Animalia	Aves	Cacatuidae	0268	*^^Callocephalon fimbriatum*		Gang-gang Cockatoo	V,P,3		27	
Animalia	Aves	Cacatuidae	0265	*^Calyptorhynchus lathami*		Glossy Black-Cockatoo	V,P,2		12	
Animalia	Aves	Strigidae	0246	*^^Ninox connivens*		Barking Owl	V,P,3		1	
Animalia	Aves	Strigidae	0248	*^^Ninox strenua*		Powerful Owl	V,P,3		3	
Animalia	Aves	Tytonidae	0250	*^^Tyto novaehollandiae*		Masked Owl	V,P,3		1	
Animalia	Aves	Neosittidae	0549	*Daphoenositta chrysoptera*		Varied Sittella	V,P		2	
Animalia	Aves	Artamidae	8519	*Artamus cyanopterus cyanopterus*		Dusky Woodswallow	V,P		9	
Animalia	Aves	Petroicidae	0380	*Petroica boodang*		Scarlet Robin	V,P		6	
Animalia	Aves	Petroicidae	0382	*Petroica phoenicea*		Flame Robin	V,P		4	
Animalia	Mammalia	Dasyuridae	1008	*Dasyurus maculatus*		Spotted-tailed Quoll	V,P	E	1	
Animalia	Mammalia	Phascolarctidae	1162	*Phascolarctos cinereus*		Koala	V,P	V	24	

Animalia	Mammalia	Petauridae	1137	*Petaurus norfolcensis*	Squirrel Glider	V,P		1
Animalia	Mammalia	Pseudocheiridae	1133	*Petauroides volans*	Greater Glider	P	V	19
Animalia	Mammalia	Pseudocheiridae	1133	*Petauroides volans*	Greater Glider population in the Mount Gibraltar	E2,P	V	19
Animalia	Mammalia	Pteropodidae	1280	*Pteropus poliocephalus*	Grey-headed Flying-fox	V,P	V	28
Animalia	Mammalia	Vespertilionidae	1357	*Myotis macropus*	Southern Myotis	V,P		1
Plantae	Flora	Asteraceae	1484	*Helichrysum calvertianum*		V		39
Plantae	Flora	Myrtaceae	4038	*Eucalyptus aggregata*	Black Gum	V	V	1
Plantae	Flora	Myrtaceae	4038	*Eucalyptus aggregata*	Eucalyptus aggregata population in the Wingecaribee local	E2,V	V	1
Plantae	Flora	Myrtaceae	4119	*Eucalyptus macarthurii*	Paddys River Box, Camden Woollybutt	E1	E	579
Plantae	Flora	Orchidaceae	4439	*^Diuris aequalis*	Buttercup Doubletail	E1,P,2	V	1
Plantae	Flora	Proteaceae	9678	*Grevillea raybrownii*		V		1
Plantae	Flora	Proteaceae	7677	*Persoonia glaucescens*	Mittagong Geebung	E1,P	V	114
Plantae	Flora	Proteaceae	8997	*Persoonia mollis subsp. revoluta*		V,P		1

Appendix E – Discharge Impact Assessment

Discharge Impact Assessment for the Bowral Sewerage Scheme

Report MHL2748-2
05/03/2021

Prepared for:

Wingecarribee Shire Council

Cover Photograph: EPA sampling point on Wingecarribee River

Discharge Impact Assessment for the Bowral Sewerage Scheme

Report MHL2748-2
05/03/2021

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Report No. MHL2748-2

First published as draft in November 2020

Manly Hydraulics Laboratory is Quality System Certified to AS/NZS ISO 9001:2008.

Executive Summary

This report has three main functions. Firstly, historical data are used to examine the concentrations over the long term (generally 2013 to 2019) in effluent quality and receiving water quality. Understanding past and present water quality is critical to understanding future conditions. This work is supplemented by the statistical analysis of a short, intensive data collection program which also forms the basis for modelling of water quality. Secondly, using a number of scenarios, projected concentrations of contaminants at two locations downstream of the discharge point are estimated. Finally, a Neutral or Beneficial Effects analysis is undertaken for each of the scenarios examined.

Wingecarribee Shire is located west of Wollongong in NSW's Southern Highlands. It covers an area of around 2,700km^2 and contains the towns of Mittagong, Bowral, and Moss Vale. The design capacity at these three sewage treatment plants (STPs) is close to capacity, hence, there is a need to increase sewage treatment capacity. Reflecting continual improvement, the level of sewage treatment in the STPs would be also upgraded.

As a part of the upgrade process for these three STPs, the NSW Environmental Protection Authority (EPA) requested that an assessment of the existing condition of the three discharging waterways be performed to understand the current and likely future water quality impacts of any proposed upgrades.

Based on the available data for the three STPs, the identified environmental values, and the long-term monitoring performed by WaterNSW, a 3-month monitoring program was designed to quantify the constituents and loads of each STP's effluent, as well as the condition of the receiving water bodies.

The environmental monitoring was performed between December 2019 and February 2020 and has filled some of the knowledge gaps present in the available water quality dataset. This additional data has facilitated statistically robust estimation of the background conditions of the Wingecarribee River and provided the basis for modelling of future conditions.

Information presented in this report summarises the results of data analysis and modelling undertaken to estimate the concentrations of contaminants after proposed upgrades of the Bowral sewage treatment plant (STP). Modelling was based on a set of scenarios provided by Wingecarribee Shire Council. The scenarios corresponded to different levels of sewage treatment, each of which was modelled for different 'equivalent populations' (EPs).

A Monte Carlo approach was used for the modelling. In such an approach, many simulations are undertaken: each using different input values, incorporating the natural variability of the environment into the analyses. The output is a range of values that are visualised in this report as probability of exceedance plots. Model outputs for the future scenarios were compared with existing conditions to determine compliance with the Neutral or Beneficial Effects (NorBE) requirements. In this report 'existing conditions' were defined using STP data collected between 1 July 2014 and 30 June 2019. Modelled results were also compared with the ANZECC water quality guidelines at two downstream locations.

A summary of the results is tabulated below. Each set of results comprises three tables. The first table details the 'tipping point' concentrations i.e. the concentrations of contaminants released from the STP that are required to just meet the NorBE concentration and load requirements. The second table details whether each scenario meets (cell shaded in green) or does not meet (cells shaded in pink) the NorBE concentration and annual load requirements. The third table estimates the concentrations of contaminants at two locations in the receiving waters that are downstream of the discharge point. Cells that are shaded in green represent a 'meaningful' improvement from existing conditions. Each scenario is compared with existing results. The relevant ANZECC guidelines are also included in this third table.

The scenarios tested only partially meet the NorBE requirements. The critical element was the NorBE annual load requirements. For some scenarios, the proposed STP effluent concentrations of BOD and TSS exceeded the existing concentrations in the STP effluent. In such cases, it will not be possible to meet the NorBE requirements. Often, the proposed concentrations of TN and TP was not sufficiently low to offset the increase in flow (expressed as an increase in equivalent population).

For most contaminants and for most scenarios, the tipping point concentrations were less than the concentrations of contaminants proposed by the different levels of treatment. Tipping point concentrations and loads were also smaller than the existing case due to the projected increase in EP in the future. This reinforces the finding that the scenarios that were modelled will only partially meet the NorBE requirements.

Concentrations of contaminants in the receiving waters upstream of the discharge locations are often in excess of the relevant ANZECC guidelines. Therefore, it is unlikely that ANZECC guidelines will be met at locations downstream of the discharge location. Relatively high upstream concentrations suggest one or more sources of contaminants (in addition to the STP discharges) – possibly from diffuse sources such as rural runoff. However, the results from the MLE and FSB (and some IDEA) scenarios will result in a reduction in the concentrations of contaminants in the receiving waters and a relative improvement in water quality.

The concentrations of TSS in the effluent were often less than that in the background waters. The consequence of this is that the concentrations of contaminants at DS-2 exceed those at DS-1.

Table E–1–1. Bowral (EP=18,692): NorBE annual loads and concentrations for the existing data and for the 'tipping point'

	Concentrations (mg/L)				Annual loads (kg/year)	
	Existing		Tipping point		Existing	Tipping point
	50%	90%	50%	90%		
TSS	4.0	8.2	2.6	5.7	6,670	6,110
TN	4.75	6.44	3.24	4.34	6,530	6,380
TP	0.135	0.244	0.101	0.182	220	215

Table E–1–2. Bowral (EP=18,692): NorBE concentration results and annual loads for each scenario

	Concentrations (mg/L)			Annual load (kg/year)			
	IDEA	MLE	FSB	Existing	IDEA	MLE	FSB
TSS	×	×	×	6,670	10,860	11,170	10,790
TN	×	marginal	✓	6,530	13,830	9,980	6,120
TP	×	marginal	marginal	220	480	280	260

Cells shaded pink indicate a failure of the NorBE conditions, while cells shaded green indicate that the relevant NorBE conditions are met. Cells that are unshaded fail the relevant NorBE condition although the value is within about 10% of the NorBE criteria.

Table E–1–3. Bowral (EP=18,692): Contaminant concentrations (50% and 90%iles) at DS-1 and DS-2 for each scenario

	Concentrations (mg/L)					
	TSS		TN		TP	
ANZECC	25		0.25		0.02	
Background (50%ile)	N/A		2.0		0.10	
	50%	90%	50%	90%	50%	90%
DS-1						
Existing	11	44	4.5	6.4	0.12	0.21
IDEA	11	42	5.6	8.8	0.16	0.41
MLE	11	41	4.3	6.2	0.09	0.25
FSB	11	42	2.9	4.4	0.10	0.24
DS-2						
Existing	17	65	3.8	5.7	0.12	0.17
IDEA	18	64	4.2	7.3	0.13	0.30
MLE	17	63	3.7	5.3	0.10	0.18
FSB	18	64	2.8	4.0	0.10	0.18

Cells shaded green indicate an improvement in water quality compared with the existing conditions.

Contents

TABLES

FIGURES

1. Introduction

This report details the results from (a) data statistical analyses and (b) numerical modelling, of the concentrations of contaminants discharged from the Bowral Sewage Treatment Plant (STP) which enters the Wingecarribee River. The primary aim of the work presented in this report is to estimate future conditions that may occur from each of a number of options for sewage treatment. This will help demonstrate that, based on suitable design parameters, discharges from the STPs will minimise risk and environmental impact to the waterways into which the discharge occurs.

The broad approach adopted in this study is to use existing data to establish a set of baseline conditions. Modelled concentrations of contaminants associated with a number of possible future scenarios are used to estimate concentrations of these contaminants in the receiving waters. Such future concentrations can be compared with the baseline conditions to quantify improvements (or otherwise) in water quality resulting from the proposed STP upgrades.

1.1. Background

The Wingecarribee Shire is located west of Wollongong in NSW's Southern Highlands and lies in the catchment that supplies the bulk of Sydney's drinking water. It covers an area of approximately 2,700km^2 and contains the towns of Mittagong, Bowral, and Moss Vale.

At present, the three sewage treatment plants (STPs) in these towns are operating close to capacity and associated load limits and effluent quality may start impacting the receiving water quality. Hence, there is a need to increase the capacity of the STPs. Reflecting continual improvement, the level of sewage treatment in the STPs would be also upgraded.

As a part of the upgrade process for these three STPs, the NSW Environment Protection Authority (EPA) has requested that an assessment be undertaken of the existing conditions in the three waterways into which the effluent is discharged. An understanding of the existing and likely future water quality impacts is critical to deciding on an appropriate upgraded level of sewage treatment.

The following report focuses on the Bowral sewerage system.

NSW Government's Manly Hydraulics Laboratory (MHL) has prepared this report with following aims:

- Document the current information available about the local environment, water quality of receiving waterways, and STP discharges
- Identify possible gaps in the knowledge the receiving water quality
- Quantify and assess the existing condition of the receiving waterways
- Describe the monitoring performed between 2019-20
- Assess the current impact of the STP discharge on the receiving waterways
- Model the impacts of the proposed upgrades on the receiving waterways and compare the results with the ANZECC guidelines

- Undertake a NorBE assessment of the STP discharge.

1.2. Structure of this report

Below is an outline of the work presented in this report.

Section **Error! Reference source not found.**: Executive summary. A broad summary of the results presented in this report.

Section **Error! Reference source not found.**: Introduction. Background information on the project, the Bowral STP and the monitoring data used in this study.

Section **Error! Reference source not found.**: Existing conditions. Summary of the results from the analyses of existing data – both effluent and river water quality. This includes information from both the long-term monitoring and from the 3-month monitoring program that forms part of this project. More detailed results are provided in Appendix B.

Section **Error! Reference source not found.**: Scenario modelling. Summarises the Monte Carlo approach to the modelling. Details the scenarios that are modelled together with the input data (concentrations of contaminants in effluent and background or upstream, effluent and river flow data). Estimates the modelled downstream concentrations for the existing and future conditions based on the scenarios examined.

Section **Error! Reference source not found.**: Neutral or Beneficial Effects (NorBE) assessment. An assessment of the loads and concentrations of contaminants in the future effluent scenarios that are modelled and a comparison with the 2013-2019 conditions. Includes an estimate of the 'tipping point' concentrations i.e. the concentrations of contaminants in the effluent that will just meet the NorBE requirements.

Section **Error! Reference source not found.**: Summary and conclusions. Summary of the results presented and an overall interpretation of the results from modelled scenarios.

Section **Error! Reference source not found.**: References.

Appendix A. Description of the analytes used in this study.

Appendix B. Supplementary data analyses. Provides additional statistical analyses to that presented in Section **Error! Reference source not found.**.

Appendix C: Modelling details. Supplements the work presented in Section 4**Error! Reference source not found.**, providing additional details to the modelling work undertaken.

1.3. Bowral STP Licence Conditions

The Bowral STP is located in the Wingecarribee River catchment near the township of Burradoo, a few kilometres south of Bowral. The Bowral STP includes the following treatment processes: activated sludge, tertiary filtration, phosphorus removal and UV disinfection. The licenced maximum discharge is 14.7 ML/day.

Treated effluent is transferred via a pipeline approximately 1.5 km long and discharges directly into the Wingecarribee River approximately 30 m downstream from Railway Rd. The

Wingecarribee River flows past the township of Berrima (approximately 5 km downstream from the discharge point) and eventually meets the Wollondilly River, which then flows into Lake Burragorang. Effluent discharged from the STP flows approximately 120 km before reaching the Lake.

Under wet weather conditions, treated effluent is discharged to Mittagong Creek, adjacent to the STP, thence into the Wingecarribee River (approximately 150 m downstream from Railway Rd (Figure 1–1).

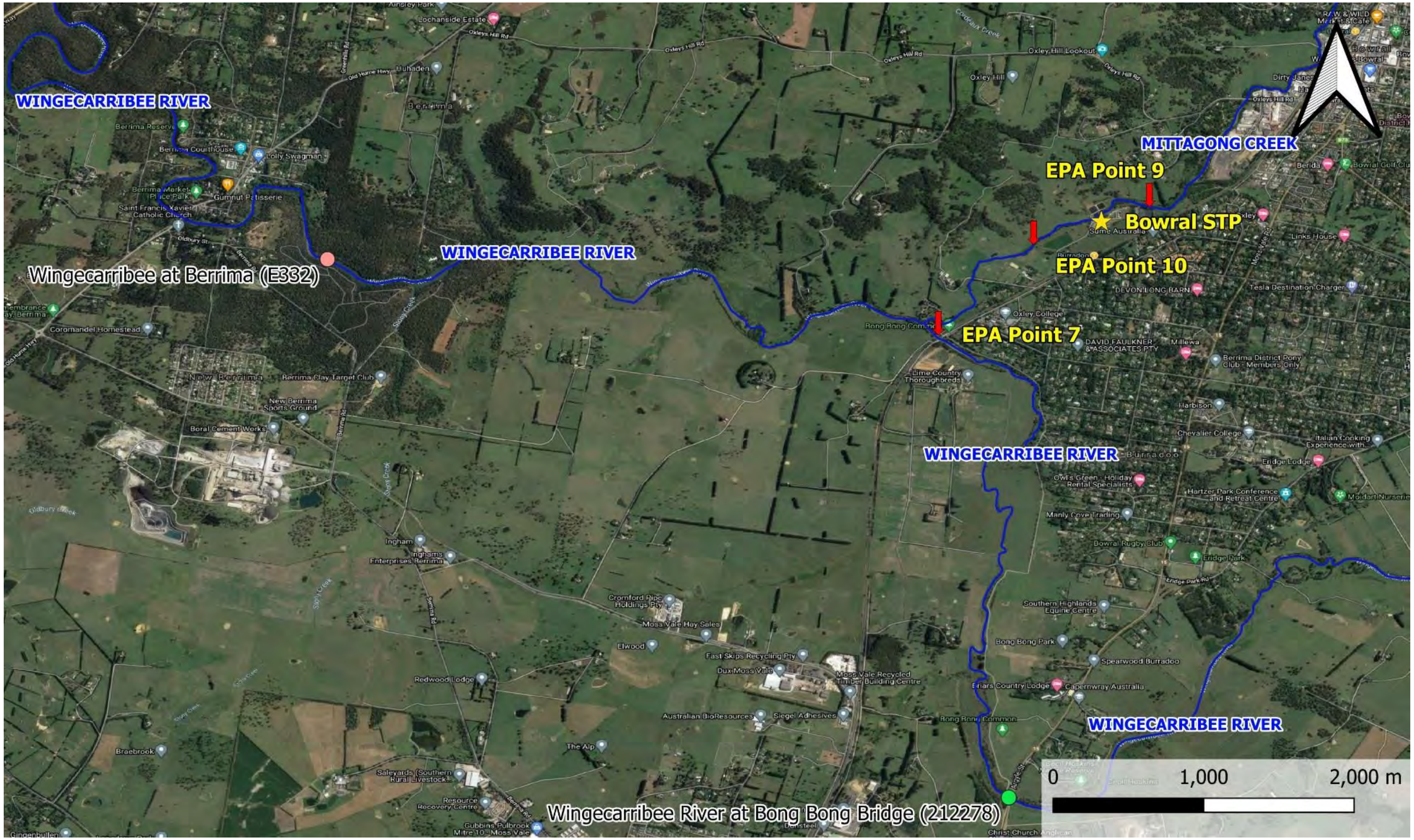

Figure 1–1. Bowral STP and receiving waters.

The concentration and annual load limits for the Bowral effluent are presented in Table 1–1. The current license arrangement allows for 14.7 ML/day combined discharge from the STP. Additionally, dry weather discharge must only occur at Point 7. Routine monitoring for effluent quantity and quality is required under the Environmental Protection Licence number 1794 (EPL, 2018).

Table 1–1. Concentration and Load Limits for Bowral STP

	Concentrations					Loads
Pollutant	Units	50%ile limit	80%ile limit	90%ile limit	100%ile limit	Annual load (kg)
Ammonia	mg/L	n/a	n/a	2	n/a	n/a
BOD	mg/L	5	n/a	10	n/a	11,000
Faecal Coliforms	cfu/100mL	n/a	200	n/a	n/a	n/a
Total Nitrogen	mg/L	7.5	n/a	10	n/a	27,500
pH	pH	n/a	n/a	n/a	6.5-8.5	n/a
Total Phosphorus	mg/L	0.3	n/a	0.5	n/a	1,650
Total suspended solids	mg/L	10	n/a	15	n/a	11,000
Oil and grease	mg/L	n/a	n/a	n/a	n/a	2,200

NOTE: ‘n/a’ indicates that there is no associated limit. These cells are also shaded.

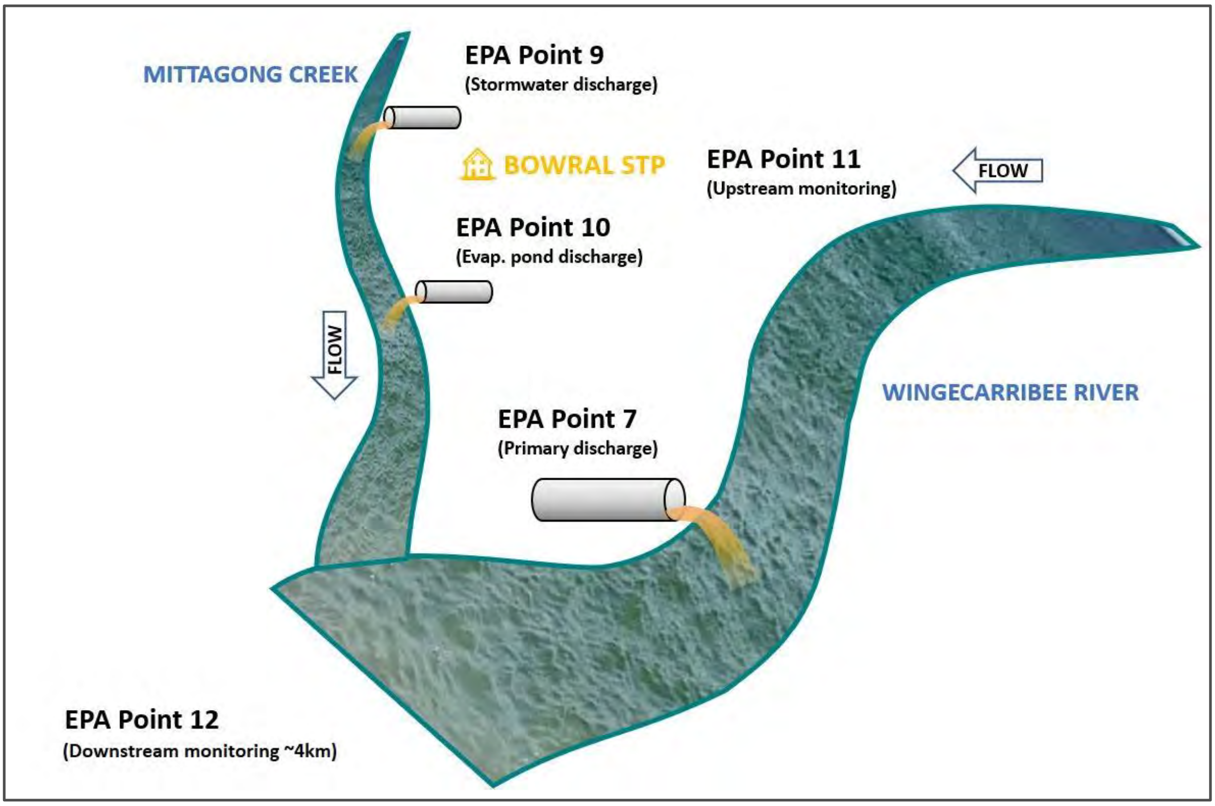

Figure 1–2. Bowral STP Licence Schematic

1.4. Long Term Monitoring Data

Long term monitoring is undertaken at a number of locations in the STP and in the receiving waters. The locations and variables measured at each location are shown in **Table 1–2**. Locations that are owned and operated by WaterNSW are for the purposes of auditing the quality of Sydney's drinking water supply. Data from these sites were used extensively to understand the current conditions of the receiving waterways.

Table 1–2. Long-term monitoring locations and variables measured

WaterNSW code	Site Description and Variables Measured	Latitude (°S)	Longitude (°E)	Period of Record
E332 (212272)	Wingecarribee River at Berrima (Q, EC, turbidity, T, pH, DO, faecal coliforms, enterococci, metals)	-34.49622	150.34153	2000-2020
212031	Wingecarribee River at Bong Bong Weir (Q)	-34.53472	150.36995	1982-2020
212075	Wingecarribee River at Sheepwash Bridge (Q, EC, T)	-34.53726	150.48082	1972-2020
212278	Wingecarribee River at Bong Bong Bridge: (turbidity, pH, DO, EC, Enterococci, E. Coli, TP, TN, filterable phosphorus, nitrate/nitrite, NH3, filtered and total manganese, filtered and total aluminium)	-34.5333	150.3918	1989-2019
STP licences	**Site Description and Variables for Licencing**	**Latitude (°S)**	**Longitude (°E)**	**Dates Analysed**
Bowral STP EPA Point 1	Satisfies monitoring for Point 7 (algae, chlorophyll, BOD, EC, nutrients, metals, pH, TSS, FC, oil and grease)	-34.49139	150.39889	2013-2019
Bowral STP EPA Point 7	Normal discharge to Wingecarribee River (see Point 1)	-34.50000	150.38667	2013-2019
Bowral STP EPA Point 8	Volume monitoring (Q)	-34.49139	150.39889	2013-2019
Bowral STP EPA Point 9	Wet weather discharge from detention ponds to Mittagong Creek (Q)	-34.49056	150.40194	2013-2019
Bowral STP EPA Point 10	Wet weather discharge from evaporation pond to Mittagong Creek (Q)	-34.49333	150.39417	2013-2019
Bowral STP EPA Point 11	Receiving waters: 25 m upstream of discharge to Wingecarribee River (alkalinity, BOD, EC, NH3, TN, NO2, NO3, TP, pH, FC, TSS, oil and grease)	-34.50000	150.38667	2013-2019
Bowral STP EPA Point 12	Berrima Weir, 5 km downstream of discharge to Wingecarribee River (alkalinity, BOD, EC, NH3, TN, NO2, NO3, TP, pH, FC, TSS, oil and grease)	-34.49417	150.34222	2013-2019

NOTES:

Coded references Q=flow, EC=electrical conductivity, T=temperature, DO=dissolved oxygen, BOD=biochemical oxygen demand, FC=faecal coliforms, NH3=ammonia, TN=total nitrogen, NO2=nitrite, NO3=nitrate, TP=total phosphorus, TSS=total suspended solids.

Other variables may also be measured at selected locations.

Not all variables are available for all times.

1.5. Environmental Monitoring: 2019-2020

Initial investigations undertaken as part of this study included data acquisition and statistical analysis, including temporal trends. Results identified several data (and knowledge) gaps that could be filled by undertaking a supplementary data collection program. Two major gaps were in the data were identified: (a) a general lack of data from upstream of the discharge locations, and (b) very limited information of the level of natural variability in the system.

The former is important because it enables a broad assessment of the relative contribution of the STP discharges with other sources, to the river water quality. For example; if the STP effluent contains a very small concentration of a particular contaminant (relative to other sources of the same contaminant such as agricultural inputs and discharges from mines) then reducing the concentration of that contaminant in the STP effluent will have little effect on the river water quality and river health. The latter is important because it enables us to quantify the amount of system variability that can be attributed to natural processes. If the background or upstream variability of a contaminant is high then it will be difficult to determine whether an observed change is simply due to natural variability or to the STP discharge.

Extensive discussions were held with Wingecarribee Shire Council, resulting in the design of a three-month monitoring program. Primarily, this program was designed to help fill the identified data gaps, characterise the existing impact of the STP discharges on the environment, and aid modelling for the design conditions associated with the different scenarios. A draft monitoring program was presented to the NSW EPA in October 2019. Based on comments and suggestions made by the NSW EPA several modifications were made to the original program design. These included monitoring for ions and enterococci, an examination of giardia and cryptosporidium and the effectiveness of UV in reducing their concentrations, and the use of alternate reference locations for the macroinvertebrate studies. (It is noted that the macroinvertebrate studies are conducted over several years and results are not yet available. Further, the effectiveness of UV disinfection in reducing concentrations of giardia and cryptosporidium was restricted to the Mittagong system and those results are not presented in this report). The following receiving water and effluent quality program was finalised and executed:

- Samples were collected on three occasions: 18 December 2019, 16 January 2020 (both under dry weather conditions) and on 20 February 2020 (under wet weather conditions).
- Samples were collected from each of the three river systems: Wingecarribee River (Bowral STP), Gibbergunyah Creek (Mittagong STP) and Whites Creek (Moss Vale STP). Only the Wingecarribee River data are used in this report.

- There were: (i) two locations upstream of the discharge point (one nominally 50 m upstream and the other nominally 1,000 m upstream of the discharge point), (ii) the effluent stream (or discharge point), and (iii) two locations downstream of the discharge point: one nominally 50 m downstream and the other between about 500 m and 5,000 m downstream of the discharge point. Where possible, the sampling locations coincided with existing water quality monitoring locations.
- Samples from the STP effluent were collected at 4 different times, approximately 2 hours apart.
- Two replicate samples were collected for each variable at each location / time. Replicates were collected between 5 and 10 minutes apart.
- Samples were analysed for 47 variables (listed in Table 2–11).

The list of the analytes and each one's importance to human health and the environment is given in Appendix A. Detailed analysis of these data forms part of Appendix B.

In addition to the sampling described above, the adopted monitoring program also includes a 2-year macroinvertebrate monitoring program. The purpose of this program is to determine the ecological impact of the STPs on the receiving waterways. Macroinvertebrate sampling will be conducted in accordance with AUSRIVAS protocols for New South Wales (Turak & Waddell, 2002) and will be used as a primary indicator for biodiversity and ecological health of the riverine systems. Results from this monitoring will be available mid-2021.

2. Existing Conditions

Water quality conditions in the Wingecarribee River were based on a set of objectives arising from the environmental values of the system; that is, the values of the people and ecosystems which rely upon them; as well as the overall land usage of the catchment.

Analyses of the effluent and water quality data in this section are based on the long-term licence conditions (for the effluent) and the two river monitoring locations; just upstream of the discharge point and at Berrima Weir (approximately 5 km downstream of the discharge point). Results from the 3-month, short term monitoring program are presented in Section 3.5.

Note: no replicates were taken for the historical data, hence the level of natural variability cannot be estimated and the likelihood of a Type II statistical error cannot be quantified.

2.1. Current Land Uses

The primary land use zones surrounding the Wingecarribee River downstream of the STP include residential, dryland agriculture, natural environments, and a small amount of industry. A map of the land use zones from 2016 is presented in **Figure 2–1**.

There are currently 29 diversion pumps and 12 storages (dams) within the catchment, some of which lie upstream of the STP discharge point. Combined, the diversions are licensed to extract approximately 1,000 ML of water from the river per year. The primary use of these diversions is for crop irrigation, although there is also at least one stock watering facility and one industrial diversion pump downstream of the STP. Water rights for this catchment allow adjacent land holders to extract water from the waterway without a license for domestic and stock purposes. Local landholders also have the right to build dams on minor streams. Such dams are allowed to capture no more than 10% of average rainfall induced runoff. The Greater Metropolitan Region Unregulated Water Sources Water Sharing Plan (2011) estimated that 21 ML/day was extracted from the Upper Nepean and Warragamba systems under these basic rights.

The natural ecosystems which rely upon the Wingecarribee River system are primarily the instream ecosystem and surrounding riparian corridor. Therefore, it is critical that the river maintains a continual baseflow and that a baseline quality of water is achieved.

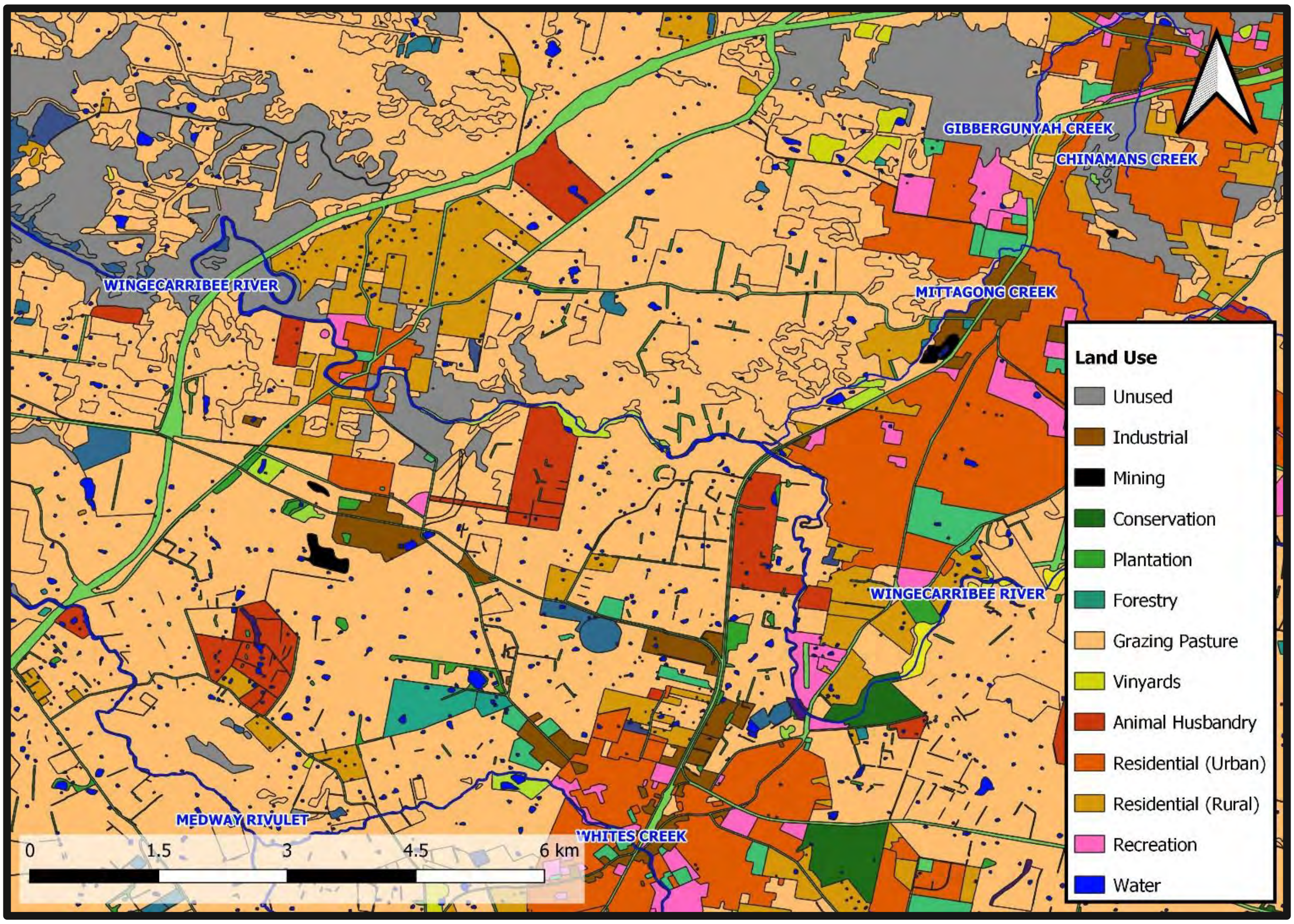

Figure 2–1 – Land Use Zoning of Wingecarribee River Catchment

2.2. Environmental Values

Waters from the Wingecarribee River eventually make their way to Lake Burragorang, the primary drinking water supply for the population of Sydney. The environmental values assigned to this waterway are found under the *Mixed-use Rural and Drinking Water with Clarification and Disinfection* region in the Healthy Rivers Inquiry into the Hawkesbury-Nepean River System (1998). The environmental values identified in that report are:

- Aquatic ecosystems
- Primary contact recreation
- Secondary contact recreation
- Visual amenity
- Drinking water – clarification and disinfection
- Irrigation water supply
- Homestead water supply

- Aquatic foods (cooked)

No site-specific environmental values or objectives have been highlighted for this region.

2.3. Effluent Quality

Statistics were generated based on an analysis of STP discharge data between 2013 and 2019 at the licence monitoring Point 1 (which satisfies the licence requirement for monitoring at Point 7). These are presented below in Table 2–1. The numbers in red brackets are the relevant EPA annual licence limits. Detailed analysis of STP data can be found in Section **Error! Reference source not found.**, Appendix B, including an assessment of the concentrations under wet weather conditions.

Table 2–1. Bowral STP Effluent Constituents (2013-19)

Variable	Units	Number	50th Percentile	80th Percentile	90th Percentile	100th Percentile
BOD	mg/L	165	2 (5)	3	4 (10)	12
TSS	mg/L	165	4 (10)	6	8 (15)	16
Conductivity	µS/cm	134	56.5	60.0	61.2	66.0
Ammonia	mg/L	165	0.6	1.01	1.3 (2)	2.6
Nitrite	mg/L	165	0.157	0.227	0.28	2.04
Nitrate	mg/L	165	3.59	4.47	5.03	7.53
Oxidised nitrogen	mg/L	165	3.7	4.53	5.1	7.53
Total nitrogen	mg/L	165	4.8 (7.5)	6.03	6.61 (10)	8.47
Total phosphorus	mg/L	165	0.135 (0.3)	0.21	0.255 (0.5)	0.67
pH		165	7.4	7.6	7.7	6.8-7.9 (6.5-8.5)
Faecal coliforms	cfu / 100mL	165	7	35 (200)	72	2500
Oil and grease	mg/L	165	2.5	2.5	2.5	2.5
Alkalinity	mg/L, CaCO3	162	62.6	71.8	76.62	87.2

*Figures in red brackets are the licence limits.

Data analysed for the combined 2013 to 2019 period meet the licence conditions. Results from each of the individual calendar years also met the relevant licence conditions.

A trend analysis was undertaken using effluent data collected from the Bowral STP between 2013 and 2019. To test the sensitivity of the time period on the slope of the trend line, the trend analysis was repeated only using data over a two-year period between 2017 and 2019. The results are summarised in Table 2–2. Arrows indicate whether the slope of the linear regression line is increasing (‘up’ arrow) or decreasing (‘down’ arrow). The statistical significance of the slope of the regression line (i.e. to determine whether it was significantly different from a line of zero slope) was tested using a t-test (e.g. Walpole, 1974). Cells that are shaded indicate that the trend line is, statistically, significantly different from a slope of zero.

For most variables, the slope of the regression line was negative, and not significantly different from a slope of zero. Statistically significant increasing trends were identified for nitrite and alkalinity (for the 2013-2019 period) and for alkalinity (for the 2017-2019 period). Assuming these linear trends continue with the same slope, the relevant concentrations (from the trend line) would exceed the 50%ile licence conditions by the year 2042, by which time changes to the sewage treatment process are likely to have improved the effluent quality.

Table 2–2. Temporal trends in the Bowral STP data.

Variable	2013-2019		t-calc	2017-2019	
	slope	significance	t-crit = +/-1.97	slope	significance
BOD	↓	NSD	-0.68	↓	NSD
TSS	↑	NSD	1.93	↓	NSD
Conductivity	↑	NSD	1.58	↑	NSD
Ammonia	↓	NSD	-0.25	↑	NSD
Nitrite	↑	SIG	2.49	↓	NSD
Nitrate	↓	NSD	-0.61	↓	NSD
Oxidised nitrogen	↓	NSD	-1.24	↓	NSD
Total nitrogen	↓	SIG	-10.57	↓	NSD
Total phosphorus	↓	NSD	-1.89	↓	NSD
pH	↓	NSD	-1.50	↓	NSD
Oil and grease	No temporal change				
Faecal coliforms	↓	NSD	-1.06	↓	NSD
Alkalinity	↑	SIG	3.60	↑	SIG

Arrows pointing up indicate an increasing trend over the time period.
Arrows pointing down indicate a decreasing trend over the time period.
NSD = the slope of the linear trend line is not statistically different from a slope of zero at the 5% level of significance.
SIG = the slope of the linear trend line is statistically different from a slope of zero at the 5% level of significance.

Estimates of the concentrations of contaminants under dry and wet weather conditions are shown in Table 2–3. Wet weather concentrations are based on combined concentrations from Points 9 and 10. The median, mean absolute difference, average and standard deviation are shown for each contaminant. Note: the median and mean absolute difference are generally more appropriate estimators of the 'central tendency' and 'dispersion' than the more commonly used mean and variance.

Concentrations under dry and wet weather conditions were compared (Section **Error! Reference source not found.**, Appendix B). A summary of the results is provided in Table 2–3. In general, the concentrations in the wet weather discharge ponds exceeded those at the dry weather monitoring location.

Table 2–3. Estimated concentrations under dry and wet weather conditions

		Dry weather component				Wet weather component			
Variable	Units	Med.	MAD*	Mean	Stdev.	Med.	MAD*	Mean	Stdev.
BOD	mg/L	2.00	1.18	2.25	1.46	3.00	2.15	3.65	3.01
TSS	mg/L	4.00	2.03	4.39	2.70	9.00	5.20	10.69	6.75
Conductivity	μS/cm	56.50	14.44	54.67	6.96	34.30	4.39	34.29	5.72
Ammonia	mg/L	0.60	0.35	0.67	0.45	1.90	0.99	2.29	1.29
Nitrite	mg/L	0.15	0.08	0.18	0.17	0.10	0.06	0.12	0.10
Nitrate	mg/L	3.60	0.81	3.67	1.08	1.12	0.62	1.32	0.81
Oxidised nitrogen	mg/L	3.71	0.80	3.77	1.08	1.23	0.65	1.44	0.85
Total nitrogen	mg/L	5.66	0.96	5.73	1.22	4.77	1.56	4.78	2.06
Total phosphorus	mg/L	0.14	0.06	0.16	0.10	0.60	0.16	0.63	0.23
pH		7.40	0.15	7.43	0.18	7.20	0.24	7.20	0.29
Faecal coliforms (log10)	(log10) cfu / 100mL	0.78	0.62	0.90	0.76	3.72	0.77	3.93	0.89
Oil and grease	mg/L	2.50	0.00	2.50	0.00	2.50	0.33	2.67	1.02
Alkalinity	mg/L, CaCO3	62.60	9.20	62.90	10.11	No data			

*MAD is the mean absolute difference.

Using information from Table 2–3, estimates can be made of the average pooled concentration of contaminants discharged to Wingecarribee River as a function of the proportion of dry and wet weather flow (Box 1).

Box 1: Estimating the average pooled concentrations of contaminants as a function of dry and wet weather concentrations.

$$Load_{TOTAL} = Load_{DRY} + Load_{WET}$$

$$Load = Flow\ (Q) \times Concentration\ (C)$$

Hence: $$Q_{TOTAL} \times C_{POOLED} = Q_{DRY} \times C_{DRY} + Q_{WET} \times C_{WET}$$

Assume that: $$Q_{DRY} = (1-x)\, Q_{TOTAl} \quad and \quad Q_{WET} = x\, Q_{TOTAL}$$

Where x is the proportion of wet weather flow to the total flow.

Then: $$Q_{TOTAL} \times C_{POOLED} = (1-x)\, Q_{TOTAl} \times C_{DRY} + x\, Q_{TOTAL} \times C_{WET}$$

And: $$C_{POOLED} = (1-x)\, C_{DRY} + x\, C_{WET}$$

Results are presented in Table 2–4.

Using the t-test for difference of means, statistically significant (at the 5% level) differences between the average dry weather concentrations and the average combined dry / wet weather concentrations occur when the proportion of wet weather exceeds about 10% of the combined conditions. That is, if the wet weather contributes less than about 10% to the dry / wet weather combination, then the resultant concentrations cannot be distinguished from concentrations obtained under dry weather conditions.

Table 2–4. Estimated concentrations as a proportion of dry / wet weather flows

Variable	Units	Dry	Wet	Proportion of wet weather flow to total discharge				
		Mean	Mean	0.05	0.10	0.20	0.30	0.50
BOD	mg/L	2.25	3.65	2.32	2.39	2.53	2.67	2.95
TSS	mg/L	4.39	10.69	4.70	5.02	5.65	6.28	7.54
Conductivity	µS/cm	54.67	34.29	53.66	52.64	50.60	48.56	44.48
Ammonia	mg/L	0.67	2.29	0.75	0.84	1.00	1.16	1.48
Nitrite	mg/L	0.18	0.12	0.18	0.18	0.17	0.17	0.15
Nitrate	mg/L	3.67	1.32	3.56	3.44	3.20	2.97	2.49
Oxidised nitrogen	mg/L	3.77	1.44	3.65	3.53	3.30	3.07	2.60
Total nitrogen	mg/L	5.73	4.78	4.87	4.87	4.86	4.85	4.83
Total phosphorus	mg/L	0.16	0.63	0.18	0.21	0.25	0.30	0.40
pH		7.43	7.20	7.42	7.41	7.39	7.36	7.31
Faecal coliforms (log10)	(log10) cfu / 100mL	0.90	3.93	1.05	1.21	1.51	1.81	2.42
Oil and grease	mg/L	2.50	2.67	2.51	2.52	2.53	2.55	2.58

2.4. River Water Quality

To assess the existing conditions in the Wingecarribee River, a temporal trend analysis was undertaken using the data collected as part of the WaterNSW long-term measurement program. Only some variables were used for these analyses, the main selection criteria being:

- At least 90% of data were above the Limit of Reading (LoR). Broadly, the LOR is the detection limit associated with the specific analytical test.
- ANZECC default guidelines, where available for the variables.

On the Wingecarribee River, long-term data from one upstream and one downstream location are available.

2.4.1. Upstream Concentrations

Upstream monitoring is required as part of the EPA licence conditions at Point 11 on the Wingecarribee River. Point 11 is located about 25m upstream of the location where the effluent from Bowral STP enters the Wingecarribee River. Basic statistics of the upstream river water quality data are given in Table 2–5. Median concentrations (Table 2–5) generally lie below the STP concentrations (Table 2–3). One notable exception is faecal coliforms, the results from which suggest a source of faecal contamination upstream of the STP discharge location.

Table 2–5. Basic statistics of water quality parameters at Point 11

Variable	Units	Number	Min.	Max.	Median	M.A.D.	Mean	StDev
BOD	mg/L	149	0.00	6.00	1.00	0.64	1.26	0.95
TSS	mg/L	140	3.00	52.00	24.00	6.13	23.89	8.21
Conductivity	μS/cm	134	7.60	44.20	16.05	4.32	17.07	7.00
Ammonia	mg/L	149	0.01	0.30	0.05	0.03	0.07	0.05
Nitrite	mg/L	140	0.00	0.13	0.004	0.010	0.010	0.021
Nitrate	mg/L	140	0.01	1.94	0.05	0.18	0.17	0.32
Oxidised nitrogen	mg/L	140	0.01	2.02	0.05	0.20	0.18	0.34
Total nitrogen	mg/L	149	0.49	4.46	0.94	0.33	1.09	0.54
Total phosphorus	mg/L	149	0.02	0.25	0.059	0.019	0.067	0.030
pH		149	6.10	7.60	7.30	0.12	7.24	0.18
Faecal coliforms (log10)	(log10) cfu / 100mL	149	1.28	3.95	2.30	0.38	2.29	0.49
Oil and grease	mg/L	Insufficient data above the limit of reading for reliable statistics						
Alkalinity	mg/L, CaCO3	139	14.40	60.50	28.30	7.03	30.14	9.29

M.A.D. is the mean absolute deviation.

Linear temporal trends in the data anomalies were assessed over two time periods: the calendar years 2013-2019 and 2017-2019. Two time periods were chosen to explore the stability of any trends over time. The 5% level of significance was used to compare the slope of the trend lines with a slope of zero (i.e. no change over time). Further details of this analysis are presented in Section **Error! Reference source not found.**, Appendix B

Trends in river water quality (Point 11) are shown in Table 2–6. For most variables, the temporal trends are not statistically different from zero (at the 5% level).

- BOD concentrations are increasing, although the slope is only just significantly different from zero.
- Both ammonia and pH have decreasing concentrations.
- Prior to 2017, many ammonia concentrations were at the limit of reading. This is the likely reason for the significant slope of the ammonia regression line.
- The slope of the regression line for alkalinity is not significantly different from zero, although it is close to the critical value.

The analysis was repeated using data from 2017-2019 and (with the exception of alkalinity) the results are consistent with those from the longer term. It is unclear why the trend in alkalinity should change markedly. Removal of the one outlier at the end of the pH data set, did not change the result.

Table 2–6. Temporal trends in concentrations at Point 11

Variable	2013-2019		t-calc	2017-2019	
	slope	significance	t-crit= +/-1.98	slope	significance
BOD	↑	SIG	1.98	↓	NSD
TSS	↑	NSD	0.16	↑	NSD
Conductivity	↑	NSD	1.79	↑	NSD
Ammonia	↓	SIG	-7.18	↓	NSD
Nitrite	↓	NSD	-0.01	↑	NSD
Nitrate	↓	NSD	-0.54	↑	NSD
Oxidised nitrogen	↓	NSD	-0.54	↑	NSD
Total nitrogen	↓	NSD	-1.57	↓	NSD
Total phosphorus	↑	NSD	0.52	↑	SIG
pH	↓	SIG	-3.24	↓	SIG
Oil and grease	Insufficient data above limit of reading for reliable statistics				
Faecal coliforms	↑	NSD	0.11	↑	NSD
Alkalinity	↑	NSD	1.96	↓	SIG

Arrows pointing up indicate an increasing trend over the time period.
Arrows pointing down indicate a decreasing trend over the time period.
NSD = the slope of the linear trend line is not statistically different from a slope of zero at the 5% level of significance.
SIG = the slope of the linear trend line is statistically different from a slope of zero at the 5% level of significance.

A t-test can be used to investigate the significance of the differences between the means of the discharges from the STP and at Point 11 (upstream).

The results (Table 2–7) indicate the concentrations of substances discharged from Point 11 are significantly lower than the concentrations of substances discharged from the STP. This is generally consistent with expectations. Two exceptions were total suspended solids and faecal coliforms. Upstream faecal coliform concentrations substantially greater than the STP concentrations is unusual. This result suggests one or more upstream source(s) of faecal contamination, although corresponding elevated concentrations of nutrients (not observed here) would also be expected.

Table 2–7. Comparing data from STP and Point 11

Variable	Averages		t-calc	Results	
	STP	Point 11	t-crit = +/-1.98	Difference	Significance
BOD	2.32	1.26	7.49	STP > Point 11	SIG
TSS	4.50	23.97	-25.18	Point 11 > STP	SIG
Cond.	54.59	16.92	54.81	STP > Point 11	SIG
Ammonia	0.70	0.07	15.72	STP > Point 11	SIG
Nitrite	0.18	0.01	10.66	STP > Point 11	SIG
Nitrate	3.66	0.17	33.93	STP > Point 11	SIG
Oxidised nitrogen	3.77	0.18	34.90	STP > Point 11	SIG
Total nitrogen	5.73	1.10	40.93	STP > Point 11	SIG
Total phosphorus	0.17	0.07	13.06	STP > Point 11	SIG
pH	7.43	7.25	10.60	STP > Point 11	SIG
Oil and grease	Insufficient data above limit of reading				
Faecal coliforms (log10)	0.92	2.28	-19.19	Point 11 > STP	SIG
Alkalinity	61.72	30.28	27.38	STP > Point 11	SIG

There are only very limited data for oil and grease that are above the limit of reading. Therefore, the results are not reliable.
NSD = the two means are not statistically different at the 5% level of significance.
SIG = the two means are statistically different at the 5% level of significance.

2.4.2. Downstream Concentrations

STP licence monitoring is required at Point 12, which is located on the Wingecarribee River at Berrima Weir, about 5 km downstream of the location where the effluent from Bowral STP enters the river. This location is also a monitoring location for WaterNSW (site E332). Analyses using the WaterNSW data are detailed in Section **Error! Reference source not found.**, Appendix B.

The distance between the STP discharge point and Berrima Weir is relatively long. Consequently, time and distance travelled, diffuse sources, and other (unknown) point sources, may confound the results. Therefore, this location may not be suitable to assess impacts on water quality directly resulting from the Bowral STP discharges. (Diffuse sources in the Wingecarribee catchment may contribute 90% of nutrients, Olley and Deere, 2003).

Basic statistics of the upstream river water quality data are given in Table 2–8. Median concentrations (Table 2–8) generally lie below the STP concentrations (Table 2–3), again with the notable exception of faecal coliforms.

Table 2–8. Basic statistics at Point 12

Variable	Units	Number	Min.	Max.	Median	M.A.D.	Mean	StDev
BOD	mg/L	149	1.00	9.00	1.00	0.68	1.46	1.00
TSS	mg/L	139	2.00	27.00	8.00	3.85	9.45	5.36
Conductivity	µS/cm	133	9.20	41.00	24.90	5.81	23.85	7.47
Ammonia	mg/L	149	0.005	0.500	0.050	0.030	0.069	0.049
Nitrite	mg/L	139	0.001	0.059	0.007	0.004	0.008	0.007
Nitrate	mg/L	139	0.01	1.26	0.14	0.15	0.19	0.21
Oxidised nitrogen	mg/L	139	0.01	1.30	0.15	0.16	0.20	0.21
Total nitrogen	mg/L	139	0.49	2.35	1.00	0.29	1.02	0.31
Total phosphorus	mg/L	149	0.010	0.321	0.042	0.023	0.053	0.039
pH		149	6.10	8.20	7.60	0.17	7.54	0.26
Faecal coliforms (log10)	(log10) cfu / 100mL	149	0.00	4.08	2.00	0.43	2.04	0.56
Oil and grease	mg/L	Insufficient data above limit of reading						
Alkalinity	mg/L, CaCO3	138	14.60	70.50	42.05	10.55	41.98	12.80

M.A.D. is the mean absolute deviation.

The significance (at the 5% level) of the slope of the linear regression line is given in Table 2–9 for the two time periods 2013-2019 and 2017-2019. Results are summarised below.

- Results for the period 2013-19 are consistent with the results for the 2017-19 period.
- Prior to 2017, many results for ammonia were below the limit of reading. This is likely the reason for the significant slope of the regression line.
- The last 3 data points for nitrate are high. Although there is no justification to change them, their removal from this analysis results in a change in the slope of the trend line.

Hence, these results should be treated with some caution.

- Total nitrogen shows a significant decreasing trend, although the impact of ammonia (as noted above) may be the reason for the significance of this trend.
- The significant decreasing trend in pH using the 2017-19 data is a result of the single low reading at the end of the data set.
- There is a significant decreasing trend in faecal coliforms. While the trend remains in the 2017-19 data, the slope of the regression line is not significantly different from a slope of zero.

Table 2–9. Temporal trends in concentrations at Point 12

Variable	2013-2019		t-calc	2017-2019	
	slope	significance	t-crit= +/-1.98	slope	significance
BOD	↑	NSD	0.48	↓	NSD
TSS	↓	SIG	-2.01	↓	NSD
Conductivity	↑	SIG	4.05	↑	SIG
Ammonia	↓	SIG	-7.33	↓	NSD
Nitrite	↓	NSD	-0.60	↑	NSD
Nitrate	↑	NSD	1.29	↑	NSD
Oxidised nitrogen	↑	NSD	1.21	↑	NSD
Total nitrogen	↓	SIG	-2.12	↓	NSD
Total phosphorus	↓	NSD	-1.63	↓	NSD
pH	↑	NSD	0.31	↓	SIG
Oil and grease	Insufficient data above limit of reading				
Faecal coliforms	↓	SIG	-2.72	↓	NSD
Alkalinity	↑	SIG	3.84	↓	NSD

Arrows pointing up indicate an increasing trend over the time period.
Arrows pointing down indicate a decreasing trend over the time period.
NSD = the slope of the linear trend line is not statistically different from a slope of zero at the 5% level of significance.
SIG = the slope of the linear trend line is statistically different from a slope of zero at the 5% level of significance.

2.4.3. Existing Impacts on River Water Quality

The current impact of the STP on the receiving waterways was estimated using historic data collected between 2013 and 2019. Background or upstream concentrations were compared with effluent data as well as downstream data to determine how the STP effluent impacted each measured analyte. A summary of the findings is presented below with detailed analysis of the STP and waterway data presented in Section **Error! Reference source not found.**, Appendix B.

Based on the results of the data analysis, the following key observations were made:

- Concentrations of suspended solids in the STP are less than those in the river. This is probably a result of the high level of sewage treatment.
- Ion concentrations show a significant difference among days, among sites and in the interaction term. Ions discharged from the STP are generally greater than concentrations in the river.
- Concentrations of some metals (aluminium, manganese and iron) are less in the STP than in the river. This may suggest an upstream source of metals.
- Concentrations of zinc are greater in the STP than in the river. The first reading of the day consistently showed the highest concentration of zinc. This may indicate an overnight discharge of zinc to the sewerage system.
- Nutrient concentrations from the STP discharges exceeded those observed in the river.
- Concentrations of indicator bacteria were generally less in the STP discharges than in the river waters. This may suggest that input from farm animals is a substantial contributor to the bacterial quality of the river.

Analysis of variance (ANOVA) was used to determine statistically significant differences among data from STP, Point 11 (upstream) and Point 12 (5 km downstream). Duncan's multiple range test was used to calculate the mean comparisons. Faecal coliform data have been log10-transformed prior to analysis.

The results are summarised in Table 2–10. In general, there is no statistically significant difference between the data from points 11 and 12. Concentrations from both of these locations are significantly less than those from the STP discharge location, as expected. A Kruskal-Wallis non-parametric analysis was also undertaken and the results agree with those from the ANOVA. Of note, concentrations of total suspended solids (TSS) and faecal coliforms in the effluent are significantly less than the concentrations in the river. The high level of sewage treatment results in very low concentrations of TSS being discharged to the Wingecarribee River. These results also suggest a source of faecal contamination upstream of the discharge location.

These results indicate that, 5 km downstream from the STP discharge location, there is (in general) no statistically significant difference between the upstream and downstream data. That is, the influence of the STP discharges at the downstream location cannot be isolated.

Table 2–10. ANOVA summary: STP, Point 11 and Point 12

Variable	ANOVA	F-calc	F-critical	Kruskal-Wallis
BOD	Point 11 = Point 12 < STP	31.4	3.02	SIG
TSS	STP < Point 12 < Point 11	425.2	3.02	SIG
Cond.	Point 11 < Point 12 < STP	1059.5	3.02	SIG
Ammonia	Point 12 = Point 11 < STP	249.2	3.02	SIG
Nitrite	Point 12 = Point 11 < STP	119.2	3.02	SIG
Nitrate	Point 11 = Point 12 < STP	1282.3	3.02	SIG
Oxidised nitrogen	Point 11 = Point 12 < STP	1362.8	3.02	SIG
Total nitrogen	Point 12 = Point 11 < STP	1095.0	3.02	SIG
Total phosphorus	Point 12 = Point 11 < STP	131.7	3.02	SIG
pH	Point 11 < STP < Point 12	96.4	3.02	SIG
Oil and grease	Insufficient variability in the data for reliable results			
Faecal coliforms (log10)	STP < Point 12 = Point 11	209.6	3.02	SIG
Alkalinity	Point 11 < Point 12 < STP	296.3	3.02	

There are only very limited data for oil and grease that are above the limit of reading. Therefore, the results are not reliable.
NSD = the two means are not statistically different at the 5% level of significance.
SIG = the two means are statistically different at the 5% level of significance.
All calculations were undertaken using 5% level of significance and the F-tests all exceeded 80% statistical power.
In the ANOVA column, the locations are ordered in terms of increasing mean values. An '=' sign indicates that there is no significant difference in the means of the data collected from the two locations either side of the '=' sign. The '<' sign indicates the mean of the data whose location label is on the left, is significantly less than that of the data whose location label is to the right.

2.5. Monitoring – 2019-2020

To help fill data gaps, a monitoring program was designed and executed. The monitoring program is detailed in Section 1.5. Below is a summary of the data collected and an interpretation of a selection of the results. Samples were collected on three occasions: 18 December 2019, 16 January 2020 and 20 February 2020. Sampling on the first two days was under dry weather conditions, while sampling on the third day was under wet weather conditions. Two replicate samples were collected at each time / location. Laboratory quality assurance was undertaken on approximately 10% of samples. Analyses of these data (not presented here) indicate that the samples were within the acceptable limits for the analytical method used.

2.5.1. Bowral STP

Samples were collected on four occasions (approximately two hours apart) on each of the three sampling days. A summary of the results for each analyte is presented in Table 2–11. Note, the median and mean absolute differences are used in place of the more commonly used mean and variance, as the former are generally better estimators of 'central tendency' and 'dispersion'.

Table 2–11. Summary of the concentrations of contaminants in the Bowral STP. Shaded cells indicate 80%ile licence values. Blank cells indicate that all data for that variable were at or below the limit of reading.

Bowral STP	Units	18 Dec 2019 (dry)		16 Jan 2020 (dry)		20 Feb 2020 (wet)	
		median	MAD	median	MAD	median	MAD
Suspended Solids	mg/L	11.500	3.750	5.500	6.000	5.000	6.375
Hydroxide Alkalinity as CaCO3	mg/L						
Carbonate Alkalinity as CaCO3	mg/L						
Bicarbonate Alkalinity as CaCO3	mg/L	75.000	2.375	85.500	9.750	73.500	1.875
Total Alkalinity as CaCO3	mg/L	75.000	2.375	85.500	9.750	73.500	1.875
Sulfate as SO4 - Turbidimetric	mg/L	114.000	1.125	105.500	8.375	38.000	75.875
Chloride	mg/L	58.500	3.125	63.000	4.250	49.000	9.125
Fluoride	mg/L	0.600	0.000	0.700	0.088	0.300	0.300
Calcium	mg/L	28.000	0.000	31.000	2.750	26.000	2.125
Magnesium	mg/L	6.000	0.000	7.000	1.000	7.000	1.000
Sodium	mg/L	70.000	1.750	72.500	2.625	36.000	33.625
Potassium	mg/L	22.000	0.000	28.000	6.250	6.000	15.750
Total Anions	meq/L	5.585	0.116	5.665	0.084	3.650	1.934
Total Cations	meq/L	5.500	0.076	5.970	0.490	3.590	1.893
dissolved Aluminium	mg/L	0.040	0.004	0.040	0.001	0.020	0.021
dissolved Arsenic	mg/L						
dissolved Cadmium	mg/L						
dissolved Chromium	mg/L						
dissolved Copper	mg/L	0.002	0.001	0.001	0.001	0.001	0.001
dissolved Lead	mg/L						
dissolved Manganese	mg/L	0.042	0.001	0.036	0.006	0.112	0.070
dissolved Nickel	mg/L	0.001	0.000	0.002	0.001	0.001	0.000
dissolved Zinc	mg/L	0.027	0.001	0.029	0.004	0.005	0.022
dissolved Iron	mg/L						
dissolved Mercury	mg/L						
total Aluminium	mg/L	0.370	0.054	0.260	0.113	0.180	0.176
total Arsenic	mg/L						
total Cadmium	mg/L						
total Chromium	mg/L						
total Copper	mg/L						
total Lead	mg/L						
total Manganese	mg/L	0.046	0.000	0.036	0.011	0.109	0.063
total Nickel	mg/L	0.001	0.000	0.001	0.000	0.002	0.001
total Zinc	mg/L	0.030	0.001	0.027	0.003	0.010	0.018
total Iron	mg/L	0.050	0.031	0.050	0.000	0.050	0.000
total Mercury	mg/L						
Ammonia as N	mg/L	0.450	0.028	1.740	1.170	1.175	0.664
Nitrite as N	mg/L	0.195	0.013	0.150	0.049	0.130	0.063

Bowral STP	Units	18 Dec 2019 (dry)		16 Jan 2020 (dry)		20 Feb 2020 (wet)	
		median	MAD	median	MAD	median	MAD
Nitrate as N	mg/L	3.700	0.223	2.100	1.615	1.325	2.228
Nitrite + Nitrate as N	mg/L	3.900	0.230	2.245	1.669	1.445	2.295
Total Kjeldahl Nitrogen as N	mg/L	2.350	0.150	3.100	0.850	1.950	0.450
Total Nitrogen as N	mg/L	6.250	0.175	5.250	0.825	3.350	2.725
Total Phosphorus as P	mg/L	0.285	0.021	0.460	0.199	0.290	0.026
Dissolved Reactive Phosphorus as P	mg/L	0.080	0.006	0.290	0.198	0.010	0.065
Chlorophyll a	mg/m³	12.000	1.125	14.000	4.625	2.500	9.250
Faecal Coliforms	cfu/100mL	93.0	34.8	160.0	104.5	1195.0	1038.3
Enterococci	cfu/100mL	10.0	6.1	41.0	39.0	165.0	182.5

*MAD is the mean absolute difference.

A 2-factor nested analysis of variance (ANOVA), times nested within days, was undertaken to identify the major source(s) of variation. Many such analyses were undertaken and they are not presented in this report (one example, for total phosphorus is shown below).

ANOVA example: Bowral STP – total phosphorus

Transform: inverse square

Normality: p-value = 0.320

Homogeneity of variance: p-value = 0.960

Source of Variation	SS	df	MS	F	P-value	F crit	% contribution
Days	76.96	2	38.48	21.22	0.000	4.2565	73.9%
Times (within Days)	16.32	9	1.81	1.28	0.338	2.7964	3.2%
Residuals	17.00	12	1.42				22.9%
Total	110.28	23					

Cells coloured pink indicate a significant difference in that term, green cells indicate no significant difference.

Days	Day 3	Day 1	Day 2
Average	-6.05	-5.41	-1.97

power
1.000

Times	Time 1	Time 2	Time 4	Time 3
Average	-5.41	-4.91	-3.85	-3.74

power
0.224

Cells that are coloured black indicate no significant difference among averages.

The following, general, conclusions were drawn from the results.

- The major contribution to the variance was from the ‘among days’ source. Concentrations of contaminants collected during wet weather day was usually considerably different from the two dry day sampling.
- Contributions to the variance from the ‘times within days’ was small. This suggests a consistent quality of effluent on each sampling day.

- Contributions to the variance from the 'residuals' term varied. Generally, it lay between above two sources of variation.

2.5.2. Wingecarribee River

The monitoring program included collecting water samples from two locations (far and near) upstream of the STP discharge point, one location at the STP discharge point (the same location used for EPA licence monitoring) and at two locations (near and far) downstream of the discharge point. For clarity of the plots, the average of the two replicates is shown for each location together with the average of the eight samples (4 times and 2 replicates at each time) collected during each sampling day at the STP.

Horizontal axes on the plots are not to scale. For the Wingecarribee River, the locations are:

- far upstream: about 800 m upstream of the STP discharge into the river (referred to as US-2),
- near upstream: about 25 m upstream of the STP discharge into the river (referred to as US-1),
- near downstream: about 5 m downstream of the STP discharge into the river (referred to as DS-1),
- far downstream: about 5,000 m downstream of the STP discharge into the river (referred to as DS-2),

Three sampling days are superimposed on each plot:

- 18 Dec 2019: red circles
- 16 Jan 2020: orange squares
- 20 Feb 2020: green triangles

Note that the first two sampling days occurred when major bushfires were burning in the region. The last sampling day occurred when heavy rains occurred in the region.

Plots are presented for physico-chemical variables (Figure 2–2), nutrients (Figure 2–3), metals (Figure 2–4, Figure 2–5 and Figure 2–6), anions (Figure 2–7) and cations (Figure 2–8). The figures show a range of responses. A brief summary is provided below:

- Suspended solids and bacteria (Figure 2–2) have lower concentrations at the STP location than the surrounding locations, indicating other sources of these contaminants are likely.
- Nutrients (Figure 2–3) generally show elevated concentrations at the STP location, indicating that the STP is a major source of nutrients to the Wingecarribee River.
- Many metals (Figure 2–4, Figure 2–5 and Figure 2–6) have elevated concentrations at locations upstream of the STP discharge location, indicating an upstream source. One exception is zinc, which shows elevated concentrations at the STP and at the near downstream location. This implicates the STP as a likely source of zinc.
- Concentrations of anions (Figure 2–7) and cations (Figure 2–8) are generally elevated at the STP and the near downstream locations, again suggestion the influence of the

STP discharges on their concentrations.

- In general, the concentrations at the far downstream location (DS-2) are close to that at the upstream locations. This indicates that mixing is complete at this distance downstream from the discharge. Preliminary dilution modelling suggests that complete mixing occurs within a few hundred metres of the discharge point.
- On occasions, the concentration at DS-2 exceeded that DS-1. This is counterintuitive. However, this situation arises when the upstream concentration exceeds the wastewater concentration or when additional pollutants are entering the system downstream of the discharge point.

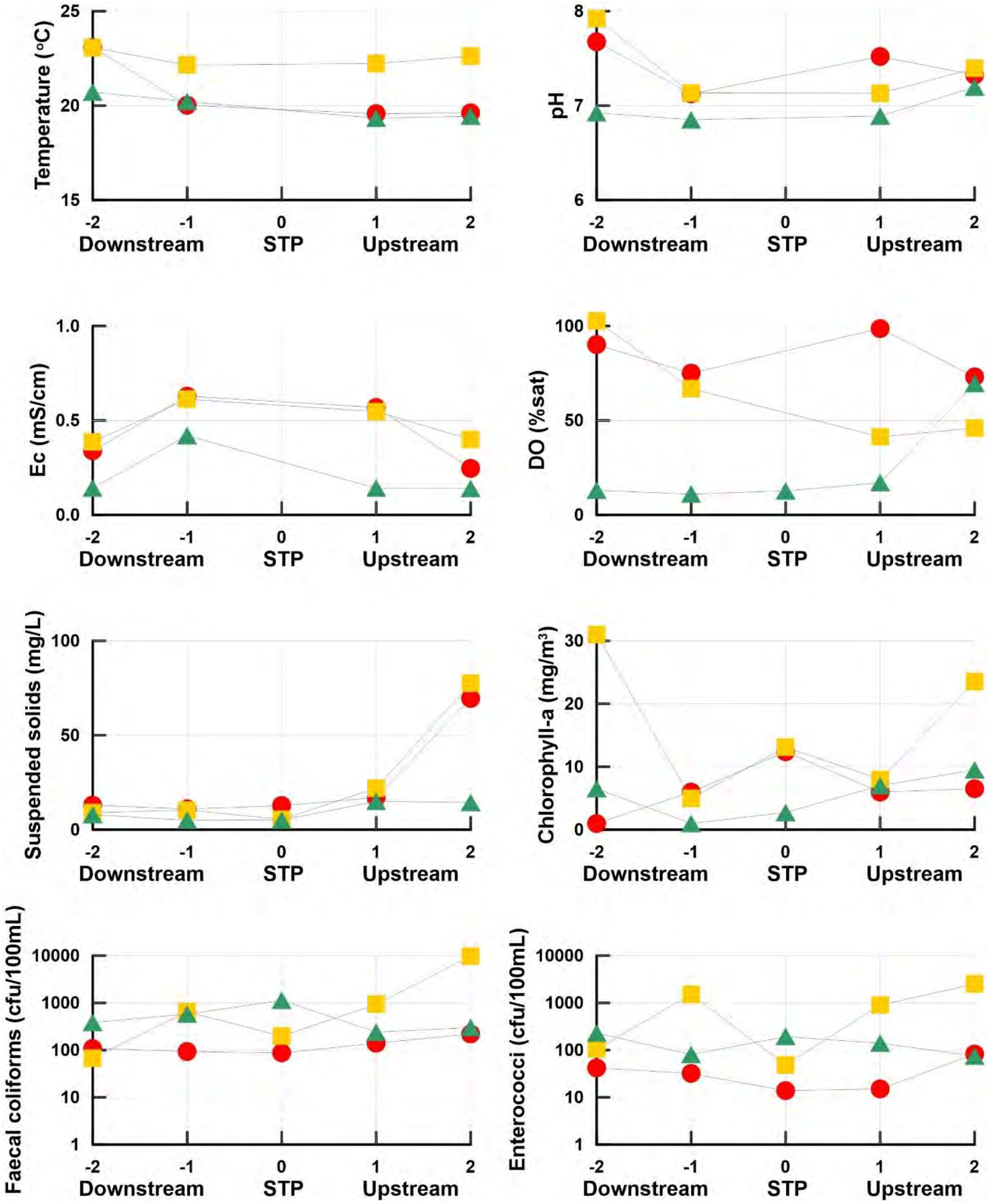

Figure 2–2. Spatial distribution of physico-chemical variables in the Wingecarribee River on the three sampling days.

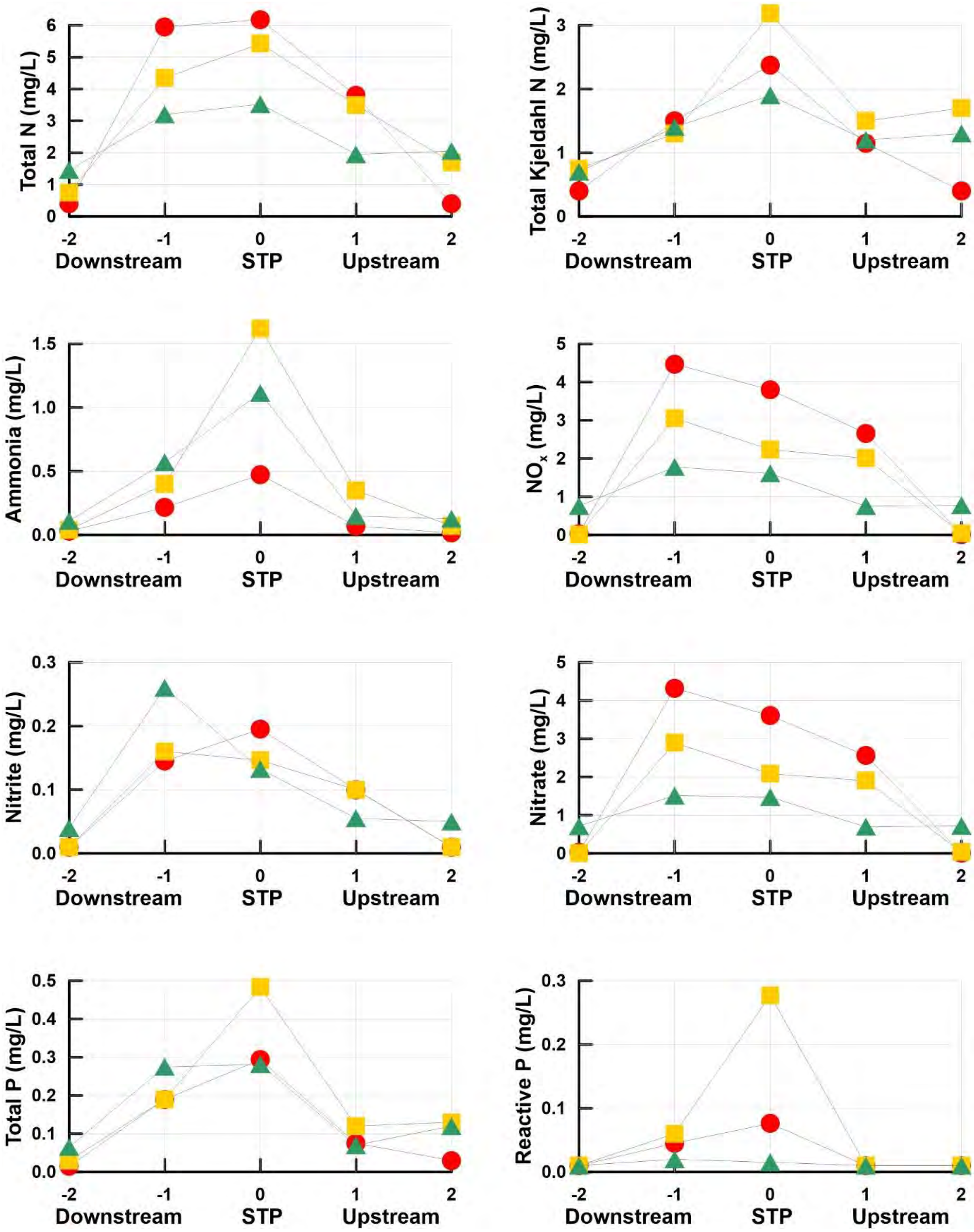

Figure 2–3. Spatial distribution of nutrients in the Wingecarribee River on the three sampling days.

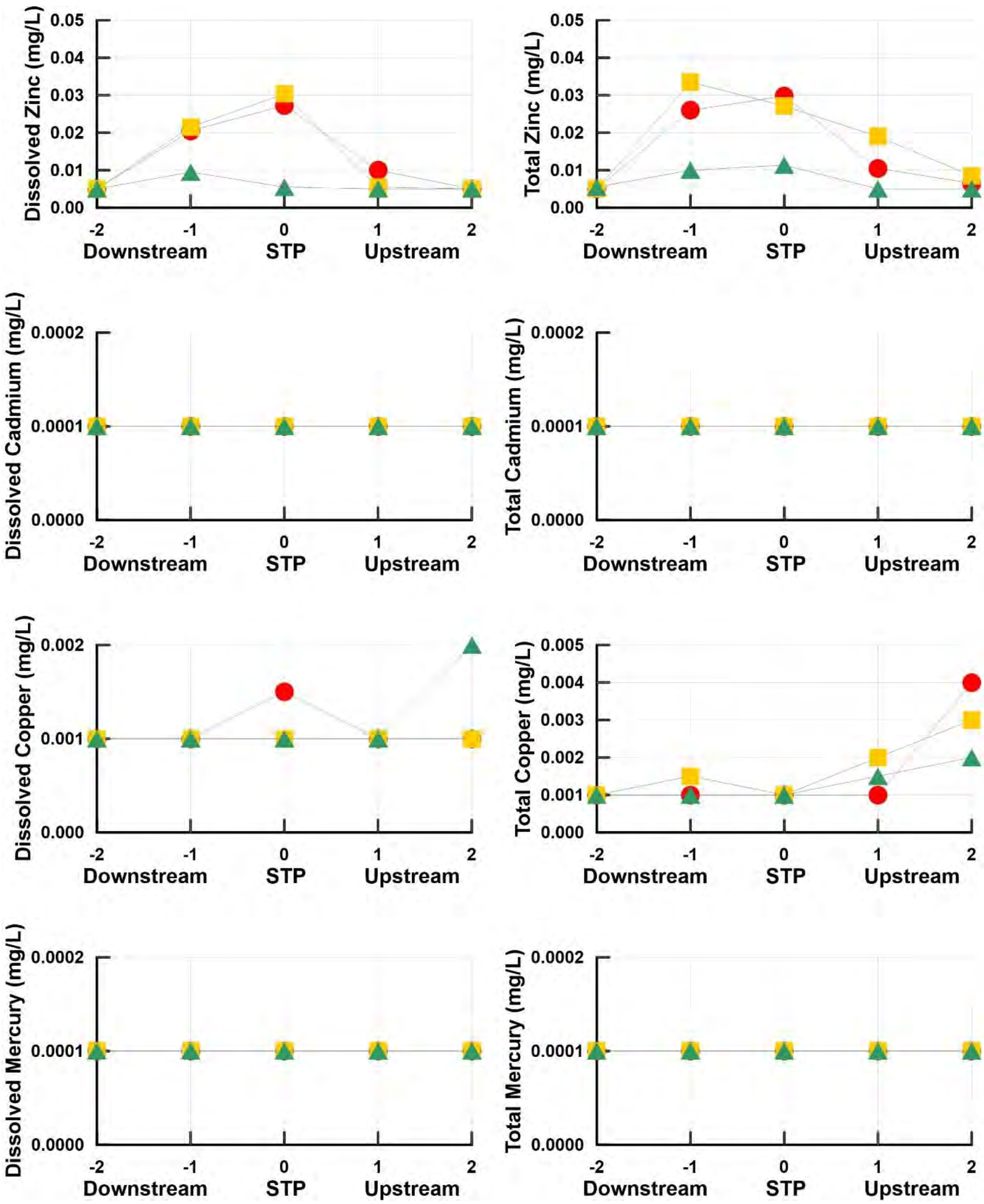

Figure 2–4. Spatial distribution of metals (a) in the Wingecarribee River on the three sampling days.

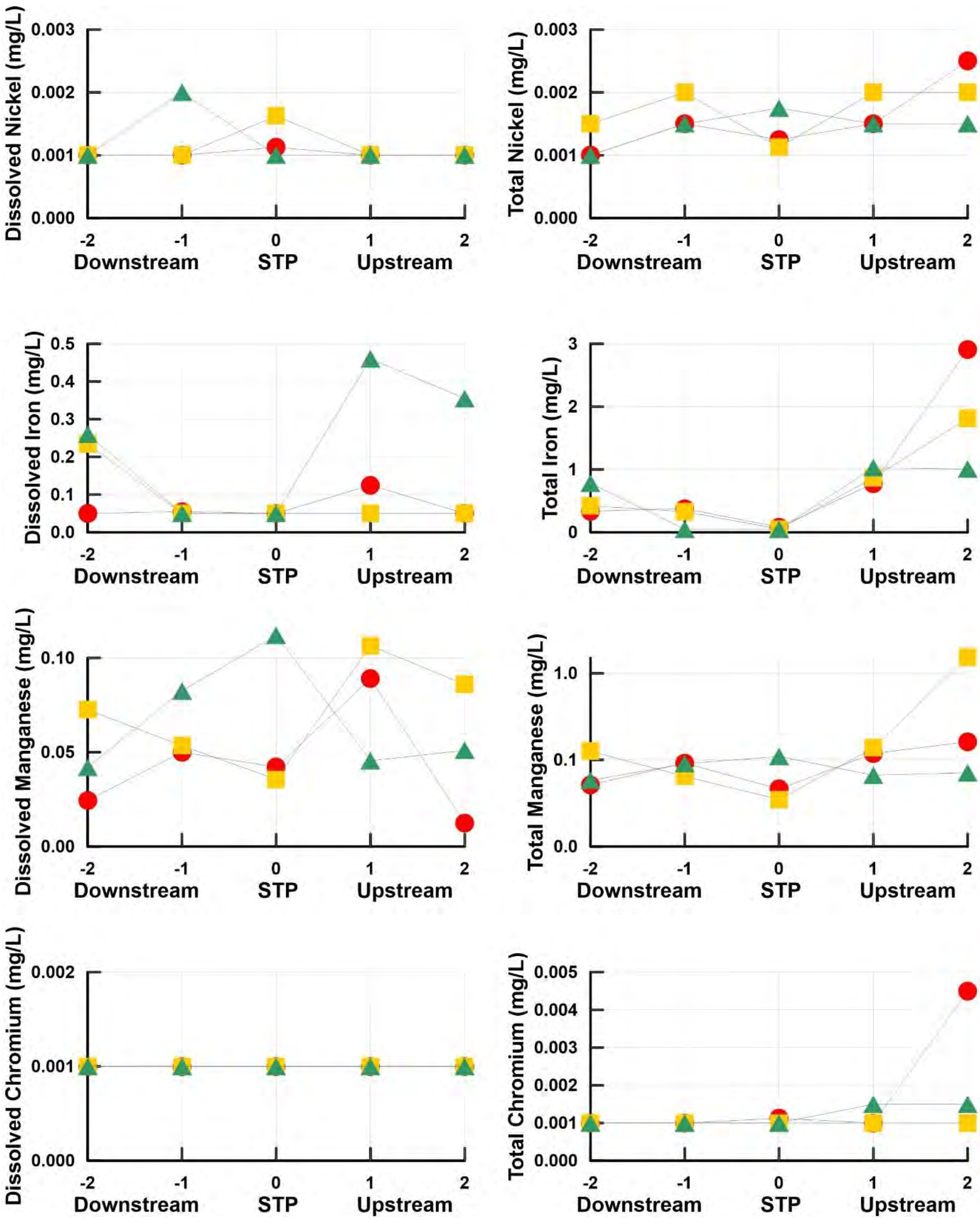

Figure 2–5. Spatial distribution of metals (b) in the Wingecarribee River on the three sampling days.

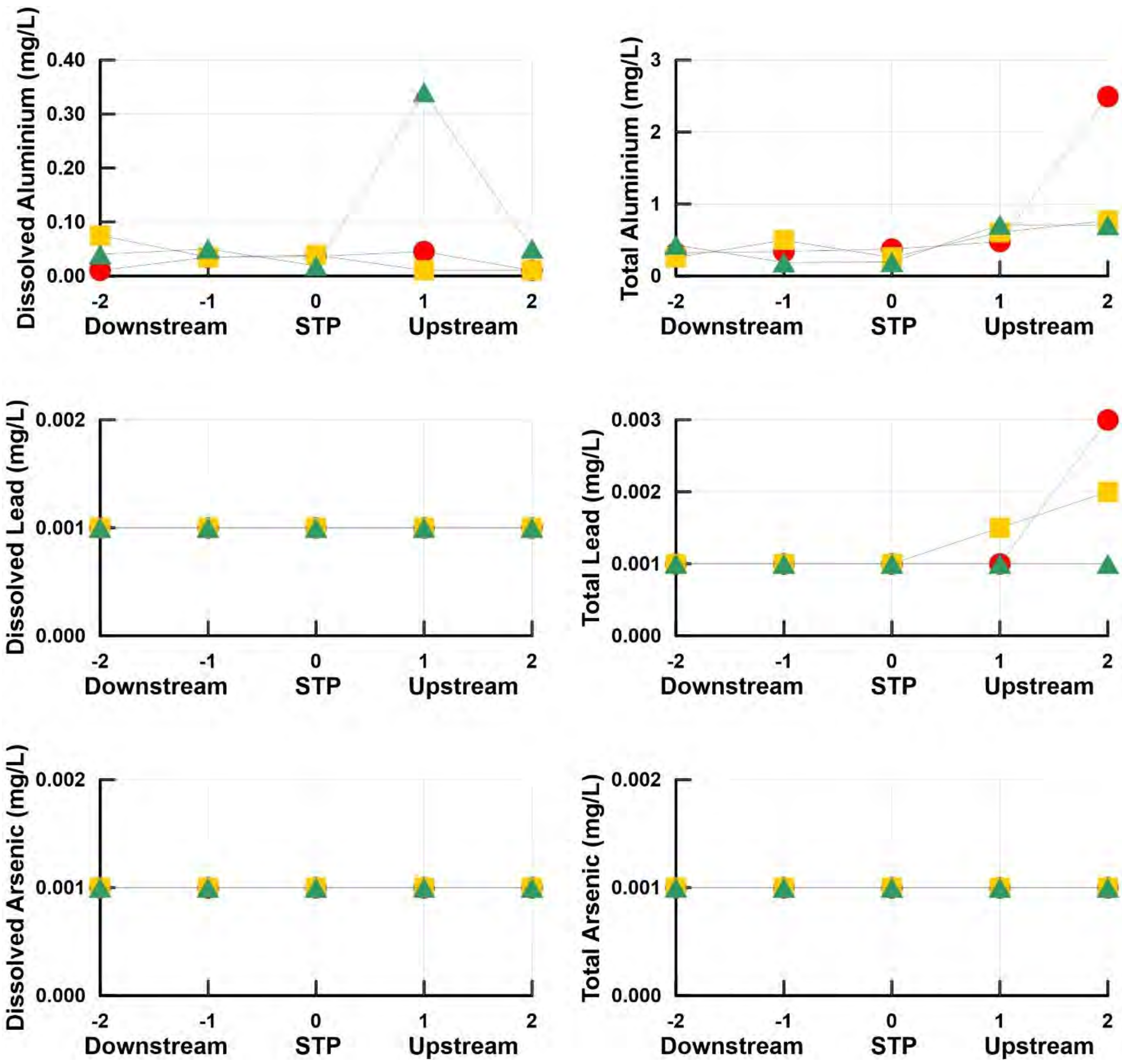

Figure 2–6. Spatial distribution of metals (c) in the Wingecarribee River on the three sampling days.

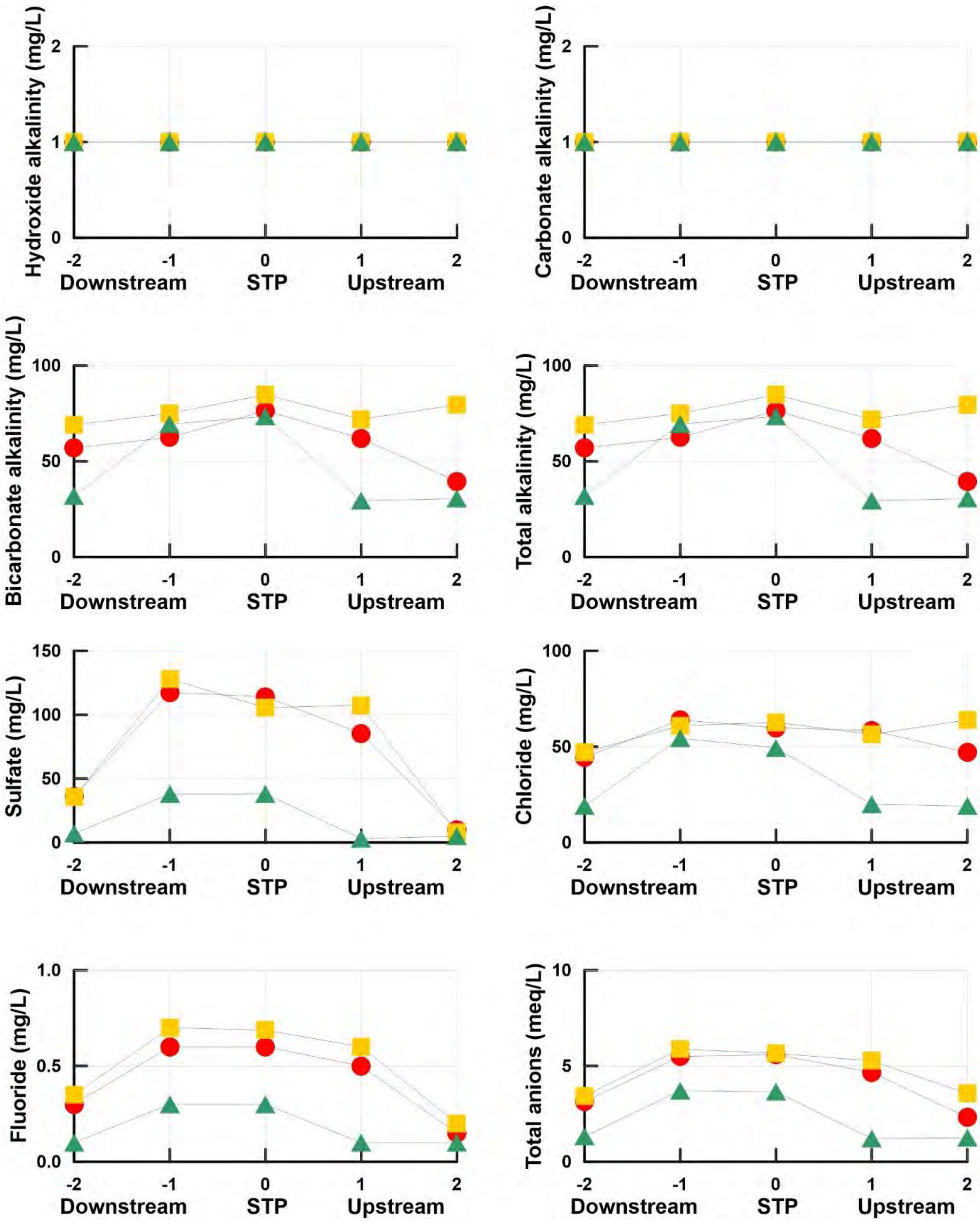

Figure 2–7. Spatial distribution of anions in the Wingecarribee River on the three sampling days.

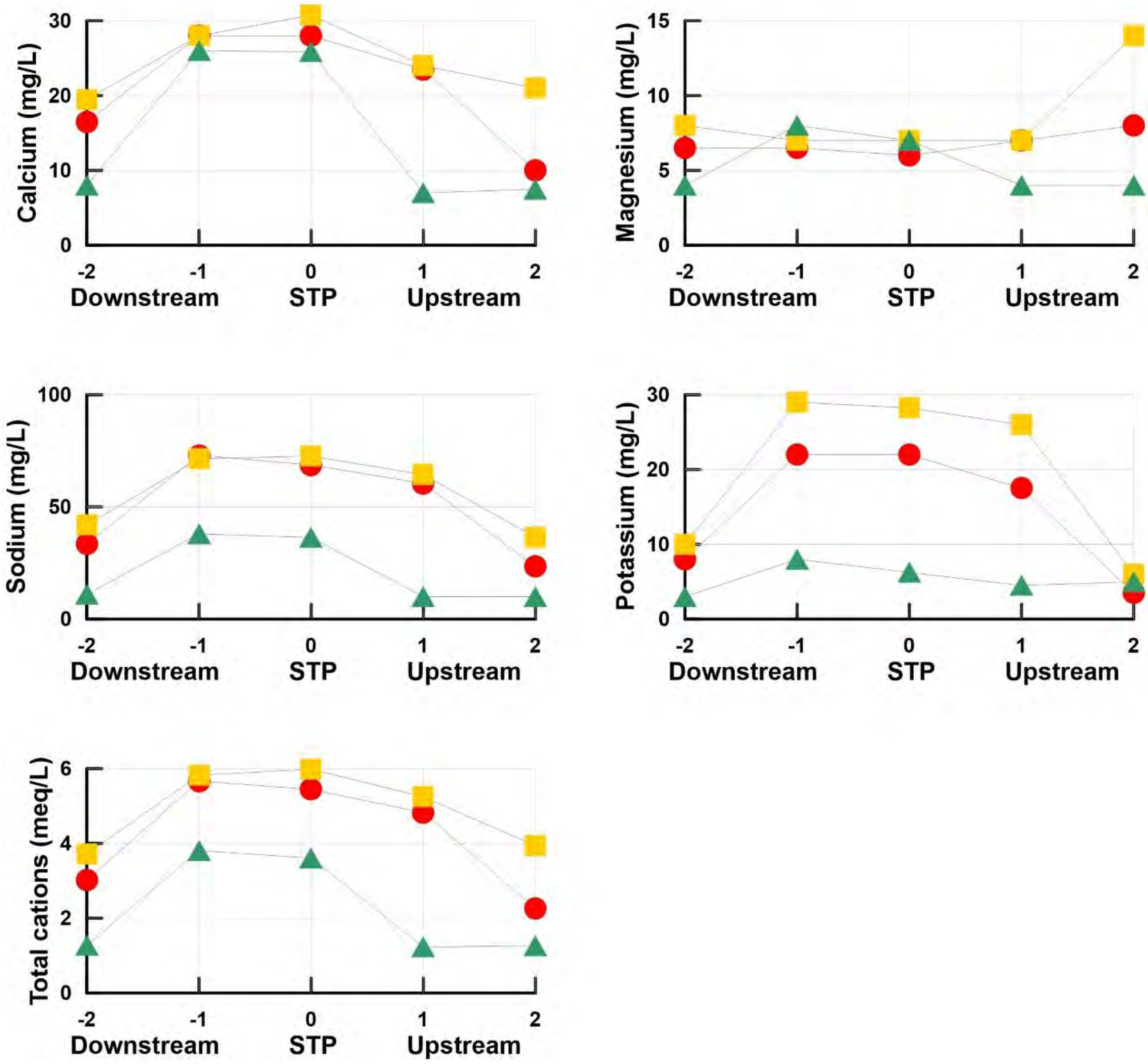

Figure 2–8. Spatial distribution of cations in the Wingecarribee River on the three sampling days.

Analysis of variance (ANOVA) is used to examine the influence of the STP discharges on the Wingecarribee River. In particular, we aim to determine whether the influence of the STP discharges can be detected at the far downstream location i.e. whether the effluent quality from the STP and water quality at the far downstream locations are significantly different. An example of the ANOVA output is provided below (for total nitrogen). Note: occasionally, some percentage contributions were negative. This cannot occur in reality and such contributions should be read as zero. This may occur when the 'mean squares" associated with the residuals terms exceeds that for one (or more) of the other terms in the source of variation.

ANOVA example: Bowral STP – total nitrogen

Transform: square root

Normal: p-value = >0.999

Homogeneity of variance: p-value = 0.633

Source of Variation	SS	df	MS	F	P-value	F crit	% contribution
Days	0.4665	2	0.2332	0.20	0.8182	3.8853	-6.6%
Sites	26.1097	3	8.7032	7.61	0.0041	3.4903	73.2%
Interaction	6.8576	6	1.1429	157.73	0.0000	2.9961	33.0%
Residuals	0.0870	12	0.0072				0.4%
Total	33.5207	23					

Cells coloured pink indicate a significant difference in that term, green cells indicate no difference.

Days	Day 1	Day 3	Day 2
Average	0.85	0.95	1.18

power
0.055

Sites	DS-2 (far)	US-1 (far)	US-2 (near)	STP
Average	-0.20	0.24	1.48	2.46

power
0.974

Cells that are coloured black indicate no significant difference among averages.

A brief, general, summary of the results is provided.

- The 'interaction' term is significant for some variables. This indicates a relationship between 'days' and 'sites' and tends to override the significance of the individual (i.e. 'days' or 'sites') sources of variation.
- Concentrations of suspended solids in the STP are less than those in the river. This is probably a result of the high level of sewage treatment.
- Ion concentrations show a significant difference among days, among sites and in the interaction term. Ions discharged from the STP are generally greater than concentrations in the river.
- Concentrations of some metals (aluminium, manganese and iron) are less in the STP than in the river. This may suggest an upstream source of metals.

- Concentrations of zinc are greater in the STP than in the river. The first reading of the day consistently showed the highest concentration of zinc. This may indicate an overnight discharge of zinc to the sewerage system.
- Nutrient concentrations from the STP discharges exceeded those observed in the river.
- Concentrations of indicator bacteria were generally less in the STP discharges than in the river waters. This may suggest that input from farm animals is a substantial contributor to the bacterial quality of the river.

2.5.3. Loads

STP loads were estimated by multiplying the median concentration (two replicates at each of four times during the day) by the total effluent flow. River loads were estimated by multiplying the median concentration at the two upstream location (two replicates at each location) by the total river flow. Load calculation results are presented in Table 2–12. Based on these load calculations, the following points are noted:

- Suspended solids: The Bowral STP contribution was generally small (<5%) under both dry and wet weather conditions.
- Ions: In dry weather, the Bowral STP contributed about 20-30% of the total load of ions in the Wingecarribee River. In wet weather, this percentage was about 5%.
- Total metals: On the two dry weather days, the Bowral STP contributed less than about 10% of the total load of aluminium, manganese and nickel. For zinc, this contribution was almost 40%. In wet weather the Bowral STP contribution was less than 5%. For all other metals that were measured, the Bowral STP contribution was less than 1% on all three sampling days.
- Nutrients: In dry weather, the Bowral STP contributed about 30-50% of the total load of nutrients in the Wingecarribee River (although the percentages for the different nutrient species, and on each day were quite variable). In wet weather, this percentage was about 5%.

Table 2–12. Estimated loads (kg/day) of contaminants in the Bowral STP and Wingecarribee River

	Wingecarribee River flow (ML/day) at Bong Bong Weir			STP flow (ML/day)			% of STP load to combined STP and river flows		
	6.79	**11.54**	**379.05**	**6.79**	**11.54**	**379.05**	**6.79**	**11.54**	**379.05**
Variable	**18 Dec 19**	**16 Jan 20**	**20 Feb 20**	**18 Dec 19**	**16 Jan 20**	**20 Feb 20**	**18 Dec 19**	**16 Jan 20**	**20 Feb 20**
Suspended Solids	281.8	565.4	5496.3	14.5	15.3	40.6	4.9%	2.6%	0.7%
Total Alkalinity as CaCO3	451.6	877.0	11371.6	94.3	237.3	596.1	17.3%	21.3%	5.0%
Sulfate as SO4	319.2	663.5	1137.2	143.3	292.9	308.2	31.0%	30.6%	21.3%
Chloride	390.5	698.1	7391.5	73.5	174.9	397.4	15.8%	20.0%	5.1%
Fluoride	2.4	4.6	37.9	0.8	1.9	2.4	24.1%	29.6%	6.0%
Calcium	149.4	259.6	2653.4	35.2	86.1	210.9	19.1%	24.9%	7.4%
Magnesium	50.9	121.2	1516.2	7.5	19.4	56.8	12.9%	13.8%	3.6%
Sodium	326.0	582.7	3790.5	88.0	201.3	292.0	21.3%	25.7%	7.2%
Potassium	78.1	184.6	1895.3	27.7	77.7	48.7	26.2%	29.6%	2.5%
total Aluminium	4.754	8.077	269.128	0.465	0.722	1.460	8.9%	8.2%	0.5%
total Arsenic	0.007	0.012	0.379	0.000	0.000	0.000	0.0%	0.0%	0.0%
total Cadmium	0.001	0.001	0.038	0.000	0.000	0.000	0.0%	0.0%	0.0%
total Chromium	0.007	0.012	0.569	0.000	0.000	0.000	0.0%	0.0%	0.0%
total Copper	0.017	0.029	0.758	0.000	0.000	0.000	0.0%	0.0%	0.0%
total Lead	0.014	0.023	0.379	0.000	0.000	0.000	0.0%	0.0%	0.0%
total Manganese	1.008	9.352	26.534	0.058	0.099	0.884	5.4%	1.0%	3.2%
total Nickel	0.014	0.023	0.569	0.001	0.003	0.016	8.5%	10.7%	2.8%
total Zinc	0.058	0.162	1.895	0.037	0.074	0.077	39.1%	31.3%	3.9%
total Iron	9.201	15.635	388.529	0.063	0.139	0.406	0.7%	0.9%	0.1%
total Mercury	0.001	0.001	0.038	0.000	0.000	0.000	0.0%	0.0%	0.0%
							4.9%	2.6%	0.7%
Total Nitrogen	16.977	28.847	758.106	7.856	14.574	27.169	17.3%	21.3%	5.0%
Total Phosphorus	0.679	1.385	36.010	0.358	1.277	2.352	31.0%	30.6%	21.3%

3. Modelled Downstream Conditions

Work presented in this section presents the results of the scenarios examined as part of this study. The scenarios modelled are described, together with the model used and the ANZECC guidelines that are used to assess the environmental impacts associated with each scenario. Results are generally shown as probability of exceedance plots at two downstream locations supplemented with tabular presentations.

3.1. Scenarios

Modelling undertaken as part of this study aims to (i) estimate the concentrations of contaminants in the waters downstream of the discharge locations and their compliance with the default ANZECC guidelines, and (ii) assess compliance of each of the proposed scenarios with the NorBE requirements. This section focuses on the first of these aims. Section **Error! Reference source not found.** provides the results of the NorBE assessment.

Three scenarios were provided by WSC, each corresponding to a set of effluent quality concentrations. The scenarios are:

- Intermittently Decanted Extended Aeration with Cloth Filters (IDEA): referred to in this report as ‘IDEA’,
- Continuous Modified Ludzack-Ettinger (MLE) Type Plant with Carbon Dosing and Cloth Filters: referred to in this report as ‘MLE’, and
- Four Stage Bardenpho (FSB) Type Plant with Carbon Dosing and Cloth Filters (referred to in this report as ‘FSB’).

Each scenario corresponds to different types of sewage treatment (IDEA, MLE and FSB). For this study, the scenarios are defined by the projected 50% and 90%ile values for each of biochemical oxygen demand (BOD), total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP). These values are shown in Table 3–1. Also included in this table are the practical quantitation limits, PQL, (DECC, 2009) and the relevant ANZECC guidelines (ANZECC, 2018). The BOD 50%ile values are ‘<2 mg/L’, which is below the PQL. Therefore, BOD is not included in the modelling components. On occasions, TSS concentrations also lay at or below the limit of reading. For the modelling component of this study, such concentrations were assumed to lie at the limit of reading. This is a conservative approach – in a practical sense, the modelled concentrations will be higher in this report than in reality.

Scenario concentrations were not provided for any other contaminants. Hence the modelling is restricted to these three contaminants only.

The licence limits for these three contaminants (both loads and concentrations) are provided in Table 3–2 (EPL; 2018). This table also includes the Equivalent Populations (EP) for 2016 and 2046. For the Bowral sewerage system, the future scenario applies to an EP of 18,692 which is projected to be reached in 2046.

The existing EP was obtained from the concept design report, Lindeque and Pante (2019) for Bowral. It exceeds the population figures from the 2016 Australian census because the concept design report EPs also include discharges from industry and commerce (expressed as an equivalent population).

STP flows for the new scenarios were based on a scaling of the flows between 1 July 2014 and 30 June 2019. The flows were scaled in direct proportion to the change in EP. Wingecarribee River flows and rainfall were unchanged.

The existing STP effluent data are, for the purposes of this study, defined to be data collected between 1 July 2014 and 30 June 2019. This period represents the base case (or 2016 simulations). This period was chosen because it is recent and is sufficiently long to include a range of environmental conditions (e.g. rainfall, STP effluent flow and quality and river flow and quality). The 50%ile and 90%ile values from the STP effluent data for this period are presented in Table 3–2.

Comparing the existing and proposed 50%ile and 90%ile shows that for many variables, the existing concentrations are less than those estimated for the future treatment options. The concentrations for the treatment options are conservative and a well-managed STP can achieve better than the design values. This is evidenced by the Bowral STP, which, through good management practices, currently performs better than the original design criteria. However, a consequence is that the projected concentrations and loads may appear higher than what will actually be achieved.

Table 3–1. Scenarios to be modelled

	IDEA with Cloth Filters		Continuous (MLE) Type Plant with Carbon Dosing and Cloth Filters		Four Stage Bardenpho (FSB) Type Plant with Carbon Dosing and Cloth Filters		PQL (Practical quantitation limits)	ANZECC
	50%ile	90%ile	50%ile	90%ile	50%ile	90%ile		
BOD (mg/L)	<2	3	<2	3	<2	3	2	15[a]
TSS (mg/L)	5	10	5	10	5	10	3	25[b]
TN (mg/L)	7	10	5	7	3	5	0.3	0.250[c]
TP (mg/L)	0.2	0.5	0.1	0.3	0.1	0.3	0.02	0.020[c]

Notes:

(a) There are no relevant ANZECC guidelines for BOD. This value represents the limit for aquaculture in freshwater. Pristine waters have BOD <1 mg/L, while tertiary treated effluent has BOD in the range 2-5 mg/L. In the absence of a suitable guideline, a reference value of 2 mg/L is used for BOD.

(b) The TSS value is based on the ANZECC guidelines for biological indicators (physical and chemical stressors).

(c) These are the ANZECC default trigger values for upland rivers in south-east Australia.

Table 3–2. Bowral STP 50%ile and 90%ile value, licence limits (loads and concentrations) and equivalent populations for the Bowral sewage treatment system.

	Bowral STP data: 1 July 2014 to 30 June 2019		Licence Concentration (mg/L)		Licence Annual load	Equivalent population	
	50%ile	90%ile	50%ile	90%ile	(kg)	2016	2046
Equivalent population						14,842	18,692
TSS (mg/L)	4.73	6.44	10	15	11,000		
TN (mg/L)	0.135	0.244	7.5	10	27,500		
TP (mg/L)	2.0	4.0	0.3	0.5	1,650		

3.2. ANZECC Guidelines

The ANZECC guidelines apply in the receiving waters (i.e. the rivers and creeks into which the effluent is discharged). The relevant ANZECC guidelines are listed in Table 3–1. It is noted that:

- The TSS value is the ANZECC guideline for biological indicators (physical and chemical stressors).
- The TN and TP guidelines are the ANZECC default trigger values for upland rivers in south-east Australia.

For brevity in this report, all of the above will be referred to as the 'ANZECC guidelines'.

The results will show that the 50%ile background concentrations (based on data from the two upstream locations) already lie above the relevant ANZECC guideline. The implication is that it will be (almost) impossible to meet the ANZECC guidelines. It is recognised that the upstream sampling regime is limited to 3 sampling days.

3.3. Modelling Approach

The modelling approach is detailed in Section **Error! Reference source not found.**, Appendix C.

In brief, a Monte Carlo approach is used. Prior to any analyses, all data were checked for consistency by examining temporal and spatial trends, as appropriate. Using available data, statistical distributions are determined for each contaminant in the STP effluent and for the dilutions at the two downstream locations. Due to the relatively small number of upstream samples available, its 'distribution' comprised the whole data set. Random samples are taken from each distribution and used as input into the dilution model (Equation 3-1**Error! Reference source not found.**; USEPA, 1988, 1995; EPA, 1993) to produce estimates of the concentrations at the two downstream locations.

Equation 3-1 $$\boldsymbol{C(x) = BG + \frac{WW - BG}{D(x)}}$$

Where:

$C(x)$ is the concentration at a distance 'x' downstream from the discharge,

BG is the background (or upstream) concentration of the contaminant (obtained from data at the two upstream locations),

WW is the concentration of the contaminant in the effluent (or STP effluent), and

$D(x)$ is the dilution at a distance 'x' downstream from the discharge location.

This process is repeated many times and a set of contaminant concentrations (at DS-1 or DS-2) results. These model results (generally in the form of probability of exceedance plots) can be compared with the ANZECC guidelines and with simulations from the base case or from other scenarios.

3.4. Results

Concentrations of the contaminants (obtained using Equation 3-1**Error! Reference source not found.Error! Reference source not found.**) for each scenario are presented in Figure 3–1 for the downstream location, DS-1, and in Figure 3–2 for the downstream location, DS-2. A summary of these results (for the 50% and 90%ile values) is given in Table 3–3. Based on repeated runs of the Monte Carlo simulations the accuracy of the 50%ile values is about 5%, while than of the 90%ile values is about 10%.

In all cases, the 50%ile background (i.e. upstream) concentration already lies close to or above the relevant ANZECC guideline. The implication is that it will be (almost) impossible to meet the ANZECC guidelines.

The STP concentration for TSS does not change for the different scenarios (the observed slight differences are due to the random inputs into the Monte Carlo simulations).

The patterns at both DS-1 (Figure 3–1) and DS-2 (Figure 3–2) are similar. Concentrations at DS-2 are less than those at DS-1, as expected due to the additional dilution achieved farther downstream.

Downstream concentrations of TSS are substantially greater than the STP concentrations (up to about a factor of 4). The reason for this is because the upstream concentrations of TSS are relatively high (and almost double the ANZECC guideline). With increasing distance downstream, effluent (with relatively low TSS concentrations) mixes with the higher upstream concentrations. Therefore, the concentrations at DS-2 exceed those at DS-1. TSS may not be a good indicator of impacts from the STP discharges because other sources of TSS (such as bank erosion; e.g. Olley and Deere, 2003) will also contribute to elevated levels of suspended solids.

Downstream nutrient concentrations are greatest for IDEA, thence MLE and the lowest concentrations are from FSB. (Note, STP concentrations of TP are the same for MLE and FSB, hence their downstream results are the same). Again, the upstream concentrations are well in excess of the ANZECC guidelines (up to about a factor of 2) and the simulated concentrations are likewise in excess of the ANZECC guidelines.

Table 3–3. Bowral (EP=18,692): Contaminant concentrations (50% and 90%iles) at DS-1 and DS-2 for each scenario.

	Contaminant (mg/L)					
	TSS		TN		TP	
ANZECC	25		0.25		0.02	
	50%	90%	50%	90%	50%	90%
Upstream	20	75	2.0	20	75	2.0
DS-1						
Existing	11	44	4.5	6.4	0.12	0.21
IDEA	11	42	5.6	8.8	0.16	0.41
MLE	11	41	4.3	6.2	0.09	0.25
FSB	11	42	2.9	4.4	0.10	0.24
DS-2						
Existing	17	65	3.8	5.7	0.12	0.17
IDEA	18	64	4.2	7.3	0.13	0.30
MLE	17	63	3.7	5.3	0.10	0.18
FSB	18	64	2.8	4.0	0.10	0.18

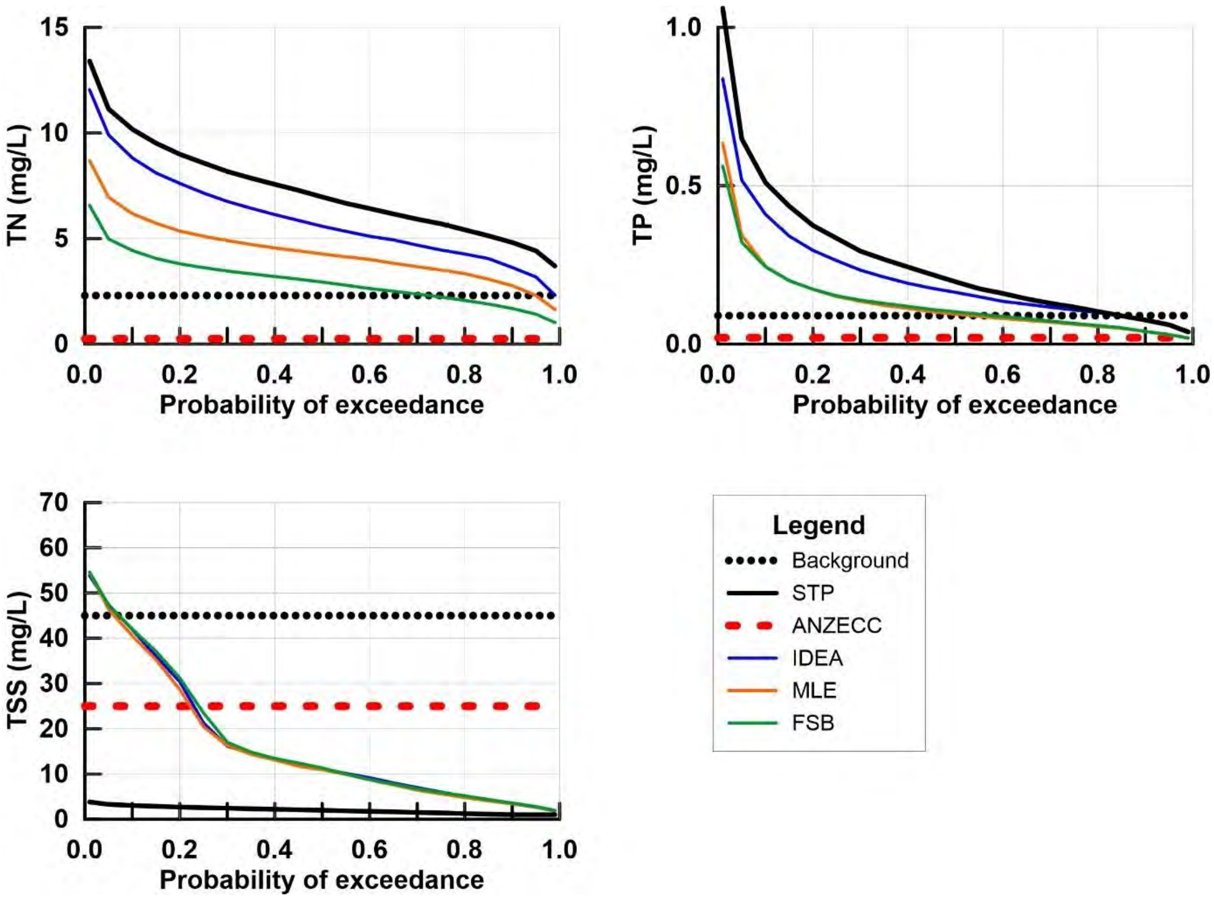

Figure 3–1. Bowral exceedance plots (EP=18,692) for concentrations simulated from the three scenarios and under existing conditions at DS-1.

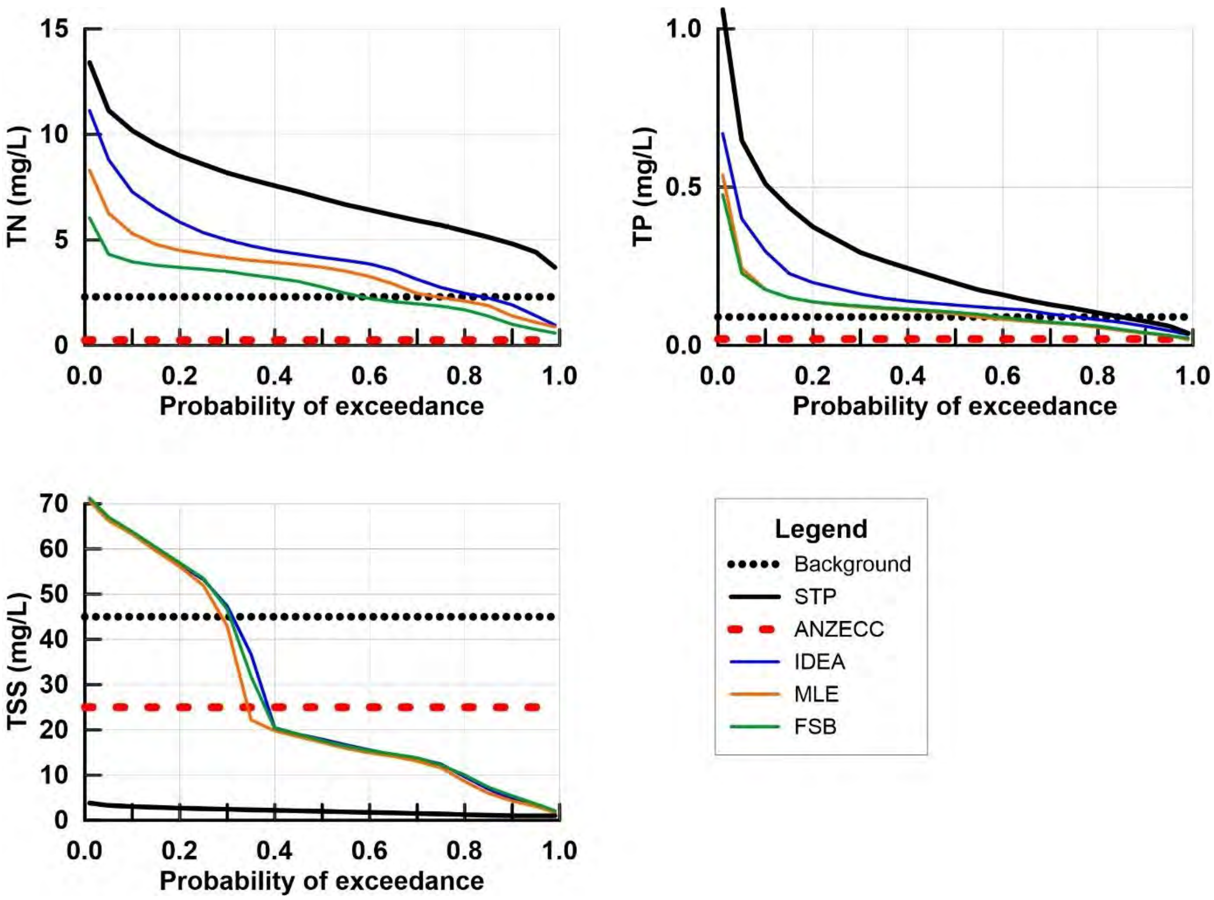

Figure 3–2. Bowral exceedance plots (EP=18,692) for concentrations simulated from the three scenarios and under existing conditions at DS-2.

4. Neutral or Beneficial Effects Assessment

Work described in this section examines the Neutral or Beneficial Effects (NorBE) associated with each of the scenarios undertaken. Further, the ‘tipping point’ for the Equivalent Population (EP) of the scenario is estimated. That is, the concentrations of the contaminants in the effluent that will ‘just meet’ the NorBE requirement. Results are presented as probability of exceedance plots and summarised in tables.

4.1. Overview

Developments that may impact Sydney’s drinking water supply must undergo a Neutral or Beneficial Effects (NorBE) assessment. The broad purpose of the NorBE is to ensure that the development has ‘no identifiable potential impact on water quality’, or the water is contained on site, or transferred to a suitable facility where it is treated to approved standards and appropriately disposed. NorBE is an assessment tool used to determine the likely impact of a development on Sydney’s drinking water catchment. Such developments are required to have a ‘neutral or beneficial effect’ on water quality in the catchment.

As part of this study, there are two major components to meeting NorBE. They are:

- Does the model indicate at least a 10% ‘improvement’ in pollutant loads for total suspended solids, total phosphorus and total nitrogen?
- Are the post-development cumulative probability pollutant concentration curves for total phosphorus and total nitrogen between the 50th and 98th percentiles equal to or less than the pre-development curves?

The document on which NorBE is based SCA (2015), makes generic references to impacts on ‘water quality’. However, there is only specific reference to TN and TP for the NorBE concentration requirements and to TSS, TN and TP for the NorBE annual load requirements. All three contaminants whose concentrations are simulated in this report, were subject to both the NorBE concentration and annual load requirements.

Load calculations used in this study are a modified version of the load calculation protocol described in DECC (2009). Load calculations are based on financial years. The purpose of the DECC (2009) protocol is to determine the fees payable for the ‘assessable’ load of a pollutant discharged from the treatment facility. The modifications of the DECC (2009) protocol centre around the treatment of data that are below the limit of reading. For the purpose of this study, data that are recorded as ‘below the limit of reading’ are assumed to be at the limit of reading. This is a conservative approach.

4.2. Tipping Point

The ‘tipping point’ is described as the concentration of contaminants in the effluent at which the NorBE requirements are just met. This was undertaking using the iterative process of changing the concentrations in the effluent, running the Monte Carlo simulations and comparing the results with the NorBE requirements.

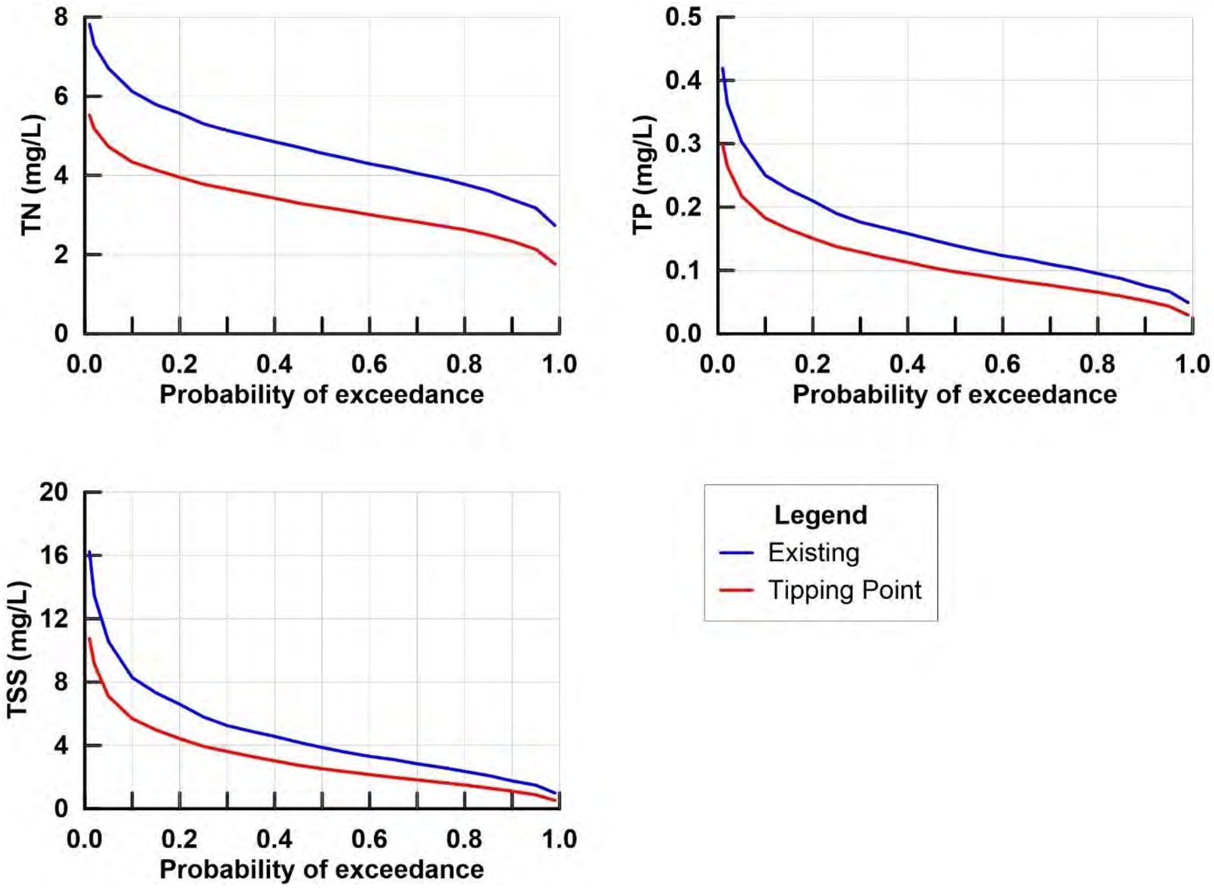

Figure 4–1. Bowral exceedance plots (EP=18,692) for the 'tipping point' concentrations and concentrations under the existing conditions.

Exceedance plots comparing the 'tipping point' concentrations with the existing concentrations for Bowral are shown in Figure 4–1. The 'tipping point' concentrations are substantially less than the existing concentrations to ensure that the NorBE load requirement is simultaneously met.

The annual loads together with the tipping point concentrations for the Bowral EP=18,692 are shown in Table 4–1. The 50%ile tipping point values for TSS lies below the PQLs. Therefore, it may not be possible to demonstrate using data, that these NorBE requirements are actually met.

Table 4–1. Bowral (EP=18,692): NorBE annual loads and concentrations for the existing data and for the 'tipping point'

	Annual loads		Concentrations			
	Existing	Tipping point	Existing		Tipping point	
			50%	90%	50%	90%
	kg/year	kg/year	mg/L	mg/L	mg/L	mg/L
TSS	6,670	6,110	4.0	8.2	2.6	5.7
TN	6,530	6,380	4.75	6.44	3.24	4.34
TP	220	215	0.135	0.244	0.101	0.182

4.3. Scenario Results

Exceedance plots comparing simulations of the IDEA scenario with the existing concentrations for Bowral (EP=18,692) are shown in Figure 4–2. The NorBE concentration requirement is that the proposed concentrations are less than the existing concentrations for the 50% to 98%iles (corresponding to the 0.50 and 0.02 probability of exceedances).

NorBE requirements for TSS, TN and TP are not met.

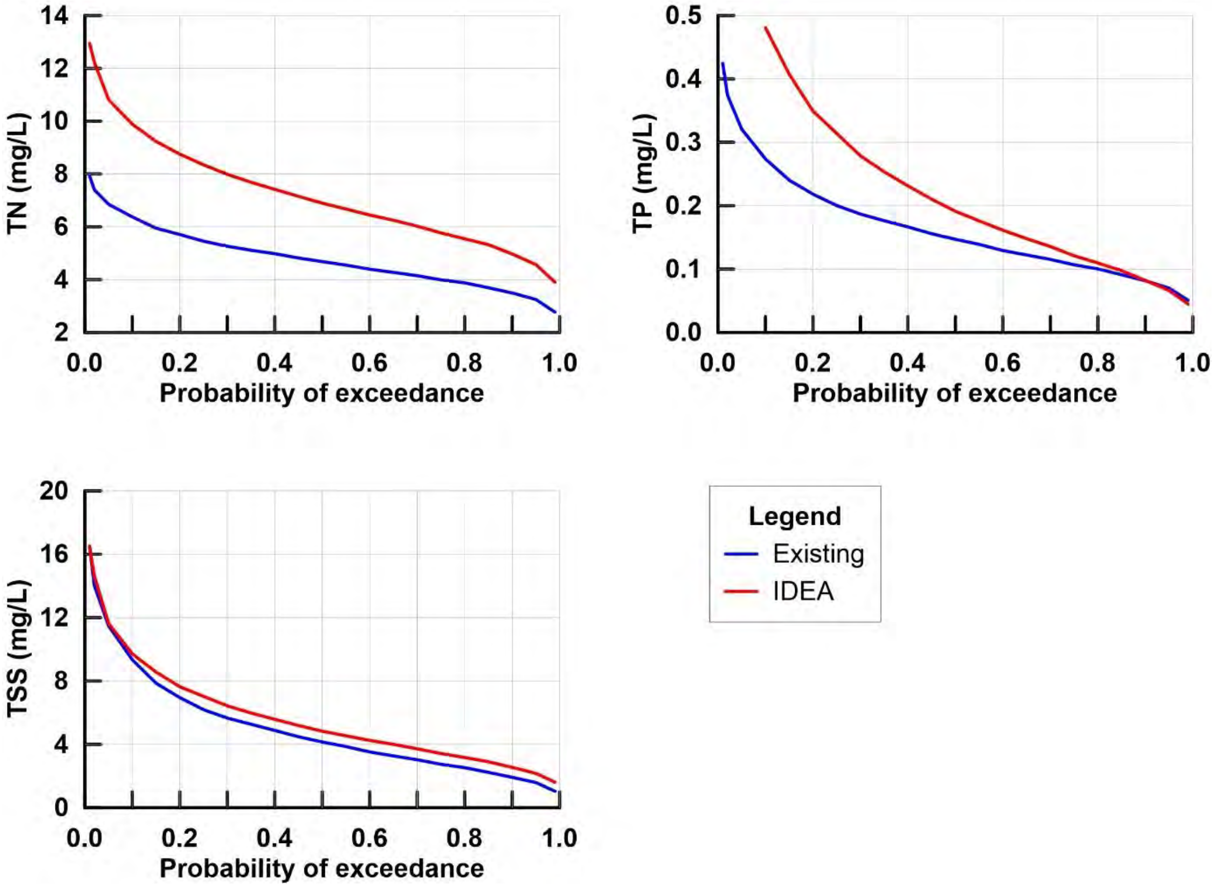

Figure 4–2. Bowral exceedance plots (EP=18,692) for the concentrations simulated from the IDEA scenario and under the existing conditions.

Exceedance plots comparing simulations of the MLE scenario with the existing concentrations for Bowral (EP=18,692) are shown in Figure 4–3. The NorBE concentration requirement is that the proposed concentrations are less than the existing concentrations for the 50% to 98%iles (corresponding to the 0.50 and 0.02 probability of exceedances).

The MLE concentrations for TP satisfy NorBE only for probability of exceedance values between 0.50 and about 0.15 (the 50% to 85%iles). TN concentrations do not meet the NorBE concentration requirement.

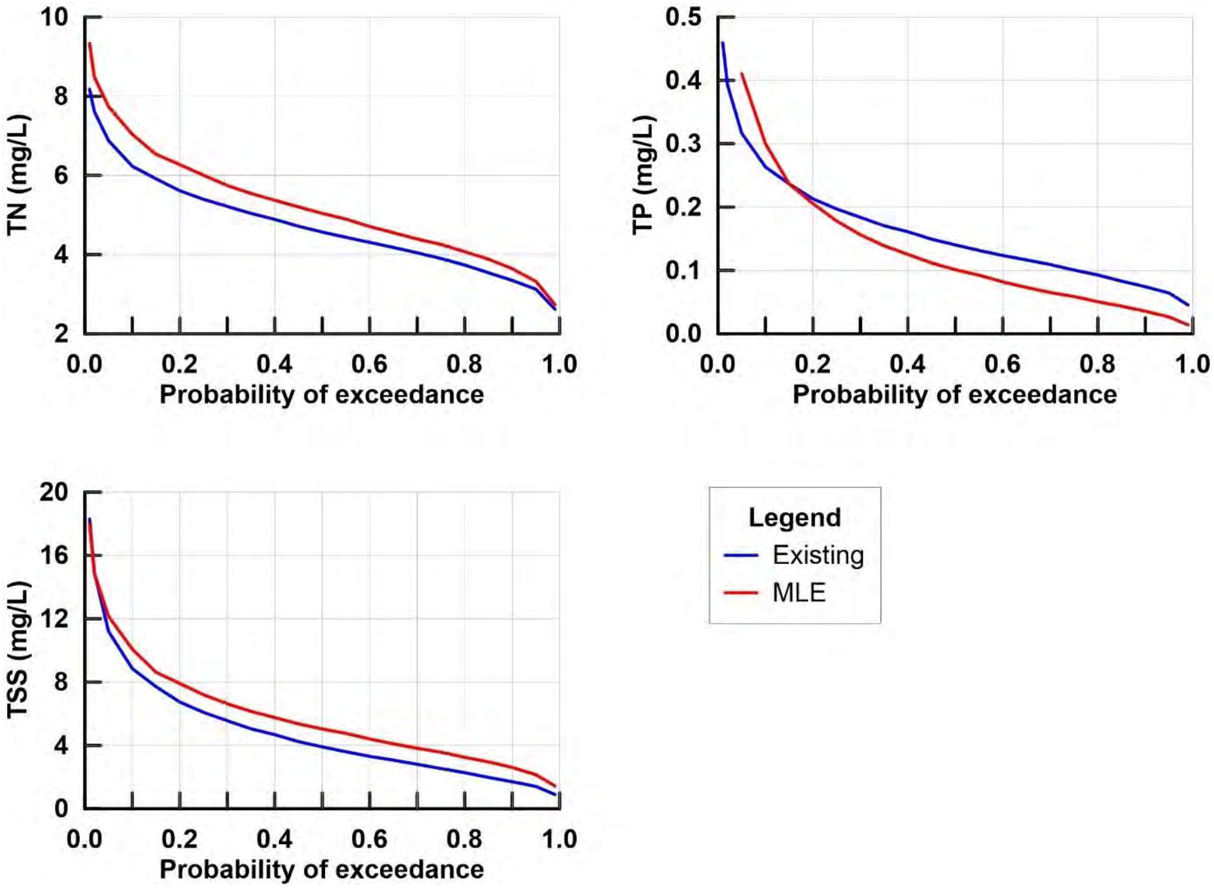

Figure 4–3. Bowral exceedance plots (EP=18,692) for the concentrations simulated from the MLE scenario and under the existing conditions.

Exceedance plots comparing simulations of the FSB scenario with the existing concentrations for Bowral (EP=18,692) are shown in Figure 4–4. The NorBE concentration requirement is that the proposed concentrations are less than the existing concentrations for the 50% to 98%iles (corresponding to the 0.50 and 0.02 probability of exceedances).

The NorBE concentration requirements for TSS and TN are met. The FSB concentrations for TP satisfy NorBE only for probability of exceedance values between 0.50 and about 0.18 (the 50% to 82%iles).

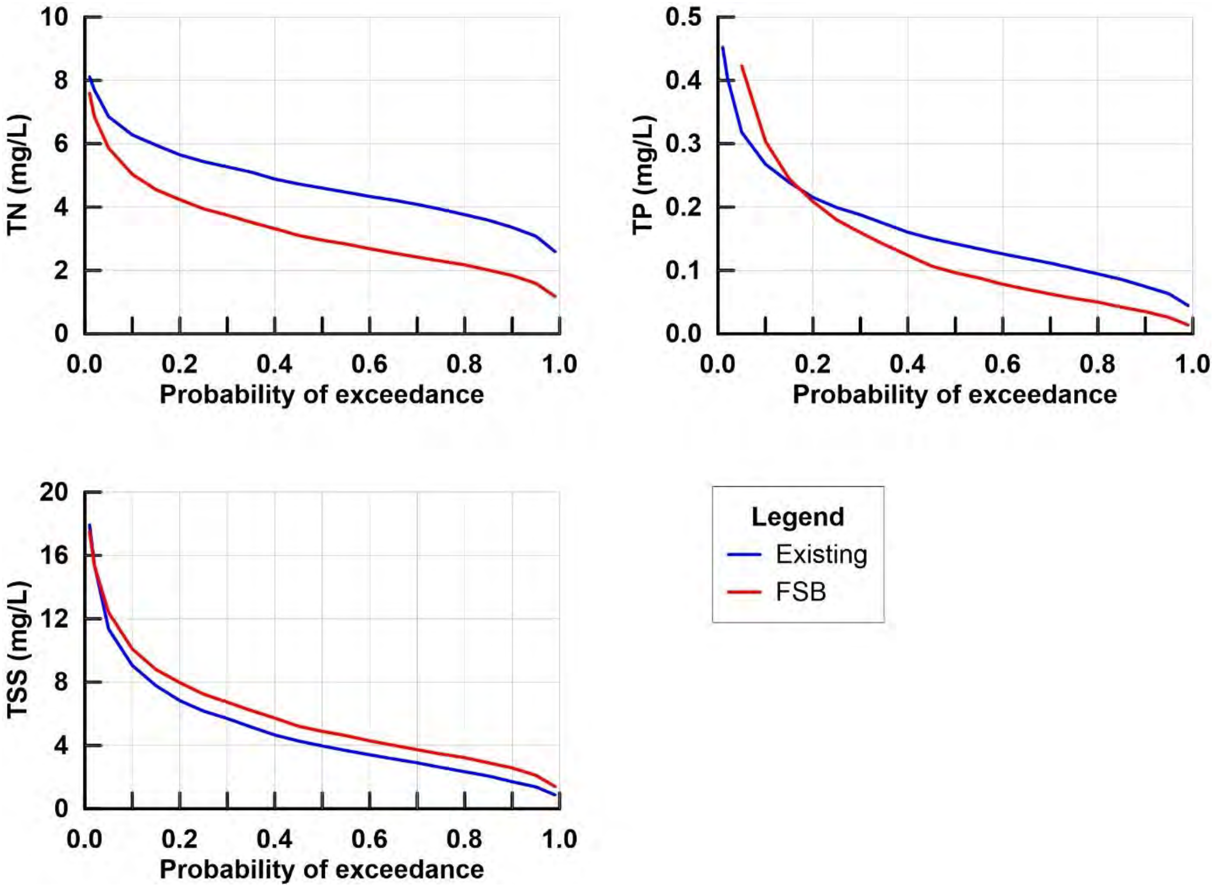

Figure 4–4. Bowral exceedance plots (EP=18,692) for the concentrations simulated from the FSB scenario and under the existing conditions.

Exceedance plots for Bowral (EP=18,692) are presented in **Figure 4–5** for each scenario with key results summarised in Table 4–2. Ticks in the table indicate that the contaminant meets the NorBE concentration requirement for that scenario. Crosses indicate that the contaminant do not meet the NorBE concentration requirement for that scenario. Table cells labelled ‘marginal’ indicate scenarios that are close to meeting the NorBE concentration requirement.

TP exceeds the NorBE concentration requirement for the MLE and FSB scenarios when the probability of exceedance is <0.20 (i.e. greater than the 80%ile).

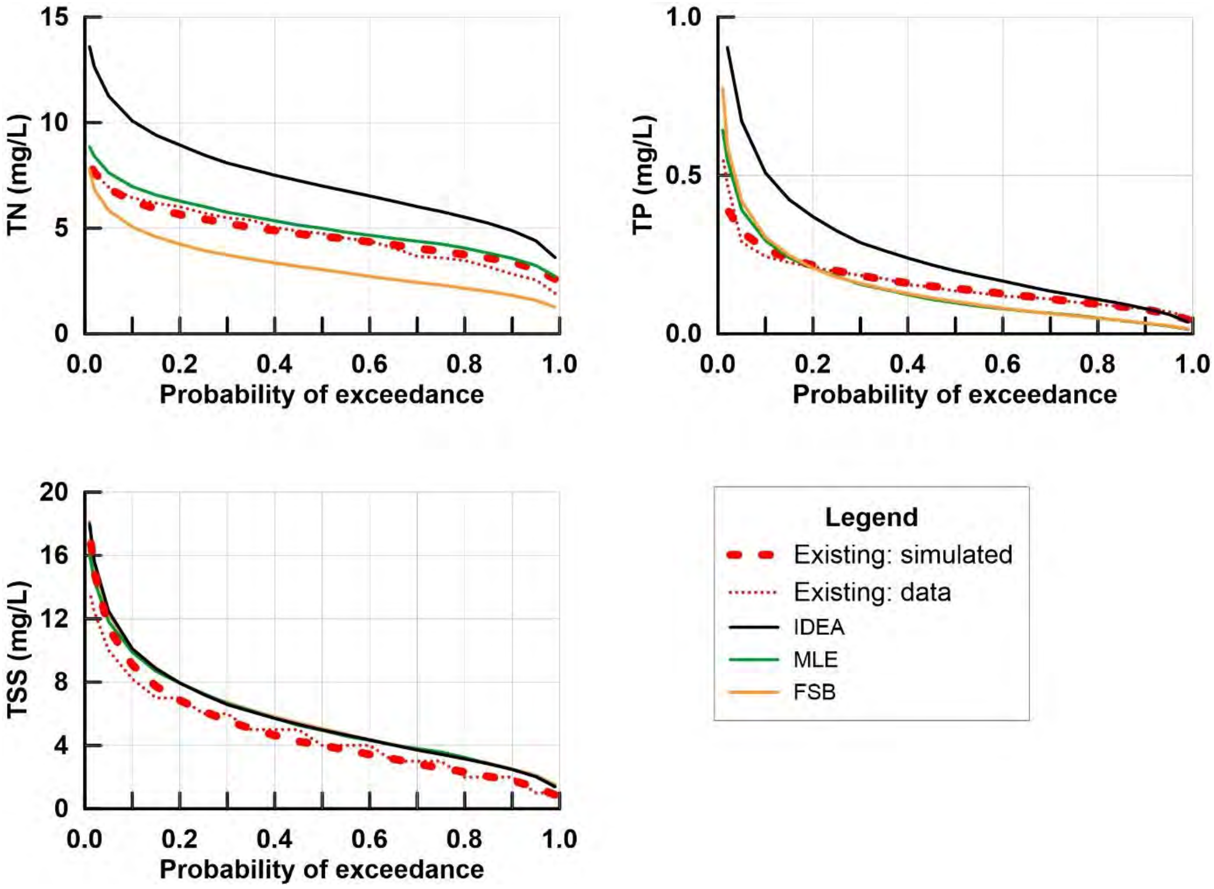

Figure 4–5. Bowral exceedance plots (EP=18,692) for concentrations simulated from the three scenarios and under existing conditions

Table 4–2. Bowral (EP=18,692): NorBE concentrations

	Scenario treatment type		
	IDEA	MLE	FSB
TSS	×	×	×
TN	×	marginal	✓
TP	×	marginal	marginal

Cells shaded pink indicate a failure of the NorBE conditions, while cells shaded green indicate that the relevant NorBE conditions are met. Cells that are unshaded fail the relevant NorBE condition although the value is within about 10% of the NorBE criteria.

Annual loads were estimated by averaging the annual loads for each of the 5 years the comprise the simulation period and multiplied by 1.1. Results are presented in Table 4–3. The scaled annual loads for TSS are close to the existing loads, almost complying with the NorBE load requirement. The FSB and MLE loads for TP almost comply with the NorBE annual load requirement.

Table 4–3. Bowral (EP=18,692): NorBE annual loads

Annual load		Scenario treatment type		
(kg/year)	Existing	IDEA	MLE	FSB
TSS	6,670	10,860	11,170	10,790
TN	6,530	13,830	9,980	6,120
TP	220	480	280	260

Cells shaded pink indicate a failure of the NorBE conditions, while cells shaded green indicate that the relevant NorBE conditions are met. Cells that are unshaded fail the relevant NorBE condition although the value is within about 10% of the NorBE criteria.

Generally, it is the annual loads (rather than the concentrations) that govern compliance with NorBE. None of the three proposed scenarios will meet NorBE. However, the FSB treatment option comes closest to meeting NorBE.

5. Conclusions

The main aims of this study are detailed in Section 1. Each of these is addressed below with a brief summary of the conclusions of the work undertaken.

Identify possible gaps in the knowledge the receiving water quality

After reviewing historical data, two major gaps were identified: a general lack of upstream data and no information on the natural variability of the system (as may be obtained from replicate sampling).

Based on the available data for the three STPs, the identified environmental values, and the long-term monitoring performed by WaterNSW, a 3-month monitoring program was designed to quantify the constituents and loads of each STP's effluent, as well as the condition of the receiving water bodies.

The environmental monitoring performed between December 2019 and February 2020 has filled some of the knowledge gaps present in the available water quality dataset. This additional data has facilitated statistically robust estimation of the upstream conditions of Wingecarribee River and provided the basis for modelling of future conditions.

Quantify and assess the existing condition of the receiving waterways

Temporal trend analysis was undertaken using long term data sets. Results from temporal trends between 2013 and 2019 indicate significantly increasing concentrations in the effluent for nitrite and alkalinity, and significantly decreasing concentrations for total nitrogen. At Berrima Weir (about 5 km downstream from the discharge location) significantly increasing trends were observed for conductivity and alkalinity, while significantly decreasing trends were observed for total suspended solids, ammonia, total nitrogen and faecal coliforms. Overall, this suggests continual improvement in the quality of the effluent over time.

Concentrations of most contaminants sampled during wet weather exceed those sampled during dry weather.

Upstream concentrations of many water quality parameters (e.g. nutrients) exceeded the ANZECC guidelines (or default trigger values). The consequence of this is that it is unlikely that these ANZECC guidelines can ever be met.

Describe the monitoring performed between 2019-20

Samples were collected on three occasions: 18 December 2019, 16 January 2020 (both under dry weather conditions) and on 20 February 2020 (under wet weather conditions). Almost 50 analytes were determined for each sample. At each sampling time / location two replicate samples were collected.

Samples from the STP were collected at 4 times (approximately 2 hours apart) on each sampling day. River samples were collected from two locations upstream from the discharge location and from two locations downstream from the discharge location.

A range of data analysis techniques was used to interpret the results (including trend analysis and ANOVA). Approximately 10% of samples were duplicated to assess the laboratory procedures. Results indicated (virtually) all samples were within the quoted accuracy for the analytical procedure used.

Assess the current impact of the STP discharge on the receiving waterways

Concentrations of nutrients, ions and zinc from the STP appear to be elevated compared with the upstream concentrations. Some metals could not be detected either in the effluent or in the receiving waters. Other metals indicated elevated concentrations at locations upstream of the STP discharge location, suggesting an upstream source of metals (possibly from mining activities). Concentrations of suspended solids and bacteria in the effluent were substantially lower than concentrations at upstream locations. Again, this suggests upstream sources of these contaminants: possibly from bed erosion (in the case of suspended solids) or livestock activities (in the case of bacteria).

Model the impacts of the proposed upgrades on the receiving waterways and compare the results with the ANZECC guidelines

A Monte Carlo approach was adopted for the modelling. That is, statistical distributions were built for the concentration of each variable (contaminants in the STP, background (i.e. upstream) contaminants in the receiving waters and dilutions at two locations in the receiving waters downstream from the discharge point). Random samples were taken from each statistical distribution under both existing conditions and for the future scenarios. This process was repeated many times resulting in statistical distributions of the output.

The resulting concentrations of contaminants in the STP for the future scenario were compared with the equivalent existing conditions. This enabled a determination of the compliance (or otherwise) with the NorBE requirements. Through an iterative process, it also enabled a determination of the concentration of contaminants in the STP effluent that is needed to just meet the NorBE requirement.

Using Equation 3-1 and input from the random samples from the statistical distributions (above) estimates were made of the concentrations of contaminants at two locations in the receiving waters, downstream from the discharge point.

For most contaminants, the upstream concentrations exceeded the ANZECC guidelines. This resulted in the downstream concentrations generally exceeding the ANZECC guidelines. This may suggest that the default ANZECC guidelines are not appropriate for this region. However, it is noted that most of the upstream data was based on sampling conducted over three days, which may not be sufficient to produce reliable statistics.

Undertake a NorBE assessment of the STP discharge.

Overall, it is unlikely that any of the scenarios tested will meet the requirements of NorBE. None of the scenarios will fully meet NorBE (FSB comes closest to meeting NorBE, but it only meets some of the NorBE requirements). However, if it is possible to add the benefit of the existing sewage treatment processes (particularly for TSS) with the FSB process, it may be possible to meet the NorBE requirements. It is stressed that NorBE does not define 'pre-development' conditions.

For some contaminants (particularly TSS) the existing concentrations are less than those proposed by one (or more) scenario. In general, this means that the NorBE concentration and / or load requirements will not be met.

The 50%ile tipping point values for TSS often lay below the PQL. Therefore, it may not be possible to confirm with data, that the NorBE requirement is met.

The 'tipping point' concentrations are substantially less than the existing concentrations to ensure that the NorBE load requirement is simultaneously met. Compliance with NorBE is usually governed by the annual loads, rather than by the concentrations.

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Appendix A Monitoring Analytes

Many analytes were measured as part of the water and effluent quality components of the project. Below is a brief summary of those analytes, their potential impact on human and environmental health (i.e. why they are important) and the relevant guidelines (drinking water or environmental).

A.1. Bacteria

Bacteria are often used as an indicator of the presence of pathogens. Perhaps the most common indicator bacteria are faecal coliforms and enterococci.

A.1.1. Faecal coliforms

Faecal coliform bacteria (more generally thermotolerant bacteria) originate from the intestines of warm-blooded animals. Elevated concentrations may occur from the discharge of wastewater, waste from livestock and domestic animals, shedding from bathers, etc. High concentrations of faecal coliforms may indicate the presence of pathogens in the water. Further, the aerobic decomposition of organic matter (that may be inferred by high concentrations of faecal coliforms) will reduce oxygen levels which may harm aquatic organisms.

Concentrations of faecal coliforms in raw sewage are of the order 10^6-10^8 cfu/100mL (Metcalf and Eddy, 2003; NHMRC, 2008).

The ANZECC (2018) guidelines for faecal coliforms are:

- Primary contact recreation: “150 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 600 organisms/100 mL)”.
- Secondary contact recreation (e.g. boating, fishing): “1000 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 4000 organisms/100 mL)”.

The ADWG (2011) for *E.coli* is zero concentration. *E.coli* is a species of faecal coliform bacteria that is directly related to faecal material.

A.1.2. Enterococci

Enterococci originate from the intestines of warm-blooded animals. Elevated concentrations may occur from the discharge of wastewater, waste from livestock and domestic animals, shedding from bathers, etc. High concentrations of enterococci may indicate the presence of pathogens in the water. Further, the aerobic decomposition of organic matter (that may be inferred by high concentrations of enterococci) will reduce oxygen levels which may harm aquatic organisms.

Concentrations of enterococci in raw sewage are of the order 10^4-10^6 cfu/100mL (Metcalf and Eddy, 2003; NHMRC, 2008).

The ANZECC (2018) guidelines for enterococci are:

- Primary contact recreation: “35 enterococci organisms/100 mL (maximum number in any one sample: 60–100 organisms/100 mL).”.
- Secondary contact recreation (e.g. boating, fishing): “230 enterococci organisms/100 mL (maximum number in any one sample: 450–700 organisms/100 mL)”.

The NHMRC (2008) guidelines provide 95%ile values for four different categories, with a risk of illness associated with each category. Category A: <40 cfu/100mL (low risk of illness), Category B: 41-200 cfu/100mL (slightly elevated risk of illness), Category C: 201-500 cfu/100mL (substantial elevation in the risk of illness), and Category D: >501 cfu/100mL (significant risk of illness).

The ADWG (2011) for enterococci is zero concentration.

A.2. Metals and metalloids

Much of the information presented in this section is based on Wright and Welbourn (2002) and ANZECC (2018).

All metals and metalloids occur naturally in the environment, mainly in rocks and sediments. Many metals are essential trace elements but may be toxic at high concentrations or at a particular valency. In water, they may attach themselves to particulate matter or exist in dissolved form where their distribution may become more widespread. Metals and metalloids generally need to be in dissolved form to be taken up by aquatic flora. However, aquatic fauna may also take in particulate matter to which metals may be attached. The bioavailability of metals is complex; often depending on the ionic form of the metal.

A.2.1. Transition metals

Cadmium: The primary uses of cadmium are in batteries, stabilisers for plastics, pigments and electroplating. Naturally occurring cadmium enters the waterways through weathering and erosion. Anthropogenic sources include agricultural runoff (via cadmium rich phosphates used as fertilisers), mines, industrial and municipal effluent discharges. High levels of cadmium in humans may result in kidney disease or osteoporosis. The bioavailability of cadmium in freshwater systems is enhanced when the pH is low. Plankton and benthic invertebrates are the most sensitive freshwater organisms to cadmium toxicity, cadmium generally inhibits their growth. Most aquatic organisms bioaccumulate cadmium.

- ADWG (2011): health guideline = 0.002 mg/L.
- ANZECC (2018) trigger values: Inorganic mercury = 0.00006 (0.0002) mg/L for the protection of 99% (and 95%) of freshwater species, respectively.

Copper: Copper is an essential trace element for most organisms. Uses of copper include: as an alloy (e.g. bronze, brass), manufacture of coins, jewellery and containers, electrical wiring, heating and cooling systems and as a supplement in foliage sprays. Natural inputs of copper to waterways include leaching from soils and runoff. Anthropogenic activities that introduce copper to the environment include: mining, agriculture and waste disposal. In general, humans can tolerate high concentrations of copper. Fish are susceptible to copper intoxification.

- ADWG (2011): health guideline = 2 mg/L, aesthetic (corrosion, colour) guideline = 1 mg/L.
- ANZECC (2018) trigger values: Inorganic mercury = 0.001 (0.0014) mg/L for the protection of 99% (and 95%) of freshwater species, respectively.

Chromium: There is some evidence to suggest that chromium is an essential element, although this assertion is not universally accepted. Chromium uses include: as a hardening agent for steel, electroplating, tanneries and in alloy production. Natural sources of chromium are limited (e.g. volcanic activity), with most being introduced to the environment through anthropogenic activities. Anthropogenic sources of chromium include the combustion of fossil fuels, wastewater discharges and metallurgical industries. Hexavalent chromium, Cr (VI), is highly toxic, is a known carcinogen and may cause mutation. It is highly toxic to fish, being easily absorbed across the gills and into the blood stream where it can bioaccumulate.

- ADWG (2011): Chromium VI health guideline = 0.005 mg/L.
- ANZECC (2018) trigger values: Chromium III = 0.008 (0.027) mg/L for the protection of 99% (and 95%) of freshwater species, respectively. Chromium VI = 0.00001 (0.001) mg/L for the protection of 99% (and 95%) of freshwater species, respectively.

Iron: Iron is a major component of steel and may be used in the production of some alloys. Natural sources of iron entering into waterways include the mobilisation of soils through weathering and erosion. Anthropogenic sources include wastewater discharges (iron may be used as a coagulant). Excessive amount of iron in the body may lead to an upset stomach, organ failure or coma. However, a deficiency of iron is usually of greater concern than an excess of iron. Generally, iron is not biologically available to aquatic organisms. Studies conducted under laboratory conditions have shown that excessive concentrations of iron may lead to toxicity in freshwater fish.

- ADWG (2011): aesthetic (taste, staining) guideline = 0.3 mg/L.
- ANZECC (2018) trigger values: Insufficient data for a guideline.

Manganese: Manganese is an abundant element in the earth's crust. It is an essential element for all organisms and is used in many manufacturing processes (e.g. as an additive to strengthen steel). Natural sources of manganese include weathering of rocks and discharges from volcanoes. Wastes from industrial processes are the primary anthropogenic source of manganese. Very high levels of manganese may cause neurological problems in humans. While manganese has been shown to be toxic to aquatic organisms, the number of studies addressing the toxicity of manganese is relatively small. Hence details on how manganese toxicity impacts aquatic organisms is limited.

- ADWG (2011): health guideline = 0.5 mg/L, aesthetic (taste, staining) guideline = 0.1 mg/L.
- ANZECC (2018) trigger values: 1.2 (1.9) mg/L for the protection of 99% (and 95%) of freshwater species, respectively.

Mercury: Mercury can enter the environment through a number of pathways including: volcanoes; coal-fired power plants; gold, cement, steel and battery production and wastewater discharges. Mercury is highly toxic and can cause a wide variety of problems in humans, particularly to the nervous system and the kidneys. Methylmercury is soluble in water hence it can easily move through the river systems and be taken up by aquatic organisms. Fish are resistant to the toxic effects of methylmercury. However, mercury can biomagnify, meaning that those higher in the food chain will have higher concentrations of mercury. It often accumulates in the muscles of fish and can be transferred to those who consume fish.

- ADWG (2011): health guideline = 0.001 mg/L.
- ANZECC (2018) trigger values: Inorganic mercury = 0.00006 (0.0006) mg/L for the protection of 99% (and 95%) of freshwater species, respectively.

Nickel: Major uses include as an alloy (e.g. coins, jewellery), batteries, electroplating, manufacturing (e.g. stainless steel, electronic equipment). It enters the waterways through natural processes such as weathering, erosion, forest fires and emissions from volcanoes. Anthropogenic inputs include mining, combustion of fossil fuels and waste disposal. Long exposure to nickel may result in respiratory illness and adverse effects on the blood and kidneys. At high concentrations, nickel and its compounds are toxic to aquatic organisms; responses in fish may include low growth and damage to tissues.

- ADWG (2011): health guideline = 0.002 mg/L.
- ANZECC (2018) trigger values: 0.008 (0.011) mg/L for the protection of 99% (and 95%) of freshwater species, respectively.

Zinc: Zinc is an essential element for most organisms. Its uses include galvanising metals, batteries, to make ointments and as an alloy (e.g. brass, bronze, soft solder). Zinc may naturally enter waterways via weathering and erosion. Anthropogenic sources of zinc include mining, burning of fossil fuels and wastewater discharges. Ingestion of excessive amounts of zinc may cause nausea and vomiting and possibly respiratory problems. Zinc is toxic to aquatic organisms and can bioaccumulate in the tissue of freshwater fish.

- ADWG (2011): aesthetic (taste) guideline = 3 mg/L.
- ANZECC (2018) trigger values: 0.0024 (0.008) mg/L for the protection of 99% (and 95%) of freshwater species, respectively.

A.2.2. Post transition metals

Aluminium: The most common uses of aluminium include cooking utensils, drink containers (e.g. cans) and building materials. Aluminium may enter the water system from runoff or from sedimented materials or wastewater discharges to the environment. Human exposure to high levels of aluminium may result in respiratory problems, or accumulation in bone or brain tissue. At low pH, aluminium interferes with phosphorus metabolism in plants. At low pH, aluminium may precipitate on the gills of fish causing asphyxiation.

- ADWG (2011): aesthetic (flocculation) guideline = 0.2 mg/L.

- ANZECC (2018) trigger values: 0.027 (0.055) mg/L for the protection of 99% (and 95%) of freshwater species, respectively (assuming that pH>6.5).

Lead: Past uses for lead have included plumbing, paints, solder, batteries and as an additive to petrol. Weathering of rocks and volcanic activity are the main natural sources of lead in the environment. Anthropogenic sources of lead include the smelting of lead ores, mines, burning of fossil fuels or wastewater discharges. High levels of lead affect the kidneys and the central nervous system. This may result in anaemia, convulsions or coma. The uptake of lead in fish usually resides in the bones or scales – the non-edible parts of the fish. In general, lead is not particularly bioavailable in freshwater systems, hence its impact on aquatic systems is less than other metals. The effects of lead on fish mortality decreases as the dissolved organic content increases.

- ADWG (2011): health guideline = 0.01 mg/L.
- ANZECC (2018) trigger values: 0.001 (0.0034) mg/L for the protection of 99% (and 95%) of freshwater species, respectively.

A.2.3. Metalloids

Arsenic: Past uses of arsenic include: as a pesticide, rodent poison, in chemical weapons and for wood preservation. Natural sources of arsenic include: weathering of rocks, soil erosion and forest fires. Anthropogenic sources include the manufacture of pesticides, coal fired power generators, mines, agricultural runoff and wastewater discharges. Human uptake is usually via drinking contaminated water or through inhalation. It is a known carcinogen and symptoms may include skin lesions, hyperpigmentation and keratosis. Arsenic is highly toxic to aquatic life with inorganic forms generally more toxic than organic forms. Aquatic flora may absorb arsenic through their roots or foliage while fish may absorb arsenic through the gills. Aquatic fauna may also bioaccumulate arsenic.

- ADWG (2011): health guideline = 0.01 mg/L.
- ANZECC (2018) trigger values: Arsenic III = 0.001 (0.0024) mg/L for the protection of 99% (and 95%) of freshwater species, respectively. Arsenic V = 0.0008 (0.0013) mg/L for the protection of 99% (and 95%) of freshwater species, respectively.

A.3. Ions

An excess of ions in water results in water being acidic (low pH or an excess of negative ions or anions) or alkaline (high pH or an excess of positive ions or cations). In turn, the pH controls the rate and direction of many chemical reactions. Ions are critical to the human body. However, too much or too little will cause health problems. A number of ions may be the result of forest burning – particularly relevant to these studies as major bush fires occurred in the Shire during this sampling program.

There is no AWDG (2011) guideline for total dissolved solids (TDS), although it is recommended that TDS<600 mg/L for palatability.

A.3.1. Anions

Anions are negatively charged atoms or molecules and include: sulfate, chloride and fluoride. (Note: phosphate, nitrite and nitrate are included in the nutrients).

Sulfate: Aluminium sulfate may be used as a flocculant in water treatment. Copper surfate may be used to help prevent cyanobacteria blooms from occurring in water storages. Burning of forests may also lead to elevated concentrations of sulfate. Sulfate is rapidly absorbed by the gastrointestinal tract and, in excessive quantities, may cause purgative effects. Sulfate may scavenge chlorine, which may interfere with the efficiency of chlorine disinfection.

Chloride: May be sourced from wastewater treatment (chlorine dioxide as a disinfectant) or natural mineral salts. Cooking with salt may also be a major source of chloride. Chloride is an essential ion in humans and animals impacting the osmotic flow of fluid in the body. Chloride is almost completely absorbed by the gastrointestinal tract and large intakes may result in increased blood pressure.

Fluoride: Concentrations of fluoride in drinking water depend largely on the types of rocks through which the water flows. Fluoride is used to protect teeth and drinking water may be dosed with fluoride to help prevent cavities. Fluoride is adsorbed quickly by the body but not metabolised. Excessive concentrations may lead to mottling of the teeth and bones becoming brittle.

ADWG (2011) guideline values are: sulfate (250 mg/L, based on the taste threshold), chloride (no guideline; although <250 mg/L, based on aesthetics), fluoride (1.5 mg/L).

A.3.2. Cations

Cations are positively charged atoms or molecules and include: calcium, magnesium, sodium and potassium. Calcium and magnesium are two cations that often cause water to become “hard” which may lead to a build-up of scale in water pipes and heating systems. Hard water also makes it difficult for soaps and detergents to perform as designed, with a subsequent flow-on effect to washing hands, dishes and clothes.

Calcium: Calcium occurs naturally in water. It’s concentrations in fresh waters is generally low (1-2 ppm) although such concentrations may be higher if lime is also present. Calcium is a critical mineral for many bodily functions. It is primarily stored in bones and teeth and has its source in dairy products and vegetables. Excessively high intake of calcium may lead to vascular and soft tissue calcification or lead to kidney stones.

Magnesium: Magnesium in water occurs naturally. It is a central atom in the chlorophyll molecule, hence is critical for photosynthesis. Magnesium is a cofactor in many enzymes involved in energy metabolism. It may also lower the risk of coronary heart disease and type 2 diabetes. Excessive concentrations of magnesium may have a laxative effect on humans.

Sodium: The sodium ion is ubiquitous in water. Leaching from the terrestrial environment, food processing and water treatment processes may introduce sodium into the aquatic environment. In general, sodium salts are highly soluble in water. Excessive levels of sodium may lead to hypertension, nausea and cerebral and pulmonary oedema.

Potassium: Potassium is an essential element for humans. The primary source of potassium is from diet. Potassium permanganate may be used in the drinking-water treatment process. Increased exposure to potassium could result in significant health effects in people with a range of pre-existing conditions e.g. kidney, heart disease, coronary artery diseases, hypertension, diabetes. Excessive concentrations of potassium may lead to nausea, diarrhoea or heart failure.

There are no individual ADWG (2011) guidelines for these cations. However, they do contribute to the overall hardness of water and ADWG (2011) recommend total hardness concentrations <200 mg/L.

A.3.3. Alkalinity

Alkalinity is the capacity of water's ability to neutralise acids (i.e. it buffers the water against a change in pH). The origin of alkalinity in natural waters is primarily the presence of weak acid salts. The main forms of alkalinity are: hydroxide, carbonate and bicarbonate alkalinity. These are usually expressed as calcium carbonate. Total alkalinity (expressed as calcium carbonate) with the degrees of hardness is described as follows (ADWG, 2011):

- <60 mg/L $CaCO_3$ (soft but possibly corrosive),
- 60 – 200 mg/L $CaCO_3$ (good quality),
- 200 – 500 mg/L $CaCO_3$ (increasing scaling problems),
- >500 mg/L $CaCO_3$ (severe scaling).

To prevent the build-up of scale in pipes and heating systems the ADWG (2011) recommend total hardness concentrations <200 mg/L.

A.4. Nutrients

Nutrients (e.g. nitrogen and phosphorus) are essential components for humans, flora and fauna. They form part of amino acids which are the building blocks for proteins and nucleic acids (such as DNA). Their presence in the environment has many sources, including: sewage treatment plants, leachate from (or failure of) septic systems, fertilizers, agricultural (and urban) runoff, animal manure, atmospheric emissions, some industrial effluents, burning forests.

In excessive quantities they can cause major problems to humans and the environment. High concentrations of nitrogen and phosphorus may lead to excessive algal growth. As the algae die and decompose the levels of oxygen in the water decrease, placing considerable stress on aquatic plants and animals.

Two nutrients considered as part of this study are: nitrogen and phosphorus.

A.4.1. Nitrogen-based nutrients

The nitrogen-based nutrients used in this study are: total nitrogen (TN), total Kjeldahl nitrogen (TKN), ammonia (NH3), nitrite (NO2) and nitrate (NO3). Nitrite and nitrate are combined to form oxidised nitrogen (NOx).

TKN is the sum of ammonia, organic nitrogen and reduced nitrogen (e.g. ammonium, NH4). It is the method first used by Johan Kjeldahl to quantify the amount of nitrogen in organic compounds. TN is the sum of TKN and NOx.

Under aerobic conditions, organic nitrogen transforms into ammonia, thence to nitrite and finally nitrate. Ammonia may occur in two forms, unionised (NH3) and ionised (NH4). The former is more toxic and under most environmental conditions represents <10% of total ammonia (NH3 plus NH4), although this depends largely on pH and temperature. Ammonia is toxic to humans and fish. In low concentrations it can be irritating to humans and dermal contact may cause burns. Ingestion can be corrosive to the airways and stomach. In fish, ammonia may inhibit the oxygen carrying capacity of blood, inhibit chemical reactions in the body, damage gills and generally weaken the immune system.

Nitrite is an intermediate product and its concentrations are generally very low (representing perhaps 10% of NOx). It is more toxic to humans than is nitrate. However, nitrate is usually more significant; when ingested it is converted to nitrite. Nitrate is soluble in water and it often attaches itself to particulate matter allowing it to move freely throughout the aquatic environment. High concentrations of nitrate in babies may lead to methemoglobinemia, in which nitrate inhibits the transport of oxygen in the blood. Long-term exposure to nitrate (via N-nitroso compounds) may result in: adverse reproduction, thyroid disruption and cancer. High concentrations of nitrate may lead to eutrophication (outlined above). High concentrations of oxidised nitrogen in fish may: reduce the blood oxygen carrying capacity, cause damage to the gills, liver and kidney and increase their vulnerability to attack by bacteria and parasites.

ANZECC (2018) default trigger values (for NSW upper rivers): total nitrogen (0.25 mg-N/L), total Kjeldahl nitrogen (no guideline), ammonia (0.013 mg-N/L), nitrite plus nitrate (0.015 mg-N/L). (Note: earlier versions of ANZECC incorrectly provide limits for ammonium rather than ammonia. An erratum was issued correcting this error). The ADWG (2011) guidelines recommend ammonia (NH3) <0.5 mg/L, based on aesthetic and corrosion considerations. No health guidelines are provided. Concentration guidelines for nitrite and nitrate are, respectively 3 mg-NO2/L and 50mg-NO3/L).

A.4.2. Phosphorous-based nutrients

Many of the considerations (e.g. sources, impacts on human health and aquatic organisms) for the nitrogen-based nutrients (above) also apply to the phosphorus-based nutrients). As part of this study, two species of phosphorus are examined: total phosphorus (TP) and dissolved reactive phosphorus (PO4). Dissolved reactive phosphorus is also referred to as soluble reactive phosphorus, dissolved inorganic phosphorus, reactive phosphorus, dissolved phosphorus. Effectively, they are all measures of orthophosphate, the biologically available form of phosphorus.

TP is (approximately) the sum of particulate phosphorus and dissolved reactive phosphorus. In general, dissolved unreactive phosphorus is only a small fraction of total phosphorus.

Unless the concentrations of phosphorus are very high, they are not toxic to humans or animals. Extremely high concentrations of phosphate may cause digestive problems in humans. In the past, phosphates from detergents have caused environmental issues such as algal blooms. Excessive amounts of phosphates used as fertilizers may run off agricultural lands and directly enter the water bodies.

ANZECC (2018) default trigger values (for NSW upper rivers): total phosphorus (0.02 mg-P/L), filterable reactive phosphate (0.015 mg-P/L). There are no ADWG (2011) guidelines for total phosphorus or dissolved reactive phosphorus.

A.5. Miscellaneous

A.5.1. Suspended solids

Suspended solids are small, undissolved particles in water. Their origin may be natural (e.g. from soil erosion or sediment resuspension) or from anthropogenic activities such as the discharge of wastewater (usually at a low level of treatment) to the local waters. Contaminants e.g. metals and pathogens, may attach themselves to particulate matter, which may in turn substantially increase the distribution of the contaminant in question. Suspended solids also reduce the clarity of water, thereby reducing light penetration and inhibiting photosynthesis. High concentrations of particulate matter in water may also block the gills of fish. High concentrations of pathogens are often associated with high concentrations of suspended solids.

A water property related to suspended solids is turbidity. Turbidity measures the light scattering property of water. The amount of scattering depends on the volume, size and composition of the suspended matter. High turbidity will impact the disinfection process of water and wastewater treatment as well as having poor aesthetic qualities.

There are no ANZECC (2018) default trigger values for NSW upper rivers. However, the closely related turbidity has default trigger values of 2-25 NTU for upper river waters. The exact relationship between suspended solids and turbidity is highly variable. However, a high concentration of suspended solids is likely to result in high concentrations of turbidity.

ADWG (2011) guidelines recommend several levels of turbidity:

- To reduce pathogens filter sizes should be such that the turbidity < 0.2 NTU.
- For chlorine disinfection, turbidity < 1 NTU.
- Based on aesthetic considerations, the turbidity < 5 NTU.

A.5.2. Chlorophyll-a

Chlorophyll is required by aquatic plants for photosynthesis. Nutrients such as phosphorus and nitrogen are largely responsible for chlorophyll in rivers. At low levels, the photosynthesis process of algae and aquatic plants releases oxygen into the water. However, elevated levels of chlorophyll-a will increase the risk of excessive algal growth and the likelihood of cyanobacteria (blue-green algae) blooms. Many species of cyanobacteria produce toxins that are harmful to aquatic life and/or human health.

There are no ANZECC (2018) default trigger values for NSW upper rivers. Likewise, there are no ADGW (2011) guidelines for chlorophyll-a. The lack of specific chlorophyll-a guidelines is puzzling, given that excessive growth may produce toxins. Perhaps the assumption is that chlorophyll-a levels will be controlled as a consequence of the controls placed on nutrient concentrations.

A.5.3. Dissolved oxygen

Dissolved oxygen is simply a measure of the amount of oxygen that is dissolved in water. The source of oxygen includes atmospheric inputs, aeration of the water due to turbulence or as a product of photosynthesis. Oxygen is required for most aquatic life. Low oxygen concentrations may lead to the growth of nuisance anaerobic microorganisms (eutrophication). Excessively high concentrations of dissolved oxygen in water may be harmful to aquatic life (e.g. "gas bubble disease") or result in the corrosion of water pipes.

ANZECC (2018) default trigger values (for NSW upper rivers): upper limit (110% saturation), lower limit (90% saturation). The ADWG (2011) has not set a drinking water guideline for dissolved oxygen based on health considerations. However, a lower limit of 85% saturation is recommended by ADWG (2011) for “aesthetic considerations” (i.e. taste, odour and the corrosion of water pipes and fittings).

A.5.4. pH

pH is a logarithmic measure of the hydrogen ion concentration of water. A pH of 7 is neutral, >7 is alkaline, and <7 is acidic. Excessively high or low pH values may corrode pipes and fittings. The efficiency of chlorine disinfection is reduced when pH levels exceed about 8. In humans, exposure to substances with high or low pH may result in dermal irritation.

ANZECC (2018) default trigger values (for NSW upper rivers): upper limit (6.5 pH units), lower limit (8.0 pH units). ADWG (2011) guidelines recommend pH levels between 6.5 and 8.5, based on the need to reduce corrosion and encrustation in pipes and fittings. Similarly, the NHMRC (2008) guidelines for pH in recreational waters are between 6.5 and 8.5.

Appendix B Monitoring Analysis

B.1. Bowral STP

Routine monitoring for effluent quantity and quality is required under the Environmental Protection Licence number 1794 (EPL, 2018a). Monitoring is summarised below:

- Effluent flow is measured at the STP (Point 8).
- Fortnightly effluent quality sampling at Point 1 (which also satisfies the monitoring licence requirement at Point 7).
- Monthly sampling at Point 11 (about 25 m upstream of Point 7) and at Point 12 (at Berrima Weir, about 5,000 m downstream from the discharge Point 7).
- Wet weather effluent quality sampling is undertaken daily when discharges occur via Point 9 (the storm detention pond) and/or Point 10 (the evaporation pond).

Daily effluent flow at Bowral STP, daily flow in the Wingecarribee River (at Bong Bong Weir) and daily rainfall at Bowral between 2013 and 2019 are presented in Figure B1. High effluent flow generally occurs with high rainfall and a corresponding high river flow, as expected. However, there is very little high river flow between 2017 and 2019. This is despite several large rainfall events during that period. Presumably, the reservoir behind Bong Bong Weir was low during this period and excess rain was used to raise water levels in the reservoir rather than being discharged to the river.

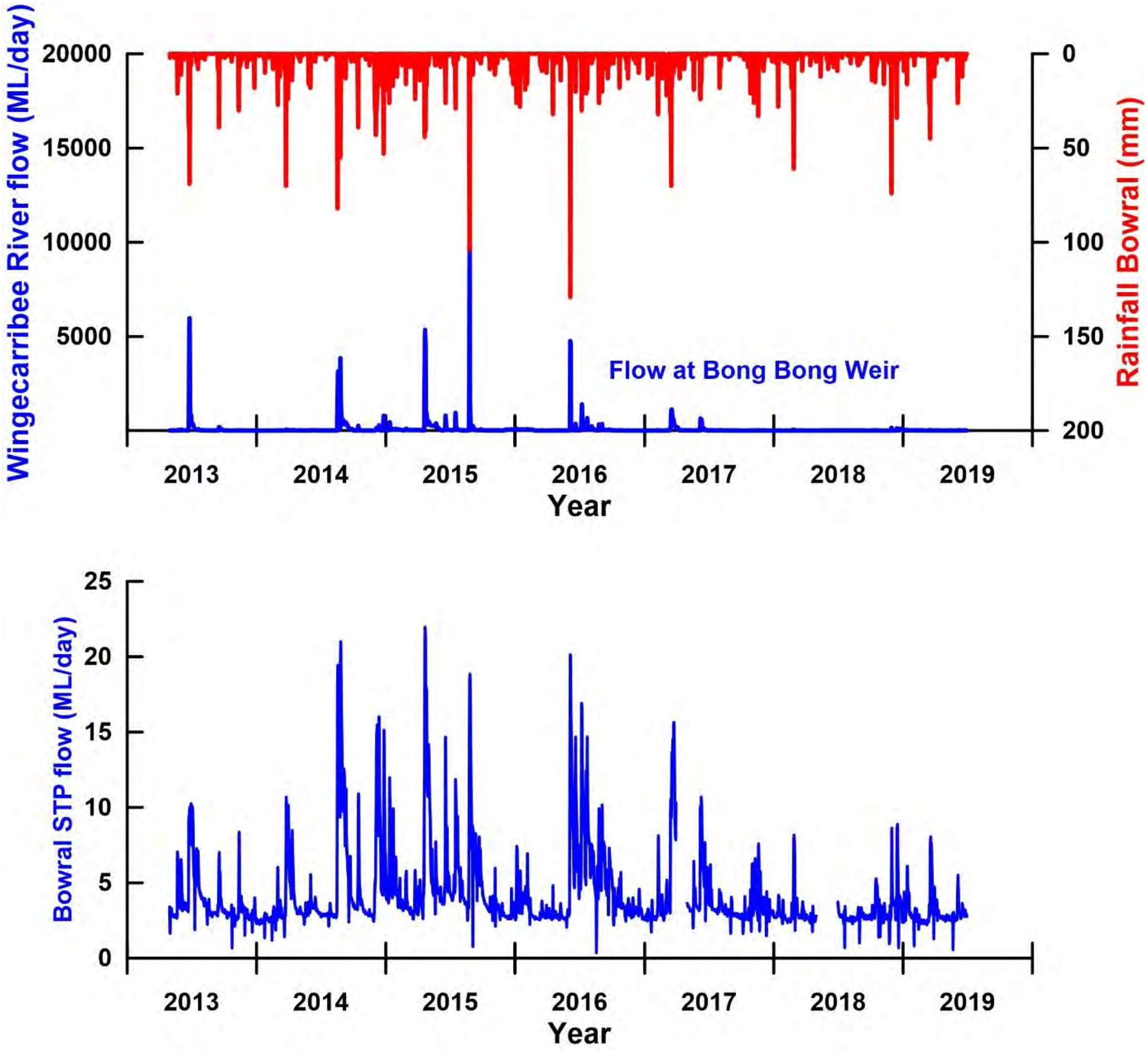


Figure B1. Effluent flow at Bowral STP, flow in the Wingecarribee River (at Bong Bong Weir) and rainfall at Bowral.

B.1.1. Dry weather discharges

Time series plots for the physico-chemical and faecal coliform indicators are shown in **Error! Reference source not found.** and those for nutrients shown in **Error! Reference source not found.**. The black dashed lines represent the linear trend, while the red lines represent the licence limits. Only those indicators for which licence concentrations are available are plotted.

Licence limits for BOD and TSS are the 50%ile and 90%ile values, the licence limit for faecal coliforms is the 80%ile value, while the licence limits for pH are the maximum and minimum values. Licence limits for total nitrogen and total phosphorus are the 50%ile and 90%ile values while the licence limit for ammonia is the 90%ile value.

Using STP data from the period 2013-2019, all licence limits are met.

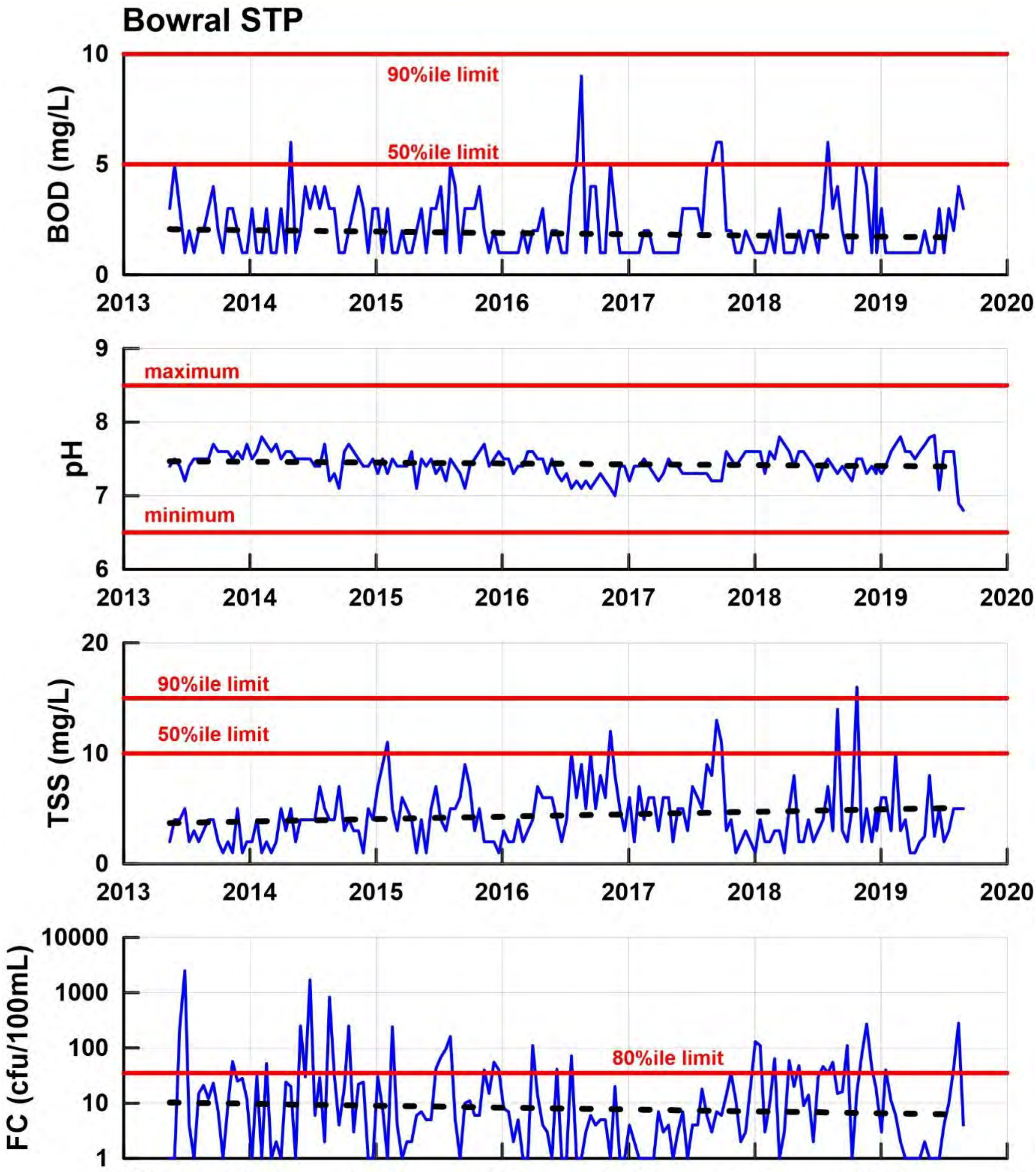


Figure B2. Physico-chemical and faecal coliform indicators of effluent quality for Bowral STP (Point 7). The black dashed lines represent the linear trend, while the red lines represent the licence limits.

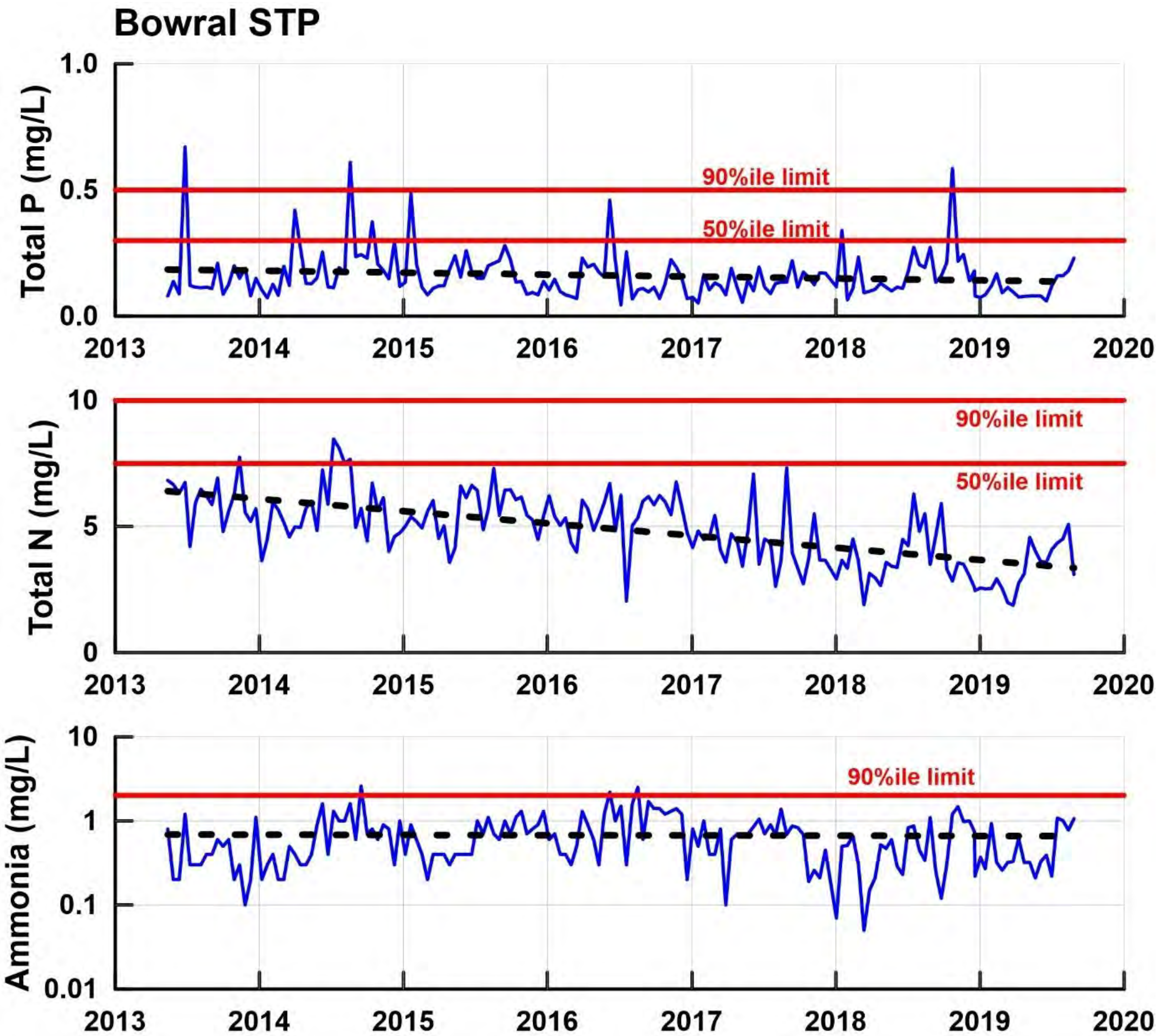


Figure B3. Nutrient indicators of effluent quality for Bowral STP (Point 7). The black dashed lines represent the linear trend, while the red lines represent the licence limits.

Basic statistics of the variables measured in the effluent are determined (**Error! Reference source not found.**). These provide a general indication of the concentrations obtained from the effluent under normal operating conditions. Often, the statistics for central tendency and dispersion are given by the mean and standard deviation of the data. However, as these data are generally not normally distributed, these two statistics have been replaced by the median and mean absolute difference (M.A.D.), which often provide better estimates of the central tendency and dispersion of the data, respectively.

$$MAD = \frac{1}{n}\sum_{i=1}^{n}|x_i - \overline{x}|$$

Table B1. Basic statistics in the Bowral STP data

Variable	Units	Number	Min.	Max.	Median	M.A.D.	Mean	StDev
BOD	mg/L	165	1.00	9.00	2.25	1.46	2.00	1.18
TSS	mg/L	165	1.00	16.00	4.39	2.70	4.00	2.03
Conductivity	µS/cm	134	26.60	66.00	54.67	6.96	56.50	14.44
Ammonia	mg/L	165	0.05	2.60	0.67	0.45	0.60	0.35
Nitrite	mg/L	165	0.01	2.04	0.18	0.17	0.15	0.08
Nitrate	mg/L	165	0.32	7.53	3.67	1.08	3.60	0.81
Oxidised nitrogen	mg/L	165	0.39	7.53	3.77	1.08	3.71	0.80
Total nitrogen	mg/L	165	2.05	9.72	5.73	1.22	5.66	0.96
Total phosphorus	mg/L	165	0.05	0.67	0.16	0.10	0.14	0.06
pH		165	6.80	7.82	7.43	0.18	7.40	0.15
Faecal coliforms (log10)	(log10) cfu / 100mL	165	0.00	3.40	0.90	0.76	0.78	0.62
Oil and grease	mg/L	165	2.50	2.50	2.50	0.00	2.50	0.00
Alkalinity	mg/L, CaCO3	162	38.80	87.20	62.90	10.11	62.60	9.19

M.A.D. is the mean absolute deviation.

B.1.2. Wet weather discharges

Daily monitoring is undertaken at licence Point 9 when effluent is discharged into Mittagong Creek. Between 2013 and 2019, monitoring occurred on 12 days (six events) and represents about 0.5% of the time (between 2013 and 2019). These data represent concentrations of variables under wet weather conditions and are shown in **Error! Reference source not found.**.

A cursory examination shows these data to have considerably greater concentrations than the STP dry weather data (**Error! Reference source not found.**). (Detailed analyses are provided in following sections). This is expected as the level of sewage treatment is likely to be lower under wet weather conditions than it is under dry weather conditions.

Table B2. Basic statistics for Point 9 wet weather discharges

Variable	Units	Number	Min.	Max.	Median	M.A.D.	Mean	StDev
BOD	mg/L	12	5.00	16.00	8.50	2.08	8.75	2.96
TSS	mg/L	12	9.00	27.00	19.50	3.58	19.08	4.64
Conductivity	µS/cm	12	21.50	34.80	28.65	3.28	28.48	4.38
Ammonia	mg/L	12	1.70	6.30	3.25	1.18	3.50	1.52
Nitrite	mg/L	12	0.05	0.53	0.11	0.17	0.23	0.19
Nitrate	mg/L	12	1.04	3.92	2.67	0.57	2.57	0.83
Oxidised nitrogen	mg/L	12	1.49	4.00	2.85	0.50	2.80	0.73

Total nitrogen	mg/L	12	6.30	11.70	8.03	0.99	8.09	1.43
Total phosphorus	mg/L	12	0.57	1.28	0.68	0.18	0.78	0.23
pH		12	6.60	6.90	6.80	0.08	6.78	0.10
Faecal coliforms (log10)	(log10) cfu / 100mL	12	3.75	5.74	5.23	0.47	5.08	0.64
Oil and grease	mg/L	12	2.50	2.50	2.50	0.00	2.50	0.00
Alkalinity	mg/L, CaCO3	No data						

M.A.D. is the mean absolute deviation.

Daily monitoring in undertaken at licence Point 10 when effluent is discharged into Mittagong Creek. Between 2013 and 2019, monitoring occurred on 53 days (seven events), representing about 2.3% of the time (between 2013 and 2019). These data represent a second set of concentrations of variables under wet weather conditions. Median concentrations (**Error! Reference source not found.**) generally lie between the STP concentrations (**Error! Reference source not found.**) and Point 9 concentrations (**Error! Reference source not found.**).

Table B3. Basic statistics for Point 10

Variable	Units	Number	Min.	Max.	Median	M.A.D.	Mean	StDev
BOD	mg/L	53	1.00	5.00	3.00	1.26	2.49	1.38
TSS	mg/L	53	2.00	36.00	8.00	3.77	8.79	5.62
Conductivity	µS/cm	53	16.30	51.30	36.00	3.87	35.61	5.16
Ammonia	mg/L	53	0.05	6.10	1.70	0.81	2.02	1.07
Nitrite	mg/L	53	0.01	0.18	0.10	0.03	0.10	0.04
Nitrate	mg/L	53	0.07	2.14	1.02	0.37	1.03	0.47
Oxidised nitrogen	mg/L	53	0.08	2.31	1.15	0.39	1.13	0.49
Total nitrogen	mg/L	53	1.07	6.13	4.26	1.12	4.03	1.30
Total phosphorus	mg/L	53	0.21	1.32	0.58	0.15	0.60	0.22
pH		53	6.50	7.80	7.30	0.18	7.29	0.23
Faecal coliforms (log10)	(log10) cfu / 100mL	53	2.30	5.23	3.61	0.59	3.67	0.72
Oil and grease	mg/L	53	2.50	10.00	2.50	0.40	2.71	1.13

M.A.D. is the mean absolute deviation.

A t-test can be used to investigate the significance of the differences between the means of the (wet weather) discharges from Points 9 and 10. Although the data may not be normally distributed, the hypothesis concerns the differences between the two means, which are normally distributed.

The results (**Error! Reference source not found.**) indicate the concentrations of substances discharged from Point 9 are significantly greater than the concentrations of substances discharged from Point 10. The opposite is true for pH and conductivity, for which readings taken at discharge Point 10 exceeded those at discharge Point 9.

The implication is that river water quality during wet weather (as a result of discharges from the Bowral STP) is governed by the type of wet weather discharge i.e. whether discharge occurs from the storm detention pond (Point 9) or the evaporation pond (Point 10).

Table B4. Comparing data from Points 9 and 10

Variable	Averages		t-calc	t-critical	Results	
	Point 9	Point 10			Difference	Significance
BOD	8.75	2.49	7.16	+/- 2.18	Point 9 > Point 10	SIG
TSS	19.08	8.79	6.66	+/- 2.09	Point 9 > Point 10	SIG
Cond.	28.5	35.6	-4.92	+/- 2.10	Point 9 < Point 10	SIG
Ammonia	3.50	2.02	3.20	+/- 2.16	Point 9 > Point 10	SIG
Nitrite	0.228	0.099	2.31	+/- 2.20	Point 9 > Point 10	SIG
Nitrate	2.57	1.03	6.23	+/- 2.18	Point 9 > Point 10	SIG
Oxidised nitrogen	2.80	1.13	7.55	+/- 2.16	Point 9 > Point 10	SIG
Total nitrogen	8.09	4.03	9.03	+/- 2.13	Point 9 > Point 10	SIG
Total phosphorus	0.780	0.596	2.54	+/- 2.13	Point 9 > Point 10	SIG
pH	6.76	7.29	-12.10	+/- 2.02	Point 9 < Point 10	SIG
Oil and grease	Insufficient data above limits of detection for reliable results					
Faecal coliforms (log10)	5.08	3.68	6.70	+/- 2.11	Point 9 > Point 10	SIG

There are only very limited data for oil and grease that are above the limit of reading. Therefore, the results are not reliable.
NSD = the two means are not statistically different at the 5% level of significance.
SIG = the two means are statistically different at the 5% level of significance.

Analysis of variance (ANOVA) was used to determine statistically significant differences among data from STP, Point 9 and Point 10. Duncan's multiple range test was used to calculate the mean comparisons. ANOVA is relatively robust to departures from normality. Faecal coliform data were log10-transformed prior to analysis.

The results are summarised in **Error! Reference source not found.**. As expected from the above results, it is generally found that the lowest concentrations occur in the STP data while the highest concentrations occur in the data from Point 9. The opposite is true with respect to conductivity and pH. A Kruskal-Wallis non-parametric analysis was also undertaken and the results agree with those from the ANOVA.

Table B5. ANOVA summary: STP, Point 9 and Point 10

Variable	ANOVA	F-calc	F-critical	Kruskal-Wallis
BOD	STP = Point 10 < Point 9	99.0	3.04	SIG
TSS	STP < Point 10 < Point 9	106.8	3.04	SIG
Cond.	Point 9 = Point 10 < STP	227.8	3.04	SIG
Ammonia	STP < Point 10 < Point 9	136.2	3.04	SIG

Nitrite	Point 10 = STP = Point 9	7.0	3.04	SIG
Nitrate	Point 10 < Point 9 = STP	151.7	3.04	SIG
Oxidised nitrogen	Point 10 < Point 9 = STP	152.6	3.04	SIG
Total nitrogen	Point 10 < STP < Point 9	64.7	3.04	SIG
Total phosphorus	STP < Point 10 < Point 9	266.5	3.04	SIG
pH	Point 9 < Point 10 = STP	70.5	3.04	SIG
Oil and grease	Insufficient variability in the data for reliable results			
Faecal coliforms (log10)	STP < Point 10 < Point 9	404.56	3.04	SIG

There are only very limited data for oil and grease that are above the limit of reading. Therefore, the results are not reliable.
NSD = the two means are not statistically different at the 5% level of significance.
SIG = the two means are statistically different at the 5% level of significance.
All calculations were undertaken using 5% level of significance and the F-tests all exceeded 80% statistical power.
In the ANOVA column, the locations are ordered in terms of increasing mean values. An ‘=’ sign indicates that there is no significant difference in the means of the data collected from the two locations either side of the ‘=’ sign. The ‘<’ sign indicates the mean of the data whose location label is on the left, is significantly less than that of the data whose location label is to the right.

The analysis provides a quantitative assessment showing that effluent quality from the STP (which receives full treatment) has lower concentrations of contaminants than the effluent quality from Points 9 and 10 (which only receive partial treatment). It confirms what is intuitively obvious.

B.1.3. Annual Loads

Annual loads for selected contaminants (biochemical oxygen demand, total suspended solids, ammonia, total nitrogen and total phosphorus) were estimated for the licence compliance periods from 2013-14 to 2018-19. Concentrations of contaminants from samples collected each fortnight were multiplied by the effluent flow on that day. The annual average was then calculated and multiplied by 365, resulting in the load in kilograms per year.

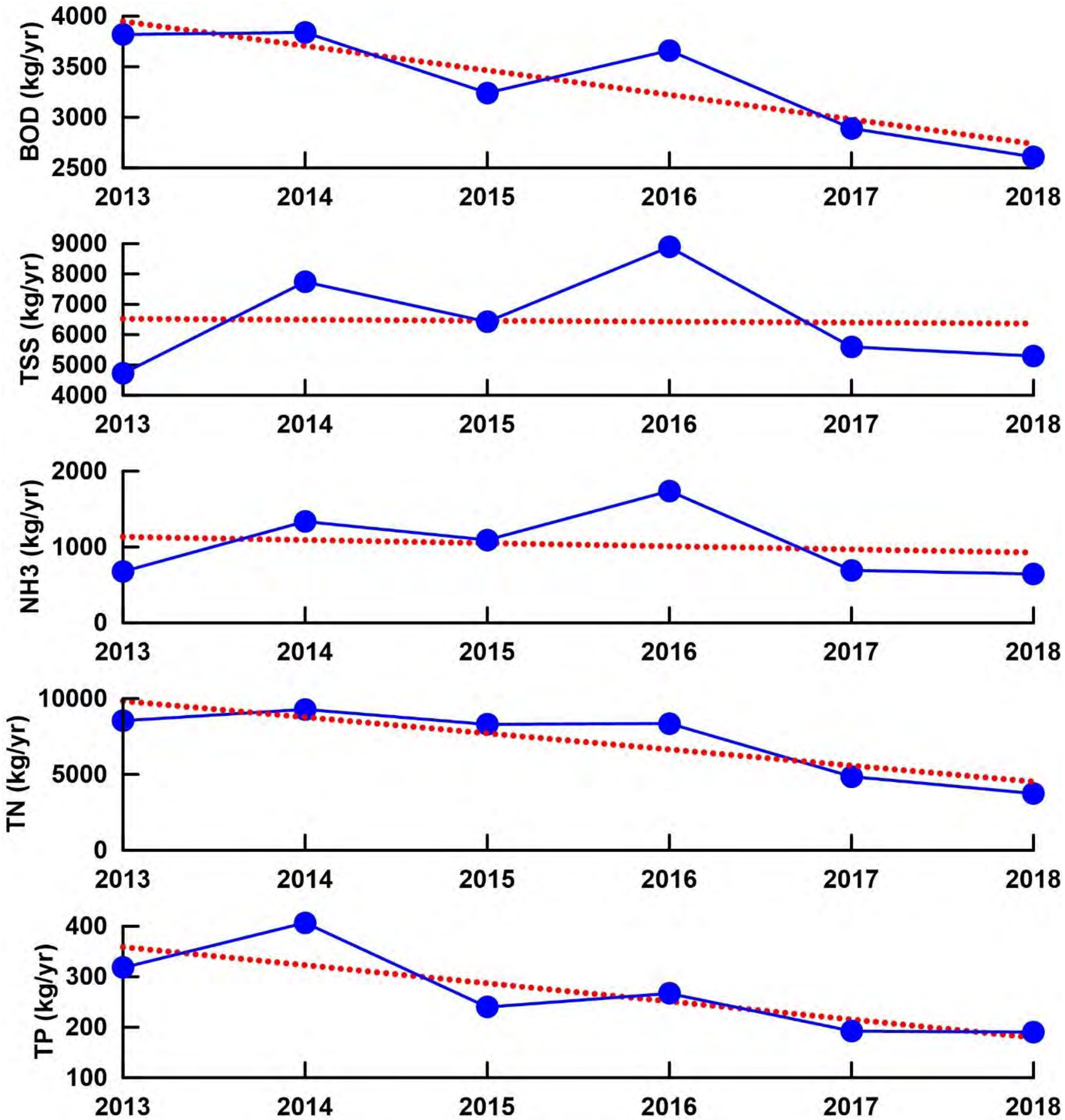


Figure B4. Annual loads for selected contaminants in the Bowral effluent.

Results of the annual loads are plotted in Figure B4. The red dotted line on each plot is the linear trend line.

Over the data period examined, the linear trends are decreasing for all contaminants (although this decreasing trend is difficult to observed for TSS). This demonstrates a continual improvement over time and a reduction in the potential impact on river water quality.

B.2. Wingecarribee River

This section focuses on water quality data obtained from the WaterNSW data set at the downstream location E332. No equivalent upstream data are available. Data collected as part of the STP licence conditions are presented in Section 2.4.1 (upstream) and Section 2.4.2 (downstream).

Water quality downstream of the Bowral STP discharge point is undertaken at Berrima Weir. The same location is used for the STP licence requirements (Point 12) and is also a monitoring location (E332) for WaterNSW. Hence two data sets are available. The focus of the analyses presented in this section is on the WaterNSW data.

Location E332 lies about 5 km downstream the Bowral STP discharge into the Wingecarribee River. Given this distance and the size of the Wingecarribee River, the impact of the Bowral STP discharge may be difficult to detect at location E322. Long term monitoring is carried out at E322 – nominally monthly from late 2000 onwards. Time series plots of selected variables are shown in **Error! Reference source not found.** (physico-chemical), **Error! Reference source not found.** (bacteria), **Error! Reference source not found.** (nutrients) and **Error! Reference source not found.** (metals). Superimposed on these plots are temporal trends and ANZECC default water quality guidelines.

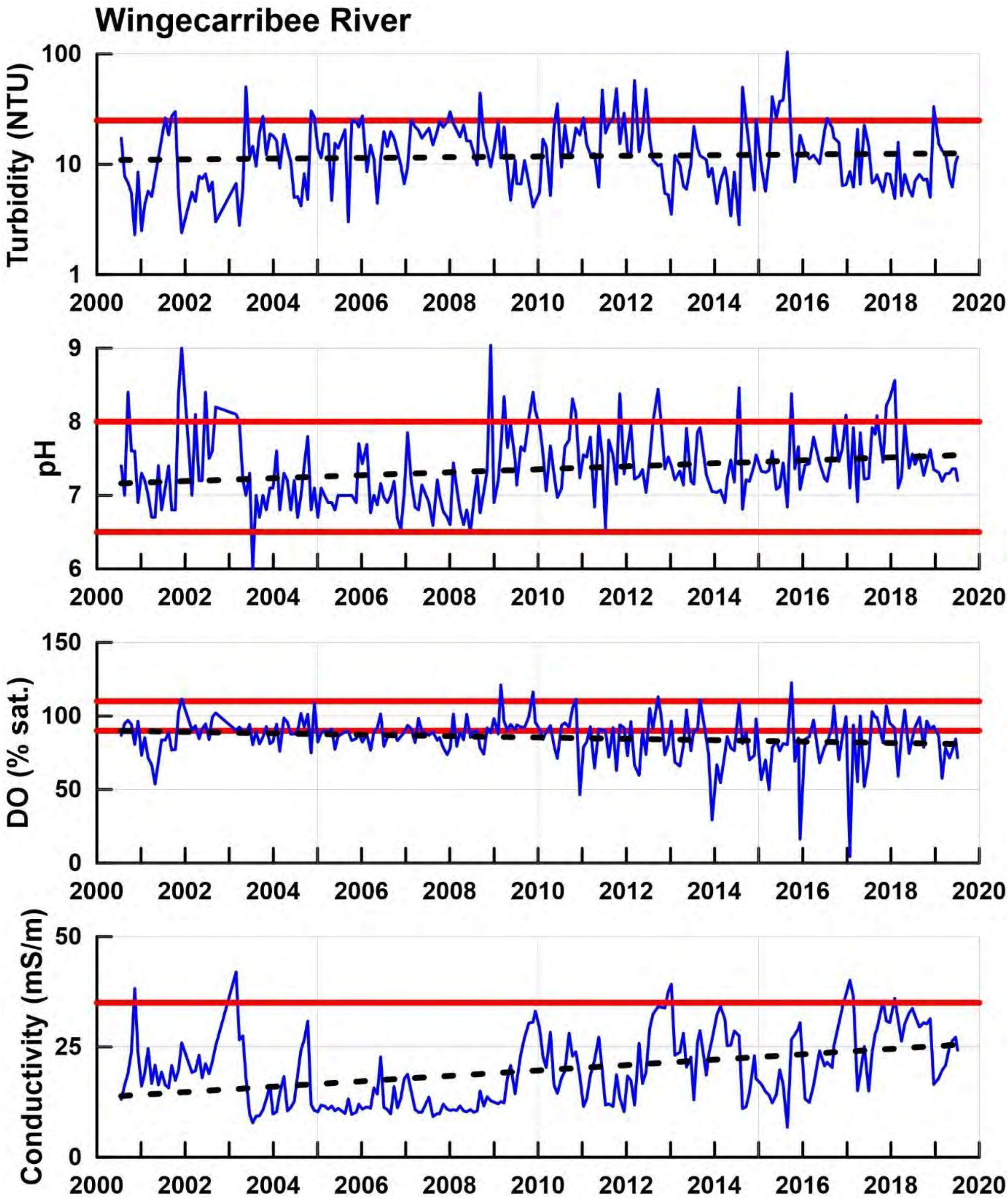


Figure B5. Physico-chemical indicators of water quality for Wingecarribee River (site E332) at Berrima Weir.

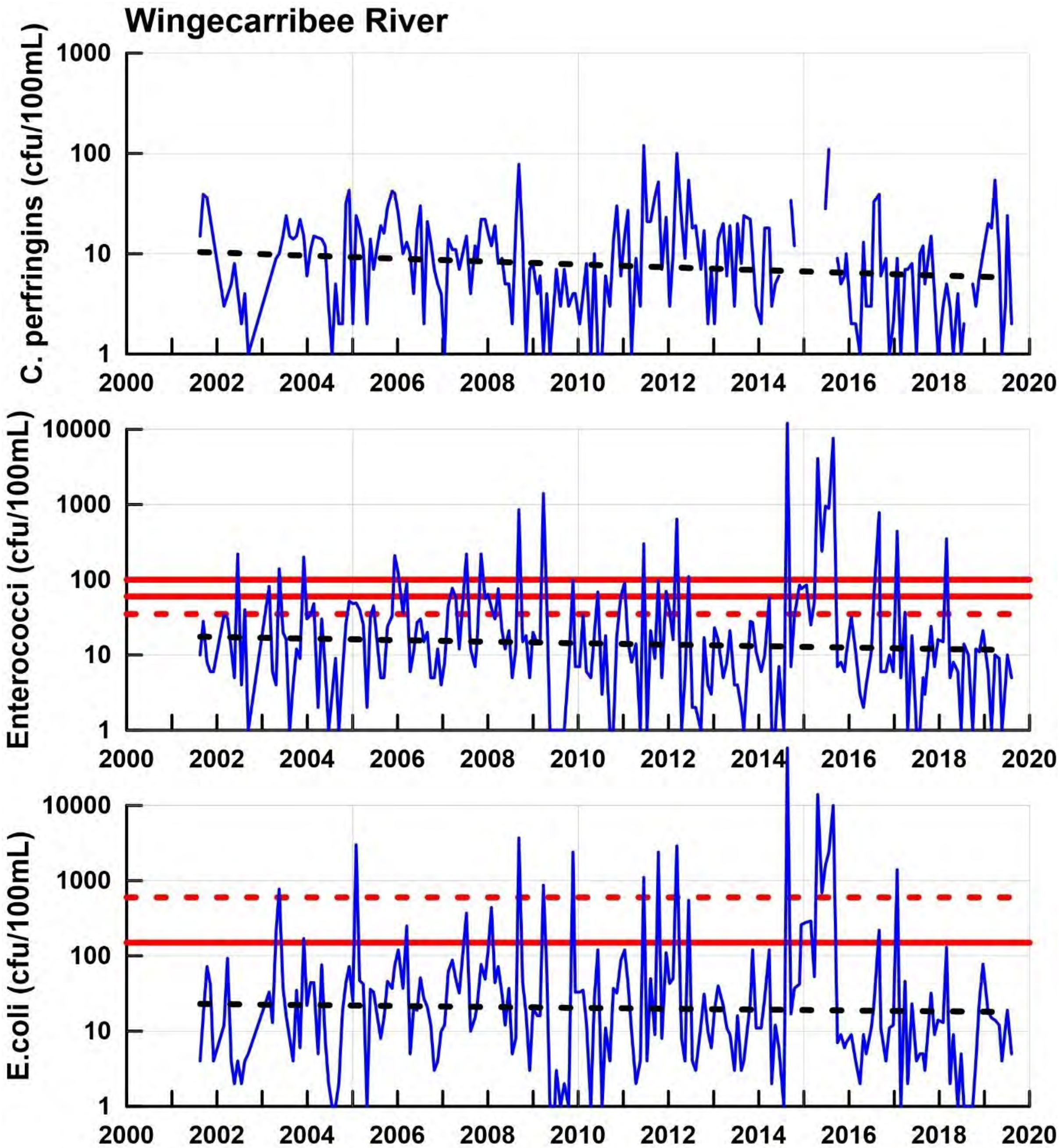


Figure B6. Bacterial indicators of water quality for Wingecarribee River (site E332) at Berrima Weir.

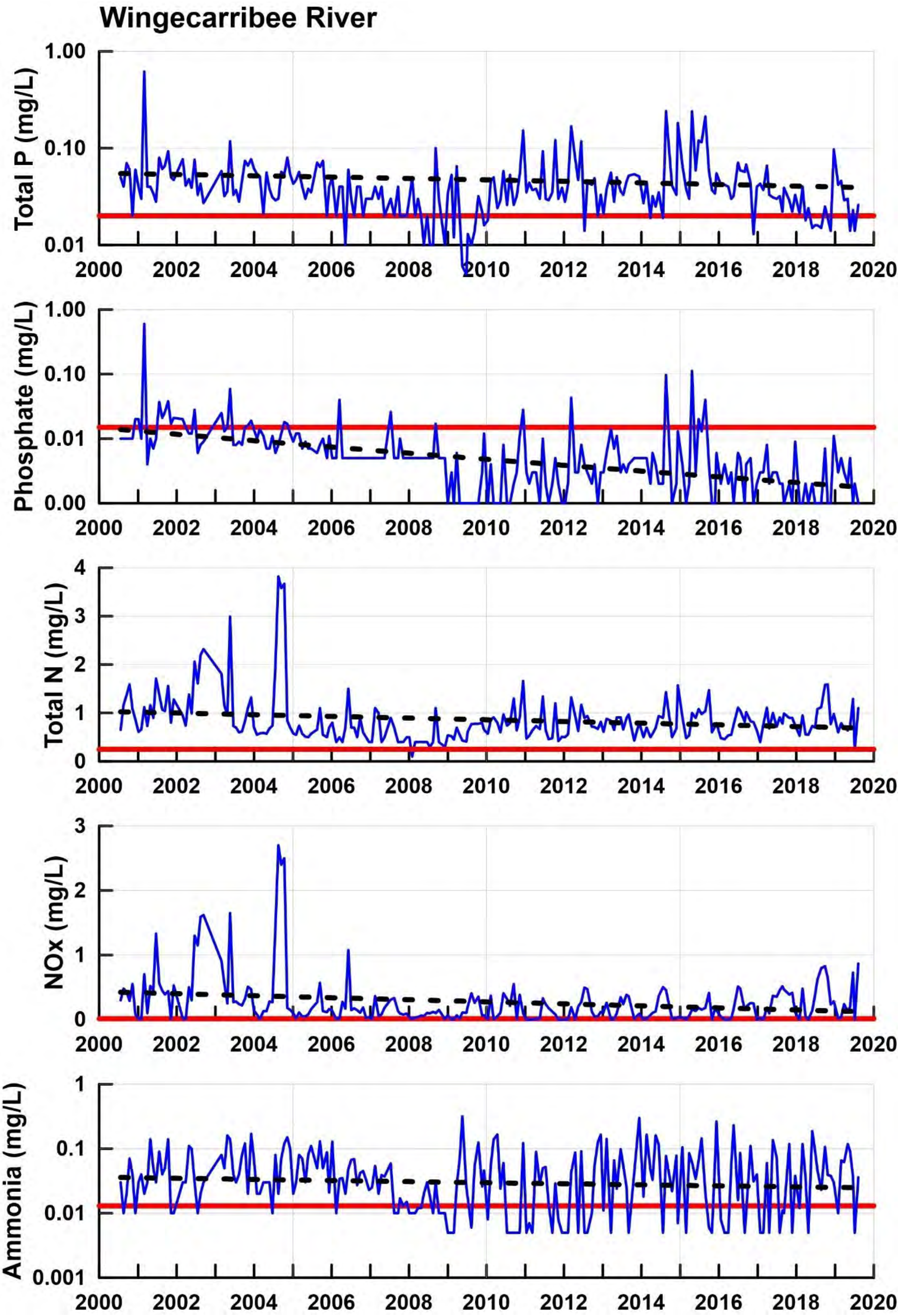


Figure B7. Nutrient indicators of water quality for Wingecarribee River (site E332) at Berrima Weir.

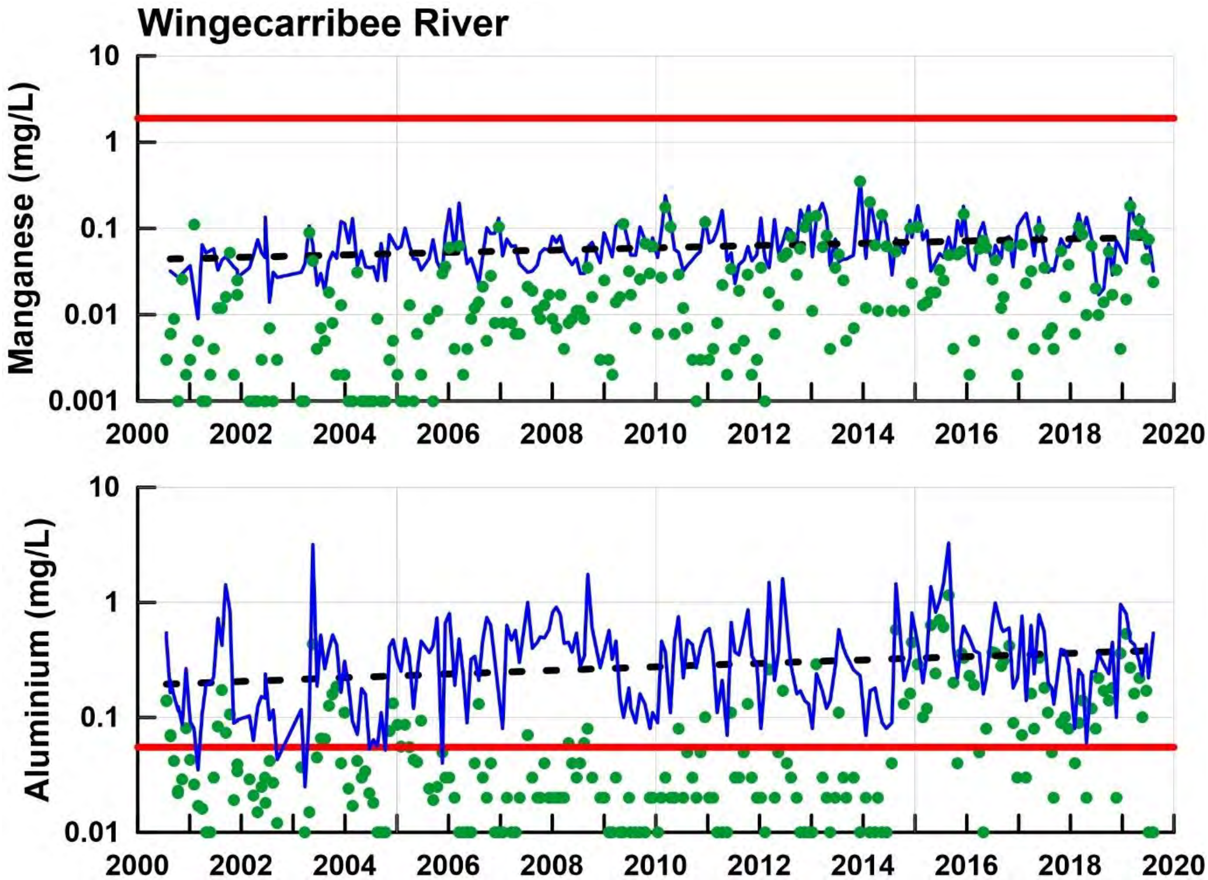


Figure B8. Metal indicators of water quality for Wingecarribee River (site E332) at Berrima Weir. The solid blue lines are totals while the green circles are filtered.

Summary statistics using the WaterNSW data at location E332 are presented in **Error! Reference source not found.**. Temporal trend lines for the periods 2013-2018 and 2015-2018 are provided in **Error! Reference source not found.**.

Table B6. Summary statistics of water quality at Berrima Weir (E332)

Variable	Units	Number	Min.	Max.	Median	M.A.D.	Mean	StDev
BOD	mg/L	149	1.00	9.00	1.00	0.68	1.46	1.00
TSS	mg/L	139	2.00	27.00	8.00	3.85	9.45	5.36
Conductivity	µS/cm	133	9.20	41.00	24.90	5.81	23.85	7.47
Ammonia	mg/L	149	0.005	0.500	0.050	0.030	0.069	0.049
Nitrite	mg/L	139	0.001	0.059	0.007	0.004	0.008	0.007
Nitrate	mg/L	139	0.01	1.26	0.14	0.15	0.19	0.21
Oxidised nitrogen	mg/L	139	0.01	1.30	0.15	0.16	0.20	0.21
Total nitrogen	mg/L	139	0.49	2.35	1.00	0.29	1.02	0.31
Total phosphorus	mg/L	149	0.010	0.321	0.042	0.023	0.053	0.039
pH		149	6.10	8.20	7.60	0.17	7.54	0.26
Faecal coliforms (log10)	(log10) cfu / 100mL	149	0.00	4.08	2.00	0.43	2.04	0.56
Oil and grease	mg/L	Insufficient data above limit of reading						
Alkalinity	mg/L, CaCO3	138	14.60	70.50	42.05	10.55	41.98	12.80

Table B7. Temporal trends at Wingecarribee River (Berrima Weir, E332)

	2013-2018			2015-2018		
	slope	Significance	p-value	slope	Significance	p-value
Turbidity (log)	↓	NSD	0.5726	↓	SIG	0.0006
pH	↑	SIG	0.0156	↑	NSD	0.1405
DO	↑	NSD	0.2103	↑	NSD	0.0603
Cond	↑	SIG	0.0194	↑	SIG	0.0000
E.coli (log)	↓	NSD	0.0530	↓	SIG	0.0002
Ent (log)	↓	NSD	0.4437	↓	SIG	0.0018
Total P	↓	NSD	0.0947	↓	SIG	0.0004
Filterable P	↓	NSD	0.1717	↓	SIG	0.0380
Total N	↑	NSD	0.1421	↑	NSD	0.2013
NOx	↑	SIG	0.0011	↑	SIG	0.0003
Ammonia	↓	NSD	0.4281	↓	NSD	0.7021
Al-filtered	↑	NSD	0.7129	↓	SIG	0.0024
Al-total	↑	NSD	0.9690	↓	SIG	0.0083
Mn-filtered	↓	SIG	0.0426	↓	NSD	0.4801
Mn-total	↓	SIG	0.0425	↓	NSD	0.2461

Arrows pointing up indicate an increasing trend over the time period.
Arrows pointing down indicate a decreasing trend over the time period.
NSD = the slope of the linear trend line is not statistically different from a slope of zero at the 5% level of significance (p-value>0.05).
SIG = the slope of the linear trend line is statistically different from a slope of zero at the 5% level of significance (p-value<0.05).

Below is a summary of the temporal trends at Berrima Weir (Water NSW location E332).

- In general, there appears to be an overall improvement in the water quality since 2016, although exceedance of the ANZECC default guidelines is still evident for some variables.
- Trends in turbidity are ‘decreasing’ and concentrations are generally below the ANZECC default guidelines.
- pH trends are ‘increasing’, although pH values are generally within the ANZECC limits.
- The trends for dissolved oxygen are ‘increasing’, although the slopes of the trend line is not significantly different from a slope of zero. Since 2016, values are below the lower limit of the ANZECC default guidelines about 50% of the time.
- The slopes of the trend lines for conductivity over the different time periods are all ‘increasing and significant’. However, the conductivity values are generally less than the ANZECC default guideline value.
- Enterococci and faecal coliforms both show similar features: a decreasing (and significant for 2015-2018) trend for each of the time periods examined. From 2016 onwards, both bacteria meet the 50%ile (and 80%ile for faecal coliforms) guidelines. The maximum guideline for enterococci is exceeded three times since 2016 (less than 8% of the time).
- The slopes of the trend lines for both total phosphorus and reactive phosphorus (phosphate) are consistent and ‘decreasing’ over the time periods examined. The slope of each of the trend lines for 2015-2018 is decreasing and significant. From 2016 onwards total phosphorus concentrations exceed the ANZECC default limit, while concentrations of reactive phosphate lie below the ANZECC default guideline.
- The slope of each of the trend lines for total nitrogen and oxidised nitrogen is ‘increasing’ (and statistically significant for oxidised nitrogen). Both variables generally exceed the ANZECC default guidelines.
- Filtered and total manganese have trend line slopes that are decreasing over time. However, concentrations are below the default ANZECC guidelines.
- The trend line slopes for filtered and total aluminium are ‘decreasing and significant’ for the period 2015-2018 and ‘increasing’ prior to this period. Concentrations of total aluminium lie above the ANZECC default guideline, while those for filtered aluminium lie above the ANZECC default guideline about 25% of the time.

Data are also collected at Berrima Weir as part of a routine STP licence monitoring program. On 14 occasions between 2013 and 2018, samples for the licence compliance were collected on the same day as the routine sampling. Using only those data collected on the same day, a t-test was undertaken on the differences between the corresponding data. All variables indicated that the hypothesised difference of zero was accepted. That is, there is no statistically significant difference between data the two data sets.

B.3. Background Concentrations in the Wingecarribee River

The background conditions of the receiving waterways in this report are defined as those concentrations that do not appear to be impacted by the discharges from the STPs. However, it is noted that other (point or diffuse) sources may influence river water quality. Influences from these other sources are considered part of the background in this study. In general, the 'background' conditions are synonymous with the data collected from upstream of the location at which the STP discharge enters the waterway.

The development of background conditions has been restricted to use of data from locations US-1 and US-2 after demonstrating the non-zero influence of the STP discharges at all downstream locations for all three rivers. Further, ANOVA results indicated a significant difference in concentrations of samples taken under dry and wet weather conditions. Therefore, two sets of background conditions have been developed: one set for dry weather conditions and one set for wet weather conditions.

Background conditions are characterised by their 'central tendency' and 'dispersion'. In this section 'central tendency' is estimated using the median and the 'dispersion' is estimated using the 'mean absolute difference' (MAD). These statistics are more robust to departures from normality than the more commonly used estimates of the mean and standard deviation. This is particularly important when only a relatively few data points are available for generating these statistics, as is the case in this study.

Summary statistics for the background concentrations are given in **Error! Reference source not found.**. Where guidelines are available, these are included in the tables and referenced in the following column. Two guideline columns are used. Where more than one value applied to a particular analyte, the most restrictive value is used.

Table B8. Estimated background concentrations – Wingecarribee River

		Dry weather		Wet weather		Guideline		Sour
	units	median	MAD	median	MAD			
Suspended Solids	mg/L	44.00	28.13	14.50	14.25	40		ANZI
Total Alkalinity as CaCO3	mg/L	66.50	13.50	30.00	2.50	20		ANZI
Sulfate as SO4	mg/L	47.00	44.13	3.00	1.75	400		ANZI
Chloride	mg/L	57.50	8.25	19.50	7.25	250		ADW
Fluoride	mg/L	0.35	0.19	0.10	0.00	1.50		ADW
Calcium	mg/L	22.00	4.38	7.00	0.75	1000		ANZI
Magnesium	mg/L	7.50	2.38	4.00	1.00	15		ANZI
Sodium	mg/L	48.00	18.00	10.00	3.50	115		ANZI
Potassium	mg/L	11.50	8.38	5.00	0.50			no gu
Total Anions	meq/L	4.10	1.14	1.22	0.28			no gu
Total Cations	meq/L	4.34	1.09	1.24	0.27			no gu
dissolved Aluminium	mg/L	0.010	0.014	0.050	0.170	0.027	0.055	ANZI
dissolved Arsenic	mg/L	0.001	0.000	0.001	0.000	0.001	0.024	ANZI
dissolved Cadmium	mg/L	0.00010	0.00000	0.00010	0.00000	0.00006	0.00020	ANZI
dissolved Chromium	mg/L	0.001	0.000	0.001	0.000	0.008	0.027	ANZI
dissolved Copper	mg/L	0.0010	0.0001	0.0015	0.0005	0.0010	0.0014	ANZI
dissolved Manganese	mg/L	0.089	0.025	0.051	0.013	1.200	1.900	ANZI
dissolved Nickel	mg/L	0.001	0.000	0.001	0.000	0.008	0.011	ANZI
dissolved Zinc	mg/L	0.0050	0.0014	0.0050	0.0000	0.0024	0.0080	ANZI
dissolved Iron	mg/L	0.050	0.056	0.355	0.173			no gu
dissolved Mercury	mg/L	0.00010	0.00000	0.00010	0.00000	0.00006	0.00060	ANZI
total Aluminium	mg/L	0.700	0.356	0.710	0.500	0.027	0.055	ANZI
total Arsenic	mg/L	0.001	0.000	0.001	0.000	0.001	0.024	ANZI
total Cadmium	mg/L	0.00010	0.00000	0.00010	0.00000	0.00006	0.00020	ANZI
total Chromium	mg/L	0.001	0.001	0.002	0.001	0.008	0.027	ANZI
total Copper	mg/L	0.0025	0.0009	0.0020	0.0008	0.0010	0.0014	ANZI
total Lead	mg/L	0.0020	0.0006	0.0010	0.0005	0.0010	0.0034	ANZI
total Manganese	mg/L	0.149	0.368	0.070	0.026	1.200	1.900	ANZI
total Nickel	mg/L	0.002	0.000	0.002	0.001	0.008	0.011	ANZI
total Zinc	mg/L	0.0085	0.0043	0.0050	0.0008	0.0024	0.0080	ANZI
total Iron	mg/L	1.36	0.61	1.03	0.51			no gu
total Mercury	mg/L	0.00010	0.00000	0.00010	0.00000	0.00006	0.00060	ANZI
Ammonia as N	mg/L	0.070	0.085	0.130	0.050	0.013		ANZI
Nitrite as N	mg/L	0.055	0.040	0.050	0.013	30		ANZI
Nitrate as N	mg/L	0.970	1.011	0.705	0.183	400		ANZI
Nitrite + Nitrate as N	mg/L	1.020	1.055	0.755	0.193	0.015		ANZI
Total Nitrogen	mg/L	2.500	1.088	2.000	0.425	0.250		ANZI
Total Phosphorus	mg/L	0.100	0.030	0.095	0.035	0.020		ANZI
Dissolved Reactive Phosphorus as P	mg/L	0.010	0.000	0.010	0.000	0.015		ANZI
Chlorophyll a	mg/L	7.00	5.13	8.00	1.00			no gu
Faecal Coliforms	cfu/100mL	635	2560	270	73	150	600	ANZI
Enterococci	cfu/100mL	505	823	75	42	35	60-100	ANZI
EC	mg/L	0.474	0.131	0.141	0.027	0.030	0.350	ANZI
pH		7.37	0.13	7.05	0.18	6.50	7.50	ANZI
DO	% sat	67.35	21.30	70.70	2.08	90	110	ANZI
Turbidity	NTU	70.00	48.58	25.25	27.48	2	25	ANZI

Appendix C Modelling Details

A Monte Carlo approach is used to estimate the concentrations of contaminants in the river waters under different sewage treatment options (i.e. scenarios). Modelled concentrations of contaminants at two points downstream from the discharge location can be compared with the ANZECC default water quality guidelines and used as a basis for undertaking a Neutral or Beneficial Effects (NorBE) assessment. This appendix details the modelling approach.

The two downstream locations are designated DS-1 (immediately downstream of the discharge point) and DS-2 (approximately 500 m downstream from the discharge location).

C.1. Overall Procedure

The basis of the Monte Carlo simulations is establishing a set of statistical distributions from which samples can be taken. The major inputs (and distributions) are the for the STP, background and dilution. Much of these results will compare existing simulations with future simulations and it is important to ensure that the basis on which these comparisons are made is the same.

The simulations need to allow for differences in concentrations arising from rainfall (i.e. dry and wet weather conditions) and for the proposed increases in population.

Prior to any analyses, all data were checked for consistency by examining temporal and spatial trends, as appropriate. Using available data, statistical distributions are determined for each contaminant in the STP effluent and for the dilutions at the two downstream locations. Due to the relatively small number of background or upstream samples available, its ‘distribution’ comprised the whole data set. Random samples are taken from each distribution and used as input into the dilution model (Equation C-1; USEPA, 1988, 1995; EPA, 1993) to produce estimates of the concentrations at the two downstream locations.

Equation C-1 $$C(x) = BG + \frac{WW - BG}{D(x)}$$

Where:

- $C(x)$ is the concentration at a distance ‘x’ downstream from the discharge,
- BG is the background concentration of the contaminant (obtained from data at the two upstream locations),
- WW is the concentration of the contaminant in the effluent (or STP effluent), and
- $D(x)$ is the dilution at a distance ‘x’ downstream from the discharge location.

This process is repeated many times and a set of contaminant concentrations (at DS-1 or DS-2) results. These model results can be compared with the ANZECC guidelines and with simulations from the base case or from other scenarios.

Results from the statistical distributions of the contaminants in the STP effluent are also used to estimate the existing concentrations and loads and to compare with the STP concentrations and loads for each scenario.

- Exceedance plots for each scenario can be used to compare with the existing conditions to determine whether the NorBE concentration requirements are met.
- Similarly, these simulations can be used to estimate the annual loads. Existing and future loads can be compared to determine whether the NorBE load requirements are met.

C.2. STP Data and Distributions

Our preference here is to compare two sets of simulations (future and existing) rather than one set of future simulations with the set of existing data. Simulations will include extreme values that are unlikely to appear in a relatively small data set. This discrepancy may impact the results, particularly load calculations. However, it is important to ensure that the simulated data are consistent with the observations.

The data set chosen for the STPs covers the 5-year period from 1 July 2014 to 30 June 2019. STP flows for the new scenarios were based on a scaling of the flows between 1 July 2014 and 30 June 2019. The flows were scaled in direct proportion to the change in equivalent population (EP) for each scenario.

Two approaches were used: one for BOD (which contained many values at or below the Limit of Reading) and one for TSS, TN and TP. A flowchart detailing the procedures for these two approaches is given in Figure C9. The simulations for this study used 10,000 random selections. Different numbers of simulations could be used, although the number should be kept large (>1,000) to ensure a range of selections are obtained.

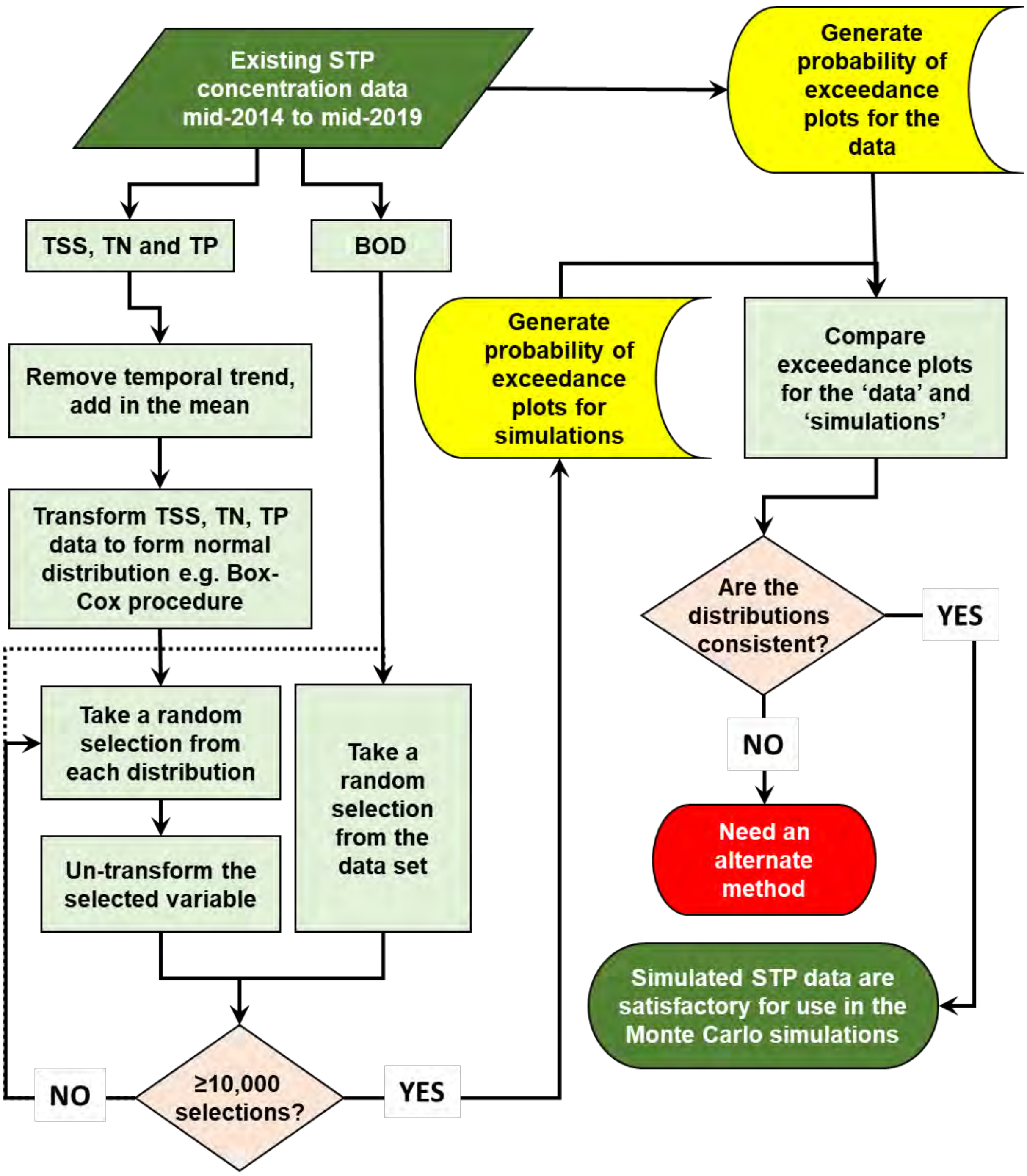


Figure C9. Flowchart for comparing STP data and simulations.

C.2.1. BOD simulations

From the BOD data set, a random sample was taken and used in the simulation. By definition, statistics generated from the BOD data and from the BOD simulations will be (almost) identical.

C.2.2. TSS, TN and TP simulations

Each data set contained a temporal trend that has the potential to introduce bias into the data. The temporal trend was removed and the mean added back into the data set. The results in a data set with the same mean and similar standard deviation compared with the original data set. However, any temporal bias that may have been present in the data has been removed.

Data were then transformed to produce a normal distribution. The procedure outlined in Box and Cox (1964) was used. For these three contaminants and for all three STPs a log transform was found to be suitable and the data transformed accordingly.

The mean and standard deviation (of the transformed data) for each contaminant and for each STP was determined. The mean and standard deviation were then used to obtain random selections from the relevant distributions. Probability of exceedance plots generated using the STP data and STP simulations can be compared (e.g. the probability of exceedance plots for the Bowral STP are shown in **Error! Reference source not found.**). Both probability of exceedance plots are essentially the same. The ‘stepping’ observed in the probability of exceedance plots for the ‘data’ arises from the relatively small number of samples available. (It is noted that for these types of studies, the 129 data points available between 1 July 2014 and 30 June 2019 is large).

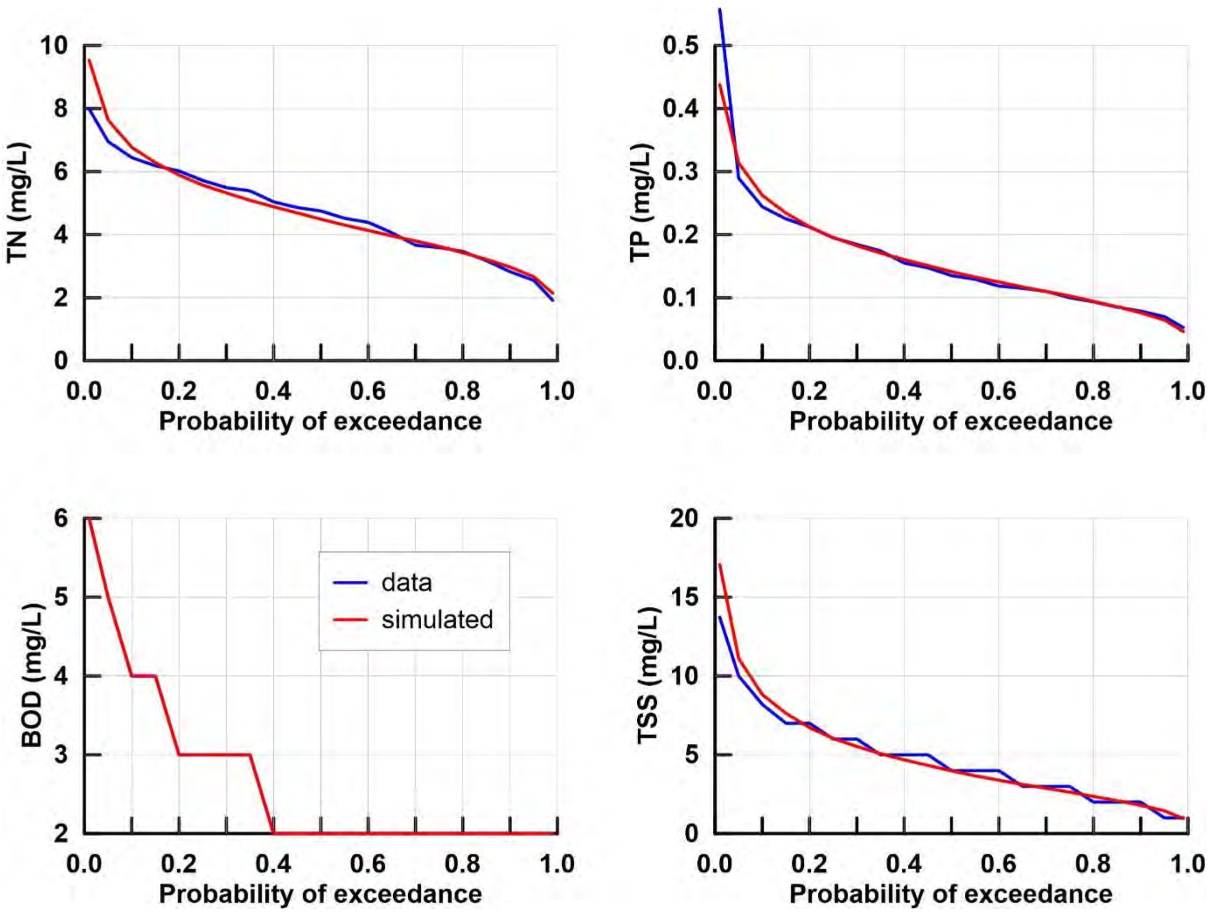


Figure C10. Comparison of STP data with STP simulations at Bowral STP.

From this analysis, we conclude that the above process for randomly selecting data from the statistical distributions results in synthetic data sets that are consistent with the original data. As anticipated, there are slight differences between the data and the simulations at very low probability of exceedances.

C.3. NorBE determinations

Compliance with the NorBE requirements is, for this study, largely governed by the changes in concentrations and loads of contaminants discharged by the STPs under future 'equivalent populations (EPs). The procedures used to check for NorBE compliance are outlined below.

Two procedures were adopted, they were:

- To determine the NorBE 'tipping point' i.e. the concentrations of contaminants in the effluent at which the NorBE conditions are just met.
- To determine compliance (or otherwise) with NorBE using the concentrations of contaminants in the effluent under different scenarios.

C.3.1. Tipping point

The following procedure was used to identify the 'tipping point' for meeting NorBE. This was an iterative process designed to converge on a set of concentrations (for TSS, TN and TP) in the effluent at which NorBE is just met. This process was conducted for each future scenarios (circa the 2046 population). The overall procedure is shown in **Error! Reference source not found.**.

Statistical distributions were determined for each contaminant and at each STP, based on the existing concentrations and effluent flows. Reiterating, the 'existing' concentrations and flows were based on statistical distributions generated from STP data collected between 1 July 2014 and 30 June 2019.

One simulation was undertaken for each day between 1 July 2014 and 30 June 2019. If rainfall exceeded 10 mm during the day, then the concentrations of the contaminants were multiplied by a factor of 1.1. This factor was determined from analyses undertaken and presented in MHL (2020); Table B8, Table B13 and Table B18. For the 'future' conditions, the concentrations were multiplied by a 'NorBE factor' (different for each contaminant) in an attempt to meet NorBE.

Effluent flows were obtained from the actual flow data on these days. For the 'future' conditions, the effluent flow was scaled according to the proportional change in EP. (For example, if the existing EP was 10,000 and the new EP was 12,000, then this scale was 1.2). The product of the concentration and the daily effluent flow resulted in the daily load of that contaminant.

The existing and future concentrations were compared. If the future concentration was less than the existing concentration for the percentiles between 50% and 98%, then the NorBE concentration condition was met. Similarly, if the future annual load, multiplied by 1.1, was less than the existing annual load, then the NorBE load condition was met.

If either of these NorBE conditions was not met, then the 'NorBE factor' was reduced and another simulation was trialled. This iterative process continued until both NorBE conditions were met. The concentrations of the contaminants in the effluent that corresponded to the successful NorBE outcome were defined to be the 'tipping point' concentrations.

Using the 'tipping point' concentrations, the process was repeated many times (at least 100) to provide confidence that compliance with the NorBE conditions did not occur through random chance.

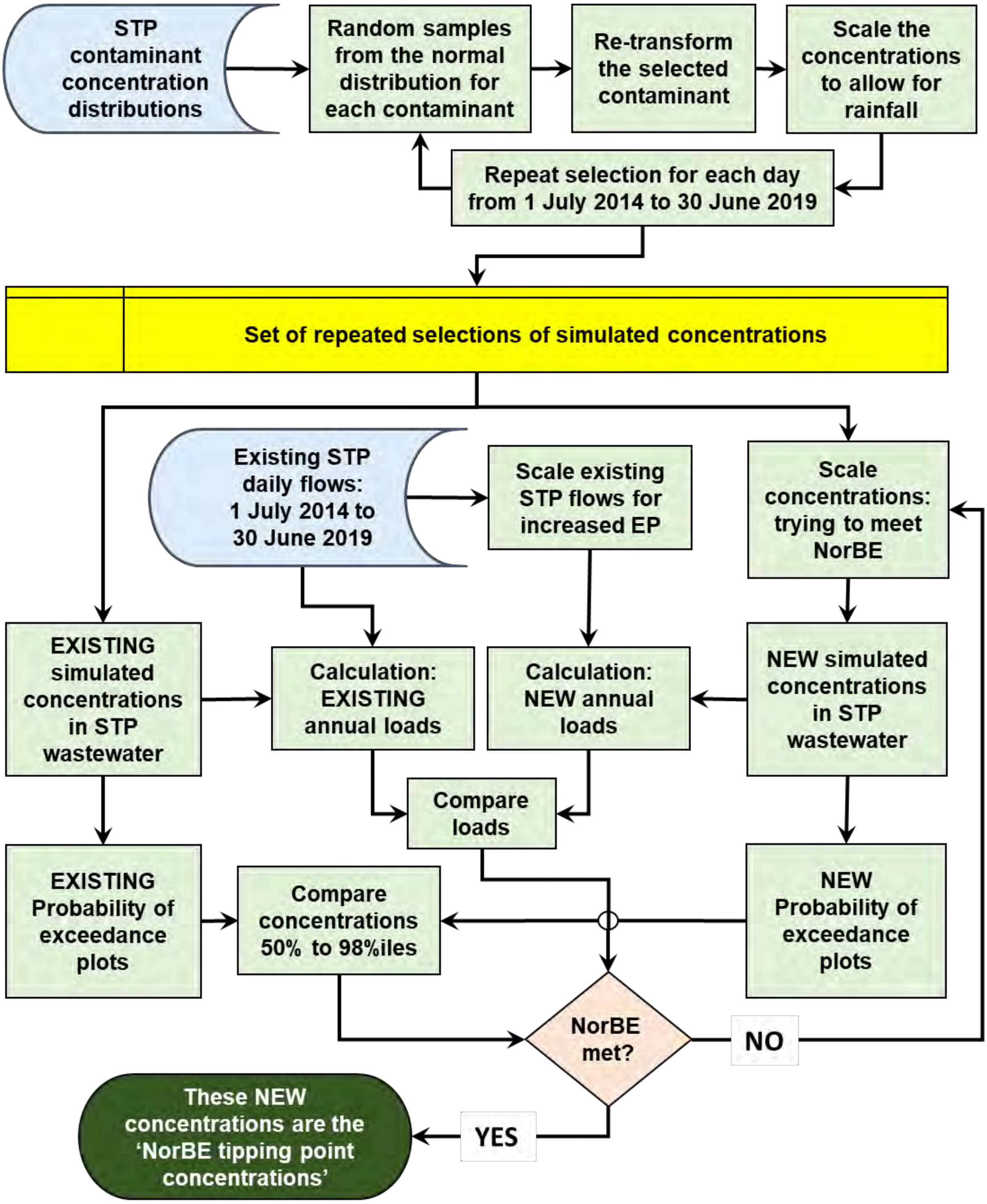


Figure C11. Procedure for selecting the concentrations of contaminants in the STP such that NorBE is just met – the 'tipping point'.

C.3.2. Scenarios

The procedure for examining the scenarios is outlined in **Error! Reference source not found.**. It is similar to the 'NorBE tipping point' procedure with a few important differences.

Statistical distributions were determined for each contaminant and at each STP, based on the existing concentrations and effluent flows. Note that the 'existing' concentrations and flows were based on statistical distributions generated from STP data collected between 1 July 2014 and 30 June 2019.

A scenario was selected. Each scenario was defined by the 50% and 90%ile values provided for each contaminant. It was assumed that the transforms to generate normal distributions from the existing data also apply to the scenarios. The 50% and 90%ile values were transformed accordingly, resulting in a normal distribution. For a normal distribution, the mean (μ) is given by the 50%ile value and the standard deviation (σ) can be estimated using Equation C-2. Statistical distributions for each contaminant and at each STP can then be determined for each scenario.

Equation C-2 $$\boldsymbol{\sigma = \frac{90\%ile - \mu}{1.282}}$$

One random sample was taken from each of the 'existing' and 'scenario' distributions for each day between 1 July 2014 and 30 June 2019. These random samples were then un-transformed. If rainfall exceeded 10 mm during the day, then the concentrations of the contaminants were multiplied by a factor of 1.1. This factor was determined from analyses undertaken and presented in MHL (2020); Table B8, Table B13 and Table B18.

Effluent flows were obtained from the actual flow data on these days. For the 'scenario' conditions, the effluent flow was scaled according to the proportional change in EP. (For example, if the existing EP was 10,000 and the new EP was 12,000, then this scale was 1.2). The product of the concentration and the daily effluent flow resulted in the daily load of that contaminant.

The existing and scenario concentrations were compared. If the scenario concentration was less than the existing concentration for the percentiles between 50% and 98%, then the NorBE concentration condition was met. Similarly, if the annual load of the scenario, multiplied by 1.1, was less than the existing annual load, then the NorBE load condition was met.

Failure of either of these criteria resulted in a non-compliance with NorBE for that scenario.

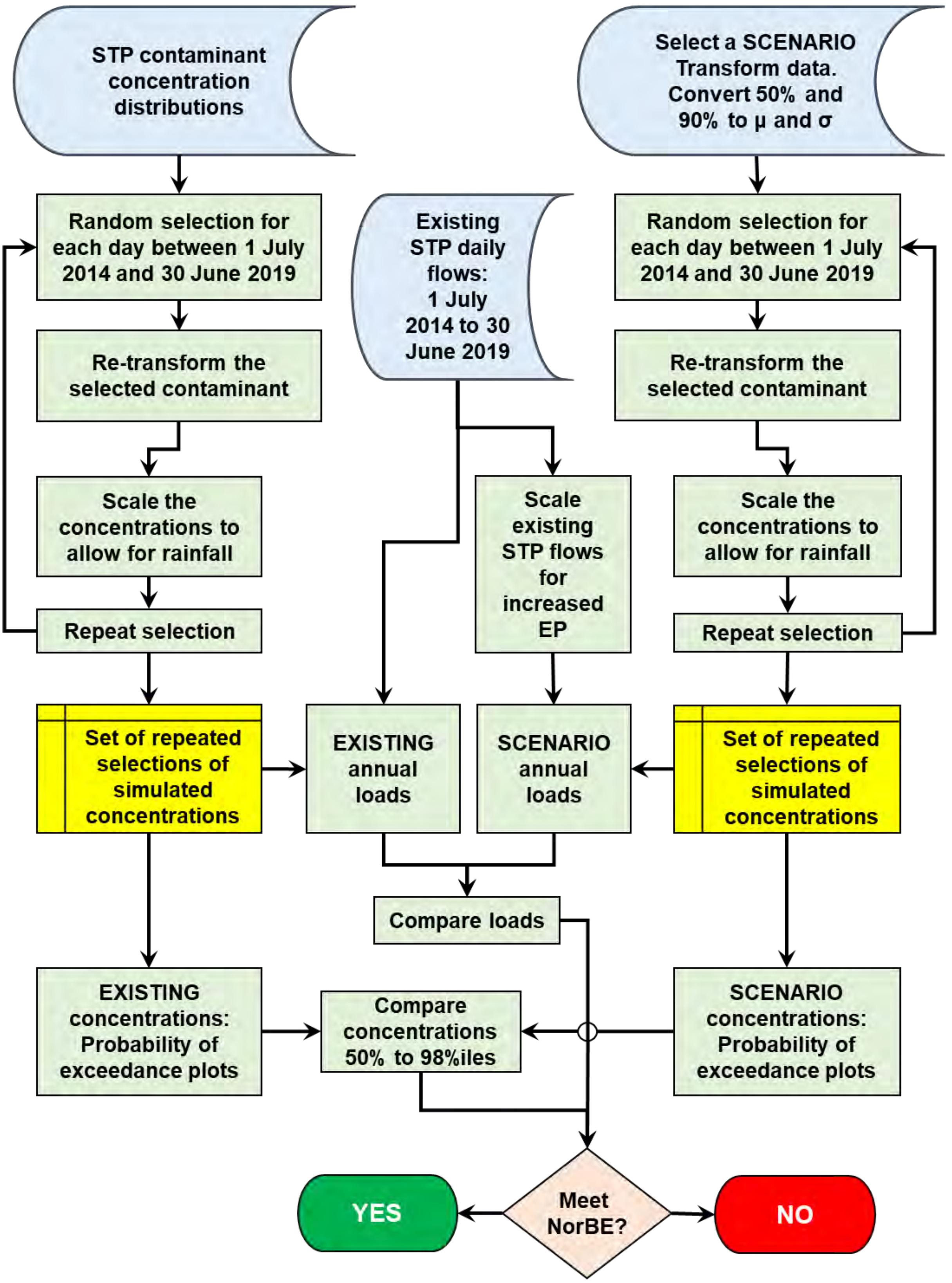


Figure C12. Procedure for determining whether a scenario will meet NorBE

C.4. ANZECC determinations

Estimates of the concentrations of contaminants can be made and the results compared with the ANZECC guidelines.

In this study, samples were collected on three sampling days (18 December 2019, 16 January 2020 and 20 February 2020). Samples for the first two days were collected under dry weather conditions, while sampling on the third day was done under wet weather conditions. Samples were simultaneously collected in the STP. Samples were analysed for a range of substances including: physico-chemical, ions, metals, nutrients and bacteria.

The locations of all monitoring sites were based on existing sampling locations (by WSC or by WaterNSW) and on safe access to the site and the water. Two replicate samples were collected from each of two locations upstream of the point at which the effluent enters the relevant water body and at two locations downstream of this point.

- Location DS-1 was within a few meters of the discharge point on the Wingecarribee River while location DS-2 was approximately 5,000m (at Berrima Weir) downstream from the discharge point.
- Location US-1 were approximately 800m upstream of the discharge point on the Wingecarribee River while location US-2 was approximately 25m upstream of the discharge point on the Wingecarribee River.

These data were used to establish the dilution of the effluent after it enters the receiving waters. Preliminary dilution modelling indicated that complete mixing of the effluent with the receiving waters occurs within about 100 m of the point at which the effluent enters the receiving water bodies, hence mixing is incomplete at DS-1 but complete at DS-2.

C.4.1. Downstream dilutions

Dilutions at the two downstream locations, DS-1 and DS-2, were estimated by using Equation C-1. Rearranging that equation, we get:

Equation C-3 $$D(x) = \frac{WW - BG}{C(x) - BG}$$

Where:

$D(x)$ is the dilution at a specified distance (x) downstream,

WW is the concentration of the contaminant in the undiluted effluent,

BG is the background or upstream concentration of the contaminant, and

$C(x)$ is the concentration of the contaminant at the downstream distance (x).

To avoid complications arising from diffuse source discharges and other point source discharges, only variables that indicated the STP as the primary source of potential contaminants were used to estimate the dilutions. Such variables should produce a spatial pattern consistent with that shown in **Error! Reference source not found.**. In this case, the two upstream and the far downstream locations are at background concentrations, the highest concentration originates from the STP and the near downstream location has a concentration between that of the STP and the far downstream location.

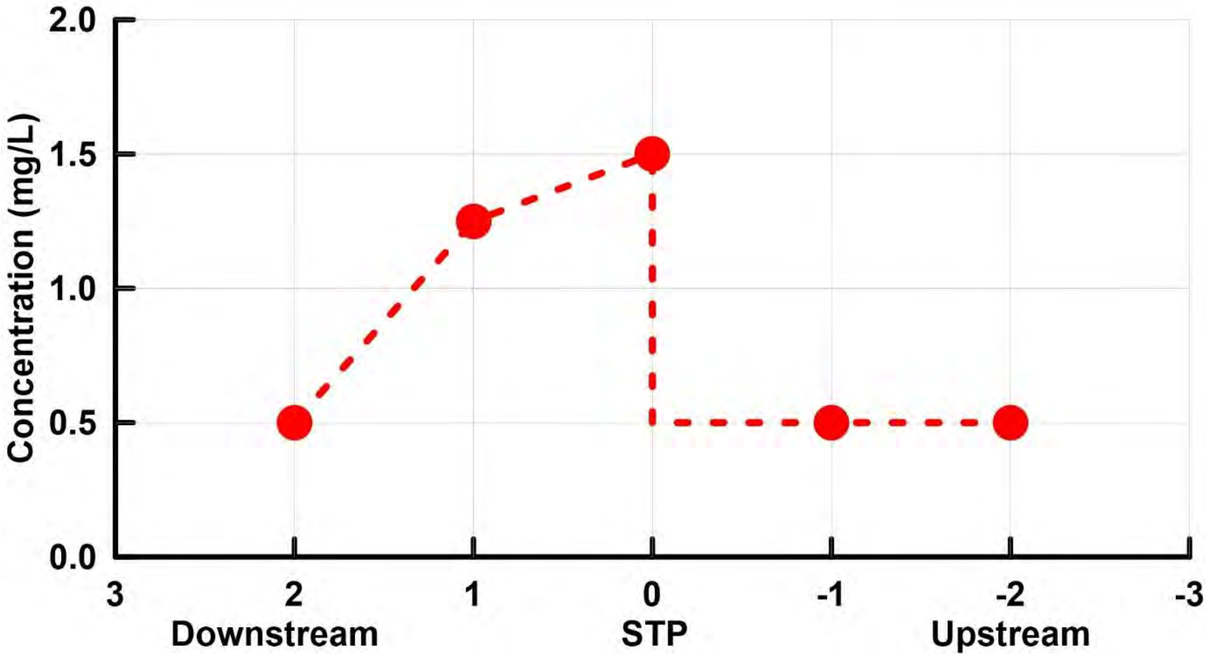


Figure C13. Spatial gradient of contaminants where the STP appears to be the primary source

*Note: to demonstrate the intent of this decision criteria, the horizontal axis is not to scale

Seven variables were identified as potential candidates for estimating the dilutions. There were: total alkalinity, total anions, total cations, aluminium, zinc, total nitrogen and total phosphorus. Spatial plots for these substances are shown in **Error! Reference source not found.**. Speciation of these substances was not used. Not all substances displayed the **Error! Reference source not found.** pattern in all river systems. Those substances that did not follow this pattern were not used in the analyses.

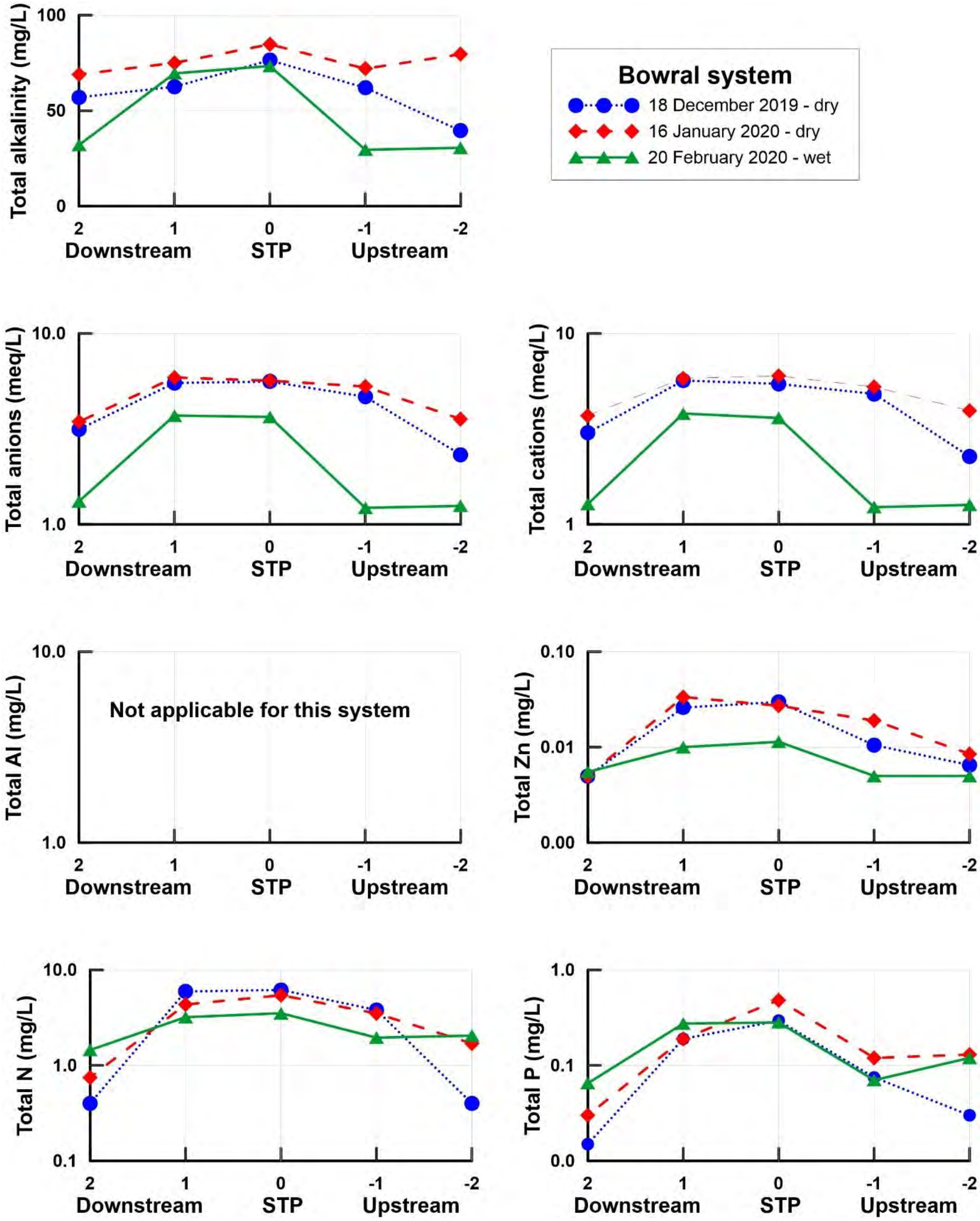


Figure C14. Spatial gradient of the selected contaminants from the Bowral system (Wingecarribee River)

Sampling carried out on the three days (above) provide the input data used in Equation C-3. The estimated dilutions are shown in Table C9. Dilutions at DS-1 are relatively low, but substantially higher under wet weather conditions.

Table C9. Downstream dilutions in each river system under wet and dry conditions.

	DS-1		DS-2	
	median	MAD	median	MAD
Wingecarribee River				
Dry	1.4	1.2	4.4	4.1
Wet	1.0	1.6	24	49

Note: MAD is the mean absolute differences (equivalent to the standard deviation in a normal distribution).

C.4.2. Upstream concentrations

Equation C-3 requires the input of background data, which is obtained from data at the two upstream locations (US-1 and US-2). These upstream data were divided into two sets – one based on data collected during dry weather and the other for data collected under wet weather conditions.

For the input of background concentrations into the Monte Carlo simulations, random selections were made from the upstream data set. If rainfall was less than 10mm, random selections were taken from the dry weather data set. If daily rainfall exceeded 10mm, the random selections were taken from the wet weather data set.

C.4.3. Downstream concentrations

The procedure for determining the downstream concentrations and comparing the results with the ANZECC guidelines (or default trigger values) is outlined in **Error! Reference source not found.**.

Concentrations of each contaminant, at each of DS-1 and DS-2, were estimated using Equation C-1. This was undertaken for both the existing conditions and for each of the future conditions.

For each contaminant, and for each day between 1 July 2014 and 30 June 2019, random selections were made from the effluent, background (either dry or wet) and dilution (either dry or wet) distributions. Daily rainfall of 10mm marked the separation between sampling from the dry or wet data sets. If the daily rainfall exceeded 10mm, the concentrations of contaminants from the effluent were increased by 10% (i.e. concentrations were multiplied by 1.1). Dilutions were scaled, in proportion to the change in EP, to allow for the change in effluent flows caused by the increase in future EP.

Equation C-4 $$D_{new} = \frac{x-1}{x} + \frac{D_{old}}{x}$$

Where:

D_{new} is the new (scaled) dilution

D_{old} is the dilution defined using the 3-day sampling data sets, and

x is the new EP divided by the base (2016) EP.

The randomly selected inputs were used in Equation 3-1 to estimate the concentration of the contaminant at the downstream locations DS-1 or DS-2. This process was repeated many times and the results used to determine probability of exceedance plots. Existing and future results were then compared, and also with the relevant ANZECC guideline.

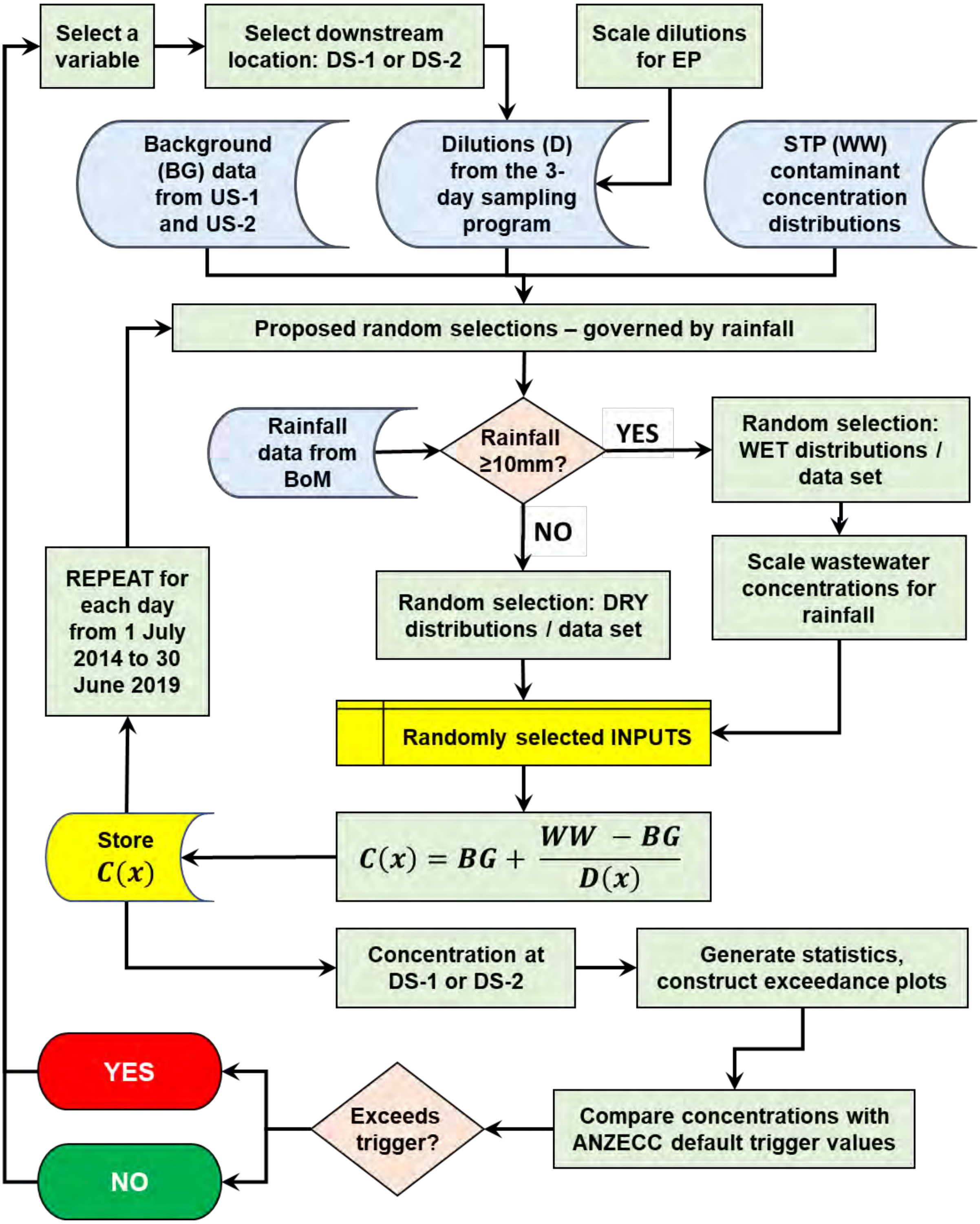


Figure C15. Procedure for estimating downstream dilutions and comparing results with ANZECC guidelines / default trigger values

Effluent samples details_ Manly Hydraulics

SL. No.	Sample name	Sample No.	Date of Received	Date of Extraction	Date of Drying	Date of Analysis	Remarks
1.	**BOWSTP**	17,19,21,23	20.02.20	27.02.20 to 03.03.20	08.03.20	12.03.20 & 04.04.20	Satisfactory
2.	**MITSTP**	17,19,21,23	20.02.20		08.03.20	12.03.20 & 04.04.20	Satisfactory
3.	**MSVSTP**	21,23,25,27	20.02.20		08.03.20	12.03.20 & 04.04.20	Satisfactory

Estrogens Analysis by LCMS QTRAP 6500^{+}

SL. No.	**Sample Name**	**Component symbol & actual concentration (ng/L)**						
		E1	**E2**	**E3**	**EE2**	**BPA**	**4-*t*-OP**	**4-NP**
1.	BOWSTP 17	9.54	<0.05	<0.05	<0.05	120.50	112.44	35.46
2.	BOWSTP 19	9.68	<0.05	<0.05	<0.05	135.26	291.23	35.97
3.	BOWSTP 21	8.59	<0.05	<0.05	<0.05	84.46	<0.05	7.33
4.	BOWSTP 23	10.42	<0.05	<0.05	<0.05	129.10	79.15	33.57
5.	MITSTP 17	6.88	<0.05	<0.05	<0.05	28.86	<0.05	11.45
6.	MITSTP 19	9.34	<0.05	<0.05	<0.05	140.71	<0.05	24.07
7.	MITSTP 21	9.12	<0.05	<0.05	<0.05	122.90	<0.05	9.12
8.	MITSTP 23	10.85	<0.05	<0.05	<0.05	117.15	<0.05	11.09
9.	MSVSTP 21	9.34	<0.05	<0.05	<0.05	105.70	<0.05	16.77
10.	MSVSTP 23	10.14	<0.05	<0.05	<0.05	107.01	<0.05	18.75
11.	MSVSTP 25	8.75	<0.05	<0.05	<0.05	83.28	<0.05	10.31
12.	MSVSTP 27	9.78	<0.05	<0.05	<0.05	119.01	<0.05	12.15
13.	**AUS effluent conc.**	<0.1-180	<0.05-54	<0.05-170	0.05-6.19	10-1,000	7.51-5,500	5.93-5,500
14.	**PNEC**	6	2	60	0.2	1600	122	330

E1: Estrone; E2: 17β-estradiol; E3: estriol; EE2-17α-ethinyl estradiol; BPA: Bisphenol A; 4-*t*-OP: 4-*tert*-Octyl phenol; 4-NP: 4-Nonylphenol; PNEC: Predicted no effect concentration.

Above are the results of the LCMS analysis of xenoestrogens on your effluent samples. Basically, most estrogens and xenoestrogens detected were in low concentrations or below our sensitive detection limits. Further most (xeno)estrogens were at the lower end of levels typically found in Australian WWTW effluents (13). Further, concentrations were below predicted no effect concentrations for most estrogens (14) (concentrations that will elicit negative toxicological responses or estrogen dependent effects in a range of aquatic taxa via toxicity testing). The only exceptions to this are some values of

E1, estrone, a human derived type of estrogen with much lower potency than estradiol, marginally exceeded PNECs of 6 ng/L in some instances, though these levels are at the lower end of what is found in effluents nationally. Further, the concentrations of 4-*t*-OP, octophenol, although well within the range of what is detected in effluents Nationally, still exceed PNEC's for octophenol in some BOWSTP samples. Overall, the concentrations of estrogenic EDCs found in this second sampling are relatively low and the risk of seeing estrogenically mediated effects in receiving waters is minimal.

Cheers
Geoff

Dr. Geoff Macfarlane
School of Environmental and Life Sciences
University of Newcastle

Appendix F – Detailed Design Report

hunterh2o

Bowral Sewage Treatment Plant Upgrade

Detailed Design Report

Wingecarribee Council

AUGUST 2021

ABN 16 602 201 552

Report Details

Report Title	Bowral Sewage Treatment Plant Upgrade: Detailed Design Report
Project No.	5804
Status	Tender – No Costs
File Location	P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\Design Development Report\Bowral STP Detailed Design Report_Tender No Costs.docx
Enquiries	Michael Collins P: (02) 4941 4926 E: michael.collins@hunterh2o.com.au

Document History and Status

Revision	Report Status	Prepared by	Reviewed by	Approved by	Issue Date
1	Draft	Michael Collins Adrian Ridgley Jason Sandford Daniel Ballinger Brett Thompson	Michael Collins	Michael Collins	13/06/2021
2	Tender – No Costs	Michael Collins Adrian Ridgley Jason Sandford Daniel Ballinger Brett Thompson	Michael Collins	Michael Collins	18/08/2021

Executive Summary

Wingecarribee Shire Council (WSC) is planning to upgrade the Bowral Sewage Treatment Plant (STP). WSC have engaged Hunter H_2O to undertake the detailed design as summarised in this report.

Project Context

Bowral STP is owned and operated by WSC and located in the Southern Highlands of NSW. The STP was last upgraded in 2006 to a nominal design capacity of 14,600 equivalent persons (EP). The urban population of Bowral in 2016 was approximately 12,500 EP, with an estimated total STP load (including non-residential loads) as high as 15,500 EP. Therefore, the current load on Bowral STP is predicted to exceed the design load. Additionally, previous investigations have found that actual STP capacity may be below design values and capacity may already be exceeded by a significant margin.

Design Basis Summary

Key design parameters adopted for the detailed designs are summarised below;

Parameter	Unit	Commissioning 2022	Design Ultimate
Hydraulic Contribution	L/EP/day	220	220
Equivalent Persons (EP)		15882	21000
Peak Dry Weather Flow (PDWF): Average Dry Weather Flow (ADWF)		2.0	2.0
Design Full Treatment Flow (DFTF):ADWF		4.0	3.0
Design Storm Treatment Flow (DSTF):ADWF		7.9	6.0
Peak Wet Weather Flow (PWWF):ADWF		17.2	13.0
Design PWWF L/s	L/s	60.060	60.060
Inlet Chemical Oxygen Demand (COD)	mg/L	600.0	600.0
Suspended Solids (SS)	mg/L	272.7	272.7
Inlet Total Nitrogen (TN)	mg/L	59.1	59.1
Inlet Total Phosphorus (TP)	mg/L	10.0	10.0
Inlet Alkalinity (Alk) as $CaCO_3$	mg/L	250.0	250.0

Scope of Upgrade Works

WSC wish to amplify and upgrade the Bowral STP to meet the following objectives:

- Increase the capacity to 21,000 EP, being the projected ultimate population.
- To improve the performance over time to meet Neutral or Beneficial Effect (NorBE) as published by the Sydney Catchment Authority.

The upgraded STP will included the following key infrastructure;

- An augmented sewage main.
- A new inlet works sized for 13 ADWF including:
  - Two mechanical band screens (duty/duty), incorporating washing and manual bypass screen
  - Screened sewage flow monitoring.
  - Duty only vortex style grit tank incorporating grit washing and dewatering
  - Odour control system, likely including extraction fans, a biofilter and an activated carbon filter.
- A new lift pump station including:
  - A new wet well.
  - Three influent pumps in duty/assist/standby configuration, each sized for 1.5 ADWF. These can be operated as duty/assist/assist under the Modified Ludzak Ettinger (MLE) configuration.
  - Two bypass (solids contact) pumps in duty/assist configuration, each sized for 1.5 ADWF.
- A new storm detention pond (SDP1) located at the site of the current Pasveers, including;

- Two storm return pumps in duty/assist configuration. Each return pump is sized for 1.5 ADWF.
  - A return rising main to the screened sewage channel.
  - An overflow to SDP2.
- The existing storm detention pond (SDP2) including:
  - Replacement storm return pumps (duty/assist) each sized for 1.5 ADWF.
  - Modifications to the existing return rising main to the screened sewage channel.
- A new bioreactor splitter box
- Two (2) new bioreactors designed as FSB but able to be operated as MLE. Each bioreactor is designed at accept 1.5 ADWF (FSB mode) or 2.25 ADWF (MLE mode), including:
  - Three (3) MLR pumps in duty/assist/assist configuration
- A new bioreactor aeration supply system including:
  - Three blowers in duty/assist/standby configuration.
- Two new secondary clarifiers
- Two RAS pumps in duty/standby configuration.
- A new scum pump station, with a single scum pump (duty only) accepting scum from the two clarifiers and delivering it to the aerobic digester or bioreactors (via the lift pump station).
- A new filter feed pump station including:
  - Three filter feed pumps in duty/assist/standby configuration delivering flows up to 3 ADWF to the tertiary filters.
- An emergency storage tank (EST), including:
  - The existing catch/balance pond to store overflows from the filter feed pump station (typically flows in excess of 3 ADWF and below 7.5 ADWF).
  - A new emergency return pump station with a single return pump sized for 1.5 ADWF.
- Tertiary filters including:
  - A new feed splitter including a filter bypass weir and pre flocculation tanks.
  - An alum dosing point to the flocculation tank.
  - Four deep bed, dual media filter cells.
  - An air scours system including duty/standby blowers.
  - A clean backwash tank and duty/standby pumps.
  - A dirty backwash tank and duty/standby pumps.
- A new UV system to replace the existing UV system, including:
  - Three in-channel UV banks in duty/assist/assist configuration (including future bank provision).
- An upgraded reclaimed effluent (RE) system including:
  - Relocation of the RE lift pump (duty only) to downstream of the new UV system.
  - The existing RE storage tank with backup potable water supply.
  - A replacement, amplified RE pumping system (proprietary) to service the increased RE pressure and flow requirements (particularly dewatering).
  - A chlorine dosing point to the RE tank feed line.
  - A separate storm clean pump providing high flow, high pressure disinfected effluent for wash down of the SPDs. This does not pass through the RE tank and does not receive chlorination.
- A new WAS pumping and thickening system including:
  - A new WAS pumping system with a duty only WAS pump.
  - A picket fence style gravity thickener with centre drive and scraper.
  - A duty only Thickened WAS (TWAS) pump, drawing TWAS from the centre well of the thickener and pumping it to the digester at a known thickness.
- An aerobic digester including:
  - The existing IDEA bioreactor.
  - The existing IDEA surface aerators in duty/duty/duty/duty configuration. Aeration should be adequate with one or even two aerators out of service.
  - The existing IDEA decanter that can be used for alternative digester thickening if the WAS thickener is out of service. This delivers supernatant to the EST via existing pipework. From there is can be returned to the head of works via the EST return pump.
  - Retention of existing instrumentation.
  - Relocation of the existing WAS pump to act as the new Digested WAS (DWAS) pump. DWAS is pumped from the digester during dewatering periods, but only while the digester is aerating.
- A new mechanical dewatering facility consisting of a single dewatering train to start, but designed to accommodate a second dewatering train operating in parallel in the future. This includes:
  - A new dewatering feed tank, complete with mixer/aerator
  - A polymer make-up, storage, dosing and dilution system. Dosing pumps in duty/duty configuration (duty/standby initially).

    - Dewatering feed pumps in duty/duty configuration (duty/standby initially).
    - A polymer dosing point to each feed line.
    - Two screw press dewatering units in duty/duty configuration (duty only initially).
    - A slewing, inclined biosolids conveyor delivering biosolids to a truck trailer (default).
    - A bunded truck trailer hard stand.
    - An awning over the truck trailer hard stand.
- The existing biosolids hardstand as a backup or if truck movements are temporarily halted.
- Retain at least one sludge lagoon as emergency liquid sludge storage.
- A foul water pump station (FWPS) including:
    - A new pump station wet well.
    - Two new foul water pumps (duty/standby).
- An alkalinity storage and dosing system.
- A new alum storage and dosing facility.
- A new chlorine storage and dosing facility.
- Site provision for future carbon storage and dosing (sucrose solution used for sizing).
- Site provision for future recycled water treatment system.

Effluent Quality Targets

The augmented and upgraded treatment facility is designed to meet the following effluent quality (i.e. 50%ile and 90%ile design targets);

Effluent Quality Parameter	50%ile	90%ile
Biochemical Oxygen Demand (BOD) mg/L	< 2	5
Total Nitrogen (TN) mg/L	3.3	5.2
Total Phosphorus (TP) mg/L	0.1	0.3
Suspended Solids (SS) mg/L	3.0	9.0
Ammonia Nitrogen (NHx-N) mg/L	0.4	1.0
Oil and Grease mg/L	< 2.5	< 2.5
Pathogens (Faecal Coliforms) CFU/100mL	16	65

The treatment facility is also designed to achieve Grade B biosolids stabilisation criteria in accordance with the NSW EPA Environmental Guidelines: Use and Disposal of Biosolids Products.

Staging

Delivery of the upgrade and augmentation works whilst maintaining effective operation of existing treatment infrastructure presents unique challenges and associated risks. Effective management of these risks is key to successful completion of the project. The design has been completed to allow concurrent operation of existing infrastructure and construction activities. This requires construction across a number of phases

A key component of this approach is to undertake construction across two stages. This allows a majority of the new equipment to be commissioned and able to accept all incoming loads such that redundancy equipment can be decommissioned, making way for the remainder of the new infrastructure.

1. Phase 1 – Site establishment
2. Phase 2 – Decommission Eastern sludge lagoon and drying beds
3. Phase 3 – Construct Stage 1 infrastructure (capable of treating commissioning loads)
4. Phase 4 – Pre Commission new infrastructure
5. Phase 5 – Cutover to new treatment processes
6. Phase 6 – Decommission redundant assets
7. Phase 7 – Construct Stage 2 infrastructure
8. Phase 8 – Commission Stage 2 infrastructure and decommission northern sludge lagoons
9. Phase 9 – Finalise earth works, roads, drainage, site fencing, landscaping etc.
10. Phase 10 – Demobilisation.

It is vital that detailed staging and interface plans are developed and implemented during the construction phase, with sufficient input from WSC to ensure effective treatment can be maintained.

Contents

Figures

Tables

Appendices

Note that due to the bulk of the documentation the following appendices are not included in the REF version of the Detailed Design Report:

- Appendix H: Geotechnical Reports
- Appendix I: Maximum Demand Calculations
- Appendix J: Safety in Design Report

1 Introduction and Background

Wingecarribee Shire Council (WSC) is planning to upgrade the Bowral Sewage Treatment Plant (STP). WSC have engaged Hunter H_2O to undertake the detailed design as summarised in this report.

1.1 Project Context

Bowral STP is owned and operated by WSC and located in the Southern Highlands of NSW. The STP was last upgraded in 2006 to a nominal design capacity of 14,600 equivalent persons (EP). The urban population of Bowral in 2016 was approximately 12,500 EP, with an estimated total STP load (including non-residential loads) as high as 15,500 EP. Therefore, the current load on Bowral STP is predicted to exceed the design load. Additionally, previous investigations have found that actual STP capacity may be below design values and capacity may already be exceeded by a significant margin.

WSC wish to amplify and upgrade the Bowral STP to meet the following objectives:

- Increase the capacity to 21,000 EP, being the projected ultimate population.
- Improve performance over time to meet Neutral or Beneficial Effect (NorBE) as outlined by Water NSW.

1.1.1 2008 Operational Issues Report

In 2008, ASpect prepared an Operational Issues Report. This report suggested the following:

- ASpect rated the capacity of the IDEA as just 6,100 EP, well below the design capacity of 10,600 EP. The aeration capacity was also stated to be lacking. The secondary treatment plant required augmentation. The following strategic options were suggested.
    - More IDEA reactors,
    - Conversion to membrane biological reactor, or
    - Conversion to a continuous flow bioreactor by adding clarifiers.
- Nitrogen removal could be improved by:
    - Increasing the sludge age and increasing the air off periods in the IDEA, or:
    - Adding dedicated anoxic zones to the IDEA, or:
    - Converting to an appropriate continuous flow bioreactor, or:
    - Include carbon dosing to any of these options.
- The accumulation of solids in the catch ponds was compromising effluent nutrient limits due to degradation of solids. Options to alleviate this included:
    - Decommission the ponds if continuous flow bioreactors were used, or
    - Construct an additional, smaller pond so the large pond could be periodically bypassed and cleaned, or
    - Install mixing in the catch ponds and catch solids in upgraded filters, or
    - Construct a sump in the pond to allow it to be drained to floor level and cleaned each day. This option was adopted by WSC.

1.1.2 2015 Future Upgrade Strategy Report

In 2015, GHD prepared an STP Capacity Assessment and Future Upgrade Strategy report. This report concluded that the capacity of the secondary treatment system was inadequate to meet the current load. The upgrade strategy proposed was:

- Increase the screening capacity and add grit removal.
- Increase the wet weather storage capacity.
- Upgrade the existing intermittently decanted extended aeration (IDEA) bioreactor and construct a new IDEA bioreactor to replace the existing Pasveer ditch bioreactors.
- Duplicate the catch pond to provide redundancy for cleaning.
- Provide an additional sludge lagoon to increase biosolids stabilisation capacity.
- Possibly replace the existing drying beds with portable mechanical dewatering.
- Add medium risk, off-site recycled water reducing discharge loads to meet NorBE requirements.

1.1.3 2017 Options Review Paper

In 2017, Public Works Advisory (PWA) prepared an Integrated Water Cycle Management Options Review Paper. PWA modified the following aspects of the upgrade strategy:

- Provide a mechanical solids removal system for the existing catch pond rather than build a second pond.
- Upgrade the cloth filters.
- Consider replacing the UV system with a break point chlorination and de-chlorination system for enhanced total nitrogen (TN) removal for future NorBE requirements.

1.1.4 2019 Concept Design Report

In 2018, PWA prepared a Concept Design Report (CDR). PWA undertook a more detailed options investigation into the best way to upgrade and amplify the various Bowral STP process units. The options centre around IDEA style bioreactors. Continuous flow bioreactors and MBRs were mentioned but not detailed in any options investigations. PWA suggested further modifications to the upgrade strategy as follows:

- Provide dual catch ponds that drain completely and include solids removal systems.
- Include future break point chlorination for TN removal (NorBE), plus de-chlorination.
- Convert one existing Pasveer bioreactor to an additional storm detention pond.
- Convert one sludge lagoon to an aerobic digester with decant thickening.
- Provide permanent mechanical dewatering facilities.

1.2 Scope of Work

In late 2019, WSC called for quotations for the Detailed Design of the Bowral STP upgrade. This was intended to be in keeping with the CDR by PWA. The scope of work for the Detailed Design was (broadly):

<u>PHASE 1</u>

- The development of a Services Delivery Plan for the project.
- A Concept Design Review and Finalisation. This included:
  - The assessment of component options and innovations.
  - A Design Development Report outlining recommended changes to the CDR.
- Design Development Workshop.
- Production of a Final Concept Design Report as a preliminary version of the Detailed Design Report (DDR). This PDR forms a part of the Final Concept Design Report and the DDR.
- An Equipment and Valving Register.
- A HAZOP workshop to assess the process design and associated risks.
- Preliminary Capital and Operating Costs
- Final Concept Design Sign Off (Hold Point 1).

<u>PHASE 2</u>

- The Detailed Design of the finalised concept. This included:
  - Production of design drawings.
  - Discipline designs (Civil, Structural , Mechanical, Electrical, Controls and Site Services).
  - A Functional Description (control system specification).
  - Design review meetings (50% and 90%).
  - A HAZOP/CHAIR workshop.
  - Revised cost estimates (50% and 90%).
  - Detailed Design Report (DDR) including Safety in Design.

<u>PHASE 3</u>

- Tender documentation.
- Technical Specification
- Assistance with completion of the Review of Environmental Factors (REF)
- Tender schedules.

<u>PHASE 4</u>

- Construction Tender Assistance

PHASE 5

- Construction Period Assistance
- Commissioning Assistance
- Process Proving Support
- The production of an Operations and Maintenance Manual

Hunter H_2O have been awarded Phases 1 - 4, with Phase 5 to be undertaken on a rates basis as required

1.3 Revised Option

The Design Development Report was prepared by Hunter H_2O during March to June 2020. This report discussed three secondary treatment options. These were:

- PWA Option – This was similar to the preferred option outlined in the CDR. This included retaining the existing IDEA, derating it, constructing a second large IDEA, constructing a new decant balance tank and converting a sludge lagoon to an aerobic digester. Break point chlorination was replaced by more advanced denitrifying IDEA bioreactors, including anoxic zones, mixed liquor recycle (MLR) pumping and carbon dosing.
- H_2O Option – This option involved utilising the existing IDEA as an aerobic digester, then constructing two new advanced denitrification IDEA bioreactors and decant balance tank as a single structure.
- FSB Option – This option involved utilising the existing IDEA as an aerobic digester, then constructing new Four Stage Bardenpho (FSB) continuous flow bioreactors and associated clarifiers.

Based on the comparisons undertaken in the Design Development Report and other supporting documentation, WSC selected to proceed with the FSB Option. The main advantages were:

- It better managed the risk of achieving future effluent quality requirements, less risk of sunken assets.
- It was capital cost neutral or advantageous.
- It was simpler to operate and control (no time sequencing and fewer set points).
- It would be identical to the style of STP required at Moss Vale STP where effluent quality projections were more stringent. This commonality provided operator mobility and familiarity advantages.
- It provided equal or better wet weather treatment capacity and performance.

Some modifications were made the further development of the design. The most significant were:

- Based on supplier advice, the solids removal performance of the disk filters, even after upgrading and amplification, was considered inadequate to meet future NorBE objectives. A decision was made to replace the existing disk filters with deep bed, dual media filters.
- The option to use the existing IDEA decanter for digester thickening was analysed in detail. It was found to require a slow decant lowering speed of around 1 mm per minute. This was considered too difficult to control introducing higher levels of risk. A decision was made to adopt pre-thickening using a picket fence (gravity thickener).
- A channel type UV system was adopted (in lieu of an in-pipe system) for improved hydraulics and control.
- A manual Storm Detention Pond (SDP) washdown system was added for cleaning of the SDPs after use.

The FSB option is described in detail in Section 4.1. A process flow diagram can be found in Appendix C.

2 Existing STP Site Description

The existing Bowral STP was last upgraded in 2006 to a nominal design capacity of 14,600 EP and consists of the following process units and systems;

- An inlet works including mechanical step screening but no grit removal.
- A storm detention pond (SDP) to store sewage flows in excess of treatment capacity. As there appears to be a capacity shortfall, this pond is utilised frequently. Storm return pumps are used to pump the stored sewage back to the head of works once the conditions allow.
- Two 2,000 EP (nominal) Pasveer Ditch style bioreactors.
- One 10,600 EP (nominal) intermittently decanted extended aeration (IDEA) bioreactor. This is likely have less capacity than this design rating. This IDEA includes:
  - Twin feed points, one at each end.
  - A centre decanter with a double-sided weir.
  - Four mechanical surface aerators.
  - Waste activated sludge (WAS) pumping.
  - No anoxic zones or mixed liquor recycle (MLR) pumps.
- A decant effluent catch/balance pond. Alum is dosed into the IDEA decant, creating solids that settle in this pond. The lack of IDEA capacity also causes occasional scouring of solids from the IDEA, adding further to solids accumulation. The pond does not fully empty and cannot be bypassed for cleaning. The pond has been modified to include a sump and sludge pump to facilitate periodic manual cleaning. Sewage must directed to the storm detention pond while catch/balance desludging is carried out.
- An alum storage and dosing system for phosphorus precipitation. The alum is dosed to all three bioreactors and the decant effluent from the IDEA only.
- An alkalinity (caustic soda) storage and dosing system for pH control.
- Two disk (cloth) filtration units. These appear to be overloaded under high flow conditions.
- A channel style ultraviolet (UV) disinfection unit sized for faecal coliform inactivation.
- Two sludge lagoons for sludge stabilisation. These are located close to residences resulting in odour annoyance issues and complaints.
- Sludge drying beds and Geobags for biosolids dewatering. The operators find it difficult to maintain the required dewatering schedule, especially in winter due to the cold and wet climate.
- A foul water pump station (FWPS) returning foul water streams from around the plant back to the head of the works for treatment.

An administration building and storage sheds also exist onsite

Sewage inflow is transferred to the treatment plant from Bowral, East Bowral and Burradoo sewage pump stations (SPS) within the township. The Burradoo SPS discharges sewage to the plant via a rising main, while Bowral and East Bowral sewage is discharged via two gravity mains. All three mains discharge to the existing inlet pump station. Treated effluent flows from the channel UV via gravity to the Mittagong River.

The Plant is located to the west of the township, off the intersection between Burradoo Road and Railway Road. The site is in relatively close proximity to residential properties. Figure 2-1 provides an aerial photograph of the Bowral STP.

Figure 2-1 Aerial Photograph of Bowral STP

3 Design Basis

This section outlines the loadings and performance that have been adopted as the detailed design basis.

3.1 Loadings

A first principles review of the loadings that were adopted by PWA in the CDR has been undertaken, based on historical census data, measured sewage flows and concentrations. Non-residential loads are based on previous reports and advice from WSC. Growth is based on historical Census growth and previous planning reports.

Hunter H_2O has relied on estimates of the population, flow records, sewage concentration data and an understanding of the catchment to determine appropriate design loads. Current loads were converted to equivalent persons (EP), standard sewage mass contributions (g/EP/d) and hydraulic contributions (L/EP/d), then extrapolated into the future.

3.1.1 Equivalent Persons

3.1.1.1 Bowral Census Data

Bowral STP services the townships of Bowral, East Bowral and Burradoo. There are a number of 2016 Census areas that cover the urban area of Bowral, including

- Bowral SA2 – This covers, Bowral, East Bowral, Burradoo plus rural areas to the Hume Freeway in the West and the Wingecarribee River to the south. It is therefore likely to include unsewered residences.
- Bowral SSC – This covers Bowral, East Bowral and a much smaller rural area to the west. It does not include Burradoo.
- Burradoo SSC – This covers Burradoo and some rural areas to the Wingecarribee River to the south.

There is no 2016 Census area that exactly reflects the sewered area serviced by Bowral STP. The most accurate area is that covered by Bowral SSC plus Burradoo SSC. It is worth noting that the sum of the populations in these two areas are slightly greater than for Bowral SA2. This is despite there being no overlap between Bowral SSC and Burradoo SSC, and the SA2 boundary was greater than the other two combined. The difference is small, but points to some inaccuracy in the way the census data was compiled.

Census data was also reviewed for the previous two Census years (2006 and 2011). The Bowral SA2 area did not exist. Instead there was a Bowral UCL. This appeared to reflect the urban centre more accurately than the SA2 areas of subsequent years (i.e. there would be fewer unsewered properties). The apparent growth from 2006 to 2011 may be due more to an increase in the Census area rather than an actual increase in sewered area population. When the 2011 Bowral and Burradoo Census areas were added, the result was significantly less than the Bowral SA2. This was the opposite of 2016.

It is apparent that there are some anomalies in the Census data that cannot be resolved within the scope of this design. The UCL area for 2006 and the SA2 area for 2011 and 2016 has been adopted in the knowledge that the SA2 may include some non-sewered residences and residents.

Table 3-1 Census Data for the Bowral Census Area

	2006 Bowral UCL	2011 Bowral SA2	2016 Bowral SA2
People(1)	11493	12154	12949
All Private Dwellings	5298	5776	6023
Occupied Dwellings	85.8%	84.9%	87.0%
Occupied Dwellings	4548	4782	5027
Occupied Occupancy Rate	2.4	2.4	2.3

	2006 Bowral UCL	2011 Bowral SA2	2016 Bowral SA2
Overall Occupancy Rate	2.2	2.1	2.1
Average Bedrooms per Dwelling		3.4	3.4
Overall Total Bedrooms		19638	20478

Note (1): People are defined as those that were at their usual place of residence. This does not include tourists or visitors.

The following information can be gleaned from this data.

- The population of Bowral appears to be growing quite rapidly. The population has grown by just under 1.3% per annum over the past 10 years. Some of this may be due to the increase in Census area between 2006 and 2011, but the population from 2011 to 2016 also grew at a similar rate.
- The occupied dwellings are slightly lower than the averages for NSW and Australia. This suggests that there may be more holiday houses or holiday rentals (non-residential EP).
- The occupancy rate of the occupied houses (2.3) is significantly less than the NSW and Australian average (both 2.6). This suggests an older demographic.
- The average bedrooms per household (3.4) is greater than the NSW average (3.0) and Australian average (3.1). This is despite the low occupancy rate. The total existing bedrooms is close to the ultimate design load of 21,000 EP.

The 2016 Census permanent population is very similar to that reported in the CDR (13,000 EP). However, some of these people would reside outside the sewerage catchment (sewered residents are likely slightly less).

3.1.1.2 IWCM EP

The CDR adopted the design EP figures of the Integrated Water Cycle Management Options Report (IWCM) produced by PWA. This in turn had adopted figures derived in the Integrated Water Cycle Management Strategy Issues Paper (IWCMI) also produced by PWA.

The methodology used is outlined in Section 4.3 of the IWCMI and is based on predicted and measured flow. The estimates relied heavily on the Infoworks model for the Bowral sewerage scheme. This provided a sum of the 'trade flow' in the Bowral catchment. This was subtracted from an estimate of the Average Dry Weather Flow (ADWF) to determine the residential flow. This was divided by the determined residential population to determine the residential hydraulic contribution and found to be 221 L/EP/d for the Bowral catchment. The total EP was then derived by dividing the ADWF by this hydraulic contribution.

These calculations (based on 2014 figures) are shown in Table 4.7 of the IWCMI and are summarised in Table 3-2 below.

Table 3-2 Calculation of 2014 Non-Residential EP for Bowral STP from the IWCMI

Parameter	Bowral Values
Estimated 2014 ADWF (kL/d)	3,200
Flow from Non-Residential Sources (kL/d) - Infoworks	517
Flow from Residential Sources (kL/d)	2,683
Hydraulic Contribution (L/EP/d)	221
2014 Non-Residential EP	2,345
2014 Residential EP	12,165
2014 Total EP	14,510
2014 Total Equivalent Tenements (ET)	6,309

The 2014 Residential EP is very similar to the 2011 Census residents. It is assumed that catchment growth was offset by the over-estimate in the Census data (unsewered residents in the Bowral SA2 Census area).

The estimation of non-residential EP is never straightforward. The figures derived in the IWCMI and CDR are based solely on flows (measured and estimated). Flow is not necessarily representative of load. For example, a discharge from a commercial kitchen may have different sewage strength than a household. In short, flow is the most variable and least representative of all EP contributions. The Non-Residential EP thus derived is 19% of the residential population. This is quite a high proportion when compared to most regional catchments.

The IWCMI assumes the non-residential EP grows at 0.25% per annum in line with the STP Capacity Assessment and Upgrade Options Report (OR) prepared by GHD. This is significantly less than the residential growth indicated in the Census (1.3%).

3.1.2 EP Mass Contributions

WSC provided three sets of sewage sampling data;

- January 2017 – This set consisted of multiple samples per day (roughly four per 24 hours) over a 72-hour period. The time between samples varies, suggesting that these were composites based on elapsed sewage volume. The effect is to provide flow weighted composites for each day.
- November 2017 – This set consisted of one result per day from the 25th October to the 17th November 2017. The sampling method is not stated.
- January 2018 – This set consisted of one result per day from the 8th January 2018 to 25th January 2018. The sampling method is not stated.

The flows for these days were imported from other supplied operational spreadsheets to convert the measured concentrations to mass loads (kg/d). The median of each set was then calculated.

All data sets appeared to under-represent the particulate components of the sewage. This can easily occur if the sampling point is insufficiently turbulent at the time of sampling (allowing solids to settle). The January 2017 data set appeared to contain the least errors. The other two appeared to grossly under-represent solids. The results have been theoretically corrected, using standard sewage fractions and ratios between components. They were corrected for solids only. The suspended solids believed settled from the incoming sewage was added, along with the equivalent particulate components of the other measurements.

The IWCM estimates for EP (including growth since 2014) were then used to determine the mass contributions of each component as presented in Table 3-3.

Table 3-3 Measured and Corrected Sewage Contributions

	Jan 2017	Nov 2017	Jan 2018	Nov 2017 Corrected	Nov 2017 Corrected	Jan 2018 Corrected
Equivalent Persons (EP)	14938	15079	15108	14938	15079	15108
Hydraulic Contribution L/EP/d	183	220	200	183	220	200
Suspended Solids (SS) g/EP/d	48.0	16.2	17.9	62.7	70.0	60.0
Chemical Oxygen Demand (COD) g/EP/d	108.4	75.7	64.4	132.9	165.2	134.4
Biochemical Oxygen Demand (BOD) g/EP/d	38.7	33.0	31.5	48.1	67.1	58.2
Total Nitrogen (TN) g/EP/d	12.2	11.5	10.1	13.1	14.5	12.5
Total Phosphorus (TP) g/EP/d	1.9	1.6	1.3	2.0	2.0	1.7

It is apparent that the results for November 2017 do not align with the other two sets of data, even once corrected. Averaging the other two data sets, and comparing these to the design contributions in the CDR, results in the corrected contributions summarised in Table 3-4. Adopted design contributions were developed by considering both the CDR and corrected measured contributions.

Table 3-4 Corrected Contributions versus Design Contributions

Contribution	CDR Design Contributions	Measured (Corrected) Contributions	Adopted Design Contributions
Hydraulic Contribution L/EP/d	220	210	220
Suspended Solids (SS) g/EP/d	60	61.4	60
Chemical Oxygen Demand (COD) g/EP/d(1)	132	133.7	132
Biochemical Oxygen Demand (BOD) g/EP/d(2)	60	53.2	60
Total Nitrogen (TN) g/EP/d	12.5	12.7	13.0
Total Phosphorus (TP) g/EP/d	3.0	1.9	2.2

Note (1): The CDR did not contain a COD contribution. An equivalent COD was determined by multiplying the design BOD by 2.2.

Note (2): Hunter H_2O does not use BOD for the design, so the contribution is irrelevant to the detailed design sizing.

The following points are worth noting from this analysis.

- Given the relatively short sewage monitoring periods and the apparent under-estimation of solids, there is nothing to suggest that the mass contributions in the CDR are incorrect, with the exception of that stated below.
- The TP contribution in the CDR appears very high when compared to typical contributions in Australia (2.0 to 2.4) and those measured. A typical design contribution of 2.2 g/EP/d is proposed. This is still conservative when compared to the measured value. It is also worth noting that TP loadings have been decreasing in recent years due to initiatives targeting reduce phosphorus within detergents.
- The TN performance predictions from process modelling are extremely sensitive to the COD:TN ratio of the sewage. The measured COD:TN ratio is less favourable than that adopted in the CDR. A TN contribution of 13 g/EP/d is proposed for the design to add conservatism to aeration design, carbon dosing and performance predictions.

3.1.3 Hydraulic Contribution

WSC provided daily flow data for the existing Bowral STP stretching back as far as 2013. The data was in multiple spreadsheets and there were periods where data was missing. The ADWF has not been constant over the period.

An analysis of rainfall was used to exclude wet weather effected days. The daily flow was excluded when more than 5 mm of rain fell in total over the preceding seven (7) days. In some cases, rain effects were still evident after seven days. As is usually the case, the average of the remaining days was very similar to the median of all days. Therefore medians were used to represent the ADWF.

An analysis was conducted to compare the hydraulic contribution of various years of data. The EP was based on the IWCMI estimates and growth rates (1.3% for residential and 0.25% for non-residential) resulting in the values of Table 3-5.

It is worth noting that the ADWF figures in Table 3-5 are the numbers as measured and recorded. These may contain recycle flows and therefore over represent actual flows, adding conservatism to the analysis.

Table 3-5 ADWF and Hydraulic Contributions over Time

Time Period	Measured ADWF (kL/d)	Estimated EP	Hydraulic Contribution (L/EP/d)
May 2013 to April 2014	3057	14592	209
May 2015 to April 2016	3624	14757	246
January 2017 to December 2017	3255	15008	217
January 2018 to December 2018	2766	15179	182
January 2019 to December 2019	2700	15351	176
January 2020 to April 2020(1)	3561	15526	229

Note (1): The 2020 figures do not represent a full year and are heavily rain effected.

It is apparent that 2018 and 2019 had considerably less flow than the other years. This may be a result of drought conditions that can lead to;

- Less dry weather infiltration.
- Water restrictions reducing shower times, etc.
- Reduced non-residential sewage generation (more water wise businesses).

Whatever the reason, the hydraulic contribution is highly variable.

Very little of the design is impacted directly by the hydraulic contribution and ADWF. The hydraulic and process design is limited by the Design Full Treatment Flow (DFTF) and Design Storm Treatment Flow (DSTF). Since these are specified as ratios to the ADWF, the hydraulic contribution does have an indirect impact on much of the facilities. It is therefore appropriate to be somewhat conservative.

The analysis above suggests that the CDR design figure of 220 L/EP/d is reasonable given the wet weather treatment components of the proposed Bowral STP (storm storage, storm treatment and emergency effluent storage). There is no impetus to add significant conservatism to the hydraulic contribution.

3.1.4 Flow Peaking Factors

3.1.4.1 Peak Dry Weather Flow

The Peak Dry Weather Flow (PDWF) is the peak flow that is received at any time during a typical dry day. This forms the basis for mass load peaking and is used to size the aeration system and chemical dosing systems. It has no direct impact on other facilities.

WSC supplied an influent flow data set that contained flows for each five minute period from 1:55 pm on 23/01/2017 to 8:10 am on 27/01/2017. The graphs for the three complete days are shown in Figure 3-1.

These days show both the variability and consistency of trends. The raw data was converted to a flow peaking factor by dividing a rolling average (30 minutes) by the daily average for each day. The influence of fixed speed sewage pumping is still evident in the graphs, causing oscillations around a moving mean. It is the moving mean of these oscillations that is the true peaking factor. The graph shows that this is typically below 2.0 ADWF.

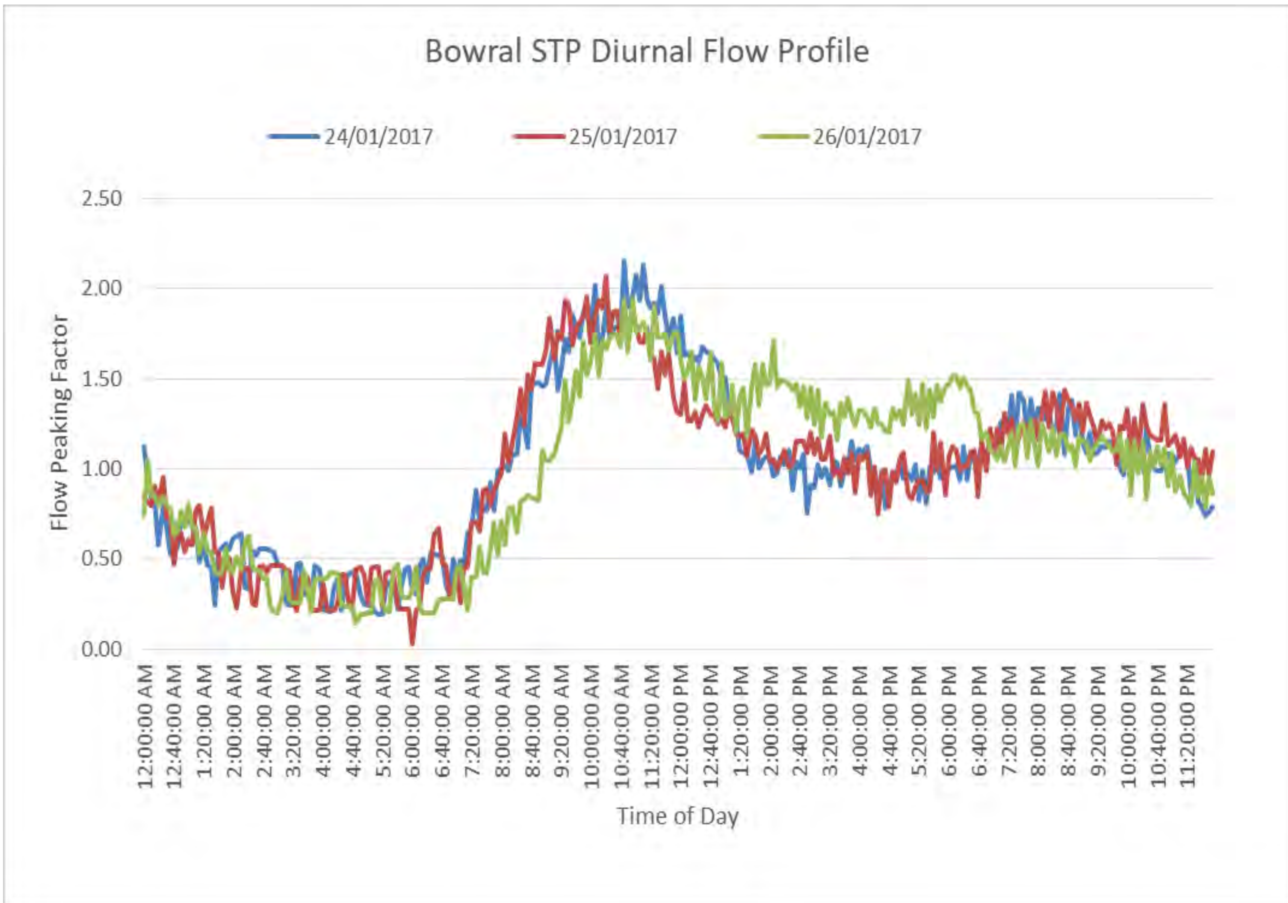


Figure 3-1 Bowral STP Diurnal Flow Profile

From this analysis, a PDWF of 2.0 ADWF appears appropriate.

The hydrograph also suggests a minimum dry weather flow (MDWF) of around 0.3 ADWF. While this does not impact on design sizing, it has been included in the loadings for completeness.

3.1.4.2 Design Full Treatment Flow

The Design Full Treatment Flow (DFTF) is the maximum flow that will receive full treatment without significantly compromising effluent quality. Flows above DFTF are stored, bypassed or given partial treatment. The DFTF dictates the size of most of the treatment units, including the bioreactors.

The NSW Department of Planning, Industry and Environment (DPIE) are likely to require a DFTF of 1.5 times the PDWF. In the case of Bowral STP, this is 3.0 times ADWF. The CDR adopted a DFTF of 3.0 ADWF and has been adopted for the design.

This DFTF is applied to the worst case FSB configuration. Under the Modified Ludzak Ettinger (MLE) configuration (see Section 5.7), the sludge age and Mixed Liquor Suspended Solids (MLSS) of the bioreactors can be reduced. This affords the opportunity to increase the DFTF to 4.5 ADWF and has been accommodated in the design.

3.1.4.3 Design Storm Treatment Flow

The Design Storm Treatment Flow (DSTF) is the maximum flow that can receive partial treatment. In the case of Bowral STP, this will pass through the secondary clarifiers. The flow in excess of DFTF and less than DSTF passes around the bioreactors to the clarifiers. This receives solids contact treatment, removing the majority of the particulate pollutants and some of the soluble pollutants.

The CDR adopted a DSTF of 7 times ADWF, however 6 times ADWF is more practical. Making the DSTF twice the DFTF will allow pumping systems (e.g. the lift pump station) to contain identical pumps to serve DFTF and DSTF conditions, reducing spares, providing greater redundancy and decreasing control complexity.

The DSTF has virtually no impact on the sizing of continuous flow bioreactors that incorporate pre-clarifier solids contact for partial treatment. Such a solids contact system typically increases the clarifier diameter marginally < 5%. However, the mixed liquor and effluent pipes must be increased in size.

The effect is that under DSTF conditions:

- For FSB mode, 3 ADWF is fed to the bioreactors and a further 3 ADWF is fed directly to the clarifiers, for a total of 6 ADWF.
- For MLE mode, 4.5 ADWF can be fed to bioreactors and a further 3 ADWF can be fed directly to the clarifiers, for a total of 7.5 ADWF.

3.1.4.4 Peak Wet Weather Flow

The Peak Wet Weather Flow (PWWF) is the highest sustained flow (i.e. within a day) that can arrive at the STP. The CDR selected a PWWF of 10 times ADWF. This is a reasonably typical design figure. The CDR states that a PWWF of 10 ADWF requires a lowering of the top water level (TWL) in the existing storm pond.

In February 2020 there was an extreme storm event over the greater Sydney region, including Bowral. WSC provided a data set of flows through Bowral STP during that period. This was a data set of flow readings recorded at the STP on the 11^{th} and the 12^{th} of February 2020. The flow readings were compiled every 2 minutes and 40 seconds for the 48 hour period.

The maximum instantaneous flow through the plant was recorded as 375 L/s. This represents 9.2 times the current ADWF or 7.0 times the future ADWF. However, because this is the flow through the inlet works, it is limited by the capacity of the lift pump station upstream of the inlet works. The rated capacity of the current lift pump station varies between references. The Overview section of the Operations & Environmental Management Plan (OEMP) states that the lift pump station capacity is 370 L/s, which is very close to the maximum flow recorded. As the inlet flow element is downstream of the lift pump station, all recorded sewage flow events are limited by the lift pump station capacity. The sewage arriving in the sewer could be greater than this.

WSC suggested a flow of 515 L/s as the maximum current flow. This represents 12.7 times the current ADWF or 9.6 times the future ADWF. After consultation with WSC, a PWWF of 13 times the future ADWF has been adopted.

3.1.4.5 Peak Instantaneous Flow

The peak instantaneous flow (PIF) is the maximum possible flow that can arrive at the STP. It is the combined capacity of all sewage pumping station (SPS) pumps plus the maximum capacity of the gravity mains. The PIF dictates the sizing of bypass conduits and weirs and can impact on the hydraulic design of the inlet works.

The Bowral sewerage scheme contains a large gravity network plus a series of pumping stations. The majority of the city of Bowral is serviced by the gravity system. The fringes of Bowral, plus the majority of East Bowral and Burradoo are serviced by SPSs and rising mains.

The final pumps stations that deliver sewage directly to Bowral STP are:

- BW1 (Burradoo) – 2 pumps at 50 L/s capacity each.
- BW11 (East Bowral) – 2 pumps at 50 L/s each.

Other SPSs pump into these SPSs and the Bowral gravity main.

The PIF was not provided in the CDR. It appears that PWA assumed that the PIF was equal to the PWWF of 10ADWF. Measurement at the STP sheds no light on the PIF, as the inlet flow element is located downstream of the lift pump station, which is limited to around 370 L/s.

Because there is a significant gravity component, it is not possible to determine whether the PIF will exceed the PWWF. WSC have expressed a desire for all flows to be mechanically screened. The design therefore assumes a PIF of 13 ADWF, catering for additional flow (provided the inlet pump station is operational) should greater than 13 ADWF arrive at the STP in the future.

3.1.5 Growth

The growth rate of both flows and loads is assumed to be the same (i.e. the hydraulic contribution of 220 L/EP/d does not change). As outlined in Section 3.1.1 the growth rates are assumed to be as follows:

- Residential = 1.3% per annum based on census data.
- Non-Residential = 0.25% per annum based on the IWCM.

The IWCM Table 2.2 suggests a steady growth rate for non-residential EP and a varying growth rate for residential EP. The residential EP starts high (1.3% to 1.5%) until 2031, then slows to lower, steady growth rate (0.7%) from 2031 to 2046.

The CDR and detailed design brief adopted a design load equivalent to the forecast ultimate load of 21,000 EP. Because an ultimate load is adopted, the growth rate has no bearing on the design. The growth rate merely predicts the increasing loads over time. The only impact is on operating costs and the forecast load at commissioning. There is little need for either to be accurate. Therefore, for the sake of simplicity, the fixed growth rates of 1.3% and 0.25% have been adopted.

The datum are the numbers contained in the IWCMI for 2014. These were:

- 12,165 EP for residential.
- 2,345 EP for non-residential.
- 14,510 EP total.

Based on these figures, the commissioning load (2022) is expected to be 15,882 EP.

3.1.6 Design Flow Summary

A summary of the design flows for each loading scenario can be found in Table 3-6.

Table 3-6 Design Flows for Bowral STP

	Commissioning - 2022	Design - Ultimate
Hydraulic Contribution L/EP/d	220	220
EP	15882	21000
PIF:ADWF	17.2	13.0
PWWF:ADWF	17.2	13.0
DSTF:ADWF	7.9	6.0
DFTF:ADWF	4.0	3.0
PDWF:ADWF	2.0	2.0
ADWF:ADWF	1.0	1.0
MDWF:ADWF	0.3	0.3
PIF ML/d	60.060	60.060
PWWF ML/d	60.060	60.060
DSTF ML/d	27.720	27.720
DFTF ML/d	13.860	13.860
PDWF ML/d	6.988	9.240
ADWF ML/d	3.494	4.620
MDWF ML/d	1.048	1.386

3.2 Sewage Characteristics

3.2.1 Sewage Concentrations

The sewage concentrations can be determined by combining the design hydraulic and mass contributions. These concentrations are summarised in Table 3-7.

Another crucial design parameter is the alkalinity concentration. This is as much dependent on raw potable water supply as it is on the residents and catchment. It can be quite variable between catchments. The alkalinity concentration will impact only on alkalinity storage volumes, dosing pumps and operating costs (alkalinity chemical consumption).

The median alkalinity results for the three sewage data sets were as follows:

- January 2017 = 356 mg/L
- November 2017 = 253 mg/L
- January 2018 = 245 mg/L

The January 2017 figure is very high for sewage and appears to be an outlier. The other two are fairly standard for sewage in Australia and form the basis for the design figure in Table 3-7. This also aligns with the figure adopted in the CDR.

Table 3-7 Sewage Concentrations for Bowral STP

Sewage Characteristic	Bowral STP
Chemical Oxygen Demand (COD) mg/L	600.0
Suspended Solids (SS) mg/L	272.7
Total Nitrogen (TN) mg/L	59.1
Total Phosphorus (TP) mg/L	10.0
Alkalinity (Alk) mg/L	250.0

3.2.1.1 Sewage Fractions

Modern design practices and process modelling requires sewage characteristics to be broken into fractions and ratios. Some of these can be measured, others cannot.

Some of the fractional components were measured for the 72 hour characterisation undertaken in January 2017. However, the period of time and number of samples is very small. As previously explained, these also appeared to be missing some solids. Based on the corrected, average sewage characteristics, the following ratios were calculated:

- NH_x-N:TN = 0.691 compared to a default of 0.667
- VSS:SS = 0.962 compared to a default of 0.900
- SCOD:COD = 0.233 compared to a default of 0.244 (once corrected for VSS:SS).
- SNTKN:TKN = 0.015 compared to a default of 0.020 (calculated from effluent measurements)

The limited measured values are not significantly different to the default domestic design values. The measured VSS:SS ratio is slightly less conservative on sludge production. However, it may be true given the lack of sand within the catchment. Once correcting for this, the default SCOD:COD becomes very close to the measured value. Therefore, the default values are adopted, except for VSS:TSS which is increased from 0.900 to 0.950 and SNTKN:TKN which is reduced from 0.020 to 0.015.

Table 3-8 Sewage Fractions for Bowral STP

Sewage Characteristic	Abbreviation	Also Known As	Ratio
Solids Ratios			
Particulate Non-Biodegradable COD: Volatile SS	PNCOD:VSS	f_{cvu}	1.420
Particulate Non-Biodegradable COD: COD	PNCOD:COD	f_{up}	0.200
Particulate Inorganic Phosphorus: Non Volatile SS	PIP:NVSS	f_{pn}	0.000
Volatile SS: SS	VSS:SS	f_{xv}	0.950
Non-Biodegradable Volatile SS: Volatile SS	NBVSS:VSS	f_{vu}	0.326
Particulate COD: Volatile SS	PCOD:VSS	f_{cv}	1.750
Particulate Biodegradable COD: Biodegradable Volatile SS	PBCOD:BVSS	f_{cvb}	1.910
Particulate TKN: Volatile SS	PTKN:VSS	f_{nv}	0.060
Particulate Phosphorus: Volatile SS	PP:VSS	f_{pv}	0.008
Soluble Ratios			
Soluble Non-Biodegradable COD: COD	SNCOD:COD	f_{us}	0.030
Soluble Biodegradable COD: Biodegradable COD	SBCOD:BCOD	f_{bs}	0.259
Soluble Non-Biodegradable TKN: TKN	SNTKN:TKN	f_{nus}	0.015
Ammonia Nitrogen: TKN	NH_x-N:TKN	f_{na}	0.667
Soluble Biodegradable Organic Nitrogen: TKN	SBOrg-N:TKN	f_{nbs}	0.055

A tabulated and graphical summary of all sewage characteristics and fractions for the Base EP case can be found in Appendix A.

3.3 Performance

3.3.1 Effluent Quality Performance

3.3.1.1 Current EPA Licence Limits

The current NSW Environment Protection Authority (EPA) licence limits for Bowral STP are summarised in Table 3-9. There are also limits applied to Faecal Coliforms (80%ile of 200 CFU/100 mL) and pH (minimum of 6.5 and maximum of 8.5).

Table 3-9 Current EPA Licence Limits

Effluent Quality Parameter	50%ile Limit	90%ile Limit
Biochemical Oxygen Demand (BOD) mg/L	5	10
Ammonia Nitrogen (NH_x-N) mg/L	-	2
Total Nitrogen (TN) mg/L	7.5	10
Total Phosphorus (TP) mg/L	0.3 mg/L	0.5 mg/L
Suspended Solids (SS) mg/L	10 mg/L	15 mg/L

The following points are notable.

- None of these limits are particularly onerous for an activated STP with filters and chemical dosing.
- These generally reflect the EPA 'Sensitive Waters' criteria. The exception is TP where the sensitive waters criteria is typically 0.3 mg/L as a 90%ile.
- The equivalent NH_x-N 50%ile target would be 0.5 mg/L.

After chemical dosing, the SS, BOD and TP performance is entirely dependent on the performance of the filters. These limits should be simple to meet even if only moderate filtration performance is met.

3.3.1.2 Recent Performance

WSC provided data files that contained recent effluent quality data. These were:

- Bowral Process Data Sheet 2018-19 – Data from July 2018 to June 2019. Samples were taken roughly four times per week and analysed on site using test kits. This contains results for orthophosphate (PO_x-P labelled as Phosphorus), NH_x-N, Nitrate Nitrogen (NO_3-N), Alkalinity and pH.
- Bowral 1819 – Data from May 2018 to April 2019. Samples were taken at fortnightly intervals and analysed by external laboratories for BOD, SS, NH_x-N, Nitrite Nitrogen (NO_2-N), NO_3-N, TN, TP, pH, Faecal Coliforms (F-Coli) and Oil and Grease (O&G).

The statistics of this data is summarised in Table 3-10.

Table 3-10 Recent Effluent Quality Performance

Effluent Quality Parameter	50%ile	90%ile
Biochemical Oxygen Demand (BOD) mg/L	< 2	5
Ammonia Nitrogen (NH_x-N) mg/L	0.4	1.0
Ammonia Nitrogen (NH_x-N) mg/L(1)	0.4	1.0
Total Nitrogen (TN) mg/L	3.3	5.2
Nitrate Nitrogen (NO_3-N) mg/L	3.5	5.4
Nitrate Nitrogen (NO_3-N) mg/L (1)	2.1	3.1
Nitrite Nitrogen (NO_2-N) mg/L	0.2	0.4
Total Phosphorus (TP) mg/L	0.1	0.3
Orthophosphate (PO_x-P) mg/L (1)	0.1	0.3
Suspended Solids (SS) mg/L	3.0	9.0
Oil and Grease (O&G) mg/L	< 2.5	< 2.5
Faecal Coliforms (F-Coli) CFU/100 mL	16	65
Alkalinity mg/L(1)	72	85

Note (1): These were based on internal monitoring which is not used to test licence compliance.

The following points are worth noting.

- Bowral STP complied with all licence limits.
- The internal and external NH_x-N indicate reasonable, but not optimal, nitrification performance. These figures are very good for a plant lacking in bioreactor and aeration capacity.
- The external nitrogen results are erroneous. TN is the sum of Organic Nitrogen (Org-N), NH_x-N and Total Oxidised Nitrogen (NO_x-N). NO_x-N is the sum of NO_3-N, NO_2-N and other, rarer oxidised nitrogen species. Therefore, TN should be significantly greater (by 1 to 2 mg/L) than the sum of NH_x-N, NO_3-N and NO_2-N. This is not the case. The reported 50%ile TN is 3.3, but the sum of the other reported components is 4.1, suggesting the actual TN could be around 6 mg/L. The 90%ile could be as high as 9 mg/L. These TN figures would still comply with the licence limits, but the margin would be small. These corrected figures are fairly typical of what can be expected from an IDEA reactor.
- The SS figures are not particularly good for a plant with filters. This suggests that the disk filters do not perform as well as deep bed filters. The 50%ile SS figure of 3 mg/L is in line with the supplier expectation.
- The internal PO_x-P results match the external TP results. As discussed in Section 3.3.1.3.1, the external TP results appear to be inexplicably low.

3.3.1.3 Future Effluent Targets

WSC is currently in negotiation with the EPA over the licence limits for the future Bowral STP. There may be some tightening of the limits, but the extent of this tightening is not known.

The CDR contains a possible set of future effluent quality targets (assumed to be 50%iles). These are based on Neutral or Beneficial Effect (NorBE) regulations. These regulations aim at limiting the loads of pollutants entering the Warragamba Dam catchment to current levels. This means as flows increase, concentrations should decrease. The possible NorBE criteria for Bowral STP were outlined in the Brief and the CDR (Table 2-6). These have been repeated here, with other relevant milestones added.

Table 3-11 Predicted NorBE Effluent Goals

Effluent Quality Parameter	Benchmark	Commissioning	Ultimate
Load (EP)	15,000	15,882	21,000
TN mg/L	5.5	5.2	4.0
TP mg/L	0.13	0.12	0.09

The targets with the greatest impact on design and risk are TP and TN. These are covered in detail below.

3.3.1.3.1 Future TP Targets

There are two mechanisms for chemical TP removal (biological TP removal has not been considered):

- Precipitation of orthophosphate (PO_x-P) through chemical dosing (e.g. alum). As the target PO_x-P decreases, the molar rate of the dose increases. Given sufficient points of dosing and a high enough molar rate, the PO_x-P can be reduced to very low levels (0.005 mg/L).
- Removing precipitants through solids separation. This occurs in the bioreactors and can then occur downstream in clarifiers, filters, membranes or additional clarifiers (clariflocculators).

The content of the phosphorus in the solids increases through precipitation. Depending on the sewage characteristics and dosing points, the solids exiting the bioreactors will contain around 5% TP by mass. Therefore, 10 mg/L of effluent SS will contain at least 0.5 mg/L of TP.

Given a small residual PO_x-P of (say) 0.1 mg/L, the following SS limits must be achieved to meet the current TP limits:

- A 50%ile TP limit of 0.3 mg/L requires a 50%ile SS of 4 mg/L.
- A 90%ile TP limit of 0.5 mg/L requires a 90%ile SS of 8 mg/L.

This is similar to the current Bowral STP performance (see Table 3-10). This suggests that, based on current SS performance, the TP performance should be close to the current limits. However, the measured performance is significantly better. The TP does not reconcile with the SS and internal measurements of PO_x-P. There appears to be incomplete digestion of the precipitated TP in the samples. It would be risky to conclude that there is any room for tightening the TP limits without providing additional treatment in the form of additional dosing points and better SS removal (e.g. deep bed filters).

There are numerous examples of plants in NSW that achieve TP licence limits of 0.1/0.3 mg/L (50%ile/90%ile) using deep bed tertiary filtration. It may be possible to achieve the same with cloth filters, but this will require trials. Given that cloth filters are designed to achieve 3 mg/L of SS (supplier information), then they should struggle to achieve a TP limits of less than 0.2/0.5 mg/L. Imposing limits below this would likely require replacement of the cloth filters or the addition of another precipitation step (such as clariflocculators).

The detailed design brief and CDR forecast the possibility of NorBE targets as low as 0.09 mg/L TP once the STP reached the ultimate design load of 21,000 EP. This is unlikely to be achievable using cloth filtration, but could be achieved using deep bed filters and pre-flocculation. Clariflocculation is unlikely required at Bowral STP at ultimate loads.

If disk filters were retained, then there may be a need to replace them with more advanced technology as the limits tighten over time. While there is no immediate impetus to replace the filters as part of the detailed design, there is a risk that the additional disk filters required as part of the amplification may become sunken assets.

Hunter H_2O cannot guarantee that the cloth filter performance will be able to attain a 50%ile of 0.1 mg/L and a 90%ile of 0.3 mg/L consistently. The imposition of 'sensitive waters criteria' could result in the need to replace the filters after the new plant is commissioned.

WSC decided to adopt new deep bed, dual media filters as part of the upgrade. This decision was based on reducing current and future compliance risks, operational issues with the current disk filters and the risk of the two additional disk filters becoming sunken assets.

In summary, the 50%ile TP limits trigger the following technologies:

- > 0.3 mg/L – Bioreactors with single point chemical dosing.
- 0.2 to 0.3 mg/L – Bioreactors plus disk filters and two points of chemical dosing.
- 0.1 to 0.2 mg/L – Bioreactors plus deep bed filters and two points of chemical dosing.
- 0.05 to 0.1 mg/L – The above plus flocculation prior to filtration (design case).
- < 0.05 mg/L – The above plus clariflocculation prior to filtration.

3.3.1.3.2 Future TN Targets

The TN targets impact on the bioreactor style and (to a lesser extent) size. The current licence limits reflect the capability of typical, modern nitrification/denitrification activate sludge bioreactors such as:

- Intermittently decanted extended aeration (IDEA).
- Sequencing batch reactor (SBR).
- Continuous flow Modified Ludzac Ettinger (MLE).

The recent Bowral STP performance is a TN of 3.3/5.2 (50%ile/90%ile). However, as explained in Section 3.3.1.2 this appears to be due to external laboratory analysis errors. The actual TN performance is more likely to be 6/9.

A minor reduction in TN targets (< 7 mg/L) could require carbon dosing to be added to all of the above bioreactor configurations. This results in a slight increase in bioreactor size and an additional chemical storage and dosing facility. The capital cost increase is low, but the operating cost increase can be considerable.

A significant reduction in TN targets (< 5 mg/L) would place the performance beyond the reasonable capability of these bioreactor processes, even with carbon dosing. The best process to achieve low TN targets is a continuous flow bioreactor with carbon dosing to a secondary anoxic zone. A typical configuration is a four stage Bardenpho (FSB) process. While not common in Australia, examples do exist. It is a relatively straightforward bioreactor configuration that is not complex to design or operate.

There is no way to improve upon an IDEA design to achieve less TN without greatly diminishing returns. However, an MLE bioreactor can be designed to be operationally converted to an FSB bioreactor at little additional cost. The FSB configuration (with carbon dosing) should be able to reliably achieve a 50%ile TN of < 3 mg/L, or even lower.

The NorBE target forecasts (see Table 3-11) suggest that an MLE process may be sufficient at commissioning. In fact, an MLE plus carbon dosing may be sufficient (with some risk) well into the future. However, as loads increase to ultimate, the MLE configuration may struggle, and an FSB bioreactor will likely be required.

The detailed design brief and CDR forecast the possibility of NorBE targets as low as 4.0 mg/L TN once the STP reached the ultimate design load of 21,000 EP. This is likely to be beyond the capability of on MLE but well within the capability of an FSB bioreactor.

Taking all these factors into account, WSC have decided to proceed with MLE bioreactors that can be operationally converted to FSB as the TN targets tighten over time. This is a low risk strategy.

In summary, the 50%ile TN targets trigger the following technologies. The trigger numbers depend on catchment conditions and sewage characteristics, with the following numbers being conservative:

- > 7 mg/L – Intermittent or MLE style continuous bioreactors.
- 5 to 7 mg/L – The above plus carbon dosing.
- 3 to 5 mg/L – FSB bioreactors with carbon dosing (design case).
- < 3.0 mg/L – The above plus post denitrification bioreactors with a second point of carbon dosing.

3.3.2 Recycled Water Performance

Recycled water (reclaimed effluent) will be used extensively on the STP site. Because it is used on site, it does not fall under the recycled water regulations.

Off-site recycled water is a future objective. This section discusses (in broad terms) the recycled water applications that the Bowral STP could supply, and what controls and/or additional treatment processes may be required. This is based on The Australian Guidelines for Water Recycling (AGWR) published in 2006.

It should be noted that recycled water applications may require specific risk assessments to be undertaken to determine appropriate treatment and management practices. This section is intended as a guide only.

The AGWR aligns recycled water applications with log reduction values (LRVs) associated with treatment processes and controls at the application site. The key tables in the AGWR are Table 3-4 (treatment processes), Table 3-5 (other controls) and Table 3-7 (recycled water applications).

The currently proposed STP processes, and relatively low cost add-on processes are summarised in Table 3-12. It should be noted that the LRVs for filtration assume that flocculation (alum dosing to filters) is employed. Claiming LRVs for these processes also require monitoring elements and alarms in addition to those currently included within the design.

Table 3-12 Process Unit LRVs

Effluent Quality Parameter	Bacteria	Viruses	Protozoa
Secondary Treatment	1.0	0.5	0.5
Tertiary Filtration	0.0	0.5	1.0
UV Disinfection	4.0(2)	0.0(1)	0.0(1)
Total for Proposed Processes	**5.0**	**1.0**	**1.5**
More Intense UV Disinfection	0.0(2)	1.0	3.0
Chlorination	4.0	4.0	0.0
Total with Additional Processes	**9.0**	**6.0**	**4.5**

Note (1) - The actual LRVs for the viruses and protozoa could be greater if UV suppliers are asked to provide them.

Note (2) – No more than 4.0 LRV can be claimed for any one process unit type.

The LRVs required for various recycled water applications are summarised in Table 3-13.

Table 3-13 Summary of Recycled Water Applications and Required LRVs

Effluent Quality Parameter	Bacteria	Viruses	Protozoa
Commercial Crops	5.0	6.1	4.8
Residential Garden Irrigation	4.6	5.8	4.4
Internal Uses (e.g. Toilet Flushing)	4.8	6.1	4.7
All Residential Uses	5.1	6.3	4.9
Municipal Irrigation	4.0	5.2	3.7
Fire Fighting	5.3	6.5	5.1

It can be seen that the effluent from the STP, as designed, falls short of any recycled water application listed. This can be resolved through additional treatment of the recycled water side-stream or management (control) practices at the re-use site.

Adding more intense UV treatment plus chlorination (including a chlorine contact tank) could make the effluent suitable for:

- Municipal irrigation
- Residential garden irrigation.

A more intense UV system that has been pre-validated for higher LRVs for viruses and protozoa could open up even more recycled water applications.

LRV credits are also available for management practices at the recycled water sites. These must be guaranteed through contracts or if WSC owns and manages the properties where recycled water is applied. These management practices and the associated LRVs are:

- Restrict public access during irrigation – 2.0 LRV
- No access after irrigation until dry (1 to 4 hours) – 1.0 LRV
- Minimum of 30 m buffer zone to nearest point of public access – 1.0 LRV
- Spray drift control – 1.0 LRV

These apply to all pathogens. Therefore, if all these controls are applied then an additional 5 LRV could be added to the LRVs resulting from processes at the STP. These controls alone would permit municipal irrigation without any additional treatment processes at the STP.

It is worth noting that dual media filters provide effective helminth removal if recycled water is to be applied to pastures grazed by livestock.

3.3.3 Biosolids Performance

3.3.3.1 Biosolids Stabilisation

It is common to design modern STPs that allow biosolids re-use as an alternative disposal option. This can prove considerably cheaper than landfill disposal or reprocessing. This could be especially the case for the Southern Highlands as one of the common uses of biosolids is forestry. There are extensive pine forests in the Southern Highlands region. However, biosolids re-use in these forests is currently prohibited as they are located within Sydney's drinking water catchment.

Grade B biosolids stabilisation criteria have been adopted as outlined within the *NSW EPA Environmental Guidelines: Use and Disposal of Biosolids Products*. Grade B will provide a wide range of beneficial disposal options, including forestry.

Biosolids have historically been stabilised at Bowral through sludge lagoons. The CDR suggested a change to aerobic digestion. This has been adopted as part of the design as it removed the major cause of the current odour annoyance issues.

There are a number of biosolids stabilisation criteria that can be used to accredit biosolids as stabilisation Grade B. Those that could be applied to aerobic digestion are:

- Mass of volatile solids in the biosolids shall be reduced by a minimum of 38%.
- Aerobically digested biosolids which do not meet requirement above must have no more than 15% further volatile solids reduction when incubated under aerobic conditions in a bench scale reactor for an additional 30 days at 20°C (typically used for extended aeration processes).
- Specific Oxygen Uptake Rate for biosolids treated by an aerobic process shall be less than 1.5 mg O_2/hour/g total solids at 20°C.

Only one of these three criteria need to be met.

3.3.3.2 Biosolids Dewatering

There were no biosolids dewatering criteria in the brief or the CDR. The CDR covered a range of mechanical thickening and dewatering technologies including the following.

Thickening:

- Screw Thickener
- Gravity Drainage Deck

Dewatering:

- Volute Dehydrator
- Screw Press
- Belt Filter Press
- Centrifuge

A Volute Dehydrator was recommended, but no final decision was made. WSC have since selected screw presses as their preferred dewatering technology (see Appendix B for further information)

The criteria used to size the different dewatering technologies was not explained in the CDR. At the inception meeting, WSC stated that they were comfortable with dewatering occurring during unmanned hours. This greatly reduces the size of the dewatering system components. The following operating criteria is suggested for sizing the dewatering process units.

- Start 10 am Mondays
- Stop 2 pm Fridays
- Normal operating period = 100 hours per week (4 days and 4 hours)
- Longest operating pause = 126 hours per week (5 days and 6 hours)

The long operating pause time can be used to catch up on dewatering after maintenance, etc. It will also allow for maintenance to be undertaken.

Other criteria include:

- A biosolids solids content of > 14%. 18% is the target for screw presses.
- A solids recovery of > 90%. 95% is the target for screw presses.
- A polymer use of < 10 kg/DST (dry solids tonne). 5 kg/DST is the target for screw presses.

Given WSC's acceptance for unsupervised operation, reliability and automated control is also be important criteria.

3.3.4 Reactor Temperatures

The reactor temperature range, particularly the winter temperature, is critical to process design. The temperature of the Bowral STP bioreactors has not historically been measured.

Hunter H_2O used its experience from similar STPs to select a minimum temperature. By way of comparison, Cooma STP has a minimum temperature of around 11 ^oC and Orange STP around 12 ^oC. These cities are subjected to periodic snowfalls. Western Sydney STPs typically have a minimum temperature of 13 ^oC, Sydney coastal plants 15 ^oC and South Coast plants 14 ^oC.

A minimum temperature of 12 ^oC has been adopted. This provides greater nitrification conservatism than that proposed in the CDR. If the temperature falls to 12 ^oC, then the sludge age of the IDEAs in the CDR would need to increase from 25 days to 30 days, increasing the size of the bioreactors. A continuous flow bioreactor would require a reduced sludge age due to the lower unaerated mass fraction. Adopting a minimum temperature of 12 ^oC allows a sludge age of 23 days for the FSB configuration or 18 days for the MLE configuration. These are equivalent to a 30 day sludge age for an IDEA.

WSC conducted bioreactor temperature testing at Moss Vale STP as the process design was progressing. This consisted of temperature readings every hour from the 13^{th} May 2020 until the 8^{th} September 2020. This would likely cover the coldest period for Moss Vale STP. The results were found to be as follows:

- Minimum average over a day = 10.3 ^oC.
- Minimum 7 day average = 11.2 ^oC.
- Minimum 14 day average = 11.8 ^oC.
- Minimum 21 day average = 11.6 ^oC.

The 14 day to 21 day average is the most relevant as it is the temperature over a sludge age (18 to 23 days) that is limiting. The data suggests that the 12 ^oC assumption appears valid. It should be noted that some scientific papers suggest that the default nitrification kinetics in the literature may include some conservatism. Therefore, the selection of 12 ^oC as the basis for sludge age calculations may already include conservatism. Selecting a temperature of 11 ^oC would increase the bioreactor size markedly and would likely be overly conservative.

The annual average and maximum summer temperature have been estimated based on experience.

- Minimum Sustained Temperature (>2 weeks) = 12 ^oC.
- Annual average Temperature = 20 ^oC.
- Maximum Summer Temperature = 28 ^oC.

3.3.5 Odours

The following high odour generation process units will be decommissioned.

- Sludge lagoons.
- Sludge drying beds.
- Geobags.

The new process units that replace these (aerobic digester and mechanical dewatering) will produce far less odours. This is because the biosolids will remain aerobic and therefore not generate highly malodourous compounds such as hydrogen sulphide and mercaptans. Allowance has also been made to cover the inlet works and lift pump station, with foul air vented to a new odour treatment system. The new STP at Bowral will generate less odours than the current STP.

No specific quantitative odour criteria have been set at this stage. The odour profile associated with the concept design was assessed by SLR in August 2019. The amended design does not include additional processes or increase the surface areas of any infrastructure when compared to the CDR. The determined theoretical odour contours should be a conservative representative of the final treatment plant.

It is worth noting that the STP licence does not quantify odour emission criteria. However, Clause L7 states that "No condition in this licence identifies a potentially offensive odour for the purposes of section 129 of the Protection of the Environment Operations Act 1997". The clause notes that "Section 129 of the Protection of the Environment Operations Act 1997 provides that the licensee must not cause or permit the emission of any offensive odour from the premises but provides a defence if the emission is identified in the relevant environment protection licence as a potentially offensive odour and the odour was emitted in accordance with the conditions of a licence directed at minimising odour".

3.3.6 Noise

The technology solutions proposed will generate some additional noise compared to the existing technology. This is purely a result of the additional drives and processes required. This noise will be mitigated by acoustic enclosures, housing equipment within buildings and screening. The exception will be the surface aerators on the aerobic digester (existing), which are difficult to screen.

It should be noted that the STP licence makes no reference to noise generated from site.

3.4 Manning, Response and Redundancy

The Bowral STP operators are expected to be on site each weekday during normal working hours. The greatest time of non-attendance is assumed to be 4 days (Easter and Christmas).

The design includes remote monitoring and alarm generation. The criticality of alarms have been set in the control system (at least three levels) with the most critical alarms resulting in remote notifications (e.g. text messages). Remote control will also be possible through telemetry.

The response time to critical alarms is assumed to be 1 hour from the time an alarm is generated to the time the operator arrives at site. Problem rectification is assumed to be 4 hours.

Non-critical equipment items (those that can be out of service for more than a day) need not have installed standby. However, a standby unit will generally be provided in store, unless it is a high cost item (e.g. dewatering unit) and there is a workaround (suspend wasting)

Critical equipment items (those that must operate within 4 hours to sustain performance) include an installed standby.

3.5 Sustainability

The new STP has been designed with sustainability in mind. This includes minimising energy consumption, re-use of treatment products and minimising greenhouse gas emissions. Some of the more significant sustainability measures are summarised below.

<u>Energy</u>

- Diffused aeration is adopted for the bioreactors. This is more energy efficient than surface aeration.
- The depth of the bioreactors has been selected to optimise diffused aeration efficiency.
- The automated control techniques on the aeration system further minimise power consumption.
- Most of the larger pumping systems include large turndown to optimise energy consumption.
- The UV system includes a large turndown, plus instruments and controls aimed at minimising energy.
- The dewatering technology selected draws less energy than rival technologies.
- Consideration is given to providing solar arrays to partially or fully offset the STP energy demand.

Re-Use

- The biosolids will be stabilised to make them suitable for a range of re-use applications.
- Reclaimed (re-use) effluent is used throughout the plant, offsetting potable water consumption.
- The design allows for the simple retrofit of processes to facilitate future off site recycled water.

Greenhouse Gas Emissions

- Energy minimisation as described above.
- There will no longer be anaerobic processes, eliminating methane production.
- Denitrification controls on the bioreactors should minimise the production of nitrous oxide.

3.6 Capacity Staging

The majority of the process units will be constructed in a single stage, sized for the ultimate load of 21,000 EP. The commissioning load of nearly 16,000 EP is over 75% of the ultimate load. Therefore, there are no practical opportunities for capacity staging.

Staging will centre on performance, particularly any additional items necessary to meet tightening licence limits or NorBE requirements. These include:

- Carbon dosing to the bioreactors.
- Off-site recycled water treatment and delivery.
- A second dewatering train.

The carbon dosing system will be sized for worst case requirements. Provisional footprint has been provided for this system and the bioreactors are designed to accommodate the additional sludge production resulting from carbon dosing in the future.

The off-site recycled water system has not been sized as part of the detailed design. However, the layout is be of their possible future inclusion.

The facilities have been designed to accommodate the second dewatering train, including footprint, connections and increased recycling flows (reclaimed effluent, filtrate, foul water, etc).

Construction staging has been considered separately (see Section 0) to allow new assets to be delivered with minimal impact on the operating plant (i.e. minimise non-compliance risks).

The lower load at commissioning should be readily accommodated within the turndown provisions of the process units within the plant. The STP should perform well as soon as it is optimised during commissioning.

4 Process Configuration and Modelling

4.1 Preferred Option

The FSB concept to be taken to detailed design consists of the following.

- An augmented inlet sewage main.
- A new inlet works consisting of:
  - Two mechanical band screens (duty/duty) each sized for 13 ADWF.
  - A bypass channel fitted with a manual screen sized for 13 ADWF.
  - Appropriate screen washing and dewatering.
  - Screened sewage flow monitoring.
  - An overflow to the new storm detention pond No 1 (SDP1) for flows above 7.5 ADWF.
  - A single vortex style grit tank sized for 7.5 ADWF.
  - A grit sparge and extraction system (pumped).
  - A single fluidised bed classifier for grit washing and dewatering.
- A new lift pump station consisting of:
  - A new wet well.
  - Three influent pumps in duty/assist/standby configuration, each sized for 1.5 ADWF. These can be operated as duty/assist/assist under the Modified Ludzak Ettinger (MLE) configuration.
  - Two bypass (solids contact) pumps in duty/assist configuration, each sized for 1.5 ADWF.
- Odour control system servicing the inlet works and inlet lift pump station, likely including extraction fans, a biofilter and an activated carbon filter.
- A new storm detention pond (SDP1) located at the site of the current Pasveers, consisting of;
  - An inlet receiving overflows from the screened sewage channel upstream of the grit tank.
  - Two storm return pumps in duty/assist configuration. Each return pump is sized for 1.5 ADWF.
  - A return rising main to the screened sewage channel.
  - An overflow to SDP2.
- The existing storm detention pond (SDP2) consisting of:
  - The existing return pump wet well with hydraulic connection to SDP2.
  - Replacement storm return pumps (duty/assist) each sized for 1.5 ADWF.
  - Modifications to the existing return rising main to the screened sewage channel.
  - New overflow pipework directing excess flows to overflow of the existing Emergency Storage Tank.
- A new bioreactor splitter box consisting of:
  - A bioreactor feed splitter, accepting influent from the lift pump station plus foul water from the FWPS. The feed splitter splits this mixture between the two bioreactors.
  - A Mixed Liquor (ML) splitter accepting ML from the two bioreactors and splitting it to the two clarifiers. A high level switch inhibits the lift pump station (PS) should one clarifier be taken out of service without the maximum flow being reduced.
  - A second (optional) alum dosing point to the ML splitter.
  - A solids contact splitter box splitting the bypass flow between the two clarifiers. It mixes with the ML, providing solids contact, before gravitating to each clarifier.
  - An alum dosing point to the common ML gravity main to the ML splitter. Mixing will occur in this gravity main, the ML splitter box and the ML gravity mains to the clarifiers.
  - A return activated sludge (RAS) splitter accepting flows from the two RAS pump stations and splitting it to the two bioreactors. This mixes with the feed before gravitating to each bioreactor.
  - An emergency overflow (alarmed) of RAS and feed directly to the bypass splitter and on to the clarifiers if one bioreactor is out of service and the operator has not capped the feed flow.
- Two (2) new bioreactors designed as FSB but able to be operated as MLE. Each bioreactor is designed at accept 1.5 ADWF (FSB mode) or 2.25 ADWF (MLE mode). Each of the bioreactors includes the following:
  - A selector zone fed with dosed feed and RAS, complete with a mixer (duty only).
  - A primary anoxic zone accepting flows from the selector and the MLR. This zone includes three mixers (duty/duty/duty) and an Oxygen Reduction Potential (ORP) element.
  - Provision for a future carbon dosing point to the primary anoxic zone.

- A primary aerobic zone that accepts flows from the primary anoxic zone. This zone includes removable aeration diffuser grids, two dissolved oxygen (DO) elements and two aeration control valves.
- An alkalinity dosing point to the primary aeration zone. This zone will also contain a combined temperature and pH element.
- A secondary anoxic zone that accepts flows from the primary aerobic zone. This can be aerated (MLE) or mixed (FSB). It will include two mixers (duty/duty) plus removable aeration grids.
- Provision for a future carbon dosing point to the secondary anoxic zone.
- A secondary aerobic zone that accepts flows from the secondary anoxic zone. This zone will include a removable aeration grid plus a DO element and an aeration control valve (which also controls air to the secondary anoxic zone when aerated).
- A de-aeration zone that accepts flows from the primary aerobic zone (FSB) or secondary aerobic zone (MLE). Stop boards are used to select the flow path. This zone is fitted with a mixer (duty only) but should remain aerobic under most conditions.
- Three (3) MLR pumps in duty/assist/assist configuration pumping ML from the de-aeration zone to the primary anoxic zone.
- A ML outlet weir from the secondary aerobic zone to the ML splitter

▪ A new bioreactor aeration supply system consisting of:
  - Three blowers in duty/assist/standby configuration.
  - Acoustic enclosures for each blower.
  - A new blower building with ventilated cooling.

▪ Two new secondary clarifiers each sized for up to 3 ADWF (FSB mode) or 3.75 ADWF (MLE mode). Each clarifier consists of:
  - ML feed pipes.
  - An energy dissipating inlet (EDI) and feed / flocculation well.
  - A rotating sludge and scum scraper with peripheral drive.
  - Self-flushing scum boxes intermittently delivering scum to the scum pump station.
  - Out board effluent launders.
  - Stamford baffles to deflect any momentum currents away from the effluent weirs.
  - An effluent pipe to the filter feed pump station (via a common main)
  - Two RAS pumps in duty/standby configuration. These extract RAS from the central floor of the clarifier and deliver to a common rising main to the RAS splitter. The RAS flow from each clarifier is individually monitored and controlled to ensure a perfect RAS split.

▪ A new scum pump station, with a single scum pump (duty only) accepting scum from the two clarifiers and delivering it to the aerobic digester or bioreactors (via the lift pump station).

▪ A new filter feed pump station consisting of:
  - Three filter feed pumps in duty/assist/standby configuration delivering flows up to 3 ADWF to the tertiary filters.
  - An overflow from the filter feed pump station to the Emergency Storage Tank (EST).
  - An optional return pipe from the EST.

▪ An emergency storage tank (EST) consisting off;
  - The existing catch/balance pond to store overflows from the filter feed pump station (typically flows in excess of 3 ADWF and below 7.5 ADWF).
  - Benching and a sump to allow the EST it to be fully drained between events.
  - A new emergency return pump station with a single return pump (duty only) sized for 1.5 ADWF.
  - An existing overflow to the existing effluent lagoon.
  - A rising main returning stored effluent to the inlet works or back to the filter feed pump station.

▪ Tertiary filters consisting of:
  - A new rising main from the filter feed pump station.
  - A new feed splitter including a filter bypass and 2 pre flocculation tanks. The filter bypass can be directed to the EST or the UV facility.
  - Two vertical shaft flocculation mixers within the flocculation tanks (1 per tank)
  - An alum dosing point to the flocculation tank.
  - Four deep bed, dual media filter cells.
  - An air scours system including duty/standby blowers (housed in a separate blower building)
  - A clean backwash tank and duty/standby pumps.
  - A return main from the clean backwash tank to the filter cells.
  - A dirty backwash tank and duty/standby pumps.

  - An overflow from the dirty backwash tank to the EST.
  - A new dirty backwash rising main from the dirty backwash tank to the FWPS.
- A new UV system to replace the existing UV system. This consists of:
  - A UV receival pit with UV transmissivity analyser and a high level switch. The high level switch inhibits the filter feed pumps if the receival pit is in danger of overflowing.
  - A UV transmissivity element.
  - Three in-channel UV banks in duty/assist/assist configuration (including space for a future bank).
  - A modulating effluent penstock for level control.
  - A manual UV channel bypass.
- An upgraded reclaimed effluent (RE) system consisting of:
  - Relocation of the RE lift pump (duty only) to downstream of the new UV system.
  - The existing RE storage tank with backup potable water supply.
  - A replacement, amplified RE pumping system (proprietary) to service the increased RE pressure and flow requirements (particularly dewatering).
  - A chlorine dosing point to the RE tank feed line.
  - A separate storm clean pump (duty only) proving high flow, high pressure disinfected effluent for wash down of the SPDs. This does not pass through the RE tank and does not receive chlorination.
- A new WAS pumping and thickening system consisting of:
  - A new WAS pumping system with a duty only WAS pump drawing from the ML splitter or the RAS splitter. This delivers WAS to the thickener or thickener bypass directly to the aerobic digester.
  - A picket fence style gravity thickener with centre drive and scraper.
  - A supernatant gravity line from the thickener to the FWPS.
  - A duty only Thickened WAS (TWAS) pump, drawing TWAS from the centre well of the thickener and pumping it to the digester at a known thickness.
- An aerobic digester consisting of:
  - New TWAS and scum feed pipes to join the existing feed manifold at one end of the digester.
  - A bypass line to divert TWAS (or WAS) plus scum around the digester to the dewatering feed tank or to the existing sludge lagoons.
  - The existing IDEA bioreactor.
  - The existing IDEA surface aerators in duty/duty/duty/duty configuration. Aeration should be adequate with one or even two aerators out of service.
  - Overflow pipework, delivering flow to the EST
  - Retention of existing instrumentation.
  - Relocation of the existing WAS pump to act as the new Digested WAS (DWAS) pump. DWAS is pumped from the digester during dewatering periods, but only while the digester is aerating.
- A new mechanical dewatering facility consisting of a single dewatering train at commissioning, but designed to accommodate a second dewatering train operating in parallel in the future. Consisting of:
  - A new dewatering feed tank, complete with mixer/aerator
  - A polymer make-up, storage, dosing and dilution system. Dosing pumps in duty/duty configuration (duty/standby at commissioning).
  - Dewatering feed pumps in duty/duty configuration (duty/standby at commissioning).
  - A polymer dosing point to each feed line.
  - Two screw press dewatering units in duty/duty configuration (duty only at commissioning). Dewatering can be accommodated with the use of only one unit by extending the dewatering period each week.
  - A filtrate collection system delivering filtrate to the FWPS.
  - A duty only, horizontal, biosolids cross-conveyor.
  - A slewing, inclined biosolids conveyor delivering biosolids to a truck trailer (default).
  - A building including acoustic insulation and ventilation.
  - A bunded truck trailer hard stand.
  - An awning over the truck trailer hard stand.
- The existing biosolids hardstand as a backup or if truck movements are temporarily halted.
- Retain at least one sludge lagoon as emergency liquid sludge storage.
- A foul water pump station (FWPS) consisting of:
  - A new pump station wet well.
  - Two new foul water pumps (duty/standby).
  - A new filter backwash main connection.

- A new thickener supernatant connection.
    - A new dewatering filtrate connection.
    - Contaminated stormwater and washwater connections from various hardstands.
    - A new foul water main to the bioreactor feed splitter.
    - A stormwater overflow to the EST.
- An alkalinity storage and dosing system consisting of:
    - New alkalinity storage tanks, cross connected and used for alkalinity storage (based on 25% sodium hydroxide).
    - Two new alkalinity dosing pumps (duty/duty), one dosing to the primary aerobic zone of each bioreactor.
    - The existing unloading and bunded storage areas.
- A new alum storage and dosing facility consisting of:
    - Two new alum storage tanks.
    - Two new (duty/standby) alum dosing pumps to dose to the bioreactor feed splitter (via the influent rising main).
    - Two new (duty/standby) alum dosing pumps dosing to the ML splitter box (via the common ML gravity main) or the filter feed.
    - A new storage bund and tanker delivery area.
- A new chlorine storage and dosing facility consisting of:
    - Intermediate bulk container (IBC) storage (duty/standby).
    - A new chlorine dosing pump (duty only), dosing to the feed to the existing RE storage tank.
- Site provision for future carbon storage and dosing (sucrose solution used for sizing).
- Site provision for future recycled water treatment system.

A process flow diagram of the proposed Bowral STP can be found in Appendix C.

Process & Instrumentation Diagrams can be found in Appendix E.

4.2 Process Model

A whole plant process model was developed by ASpect to mimic the proposed processes at Bowral STP. The model used was **H_2O_{ptions}**, a detailed steady state modelling package developed in-house by ASpect.

The modelling assumptions adopted were:

- The process flow is as detailed in Appendix C
- The sewage characterisation is as developed in Section 3.2 and detailed in Appendix A
- Default steady state kinetics as published in *Biological Wastewater Treatment*, published by IWA.
- Other sizing criteria as published in the tables in Section 5.
- Facility sizing as summarised in the tables in Section 5.

A process flow and mass balance diagram are provided in Appendix D. This corresponds to future loading (21,000 EP) at Bowral STP under worst case winter temperature conditions, including carbon dosing.

4.3 Modelling Scenarios

Two loading scenarios were modelled for Bowral STP:

1. Current – The loading at commissioning in 2022 (15,822 EP) with one dewatering train.
2. Future – The future, ultimate, design loading (21,000) with two dewatering trains.

Three seasonal scenarios were also modelled.

1. Winter (12 °C)
2. Typical (20 °C)
3. Summer (28 °C)

Two facility scenarios were also modelled. These reflect the following scenarios.

1. FSB – This is the STP operating to meet long term NorBE requirements (lower TN). The plant is operated in FSB mode with the secondary anoxic zone mixed but not aerated. This creates a second

anoxic zone and second aerobic zone. The DFTF is 3 ADWF and the DSTF is 6 ADWF. When carbon is dosed to the second anoxic zone, a TN well below 4 mg/L can be achieved year round.

2. MLE – This is the STP operating with TN limits less stringent than the long term NorBE limits. The plant is operated in MLE mode with the secondary anoxic zone aerated. This creates a single larger primary aerobic zone. The increase in aerobic fraction, allowing the sludge age and MLSS to be reduced. This reduction in MLSS results in faster clarifier settling, so the DFTF increases from 3 ADWF to 4.5 ADWF and the DSTF increases from 6 ADWF to 7.5 ADWF. When carbon is added to the primary anoxic zone an effluent TN of 4 mg/L is possible for most of the year, increasing to 6 mg/L over winter.

Therefore, there were a total of twelve (12) scenarios modelled. The results of each model run were stored in a data cube. This data cube was then interrogated to determine the worst case sizing for each process unit. In most cases, sizing was dictated by the Future, MLE, Winter scenario. Exceptions are noted in Section 5.

A process flow and mass balance diagram for Bowral STP under Future, MLE, Winter conditions can be found in Appendix D.

5 Process Unit Design and Sizing

Presented below is an overview of the design and sizing for each process unit. The presented control philosophy represents a summary only and full functionality is detailed within the Functional Specification.

5.1 Odour Control

5.1.1 Purpose

The purpose of the odour control system is:

- To draw air through the covered inlet works and inlet lift pumping station to prevent corrosion.
- To remove malodours (particularly hydrogen sulphide) from the inlet works.

5.1.2 Equipment and Instruments

The odour control system will be a performance based supplier package. The exact equipment and instrumentation are not known. The following is a guide only for the purpose of accommodating the final configuration within the civil and electrical designs.

- Two (2) variable speed fan drives in duty/standby configuration.
- Two (2) variable speed pump drives (e.g. nutrient dosing, recirculation).
- Eight (8) analogue elements (e.g. flow, pressure, H_2S, pH, etc).
- Twelve (12) digital switches (e.g. flow, differential pressure, proximity, level, etc).

5.1.3 Description

The odour control system will be a performance based supplier package. The following is a general description based on similar proprietary systems.

Air is drawn from various covered units and channels in the inlet works. These include:

- The sewage receival channel upstream of the screens.
- Each screen enclosure (2 off).
- The screen outlet channel.
- The screened sewage channel.
- The grit tank inlet channel.
- The grit tank.
- The grit outlet channel.
- The grit classifier enclosure.
- The lift pump station (2 off).

Air is drawn from these areas and through the odour control system using fans. These are typically on the discharge side of the odour control facility to maintain a negative pressure (prevent foul air escaping) and to protect the fans from entrained solids / fats and oils / low pH's etc.

The odour control facility is likely to consist of some form of biofilter followed by an activated carbon filter. The biofilter will contain media for the biomass to grow on. The biomass is kept moist with the use of recycled effluent and supported with nutrient dosing. The biomass will remove the majority of hydrogen sulphide through synthesis. Biomass will slough from the media and return with the foul water to the bioreactor for treatment.

Air treated through the biofilter will then pass through an activated carbon filter. This removes residual hydrogen sulphide as well as other odourous compounds (e.g. mercaptans). The media within the activated carbon filter will require periodic replacement. The clean air will then pass through the fans and a stack for disposal to atmosphere. Any water (mainly RE) passes back to the inlet works ahead of the screens.

5.1.4 Design Assumptions

The following assumptions have been adopted for the process design. Only the assumptions that impact on the remainder of the plant have been included.

- The maximum odour control RE flow is as outlined by equipment suppliers.
- The maximum odour control RE flow is assumed to be continuous.
- The organic and solids loading on the plant is assumed to be negligible.

See Table 5-1 for details.

5.1.5 Turndown and Redundancy

There will be duty/standby odour fans. The failure of a fan will not impact on odour control performance.

The fan size is based on air changes (covered inlet works volume) rather than sewage flow. There is little need for turndown. Once the flow rate is set, the fans are intended to operator continuously.

It will be possible to bypass either the biofilter or the activated carbon filter if required for maintenance.

Pumps utilised within the odour control system a small and generic and can be readily replaced. The system will continue to operate for some time (days) before performance is impacted.

5.1.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-1. Only the parameters that impact on the process sizing of the remainder of the STP are included.

Table 5-1 Odour Control Process Sizing

	Units	Process Design Assumptions	Process Design Sizing
Max Odour Control RE	L/s	0.2	
Odour Control RE Operation	h/d	24.0	
Maximum Odour Control RE	ML/d		0.018
Adopted Flow Rate	Nm^3/h	15 air changes / hour	5,500
Anticipated Fan Size (each)	kW		5.5

The maximum odour control spray (L/s) should be imposed as a condition of contract as it effects the size of downstream units (bioreactors, UV units, etc). The screen spray duration does not affect sizes, merely operating costs (e.g. pumping power).

5.1.7 Control Philosophy

The control philosophy of the odour control system will be provided by the supplier.

5.2 Screening

5.2.1 Purpose

The purpose of the screening system is:

- To monitor sewage flow and volume.
- To provide a rolling average sewage flow for the control of various process units in the STP.
- To remove gross solids from the sewage to:
  - Protect downstream pipes from blockage.
  - Protect downstream equipment from failure.
  - Improve the quality of biosolids.

- Prevent the discharge of gross, non-biodegradable solids.
- To wash the collected screenings to:
  - Return biodegradable food to the treatment process to assist TN removal.
  - Reduce the propensity for odour generation from stored screenings.
- To dewater the collected screenings to reduce their mass and disposal cost.
- To shed flow in excess of DSTF to the storm detention ponds.

5.2.2 Equipment and Instruments

The screening system consists of the following mechanical equipment and instruments.

- One (1) sewage flow element (level and velocity elements) on the sewage gravity main.
- One (1) flow element on the sewage rising main.
- One (1) level element upstream of the screens.
- One (1) level switch upstream of the screens.
- One (1) level switch in the bypass screen channel.
- Two (2) variable speed, reversible band screens (duty/standby).
- One (1) Low pressure switch on the RE supply line.
- Two (2) spray water solenoid valves, one for each screen.
- Two (2) spray water flow switches, one for each screen.
- One (1) screenings sluice solenoid valve.
- One (1) screenings sluice flow switch.
- One (1) screening bypass chute proximity switch (closed).
- One (1) fixed speed, reversible, washpactor impellor.
- One (1) torque switch for the washpactor impellor.
- One (1) fixed speed, reversible, screenings washpactor screw.
- One (1) torque switch for the screenings washpactor screw.
- One (1) level element for the screenings washpactor.
- Two (2) washwater solenoid valves for the screenings washpactor.
- One (1) flow switch for the washpactor washwater.
- One (1) actuated valve for the washpactor drain.
- Two (2) proximity switches (open and closed) for the washpactor drain valve.
- One (1) level element downstream of the screens, doubling as a sewage flow element.
- One (1) level element downstream of the screens, doubling as a grit feed flow element and overflow flow element.
- One (1) sewage overflow high level switch.

There is also a proximity switch on the access hatch to each screen (2 off). This is a field interlock to the screen drive (fail and latch drive if not closed) and is not connected to the SCADA.

5.2.3 Description

Sewage from the Bowral catchment is delivered to Bowral STP through a single gravity main. Sewage pump stations in the Bowral sewerage system deliver to this gravity main. Therefore, flow can be highly variable over short periods. The process units (lift pump station, bioreactors, clarifiers and filter feed pump station) tend to attenuate these variable flows, smoothing them as they pass through the plant. The inlet works is sized to treat the estimated PWWF (13 ADWF) that could be delivered to the STP.

WSC have a strong desire to gravity feed through the inlet works. This, combined with a new storm detention pond, creates significant headloss restrictions through the inlet works. This has required hydraulic design ingenuity and a few compromises. One of these is that there is no opportunity to provide an accurate, magnetic flow element on the sewage main. Incoming flow is measured by a level / velocity flow element within the final manhole before sewage enters the receival chamber.

The screened sewage flow is monitored continuously with the use of a sewage flow element between the screens and the grit tank. This flow element consists of a flume, a level element and a flume equation. This is not as accurate as a magnetic flow element.

This flume also acts as the screen tail-water hydraulic control for the screens during high flow (when the capacity of the lift pump station is exceeded). The intentional partial drowning of this flume during high flows (see the discussion on sewage overflows) means that the flow readings will be inaccurate at such times.

However, this flume does provide a reasonable indicator of sewage flow most of the time. A rolling average is applied to the sewage flow in order to smooth short term flow variability. This rolling average is used the return pumping systems (two in the storm retention system and one for emergency effluent storage) for control of the return pump flows. This only occurs during low flow periods when the flume is not drowned out. The relatively inaccurate sewage flow element is suitable for this purpose. Other more accurate flow measurements are used for the control of more sensitive process units. The level over the overflow weir is used to approximate overflow flow and volume. The difference between the gravity main flow meter and the measurements on the flow meters from one the pumped lines to the bioreactor provide an indication of bypass flow directed to the storm ponds.

The grit feed flow and overflow flow are added to produce a calculated screened sewage flow and volume. The two sewage flows upstream of the screens are also added to produce a calculated sewage flow. Neither are particularly accurate. The screened sewage flow should be more accurate for flows up to 7.5 ADWF, before the flume is drowned. The sewage flow should be more accurate for flows above 7.5 ADWF.

There are two band screens in duty/duty configuration, each sized for PWWF. Under normal circumstances, each operates in parallel, but one can be taken out of service for maintenance without compromising the screening of PWWF. The band screens have 5 mm perforations. This 5 mm two dimensional perforation provide superior screening compared with the 5 mm; one dimensional step screen slots proposed in the CDR. Therefore, screening performance should be superior.

Flow enters the centre of the band and flows outward through the screens. The screen motion is triggered by timer or high upstream level, whichever occurs first. If both screens are in service, then they typically operate in a lead/lag configuration, with only one screen operating at a time. Under high level conditions, both can operate continuously and concurrently. The bands rotate, lifting screenings up the inside of the screens. Washwater is used to wash the screenings from the screens and into a screenings sluice. More sluice water can be used (optional) to flush the screenings to the washpactor.

Each screen can be isolated with the use of upstream and downstream penstocks. If both screens are isolated, or if the screens blind due to failure, then the upstream level rises, an alarm is generated, and sewage overflows a screen bypass weir, through a manual screen and back to the downstream channel. If the manual screen blinds then it will overtop and also continue to the downstream channel. Overtopping of the manual screen is separately alarmed.

The screenings from the band screens are sluiced with water to the washpactor. Screenings are initially drained under gravity through a sieve in the washpactor. This drain water is returned to the sewage channel upstream of the screens. After a certain number of screen operating cycles, or based on washpactor level, the drain valves closes, water is added and an impellor is used to agitate and wash the screenings. A separate shaftless screw moves and compacts the screenings as they are washed. The cleaned and dewatered screenings are deposited into a screenings bin / trailer. The washpactor then rinses, drains and is ready to accept more screenings. Screenings can continue to be deposited into the washpactor during the washing.

If the washpactor fails, then screenings can be diverted via a manual chute to a perforated bin on the hardstand. An alarm is generated if this chute is open. The screenings hardstand drains to the sewage channel.

Reclaimed effluent (RE) is used for screenings extraction, sluicing and washing. These functions are controlled by solenoid valves. A flow switch on a rotameter alarms each RE flow. A lack of RE will result in screen and/or washpactor failure.

Screened sewage flows from the screening unit to the grit tank via a channel. This channel includes a level element, a flume and a sewage overflow weir. The flume acts as a hydraulic control on the tail-water of the screens, preventing high headloss across the screens and ensuring sufficient effective screening area during high flow events. It also provides sewage flow monitoring and limits the flow through to the grit chamber to PSTF. A separate high level switch alarms overflows. Screened sewage overflows a weir within the flume channel and gravitates to storm detention pond 1. The level over the weir provides an estimate of this overflow flow while it is occurring.

The height of the overflow weir upstream of the flume dictates that maximum flow that can pass through to the lift pump station. In the event of pump failure (or if operators elect not to run solids contact mode) sewage will back up through the grit tank and flood out the flume, causing additional flow over the bypass weir. The design intent is for 6 ADWF in FSB configuration or 7.5 ADWF in MLE configuration. Adjustable weir plates on the bypass weir accommodates this flexibility.

5.2.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The maximum screen feed flow is the sewage PWWF plus the maximum odour control RE flow.
- The overflow manual screen is designed for PWWF plus the maximum odour control RE flow.
- Each band screen is designed for PWWF plus the maximum odour control RE flow.
- Screenings dry mass production has been based on conservative, published capture rates.
- Screening wet mass and volume production is based on typical solids content and bulk density.
- Screening spray water, sluice water and wash water flow are based on supplier advice. Spray water use is assumed to be continuous under worst case conditions.
- Screening spray water, sluice water and wash water use under typical conditions is based on estimates.
- The maximum sewage overflow is assumed to be:
  - The sewage PWWF, plus
  - The maximum odour control RE flow, plus
  - The maximum screen RE flows.

See Table 5-2 for details.

5.2.5 Turndown and Redundancy

There are two mechanical screens (duty/standby). If a screen fails, then this has no impact on screening capacity. If both screens fail, then flow will automatically overflow the inlet chamber and pass through a manually raked screen. Screening will continue, but operator effort will increase. Effluent quality is not dependent on screening. This is a very high level of redundancy.

There is only one washpactor (duty only). It is possible to continue to use the washpactor if the impellor fails, the level element fails, or the drain valve fails open. If the washpactor screw fails, then washing and dewatering will cease. Wet screenings would be manually diverted to the hardstand or to a perforated bin. Screening can still continue, but additional manual handling would be required. The relatively low impact does not warrant a standby washpactor.

If the upstream level element fails, then screening continues based on timer. The high level switch will trigger continuous screen operation. Screening is not impacted.

The grit feed flow element (level element) can be used for return pumping control. But alternative control modes exist. There is no impact on any other operation.

Under automated control, the screens and washpactor will operate only when required. They will automatically operate less frequently when the flow and screening load is less. Therefore, power consumption should be reasonably proportional to flow.

5.2.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-2. Worst case sizing is for the Future loading scenario and does not vary with other scenarios.

Table 5-2 Screening System Process Sizing

	Units	Process Design Assumptions	Process Design Sizing
Number of Duty Screens		2	
Max Odour Control RE	L/s	0.2	
Odour Control RE Operation	h/d	24.0	
Max Screen Spray	L/s	10.0	
Screen Spray Operation	h/d	2.0	
Max Screen Wash	L/s	1.0	

	Units	Process Design Assumptions	Process Design Sizing
Screen Spray Operation	h/d	2.0	
Screen Capture Rate	dry kg/ML	10	
Screenings Solids Content	w/w	50%	
Screenings Bulk Density	kg/m^3	550	
Screenings Washpactors		1	
Screenings Storage Required	d	7	
Number of Screenings Bins / Trailers		1	
Max Flow per Screen Unit	L/s		695
Max Screen Bypass Flow	L/s		695
Max Screen RE	L/s		11.0
Screen RE Operation	h/d		2.0
Screen RE Use	L/d		79,200
Avg Screen Volume Captured	L/d		168
Avg Screen Mass Captured	wet kg/d		92
Screw Press Capacity Each	L/h		91
Screw Press Capacity Each	wet kg/h		50
Screen Bin / Trailer Volume Each	L		1,176

The maximum screen spray (L/s) should be imposed as a condition of contract as it effects the size of downstream units (bioreactors, UV units, etc). The screen spray duration does not affect sizes, merely operating costs (e.g. pumping power).

5.2.7 Control Philosophy

There is a sewage rising main flow element. There are also level and velocity elements in the inlet manhole on the sewage gravity main. Signals from the level and velocity elements are converted to a gravity sewage flow in the SCADA. The two sewage flows (rising main and gravity) are added to produce a sewage flow. The sewage flow calculation is suspended if any element fails. The integrated volume since midnight and for the previous day, for each sewage flow and the total, are also calculated and displayed.

The grit feed flow of is monitored continuously using a level element and a flume equation. The channel level and grit feed flow are recorded and displayed in real time. The integrated volume since midnight and for the previous day is also calculated and displayed. A rolling average is used to smooth the grit feed flow for the use of return pumping control (storm return and emergency effluent return). An alarm is generated if the rolling average grit feed flow exceeds a high level.

If the screened sewage level exceeds a high level or the high level switch is activated, then a sewage overflow alarm is generated, and overflow flow monitoring is enabled. The sewage overflow flow calculated in the SCADA is based on the level over the weir. This overflow flow is recorded and displayed in real time while ever the overflow level switch is activated. The integrated volume since midnight and for the previous day are also calculated and displayed.

The grit feed flow and sewage overflow flows are added in real time to produce a screened sewage flow. This screened sewage flow is recorded and displayed in real time. The integrated volume since midnight and for the previous day are also calculated and displayed. An alarm is generated if the difference between the sewage flow (sum of the two sewage flows) and screened sewage flow (sum of the grit feed flow and the sewage overflow flow) exceeds an alarm set point. The only one of these flows which is used for control is the grit feed flow. The rolling average grit feed flow is used for the control of a number of downstream facilities, including:

- The storm detention pond 1 return pumps.
- The storm detention pond 2 return pumps.
- The emergency storage return pumps.
- The grit extraction sequence.

If the grit feed flow (level) element fails, then the return pumps and grit extraction revert to timer control.

There are two screens in duty/duty configuration. The wash-water to each screen is fitted with a solenoid valve and flow switch. If the flow switch in the screen wash-water is not activated within a delay time after the solenoid opens, then an alarm is generated, and the screen is failed and latched. The screen access hatch is fitted with a closed proximity switch. The respective screen will stop and latch unless the hatch is fully closed. This is a field interlock. This switch is not connected to the SCADA. A drive alarm will also fail and latch the screen.

The speed of the screen and the direction can be manually adjusted by the operator.

There is a separate solenoid valve and flow switch on the screen sluice water. If the flow switch in the screen sluice water is not activated within a delay time after the solenoid opens, then an alarm is generated but the screening sequence continues as normal.

The level in the screen inlet chamber is monitored with a level element and high level switch. These are used for the control of the screens and alarming.

- Start level – Trigger a screen sequence in lead/lag mode.
- High level or level switch – Alarm and trigger a screen sequence in concurrent mode.

Once triggered, the screens will run until the sequence expires. If the trigger condition no longer applies, then the sequence ends. If the trigger condition still applies, then the sequence is repeated. The screen sequence can also be triggered by the operator or based on timer.

The upstream level element and switch alarms mechanical screen bypasses. A separate level switch alarms overtopping of the manual bypass screen.

There is a low pressure switch in the RE supply line to the screening system. An alarm is generated if low pressure is detected in the inlet works RE supply.

The screens are designed to operate concurrently. Once a screen sequence is triggered, the following occurs.

- The screen starts, the sluice water solenoid valve opens, the corresponding screen spray water solenoid valve opens and the run timer starts.
- When the run timer expires, the screen stops and the spray water run on timer starts.
- When the spray water run on timer expires, the screen spray water and sluice water solenoid valves close.

There is a closed proximity switch on the screenings bypass chute. An alarm is generated if the bypass chute is not closed.

There is a single screening washpactor. This includes a fixed speed, reversible impellor drive, a fixed speed, reversible screw drive, an actuated drain valve (with open and closed switches) and two washwater solenoid valves. There is also a level element.

If the drain valve fails to open or close within a time-out period, then it will attempt to open then fail and latch. If it does not open, then all drives will fail and latch. If it fails open then the washpactor will switch to Throughput mode.

The impellor drive is fitted with a torque switch. If the torque switch is triggered then the impellor dive will fail and latch and the washpactor will switch to Throughput mode.

The screw drive is fitted with a torque switch. If the torque switch is triggered, then it will reverse (timer) to attempt to free the blockage. If the toque switch is triggered again, or the screw drive fails, then all washpactor drives fail and latch.

There are two operating modes for the washpactor. These are:

- Normal mode – The washpactor operates in a washing and compacting sequence.

Normal Mode

The Normal mode sequence is triggered if:

- An operator adjustable number of screen cycles has completed, or
- A washpactor start level is exceeded, whichever occurs first.

Once triggered then the washpactor adopts three phases in sequence:

- Wash – The hopper fills, and impellor starts and the screw operates intermittently.
- Empty – The screw operates continuously; the drain valve opens and the hopper drains.
- Rinse – The wash-water continues to clean the hopper and screw.

Throughput Mode

The Throughput mode sequence is triggered if:

- The upstream screen level exceeds the high high level or high level switch (concurrent screen operation), or
    - A screen sequence starts, AND
    - The washpactor level element is failed, or
    - The washpactor impellor is failed, or
    - The drain valve is failed and is fully open.

Once triggered, a Throughput cycle sequence involves continuous screw and wash-water operation until the screen sequence ceases and a run on time has expired.

There is also a washpactor high level sequence that is aimed and clearing drain blockages. If this sequence does not result in the level falling then the washpactor fails.

5.3 Grit Removal

5.3.1 Purpose

The purpose of the grit removal system is:

- To remove dense, non-biodegradable and abrasive solids from the sewage to:
    - Protect downstream pipes from blockage.
    - Protect downstream equipment from wear and tear.
    - Prevent loss of effective tankage from the accumulation of grit.
- To wash the collected grit to:
    - Return biodegradable food to the treatment process to assist TN removal.
    - Reduce the propensity for odour generation from stored grit.
- To dewater the collected grit to reduce its mass and disposal cost.

5.3.2 Equipment and Instruments

The grit removal system consists of the following mechanical equipment and instruments.

- One (1) fixed speed, grit tank paddle mixer (duty only).
- One (1) grit tank sparge control valve.
- Two (2) proximity switches for the grit sparge valve (open and closed).
- One (1) flow switch for the grit sparge.
- One (1) fixed speed grit extraction pump.
- One (1) no flow switch for the grit extraction pump.
- One (1) closed switch on the grit washer access hatch
- One (1) fixed speed grit wash agitator.

- One (1) grit wash-water solenoid valve.
- One (1) flow switch for the grit wash-water.
- One (1) grit classifier pressure element.
- One (1) grit organics discharge control valve.
- Two (2) proximity switches on the grit organics discharge control valve (open and closed).
- One (1) variable speed, reversible grit classifier inclined screw (duty only).
- One (1) grit classifier screw torque switch.

The grit feed flow element can also be used for control of the grit system

5.3.3 Description

Screened sewage flows from the screening system to the grit tank via a concrete channel. Returns from the storm detention ponds and emergency storage tank are also directed to this channel. These have already been screened before entering the storages. They are therefore returned downstream of the screens and the grit feed flow element so as not to corrupt the grit feed flow measurements. This is critical as the grit feed flow is used to control these return flows.

A single, vortex type grit tank is used to separate grit from other solids. The grit falls to the bottom of the grit tank, where it is collected and stored. Lighter solids remain in suspension and pass through the grit tank. The grit paddle helps maintain the vortex and keep organics in suspension regardless of flow.

The grit tank paddle operates continuously to provide circular (vortex) flow. If the grit paddle fails, then an alarm is generated. The grit tank can be kept online, but organic separation will suffer. This is not a major issue because grit washing is later undertaken in the grit classifier. Stop boards can be used to manually isolate and bypass the grit tank for maintenance.

The grit extraction sequence can be triggered by elapsed time, or cumulative grit feed volume, whichever occurs first. There is reclaimed effluent sparge valve and a grit extraction pump. The sparge mixes and suspends the grit and the extraction pump delivers it to the classifier. Both occur concurrently. A manual valve can direct reclaimed effluent to the grit pump suction line. This can be used to clear blockages in the grit extraction pipework.

A camlock fitting is provided to allow a sucker truck to remove grit directly from the grit tank should the grit pump or classifier be out of service for an extended period.

There is a single, fluidised bed grit washer. This consists of a grit wash agitator, washer screw and washing valves. Grit slurry is pumped from the grit tank to the agitator chamber. Here it is fluidised and washed as it is extracted. Organic solids are separated from the grit and overflow a weir in the agitator chamber. After a number of grit extraction cycles have been completed, an organics discharge valve opens, drawing organics from a lower level in the chamber. The result is that the majority of the organics are flushed from the grit and return to the inlet works.

The washer screw is controlled separately. The grit accumulation in the agitator chamber eventually leads to an increase in pressure. A high pressure set point triggers the screw to start. It then runs for a preset time to extract some of the grit from the washer. The washer screw lifts the washed grit, allowing water to drain back through the screw. The washed grit falls from the end of the washer to the grit bin.

The grit washer and bin are located within a bund. This bund also drains back into the inlet works. Contaminated rainwater that collects in the bund is treated through the STP.

Screening and degritted sewage flows under gravity from the grit tank to the lift pump station via the inlet discharge chamber.

5.3.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The grit system is designed for:
  - Sewage DSTF, plus
  - Maximum odour control RE flow, plus
  - Maximum screen RE flow.
- Grit dry mass production has been based on conservative, published capture rates.

- Grit wet mass and volume production is based on typical solids content and bulk density.
- The maximum grit sparge and wash-water flow and typical duration has been based on supplier advice.

See Table 5-3 for details.

5.3.5 Turndown and Redundancy

There is only one grit tank, grit paddle, extraction pump, grit agitator and washer screw (all duty only). The failure of the grit paddle results in the capture of more putrescible solids with the grit. However, grit extraction can still continue. Failure of the grit sparge valve or grit pump suspends grit extraction. Grit extraction can also continue even if the any of the grit washer drives fail. However, grit will not be washed and will accumulate in the classifier.

None of these failures prevents flow passing through the grit tank for grit collection. A sucker truck can be connected to the grit tank extraction pipe to remove grit from the grit tank due to a sustained failure of any equipment items. The grit tank can also be manually bypassed for maintenance. Effluent quality is not dependent on grit removal. Any grit that passes around the grit tank will settle in the lift pump station, where it can be periodically removed with a suction pump and tanker. Therefore, it is possible to bypass the grit removal system for short periods to rectify faults or maintain the equipment (stopboards have been provided for this purpose) A standby grit tank or standby equipment is therefore not warranted.

The grit paddle operates continuously, regardless of flow. The grit scouring and extraction operation is triggered predominantly by elapsed flow. Therefore, the operation of most of the units is dependent on flow, ensuring power consumption and wear and tear are proportional to flow.

5.3.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-3. Worst case sizing is independent of the design scenario.

Table 5-3 Grit Removal System Process Sizing

	Units	Process Design Assumptions	Process Design Sizing
Number of Duty Grit Tanks		1	
Max Grit Sparge	L/s	5.0	
Grit Sparge Operation	h/d	1.0	
Max Grit Wash	L/s	1.5	
Grit Wash Operation	h/d	1.0	
Grit Capture Rate	dry kg/ML	30	
Dewatered Grit Solids Content	w/w	50%	
Dewatered Grit Bulk Density	kg/m3	1600	
Duty Grit Washer		1	
Grit Storage Required	d	7	
Number of Grit Bins / Trailers		1	
Maximum Flow per Grit Tank	L/s		412
Maximum Grit Bypass Flow	L/s		412

	Units	Process Design Assumptions	Process Design Sizing
Max Grit RE	L/s		6.5
Grit RE Operation	h/d		1.0
Grit RE Use	L/d		23,400
Avg Grit Volume Captured	L/d		173
Average Grit Mass Captured	wet kg/d		277
Grit Washer Capacity Each	L/h		94
Grit Washer Capacity Each	kg/h		150
Grit Bin Volume Each	L		1,213

5.3.7 Control Philosophy

sequence is not suspended.

There is an actuated valve on the grit sparge line, including an open and closed switch. If the valve fails to open or close within a time out period, then the valve will attempt to close and then fail. The sparge line is fitted with a flow switch. If no flow is detected with the open switch active, then an alarm is generated. A sparge alarm (valve failure or no flow) suspends the extraction sequence (fail and latch pump).

There is a single fixed speed grit pump (duty only). This is fitted with a flow switch. The pump is failed and latched if no flow is detected after a time delay after the pump starts.

There is solenoid valve on the grit wash line into the agitator tank of the grit washer. This is fitted with a flow switch. An alarm is generated unless the flow switch is activated within a time out period after the solenoid opens. There is no automated response to a wash alarm.

There is a fixed speed grit wash agitator. There is no automated response to agitator failure.

There is a separate, variable speed, reversible screw git washer drive. This includes a high torque switch. If the high torque is activated then the screw reverses for an operator set time, then switches back to forward direction and continues. If this occurs for a number of cycles, then the screw fails and latches.

There is a closed proximity switch on the grit washer access match. The agitator and screw drives both stop and are inhibited unless the access hatch is fully closed.

The following conditions lead to the grit extraction sequence being suspended:

- Grit sparge failed (no flow).
- Grit pump failed (drive, no flow).
- Grit washer screw failed (drive or over-torque).

The grit extraction sequence is triggered based on elapsed grit feed volume, or elapsed time, whichever occurs first. The elapsed time setpoint is used to start the grit extraction sequence if the grit feed flow element is failed.

When the volume or time has elapsed, the following sequence occurs.

- The grit sparge valve opens and RE is used to sparge the grit in the grit tank.
- The grit wash water solenoid valve opens and fluidises the grit bed in the washer.
- After a delay, the grit wash agitator starts.
- After a delay, and with the sparge and agitator still running, the grit pump starts and pumps the grit slurry to the washer.
- Once the extract time expires, the grit tank sparge valve closes and the grit pump stops.
- One is added to the grit extraction cycle counter. If the counter equals or exceeds an operator set number of extraction cycles, then the organics valve opens and the counter is reset to zero. Otherwise the valve remains closed.

- After a delay, the agitator stops.
- After a delay the grit wash solenoid closes.
- If the organics valve is open, then it closes.

The grit washer screw operation is not linked directly to the grit extraction sequence. The screw drive is triggered based on a high pressure set point in the grit agitator tank. The following sequence then occurs.

- The classifier screw starts.
- After a run period has expires, the classifier screw drive stops.
- The screw drive is inhibited from operating for a dwell time. Thereafter, the high pressure set point can restart the sequence.

5.4 Storm Detention and Return System

5.4.1 Purpose

The purpose of the storm detention system is:

- To accept screened sewage flows in excess of the DSTF
- To accept all flows as required occasionally for plant maintenance or power failure.
- To store screened sewage under extreme wet weather or emergency conditions.
- To settle solids prior to overflow to the environment once storage is exceeded.
- To return stored sewage and settled solids for treatment once conditions allow.
- To control the return flows as fast as possible without exceeding treatment capacity.
- To assist manual cleanout once emptied.
- To alarm overflows and failures.

5.4.2 Equipment and Instruments

- One (1) storm detention pond 1 (SDP1) level element (zone 1).
- Four (4) SDP1 level switches
- Two (2) variable speed SDP1 return pumps (duty/assist).
- Two (2) low flow switches, one for each SDP1 return pump.
- One (1) SPD1 return flow element.
- One (1) storm detention pond 2 (SPD2) level element, doubling as a plant bypass flow element.
- Three (3) SPD2 level switches.
- Two (2) variable speed SPD2 return pumps (duty/assist).
- Two (2) low flow switches, one for each SDP2 return pump.
- One (1) SPD2 return flow element.

5.4.3 Description

Screened sewage in excess of DSTF overflows a weir in the screened sewage channel of the inlet works and gravitates to SDP1. The operator can also shut down the lift pump station to undertake rare maintenance items (e.g. to repair or clean out splitter boxes, the filter feed pump station, etc. The SDPs provide many days of storage at average flow, allowing such repairs or maintenance to be undertaken.

There are two SPDs in series, SPD1 (new) and SPD2 (pre-existing). The intent is for most of the settleable sewage solids to settle in SDP1. This reduces clean-up time. If SPD1 fills, then it overflows to SPD2. If SPD2 fills then it overflows to the discharge of EST. The long retention time and slow rise rate should provide excellent primary treatment before discharge. This, in addition to stormflow dilution of the sewage, should result in reasonable bypass quality given that the receiving water should also be flowing under such wet weather conditions. Each overflow weir is alarmed.

Stored storm sewage is returned to the inlet works when conditions allow (e.g. wet weather flows subside). The intent is to return the stored sewage as fast as possible without exceeding treatment capacity. This reduces the storage time (reducing odour risks) and makes storage available for another event. This is achieved with the use of two return pump stations, one for each SDP. There is a similar return pumping system for the EST. Only one of these systems can be active at any time. Returns do not start until the operator activates them, and only one can be activated at a time.

There are two modes for the return pumps. These are:

- Flow Mode – Return flow varies inversely to sewage flow.
- Speed Mode – The pump speed is fixed and operates for a set duration.

The intent of the Flow mode is to maintain a constant inflow to the grit tank and lift pump station. The operator sets lift pump station inflow (say DFTF). The return flow then increases as the grit feed flow decreases, and vice versa. The result should be a constant feed flow to the bioreactors until the respective SDP is emptied.

Speed mode is used as a backup if the grit feed or return flow elements are failed.

The floors in the ponds slope to a sump. Once empty, hoses can be used to flush settled solids to the sumps. These are supplied with high flow reclaimed effluent from the dedicated storm clean pump (see Section 5.21).

5.4.4 Design Assumptions

The following assumptions have been adopted for the process design.

- SDP1 is assumed to drain completely into the sump.
- Since SPD1 will typically be empty, the depth of SDP1 is shallow to avoid possible groundwater buoyancy issues.
- The volume of SDP2 takes account of the lowering top water level (TWL). This is necessary to allow sewage to gravitate through the new inlet works and SPD1. SPD2 is assumed to drain completely.
- The return pumps are sized identically to the lift pump station pumps (just over 1.5 ADWF each).
- Stated 'times to empty' are based one pump running and limiting the inflow to the lift pump station to under DFTF (3 ADWF). However, this flow can be increased above DFTF (e.g. MLE mode or if storm treatment is deemed adequate), resulting in the assist pump also operating. The DFTF can be higher if the bioreactors are in MLE mode rather than FSB mode due to the lower sludge age and mixed liquor suspended solids (MLSS) concentration in the MLE mode.
- The 'times to empty' have been based on the diurnal profile (see Figure 3-1). This accounts for the short periods of the day when the sewage flow exceeds 1.5 ADWF resulting in the return pump rate slowing.

See Table 5-4 for details.

5.4.5 Turndown and Redundancy

There are two return pumps for each SDP. These operate as duty/assist, but typically operate as duty/standby. The failure of one pump does not result in any significant loss of return capacity (times to empty are based on one pump operating). The failure of two pumps will prevent returns, but this has no immediate consequence. As all four pumps are identical, the assist pump from the other SDP can be relocated. This is a very high level of redundancy.

The failure of the return flow elements or sewage element results in the pumps switching to speed control. Return pumping will continue to occur.

The failure of the level element does not impact on return pumping. The level switches are used as a backup.

The turndown (one return pump operating at minimum speed) should be sufficient allow continuous pumping all day, including during PDWF.

5.4.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-4. The worst case sizing for storage and return is the Future FSB option as this is when sewage flows are greatest and DFTF is least. The sizing does not vary with season.

Table 5-4 Storm Detention Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)
SDP1 Active Volume	ML	1.65	
SPD1 TWL Depth	m	2.75	
SDP2 Active Volume	ML	16.000	
Sewage ADWF	ML/d	4.620	
Sewage PWWF:ADWF	ADWF	13.00	
SDP1 Return Pumps		2	
SDP2 Return Pumps		2	
Reduced Return Flow	h	4.0	
Average Reduced Return Flow	ADWF	0.3	
Total Storm Detention Storage	ML		19.0
Sewage DSTF:ADWF	ADWF		6.00
Storage at PWWF	h		7.6
Storage at PWWF - DSTF	h		14.1
Storage at ADWF	d		4.1
SPD1 Inflow Rate at PWWF	ML/d		32.3
Max Return Rate	ADWF		1.67
Equivalent Return Flow	ADWF		1.62
Return Pump Size	L/s		89.1
SDP1 Return Pumps Tot	L/s		178.1
Time to Drain SDP1	d		0.4
SDP2 Return Pumps Tot	L/s		178.1
Time to Drain SDP2	d		2.1

The return times can be reduced under the MLE scenario. The DFTF can be increased to 4.5 ADWF allowing both return pumps to run in parallel. This could halve the return times without compromising treatment.

5.4.7 Operating Philosophy

The overflow weir at the inlet works is alarmed by the level element and high level switch in the screened sewage channel (see Section 5.3.7).

The return pumping systems are typically both set to Unavailable. Therefore, the return pumps do not operate as the SDPs fill. The level in SDP1 and SDP2 is monitored with a level element. The real time level, average level today and average level yesterday are calculated, displayed and recorded.

There is a high level switch in SPD1 and SDP2. These alarm overflows. If overflow of SPD2 is detected (high level switch), then the level is converted to an approximate flow with the use of a weir equation in the SCADA. The real time bypass discharge flow, integrated volume today and integrated volume yesterday are calculated, displayed and recorded. The integrated bypass discharge duration today and yesterday is also calculated displayed and recorded.

There is a low level switch in SPD1 and SDP2. The return pumps will stop and become Unavailable once this level, or a stop level set point (level element) is reached, whichever occurs first. This switch therefore acts as a backup to the level element for pump control.

There is a low low level switch in SPD1 and SDP2. These act as a dry cut out, failing and latching both respective pumps if this switch is activated.

Two SDP1 return pumps operate in duty/assist configuration. The operator can select the duty allocation (2 off) in the supervisory control, automation and data acquisition (SCADA) system. The SCADA will automatically change the duty each time the duty pump stops.

Two SDP2 return pumps operate in duty/assist configuration. The operator can select the duty allocation (2 off) in the SCADA. The SCADA will automatically change the duty each time the duty pump stops.

There is a flow element for each SDP return. This is used for monitoring and can also be used for control of the feed return pumps (Flow mode only). The real time flow, integrated volume today and integrated volume yesterday are calculated, displayed and recorded. There are separate no flow set points for each return. An alarm will be generated and the respective duty pump will be failed if the flow is below the no-flow set point after a duty pump that has been running for more than its no flow delay period.

The speed of each pump is limited between Maximum Pump Speed and Minimum Pump Speed set points, regardless of the control mode.

The control philosophy of each set of return pumps, SPD1, SPD2 and emergency (see Section 5.17.7) is identical. The default is that they are all Unavailable. The operator can select to make one system Available, and one system only. The Available system will operate and empty the respective storage. The others will remain idle. Once a storage is emptied, the system once again becomes Unavailable. Return pumping never starts automatically. Return pumping will stop if the operator selects it as Unavailable, or the storage is emptied.

There are two possible control modes for the return pumps:

- Flow Mode – The operator sets a target lift pump station inflow. The target return flow is calculated by subtracting the rolling average sewage flow from the target lift pump station inflow. Therefore, the return flow target changes in real time, decreasing as the sewage flow increases and increasing as the sewage flow decreases. The result is a near constant flow into the lift pump station. The return flow will stop and the pumps will be made Unavailable if the grit feed flow exceeds a high inhibit flow or the storage is emptied, whichever occurs first. If either the sewage or respective return flow element fails then control reverts to Speed mode.
- Speed Mode – The speed of the return pumps and run duration is set by the operator. The return pumps stop and become unavailable once the duration is exceeded or the storage is emptied, whichever occurs first. The return flow will stop and the pumps will be made Unavailable if the grit feed flow exceeds a high inhibit flow.

5.5 Lift Pump Station

5.5.1 Purpose

The purpose of the lift pump station system is:

- To control influent (bioreactor feed) flows to DFTF.
- To monitor bypass (reactor bypass) and influent flows.
- To deliver screened and degritted sewage to the bioreactors (influent) and clarifiers (bypass).
- To alarm bioreactor splitter bypass events if one bioreactor is isolated.
- To prevent overflows from the mixed liquor (ML) splitter if one clarifier is out of service.

5.5.2 Equipment and Instruments

The following equipment forms the lift pump station system.

- One (1) lift pump station level element.
- Four (4) lift pump station level switches.
- Three (3) variable speed influent pumps (duty/assist/standby or duty/assist/assist).
- One (1) RAS splitter high level switch.
- One (1) feed splitter high level switch.
- One (1) ML splitter high level switch.
- One (1) influent flow element.
- Two (2) variable speed bypass pumps (duty/assist).
- One (1) bypass flow element.
- Two (2) high level switches, one for each clarifier weir.

5.5.3 Description

Screened and degritted sewage flows from the inlet works to the lift pump station. There are three (3) influent pumps and two (2) bypass pumps in the lift pump station. The influent pumps deliver degritted sewage up to the DFTF (set by operator) to the bioreactor splitter. There it is mixed with foul water and return activated sludge (RAS) before flowing to the bioreactors. The influent flow is monitored. The influent is fully treated through the bioreactors and clarifiers.

The bypass pumps deliver degritted sewage above DFTF and below DSTF (also set by operator) to the bypass splitter. Here it is mixed with mixed liquor (ML) from the bioreactors and flows to the clarifiers. This provides partial treatment (solids contact). Solids are enmeshed in the activated sludge flocs. These solids are removed with the activated sludge in the clarifiers and returned in the Return Activated Sludge (RAS) to the bioreactors for treatment. Some of the soluble pollutants are also returned with the RAS flow for treatment. Other soluble components may also be sequestered into the activated sludge biomass and returned to the bioreactors. The result is that the flows up to DFTF are fully treated and the flows between DFTF and DSTF are partially treated. These partially treated flows should be suitable for filtration and effective UV disinfection.

The bypass main can be manually drained back to the lift pump station after each bypass event.

Alum is dosed into the influent main and to the ML splitter box (optional) to precipitate phosphorus.

There are three possible control modes for the influent and bypass pumps:

- Flow Mode – Flow varies with level.
- Speed Mode – Pump speed varies with level.
- Backup Mode – Pump speed is fixed and operation is based on level switches.

The influent flow is monitored and used for the control of the influent pumps and alum dosing to the bioreactors. The influent flow is added to the foul water flow to create a calculated bioreactor feed flow. This bioreactor feed flow is used for the control of other chemical dosing, MLR pumping and RAS pumping. A backup influent flow profile can be recorded by the operator to be used for control if the influent flow element fails. The bypass flow is monitored and used for the control of the bypass pumps.

There is a level switch in the RAS and feed splitters (alarms only). These warn the operator of a bioreactor bypass. This should only occur if one bioreactor is out of service and isolated. The operator can then reduce the maximum influent flow set point to prevent this.

There is also a level switch in the ML splitter. If activated, this will fail and latch all feed and bypass pumps to prevent overflow of the splitter. This should only occur during wet weather and with one clarifier out of service. Again, this can be prevented by reducing the maximum (DFTF and DSTF) set points in the lift pump station.

There is a high level switch in each clarifier. This should only be activated if the effluent pipelines block. The activation of either switch causes all lift pumps to fail and latch.

5.5.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The maximum influent flow is

    - The sewage DFTF, plus
    - The maximum odour control RE flow, plus
    - The maximum screen RE flow, plus
    - The maximum grit RE flow.
- The DFTF can be higher if the bioreactors are in MLE mode rather than FSB mode due to the lower sludge age and mixed liquor suspended solids (MLSS) concentration in the MLE mode.
- The maximum bypass flow is the difference between DSTF and DFTF.
- The active volume of the lift pump station is less than the total volume as the lift pump station has no sump.
- The active volume of the lift pump station is based on a minimum storage time at maximum flow. This storage time is to allow for smooth level and flow control over a wide range of flows.

See Table 5-5 for details.

5.5.5 Turndown and Redundancy

There are three influent pumps. These operate as duty/assist/standby in FSB mode and can operate as duty/assist/assist in MLE mode. The failure of one pump does not result in any loss of rated DFTF capacity. The failure of two pumps will result in the loss of wet weather treatment capacity and a small amount of dry weather treatment capacity. This could result in a short duration overflow to SDP1 during the morning peak. It can be returned soon after. This is a very high level of redundancy.

There are two bypass pumps. These operate as duty/assist. These are not required for dry weather treatment.

The failure of the influent flow element or bypass flow element results in the pumps switching to speed control. Influent and bypass pumping will continue to occur. Similar, backup control exists for other systems that utilise the influent flow.

The failure of the level element results in fixed speed Backup control. Treatment of all dry weather will continue.

The turndown (one feed pump operating at minimum speed) should be sufficient to match ADWF, even under Current loading conditions. The duty influent pump will start and stop at low speed under low flow conditions (at night). This should have no adverse impact on the process.

5.5.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-5. Worst case sizing is for the pump station and feed pipe sizing is the Future MLE scenario. The worst case sizing for the pumps is the Future FSB scenario. The sizing does not vary with season.

Table 5-5 Lift Pump Station Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Sewage ADWF	ML/d	4.620		
Maximum Odour Control RE	ML/d	0.018		
Maximum Screen RE	ML/d	0.950		
Maximum Grit RE	ML/d	0.562		
Lift PS Storage at Max Inflow	mins	10		
Lift PS Active Volume		80%		
Number of Lift PS Tanks		1		

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Sewage DFTF:ADWF	ADWF		3.00	4.50
Max Lift PS Flow at DFTF	ML/d		15.390	22.320
Max Lift PS Flow at DFTF	L/s		178.1	258.3
Sewage DSTF:ADWF	ADWF		6.00	7.50
Max Lift PS Flow at DSTF	ML/d		29.250	36.180
Max Lift PS Flow at DSTF	L/s		338.5	418.8
Duty Influent Pumps			2	3
Duty Bypass Pumps			2	2
Lift Pump Capacity Each	L/s		89.1	86.1
Lift Pump Capacity Each	:ADWF		1.67	1.61
Lift PS Volume Each	m^3		254	314

The slight difference in pump sizing between the scenarios is due to the RE flow in the inlet works. This maximum RE flow is shared between fewer feed pumps under the FSB scenario.

5.5.7 Control Philosophy

Three influent pumps operate in duty/assist/assist configuration. The operator can select the duty allocation (6 off) in the SCADA. The failure of a duty or assist pump results in it being allocated as standby and the next available allocation (2 off) being selected by the SCADA. The SCADA will automatically change the duty to the next available allocation each time the duty pump stops.

Two bypass pumps operate in duty/assist configuration. The operator can select the duty allocation (2 off) in the SCADA. The SCADA will automatically change the duty each time the duty pump stops.

There is a no flow set point for the influent and bypass flow elements. An alarm will be generated and the duty pump will be failed and latched if the measured flow is less than the no flow switch after the duty pump has been running for more than its no flow delay period.

The speed of each pump is limited between Maximum Pump Speed and Minimum Pump Speed set points, regardless of the control mode.

The lift pump station is fitted with a level element and four level switches.

- The high high level switch generates an alarm that indicates that an overflow from the inlet works is imminent. It is also used for to start the bypass pump(s) if Backup mode is selected.
- The high level switch is used to start the influent pump(s) if Backup mode is selected. It generates no alarm.
- The low level switch is used to stop all of the pump(s) but only if Backup mode is selected. It generates no alarm.
- The low low level switch acts as a dry cut out, failing and latching all pumps if this switch is activated, regardless of operating mode.

The level element is used for level monitoring as well as pump control when in Flow or Speed control modes. Failure of this level element results in the pump control mode switching to Backup. The operator can set alarm level set points for near overflow and overflow levels.

The influent main is fitted with a flow element. This is used for monitoring and can also be used for control of the influent pumps (Flow mode only) and bioreactor alum dosing. A rolling average influent flow is calculated and recorded over an adjustable time period. The operator can select a previously recorded influent rolling average and copy it to a backup influent profile. This can be selected to be used as a substitute for the influent flow for flow paced control of the bioreactor alum dosing pump. The operator selects a 'typical' rolling average influent profile from history. The SCADA replicates this as a flow profile with 15 minute increments over a 24 hour period.

The influent flow is added to the foul water flow to produce a calculated bioreactor feed flow. A rolling average influent flow is also calculated and recorded over an adjustable time period. If the foul water flow element fails, then it is assumed to be zero, and the bioreactor feed flow continues to be calculated. If the influent flow element fails, then the bioreactor feed calculation fails. The operator can choose to select the backup influent flow profile to calculate the bioreactor feed flow.

The rolling average bioreactor feed flow can be used for flow paced control of the following systems:

- The MLR pumping system.
- The carbon dosing pump (future).
- The alkalinity dosing pump.
- The secondary alum dose (if dosing to the ML splitter and clarifiers).
- The RAS pumping system.

The bypass main is fitted with a flow element. This is used for monitoring and can also be used for bypass pump control (Flow mode only).

The real time flow, integrated volume today and integrated volume yesterday are calculated, displayed and recorded for each of the following flows:

- Influent flow
- Bypass flow
- Bioreactor feed flow

If the level in the feed chamber of the bioreactor splitter rises to the high level switch, then an alarm is generated. If the level in the RAS chamber of the bioreactor splitter rises to the high level switch, then an alarm is generated.

If the level in the ML splitter rises to the level switch then an alarm is generated and all influent and bypass pumps fail and latch. If the level in either clarifier rises to a high level switch then all influent and bypass pumps fail and latch.

There are three possible control modes for the influent and bypass pumps:

- Flow Mode – The level in the lift pump station is converted to flow targets for the influent and bypass pumps. The flow targets vary with the lift pump station level, increasing as the level rises and decreasing as the level falls. The influent pump(s) speed modulates to try to achieve an influent flow target in the influent flow element. The influent flow target is limited to DFTF (operator adjustable). If the level continues to rise, then a bypass flow target is generated. The bypass flow target is capped to the difference between the DSTF and DFTF (operator adjustable). If either flow element fails then control reverts to speed mode.
- Speed Mode – The level in the lift pump station is converted to speed targets for the influent and bypass pumps. The speed targets vary with the lift pump station level, increasing as the level rises and decreasing as the level falls. The influent pump(s) speed is set to achieve the influent speed target. If the level continues to rise, then a bypass speed target is generated. If the level element fails then control reverts to Backup mode.
- Backup Mode – This is not intended to be a normal operating mode, but rather as an emergency backup if the level element fails. The influent and bypass pump(s) operate at a constant speed. The start and stop of the pump(s) are based on the level switches in the lift pump station.

5.6 Bioreactor Splitter

5.6.1 Purpose

The purpose of the bioreactor's splitter is:

- To evenly split the bioreactor feed (influent plus foul water) between the two bioreactors.
- To evenly split the return activated sludge (RAS) between the two bioreactors.

- To allow a bioreactor to be manually isolated if necessary for maintenance.

5.6.2 Equipment and Instruments

There are no equipment or instruments associated with the bioreactor splitter. The level switches are used for lift pump station alarming and control (see Section 5.5).

5.6.3 Description

Influent from the lift pump station is delivered to the feed chamber of the bioreactor splitter. Alum is dosed to the influent main allowing adequate mixing time before reaching the feed chamber. The foul water from the foul water pump station (FWPS) is also delivered to the feed chamber, where it mixes with the dosed influent. This mixture is split two ways using weirs before falling into to a combined feed and RAS chamber. Feed to either bioreactor can be isolated manually using stop boards at these weirs.

The bioreactor feed flow is the sum of the influent flow from the lift pump station and the foul water flow from the FWPS. This is added together in the SCADA and used for the flow pacing of dosing systems, MLR and RAS.

RAS from the RAS pump station is delivered to the RAS chamber of the bioreactor splitter. This RAS is split two ways with weirs before falling into a combined feed and RAS chamber. RAS to either bioreactor can be isolated manually using stop boards at these weirs. To isolate a bioreactor, both the feed and the RAS stop boards must be in place.

The combined RAS and feed gravitates to the selector zone of each bioreactor that are hydraulically designed to accommodate half the DFTF (MLE mode) and half the maximum RAS flow. If one bioreactor is isolated then the operator should reduce the DFTF cap in the lift pump station. This in turn will reduce the RAS flow (flow paced). If the operator neglects to do this, then the remaining bioreactor may get hydraulically overloaded. This could flood the feed and RAS weirs, causing the level to rise in the feed and RAS chambers. Emergency overflow weirs are provided to direct the flow to the ML splitter, bypassing some flows around the bioreactor, but preventing overflow of the bioreactor splitter walls. This event is alarmed with a high level switch.

5.6.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The maximum influent flow is:
  - The sewage DFTF (up to 4.5 ADWF), plus
  - The maximum odour control RE flow, plus
  - The maximum screen RE flow, plus
  - The maximum grit RE flow.
- The maximum influent flow should be capped to half of this if one bioreactor is out of service and isolated. Otherwise a portion of the feed could overflow the bioreactor splitter directly to the ML splitter and clarifiers.
- The maximum foul water flow is the maximum capacity of the duty foul water pump. This is not capped with one bioreactor out of service. Therefore, the limiting condition is with one bioreactor out of service (half the maximum influent flow plus all of the foul water flow).
- The maximum RAS flow is the combined capacity of the duty RAS pumps. If one bioreactor is out of service and isolated, then the cap on the influent flow should automatically cap the RAS flow (flow paced). Since this flow pacing includes the foul water flow, then the RAS flow with one bioreactor out of service is slightly greater. If the RAS is increased above optimum under such conditions then a portion of the RAS will mix with the feed and could overflow the splitter directly to the ML splitter and clarifiers.
- The maximum capacity of the bypass flow is the worst case difference between DSTF and DFTF.

See Table 5-6 for details.

5.6.5 Turndown and Redundancy

There is no equipment associated with the bioreactor splitter.

There is no way of bypassing the bioreactor splitter. If there is a need to take the splitter out of service for maintenance and repair then the lift pump station and RAS pump stations must all be turned off. Sewage can be stored in the SDPs until maintenance is complete. There should be no need for such maintenance.

5.6.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-6. Worst case sizing is for the Future MLE scenario. The sizing does not vary with season.

Table 5-6 Bioreactor Splitter Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Sewage ADWF	ML/d	4.620		
Maximum Odour Control RE	ML/d	0.018		
Maximum Screen RE	ML/d	0.950		
Maximum Grit RE	ML/d	0.562		
Maximum FWPS	ML/d	2.340		
Maximum RAS Flow	ML/d	16.389		
Maximum Reactor Spray	ML/d	0.086		
Bioreactors		2		
Bioreactor with 1 O/S		1		
Sewage DFTF:ADWF	ADWF		3.00	4.50
Sewage DSTF:ADWF	ADWF		6.00	7.50
Feed at DFTF	ML/d		17.730	24.660
DFTF Feed Flow Each	ML/d		8.865	12.330
DFTF Feed Flow Each	L/s		102.6	142.7
DFTF Feed with 1 O/S	ML/d		10.035	13.500
DFTF Feed with 1 O/S	L/s		116.2	156.3
Max RAS Flow Each	ML/d		8.195	8.195
Max RAS Flow Each	L/s		94.8	94.8
Max RAS Flow with 1 O/S	ML/d		9.276	8.972
Max RAS Flow with 1 O/S	L/s		107.4	103.8
Max Feed & RAS Each	ML/d		17.060	20.525
Max Feed & RAS Each	L/s		197.5	237.6
Max Feed & RAS with 1 O/S	ML/d		19.312	22.473

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Max Feed & RAS with 1 O/S	L/s		223.5	260.1
Max ML Each	ML/d		17.103	20.568
Max ML Each	L/s		198.0	238.1
Max ML Each with 1 O/S	ML/d		19.398	22.559
Max ML Each with 1 O/S	L/s		224.5	261.1
Max Bypass Flow	ML/d		13.860	13.860
Max Diluted ML Flow	ML/d		48.066	54.996
Max Diluted ML Flow	L/s		556.3	636.5

5.6.7 Control Philosophy

The control philosophy for calculating the bioreactor feed flow is covered in Section 5.5.7.

5.7 Bioreactors

5.7.1 Purpose

The purpose of the bioreactors is:

- To accept and treat sewage, foul water return and recycled sprays.
- To hold and sustain a viable activated sludge biomass, to:
    - Capture solids and break down and consume biodegradable solids, removing SS.
    - Remove soluble organics and thus BOD.
    - Convert ammonia to oxidised nitrogen (nitrification), removing NH_x-N.
    - Convert oxidised nitrogen to nitrogen gas (denitrification), removing TN.
    - Capture phosphorus precipitants, removing TP.
- To manage sludge settleability to maintain necessary capacity.

5.7.2 Equipment and Instruments

This section is confined to the equipment that is not related to other bioreactor systems. Equipment for aeration, mixing, MLR pumping and WAS pumping is covered in their respective sections.

The bioreactor consists of the following mechanical equipment and instruments.

- Two (2) spray solenoid valves, one for each bioreactor.
- Two (2) low flow switches, one for each solenoid.

5.7.3 Description

There are two bioreactors in duty/duty configuration. It may be possible to treat sewage in one bioreactor, particularly in summer, or under Current loading conditions, but this is not recommended unless it is necessary for maintenance. The ability to effectively treat sewage using a single bioreactor reduces as the connected load increases or temperature decreases.

The bioreactors are designed to be operated in two process configurations:

- The Modified Ludzac Ettinger (MLE) configuration (anoxic-aerobic).
- The Four Stage Bardenpho (FSB) configuration (anoxic-aerobic-anoxic-aerobic).

The FSB configuration is capable of achieving a lower effluent TN concentration than the MLE configuration. It requires a larger unaerated mass fraction (adding a second anoxic zone). This means that the operating sludge age and mixed liquor suspended solids (MLSS) increases. This increase in MLSS decreases the DFTF capacity. This is why the bioreactors are rated for a DFTF of 4.5 ADWF under MLE mode and 3.0 ADWF under FSB mode.

Under the MLE mode, the secondary anoxic zone is aerated. Therefore, the primary aerobic, secondary anoxic and secondary aerobic zones become one, larger, primary aerobic zone. The MLR is drawn from the secondary aerobic zone (via the de-aeration zone) as this is where the nitrate concentration is at its highest, reducing the MLR pumping rate required.

The following is required to convert the bioreactors from MLE to FSB configuration.

- The aeration grids in the secondary anoxic zone are isolated manually with valves (although they should be intermittently exercised if left in situ).
- The mixers in the secondary anoxic zone are switched on.
- The stop boards between the primary aerobic and de-aeration zone are removed.
- The stop boards between the secondary aerobic and de-aeration zone are inserted.
- FSB mode is selected within the control system (aeration control system does not consider the secondary anoxic aeration control valve)
- The carbon dose is directed to the secondary anoxic zone (future).

This can be achieved operationally in a matter of minutes and can be reversed at any time.

Bioreactor feed is a mixture of screened and degritted sewage (within DFTF), foul water from the FWPS and alum. The combined feed flows from the bioreactor flow splitter to the two bioreactors. RAS is also returned from the clarifiers to the bioreactor splitter, where it is split and mixed with the bioreactor feed before being delivered to the selector zone of each bioreactor. Each bioreactor can be manually isolated using feed and RAS stop boards. If one bioreactor is isolated, then the influent should be capped to 2.25 ADWF or below at the lift pump station. Otherwise there is a danger that feed and RAS could overflow from the bioreactor splitter to the ML splitter, bypassing the bioreactors directly to the clarifiers.

Equipment such as mixers, aeration, and MLR pumping should continue to operate even if a bioreactor is isolated. These should be switched off manually if a bioreactor must be drained. If draining is required then a large portion of the biomass should initially be pumped to the other bioreactor with the use of a portable pump. The remainder can be pumped to the aerobic digester or dewatering.

Screened and degritted sewage (influent), foul water and alum combines with RAS at the splitter. It is then delivered to the anoxic selector zone of each bioreactor. Here it is mixed by a single mixer that operates continuously. Sewage solids are enmeshed in the biomass flocs. Nitrate is returned from the clarifiers via the RAS pumping system. It is denitrified (converted to nitrogen gas) in the selector zone. The selector zone has a high concentration of food (SBCOD). The SBCOD is more than can be synthesised in the small selector zone. This promotes sequestration (the SBCOD is drawn into the biomass cells for later consumption). This selects (favours) floc forming organisms (some of which can sequester) over filamentous organisms (which cannot sequester). This reduces the risk of filamentous bulking and poor settlement that can otherwise compromise wet weather treatment capacity. In short, the aim of the selector is to reduce the risk of bulking (poor settling) and foaming.

The mixed liquor flows from the selector to the primary anoxic zone. The primary anoxic zone contains a number of mixers, all of which operate continuously. The anoxic ML from the selector is mixed with nitrate returned from the primary aerobic zone via the mixed liquor recycle (MLR) pumping system. The remainder of the sewage SBCOD is consumed in this zone. Carbon dosing can also occur to this zone (future) if required to trim further TN from the effluent. Most of the denitrification is achieved in this zone. The MLR pumping rate is adjusted to try to achieve a small but measurable NO_x-N at the end of the primary anoxic zone. The MLR recycle rate will need to be increased in summer and decreased in winter to achieve this. Much of the particulate biodegradable carbon is also broken down and consumed in the primary anoxic zone.

The anoxic mixed liquor flows from the primary anoxic zone to the primary aerobic zone. There is a submerged weir between these two zones to reduce backflow of oxygen into the primary anoxic zone. The mixed liquor is aerated through removable diffuser grids. Valves control the air flow through these grids to try to maintain a constant dissolved oxygen (DO) concentration in the primary aerobic zone. Typically, the valves control to a lower DO at the start of the primary aerobic zone, and a higher DO at the end of the primary aerobic zone. The lower DO at the start of the zone significantly reduces aeration demand (and energy costs). It can also promote aerobic denitrification, helping to further trim TN in the effluent. The vast majority of nitrification (conversion of NH_x-N to NO_x-N) occurs in the primary aerobic zone.

The flow path and process then differs depending on the operational configuration.

MLE Mode

Under MLE mode, stop boards isolate the weir between the primary anoxic and de-aeration zone. All the aerobic mixed liquor flows to the secondary anoxic / swing zone. Because this is also aerated, the primary aerobic, secondary anoxic and secondary aerobic zones combine to form one, larger, primary aerobic zone. The mixed liquor is aerated through smaller, removable diffuser grids in the secondary anoxic and secondary aerobic zones. A valve controls the air flow through these grids to maintain a constant dissolved oxygen (DO) concentration in the secondary aerobic zone. Most of the aerobic mixed liquor flows from the secondary aerobic zone to the de-aeration zone (and is ultimately returned to the primary anoxic zone). The remainder exits the bioreactor to the ML splitter, and on to the clarifiers.

FSB Mode

Under FSB mode, most of the aerobic mixed liquor flows from the primary aerobic zone to the de-aeration zone. The remainder flows to the secondary anoxic zone. This is not aerated, but is mixed, creating a second anoxic zone to further trim TN. Because all the sewage food has been consumed in the primary anoxic and primary aerobic zones, food must be added to the secondary anoxic zone through carbon dosing (future) to maximise this removal. The intent is to completely remove all NO_x-N in this zone. However, the decay of biomass in the secondary anoxic and secondary aerobic zone releases more NH_x-N. This is nitrified in the secondary aerobic zone, resulting in a small NO_x-N residual in the effluent. A valve controls the air flow through the aeration grid in the secondary aerobic zone to maintain a constant dissolved oxygen (DO) concentration. The secondary aerobic zone is isolated from the de-aeration zone with stop boards. Therefore, all the aerobic mixed liquor exits the bioreactor to the ML splitter, and on to the clarifiers.

MLR pumps are located in the de-aeration zone. The de-aeration zone is mixed but not aerated. However, because the flow through it is so great (high MLR pumping rate) it remains aerobic, be it with a lower DO than the other zones. This reduces the adverse impact that the DO has on denitrification in the primary anoxic zone. In essence, the de-aeration zone forms part of the primary anoxic zone, but some nitrification still continues due to the residual DO. The de-aeration zone is fed from the end of primary aerobic zone. In MLE configuration, this is the secondary aerobic zone. In FSB configuration this is the primary aerobic zone. The MLR pumps deliver this from the de-aeration zone to the primary anoxic zone. The de-aeration zone is continuously mixed with a single mixer.

Only one de-aeration zone stop board is provided per bioreactor. This is to ensure that only one de-aeration zone inflow weir can be isolated. If both are isolated, and the MLR pumps operate, then the level in the de-aeration zone will be drawn down and the non-structural baffle walls could fail. A note explaining this will be included in the operations manual.

The aerobic mixed liquor flows from the secondary aerobic zone of each bioreactor to the ML splitter. Here it is mixed with a second alum dose (optional). Bypass flows from the lift pump station (under wet weather conditions) are also split separately and mix with the ML, diluting the ML and reducing the MLSS before settling in the clarifiers. This mixture of ML and bypass (plus optional alum) flows to the clarifiers.

There is a diluted sludge blanket in the clarifiers. Under normal conditions, the MLSS in this settling zone is thin and makes up only a small fraction of the overall biomass. It thickens as flows increase. This causes biomass to shift from the bioreactors to clarifiers under high flow conditions, resulting in a reduction of MLSS concentration in the bioreactors. The opposite occurs as the flows decrease. The overall mass of activated sludge in the system does not change. It merely migrates from the bioreactors to clarifiers and back again. The biomass in the clarifiers typically makes up around 5% of the total biomass, but this can increase to 20% as the flows increase to DFTF.

The biomass in the clarifier sludge blanket can continue to denitrify, reducing DO and NO_x-N in the RAS before it is returned to the selector zone. This is not necessary or even desirable, but it is accounted for in the process design.

There are automated sprays fitted to each bioreactor for scum and foam control if required. These sprays operate intermittently based on timer.

5.7.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The sludge yield (see Table 5-7) was modelled using default steady state kinetics as published in *Biological Wastewater Treatment*. This yield includes the mass of recycled pollutants in the RE and foul water.
- The sludge age was set using nitrifier kinetics using a nitrification safety factor of around 1.3. This is equivalent to a sludge age of 30 days in an advanced IDEA bioreactor under the same temperature conditions.
- Chemical sludge production was based on the assumptions in Section 5.29. The precipitants formed are assumed to be aluminium phosphate ($AlPO_4$) and aluminium hydroxide ($Al(OH)_3$).
- The maximum feed flow is:
  - The sewage DFTF (3.0 ADWF for FSB and 4.5 ADWF for MLE), plus
  - The maximum odour control RE flow, plus
  - The maximum screenings RE flow, plus
  - The maximum grit RE flow, plus
  - The maximum FWPS flow, plus
- The maximum bypass flow is the difference between DSTF and DFTF (3.0 ADWF).
- The maximum DFTF effluent flow is the maximum feed flow plus the bioreactor RE flow.
- The maximum DSTF effluent flow is the maximum feed flow plus the maximum bypass flow plus the maximum bioreactor RE flow.
- The maximum influent flow with one bioreactor out of service is half the maximum influent flow. The maximum foul water flow and bioreactor spray flow remain unchanged. The maximum RAS flow with one bioreactor out of service is more than half the maximum RAS flow due to the impact pf the maximum foul water flow.
- The bioreactor depth was selected to be near optimal for diffused aeration efficiency.
- The bioreactor volume was maximised while still fitting within available site area. The dimensions were adopted to produce a near square structure to optimise concrete costs.
- The dimensions of each zone were selected based on experience and verified through nitrification and denitrification kinetics.
- The carbon dose was assumed to be the minimum required to meet denitrification goals (see Section 5.12).
- The amount of biomass in the clarifiers was estimated using flux theory and mass balance equations. It was based on ADWF conditions and kept constant between scenarios.
- The biosolids in the clarifiers was included in the sludge age and all other process calculations. The hydraulic sludge age (excluding clarifiers and effluent SS) is slightly less than the true sludge age.

See Table 5-7 and Table 5-8 for details.

5.7.5 Turndown and Redundancy

If one bioreactor is taken out of service, then the maximum influent set point in the lift pump station should be reduced to 2.25 ADWF. This is more than sufficient to treat PDWF. If the operator does not do this, then the bioreactor splitter emergency weirs may overflow, directing some flows around the bioreactor to the clarifiers. This is alarmed.

It may be possible to treat future loads using one bioreactor in warmer months by reducing the sludge age and decreasing the maximum influent flow to below DFTF. Critical equipment redundancy is outlined in the aeration, mixing, MLR and WAS sections. The limiting condition is likely to be aeration demand during peak loading periods during the day. This may cause elevated effluent NH_x-N during these periods. This could be combatted by reducing the DFTF further and using SDP1 as a dry weather balancing tank.

There is no practical lower limit to MLSS. Therefore, there is no limit to bioreactor turndown. Other sections should be consulted for more details on bioreactor equipment turndown.

5.7.6 Process Sizing

Details of the biomass yield assumptions and resulting biomass yield can be found in Table 5-7. This feeds into the process sizing of the bioreactors. Worst case sizing is for the Future, Winter, FSB option.

Table 5-7 Loading and Biomass Yield

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Temperature	ºC	12		
Sludge Age(1)	d		24	19
Feed Non Volatile SS (NVSS)	kg/d		125	125
Feed NBVSS	kg/d		427	427
Biodegradable COD (BCOD) Consumed	kg/d		2133	2134
Active Normal Heterotrophic Organisms (NHOs)	kg/d		189	232
NHO Endogenous Residue	kg/d		173	168
Nitrogen Nitrified	kg/d		198	196
Nitrifier Active Mass	kg/d		11	12
Nitrifier Endogenous Residue	kg/d		2	1
PO_x-P Precipitated	kg/d		39	39
Chemical Precipitants	kg/d		255	253
Total Yield	kg/d		1182	1219
VSS:SS Ratio			68%	69%
Total SS Inventory	kg		28369	23158

Note (1) – This is the actual sludge age (includes biomass in the clarifiers and effluent SS). The hydraulic sludge age is one day less.

It should be noted that the maximum value for some components of the yield are greater in summer than winter. Winter represents the worst case for the total yield (highest MLSS).

It can be seen that the FSB scenario is the worst case for total SS inventory and therefore sizing of the bioreactors. This is due to the longer sludge age required to support the secondary anoxic zone. The lower sludge age and MLSS of the MLE scenario provides an opportunity to increase the DFTF from 3.0 ADWF to 4.5 ADWF without compromising capacity.

The bioreactors were sized based in this inventory and other parameters. Details of the process sizing assumptions and resulting process sizing can be found in Table 5-8. Worst case sizing is for the Future, Winter MLE scenario.

Table 5-8 Bioreactor Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Temperature	ºC	12		
Effluent SS	mg/L	5.0		
Biomass Volume Total	ML	7.691		
Max Bioreactor Spray	L/s	1.0		
Bioreactor Spray Operation	h/d	12.0		
Solids Retention Time	d		24	19
Unaerated Mass Fraction			51.6%	43.2%
Nitrification Safety Factor			1.3	1.3
SS Yield	kg/d		1182	1219
Total Inventory	kg		28369	23158
Bioreactor MLSS	mg/L		3689	3011

The bioreactor geometry was designed specifically to suit the Bowral STP needs. The full details of the bioreactor geometry can be found in Table 5-9. A dimensioned plan sketch is also provided in Figure 5-1. The geometry is identical for all scenarios but optimised for the Future FSB scenario.

Table 5-9 Bioreactor Geometry

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)
Bioreactors		2	
Inside Length Each	m	40.3	
Inside Width Each	m	20.3	
Bioreactor Liquid Depth	m	4.6	
Bioreactor Depth to Coping	m	5.0	
Pass 1 Liquid Width		40%	
Selector Liquid Length		5%	
Primary Aerobic Length		70%	
Secondary Anoxic Width		50%	
Secondary Aerobic Length		50%	
Clarifiers		2	
Clarifier Inside Diameter Each	m	22.0	
Clarifier Side Wall Depth	m	4.0	

Equivalent Clarifier Blanket	m	0.5	
Bioreactor Liquid SA Each	m^2		795
Bioreactor Volume Each	ML		3.655
Bioreactor Volume Total	ML		7.311
Clarifier SA Each	m^2		380
Clarifier SA Total	m^2		760
Clarifier Biomass Volume	ML		0.380
Total Biomass Volume	ML		7.691
Selector Fraction			2.0%
Primary Anoxic Fraction			38.3%
Primary Aerobic Fraction			42.3%
Secondary Anoxic Fraction			8.8%
Secondary Aerobic Fraction			4.3%
De-Aeration Fraction			4.3%
MLE Unaerated Mass Fraction			43.2%
FSB Unaerated Mass Fraction			51.6%

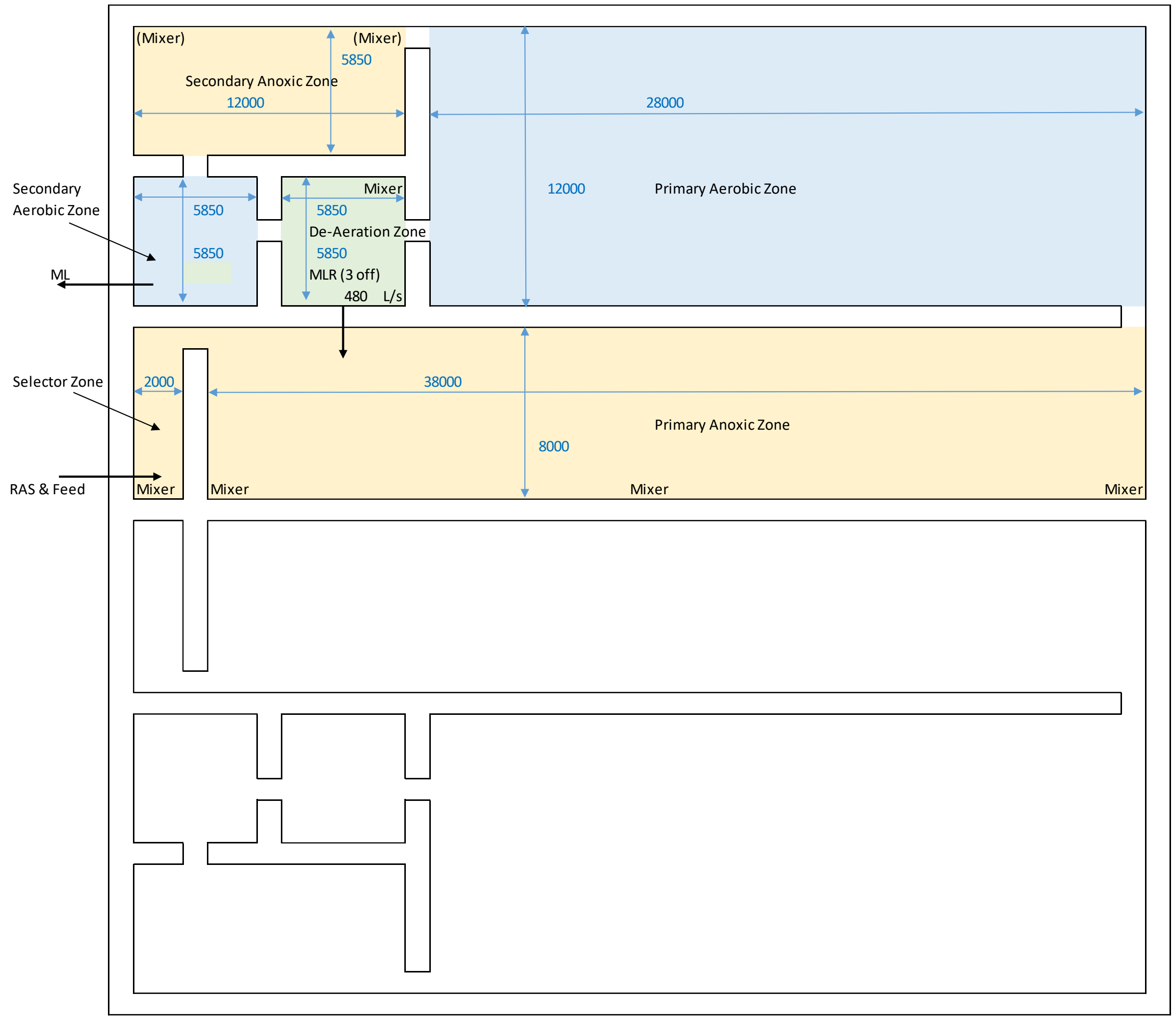


Figure 5-1 Bioreactor Sketch

The clarifiers were then sized to suit the flow and MLSS conditions.

5.7.7 Control Philosophy

The bioreactor spray solenoids open and close based on timer. An alarm is generated if no flow is detected after a time delay after the solenoid opens.

The control of other process units is included in separate sections hereafter.

5.8 Clarifier Splitter

5.8.1 Purpose

The purpose of the clarifier splitter is:

- To accept ML from the two bioreactors.
- To evenly split the ML between the two clarifiers.
- To evenly split reactor bypass flows between the two clarifiers.
- To allow a clarifier to be manually isolated if necessary for maintenance.

It is worth noting that the clarifier splitter forms part of the same structure as the bioreactor splitter.

5.8.2 Equipment and Instruments

There are no equipment or instruments associated with clarifier splitter. The level switch is for lift pump station control and is covered in Section 5.5.

5.8.3 Description

The ML from each bioreactor gravitates to the ML splitter. The bypass flows (solids contact) from the lift pump station are split separately before mixing with the ML. This dilutes the ML, meaning it settles faster in the clarifiers. This faster settling rate compensates for the higher clarifier rise rate caused by the bypass flow. The solids flux applied to the clarifiers remains unchanged.

Alum can also be dosed to the ML splitter (secondary dose) for TP trimming. Mixing in the ML splitter and ML gravity mains provides contact between the ML, the bypass and the alum. This creates solids contact conditions, enmeshing sewage solids and alum precipitants within the activated sludge flocs. These solids are then removed in the clarifiers and return to the bioreactor via the RAS for treatment.

Feed to either clarifier can be isolated manually using stop boards at the ML and bypass splitter weirs.

The clarifier feed pipes are hydraulically designed to accommodate half the DSTF (MLE mode) the maximum foul water flow and slightly more than half the maximum RAS flow. If one clarifier is isolated then the operator should reduce the DFTF and DSTF caps in the lift pump station. This in turn will reduce the RAS flow (flow paced). If the operator neglects to do this, then the remaining clarifier may get hydraulically overloaded. This could flood clarifier splitter weirs, causing the level to rise in the ML splitter. This event is alarmed with a high level switch. All the lift pumps will then fail and latch to prevent overtopping of the clarifier splitter.

5.8.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The maximum influent flow is:
  - The sewage DFTF (4.5 ADWF for MLE and 3.0 ADWF for FSB), plus
  - The maximum odour control RE flow, plus
  - The maximum screen RE flow, plus
  - The maximum grit RE flow.
- The maximum influent flow should be capped to 2.25 ADWF if one clarifier is out of service and isolated.
- The maximum foul water flow is the maximum capacity of the duty foul water pump. This is not capped with one clarifier out of service. Therefore, the combined influent and foul water flow with one bioreactor out of service is slightly greater than with both in service.
- The maximum bioreactor spray flow is included, even if one clarifier is out of service.
- The maximum RAS flow is the combined capacity of the duty pumps. If one clarifier is out of service and isolated, then the cap on the influent flow should automatically cap the RAS flow (flow paced). Since this flow pacing includes the foul water flow, then the RAS flow with one bioreactor out of service slightly greater. If the RAS is increased above optimum under such conditions then a portion of the RAS will mix with the feed and could overflow the splitter directly to the clarifiers.
- The bypass flow is the worst case difference between DSTF and DFTF (3.0 ADWF). The maximum bypass flow should be capped at 1.5 ADWF if one clarifier is out of service.

See Table 5-10 for details.

5.8.5 Turndown and Redundancy

There is no equipment associated with the clarifier splitter.

There is no way of bypassing the splitter. If there is a need to take the splitter out of service for maintenance and repair then the lift pump station and RAS pump station must both be turned off. Sewage can be stored in the SDPs until maintenance is complete. There should be no need for such maintenance.

Flushing flows are supplied during PDWF conditions (2 ADWF). This is roughly 40% the design flow. This should be sufficient to maintain flushing flows in all conduits. However, if the conduits were sized for twice the design flow (designed for full flow with one clarifier out of service) then the conduit sizes would be doubled and flushing flows would be insufficient. This the reason that there is a need to restrict influent and bypass flows if one bioreactor is out of service. This is still sufficient to treat PDWF.

5.8.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-10. Worst case sizing is for the Future MLE scenario. The sizing does not vary with season.

Table 5-10 Clarifier Splitter Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Sewage ADWF	ML/d	4.620		
Maximum Odour Control RE	ML/d	0.018		
Maximum Screen RE	ML/d	0.950		
Maximum Grit RE	ML/d	0.562		
Maximum FWPS Flow	ML/d	2.340		
Maximum Reactor Spray	ML/d	0.086		
Maximum RAS Flow	ML/d	16.389		
Clarifiers		2		
Clarifiers with 1 O/S		1		
Sewage DSTF	ADWF		6.00	7.50
Maximum ML Flow	ML/d		48.066	54.996
Maximum ML Flow	L/s		556.3	636.5
Maximum ML Flow Each	ML/d		24.033	27.498
Maximum ML Flow Each	L/s		278.2	318.3
Max ML Each with 1 O/S	ML/d		26.328	29.489
Max ML Each with 1 O/S	L/s		304.7	341.3
Maximum SE Flow	ML/d		31.677	38.607
Maximum SE Flow	L/s		366.6	446.8
Maximum SE Flow Each	ML/d		15.838	19.303
Maximum SE Flow Each	L/s		183.3	223.4
Max SE Each with 1 O/S	ML/d		17.052	20.517
Max SE Each with 1 O/S	L/s		197.4	237.5

5.8.7 Control Philosophy

There are no automated controls for the clarifier splitter.

5.9 Secondary Clarifiers

5.9.1 Purpose

The purpose of the secondary clarifiers is:

- To dissipate momentum currents from mixed liquor entering the clarifiers.
- To complete flocculation in order to reduce turbidity in the secondary effluent.
- To separate activated sludge biomass from secondary effluent substrate.
- To settle and thicken the biomass and move it to the RAS withdrawal well.
- To capture and collect scum and prevent it from accumulating and entering the secondary effluent.

5.9.2 Equipment and Instruments

The clarifiers consist of the following mechanical equipment and instruments.

- Two (2) variable speed, peripheral scraper drives, one for each clarifier.
- Two (2) high torque switches, one for each scraper mechanism.
- Two (2) proximity switches (plough), one on each scraper mechanism.
- Two (2) proximity switches (rotation detection), one on each scraper mechanism.
- Two (2) high level switches within the clarified effluent launders.

5.9.3 Description

There are two secondary clarifiers in duty/duty configuration. Each clarifier can be isolated at the clarifier splitter (ML and bypass) and taken out of service for maintenance. PDWF can be accommodated with one clarifier out of service provided the sludge age and MLSS is reduced (e.g. MLE mode or FSB mode in summer). The RAS pumping system can be used to drain most of the contents of the clarifier and pump it back to the bioreactors.

Mixed liquor (ML) from the clarifier splitter enters the central well of each clarifier. It is released through and Energy Dissipating Inlet (EDI) which reduces momentum currents as the ML enters the centre well. A bottomless feed well surrounds the EDI, creating a flocculation zone and directing the ML downward rather than outward. Biomass settles below the bottom of the feed well. Clear substrate (secondary effluent) rises outside the feed well and overflows peripheral weirs. The peripheral weirs are outside the wall of the clarifier. Submerged Stamford baffles on the clarifier walls (below the weirs) deflect any momentum currents that can pass along the clarifier floor and up the walls.

Each clarifier has a rotating mechanism with floor and surface scrapers. The floor scrapers assist with thickening as well as directing the thickened ML to the centre well. Here it is extracted with the use of the return activated sludge (RAS) pumps. The surface scrapers direct any floating scum or foam to scum boxes, from where it is flushed under gravity to the scum pump station.

The scraper mechanism includes a bridge with peripheral access stairs. This entire mechanism, including the bridge, scrapers and stairs, rotates. A plough rail and switch automatically stops and fails the mechanism if the stairs contact an object. An over-torque switch also protects the mechanism. Another proximity switch is used to detect clarifier mechanism rotation, with an alarm generated if the mechanism fails to complete a rotation within a set time.

Effluent flows over the peripheral weirs. It is collected and flows to the filter feed pump station under gravity. A high level switch in the peripheral launders alarms blockages in the effluent pipework and shuts down the lift pump station.

Settling occurs at a rate that is dependent on the sludge thickness (MLSS) and the sludge settleability (e.g. stirred Sludge Volume Index or sSVI). Settleability can be converted to flux constants (Vo and n). These combine with MLSS to determine the rate of settling of the sludge blanket. The rate of settling of the sludge blanket must be greater than the rise rate in the clarifier, else clarification failure occurs and biomass is scoured into the effluent. Settling rates increase as MLSS decreases or sSVI decreases. The maximum flow that can be treated is therefore dependent on the MLSS and sSVI. The operator can reduce the DFTF at the lift pump station if the MLSS and sSVI conditions are poor, and vice versa.

The bioreactor bypass flow has very little influence on settling rates. This is because settling is limited by solids flux (kg/m^2/h) more than the rise rate (m/h). Because the bypass flow does not displace ML out of the bioreactors, the flux does not increase. However, the maximum flux limit does decrease slightly as the MLSS thins. Therefore, DSTF conditions are still limiting, if not by much. The bypass adds about half a metre to the clarifier diameter.

According to one dimensional flux theory, the sludge blanket level in the clarifier remains constant. It stays at the base of the central flocculation well. The combined effect of underflow velocity (liquid being drawn down by RAS pumping) and settling rate, means that the blanket is typically diluted to a concentration that is much less than the MLSS. It is only a thin layer at the base and centre of the clarifier that reaches RAS thickness. As more flux is applied to the clarifier (higher feed and RAS rates) then blanket does not rise, but rather thickens. This means there is more biomass in the clarifier and less in the bioreactors. This reduces the MLSS in the bioreactors, reducing the applied flux. Therefore, storage volume in the clarifiers (below the flocculation well) adds capacity safety. However, the reduction in MLSS in the bioreactors under high flow conditions reduces the mass of nitrifiers being aerated. This can cause ammonia spikes during high flow events during winter. Nevertheless, generous storage is an overall positive as it reduces the risk of catastrophic capacity failure. The side wall depth of the clarifiers is therefore generous.

Once the applied flux reaches the flux limit, the concentration of sludge in the clarifiers rises to the bioreactor MLSS. Then, and only then, should the blanket begin to rise above the bottom of the flocculation well. Eventually, the blanket will rise to near the effluent weirs where local velocities will scour it over the weirs. It is vital that the DFTF be reduced if this begins to occur. Loss of significant biomass to the effluent will rapidly foul the filters. The loss of biomass from the bioreactors will also lead to a medium term loss of performance.

5.9.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The clarifiers have been designed using single dimensional flux theory.
- The conversion factors used to convert sSVI to Vo and n (flux constants) are as published in Table 3.3 (Pitman $sSVI_{3.5}$) of the IAWQ publication entitled *Secondary Settling Tanks: Theory, Modelling, Design and Operation* by Ekama et al.
- The worst case sSVI reflects a sludge suffering from mild bulking.
- The maximum effluent flow under DFTF conditions is:
  - The sewage DFTF (3.0 ADWF for FSB mode and 4.5 ADWF for MLE mode), plus
  - The maximum odour control RE flow, plus
  - The maximum screen RE flow, plus
  - The maximum grit RE flow, plus
  - The maximum FWPS flow,
  - The maximum bioreactor RE flow.
- The maximum bypass flow is the difference between the DSTF and the DFTF (3.0 ADWF).
- The maximum effluent flow under DSTF conditions is the maximum effluent flow under DFTF conditions plus the maximum bypass flow.
- The maximum bioreactor MLSS is as calculated in Section 5.7.6.
- The clarifier diameter (see Section 5.7.6) was adjusted to just meet worst case design conditions.
- The worst case MLSS dilution under DSTF conditions is calculated by mass and flow balance.

See Table 5-11 for details.

5.9.5 Turndown and Redundancy

The clarifiers are provided in duty/duty configuration. Under MLE configuration, a DFTF of 2.25 ADWF can be accommodated with one secondary clarifier out of service. This is greater than PDWF. The DFTF falls to 1.5 ADWF under FSB configuration in winter. In warmer months, the MLSS can be reduced by reducing the sludge age. Therefore, a single clarifier can treat dry weather flows under most conditions. The operator simply reduces the DFTF cap at the lift pump station. Even under worst case conditions (maximum load, mid-winter, FSB mode) only a small volume will pass over inlet works overflow weir during the diurnal peak. It will be stored in SDP1 and can be returned later the same day.

Each clarifier mechanism is duty only. A clarifier can remain in service, even if the mechanism fails, but it may fail at a lower DFTF.

A clarifier may periodically need to be drained for mechanism maintenance or to replace the scrapers.

There are no analogue monitoring elements.

5.9.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-11. Worst case sizing is for the Future MLE scenario under Winter conditions.

Table 5-11 Secondary Clarifier Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Design sSVI	mL/g	100		
Alpha	m/h	14.88941		
Beta	g/mL	0.00808		
Gamma	L/g	0.22632		
Delta	L/mL	0.00264		
Clarifier SA Total	m^2	760		
Sewage ADWF	ML/d	4.620		
Maximum Odour Control RE	ML/d	0.018		
Maximum Screen RE	ML/d	0.950		
Maximum Grit RE	ML/d	0.562		
Maximum FWPS	ML/d	2.340		
Maximum Bioreactor Spray	ML/d	0.086		
Clarifiers		2		
Clarifier Inside Diameter Each	m	22.0		
Clarifier Side Wall Depth	m	4.0		
Flux Constant Vo	m/h		6.64	6.64
Flux Constant n	kg/m^3		0.49	0.49
Sewage DFTF	ADWF		3.00	4.50
Bioreactor MLSS	mg/L		3689	3011
DFTF Sludge Settling Rate	m/h		1.1	1.5
DFTF Solids Flux	$kg/m^2/h$		6.6	6.5

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Clarifier Overflow at DFTF	ML/d		17.817	24.747
Clarifier Overflow at DFTF	m/h		0.98	1.36
Clarification Capacity at DFTF			90%	90%
Sewage DSTF	ADWF		6.00	7.50
Solids Contact Flow	ML/d		13.860	13.860
DSTF Clarifier Feed MLSS	mg/L		2586	2225
DSTF Sludge Settling Rate	m/h		1.9	2.2
Clarifier Overflow at DSTF	ML/d		31.677	38.607
Clarifier Overflow at DSTF	m/h		1.7	2.1
Clarification Capacity at DSTF			93%	95%
Clarifier Overflow at DSTF	ML/d		31.677	38.607

It is apparent that the limiting condition is DSTF under the MLE configuration. The clarifier is sized to the nearest 0.5 m diameter, so there is a small spare capacity even under these conditions. There is greater spare capacity under DFTF conditions because the flux limit is slightly greater.

5.9.7 Control Philosophy

Each clarifier mechanism has a single, variable speed, peripheral drive. The drive speed is varied in the field only. An alarm is generated if this drive fails. A clarifier mechanism drive is also failed and latched the high torque switch or proximity (plough) switch is activated.

The clarifier bridge triggers a proximity switch (rotation) each time the mechanism completes a rotation. An alarm is generated if a rotation time out expires.

The high level switch within the clarified effluent launder raises an alarm and fails and latches the inlet and bypass pumps when activated.

5.10 Return Activated Sludge System

5.10.1 Purpose

The purpose of the Return Activated Sludge (RAS) system is:

- To extract settled and thickened biomass from the clarifiers and return it to the bioreactors.
- The control the thickness of the RAS to prevent thickening failure in the clarifiers.
- To balance the RAS flow evenly between the clarifiers to prevent premature capacity failure.
- To optimise RAS flow to reduce power consumption.

5.10.2 Equipment and Instruments

The RAS system consists of the following mechanical equipment and instruments.

- Four (4) variable speed RAS pumps (duty/standby duty/standby), two per clarifier.
- Two (2) RAS flow elements, one for each clarifier.
- Two (2) level switches, one for each RAS bund sump.

There are also two sump pumps, one for each RAS bund sump. These are self-contained, operating off local 240V power supplies. They are not connected to the SCADA.

5.10.3 Description

Each clarifier has a dedicated duty RAS pump plus an installed standby. These draw thickened ML from the centre base of the clarifiers and pump it via a common RAS rising main to the RAS chamber in the bioreactor splitter. There it is split and delivered back to the bioreactors.

The RAS pumps for each clarifier are located within a pit. These pits are necessary to ensure that there is a positive suction head on the pumps. A high level in either pit is alarmed. Each pit also contains a sump pump that can be used to pump stormwater to the stormwater system. In response to the high level alarm, the operator can start these pumps in the field. They will then operate until manually stopped or the level falls to a self-contained low level switch.

It is critical that the RAS flow from each clarifier is close to identical. If the RAS flow from one is less, then the rise rate will be greater and it will fail first. A 10% RAS flow discrepancy will lead to a 10% loss of plant capacity. This is why the RAS pipework and configuration from each clarifier is identical. A separate RAS flow element is also provided for each clarifier with the control system continuously balancing the underflow from each clarifier.

There is a maximum thickness that the RAS can achieve. This depends on the settlement conditions (sSVI). This maximum thickness and the MLSS dictates the minimum possible ratio between the RAS flow and bioreactor feed flow (known as the RAS recycle rate). A higher RAS recycle rate is acceptable. However, it does increase the power costs and the thickness of the sludge blanket in the clarifier sludge blanket. It is therefore desirable to keep the RAS rate close to the optimum RAS rate, but erring on the higher side. If the RAS rate is less than the required minimum then the clarifier will lose mass balance. There will be more solids entering the clarifier than leaving it. This will eventually result in the sludge blanket rising and being scoured over the weirs. This is referred to as thickening failure. Unfortunately, it looks identical to clarification failure, so it is difficult to diagnose which of the two is occurring.

There are three operating modes for the RAS pumps:

- Flow Paced Mode – The RAS flow remains proportional to the bioreactor feed flow.
- Speed Mode – The RAS pump speed remains proportional to bioreactor feed flow.
- Constant Flow Mode – The RAS flow remains constant.

Flow Paced mode reduces power costs and is the recommended operating mode. The RAS system reverts to Speed mode if either RAS flow element fails. The RAS system reverts to Constant Flow mode if the influent flow element fails. The operator can choose to use the backup influent flow profile and retain flow paced or speed mode. The RAS pumps can also be operated in manual at a constant speed.

There is a limit to the turndown on the RAS pumps. The pumps are sized for DFTF. They are unable to turn down to the ideal flow for ADWF or below. This means that the RAS recycle rate increases at low flow, resulting in a reduction in RAS thickness. This makes drawing waste activated sludge (WAS) from the RAS problematic as the thickness is always varying. It is not possible to tightly control the bioreactor sludge age if wasting from the RAS and therefore it is not recommended. However, the opportunity is provided in the design.

5.10.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The RAS pumping system has been designed using single dimensional flux theory.
- The conversion factors used to convert sSVI to Vo and n (flux constants) are as published in Table 3.3 (Pitman $sSVI_{3.5}$) of the IAWQ publication entitled *Secondary Settling Tanks: Theory, Modelling, Design and Operation* by Ekama et al.
- The worst case sSVI reflects a sludge suffering from mild bulking.
- The RAS system capacity has been set to the critical underflow rate rather than to the design duty point. The RAS pumping capacity is therefore proportional to the clarifier surface area rather than flows or other design conditions. This ensures that the RAS pumps can never be the capacity limitation on the bioreactors (clarification failure will always occur before thickening failure).
- The maximum bioreactor MLSS is as calculated in Section 5.7.6.

- The clarifier diameter (see Section 5.7.6) was adjusted to just meet worst case design conditions. The RAS pump size is proportional to clarifier size (critical underflow method).

See Table 5-12 for details.

5.10.5 Turndown and Redundancy

There are two sets of RAS pumps. Each clarifier has a dedicated duty and installed standby RAS pump. The failure of a single pump has no impact on capacity. The failure of both pumps for a single clarifier requires manual intervention. The clarifier must be manually isolated (within a few hours) until a pump can be repaired or replaced with the standby pump from the other clarifier.

If either RAS flow element fails then the control automatically switches to Speed mode. If the influent flow element fails then the control automatically switches to Constant Flow mode or the operator can adopt the backup influent flow and continue with Flow mode or Speed mode. The duty pumps can also be operated in manual at a constant speed.

There is a limitation on RAS pump turndown. This does not adversely impact process performance. It merely results in a small increase in RAS pumping power consumption over the day. The only way to rectify this minor deficiency would be to provide duty/assist/standby pumps for each clarifier. The increase in capital cost and control complexity is not considered warranted.

5.10.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-12. Worst case sizing is based on critical underflow which is independent of the scenario. The ideal operating conditions change with scenario (Winter is worst case).

Table 5-12 Return Activated Sludge Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Design sSVI	mL/g	100		
Alpha	m/h	14.88941		
Beta	g/mL	0.00808		
Gamma	L/g	0.22632		
Delta	L/mL	0.00264		
Duty RAS Pumps		2		
RAS Pumps at ADWF		2		
Target RAS Pump Turndown	of Max	40%		
Bioreactor Feed at ADWF	ML/d		5.650	5.732
Critical RAS Thickness	mg/L		8,158	8,158
Critical Underflow	m/h		0.90	0.90
Required RAS Capacity	m^3/h		683	683
RAS Pumps Each	L/s		94.8	94.8

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Ideal RAS Recycle Rate			0.83	0.59
Minimum RAS Flow Total	L/s		75.9	75.9
ADWF RAS Flow	ML/d		6.556	6.556
RAS Rate at ADWF			1.16	1.14
Bioreactor MLSS	mg/L		3689	3011
DFTF RAS Flow	ML/d		14.705	14.478
DFTF RAS Flow	L/s		170.2	167.6
RAS Capacity at DFTF	mL/g		90%	88%

It is apparent that the RAS capacity will never be limiting. This is desirable to ensure that the clarification capacity (size of the clarifiers) can be fully utilised regardless of conditions.

The RAS recycle rate under ADWF conditions is greater than the ideal RAS recycle rate. There is no adverse impact on process, merely pumping power and energy use. However, it means that the RAS concentration will vary even if RAS flow paced control is adopted. This reduces the accuracy of sludge age control if WAS is drawn from the RAS rather than the ML.

5.10.7 Control Philosophy

There are two dedicated RAS pumps for each clarifier. These operate in duty/standby configuration. The operator can select the duty allocation (2 off) in the SCADA. The failure of a duty pump results in it being allocated as standby. The SCADA will automatically change the duty after a duty change duration has expired.

There is a common no-flow set point for the RAS flow. An alarm will be generated and the corresponding pump will be failed and latched if the measured flow is below the no-flow set point on a pump that has been running for more than its no flow delay period.

The speed of each pump is limited between Maximum Pump Speed and Minimum Pump Speed set points, regardless of the control mode.

Since the clarifiers operate at a constant level, there are no level elements. There is no dry cut-out protection for the RAS pumps. The operators must take care when emptying an isolated clarifier using the RAS pumps.

The RAS main from each clarifier is fitted with a flow element. This is used for monitoring and can also be used for control of the RAS pumps (Flow Paced or Constant Flow modes only). The real time flow, integrated volume today and integrated volume yesterday are calculated, displayed and recorded for each clarifier and in total.

There are three possible control modes for the RAS pumps:

- Flow Paced Mode – The bioreactor rolling average feed flow is calculated constantly by added the foul water flow to the influent flow. This is multiplied by the RAS recycle rate set point to produce a RAS flow target. This is divided by the number of operating clarifiers to produce a RAS flow target for each clarifier. Each duty RAS pump modulates to try to achieve this RAS flow target (proportional integral derivative, or PID loop). If a RAS flow element fails then the control reverts to Speed mode. If the influent flow element fails then the control reverts to Constant Flow mode. Alternatively, the operator can select to use the backup influent flow profile and continue to use Flow Paced or Speed mode.
- Speed Mode – The bioreactor rolling average feed flow is calculated constantly by added the foul water flow to the influent flow. This is multiplied by the RAS speed rate set point to produce a RAS speed target. This is divided by the number of operating clarifiers to produce a RAS speed target for each clarifier. Each duty RAS pump operates at the target speed. If the influent flow element fails then the

control reverts to Constant Flow mode. Alternatively, the operator can select to use the backup influent flow profile and continue to use Speed mode.

- Constant Flow Mode – The operator sets a total RAS flow. This is divided by the number of operating clarifiers to produce a RAS flow target for each clarifier. Each duty RAS pump modulates to try to achieve this RAS flow target (PID loop). If a RAS flow element fails then the control reverts to Speed mode.

The operator can also operate the RAS pumps in manual by turning each duty RAS pump on and manually setting a fixed speed.

Both clarifiers must operate under the same mode to ensure an equal RAS flow split between the clarifiers.

There is a high level switch in each RAS pumping station bund sump. An alarm if generated if either level switch is activated.

The sump pumps are not connected to the SCADA. These are manually operated in the field with no monitoring or alarms.

5.11 Scum System

5.11.1 Purpose

The purpose of the scum system is:

- To capture scum and foam and prevent it entering the secondary effluent.
- To extract scum from the clarifiers and deliver it to the digester or lift pump station.

5.11.2 Equipment and Instruments

The scum system consists of the following mechanical equipment and instruments.

- One (1) fixed speed scum pump (duty only).
- One (1) scum flow element.
- Three (3) scum pump station level switches.

5.11.3 Description

From time to time, scum and foam can form of the surface of the secondary clarifiers. Foaming is typically linked to filamentous sludge bulking. Each clarifier has a fixed scum baffle that prevents scum and foam from overflowing the weirs into the secondary effluent.

Each clarifier mechanism has a surface scum skimmer that rotates with the mechanism. It sweeps the scum to the periphery of the clarifier. Each clarifier has a number of scum boxes. These have beaches that lead to a dry scum box. The scum skimmer pushes the floating scum over the dry beach and into the box. The skimmer then mechanically triggers a flush of water from the clarifier surface into the scum box. This flushes the scum down a gravity main to the scum pump station.

There is a single scum pump station that services both clarifiers. This is a simple pump station with a single duty pump and three level switches (start, stop and dry). The fixed speed scum pump operates according to these level switches to drain the scum pump station. The scum can be pumped to the aerobic digester or to the lift pump station if the digester is out of service. The destination is set by the operator using manual valves.

The coping level of the scum pump station is above the TWL of the clarifiers and at the same height as the external launders. Therefore, the scum pump station cannot overflow. If the scum pump fails then scum will fill the pump station and back up into the scum boxes, preventing extraction.

A time out alarm is generated if the scum pump operates for longer than an operator adjustable timer. This indicates that a scum box could be leaking. The scum pump fails under such conditions.

The scum from each clarifier can be isolated using manual valves. This allows the scum pump station to be isolated and drained for maintenance.

There is a scum flow element. This flow meter is used for no-flow detection and to record the daily scum volume (which should be constant day to day). This daily scum volume assists the operator to set the desired thickened WAS volume to achieve the desired digester sludge age (see Section 5.15).

5.11.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The number and volume of the scum boxes has been based on the clarifier diameter and experience.
- The clarifier mechanism rotation time is based on clarifier diameter and experience.
- The storage time in the scum pump station is based on response time.
- The scum pump size has been selected based on the smallest viable pump.
- The scum solids are ignored in the process model. It is modelled as the liquid phase only

See Table 5-13 for details.

5.11.5 Turndown and Redundancy

There is a single duty scum pump. The failure of the scum pump does not result in overflow and has very little process consequence. The scum pump station provides sufficient storage volume to rectify a fault or replace with a standby pump in store.

The failure of the scum flow element has no material impact on control. There is no scum turndown. Scum volume is constant regardless of conditions. The scum pump power draw is very small.

5.11.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-13. There is no difference between scenarios.

Table 5-13 Scum System Process Sizing

	Units	Process Design Assumptions	Process Design Sizing
Scum Box Volume Each	L	50	
Scum Boxes per Clarifier		2	
Clarifiers		2	
Rotation Time Each	min	30	
Scum Drain Each	L/s	25.0	
Duty Scum Pumps		1	
Scum Pump Each	L/s	1.0	
Scum Storage	h	4	
Scum Tanks		1	
Active Volume		80%	
Scum Drain Total	L/s		50.0
Scum Volume Total	ML/d		0.010
Max Scum Flow	L/s		1
Scum Pump Operation	h/d		2.7
Minimum Scum Tank Volume Each	m^3		2.0

5.11.7 Control Philosophy

There is a single duty, fixed speed scum pump.

There is a scum flow element. The instantaneous scum flow, integrated volume today (since midnight) and integrated volume yesterday (midnight to midnight) are calculated, displayed and recorded. There is a no-flow set point. An alarm will be generated and the pump will be failed and latched if the flow is below the no-flow set point after the pump that has been running for more than its no flow delay period.

There are three flow switches in the scum pump station. If the level rises to the high level switch then the pump will start. If the level falls to the low level switch then the pump will stop. If the level falls the low low switch then an alarm is generated and the pump will fail and latch.

If the pump operates for longer than a time out set point then an alarm is generated and the pump will fail and latch.

5.12 MLR Pumping System

5.12.1 Purpose

The purpose of the mixed liquor recycle (MLR) pumping system is:

- To return NO_x-N from the de-aeration zone to the primary anoxic selector for denitrification.
- To match the amount of oxidised nitrogen returned to the incoming substrate so as to optimise denitrification.

5.12.2 Equipment and Instruments

The MLR pumping system consists of the following mechanical equipment and instruments.

- Six (6) variable speed MLR pumps, three per bioreactor.
- Two (2) primary anoxic zone oxygen reduction potential (ORP) elements, one per bioreactor.

5.12.3 Description

The MLR pumps transfer nitrate from the primary aerobic zone, via the de-aeration zone, to the primary anoxic zone. The discharge to the anoxic zone mixes the MLR with the incoming bioreactor feed and RAS. The biodegradable carbon in the feed promotes rapid denitrification, converting the nitrate to nitrogen gas. Biodegradable carbon (future) can also be dosed to the primary anoxic zone to increase the denitrification potential and performance. Denitrification consumes the soluble biodegradable substrate, preventing it from reaching the aerobic zone. This is known to reduce the risk of filamentous bulking and poor settleability.

It is important to achieve full denitrification (near zero NO_x-N) conditions in the primary anoxic zone. If the nitrate concentration bleeding from the primary anoxic zone to the primary aerobic zone is high, then filamentous bulking can occur. Ideally, the NO_x-N concentration should be measurable but low (0.1 to 0.5 mg/L) in the primary anoxic zone. NO_x-N (mainly NO_3-N or nitrate) is difficult to measure in real time. Oxygen reduction potential (ORP) can be used as a surrogate. The presence of nitrate results in a small, negative ORP (-150 to -200 mV). Once nitrate is depleted, the ORP will fall below this. The MLR pumping should be adjusted to maintain the ORP in the ideal range. The ORP elements are used for monitoring and alarming only. They are not used to control the MLR directly. Instead, the operator should adjust the MLR pumping set points to optimise the ORP and denitrification.

If the MLR is insufficient, then NO_x-N will be depleted before the end of the primary anoxic zone. This wastes the available denitrification potential, resulting in elevated TN in the effluent. If the MLR is too high, then the denitrification potential will be fully utilised. However, the higher than necessary MLR flow also returns more DO than necessary. This DO cuts into the denitrification potential, also resulting in elevated effluent TN. However, this has less impact than under-recycling.

It is desirable to change the MLR flow proportionally to feed flow to match nitrate return to incoming substrate. Therefore, the typical operating mode is to flow pace the MLR to the bioreactor feed. A typical influent flow profile is used as a backup if the influent flow element fails. A speed profile mode is also provided as a backup.

The denitrification potential of the primary anoxic zone changes significantly with temperature, increasing in summer and decreasing in winter. Therefore, the MLR rate should be adjusted frequently in response to temperature changes. As the effluent NO_x-N falls (e.g. in summer or due to carbon dosing to the primary anoxic zone), the MLR rate must increase exponentially. There is a limit to practical pumping capacity. The maximum MLR rate has been set to achieve the worst case effluent TN requirement. It may not be possible to fully load the primary anoxic zone with NO_x-N in summer, but there is no adverse process consequence. The required effluent TN will still be bettered.

There are dedicated MLR pumps for each bioreactor. These are in duty/assist/assist configuration providing significant turndown. It is possible to operate with one assist pump out of service, but this may compromise denitrification slightly, but typically only in summer.

There are two modes of MLR control.

- Speed Paced Mode – The speed and number of MLR pumps change with bioreactor feed flow.
- Speed Profile Mode – The speed and number of the MLR pumps change throughout the day.

Denitrification also occurs in the secondary anoxic zone (FSB configuration only). Since all sewage substrate has been consumed before reaching the secondary anoxic zone, the rate of denitrification is very low. To counter this, carbon dosing is required. There is less need for denitrification tuning in the secondary anoxic zone. A slight overdose of carbon will ensure complete denitrification. Any excess carbon will be rapidly removed in the secondary aeration zone.

The MLR pumps have non return valves on their discharge. These can be raised and lowered for inspection and maintenance. A stick indicator above water level indicates valve operation in the field.

5.12.4 Design Assumptions

The following assumptions have been adopted for the process design.

- Denitrification has been determined through default steady state kinetics.
- Optimum MLR recycle under MLE mode has been based on the standard generic polynomial equation in *Biological Wastewater Treatment*. The clarifier sludge blanket, selector zone, de-aeration zone and primary anoxic zone are all assumed to act as one primary anoxic zone. This is valid provided that nitrate in the RAS is not fully depleted in the clarifier sludge blanket or selector. This was confirmed in the model.
- Optimum MLR recycle under FSB mode was based on a generic polynomial equation specifically developed for this project. This has the same assumption as above, plus the assumption that complete denitrification occurs in the secondary anoxic zone. Both were confirmed during modelling.
- Carbon dosing (if required) was optimised through model iteration.
- The target effluent quality used to calculate the carbon dose under the MLE configuration was a TN of 6 mg/L in Winter and 4 mg/L under Typical and Summer conditions. Carbon dosing was found not to be needed in summer.
- The TN effluent quality under the FSB scenarios was the minimum possible.
- The MLR pumps were sized to exceed the MLR flow (recycle rate) necessary to meet a TN of 4 mg/L under MLE mode. This falls short of the MLR flow required to optimise denitrification in summer. Optimising summer denitrification (doing better than required) leads to impractically sized MLR pumps.
- Denitrification during typical temperature conditions is sufficient to meet 50%ile NorBE TN targets.

See Table 5-14 for details.

5.12.5 Turndown and Redundancy

There are three MLR pumps per bioreactor. These operate as duty/assist/assist. The failure of one MLR pump could lead to some loss of denitrification, but TN limits should still be able to be met under most conditions. The MLR capacity may be insufficient during peak diurnal loading periods, but the impact on effluent quality should be minimal. A reduction in denitrification does not result in adverse process conditions.

The failure of the influent flow element results in the MLR pumps switching to Speed Profile control. MLR pumping will continue to occur. The operator can choose to use the backup influent flow profile and continue to use Flow Paced mode.

The failure of the ORP analysers has no effect on the process or automated control.

The use of duty/assist/assist pumps increases the turndown. Operating the MLR pumping system higher than necessary (winter and low flow) has little impact on power (low head) and only a minor impact on the process (slightly higher effluent TN). Therefore, the turndown should be sufficient for all scenarios.

5.12.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-14.

Table 5-14 MLR Pumping Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
MLR Pumps		6		
Min MLR Pumps		2		
MLR Pumps Each	L/s	160.0		
MLR Turndown	of Max	50%		
Feed & Spray	ML/d		5.650	5.732
Max MLR Total	L/s		960.0	960.0
Min MLR Total	L/s		160.0	160.0
Maximum MLR Rate	:1		14.7	14.5
Typical MLR Rate(1)	:1		14.7	14.5
Minimum MLR Rate	:1		2.4	2.4

Note (1) – The Typical MLR rate is the optimised recycle rate under Typical temperature conditions.

The denitrification performance of each option under each seasonal condition was modelled in detail. The myriad of assumptions (many of which cannot be confirmed) makes denitrification predictions prone to error. The performance predictions should be seen as a guide only. However, the operational flexibility and process head room provided in the design suggests that the worst case NorBE targets should be able to be net provided carbon dosing occurs in the future. The predictions in Table 5-15 are for typical temperature conditions and represent NorBE (annual 50%ile) conditions.

Table 5-15 Denitrification Predictions

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Temperature	°C	20		
Overall COD:N Ratio		7.92		
NO_x-N:O Ratio		2.86		
Active Mass	kgVASS		3616	3530
Selector Fraction			2.0%	2.0%

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Primary Anoxic COD Dose	mg/L		0	29
SBCOD Entering Selector	kgCOD/d		581	747
Selector Denitrification Potential	kgN/d		57	55
DO-N Entering Selector	kgN/d		1	1
NO_x-N Entering Selector	kgN/d		5	9
NO_x-N Removed in Selector	kgN/d		5	9
Primary Anoxic Fraction			38.3%	38.3%
SBCOD Entering 1st Anoxic	kgCOD/d		581	720
1st Anoxic Denit Potential	kgN/d		206	221
DO-N Entering 1st Anoxic	kgN/d		37	44
NO_x-N Entering 1st Anoxic	kgN/d		169	177
NO_x-N Removed in 1st Anoxic	kgN/d		169	177
Optimum MLR Recycle Rate			12.1	13.5
NO_x-N Entering 1st Aerobic	kgN/d		0	0
NO_x-N Created in 1st Aerobic	kgN/d		200	205
NO_x-N Entering De-Aeration	kgN/d		169	177
NO_x-N Not Recycled in MLR	kgN/d		30	28
DO in 1st Aerobic	mg/L		2.0	2.0
Secondary Anoxic Fraction			8.8%	8.8%
Secondary Anoxic COD Dose	mg/L		24	0
SBCOD Entering 2nd Anoxic	kgCOD/d		135	0
2nd Anoxic Denit Potential	kgN/d		39	0
DO-N Entering 2nd Anoxic	kgN/d		9	0
NO_x-N Entering 2nd Anoxic	kgN/d		30	0
NO_x-N Removed in 2nd Anoxic	kgN/d		30	0
NO_x-N Entering 2nd Aerobic	kgN/d		0	0

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
NO_x-N Created in 2nd Aerobic	kgN/d		9	0
NO_x-N Leaving 2nd Aerobic	kgN/d		9	0
DO in 2nd Aerobic	mg/L		4.0	0.0
De-Aeration Fraction			4.3%	4.3%
De-Aeration Denitrification Potential	kgN/d		11	10
DO-N Entering De-Aeration	kgN/d		48	54
DO Removed in De-Aeration	kgN/d		11	10
DO Leaving De-Aeration	kgN/d		37	44
DO in De-Aeration	mg/L		1.6	1.6
NO_x-N in De-Aeration	mg/L		2.5	2.3
Clarifier Fraction			4.9%	4.9%
RAS Recycle Rate			1.2	1.1
RAS Denitrification Potential	kgN/d		13	12
DO-N Entering RAS	kgN/d		9	5
NO_x-N Entering RAS	kgN/d		5	15
NO_x-N Removed in RAS	kgN/d		4	8
NO_x-N Leaving RAS	kgN/d		1	7
DO in RAS	mg/L		0.0	0.0
NO_x-N in RAS	mg/L		0.1	1.1
Nitrification Capacity	kgN/d		208	205
NO_x-N in Feed	kgN/d		4	2
NO_x-N Denitrified	kgN/d		208	194
NO_x-N in Effluent and WAS	kgN/d		4	13
NO_x-N Denitrified			98%	94%
TN in Effluent	mg/L		2.5	4.0
NO_x-N in Effluent	mg/L		0.7	2.3

Once carbon is added, the seasonal NO_x-N performance does not vary. All that occurs is that the carbon dose needs to increase in winter and decrease in summer. The exception is for the MLE option. The carbon dose must increase unreasonably to meet an effluent TN of 4 mg/L in winter. This is because the NH_x-N is so high, making the NO_x-N unachievable with a single anoxic zone. The modelled TN performance in the Winter FSB scenarios is just higher than 4.0 mg/L due to the conservatism in steady state effluent NH_x-N predictions. The NH_x-N performance is likely to be significantly better than the modelled predictions. This is because the bioreactors include baffled aeration cells creating plug flow conditions (little short-circuiting of NH_x-N).

The performance of the MLE option with no carbon dosing was shown to be a TN range of around 4.0 to 11.0 mg/L (summer to winter), with a typical annual average of less than 6 mg/L. The actual winter performance is likely to be better than this as the NH_x-N concentration is likely to be significantly better than that predicted by steady state kinetics due to the plug flow within the aerobic zone. The NO_x-N in the effluent is predicted to be 7 mg/L in winter without carbon dosing. Therefore the winter TN performance should be less than 9 mg/L. These predictions better the current licence conditions suggesting that carbon dosing could be deferred unless or until NorBE targets are imposed. However, given the inherent uncertainty of denitrification performance predictions, including carbon dosing facilities would be a low cost and low risk strategy. Constructing carbon dosing is relatively inexpensive. Operating carbon dosing, however, is relatively expensive.

5.12.7 Control Philosophy

Three MLR pumps in each bioreactor operate in duty/assist/assist configuration. The operator can select the duty allocation (6 off) in the SCADA. The failure of a duty or assist pump results in it being allocated as standby and the next available allocation (2 off) being selected by the SCADA. The SCADA will automatically change the duty to the next available allocation each time the time out expires.

The speed of each pump is limited between Maximum Pump Speed and Minimum Pump Speed set points, regardless of the control mode.

There are two possible control modes for the MLR pumps:

- Speed Paced – The rolling average bioreactor feed flow is converted to a total MLR speed. The operator sets a minimum feed flow and minimum MLR flow, plus a maximum feed flow and maximum MLR speed. If the feed flow is less than the minimum then the minimum MLR speed is adopted. If the feed flow is greater than the maximum flow then the maximum MLR flow is adopted. If the feed flow is between the minimum and maximum flows then the MLR speed is interpolated. The speed target is divided by the number of operating bioreactors. The MLR speed per bioreactor then determines the number of pumps and the speed of each pump. If the influent flow element fails then Speed Profile mode is selected. The operator can also select to use the backup influent flow profile and then continue to run in Speed Paced mode.
- Speed Profile Mode – The operator sets the total MLR speed for each hour of the day. The speed target for that time of day is divided by the number of operating bioreactors. The MLR speed per bioreactor then determines the number of pumps and the speed of each pump.

The MLR pumps can also be operated in manual with the operator setting a fixed speed of each pump.

Each bioreactor primary anoxic zone is fitted with an ORP element. These are monitored continuously. They are not used for control but can be used for alarming. ORP alarms apply regardless of the MLR pump control mode. An alarm will be generated if the ORP increases above a high level or falls below a low level for greater than a delay time. There is no automated response to these alarms. The ORP is monitored in real time. The average ORP for today and yesterday is also recorded.

5.13 Aeration System

5.13.1 Purpose

The purpose of the aeration system is:

- To provide dissolved oxygen (DO) to the bioreactors to:
    - Support the biological breakdown of BCOD and synthesis of normal heterotrophic organisms (NHOs).
    - Support biological nitrification (oxidation of ammonia) and synthesis of nitrifiers.

- Support the respiration and endogenous decay of the biomass.

- To optimise the supply of aeration to minimise energy demand and maximise denitrification.
- To control the DO in various zones to optimise nitrification and denitrification.
- To alarm DO conditions that may adversely affect performance.
- To mix the aerobic zones of the bioreactors.

5.13.2 Equipment and Instruments

The aeration system consists of the following mechanical equipment and instruments.

- Three (3) variable speed blowers in duty/assist/standby configuration.
- Three (3) low pressure switches, one for each blower suction.
- Three (3) high pressure switches, one for each blower discharge.
- Three (3) high temperature elements, one for each blower discharge.
- Three (3) low flow switches, one for each blower discharge.
- One (1) pressure element on the common air main.
- One (1) temperature element on the common air main.
- Two (2) flow elements, one for each bioreactor.
- Two (2) fixed speed exhaust fans on the blower building.
- One (1) high temperature switch in the blower building.
- One (1) temperature switch in the switch room.
- Six (6) air control valves, three for each bioreactor.
- Six (6) position elements, one for each air control valve.
- Six (6) DO elements, three for each bioreactor.

5.13.3 Description

Maintaining optimum DO in the aerobic zones of the bioreactors is critical to performance. A DO above 2 mg/L wastes power and does little to improve performance. A DO below 1.5 mg/L inhibits (slows) nitrification. Nitrification effectively stops below 0.5 mg/L. A high DO, especially near MLR suction, reduces denitrification effectiveness. Operating at a slightly low DO at the start of the primary aerobic can help trim effluent NO_x-N through aerobic denitrification. These competing requirements favour tight zone control of DO. For example, the ideal may be to have a DO of 1.0 mg/L at the start of the primary aerobic zone, rising to 1.5 mg/L at the end of the primary aerobic zone, then rising again to 2.0 mg/L at the secondary aerobic zone. These DO set points can be reduced in summer to reduce power and trim effluent TN, then increased in winter to ensure full nitrification (low effluent NH_x-N).

The aeration zones of the bioreactors are fitted with diffused aeration grids fed by blowers (duty/assist/standby). The diffuser grids are removable. The aeration zones are aerated continuously.

There are three separate DO control zones in each bioreactor. Two are in the primary aerobic zone. One is in the secondary aerobic zone. There is an air control valve and DO element for each zone (three for each bioreactor and total of six). These air control valves modulate to try to maintain the rolling average DO at the desired set point. These set points remain constant. The valves open as the DO demand increases and close as the DO demand decreases. Each DO zone is thus controlled individually and precisely.

There is a spare DO element available in store. There is a spare plug in point at each installed DO element location. The spare DO element can be temporarily installed in any of the six locations and used to verify the DO in that location. Field readings can be compared. However, the DO reading from the temporarily mounted DO element is not transmitted to the SCADA.

The blower(s) operate to achieve a pressure set point in the common air main. As the valves open, the pressure drops and the blower(s) speed up to compensate. This is a simple system with a pressure PID loop for the blowers and DO PID loop for each valve.

There is a risk that valves can slowly close over time, artificially increasing the blower pressure and wasting energy. To avoid this, the 'most open valve' control loop can be enabled. This continuously looks at the most open of the six valves. The blower pressure set point is then adjusted on a slow PID loop to try to maintain the most open valve at an open position target. That way at least one valve is almost fully open at all times and the blower pressure is maintained as low as possible to save power.

A rolling average function is applied to each DO element to smooth out the signal for alarming and valve control. Alarms are generated if the DO falls too low or rises too high in any element.

There are two modes of blower control.

- Pressure Control – The duty blower(s) speed modulates to try to maintain the pressure target.
- Speed Profile Control – The speed of the blower(s) is set by the operator for 30 minute increments.

The control system automatically switches to speed profile control if the pressure elements fails.

The air suction to the blowers is monitored with a low pressure switch. This will generate an alarm indicating that the air filter needs cleaning or replacing. The discharge pipework of each blower is also fitted with high pressure, high temperature and low flow switches. Activation of any of these switches will generate an alarm and fail the respective blower.

The common air discharge from the blowers is monitored for temperature and pressure. The air main to each bioreactor is fitted with a flow element. The flow, temperature and pressure are converted to normal air flow for each bioreactor for the purpose of monitoring.

Exhaust fans on each blower acoustic enclosure operate when the respective blower operates. The fans are driven from a coupling to the main blower motor. Exhaust fans in the blower building operate based on the internal building temperature in accordance with a temperature switch. There is also a high temperature switch within the switchroom for alarm purposes only.

5.13.4 Design Assumptions

The following assumptions have been adopted for the process design.

- A COD balance is used to determine the average carbonaceous oxygen demand.
- Default steady state kinetics are used to determine the endogenous decay component.
- The difference is assumed to be the synthesis component.
- Chemistry is used to determine the average nitrification oxygen demand.
- Denitrification was determined from first principals using default steady state kinetics.
- Chemistry is used to determine the average denitrification oxygen payback.
- Oxygen entering the reactor (feed and spay) is used to determine additional payback.
- Oxygen leaving the reactor (effluent, scum and WAS) is used to determine additional demand.
- Load peaking is assumed to be the PDWF:ADWF ratio.
- Load peaking is applied to PBCOD synthesis, nitrification and denitrification.
- Flow peaking is assumed to be DFTF:ADWF.
- Flow peaking is applied to DO entering and leaving the bioreactors.

See Table 5-16 for details.

5.13.5 Turndown and Redundancy

The blowers are provided in duty/assist/standby configuration. The peak demand for the worst case scenario (Future FSB Summer) can be provided if one blower is failed. The average demand for Future loading can probably be supplied with two blowers failed, but ammonia breakthrough could occur during peak loading periods. This could be accommodated by reducing the DFTF at the lift pump station and utilising SDP1 as a sewage balance tank.

The system is designed to treat the worst case future load with both bioreactors in service. If one bioreactor is out of service, then there may be insufficient diffusers to transfer the required oxygen to one bioreactor for some of the day. Once again, ammonia breakthrough may occur, but can be offset by using SPD1 as a sewage balance tank.

There are multiple, removable diffuser grids in each bioreactor.

DO control can be sustained even if some DO elements fail. A different DO element and set point can be used to control the effected valve. Alternatively the valve position can remain open and fixed, with all others modulating. The failure of two DO elements in one bioreactor can be ameliorated by transferring one from the other bioreactor or using the spare in store.

Blower speed profile mode can be used as a backup if the air pressure element fails.

The flow, pressure and temperature elements are used for monitoring and alarming. The aeration system can continue to operate with any or all of these failed.

The turndown available will be dependent on the equipment supplied. However, turndown should be to around 20% of peak demand. Average demand for Current loading is around 50% of the peak demand under Future loading. Therefore aeration should be continuous under all conditions without the DO becoming excessive.

5.13.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-16. Worst case sizing is for the Future Summer FSB scenario. The winter scenarios have a slightly greater actual oxygen uptake rate (AOR) due to reduced denitrification performance, but this is offset by improved oxygen transfer under colder conditions.

Table 5-16 Aeration Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB Summer)	Process Design Sizing (Future MLE Summer)
Load Peaking Factor	:1	2		
Bioreactor Blowers		2		
Temperature	°C		28	28
Bioreactor MLSS	mg/L		3494	2786
Oxygen in Effluent and WAS	mg/L		4.0	2.0
NO_x-N in Effluent and WAS	mg/L		0.7	2.2
Oxygen in Feed and Spray	kgN/d		1.4	0.8
Carbonaceous O_2 Demand	kgO/d		1801	1692
Nitrification O_2 Demand	kgO/d		966	963
Denitrification O_2 Payback	kgO/d		612	581
Oxygen in Effluent and WAS	kgN/d		7.9	4.0
Average AOR	kgO/d		2173	2083
Aeration Peaking Factor	:1		1.44	1.45
Peak AOR	kgO/d		3124	3028
Bioreactor Peak AOR	kgO/h		130	126
Blower Peak AOR Each	kgO/h		65.1	63.1
Aeration Alpha Factor (including fouling allowance)			0.55	0.55
Aeration Beta Factor			0.95	0.95
Average DO Target	Mg/L		1.5	1.5

	Units	Process Design Assumptions	Process Design Sizing (Future FSB Summer)	Process Design Sizing (Future MLE Summer)
Bioreactor Maximum SOTR	kgO/h		330	320
Bioreactor Minimum SOTR	kgO/h		80	77
Aerobic Zone 1 Aeration Requirement	% of Total		81	91
Anoxic Zone 2 Aeration Requirement	% of Total		13	0
Aerobic Zone 2 Aeration Requirement	% of Total		6	9

SOTR determined based on ASCE "Measurement of Oxygen Transfer in Clean Water)

5.13.7 Control Philosophy

Three blowers operate in duty/assist/standby configuration. The operator can select the duty allocation (6 off) in the SCADA. The failure of a duty or assist blower results in it being allocated as standby and the next available allocation (2 off) being selected by the SCADA. The duty will change automatically once the duty time has expired.

There are six DO elements. The real time DO and a rolling average DO for each is monitored and displayed. The average DO for each DO element for today and yesterday is also calculated. Each of the six DO elements has a separate DO target and a DO deadband. An alarm is generated if the rolling average DO is higher than the DO target plus the deadband or lower than the DO target minus the deadband for more than a DO alarm delay time.

There are six aeration control valves. Each control valve uses one DO element for control. The operator can assign any valve to any DO element. If two valves are assigned to the one DO element then their positions remain identical. If a DO element fails then any valves using it for control will retain their current position unless or until allocated a new DO element for control. Each valve modulates to try to maintain the rolling average DO at the DO target.

There are a number of switches that detect conditions that could damage the equipment. The following alarms apply.

- Blower failed (fail and latch respective blower).
- Blower suction pressure low (fail and latch the respective blower).
- Blower discharge pressure high (fail and latch the respective blower).
- Blower discharge temperature higher than maximum set point (fail and latch the respective blower).
- Blower discharge temperature element failed (fail and latch the respective blower).
- Blower no flow (fail and latch the respective blower).

There are two blower room exhaust fans in duty/duty configuration. If the temperature is sustained above a high temperature switch for more than a delay time, then both fans will start. If the temperature is sustained below this temperature for more than a delay time then both fans stop.

There is also an exhaust fan on each blower acoustic enclosure. These are operated from a direct connection to the blower drive and operate whenever the respective blower operates. There are no separate controls, monitoring or alarms on these blower fans.

There is a temperature switch in the switchroom. This generates an alarm but there is no automated response.

The pressure and temperature in the common air main are monitored continuously. The flow elements in each bioreactor main (2 off) are also monitored continuously. These flows are converted to normalised air flow in the SCADA. Each of these normalised air flows is integrated to provide a normalised air volume for the current day (since midnight) and the previous day (midnight to midnight). An alarm is generated if the differential between the normalised air flows exceeds an alarm value.

There are two possible control modes for the duty blowers. These are:

- Pressure Mode – The blower(s) speed modulates to try to sustain the pressure target in the common pressure main.
- Speed Profile Mode – A speed profile (one hour increments) is set by the operator for a 24 hour period. The blower(s) speed matches the speed set point for that time of day.

Pressure Mode relies on the pressure element in the common air main. The failure of the pressure element results in the control switching to Speed Profile mode. The operator can also select Speed Profile mode.

There is an optional addition to the Pressure Mode called Most Open Valve control. If selected by the operator, the SCADA constantly scans the air valve positions to determine the most open valve. The SCADA adjusts the blower pressure target (slow PID loop) to try to maintain the most open valve at the target open valve position. If this option is not selected, then the target blower pressure remains constant.

5.14 Bioreactor Mixing

5.14.1 Purpose

The purpose of bioreactor mixing is:

- To keep the biomass in the anoxic zones in suspension.
- To mix biomass, oxidised nitrogen and food to assist denitrification in the anoxic zones.

5.14.2 Equipment and Instruments

The bioreactor mixing system consists of the following mechanical equipment and instruments.

- Two (2) fixed speed, reversible selector zone mixers, one per bioreactor.
- Six (6) fixed speed, reversible primary anoxic zone mixers, three per bioreactor.
- Four (4) fixed speed, reversible secondary anoxic zone mixers, two per bioreactor.
- Two (2) fixed speed, reversible de-aeration zone mixers, one per bioreactor.

The aeration equipment detailed in Section 5.13.2 is also used for mixing of the aerobic zones.

5.14.3 Description

The anoxic zones of each bioreactor are mixed continuously. Mixing is provided by seven mixers in each bioreactor, one in the selector zone, three in the primary anoxic zone, two in the secondary anoxic zone and one in the de-aeration zone. The mixers in the secondary anoxic zone and de-aeration zone are the same size and interchangeable. Mixing is also provided in the aerobic zones by the aeration system.

All mixers operate continuously. The exception are the mixers in the secondary anoxic zone. They operate continuously in FSB mode and do not operate in MLE mode. There is no mixer control system. They are simply turned on or off manually. Drive failure is alarmed. Each mixer can be removed, without draining the bioreactor, for inspection, cleaning or maintenance. The mixer motor direction can be reversed in the field to help clear rags and other debris.

The direction of the mixers can be manually adjusted in the field. They can be rotated through a vertical axis without lifting them and their vertical angle can also be adjusted by lifting them. Operators can periodically rotate them to resuspend any settle solids in corners or other dead zones. This is not essential and settled solids do not compromise performance and will find their own natural benching.

Mixer directions and angles should be adjusted to best mix each zone. Surface turbulence should be minimised to reduce oxygen transfer from the surface.

There is no dry cut out level detection. Mixers can (and should) be operated as a bioreactor is drained but should be switched off manually once the level risks dry operation.

5.14.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The mixing energy required is based on 'rule of thumb' defaults. For the purposes of electrical design Final mixer selection will be undertaken by the supplier in accordance with the Process Specification.

The aerated mixing criteria was checked by Hunter H_2O using alternative methods based on air flow criteria. This is detailed further in Section 5.14.6.

See Table 5-17 for details.

5.14.5 Turndown and Redundancy

There are seven anoxic zone mixers per bioreactor. All these are all duty in FSB mode. Two (secondary anoxic zone) are standby in MLE mode. The failure of an anoxic zone mixer will result in reduced mixing in that anoxic zone. This will result in a minor reduction in denitrification and a small increase in settling risk. A mixer can be out of service for an extended period without significantly compromising the process or treatment. Therefore there is no need for an installed standby mixer, with standby units provided in store.

The blowers are provided in duty/assist/standby configuration. This provides adequate installed redundancy. Mixing is proportional to tank size, not loading. There is no need for turndown.

5.14.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-17. There is no difference between scenarios other than the number of operating mixers.

Table 5-17 Bioreactor Mixing Process Sizing

	Units	Process Design Assumptions	Process Design Sizing
Mixing Power	W/m^3	15	
Bioreactors		2	
Selector Each	m^3	74	
Selector Mixers Total		2	
Primary Anoxic Each	m^3	1398	
Primary Anoxic Mixers Total		6	
Secondary Anoxic Each	m^3	323	
Secondary Anoxic Mixers Tot		4	
De-Aeration Each	m^3	157	
De-Aeration Mixers Total		2	
Selector Mixers Each	kW[1]		1.1
Primary Anoxic Mixers Each	kW[1]		7.0
Secondary Anoxic Mixers Each	kW[1]		2.4
De-Aeration Mixers Each	kW[1]		2.4

[1] Indicative mixer energy requirements.

A check of aerated mixing performance of the aerobic zones based on air flow has been undertaken. The criteria was that air flow should exceed 2.5 $m^3/h/m^2$ of reactor surface area. Conversion from AOR to SOTR to air flow suggests that the mixing requirement will be exceeded. Mixing should not be limiting, and the blowers should be sized to meet the maximum AOR demand.

5.14.7 Control Philosophy

The anoxic zone mixers operate continuously. They are started and stopped manually by the operators in the field or through the SCADA. Alarms are generated upon failure of a mixer and the associated mixer will stop and latch.

5.15 WAS Thickening System

5.15.1 Purpose

The purpose of the Waste Activated Sludge (WAS) thickening system is:

- To control the sludge age of the biomass in the bioreactors to optimise process performance.
- To prevent the mixed liquor suspended solids (MLSS) getting too high and compromising capacity.
- To thicken WAS to increase the digester sludge age and reduce dewatering run times.
- To control the digester sludge age.
- To deliver TWAS to the aerobic digester for stabilisation.
- To allow thickener bypass for maintenance.
- To maximise solids recovery, minimise recycling solids loads and maximise bioreactor capacity.

5.15.2 Equipment and Instruments

The WAS thickening system consists of the following mechanical equipment and instruments.

- One (1) variable speed WAS pump.
- One (1) WAS flow element.
- Ove (1) fixed speed picket fence drive.
- One (1) torque switch for the picket fence drive.
- Two (2) level switches in the picket fence thickener.
- One (1) variable speed thickened WAS (TWAS) pump.
- One (1) temperature switch on the TWAS pump stator.
- One (1) fixed speed cooling fan for the TWAS pump.
- One (1) high pressure switch on the TWAS pump discharge.
- One (1) TWAS flow element.

5.15.3 Description

WAS is drawn from the bioreactors and pumped to the WAS thickener. Thickened WAS (TWAS) is drawn from the thickener and pumped to the aerobic digester for stabilisation.

Manual valves can be used to pump WAS and scum to various locations as follows:

- WAS can bypass the thickener for maintenance of the thickener. Typically, WAS would be drawn from the RAS splitter during this time. Thickening can occur in the digester through manual operation of the digester decanter.
- TWAS and scum can bypass the digester directly to the dewatering feed tank for maintenance of the digester. Remote manual operation of the WAS and TWAS pumps is required to prevent dewatering feed tank overflow.
- Digested WAS (DWAS) can be directed to the existing sludge lagoons via the existing pipework. This is an emergency operating condition (e.g. long term loss of the dewatering facility). The WAS, TWAS and Scum can also bypass the digester and be directed to the sludge lagoons if required.

WAS wasting is critical to bioreactor capacity and performance. It dictates the sludge age. Another name for sludge age is Solids Retention Time (SRT). The sludge age is defined as the mass of sludge held in the bioreactors (inventory) divided by the mass of sludge wasted each day (yield). If the WAS concentration is the same as the bioreactor concentration, then the sludge age can be approximated by dividing the bioreactor volume by the WAS volume wasted each day. This is referred to as hydraulic wasting.

If the WAS volume wasted each day is too low, then the sludge age increases, increasing the mixed liquor suspended solids (MLSS). If the MLSS gets too high (design of greater than 3,800 mg/L for FSB mode and 3,100 mg/L for MLE mode) then the settlement rate could reduce to the point where sludge scouring occurs from the clarifiers during high flows. If the WAS volume is too high, then the sludge age could fall below the minimum required to sustain nitrification, especially in winter. This will result in nitrification failure and high effluent ammonia.

The minimum sludge age for nitrification changes with temperature (increases as temperature decreases) and aeration (increases as aerobic fraction decreases or DO decreases). The design sludge age for Bowral STP is the minimum required in winter, but it can be reduced in warmer months.

It is advisable to operate at a constant bioreactor sludge age unless there is a pressing need to change it (e.g. the MLSS is getting too high). It is advisable to lower the sludge age if operating with one bioreactor or one clarifier out of service for an extended period. This should be done only when the bioreactor temperature is high (summer). In any case, the process is most stable when the sludge age is known and tightly controlled. Constant sludge age operation is more stable than constant MLSS operation. The MLSS should be allowed to fluctuate with temperature and load, provided the MLSS does not get too high and compromise clarifier settlement.

WAS can be wasted from the ML splitter or the RAS splitter. Tight sludge age control is compromised if wasting RAS because the RAS thickness varies. The operator can select to waste RAS, but this should be based on daily time. SRT control is not appropriate when wasting RAS. When wasting ML, the WAS concentration is the same as the bioreactor concentration (MLSS). Therefore the mass wasted is proportional to the volume wasted. Sludge age can be controlled based on volume alone with no need for mass calculations.

Sludge age control is not compromised even if bypass pumping commences (above DFTF). This is because the ML is diluted after the ML splitter. Undiluted ML is still drawn from the ML splitter.

Calculation of the volume of WAS wasted each day is undertaken by the SCADA based on set points. The WAS flow element is used to monitor and control the flow and daily volume of WAS wasted. A timer mode is used as a backup if the WAS flow element fails. The WAS flow is monitored in real time. The integrated volume wasted for the day and the previous day is also recorded. This is used to calculate the rolling average bioreactor sludge age.

There is a single picket fence style gravity thickener. This is used to thicken the WAS, control the digester sludge age and reduce dewatering run times. Tight thickness control is essential. If the TWAS is too thin, then the digester sludge age is reduced and stabilised biosolids may not meet re-use guidelines. Thin WAS may also lead to high DWAS volumes, increasing the dewatering run time per week. If the TWAS is too thick, then this can also compromise digester performance. Air transfer rates can be severely compromised once the digester thickness exceeds around 1.2%. This can lead to poor stabilisation and development of odours.

Picket fence (gravity) thickeners are ideal for aerobic digester pre-thickening. This is because the thickness can be tightly controlled. This is achieved by controlling the TWAS flow and volume relative to the WAS flow and volume. For example, if the TWAS volume is half the WAS volume then the thickness will be nearly exactly doubled (small differences result from solids carryover into the supernatant)

The picket fence thickener operates in a similar way to a secondary clarifier. However, the thickness in the sludge blanket is typically greater than the critical thickness. Unlike clarifiers, which promote unhindered settling, the settling rate in the thickener is hindered. Compression settling occurs in the thickener, which is a much slower rate. This is similar to the compressive settling that occurs at the end of a settling cylinder test. The picket fence acts more as a slow stirrer than a scraper, just like the stirrer in a stirred settling cylinder. This assists compressive settling. Nevertheless, the rise rate in the thickener much be significantly less than the clarifiers to prevent failure. The principles are otherwise the same. The picket fence speed can be mechanically adjusted in the field, but adjustment should not be required after commissioning.

Clear supernatant overflows the peripheral weirs and flows under gravity to the FWPS. It is then returned to the bioreactors for treatment.

There is a single, duty TWAS pump (with integrated cowling fan) and flow element. This is used to tightly control the TWAS, digester thickness and digester sludge age. Once again, it is important to control the sludge age of the digester to optimise digester performance.

There are a number of control modes for the TWAS pump. These are:

- Sludge Age – This is used to tightly control the digester sludge age. The digester volume is divided by the desired sludge age to produce a target digester feed volume each day. The scum volume from the previous day is subtracted from the target digester feed volume to produce a TWAS volume target. This is divided by the daily WAS run time to produce a target TWAS flow. The TWAS pump operates to achieve this flow.
- Thickness – This is used to tightly control TWAS thickness rather than digester sludge age. The operator sets a flow pacing ratio between the WAS and TWAS flow.
- Speed – This is a backup mode if the TWAS flow element is out of service. The operator sets a speed ratio between the WAS pump and TWAS pump.

The WAS pump fails if the level in the thickener rises to a high level. This should only occur if the supernatant line is blocked.

Under any mode, the TWAS pump is inhibited if the level in the thickener falls below a low level switch. Otherwise, the TWAS pump starts when the WAS pump starts and stops (after a run on delay) after the WAS pump stops.

The TWAS pump is a progressive cavity pump to provide tight flow control under low flow conditions and a large turndown.

5.15.4 Design Assumptions

The following assumptions have been adopted for the process design.

- WAS is assumed to be wasted as ML (worst case).
- The pump has been designed to accommodate a minimum hydraulic sludge age that is much lower than the design sludge age. This, combined with the ability to waste RAS, allows the MLSS to be reduced rapidly if ever needed.
- The hydraulic sludge age has been back calculated based on the true sludge age. The true sludge age accounts for biomass in the clarifiers and biomass loss as SS in the effluent. The hydraulic sludge is slightly less than the true sludge age.
- The thickener diameter is based on design criteria published in Wastewater Engineering (Metcalf and Eddy) customised by experience. The worst case of loading rate (m/d), surface overflow rate (m/d) and solids flux (kg/m^2/d) has been used to determine the thickener surface area and diameter.
- The thickener solids recovery has been based on experience.
- The TWAS pump capacity has been based on a minimum digester sludge age, below which stabilisation and dewatering run time is likely to be compromised.

See Table 5-18 for details.

5.15.5 Turndown and Redundancy

There is only one WAS pump. The failure of the WAS pump prevents wasting from the bioreactors until it is repaired or replaced. The mixed liquor suspended solids (MLSS) in the bioreactor will increase slowly over this time. However, this will have a negligible impact on capacity if the pump is back in service within a few days. Therefore there is no need for an installed standby pump.

There is only one TWAS pump. The failure of the TWAS pump results in the WAS pump also failing until the TWAS pump is replaced by a pump in store or the thickener is bypassed, again this is no need for an installed standby pump

The failure of the WAS flow element results in the WAS pump switching to speed and timer control. Wasting will continue to occur. The failure of the TWAS flow element results in the TWAS pump switching to speed control. Thickening can continue to occur.

WAS wasting is based on the bioreactor volume, not the wastewater flow or loading. There are no turndown issues related to WAS wasting. The TWAS pump has significant turndown. The digester thickness is likely to be the low flow limitation of the TWAS pump, not the pump turndown.

5.15.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-18 and Table 5-19. The limiting condition is MLE mode as this has a lower design sludge age.

Table 5-18 WAS Pumping Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Bioreactors		2		
Bioreactor Volume Each	ML	3.655		
Duty WAS Pumps		1		
Minimum Sludge Age	days	12		
Design Hydraulic SRT	d		23.4	18.5
WAS Pumps Each	L/s		7.1	7.1
Maximum WAS Flow	L/s		7.1	7.1

Table 5-19 WAS Thickening Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Digester Volume	m^3	3107		
Digester Operating SRT	d	40		
Minimum Digester SRT	d	25		
Scum PS	ML/d	0.010		
Thickener Recovery		99%		
Duty TWAS Pumps		1		
Thickeners		1		
Thickener Diameter Each	m	7.5		
Thickener Depth Each	m	3.0		
Loading at Capacity	m/d	20.0		
Flux at Capacity	$kg/m^2/d$	28.8		
Overflow at Capacity	m/d	15.0		
Target TWAS Volume	ML/d		0.068	0.068

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
WAS Load	kg/d		1155	1192
TWAS Load	kg/d		1144	1180
Target TWAS Thickness	mg/L		16803	17338
Typical Supernatant Flow	ML/d		0.245	0.328
Supernatant SS	mg/L		47.1	36.4
Max TWAS Flow	ML/d		0.115	0.115
TWAS Pumps Each	L/s		1.3	1.3
Thickener SA	m^2		44.2	44.2
Max Thickener Loading Rate	m/d		13.8	13.8
Typical Flux	$kg/m^2/d$		26.2	27.0
Maximum Supernatant Flow	ML/d		0.609	0.609
Maximum Overflow Rate	m/d		13.8	13.8
Worst Case Capacity	m3		92%	94%

5.15.7 Control Philosophy

The WAS pump operates in duty only configuration. The start time and duration of WAS pumping is set by the operator.

There is a no-flow set point for the WAS flow element. The WAS pump will fail if the flow is below this set point after delay time after start.

The WAS pump will also fail and latch if the thickener bypass setpoint is not true and:

- The picket fence drive fails (drive failure or over torque), or
- The TWAS pump fails (drive failure, no flow, high temperature or high pressure), or
- The level in the thickener rises to the high level switch.

There is a WAS flow element located on the WAS main. The real time flow, the integrated volume since midnight and the total WAS volume for the previous day are all calculated, displayed and recorded. These volumes are converted into the calculated sludge age based on the previous day, and also as a rolling overage over one sludge age.

The WAS wasting times are also monitored. These include the integrated duration since midnight and the total WAS wasting time for the previous day.

There are two possible control modes for the WAS wasting cycle. These modes are:

- Sludge Age Mode
- Timer Mode

Sludge Age mode relies on the WAS flow element. The failure of the WAS flow element results in the control switching to Timer mode. The operator can also select Timer control mode. The operating description of each mode is covered hereunder.

<u>Sludge Age Mode</u>

The following control philosophy applies if Sludge Age mode is selected.

- The sequence begins at the WAS start time of day set point.

- The target WAS volume per day is calculated as follows. The bioreactor volume (kL) is multiplied by the number of bioreactors in service. This is then divided by the sludge age target to produce the target WAS volume per day (kL).
- The target WAS volume per day is divided by the WAS operating duration set point to determine the WAS flow target.
- At the start time each day, the daily WAS volume is set to zero and the WAS pump starts.
- The speed of the WAS pump modulates to achieve the calculated WAS flow target.
- The WAS pump stops once the integrated WAS volume (kL) equals the target WAS volume per day.

Timer Mode

The following control philosophy applies if Timer control is selected (sludge age mode is deselected).

- The sequence begins at the WAS start time of day set point.
- The integrated WAS volume is set to zero, the timer is set to zero and the WAS pump starts.
- The WAS pump operates at the set point speed.
- The WAS pump stops once the WAS timer reaches the WAS duration set point.

The picket fence operates continuously. The picket fence will fail if the high toque switch is triggered.

The TWAS pump operates in duty only configuration. The TWAS pump does not operate if the thickener bypass set point is selected by the operator. Otherwise, the start time and duration of TWAS pumping is linked to WAS pumping. The TWAS pump will start when the WAS pump starts. The TWAS pump will stop after a run on delay after the WAS pump stops. The TWAS pump will also be inhibited if the level in the thickener falls below the level switch. The TWAS pump is available to start once the level rises above the switch.

There is a no-flow set point for the TWAS flow element. The TWAS pump will fail if the flow is below this set point after delay time after start.

The TWAS pump will also fail and latch if the discharge pressure switch is activated or the high stator temperature switch is activated. There is a separate cooling fan on the TWAS pump drive. This is interlocked with the TWAS pump drive. The cooling fan operates whenever the pump operates, starting and stopping with the pump drive. The TWAS pump can continue to operate if the cooling fan fails.

There is a TWAS flow element located on the TWAS main. The real time flow, the integrated volume since midnight and the total TWAS volume for the previous day are all calculated, displayed and recorded. These volumes are converted into the calculated digester sludge age based on the previous day, and also as a rolling overage over one sludge age.

The TWAS run times are also monitored. These include the integrated duration since midnight and the total TWAS wasting time for the previous day.

There are three possible control modes for the TWAS pumping. These modes are:

- Sludge Age Mode
- Thickness Mode
- Speed Paced Mode

Thickness mode also relies on the WAS flow element and the TWAS flow element. The failure of the WAS flow element results in control switching to Sludge Age Mode. Sludge Age mode relies on the TWAS flow element. The failure of the TWAS flow element results in the control switching to Speed Paced mode. The operator can also select Speed Paced mode. The operating description of each mode is covered hereunder.

Sludge Age Mode

The following control philosophy applies if Sludge Age mode is selected.

- The sequence begins at the WAS start time of day set point.
- The digester volume (kL) is divided by the sludge age to produce a digester feed volume target (kL).
- The scum volume for yesterday (kL) is subtracted from the digester feed volume target (kL) to produce the TWAS volume target.
- The target TWAS volume target is divided by the WAS operating duration set point to determine the TWAS flow target.
- The TWAS pump starts when the WAS pump starts.
- The speed of the TWAS pump modulates to achieve the calculated TWAS flow target.
- The TWAS pump stops after a run on delay after the WAS pump stops.

Thickness Mode

- The TWAS pump starts when the WAS pump starts.
- The TWAS flow target is continuously calculated by dividing the measured WAS flow by the thickening ratio set point. The TWAS pump modulates to try to maintain the TWAS flow target.
- The TWAS pump stops after a run on delay after the WAS pump stops.

Speed Paced Mode

- The TWAS pump starts when the WAS pump starts.
- The TWAS pump speed is continuously calculated by multiplying the WAS pump speed by the speed ratio set point.
- The TWAS pump stops after a run on delay after the WAS pump stops.

5.16 Filter Feed Pump Station

5.16.1 Purpose

The purpose of the filter feed pump station system is:

- To shed wet weather flows in excess of DFTF.
- To control filter feed flows to DFTF.
- To monitor filter feed flows and detect filter bypasses.
- To deliver secondary effluent to the filters.
- To prevent overflow of the UV facilities.

5.16.2 Equipment and Instruments

The following equipment forms the filter feed pump station system.

- One (1) filter feed pump station level element.
- Four (4) filter feed pump station level switches.
- Three (3) variable speed filter feed pumps (duty/assist/standby).
- One (1) filter feed flow element.
- One (1) level switch in the filter bypass chamber.
- One (1) level switch in the UV receival pit.

5.16.3 Description

Secondary effluent flows under gravity from the clarifiers to the filter feed pump station (FFPS). Emergency storage return flows can also be pumped directly to the filter feed pump station as an option.

Flows in excess of DFTF cause the level in the pump station rise and overflow to the EST (existing catch/balance pond). The filter feed pump station therefore acts as the hydraulic control for bypasses to the EST and (if that fills) to the existing effluent lagoons and discharge.

There are three (3) filter feed pumps in the filter feed pump station (duty/assist/standby). The filter feed pumps deliver secondary effluent up to the DFTF (set by operator) to the filters. The filter feed flow is monitored.

Alum is dosed into the filter feed flocculation chamber as a coagulant to enhance solids removal across the filters and precipitate phosphorus. These precipitants are removed in the filters. The operator can choose to dose to the clarifiers (ML collection box) or filters (flocculation chamber) but not both.

There are three possible control modes for the filter feed pumps:

- Flow Mode – Flow varies with level.
- Speed Mode – Pump speed varies with level.
- Backup Mode – Fixed speed based on level switches.

The filter feed flow is monitored and used for the control of the filter feed pumps and alum dosing.

There is a level switch in the filter bypass chamber of the filter feed splitter (alarm only). This warns the operator of a filter bypass (to the EST or UV system). This should only occur if more than one filter is out of service or queued for backwash. The operator can then choose to reduce the maximum filter feed flow set point or close a valve and allow partial filter bypass directly to the UV system.

There is a level switch in the UV receival pit. This can cause the filter feed pumps to fail so as to prevent overtopping of the UV receival pit or UV channel. This should only occur if the UV modulating penstock fails.

5.16.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The maximum filter feed flow is:
  - The sewage DFTF (3 ADWF only), plus
  - The maximum odour control RE flow, plus
  - The maximum screen RE flow, plus
  - The maximum grit RE flow, plus
  - The maximum FWPS flow, plus
  - The maximum bioreactor RE flow.
- The sewage DFTF is limited to 3 ADWF regardless of the operating mode of the bioreactors. However, maximum recycle flows (see above) are also included, meaning the maximum filter feed flow is well above 3 ADWF.
- The active volume of the filter feed pump station is less than the total volume as the filter feed pump station has no sump.
- The active volume of the filter feed pump station is based on a minimum storage time at maximum flow. This storage time is to allow for smooth level and flow control over a wide range of flows.

See Table 5-20 for details.

5.16.5 Turndown and Redundancy

There are three filter feed pumps. These operate as duty/assist/standby. The failure of one pump does not result in any loss of rated DFTF capacity. The failure of two pumps will result in the loss of wet weather treatment capacity and a small amount of dry weather treatment capacity. This could result in a short duration overflow to EST during the morning peak. It will be returned soon after. This is a very high level of redundancy.

The failure of the filter feed flow element results in the pumps switching to speed control. Filter feed pumping will continue to occur. Similar, backup control exists for other systems (e.g. the secondary alum dose to the filters) that utilise the filter feed flow.

The failure of the level element results in fixed speed control. Treatment of all dry weather flows will continue, but filtration performance could suffer due to step changes in filter feed rate.

The turndown (one feed pump operating at minimum speed) should be sufficient to match ADWF, even under Current loading conditions. The duty filter feed pump will start and stop at low speed under low flow conditions (at night). This may have a slight impact on filtration performance but given that the flows will remain well below the filtration design rating, this should be minor.

5.16.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-20. Worst case sizing does not change with scenarios.

Table 5-20 Filter Feed Pump Station Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future)
Sewage ADWF	ML/d	4.620	
Maximum Odour Control RE	ML/d	0.018	
Maximum Screen RE	ML/d	0.950	
Maximum Grit RE	ML/d	0.562	

	Units	Process Design Assumptions	Process Design Sizing (Future)
Maximum FWPS	ML/d	2.340	
Maximum Bioreactor Spray	ML/d	0.086	
Sewage DFTF	ADWF	3.0	
Filter Feed Pumps		2	
FFPS Storage at Max Outflow	mins	10	
FFPS Active Volume		80%	
Number of FFPS Tanks	ML/d	1	
Maximum Filter Feed Flow	ML/d		17.817
Maximum Filter Feed Flow	L/s		206.2
Filter Feed Pumps Each	L/s		103.1
Minimum FFPS Volume Each	m^3		154.7

5.16.7 Control Philosophy

Three filter feed pumps operate in duty/assist/standby configuration. The operator can select the duty allocation (6 off) in the SCADA. The failure of a duty or assist pump results in it being allocated as standby and the next available allocation (2 off) being selected by the SCADA. The SCADA will automatically change the duty to the next available allocation each time the duty pump stops.

There is a no flow set point for the filter feed. An alarm will be generated and the pump will be failed and latched if the flow through the filter feed flow element is below the no flow set point after the duty pump has been running for more than its no flow delay period.

The speed of each pump is limited between Maximum Pump Speed and Minimum Pump Speed set points, regardless of the control mode.

The filter feed pump station is fitted with a level element and four level switches. The high high level switch indicates that an overflow from to the EST is occurring. The high level switch is used to start the pump(s) if Backup mode is selected. It generates no alarm. The low level switch is used to stop the pump(s) but only if Backup mode is selected. It generates no alarm. The low low level switch acts as a dry cut out, failing and latching all pumps if this switch is activated.

The level element is used for level monitoring as well as pump control when in Flow or Speed control modes. Failure of this level element results in the pump control mode switching to Backup. The operator can set alarm levels for near overflow and overflow levels.

The filter feed main is fitted with a flow element. This is used for monitoring and can also be used for control of the filter feed pumps (Flow mode only) and alum dosing. The real time flow, integrated volume today and integrated volume yesterday are calculated, displayed and recorded.

If the level in the filter bypass chamber (filter feed splitter) rises to the overflow level switch, then an alarm is generated.

If the level in the UV receival pit rises to a high level, then all filter feed pumps will fail and latch.

There are three possible control modes for the filter feed pumps:

- Flow Mode – The level in the filter feed pump station is converted to a flow target for the filter feed pumps. The flow target varies with the filter feed pump station level, increasing as the level rises and decreasing as the level falls. The filter feed pump(s) speed modulates to try to achieve the filter feed flow target in the filter feed flow element. The filter feed flow target is limited to DFTF (operator adjustable). If the flow element fails then control reverts to Speed mode.

- Speed Mode – The level in the filter feed pump station is converted to speed targets for the filter feed pumps. The speed target varies with the lift pump station level, increasing as the level rises and decreasing as the level falls. The filter feed pump(s) speed are set to achieve the filter feed speed target. If the level element fails then control reverts to Backup mode.
- Backup Mode – This is not intended to be a normal operating mode, but rather as an emergency backup if the level element fails. The filter feed pump(s) operate at a constant speed. The start and stop of the pump(s) are based on the level switches in the filter feed pump station.

5.17 Emergency Storage and Return System

5.17.1 Purpose

The purpose of the emergency storage and return system is:

- To accept and store secondary effluent flows in excess of the filter DSTF as set by the operator.
- To accept and store all secondary effluent flows as required occasionally due to poor effluent quality.
- To accept and store overflows from the filter feed pump station (FFPS).
- To accept and store overflows from the filter feed splitter (as an option).
- To accept and store overflows from the dirty backwash tank.
- To accept and store overflows from the foul water pump station (FWPS), mainly stormwater.
- To accept and store backup supernatant (manual decant flows) from the aerobic digester.
- To accept and store drain water from the chemical unloading bund.
- To settle solids prior to overflow to the environment once storage is exceeded.
- To return stored wastewater (typically secondary effluent) for treatment once conditions allow.
- To control the return flows as fast as possible without exceeding treatment capacity.
- To assist manual cleanout once emptied.
- To alarm overflows and failures.

5.17.2 Equipment and Instruments

- One (1) emergency storage level element, which doubles as a tertiary bypass flow element.
- Three (3) emergency storage level switches.
- One (1) variable speed emergency return pump (duty only).
- One (1) emergency return flow element.

5.17.3 Description

Partially or fully treated secondary effluent in excess of the filter DFTF overflows a weir in the filter feed pump station and gravitates to the EST (old catch/balance pond). The overflow threshold is controlled by the filter feed pump station. The operator sets the DFTF at the pump station. Secondary effluent flows in excess of this cause the filter feed pump station level to rise until it overflows. Therefore, the operator has tight control over the tertiary bypass threshold and can change it to suit the conditions.

The operator can also shut down the filter pump station to undertake rare maintenance items (e.g. to repair or clean out the filter feed splitter, UV channel, etc) or due to poor secondary effluent quality that requires re-treatment. The EST provides more than half a day’s storage at average flow.

An overflow can also occur from the filter feed splitter prior to flocculation. This should only ever occur if two or more filter cells are out of service or backwashing and the filter feed flow is greater than PDWF. This overflow is typically directed to the EST, but is can be directed directly to the UV units (filter bypass).

Any overflow from the filter dirty backwash tank also gravitates to the EST. This should only ever occur if the dirty backwash tank level element has failed.

Any overflow from the FWPS also gravitates to the EST. This should only occur during wet weather if the foul water pump cannot keep pace with the incoming contaminated site stormwater. The dewatering filtrate and dirty backwash flows to the FWPS should have been inhibited under such conditions. Therefore the FWPS overflow should be relatively clean.

Drain water from the chemical delivery bund can also be directed to the EST via a manual valve. This is closed during deliveries to contain any spills.

If the EST fills, then it overflows (alarmed) to the pre-existing effluent ponds. Evaporation from the effluent ponds provides additional storage. If these fill, then the secondary effluent overflows to discharge. The long retention time in the ponds and slow rise rate should provide excellent additional treatment including some disinfection.

The level over the EST overflow weir is used to approximate the tertiary bypass flows to the effluent ponds.

Stored secondary effluent is returned to the process when conditions allow (e.g. wet weather flows subside). There are two possible return points; the inlet works (screened sewage channel) or directly back to the filter feed pump station. The operator selects the destination manually in the field. The intent is to return the stored effluent as fast as possible without exceeding treatment capacity. This reduces the storage time and makes storage available for another event. This is achieved with the use of an emergency return pump station.

There are similar return pump stations for SDP1 and SDP2. Only one of these systems can be active at any time. Returns do not start until the operator activates them, and only one can be activated at a time.

There are two modes for the return pump. These are:

- Flow Mode – Return flow varies inversely to sewage flow.
- Speed Mode – The pump speed is fixed and operates for a set duration.

The intent of the Flow mode is to maintain a constant inflow to the lift pump station or filter feed pump station (depending on the return location). The operator sets a total flow (say DFTF). The return flow then increases as the sewage flow decreases, and vice versa. The result should be a constant feed flow to the bioreactors or filters until the EST is emptied.

The return flow rate may not be ideal if returning directly to the filter feed pump station. This is because there is attenuation and delays between the sewage flow element (used for return control) and the filter feed pump station. However, any error would merely result in an overflow back to the EST.

Speed mode is used as a backup if the sewage or return flow elements are failed.

The floor in the EST slopes to a sump. Once empty, hoses can be used to flush settled solids to the sump.

5.17.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The active volume of the EST is as outlined in the CDR. The EST is assumed to drain completely into the sump.
- The return pump is sized identically to the lift pump station pumps (just over 1.5 ADWF each).
- The time to empty is based limiting the inflow to DFTF.
- The time to empty has been based on the diurnal profile (see Figure 3-1). This accounts for the short periods of the day when the sewage flow exceeds 1.5 ADWF resulting in the return pump rate slowing.

See Table 5-21 for details.

5.17.5 Turndown and Redundancy

There is a single, duty only return pump. The failure of the pump will prevent returns, but this has no immediate consequence. As this pump is identical to the four SDP return pumps, the assist pump from one of the SDPs can be relocated.

The failure of the return flow elements or sewage flow element results in the pump switching to speed control. Return pumping will continue to occur.

The failure of the level element does not impact on return pumping. The level switches are used as a backup.

The turndown (the return pump operating at minimum speed) should be sufficient to allow continuous pumping all day, including during PDWF.

5.17.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-21. The worst case sizing for storage is Future MLE. The worst case sizing for pumping is Future FSB. The sizing does not vary with season.

Table 5-21 Emergency Storage Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Existing Catch Pond Volume	ML	2.700		
Duty Return Pumps		1		
Maximum SE Flow	ML/d		31.665	38.595
Filter Feed PS	ML/d		17.805	17.805
Max Inflow and Overflow	L/s		366.5	446.7
Return Pump Each	L/s		89.1	86.1
Average Return Rate	ADWF		1.62	1.57
Storage at Max Inflow	h		2.0	1.7
Storage at DSTF	h		4.7	3.1
Time to Drain Storage	h		8.6	8.9

5.17.7 Control Philosophy

The overflow weir in the filter feed pump station is alarmed by the level element and high level switch (see Section 5.16.7).

The return pumping system is typically set to Unavailable. Therefore the return pump stays off as the EST fills. The level in the EST is monitored with a level element. The real time level, average level today and average level yesterday are calculated, displayed and recorded.

There is a high level switch on the EST. This alarms overflows. If overflow of the EST is detected, then the level over the weir is converted to an approximate flow using a weir formula in the SCADA. The real time tertiary bypass flow, integrated volume today and integrated volume yesterday are calculated, displayed and recorded. The integrated tertiary bypass discharge duration today and yesterday is also calculated displayed and recorded.

There is a low level switch in the EST. The return pump will stop and become Unavailable once this level, or a stop level set point (level element) is reached, whichever occurs first. This switch therefore acts as a backup to the level element for pump control.

There is a low low level switch in the EST. This acts as a dry cut out, failing and latching the pump if this switch is activated.

A single return pump is provided in duty only configuration. There is also an emergency return flow element. There is a no flow set point for the emergency return flow. An alarm will be generated and the pump will be failed and latched if the return flow is less than the no-flow set point after the pump has been running for more than its no flow delay period.

The speed of the pump is limited between Maximum Pump Speed and Minimum Pump Speed set points, regardless of the control mode.

The return main is fitted with a flow element. This is used for monitoring and can also be used for control of the return pump (Flow mode only). The real time flow, rolling average flow, integrated volume today and integrated volume yesterday are calculated, displayed and recorded.

The control philosophy of each set of return pumps, SPD1, SPD2 and emergency (see Section 5.4.7) is identical. The default is that they are all Unavailable. The operator can select to make one system Available, and one system only. The Available system will operate and empty the respective storage. The others will remain idle. Once a storage is emptied, the system once again becomes Unavailable. Return pumping never starts automatically. Return pumping will stop if the operator selects it as Unavailable, or the storage is emptied.

5.18 Filter Feed Splitter

5.18.1 Purpose

The purpose of the filter feed splitter is:

- To split filter feed evenly between operating filters.
- To limit the feed flow to each filter to within its capacity.
- To flocculate filter feed with alum prior to filtration.
- To shed flow in excess of filtration capacity to the EST or directly to the UV system.
- To prevent dosed alum from bypassing the filters.

5.18.2 Equipment and Instruments

The filter feed system consists of the following mechanical equipment and instruments.

- Two (2) variable speed mixers in the flocculation zone.

5.18.3 Description

Filter feed is delivered to the filter feed splitter by the filter feed pump station. The filter feed is capped to DFTF (operator adjustable) by the filter feed pump station control system.

The filter feed enters a bypass chamber in the splitter. The purpose of this chamber is to shed flows in excess of the hydraulic capacity of the filters. The filters are design for a maximum of DFTF with three cells in service. If two or more cells are out of service (e.g. queued for backwash), then the level will hydraulically back up through the splitter leading to an overflow from the bypass chamber. This overflow will normally be directed to the EST. A manual valve can be closed to create a filter bypass directly to the UV system. This overflow is alarmed but the flow is not individually measured. The location of the overflow, upstream of the flocculation tank, ensures that flocculation can continue without alum precipitants settling in the EST or bypassing the filters.

There is a submerged hydraulic connection between the bypass chamber and the flocculation tanks. There are two mixers, one in each flocculation tank. These mixers operate continuously (manual start by the operator) if the operator chooses to dose alum to the filters. The speed of these mixers can be adjusted to optimise flocculation performance. Alum is dosed into the first flocculation tank. This dose (if used) is typically flow paced with the filter feed flow.

The flocculated filter feed enters a four way splitter. Discharge bellmouths ensure an even flow split between operating filters. The maximum flow over each bellmouth is limited to the maximum filter feed flow divided by three filters. Actuated valves upstream of the bellmouths close if the filter is queued for backwash, in backwash or out of service due to breakdown or maintenance. If more than one filter is off line for any of these reasons, and the filter feed flow is high, then the level will back up through the splitter leading to an overflow to the EST or filter bypass. The flow remains evenly split between all filters whose valves are open.

5.18.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The maximum filter feed pump station flow is:

- The sewage DFTF (3 ADWF only), plus
- The maximum odour control RE flow, plus
- The maximum screen RE flow, plus
- The maximum grit RE flow, plus
- The maximum FWPS flow, plus
- The maximum bioreactor RE flow.

▪ The maximum flow to each filter is this the maximum filter feed pump station flow divided by three (one cell on backwash).
▪ The maximum filter bypass flow (to the EST or UV units) is the capacity of the filter feed pump station.
▪ Flocculation time is based on maximum filter feed flow conditions. This flocculation time has been selected as a practical compromise between perfect flocculation under (rare) high flow conditions, sizing of the flocculation tank and mixing power.

Further details are provided in Table 5-22.

5.18.5 Turndown and Redundancy

There are two flocculation mixers (duty/duty). If one mixer fails, then flocculation may be slightly compromised. If both mixers fail then the dosing location can be switched to the ML splitter box (clarifier feed). Dosing to the filters could still occur, but mixing would be driven by flow alone and may be inadequate under low flow periods.

There are no analogue elements in the filter feed splitter.

There is no turndown limitation.

5.18.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-22. Sizing is independent of scenarios.

Table 5-22 Filter Feed Splitter Process Sizing

	Units	Process Design Assumptions	Process Design Sizing
Maximum Filter Feed Flow	ML/d	17.805	
Filter Cells		4	
Minimum Cells on Line		3	
Minimum Flocculation Time	mins	5.0	
Active Flocculation Volume		100%	
Flocculation Tanks		1	
Flocculation Tank Mixers		2	
Maximum Sheer Rate	s-1	60	
Average Filter Feed Flow	ML/d		5.321
Maximum Feed Per Cell	ML/d		5.935
Maximum Feed Per Cell	L/s		68.7
Maximum Filter Bypass	ML/d		17.805
Maximum Filter Bypass	L/s		206.1
Flocculation Tank Volume	m^3		62

5.18.7 Control Philosophy

There is no automated control of the mixers. The operator merely selects them as on or off and sets their speed within SCADA. An alarm is generated if either mixer fails.

5.19 Tertiary Filtration

5.19.1 Purpose

The purpose of the tertiary filtration system is:

- To remove chemical precipitants from tertiary phosphorus polishing.
- To polish suspended solids, BOD and total nitrogen from the secondary effluent.
- To improve the performance and reduce the energy demand of downstream UV treatment.
- To return filter backwash to the bioreactors (via the FWPS) for treatment.
- To prevent damage to the filters and loss of media during backwashing.
- To protect the plenum floor from damage.
- To prevent overflow of the filter structure.

5.19.2 Equipment and Instruments

The tertiary filtration system consists of the following mechanical equipment and instruments.

- Four (4) filter inlet valves (duty/duty/duty/duty), one per filter.
- Four (4) open proximity switches, one per inlet valve
- Four (4) closed proximity switches, one per feed inlet valve
- Four (4) filter effluent valves (duty/duty/duty/duty), one per filter.
- Four (4) position elements, one per effluent valve.
- Four (4) filter ripening valves (duty/duty/duty/duty), one per filter.
- Four (4) position elements, one per ripening valve.
- Four (4) filter dirty backwash valves (duty/duty/duty/duty), one per filter.
- Four (4) open proximity switches, one per dirty backwash valve.
- Four (4) closed proximity switches, one per dirty backwash valve.
- Four (4) filter clean backwash valves (duty/duty/duty/duty), one per filter.
- Four (4) open proximity switches, one per clean backwash valve.
- Four (4) closed proximity switches, one per clean backwash valve.
- Four (4) filter air scour valves (duty/duty/duty/duty), one per filter.
- Four (4) open proximity switches, one per air scour valve.
- Four (4) closed proximity switches, one per air scour valve.
- Four (4) filter air bleed valves (duty/duty/duty/duty), one per filter.
- Four (4) open proximity switches, one per air bleed valve.
- Four (4) closed proximity switches, one per air bleed valve.
- Four (4) filter level elements, one per filter.
- Four (4) filter differential pressure elements, one per filter.
- One (1) clean backwash tank level element.
- One (1) clean backwash tank level switch.
- Two (2) variable speed clean backwash pumps (duty/standby).
- One (1) clean backwash flow element.
- One (1) pressure switch in the clean backwash main.
- Two (2) variable speed air scour blowers in duty/standby configuration.
- Two (2) low pressure switches, one for each blower suction.
- Two (2) high pressure switches, one for each blower discharge.
- Two (2) high temperature switches, one for each blower discharge.
- Two (2) low flow switches, one for each blower discharge.
- One (1) pressure element on the common air main.
- One (1) flow element on the common air main.
- Two (2) fixed speed exhaust fans on the air scour blower building.

- One (1) high temperature switch in the air scour blower building.
- One (1) dirty backwash tank level element.
- Four (4) dirty backwash tank level switches.
- Two (2) variable speed dirty backwash pumps (duty/standby).
- Two (2) low flow switches, one per dirty backwash pump.
- One (1) dirty backwash submersible mixer.

5.19.3 Description

Secondary effluent from the filter feed pump station is pumped to the filters via the filter feed splitter. Alum can be dosed (optional) to the flocculation tank in the filter feed splitter to trim phosphorus from the effluent. These alum precipitants, plus the solids in the secondary effluent, are removed in the filters.

The filters are deep bed, dual media, constant level, constant rate filters. These have level plenum floors with a cavity below. There are numerous nozzles through the plenum floor. Over the plenum floor there are multiple layers of gravel, a layer of sand and a layer of filter coal (anthracite). Each layer is of a uniform grain size and density. The coal layers provide voids to store filtered solids between backwashes. The sand layers provide fine filtering, but little storage. The gravel layers are merely to support the filtration media. The sand and coal layers mix during air scour and backwash, then re-stratify during high rate backwash. Air scour and backwash is controlled to flush solids, but prevent loss of media, during backwash. However, some media loss does occur over time (years) so the media needs occasional replacement.

There are four filters (cells). Flow is split evenly between the operating cells with the use of filter feed bellmouths. Any cell can be taken out of service simply by closing the inlet valve. A filter cell should ideally be backwashed before being left out of service.

Each cell has a seven motorised valves. These are:

- Feed (open/closed, typically open).
- Effluent (modulating, typically open).
- Ripening (modulating, typically closed).
- Clean backwash (open/closed, typically closed).
- Air scour (open/closed, typically closed).
- Air bleed (open/closed, typically closed).
- Dirty backwash (open/closed, typically closed).

Each cell also has a level element and differential pressure element. The differential pressure element measures the headloss across the filter media.

Feed enters each cell via the feed splitter and open feed valve. The effluent valve modulates to achieve a constant level in the cell. Immediately after backwash, the headloss through the media is low and the effluent valve is mostly closed to compensate. As solids accumulate in the media, the headloss across the media increases and the effluent valve opens more to compensate, keeping the level constant.

Backwash is triggered periodically based on time or a high filter differential pressure (headloss), whichever occurs first. Each cell is typically backwashed once per day and backwashing takes roughly 30 minutes to complete. Under high flow and/or high solids loading conditions, the backwash frequency may increase to twice per day per cell. Only one cell can be backwashed at a time. Under high loading conditions, backwashes can queue.

There are two backwash tanks. The clean backwash tank stores tertiary effluent ready for backwashing through the filters. Once full, the clean backwash tank overflows to the UV disinfection system. Flow to the UV system is therefore periodically suspended while the clean backwash tank refills after a backwash.

The dirty backwash tank stores the backwash once it has passed back through the filters. From there it is pumped to the FWPS at a much lower flow rate, and then back to the bioreactors for treatment. The dirty backwash tank should never fill. If it does (due to control failure) then it will overflow to the EST, from which it can be pumped back to the inlet works. A single submerged mixer works to keep backwash solids in suspension to prevent accumulation.

The sizing of the backwash tanks allows for two consecutive backwashes. A third consecutive backwash will be delayed until the clean backwash tank is sufficiently full and the dirty backwash tank is sufficiently empty. The limiting condition is usually the dirty backwash tank. If the dirty backwash tank is full, then it may take three hours or more for dirty backwash storage capacity to be restored. This still provides for eight backwashes per day (two per cell).

During the design, consideration was given to combining the dirty backwash tank and the FWPS into one pump station. However, as the FWPS also collects contaminated stormwater, there was a concern that the dirty backwash tank could fill during sustained rain events. This could inhibit filter backwashing at a time when frequent backwashing becomes more critical. Therefore a decision was made to keep the two tanks separate and double pump the dirty backwash (small flow) back to the bioreactors.

If a backwash is triggered (high headloss, timer or initiated by the operator) then the following sequence occurs:

- Drain down – The feed valve closes and the effluent valve fully opens. The effluent valve closes when the level falls to the drain down level, just above the filter media. This level is below the backwash trough.
- Air scour – The air scour valve opens and the scour blower starts. The blower speed modulates to maintain a constant flow in the air scour flow element. Air scouring will agitate the filter media mainly targeting the surface of the filter bed as most of the clogging happens in the top of the filter bed.
- Combined air and Low rate backwash – Once a scour time has expired, the low backwash phase commences. The air scour valve remains open and blower keeps running, the clean backwash and dirty backwash valves open and the clean backwash pump starts. The clean backwash pump modulates to maintain a low backwash flow. The level in the cell begins to rise and the air sparge keeps solids in suspension.
- High backwash – Once the level reaches the air scour cut-off level (just below the backwash trough) the blower stops and the air scour valves closes. The air bleed valve opens to release the air stored beneath the plenum. This valve remains open during high backwash to act a pressure relief to prevent damage to the plenum floor. The high pressure switch and common pressure relief line on the clean backwash pump discharge is also used for this purpose. The clean backwash pumping rate increases to the high backwash rate. The solids are lifted upward with the high rise rate and overflow the backwash trough. The high rate is set to prevent the filter media being washed out. Instead the layers re-stratify due to their differing sizes and densities.
- Fill – Once the backwash time expires, the clean backwash pump stops and the clean and dirty backwash valves close. The air bleed valve also closes. The feed valve opens and the cell begins to fill.
- Ripening – Once the level reaches the operating level, the ripening valve opens and modulates to control the level. The ripening valve directs the effluent from that cell to the dirty backwash tank. This is because solids breakthough can often occur for a short period after backwash. Once the ripening time expires, the ripening valve closes and the effluent valve opens and begins to modulate to control level. The filter is now back in service.

The dirty backwash and ripening effluent are directed to the dirty backwash tank. This attenuates the high backwash flows by storing them and pumping them back to the FWPS over a longer period. This reduces the size of the FWPS, and all other process units in the flow loop (clarifiers, filter feed and filters).

Backwashing is inhibited if there is insufficient clean water to complete it, or insufficient spare storage capacity in the dirty backwash tank. If a high differential pressure is detected in another filter cell during that time, then its feed valve closes and it is queued for backwash.

The system is designed and sized to have one cell out of service for backwashing at a time. If a second cell is out of service, or its feed valve is shut due to high differential pressure, then this could trigger a filter bypass (overflow before the flocculation tank). PDWF should be able to be accommodated through two filter cells without triggering a filter bypass.

5.19.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The design assumes four cells, with no more than one out of service for backwashing at any one time.
- The filters must accept DFTF from the filter feed pump station (3 ADWF plus plant recycles) with only three cells in service.
- The maximum loading rate with four cells in service must be less than 10 m/h.
- The maximum loading rate with three cells in service must be less than 13 m/h.
- The filters are slightly oversized for Bowral STP so that the same filters and associated equipment can be used at Moss Vale STP (which has a greater hydraulic contribution).

- The maximum backwash rate is based on standard design criteria with some conservatism for tuning.
- The air scour rate is based on standard design criteria.
- The typical backwash duration is based on experience with some design conservatism. The maximum backwash duration offers significant design conservatism.
- The backwash tanks have been sized for two normal backwash or one unusually large backwash.
- The typical time between backwashes (per cell) is assumed to be 24 hours (4 per day). The maximum number of backwashes is assumed to be twice this (each cell twice per day).
- The dirty backwash pumps have been sized to return eight normal backwashes per day.

See Table 5-23 for details.

5.19.5 Turndown and Redundancy

There are four filter cells in duty/duty/duty/duty configuration. The maximum filter feed flow (DFTF plus maximum recycles) can be accommodated with one cell out of service. PDWF should be able to be accommodated with two cells out of service. Partial filter bypasses could occur if these conditions are exceeded. These are either stored in the EST or directed through the UV for disinfection prior to discharge.

There is no installed standby for the level element, differential pressure element or valves for each cell. All these must be operable for a cell to function. The loss of any one instrument or equipment item will reduce the available cells to three (DFTF treated) or two with one of backwash (PDWF treated). Standby equipment is provided in store. All replacements should be able to be completed within four hours.

The clean and dirty backwash pumps and the air scour blowers are provided in duty/standby configuration. Failure of one of each unit does not compromise treatment. Failure of both units will lead to eventual filter blinding, isolation and bypass. The bypassed flows should still be able to meet current licence conditions. Filtration would need to be out of service for a long period to impact significantly on 50%ile NorBE requirements.

The clean water pump, dirty water pump and air scour blower can all operate in a backup mode if the flow elements are failed. Backwashes can be undertaken (triggered by the operator only) even if the clean and dirty backwash tank level elements are out of service. However, the operator must undertake visual level inspection to ensure sufficient storage is available to complete the backwash.

There is no turndown limit on filtration flow.

Failure of the backwash tank mixer does not impact on system capacity but increases the risk of solids accumulation. Manual intervention (i.e. hosing) can be used if a mixer is unavailable, there is no need for provision of a standby mixer.

Backwash flows are based on filter area, which does not change with flow or load. There is no need for significant turndown.

5.19.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-23. The sizing does not vary with scenario or season.

Table 5-23 Filter Process Sizing

	Units	Process Design Assumptions	Process Design Sizing
Maximum Filter Feed PS Flow	ML/d	17.805	
Filter Cells		4	
Minimum Cells on Line		3	
Filter Cell SA Each	m^2	20	
Typical Backwash Rate	m/h	50	
Typical Backwash Duration	min	6	

	Units	Process Design Assumptions	Process Design Sizing
Combined B/W Duration	min	3	
Filter Air Scour Rate	m/h	60	
Air Scour Duration	min	5	
Clean Backwash Pumps		1	
Clean B/W Pump Turndown		30%	
Air Scour Blowers		1	
Stored Clean Backwashes		2	
Clean Backwash Tanks		1	
Effective Clean B/W Volume		80%	
Stored Dirty Backwashes		2	
Dirty Backwash Tanks		1	
Effective Dirty B/W Volume		100%	
Typical B/W Frequency	h per cell	24	
Worst Case B/W Frequency	h per cell	12	
Duty Dirty Backwash Pumps		1	
Backwash Tank Mixers		1	
Mixing Energy		>10	W/m^3
Solids Recovery		95%	
Maximum Feed SS	mg/L	20.0	
Coal Depth	m	1.5	
Maximum Filter Feed Flow	m^3/h		742
Max Filtration Rate During B/W	m/h		12.4
Max Filtration Rate Without B/W	m/h		9.3
Filter Capacity			95%
Typical Filter Feed SS	mg/L		11.3
TE SS	mg/L		0.6
TE TP	mg/L		0.09
Clean B/W Pumps Each	L/s		285
Min Backwash Flow	L/s		85

	Units	Process Design Assumptions	Process Design Sizing
Min Backwash Rate	m/h		15
Air Scour Blowers Each	m^3/h		1200
Max Clean B/W Volume	m^3		200
Typical Clean B/W Volume	m^3		117
Clean B/W Tank Each	m^3		291
Worst Case B/W Stored			1.2
Typical Dirty B/W Volume	m^3		117
Dirty B/W Tank Each	m^3		233
Worst Case B/W Stored			1.2
Dirty Backwash Pumps Each	L/s		10.8
Dirty Backwash	:Feed		8%
Backwash SS	mg/L		123
Typical Solids Loading	kg/d		60.2
Typical Storage	kg/m^3		0.5
Worst Case Storage	kg/m^3		1.6

The worst case solids storage is slightly greater than the 1.5 kg/m^3 often used as a design criteria. However, this is based on continuous DFTF conditions (including maximum plant recycles) and a filter feed quality of 20 mg/L. This would be a rare event at worst. If the solids storage capacity is ever exceeded, then the dirty backwash tank volume may start to inhibit on-time backwashes. This may lead a short period where more than one cell is out of service, and a partial filter bypass. These bypasses should be short-lived and only a fraction of the treated volume. The selection of 20 mg/L is also quite arbitrary. Increasing the storage volume (filter depth) further may not negate the possibility of partial filter bypass under worst case conditions.

The coal depth has been increased above the more typical design value (0.7). The selected coal depth and associated solids storage is seen as being a practical balance between cost, risk and consequence.

The maximum loading rates (m/h) are within the design limits. It would be possible to reduce the filtration system sizing by around 5%. However, this 5% safety margin was retained so that the filters at Moss Vale STP can be identically sized despite the higher per capita hydraulic contribution and more stringent performance requirements.

5.19.7 Control Philosophy

Each filter cell includes a filter feed valve, an effluent valve, a ripening valve, a clean backwash valve, a dirty backwash valve, an air scour valve, an air release valve, a level element and a differential pressure element. The respective feed valve to a cell will close and latch if any of these valves or instruments fail. Any valve that fails to open or close within a time out period will attempt to fail closed.

Two clean backwash pumps operate in duty/standby configuration. The operator can select the duty allocation (2 off) in the SCADA. The failure of a duty pump results in it being allocated as standby. The SCADA will automatically change the duty to each time the duty pump stops. A filter feed penstock will also close if the level in the respective cell exceeds a high level. It can automatically open again (if called upon to do so) if the level falls to the target level.

The clean backwash pumps will not operate under the following conditions:

- A backwash pump drive is failed (fail and latch respective pump).
- The flow in the clean backwash flow element is below a no-flow set point after the duty pump that has been running for more than its no flow delay period (fail and latch respective pump).
- The level in a cell is above a high level and its respective clean backwash valve is not fully closed (fail and latch both pumps).
- The level in the clean backwash tank is below the stop level (inhibit both pumps).
- The level in the clean water tank is below the dry cut out level (fail and latch both pumps).
- The level in the dirty backwash tank is above the high level (inhibit both pumps).
- The level in the dirty backwash tank is above the high high level or level switch (fail and latch both pumps).
- No pair of clean backwash valve and dirty backwash valve (i.e. from the same cell) are both fully open (inhibit both pumps).
- More than one clean backwash valve is not fully closed (fail and latch both pumps).

The clean backwash tank is fitted with a level element and a low level switch. The level element reads and records the level in real time. A surface area set point and stop level set point is used to convert the level to available backwash volume. The required backwash volume is calculated based on clean backwash flow and time set points. A backwash sequence will not begin automatically unless the available clean backwash volume is greater than the required volume. If the clean backwash level element is failed, then automated backwash initiation is suspended. The operator can initiate a backwash after first inspecting the clean backwash tank.

If a backwash sequence is suspended due to a low level in the clean backwash tank, then the cell will return to the backwash queue. The backwash sequence will need to restart from the beginning.

There are two possible control modes for the clean backwash pumps:

- Flow Mode – The operator sets low backwash flow and high backwash flow set points. The pump starts and stops according to the backwash sequence. When operating, the speed modulates to try to achieve the clean backwash flow target in the flow element. If the flow element fails then control reverts to Speed mode.
- Speed Mode – The operator sets low backwash speed and high backwash speed set points. The pump starts and stops according to the backwash sequence. When operating, the pump speed is directly set to these speeds.

Two dirty backwash pumps operate in duty/standby configuration. The operator can select the duty allocation (2 off) in the SCADA. The failure of a duty pump results in it being allocated as standby. The SCADA will automatically change the duty each time the duty pump stops.

The dirty backwash pumps will not operate under the following conditions:

- A backwash pump drive is failed (fail and latch respective pump).
- The no-flow switch is activated on a pump that has been running for more than its no flow delay period (fail and latch respective pump).
- The level in the dirty backwash tank is below the stop level (inhibit both pumps).
- The level in the dirty backwash tank is below the dry cut out level (fail and latch both pumps).
- The level in the FWPS is above the inhibit level or overflow switch (inhibit both pumps).

The dirty backwash tank is fitted with a level element and a three level switches. The high high level switch warns of overflow, fails the clean backwash pumps and generates an alarm. The high level switch is used to start the duty pump, but only in Backup mode. It does not generate an alarm. The low level is used to stop the duty pump, but only if in Backup mode. It does not generate an alarm. The low low level switch fails both pumps and generates an alarm.

The level element reads and records the level in real time. A surface area set point and high level set point is used to convert the level to available storage volume. The required backwash volume is calculated based on clean backwash flow and time set points. A backwash sequence will not begin automatically unless the available dirty backwash storage volume is greater than the required volume. If the level element is failed, then automated backwash initiation is suspended. The operator can initiate a backwash after first inspecting the dirty backwash tank.

If a backwash sequence is suspended due to a high level in the dirty backwash tank, then the cell will return to the backwash queue. The backwash sequence will need to restart from the beginning.

There are two possible control modes for the dirty backwash pumps:

- Speed Mode – The operator sets the target speed. The pump starts and stops according to the level set points in the dirty backwash tank. If the level element fails, then the pump reverts to Backup mode.
- Backup Mode – This is not intended to be a normal operating mode, but rather as an emergency backup if the level element fails. The dirty backwash pump operates at a constant speed. The start and stop of the pump is based on the level switches in the dirty backwash tank.

Two air scour blowers operate in duty/standby configuration. The operator can select the duty allocation (2 off) in the SCADA. The failure of a duty blower results in it being allocated as standby. The SCADA will automatically change the duty to each time the duty blower stops.

The air scour blowers will not operate under the following conditions:

- A blower drive is failed (fail and latch respective blower).
- The no-flow switch is activated on a blower that has been running for more than its no flow delay period (fail and latch respective blower).
- The discharge pressure is high (fail and latch the respective blower).
- The discharge temperature is high (fail and latch the respective blower).
- No air scour valve is fully open (inhibit both blowers).
- More than one air scour valve is not fully closed (fail and latch both blowers).

There are two possible control modes for the air scour blowers:

- Flow Mode – The operator sets an air scour flow target. The blower starts and stops according to the backwash sequence. When operating, the speed modulates to try to achieve the air scour flow target in the flow element. If the flow element fails then control reverts to Speed mode.
- Speed Mode – The operator sets an air scour speed. The blower starts and stops according to the backwash sequence. When operating, the blower speed is directly set to this speed.

The speed of each pump and blower is limited between Maximum Speed and Minimum Speed set points, regardless of the control mode.

There are two blower room exhaust fans in duty/duty configuration. If the temperature is sustained above a high temperature switch for more than a delay time, then both fans will start. If the temperature is sustained below this temperature for more than a delay time then both fans stop.

There is also an exhaust fan on each blower acoustic enclosure. These are operated from a direct connection to the blower drive and operate whenever the respective blower operates. There are no separate controls, monitoring or alarms on these blower fans.

Typically, all filter cells are in the Filter phase. The following occurs when a cell is in the Filter phase.

- The feed valve is fully open.
- The effluent valve modulates to try to achieve a level set point.
- All other valves are fully closed.

Each cell stays in Filter phase until one of the following conditions occurs:

- The differential pressure exceeds a high set point, or
- The maximum time between backwashes is exceeded, or
- The operator places it in the backwash queue, whichever occurs first.

The cell remains in the Queue phase until conditions allow a Backwash phase to commence. A Backwash Phase cannot commence until:

- No other cell is in the Backwash phase, and
  - There is sufficient volume in the clean and dirty backwash tanks to complete the backwash, or
  - The operator initiates a Backwash phase.

If a cell is in the Queue phase, then it will continue to operate as though it was in the Filter phase unless or until a high level or differential pressure alarm is generated. If that occurs then the feed valve will close, resulting in the level falling and the effluent valve closing.

Once a cell enters the backwash phase, the following sequence occurs:

- The feed penstock closes.
- The effluent valve fully opens.
- Once the drain down level set point is reached, the effluent valve closes.

- The air scour valve opens.
- The duty blower starts and operates in Flow mode or Speed mode.
- After a scour time set point has expired, the clean backwash valve opens and the dirty backwash valve opens.
- The clean backwash pump starts and operates in low Flow or low Speed mode.
- Once the level in the cell rises to a scour inhibit level set point, the blower stops, the air scour valve closes and the air release valve opens.
- The clean backwash pump operates in high Flow or high Speed mode.
- Once the high backwash time set point expires, the clean backwash pump stops, the clean backwash valve closes, the dirty backwash valve closes and the air release valve closes.
- The feed penstock opens.
- Once the level rises to the operating level set point, the ripening valve opens and modulates to maintain the level.
- Once the ripening time set point has expired, the ripening valve closes, the effluent valve opens and the Filter phase is initiated.

5.20 UV Disinfection

5.20.1 Purpose

The purpose of the ultraviolet (UV) disinfection system is:

- To de-activate pathogens and meet effluent F-Coli licence limits.
- To assist in the disinfection of RE used around the STP.
- To minimise UV power consumption while maintaining effective disinfection.
- To alarm conditions that could lead to licence non-compliance.

5.20.2 Equipment and Instruments

The UV disinfection system consists of the following mechanical equipment and instruments.

- One (1) level switch in the clean backwash tank.
- One (1) UV flow element.
- One (1) UV transmissivity (UVT) element in the UV receival pit.
- One (1) level element in the UV channel.
- Two (2) level switches in the UV channel.
- Three (3) UV banks in duty/assist/assist configuration.
- Three (3) UV intensity (UVI) elements, one per UV bank (subject to supplier configuration).
- One (1) modulating penstock in the UV discharge channel.
- One (1) position element on the modulating penstock.

The UV controller also sends a calculated UV dose signal to the SCADA for monitoring and alarming.

5.20.3 Description

The UV system feed consists of tertiary effluent from the filters and secondary effluent (filter bypass) from the filter feed overflow (if the manual valve on the overflow line to the EST is closed). This is mixed before entering the UV receival pit.

UV disinfection utilises UV light in a tight bandwidth to damage the DNA of pathogens so that they are inactivated and cannot reproduce. The dose required for effective disinfection is based on the pathogens targeted (in this case bacteria), the flow and the ability of the UV light to pass through the liquid (the transmissivity).

The UV channel contains three UV banks in duty/assist/assist configuration. Room is available for the installation of a fourth (standby) bank in the future if deemed necessary. These are sized to treat 3 ADWF plus recycles. Only two banks are required for PDWF conditions, and only one bank is required for ADWF conditions.

The UV banks are proprietary units. These include their own control panel and instrumentation. The SCADA does not control the UV banks directly. The UV dose is varied by the controller to keep pace with flow, adjusted for UV transmissivity. The UV control system requires input signals for flow and UV transmissivity. The controllers provide a variety of outputs to the SCADA including UV dose and faults. A low dose is alarmed. The SCADA controls duty cycling based on fault detection.

The UV units contains automated wipers. These periodically clean the UV lamp tubes.

Supplier warranties typically limit the flow and the average number of starts per day of each UV bank. UV banks must warm up after starting before they are effective. The UV banks can remain on for extended periods after flow ceases, but this wastes power. Eventually, a bank that operates without flow may overheat and fail. It is therefore desirable to maintain flow through the UV system as continuously as possible. Near continuous effluent flow from the bioreactors and turndown (duty/assist) in the filter feed pump station should maintain near continuous flow through the UV unit, except when filter backwash is occurring.

In low flow conditions, it can take many hours to refill the clean backwash tank after backwashing, especially if two filters are backwashed consecutively. This could cause the UV banks to switch off due to time-out or overheat protection conditions. The duty unit must then turn on and warm up before effective disinfection is re-instated. Therefore, if the duty UV unit is off due to a recent backwash, it will restart based on a start level in the clean backwash tank, giving it time to warm up before the clean backwash tank overflows and effluent flow recommences.

The number of operating UV banks and the power to each bank is determined by the UV controller based on flow and UVT. Failure of the UVT or flow element results in the system adopting worst case defaults. The UV banks can continue to operate, be it at greater power than necessary. The failure of a UVI element results in the relevant bank being made second assist. If called upon to start, it will operate at maximum power.

There is a modulating penstock at the discharge end of the UV channel. The penstock modulates to maintain a constant level in the UV channel. A high level can result in a portion of the flow being too high over the UV banks to receive adequate treatment. This is alarmed. A low level can result in some lamps being above water level. This is also alarmed and can lead to the banks failing due to overheating.

There is a high level switch in the UV receival pit. This stops the filter feed pumps to try to prevent overflow should the UV channel be isolated or if the UV level control system fails. However, it may take some time for the flow through the filters and clean water tank to cease after the filter feed pumps stop. It is unlikely that there will be sufficient freeboard in the UV receival pit and channel to accommodate this residual flow. Therefore an overflow weir is also incorporated to prevent overtopping of the structures. A UV bypass can also be manually initiated by opening a manual bypass valve. Under such circumstances, the level in the receival pit will remain below the high level switch, so the filter feed pumps can continue to operate.

The UV channel can be manually bypassed for maintenance or cleaning with the use isolation penstocks and the bypass valve. This should be a rare event as each UV bank can be lifted from the channel for maintenance or lamp replacement if necessary. A bank will switch off if its inspection hatch is opened.

UV disinfected effluent and UV bypass are directed to the reclaimed effluent lift system prior to discharge. If flow is bypassing the UV units or an alarm indicates ineffective disinfection then it is up to the operator to decide if this warrants the cessation of reclaimed effluent lift pumping. RE supply can continue using potable water to the RE storage tank.

The UV control system is proprietary and is controlled via a standalone PLC accessed by an HMI adjacent to the UV units. A small number of hard wired signals as outlined within the Electrical Drawings are provided with all remaining communications being delivered via communications.

5.20.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The UV units are sized to accommodate the maximum flow of the filter feed pumps, being:
  - Sewage DFTF (3ADWF), plus
  - Maximum odour control RE flow, plus
  - Maximum screen RE flow, plus
  - Maximum grit RE flow, plus
  - Maximum FWPS capacity, plus
  - Maximum bioreactor RE flow.

See Table 5-24 for details.

The UV units do not affect process parameters and as such there is no process design component. However, the following has been included in the supplier specification.

- Minimum UV transmissivity of 60% based on the CDR. This is conservative for filtered effluent and allows for compromised feed quality based on partial or complete filter bypass.
- Effluent E.Coli concentration of 200 cfu/100mL as an 80%ile.

5.20.5 Turndown and Redundancy

There are three UV banks. These operate as duty/assist/assist. Provision is made for the installation of a fourth (standby) bank if deemed necessary in the future. All dry weather flows can be treated with one bank out of service. If UVT conditions are favourable, then it may be possible to treat all dry weather flows with two banks out of service. Installing a fourth bank as standby seems unwarranted.

Failure of the modulating weir, level element or position element will result in the penstock failing in its current position or being set to a default position. This should be suitable for most flows conditions but could result in minor short-circuiting under high flow and level conditions.

Failure of the UV transmissivity element results in the UV banks assuming worst case transmissivity. They will continue to function at a higher power than necessary. Disinfection will continue to occur.

The failure of the UV flow element results in maximum flow being assumed. The UV units will continue to function at a higher power than necessary. Disinfection will continue to occur.

Failure of a UVI element results in the associated bank being set as second assist. If it is called upon to operate, then it will operate at maximum power. Disinfection will continue to occur.

The turndown (one UV unit operating at minimum power) should be more than sufficient to meet Current and Future ADWF conditions. Low flow conditions (at night) could result in more power than necessary being used. However, these are low power conditions anyway.

The worst case backwash frequency of eight per day should not cause UV starts to be exceeded. This is because these occur at high flow when the clean backwash tank will refill rapidly and the UV units will not time out or overheat. The typical backwash frequency of four per day will not cause starts per day to be exceeded, even without duty cycling.

5.20.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-24. Worst case sizing is independent of scenarios.

Table 5-24 UV System Process Sizing

	Units	Process Design Assumptions	Process Design Sizing
UV Banks		3	
Design UVT		60%	
Maximum UV Feed Flow	ML/d		17.817
Maximum UV Feed Flow	L/s		206.2
UV Banks Each	L/s		68.7

5.20.7 Control Philosophy

Three UV banks and UVI elements operate in duty/assist/assist configuration. With duty rotation managed by the systems proprietary controller.

A UV bank will fail if:

- A UV unit fault is detected by the UV PLC (respective bank failed and latched).
- The level is below the dry level set point or low level switch (all banks failed and latched).
- The operator sets it as out of service.

The UV channel level is monitored in real time. An alarm is generated if the level is above a short-circuit level (set point or switch) or below a low level (set point). An alarm is generated and all banks fail and latch if the level falls below a dry level (set point or switch).

The penstock modulates to maintain a target level in the UV channel. If the penstock or position element fails, then it will fail in its current position. If the level element fails, then the penstock will adopt a default position.

UV flow is monitored continuously. The real time flow, cumulative volume today and cumulative volume yesterday are calculated, displayed and recorded. If the UV flow element fails then the UV controller assumes a default maximum flow set point for the purpose of UV control.

There is a UV transmissivity (UVT) element. This provides a signal to the UV unit controller to adjust the UV output. If the UVT element fails, then a default UVT set point is adopted as the input to the UV controller. Alarms are generated if the UVT drops below low and low low levels, but there is no automated response. The real time UVT, plus the average UVT for the current and previous day (midnight to midnight) are calculated, displayed and recorded.

Lamp cleaning is controlled by the proprietary UV controller.

The number of operating UV banks is determined by the proprietary UV controller based on UVT and flow.

At least one UV bank will typically be running. The events that result in the duty UV bank stopping are:

- The level in the clean water backwash tank is below the UV start switch, and
- The filter bypass switch is not activated, and
- UV time-out has expired.

If the duty UV unit is stopped, then the events that lead to it starting are:

- The level in the clean water backwash tank is above the UV start switch, or
- The filter overflow switch is activated and the filter bypass set point is selected.

The UV controller generates signals of UV intensity (UVI) and UV dose. These are displayed in the SCADA in real time. Alarms are generated if either fall below low levels or low low levels for longer than an alarm delay times (i.e. the alarm condition must be continuous for this time before an alarm is generated). There is no automated response to these alarms. The UVI alarms are also suspended until the UV warmup period has expired.

The average UV dose for the UV unit is calculated for the current day (midnight to now) and previous day (midnight to midnight).

The UV run time for each bank is integrated between lamp replacements. An alarm is generated if the lamp life of any bank is exceeded.

5.21 Reclaimed Effluent System

5.21.1 Purpose

The purpose of the reclaimed effluent system is:

- To provide sufficient storage of effluent to supply the RE system during times of low or no flow.
- To supply RE to the odour control system to keep the odour control biomass moist.
- To supply RE to the inlet works for screen and grit handling and washing.
- To supply RE to the dewatering facility for polymer dilution and dewatering sprays.
- To supply RE to the bioreactor sprays.
- To supply RE for general site cleaning and hose down.
- The supply RE for grounds watering.
- To maintain the RE in an appropriate pressure range.
- To supply high flow, high pressure storm clean water for cleaning the SPDs and EST.
- To discharge excess final effluent to the discharge point.
- To monitor and record the flow of RE and final effluent.

5.21.2 Equipment and Instruments

The reclaimed effluent (RE) system consists of the following mechanical equipment and instruments.

- Two (2) RE lift pump level switches.
- One (1) fixed speed RE lift pump.
- One (1) flow switch for the RE lift pump.
- One (1) variable speed storm clean pump.
- One (1) RE tank pressure element, doubling as a level element.
- One (1) RE tank pressure switch, doubling as a level switch.
- Three (3) variable speed RE pumps in duty/assist/standby configuration (subject to supplier configuration).
- Three (3) flow switches, one per RE pump (subject to supplier configuration).
- One (1) RE pressure element (subject to supplier configuration).
- One (1) RE pressure switch (subject to supplier configuration).
- One (1) pressure element in the RE main.
- One (1) open switch on the pressure element isolation valve.
- One (1) RE flow element.

5.21.3 Description

There are a number of uses for non-potable water around the STP site. These are:

- RE for the inlet works odour control biofilter.
- RE for the inlet works (screens, screen washing, grit sparge, grit wash).
- RE for dewatering (polymer dilution and dewatering spray).
- Sprays for the bioreactors.
- Hose points at various locations for hosing down and cleaning.
- Grounds watering.
- High flow, high pressure storm clean water for cleaning the SDPs after they empty.

Rather than use potable water for these purposes, this is sourced from fully treated and disinfected effluent. There is no automated shutdown of this system in response to UV bypass or failure. The inlet works must continue to receive a supply of spray and wash water at all times (enclosed within the screen). Similarly, the dewatering system cannot operate without RE. Other uses can be suspended by the operator if disinfection is considered sub-standard.

All but the storm clean water supply is chlorinated and stored in a RE tank. The storm clean water is not chlorinated and there is no storage. The operator can therefore only use this system when there is sufficient, continuous flow through the plant. The operator starts and stops this pump manually, but it will also stop if there is insufficient treated effluent to supply the pump. This pump is sized for a maximum of two SDP washdown hoses to be used concurrently. This water is supplied to the SDPs and EST using a separate, dedicated ring main to the rest of the RE system.

There is a backup potable water supply to the RE tank with a hand valve. The hand valve can be opened manually by the operators to supply potable water to the tank and RE pumps if ever needed. If the potable water flow is greater than the RE demand then the RE tank may fill and overflow into the effluent discharge line. This should be rare as the RE tank has been sized to be able to supply the predicted RE demand throughout low sewage flow periods through the night.

Fully treated and disinfected water from the UV units is lifted to a RE tank (existing) with the use of a RE lift pump. This operates to maintain a full level in the RE tank whenever disinfected effluent is available. The intent is to provide sufficient RE storage to maintain critical RE (odour control, inlet works and dewatering) during low flow periods through the night. The RE is dosed with chlorine on the way to the RE tank for added disinfection. There is no chlorine residual monitoring or control. The operator merely sets a dose and the chlorine dosing pump operates whenever the lift pump operates.

RE is drawn from the tank through a proprietary RE pumping system that includes three RE pumps (duty/assist/standby) and a pressure vessel. The pumps are pressure controlled. This system discharges to a pressurised ring main around the site.

During most of the day, the disinfected effluent flow should exceed the RE demand. The RE tank will typically remain full.

The RE flow is monitored by a flow element. There is no final effluent flow element. The only difference between the UV flow (monitored) and the final effluent flow (not monitored) is the RE and storm clean flow. There is no flow element on the RE lift or the storm clean mains. Therefore it is not possible to calculate the final effluent flow in real time. However, the final effluent daily volume can be calculated by subtracting the RE volume from the UV volume. This figure is provided in the SCADA.

5.21.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The RE pumps are sized to accommodate:
  - The maximum odour control RE use, plus
  - The maximum screen RE use, plus
  - The maximum grit RE use, plus
  - The maximum dewatering RE use (future with two trains), plus
  - The maximum bioreactor RE use, plus
  - The maximum combined hose and ground watering use (around 2 concurrent hose points).
- The RE tank is sized to provide long term supply of RE under plant low flow or bypass conditions.
- The existing RE tank size is as stated in the CDR.
- The RE lift pump size is as stated in the OEMP.
- The storm clean pump has been sized based on WSC measurements of current hose points.

See Table 5-25 for details.

5.21.5 Turndown and Redundancy

The lift pump is provided in duty only configuration. The failure of the lift pump can be accommodated by substituting potable water supply to the RE tank.

The number of RE pumps will be determined by the supplier to meet the flow range required. A standby will be required such that one pump can fail without compromising maximum RE supply. If all pumps fail then it may be necessary to cease dewatering and bypass the screening and grit systems until the RE supply can be reinstated. This should be rare and has little immediate process consequence.

Failure of the RE tank level element can be accommodated by operating the RE lift pump in a Backup mode.

Failure of the RE tank level element has no effect on RE pump operation. The tank will rarely (if ever) drain. A low level cut out switch will fail the pumps if activated.

The flow elements are for monitoring only. There is no process or control consequence to failure.

The RE pressure element is critical to RE control. It is rare for such an element to fail.

The storm clean pump is provided in duty only configuration. Pump failure will delay post storm cleaning (rare) until it can be repaired or replaced.

The RE pump turndown should merely be sufficient to meet starts per hour of the pumps. This can be determined by the supplier based on usage rates provided in the specification.

5.21.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-25. Sizing is independent of scenarios as it is based on equipment and cleaning requirements, which should be identical under all scenarios. The only variable would be ground watering. Ground watering and hosing is provided as a single use. Under worst case conditions, ground watering may need to be suspended while hosing occurs. This is unlikely.

Table 5-25 Reclaimed Effluent Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Current)	Process Design Sizing (Future)
RE Low Lift Pumps		1		
RE Low Lift Pumps Each	L/s	7.0		
Existing RE Tanks		1		
RE Tank Volume Each	m^3	35		
RE Tank Useable Volume		80%		
Watering RE Max Flow	L/s	1.0		
Watering Operation	h/d	1.0		
RE Pumps		2		
Storm Clean Hose		2		
Storm Clean Hose Each	L/s	12.0		
Storm Clean Pumps		1		
Screen RE Max Flow	L/s		11.0	11.0
Screen RE Operation	h/d		2.0	2.0
Screen RE Use	m^3/d		79	79
Grit RE Max Flow	L/s		6.5	6.5
Grit RE Operation	h/d		1.0	1.0
Grit RE Use	m^3/d		23	23
Reactor Spray Max Flow	L/s		1.0	1.0
Reactor Spray Operation	h/d		12.0	12.0
Reactor Spray Use	m^3/d		43	43
Dewatering RE Max Flow	L/s		2.8	5.5
Dewatering Operation	h/d		7.6	3.8
Dewatering RE Use	m^3/d		75	75
Watering RE Use	m^3/d		4	4
Total RE Use	m^3/d		242	242
Total RE Max Flow	L/s		22.5	25.2
RE Pumps Each	L/s		11.2	12.6
Total RE Operation	h/d		3.0	2.7

	Units	Process Design Assumptions	Process Design Sizing (Current)	Process Design Sizing (Future)
Time to Fill RE Tank	mins		67	67
Overnight RE Use	m^3/h		12	18
Overnight RE Use	ADWF		0.08	0.09
RE Storage at Max Demand	h		0.3	0.3
RE Storage at Average Demand	h		2.8	2.8
Storage at Overnight Demand	h		2.3	1.6
Maximum Storm Clean Flow	L/s		24.0	24.0
Storm Clean Pumps Each	L/s		24.0	24.0

5.21.7 Control Philosophy

The RE lift pump operates in duty only configuration. The RE lift pump is fitted with a flow switch. An alarm will be generated and the pump will be failed and latched if the no-flow switch is activated once the pump has been running for more than its no flow delay period.

The storm clean pump operates in duty only configuration.

There is a low level switch in the pump station. The lift pump and storm clean pump will fail and latch if the level falls to this level.

The storm clean pump is normally switched to manual and off. If storm cleaning is required, then the operator switches the pump to auto. The pump will then operate while ever the level in the RE lift pump station is above the start level switch. The operator switches it back to manual and turns it off once cleaning is complete.

There are two operating modes for the RE lift pump. These are:

- Level mode – The RE lift pump starts and stops based on level set points in the RE tank.
- Backup mode – The RE lift pump operates near continuously. The RE tank overflows back to the discharge. The chlorine dosing system is automatically suspended in this mode.

The mode automatically switches to Backup mode if the RE tank level element fails. Each mode is described below:

<u>Level Mode</u>

The RE lift pump will start if:

- The lift PS level is above the stop switch, and
- The RE tank is below the lift pump start level set point.

The RE lift pump will stop if:

- The lift pump level is below the stop switch, or
- The RE tank is above the lift pump stop level set point.

<u>Backup Mode</u>

The RE lift pump will start if:

- The lift PS level is above the stop switch.

The RE lift pump will stop if:

- The lift pump level is below the stop switch.

Three RE pumps operate in duty/assist/standby configuration and are controlled by their own proprietary controller. Duty changeover is managed by the controller with a select number of hard wired signals linked to the site PLC, the remainder of signals are carried over communications links.

Each pump is fitted with a flow switch. An alarm will be generated and the pump will be failed and latched if the no-flow switch is activated on a pump that has been running for more than its no flow delay period.

The speed of each pump is limited between maximum and minimum speed set points.

The RE tank is fitted with a level element and a level switch (both based on pressure). The low level switch acts as a dry cut out, failing and latching all RE pumps if this switch is activated. The level element is used for level monitoring as well as pump inhibit control if the level in the tank falls below a RE pump stop set point. If the level element fails then then RE pumps will continue to operate.

The RE common main is fitted with a flow element. These is used for monitoring only. It does not generate high or low flow alarms. The real time RE flow, integrated volume today and integrated volume yesterday are monitored for RE. The integrated final effluent volume today and yesterday is calculated by subtracting the RE volume from the UV volume. The real time final effluent flow is not calculated.

The RE pumps operate based on a proprietary controller (likely to be pressure controlled).

The pressure in the RE main as monitored by a pressure element. The RE pressure is monitored in real time. The average pressure for today and the previous day is also calculated and displayed. Alarms are generated if the pressure is high or low, but there is no automated response.

These is an open proximity switch on the pressure element isolation valve. An alarm is generated unless this valve is fully open.

The control of the RE pumps will depend on the proprietary system. The following is an example control system only.

There is only one possible control mode for the RE pumps, being pressure mode.

- The duty pump starts when the pressure in the RE discharge falls to the start pressure.
- Once started, the duty pump speed modulates (PID loop) to try to match the pressure in the RE pressure element to the target set point. The speed of the duty pump is bounded by the minimum and maximum speeds. As the use of RE increases, so will the speed of the duty RE pump.
- If the duty pump increases to maximum speed, and the assist pump is not available, then the duty pump stays in its PID loop.
- If the duty pump speed increases to maximum speed, stays there for longer than the assist delay time, and the assist pump is available, then the assist pump starts and modulates to maintain the required pressure.. The speed of the pumps is identical and is bounded by the minimum and maximum speeds. As the use of RE increases, so will the speed of the duty and assist RE pumps.
- If the pump speeds decrease to minimum speed and stay there for longer than the assist delay time, then the assist pump stops and the duty pump increases to maximum speed. Then the duty pump speed modulates (PID loop) to try to match the pressure in the RE main to the target set point.
- If the pressure increases to the stop pressure then the duty pump will stop.

If at any time the level in the RE tank falls below the RE pump inhibit level set point, then all pumps will stop. The duty pump will restart once the level increases above the inhibit level.

5.22 Aerobic Digester

5.22.1 Purpose

The purpose of the aerobic digester is:

- To stabilise activated sludge biosolids so they are suitable for re-use.
- To reduce the dry mass of biosolids to reduce transport and disposal costs.
- To remove nitrogen from the recycled supernatant, reducing the TN in the effluent.
- To provide a consistent DWAS feed to help optimise dewatering.

5.22.1.1 Equipment and Instruments

There is no equipment or instruments associated with the digester other than those in the, aeration and DWAS pumping systems (see the following sections).

5.22.2 Description

The old IDEA bioreactor has been re-used as an aerobic digester

TWAS from the thickener and scum from the clarifiers is pumped to the aerobic digester. WAS can also be pumped directly to the digester if the overflow thickener is being bypassed for maintenance. These streams have alternative destinations should the aerobic digester be out of service. The scum can be directed to the lift pump station and the WAS, DWAS and scum can bypass the digester to the dewatering feed tank or to the sludge lagoons.

If the thickener is being bypassed, then the operator can draw WAS from the RAS (pre-thickened) instead of the ML. However, this will still be thicker than the TWAS from the thickener. If sustained, this could cause the digester sludge age to be compromised. If could also lead to DWAS volumes that are greater than the capacity of the dewatering system.

The TWAS (or WAS) and scum combine and enter the digester through one of the pre-existing feed manifolds. The digester feed is therefore dispersed across the feed end of the digester near floor level. The daily digester feed volume is calculated by adding the scum volume to the DWAS volume (or the WAS volume is the thickener is being bypassed). A rolling seven day volume is also calculated to assist the operator in settling weekly dewatering run volumes. The digester feed volume must match the DWAS volume over time for the digester to remain close to TWL. The digester level will fill slightly between dewatering runs, then slowly lower again while dewatering is occurring.

The digester operates in cycles and phases. The number of cycles per day and the length of each phase in the cycle is set by the operator in the SCADA. There are two phases in each cycle:

- Aerate – The contents are mixed through mechanical aeration and organic components of the WAS and scum are broken down. Ammonia is released as the solids break down. This is converted to oxidised nitrogen (mainly nitrate) in a process known as nitrification.
- Settle – The aerators stop. The digester contents stop mixing and begin to settle. Manual decanting can occur during this time if desirable. There is no automated control during the Settle phase. Nitrate removal (denitrification) occurs during Settle once the remnant dissolved oxygen (DO) is depleted.

The operator selects the start time of day of the first cycle. The start time of each phase is then calculated and mapped by the SCADA for the whole day. This is referred to as the digester cycle timetable. In the event of recovery from power failure the digester will restart automatically in the phase that it should be in at that time of day. The digester cycle timetable is remapped if the operator changes the cycle or phase timing via the SCADA.

The DWAS pump operation is also linked to the digester cycle timetable. The intent is to pump DWAS to the dewatering feed tank during Aerate only, when the digester is fully mixed and the DWAS is at a known and constant concentration.

The digestion process is an extension of the endogenous respiration process that occurs within the bioreactors. The exception is that under aerobic digestion conditions, the ‘inert’ volatile suspended solids (VSS) from the sewage is also broken down, possibly due to the growth and dominance of specialist aerobic organisms. This reduces the overall VSS significantly, provided that the sludge age in the digester is long enough. The digester sludge age is controlled by loading digester feed of a known volume each and every day. This is set through thickening control. If digester decanting is occurring, then it’s the DWAS volume that dictates the digester sludge age.

A high level overflow prevents surcharge of the structure and flows to the EST.

5.22.3 Design Assumptions

The following assumptions have been adopted for the process design.

- The digester dimensions are as per the construction drawings (DWG B3 and DWG 12A).

- The digester operating levels are as per the construction drawings (DWG 12A). The digester operates near the pre-existing top water level.
- The design digester sludge age (40 days) is based on experience and theoretically tested against stabilisation parameters (VSS destruction > 38% or SOUR < 1.5 gO/kgSS/d where SOUR is the specific oxygen uptake rate). Only one of these parameters must be met to attain Stabilisation Grade B, but modelling predicts that both are met.
- The sewage non-biodegradable VSS mass loss rate is based on Hunter H2O research. It is assumed to not change with temperature.
- All biodegradable VSS (BVSS) is in the form of active organisms BVSS.
- All other kinetics are based on defaults in *Biological Wastewater Treatment* with the exception of denitrification rate. This is based on endogenous (K3) rate rather than digestion (K4) rate. This is also based on experience that suggests that complete denitrification occurs if the Aerate portion of the cycle is 50%.
- The maximum design thickness of 1.0% (40 days at ultimate loading) is conservative. A thickness of up to 1.2% is more typical.
- The digester is assumed to increase in volume during periods during the week when dewatering is not occurring. The worst case volume occurs just before weekly dewatering begins.

See Table 5-26 and Table 5-27 for details.

5.22.4 Turndown and Redundancy

There is only one digester. All mechanical maintenance can be undertaken without draining the digester. The digester can be bypassed if it needs to be drained for any reason. This has no impact on effluent quality, however, the resulting dewatered biosolids will need to be reprocessed or sent to landfill.

Mechanical redundancy is covered in the respective sections.

There is no necessity for turndown. Under Current loads, the digester can be operated thinner or at a longer sludge age (reduced dewatering times). Both improve performance.

5.22.5 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-26 and Table 5-27. Worst case sizing is for the Future, Winter, MLE scenario.

Table 5-26 Digester Geometry

	Units	Process Design Assumptions	Process Design Sizing
Old IDEA Floor Width	m	14.000	
Old IDEA Floor Length	m	37.000	
Old IDEA Angled Side Width	m	6.930	
Old IDEA Coping Level (CPL)	m	4.620	
Old IDEA Bottom Water Level (BWL)	m	3.020	
Old IDEA Top Water Level (TWL)	m	3.720	
Old IDEA Batter Slope	:1	1.5	
Old IDEA SA at TWL	m^2		1212
Old IDEA BWL Volume	m^3		2327
Old IDEA TWL Volume	m^3		3107

The process sizing varies between scenarios. The worst case for digester thickness is the Future, Winter, MLE scenario. There is very little difference between the MLE and FSB scenarios, but the reduced bioreactor sludge age of the MLE scenario results in slightly greater sludge yield. The Current MLE scenario is provided for comparison.

Table 5-27 Digester Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Current MLE)	Process Design Sizing (Future MLE)
Digester Operating SRT	d	40		
Swg NBVSS Mass Loss Rate	d^{-1}	0.06		
Dewatering Operating	h/w		97.1	48.5
Max Catchup Period	h/w		70.9	119.5
Average Digester Feed Flow	ML/d		0.078	0.078
Average Digester Feed Load	kg/d		894	1180
Digester Feed Thickness			1.15%	1.52%
Typical Fill Depth	m		0.19	0.32
NHO BVSS Before Digestion	kg/d		136	180
NHO BVSS After Digestion	kg/d		16	21
Auto BVSS Before Digestion	kg/d		7	9
Auto BVSS After Digestion	kg/d		3	4
Swg NBVSS Before Digestion	kg/d		313	413
Swg NBVSS After Digestion	kg/d		92	122
DWAS Thickness			0.71%	0.93%
VSS in	kg/d		616	814
VSS out	kg/d		271	358
VSS Reduction			55%	55%
BVSS:VSS Out			7%	7%
SOUR	gO/kgSS/h		1.27	1.27

It is apparent that, under worst case conditions, the VSS reduction and SOUR are significantly better than the biosolids guidelines require for Grade B stabilisation. This is despite the design sludge age being less than that in the CDR (60 days).

Under Current loading conditions, the digester thickness at the design sludge age is just 0.7%. There will be significant safety during the early years of operation. This could be utilised by increasing the digester sludge age to (say) 55 days, reducing the TWAS volume, increasing the digester thickness and reducing the dewatering time per week.

5.22.6 Control Philosophy

The operator enters the digester cycle set points as follows:

- Cycles per Day
- Cycle 1 Start Time (hh:mm)
- Aerate Phase Time (min)

The SCADA calculates the cycle time and the Settle phase Time. The SCADA then calculates the digester cycle timetable that shows the start and finish time of each phase. The SCADA then continuously checks the current time to determine what phase the digester is in and therefore what equipment to control.

These set points are entered into a test system that does not affect the mapping being currently used. This allows the operator to enter and test set points and the resulting calculated cycle timetable without interrupting the cycles currently being used. Once the operator is satisfied with the test cycle timetable, then they select it to be applied. Only then do the new set points take effect.

Automatic daylight saving time changeover MUST BE DISABLED in the SCADA computer and PLC timers. Alternatively another method must be used to ensure clocks remain in sync and cycles remain unaffected at daylight saving changeover dates.

In the event of a power restoration after failure, or if the operator changes any of the set points above and selects the test timetable to be applied, then the digester will immediately resume automated operation as per its current phase.

The automated control of the bioreactors in each phase is as follows:

- Aerate – The aerators operate under automated control (see Section 5.23.7)
- Settle – There is no automated control.

The operation of the DWAS pumping system (see Section 5.24.7) is also linked to the cycle timetable.

5.23 Digester Aeration System

5.23.1 Purpose

The purpose of the digester aeration system is:

- To mix the contents of the aerobic digester.
- To provide oxygen for the endogenous decay of the digester biomass.
- To provide sufficient DO to support nitrification of released ammonia.
- To control the DO to optimise denitrification and power consumption.
- To prevent aeration and mixing if there is a danger of digester overflow.

5.23.2 Equipment and Instruments

The digester aeration system consists of the following mechanical equipment and instruments.

- Four (4) variable speed aerators (duty/duty/duty/duty).
- One (1) DO element.
- One (1) temperature and pH element.
- One (1) ACL level switch on the decanter.

5.23.3 Description

The four pre-existing floating surface aerators are retained and used for aeration and mixing of the digester. Each is fitted with a variable speed drive. They typically all operate concurrently, but the worst case aeration demand can be supplied with one out of service.

The aerobic decay of biomass creates the following aeration demands:

- Carbonaceous – The loss of VSS mass results in a loss of COD mass which is directly related to the DO that must be supplied.
- The loss of VSS results in a release of nitrogen in the form of NH_x-N. This must be nitrified.

The end result is that NO_x-N is created in the aerobic digester. This can be removed through denitrification during the air off periods (Settle). It is important that sufficient DO is sustained to support nitrification. However, too much DO can result in sub-optimal denitrification. Insufficient denitrification can result in the digester pH falling and high NO_x-N returns to the bioreactors via the supernatant. This will in turn lead to additional NO_x-N in the effluent. It is therefore important to control nitrogen in the digester through DO and cycle control.

There is a single DO element in the digester. This is used for monitoring and alarming only. A pH and temperature element are also provided for monitoring an alarming. The real time DO, pH and temperature, plus the average results for today and yesterday are monitored, calculated, displayed and recorded.

The aeration demand can change seasonally, but it should be reasonably consistent between cycles. Therefore it is simpler to control the aerator speed directly rather than through DO feedback control. The Aerate phase is broken into four equal time periods. The operator can set the speed of each aerator individually for each time period. A speed of zero means the aerator stops for that time period.

At the start of the Aerate phase, all aerators operate at maximum speed for a mix period. This mixes the digester contents. Aeration control of each aerator then reverts to speed profile. The operator should adjust the speed profile set points to ensure adequate mixing and to control the DO.

All aerators stop at the end of the Aerate phase or if a high level is detected within the digester.

5.23.4 Design Assumptions

The following assumptions have been adopted for the process design.

- Default steady state kinetics are used to determine the endogenous decay component.
- A sewage NBVSS loss rate is used to determine the additional carbonaceous demand.
- A COD balance is then used to determine the average carbonaceous oxygen demand.
- Chemistry is used to determine the average nitrification oxygen demand.
- Denitrification was determined from first principals using default steady state kinetics. Endogenous decay denitrification rates have been adopted. These are typically conservative. Experience suggests that full denitrification occurs if the air off period is 50% of the digester cycle.
- Chemistry is used to determine the average denitrification oxygen payback.
- Oxygen entering the digester (TWAS and Scum) is used to determine additional payback.
- Oxygen leaving the digester (DWAS) is used to determine additional demand.
- Load peaking is based on the Aerate portion of the cycle.
- The size of the aerator motors is based ASpect's 2008 report.
- The aerator efficiency is based on the CDR.
- The AOR:SOR ratio is based on experience. This is less than what is expected for a bioreactor due to the high solids content in the digester. The maximum Standard Oxygen Transfer Rate (SOR) is therefore assumed to be significantly less than the 152 kgO_2/h in the OEMP.

See Table 5-28 for details.

5.23.5 Turndown and Redundancy

There are four aerators. The worst case oxygen demand should be met with one aerator out of service. If two aerators are out of service, then it may be possible to meet the worst case aeration demand by extending the Aerate phase time.

The failure of the DO element has no impact on aeration.

Each aerator's speed can be adjusted. Aerators can also be operated intermittently. This should provide sufficient turndown for any likely condition.

5.23.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-28. Worst case sizing is for the Future, Summer, MLE scenario.

Table 5-28 Digester Aeration Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Oxygen in S/N and DWAS	mg/L	1.0		
Aeration Time	h/d	12		
Sludge Age	d	40		
Digester Volume	m^3	3107		
Number of Cycles per Day		6		
AOR:SOR Ratio		0.50		
Efficiency	kgO/kWh	1.5		
Number of Aerators		4		
Current Motor Size Each	kW	30		
Temperature	^{o}C		28.0	28.0
Denitrification Potential	kgN/d		31.0	36.0
NO_x-N in Supernatant and DWAS	mg/L		80.4	36.2
Oxygen in Digester Feed	kgN/d		0.1	0.1
Carbonaceous Demand	kgO/d		543.7	564.8
Nitrification Demand	kgO/d		140.3	146.6
Denitrification Payback	kgO/d		70.1	84.2
Oxygen in DWAS	kgN/d		0.0	0.0
Average AOR	kgO/d		613.6	627.1
Peak AOR	kgO/h		51.1	52.3
Approximate Max SOR	kgO/h		102.3	104.5
Approximate Power Required	kW		68.2	69.7
Required Motor Size Each	kW		17.0	17.4
Capacity			57%	58%
SOR Each	kgO/h		25.6	26.1

It is apparent that the existing aerators should have more than sufficient capacity to meet worst case demand.

Modelling suggests that full denitrification will occur in Winter but not Summer. This appears counter-intuitive. However, it is due to increase in decay rate and subsequent decrease in active mass during summer. There is simply less biomass in summer to denitrify. The NH_x-N released is also less, but this is not enough to offset the difference. In reality, full denitrification is likely to occur year round, reducing the aeration demand in summer from that shown in Table 5-28.

5.23.7 Control Philosophy

The DO, pH and Temperature are all monitored in real time. None of these are used for control. The average pH and temperature for today and yesterday is calculated, displayed and recorded. The average DO during the Aerate phases for today and yesterday is also calculated, displayed and recorded.

High and low alarms can be set for DO. These apply only during the Aerate phase. A low alarm can be set for pH. An alarm is generated if the alarm conditions occurs for longer than an alarm delay.

All aerators are inhibited from operating if a high level is detected within the digester

The aerators can operate once these conditions no longer exist.

The Aerate phase is broken into four equal time periods. The speed of each aerator can be individually set by the operator for each time period. A speed of zero indicates that the aerator should be stopped. The SCADA continuously looks which time period applies and sets the speed of each aerator accordingly.

The aerators start at low speed at the start of each Aerate phase. They then all increase to high speed for a certain mixing period. Once the mixing period has expired, then each aerator operates according to the speed profile as described above. All the aerators stop at the end of the Aerate phase.

If an aerator fails, then an alarm is generated and it is failed and latched.

5.24 DWAS Pumping and Storage System

5.24.1 Purpose

The purpose of the digested waste activated sludge (DWAS) storage and pumping system is:

- To transfer DWAS from the aerobic digester to the dewatering feed tank while it is mixed.
- To store DWAS for dewatering between Aerate phases in the aerobic digester.
- To transfer DWAS to the sludge lagoons under emergency conditions.

5.24.2 Equipment and Instruments

The DWAS pumping and storage system consists of the following mechanical equipment and instruments.

- One (1) variable speed DWAS pump (duty only).
- One (1) DWAS flow element.
- One (1) variable speed dewatering feed tank jet aerator.
- One (1) dewatering feed tank level element.
- Four (4) dewatering feed tank level switches.

5.24.3 Description

It is important to maintain a near constant solids concentration in the dewatering feed. Sudden changes in concentration can lead to sub-optimal polymer dosing, solids recovery and biosolids moisture content. It is therefore important to waste DWAS from the digester only when it is fully mixed (aerated).

Wasting DWAS while mixed also allows DWAS flow and volume to be used to control the digester sludge age. This results in stable digestion performance, aeration demand and DWAS thickness, all of which are critical to optimised digestion and dewatering.

The intent of the DWAS pumping and storage system is to fill the dewatering feed tank when the digester is in the Aerate phase and provide buffer storage to allow dewatering to continue while the digester is in the Settle and phase. The dewatering feed tank capacity has been sized to accommodate up to two hours of maximum (Future) dewatering feed flow. Two hours should cover the longest realistic Settle phase time.

The dewatering feed tank can also be filled with undigested TWAS. This allows the digester to be taken out of service or in response to long term decanter failure. There is no automated system for filling the dewatering feed tank with the TWAS pump (digester bypass). This must be undertaken manually by the operator (but can be done via the SCADA). This is an infrequent event and the worst case consequence is an overflow of WAS from the dewatering feed tank to the FWPS and back to the bioreactors.

The DWAS (or TWAS) can also be diverted to the existing sludge lagoons via the existing WAS main. This can be used to rapidly empty the digester or in response to long term failure of the dewatering facility.

The intent is for the operator to enter a weekly DWAS volume. This should be the same as the rolling weekly digester feed volume calculated and displayed in the SCADA (see Section). The operator then starts the weekly dewatering run. The dewatering run ends when the weekly DWAS volume has passed through the DWAS flow element. Dewatering then continues when the dewatering tank is emptied after the weekly DWAS volume has been met. This ensures that the dewatering feed tank is empty at the end of each weekly dewatering feed run. DWAS pumping can also be based on pump run duration.

A single (duty only) jet aerator is provided in the dewatering feed tank. This mixes and aerates the contents of the dewatering feed tank. The aerator stops when the tank reaches a low level.

The dewatering system can be made Available or Unavailable by the operator. If Available, then a dewatering start-up sequence will be automatically triggered based on a high level in the dewatering feed tank. The dewatering shutdown sequence will be triggered by a low level in the dewatering feed tank and a delay time. Therefore the dewatering facility control is a 'slave' to the DWAS pumping and storage system control. The dewatering system should run continuously until the weekly DWAS volume has been reached, then stop when the dewatering feed tank is emptied and a time out has expired.

There are two control modes for the DWAS pump. These are:

- Level mode – The DWAS pump starts and stops during the digester Aerate phase based on level set points in the dewatering feed tank. The DWAS pump will also stop, and remain stopped, once the weekly DWAS volume or duration has expired.
- Backup Mode – The DWAS pump starts and stops during the digester Aerate phase based on level switches in the dewatering feed tank. The DWAS pump will also stop, and remain stopped, once the weekly DWAS volume or duration has expired.

An alarm is generated if the dewatering feed tank reaches an overflow level set point. Any overflows return to the bioreactor via the FWPS.

5.24.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The digester TWL volume is as outlined in Table 5-26.
- The maximum dewatering feed rate is based on the capacity of the dewatering units. The system is sized for the future scenario that could include a second dewatering train. The Current scenario includes only one train.
- The buffer storage in the dewatering feed take includes sufficient capacity for the longest likely Settle phase time.
- The size of the DWAS pump is based on the size of the existing IDEA WAS pump, which could be retained and used. The existing WAS pump capacity size is based on the OEMP.
- The size of the jet pump is based on rule of thumb mixing criteria. This will be confirmed by suppliers.

See Table 5-29 for details.

5.24.5 Turndown and Redundancy

There is a single duty DWAS pump. Dewatering can continue if the DWAS pump fails. Longer term failure will lead to an automated dewatering system shut-down. Biomass can then be stored in the digester or in the bioreactors while the pump is replaced.

The DWAS pump can continue to operate based on Duration mode if the DWAS flow element fails.

If the dewatering feed tank level element fails, then a backup mode is initiated based on level switches.

There is no need for turndown. The DWAS pump will operate for shorter periods per week if the digester sludge age is increased.

5.24.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-29. The Current and Future MLE scenarios (Winter) are provided to show the difference between one and two dewatering trains. The FSB scenarios are almost identical, but with slightly less solids in the dewatering feed (longer bioreactor sludge age).

Table 5-29 DWAS Pumping and Storage System Sizing

	Units	Process Design Assumptions	Process Design Sizing (Current MLE)	Process Design Sizing (Future MLE)
Digester Volume Total	m^3	3107		
Typical Digester SRT	d	40		
Max Dewatering Operation	h/w	100		
DWAS Buffer Storage	h	2.0		
DWAS Buffer Tanks		1		
Effective Volume		100%		
Number of DWAS Pumps		1		
Existing WAS Pump Each	L/s	27		
DWAS Buffer Tank Jet Pumps		1		
DWAS Mixing Power	W/m^3	40		
Max Dewatering Feed	m^3/h		6.5	13.0
Average Dewater Feed Solids	kg/d		549	724
Typical Dewatering Operation	h/w		97.1	48.5
Typical Dewatering Load	kg/h		40	104
Average Digester Thickness			0.71%	0.93%
Typical Feed Solids(1)			0.61%	0.80%
Minimum Digester SRT	d		38.8	19.4
DWAS Buffer Tanks Each	m^3		13	26
Jet Pump Motor Each	kW		0.5	1.0

Note (1) - The feed solids are adjusted for the polymer dilution water, which thins the feed from the digester concentration.

The dewatering system has been designed for two parallel dewatering trains operating as duty/duty (as per the Future MLE scenario). However, only one train will initially be provided. This is reflected in the Current scenario.

5.24.7 Control Philosophy

The dewatering feed tank contains a level element and four level switches. The level switches perform the following functions.

- The high high level switch stops the DWAS pump but only in Backup mode. It also raises an imminent overflow alarm, which is disabled when in Backup mode.
- The high level switch starts the DWAS pump if not running, but only in Backup mode. It also starts the duty dewatering feed pump (see Section 5.25.7) if not running, but only in Backup mode. This switch generates no alarm.
- The low level switch inhibits the jet aerator, but only in Backup mode. If in backup mode, the jet aerator will operate continuously if the level is above this switch and will not operate if the level is below this switch. This switch generates no alarm.
- The low low level switch acts as a dry cut out for the jet aerator and dewatering feed pumps (see Section 5.25.7). The jet aerator and dewatering feed pumps will fail and latch if the level in the dewatering feed tank drops below this switch. This occurs regardless of the control mode. This generates an alarm.

Typically, it is the level element that controls the DWAS pump, the jet aerator and the duty dewatering feed pump. This is the Level mode. Control of these equipment items automatically switches to Backup mode if the dewatering feed tank level element fails.

There is a single duty, variable speed jet aerator in the dewatering feed tank. The jet aerator will operate whenever the dewatering feed tank level is above the aerator start level set point (Level mode) or the low level switch (Backup mode). It will stop if the level falls below the jet aerator stop level set point (Level mode) or the low level switch (Backup mode). The speed of the jet aerator is set by the operator. DWAS and dewatering feed pumping will continue if even if the jet aerator is stopped or failed.

There is a single duty, variable speed DWAS pump and a DWAS flow element. The pump speed is set by the operator. There is a no flow set point in the DWAS flow element. An alarm will be generated and the pump will be failed and latched if measured flow is below the no-flow set point after the pump that has been running for more than its no flow delay.

The DWAS pump operation is linked to the digester cycle map. The DWAS pump is inhibited from operating unless the digester is in the Aerate phase.

The DWAS pump is normally Unavailable. It will not operate until it is made Available by the operator. Once Available, it will continue to be Available until:

- It is made Unavailable by the operator, or
- The weekly DWAS volume has been achieved (Sludge Age trigger), or
- The weekly run duration has been achieved (Duration trigger).

The DWAS pump will not run unless it is set to Available.

The cumulative run time and DWAS volume since it was last made Available is calculated, displayed and recorded. These are set to zero each time the DWAS pump is made Available. The cumulative volume for today and yesterday is also displayed and recorded.

The DWAS pump termination trigger automatically switches to Duration trigger if the DWAS flow element fails.

There are two control modes for the DWAS pump.

- Level mode – The DWAS pump starts when the level in the dewatering feed tank is below the DWAS pump start level set point AND the digester is in the Aerate phase. The DWAS pump stops when the level in the dewatering feed tank is above the DWAS pump stop level set point OR the digester is not in the Aerate phase. An alarm is generated if the level falls to a low level. An alarm is also generated if the DWAS tank level exceeds an imminent overflow or overflow level set point.
- Backup mode – The DWAS pump starts when the level in the dewatering feed tank is below the high level switch AND the digester is in the Aerate phase. The DWAS pump stops when the level in the dewatering feed tank is above the high high level switch OR the digester is not in the Aerate phase. The high high switch level alarm is disabled.

If the level element is failed, the DWAS pump mode automatically switches to Backup mode.

5.25 Sludge Dewatering

5.25.1 Purpose

The purpose of sludge dewatering is:

- To dewater biosolids to reduce transport and disposal costs.
- To convey biosolids to out loading system
- To distribute biosolids evenly across the trailer.
- To capture filtrate and return it to the process for treatment.
- To minimise the solids in the filtrate that would otherwise compromise plant capacity.

5.25.2 Equipment and Instruments

The sludge dewatering system consists of the following mechanical equipment and instruments. This is based on a single, duty only, dewatering train (Current scenarios). The design (Future scenarios) caters for a second train to be added later if needed.

- Two (2) variable speed dewatering feed pumps (duty/standby).
- Two (2) temperatures switches, one for each dewatering feed pump.
- Two (2) fixed speed cooling fans, one for each dewatering feed pump drive.
- Two (2) pressure switches, one for each dewatering feed pump.
- One (1) flow switch for the dewatering feed pump pressure relief
- One (1) dewatering feed flow element (provision for second).
- Two (2) variable speed polymer dosing pumps (duty/standby).
- Two (2) temperature switches, one for each polymer dosing pump stator.
- Two (2) fixed speed cooling fans, one for each polymer dosing pump drive.
- Two (2) flow switches, one for each polymer dosing pump.
- One (1) flow switch for the polymer dosing pump pressure relief.
- Two (2) polymer dilution water solenoid valves.
- Two (2) flow switches, one for each polymer dilution water supply.
- One (1) variable speed, reversible dewatering screw press (provision for second).
- One (1) torque switch for the dewatering screw press (provision for second).
- One (1) torque element for the dewatering screw press (provision for second).
- One (1) pressure element for the dewatering screw press (provision for second).
- One (1) solenoid valve of the screw press wash water (provision for second).
- One (1) flow switch on the screw press wash water (provision for second).
- One (1) fixed speed dewatering screw press air compressor.
- One (1) pressure switch for the screw press compressed air.
- One (1) compressed air solenoid valve (provision for second).
- One (1) dewatering screw press pressure cone solenoid valve (provision for second).
- One (1) fixed speed cross conveyor.
- One (1) torque switch for the cross conveyor.
- One (1) motion detection proximity switch for the cross conveyor.
- One (1) fixed speed inclined conveyor.
- One (1) torque switch for the inclined conveyor.
- One (1) motion detection proximity switch for the inclined conveyor.
- One (1) reversible, fixed speed slewing drive for the inclined conveyor.
- Two (2) proximity switches on the slewing conveyor.

The polymer dosing tank pressure (level) element and switches are also used (see Section 5.26.2).

The dewatering feed tank level element and switches are also used (see Section 5.24.2).

5.25.3 Description

DWAS is drawn from the dewatering feed tank and dewatered through a single dewatering train. A second dewatering train has been included in the design as a future option. The intent will be to run both units in parallel if available. The dewatering feed tank, filtrate pipes, RE system, FWPS and the main plant process train have all been designed to accommodate a doubling of all dewatering feed, RE and filtrate flows. This description is based on the single dewatering train (Current scenario). The duty/standby feed pumps and polymer dosing pumps will become duty/duty under the Future scenarios.

The dewatering feed pumps, polymer dosing pumps, screw press and conveyors all operate as a single system. When operating, they all operate concurrently to turn DWAS into biosolids cake (deposited in a truck trailer) and filtrate (returned for treatment via the FWPS). Typically, these all operate continuously to process a continuous, weekly dewatering run.

The duty dewatering feed pump, polymer dosing pump, and polymer dilution solenoid are all interlocked. The target dewatering feed flow rate and polymer dosing rate are set by the operator. A slower feed rate could improve dewatering performance, but the weekly dewatering duration increases. If the digester sludge age is increased, then the dewatering run time is reduced and vice versa.

The screw press has a single drive, a wash water solenoid and an air compressor. The air compressor operates continuously to maintain design pressures. The compressed air creates a back pressure on the biosolids, which can be adjusted in the field. Dewatering feed (DWAS) is mixed with diluted polymer before entering the screw press. The screw press contains an auger and a filter basket. The auger is a screw with tightening gaps. As the sludge moves up the screw, it is compressed. The amount that it is compressed is influenced by the compressed air pressure setting. Filtrate that is squeezed from the sludge, flows out through the filter basket and is collected within the unit. It flows via gravity to the filtrate main, gravitating to the FWPS. Spray water (RE) is used to intermittently clean the filter basket during operation, and then to clean the press during shut-down. This RE spray water returns with the filtrate.

Dewatered biosolids fall from the end of the press onto a fixed speed cross conveyor. This conveyor will also service the second, future unit. The cross conveyor delivers the biosolids to an inclined conveyor that subsequently lifts the biosolids into a truck trailer. Flexibility is provided to allow biosolids to be discharged onto the trailer hardstand if required. The included conveyor is fitted with a separate, fixed speed, reversible slewing drive and position switches. The inclined conveyor pivots around a vertical axis, filling the trailer length more evenly.

The dewatering system acts as a 'slave' to the DWAS control system. If Available (usual), then the dewatering system will automatically undergo a start-up sequence once the level in the dewatering feed tank reaches a dewatering start level. The dewatering system will commence a shutdown sequence once the level in the dewatering feed tank reaches a dewatering stop level, the dewatering feed pump stops and a time out period expires. The latter should only occur once the desired weekly DWAS volume has been processed. However, a shut-down sequence will also be initiated (after a time out delay) if the dewatering feed pump stops for any other reason (such as various equipment failures).

The dewatering start-up sequence is as follows.

- The conveyors start.
- The screw press starts.
- The dewatering feed pump and polymer dosing pump starts.

The dewatering shutdown sequence is as follows.

- The dewatering feed pump and polymer dosing pump stop.
- After a time delay, the screw press wash starts.
- The wash stops and the screw press stops.
- After a time delay, the conveyors stop.

5.25.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The maximum dewatering period is 100 hours per week (e.g. 10 am Monday to 2 pm Friday).
- The actual dewatering period is based on the typical DWAS volume (digester sludge age) and the screw press hydraulic capacity (supplier advice). It is assumed that the dewatering units are operated at full capacity as this is the worst case for the hydraulic design of the STP.
- The digester sludge age is common to all scenarios. This leads to a lower feed concentration under the Current scenarios. It is possible to increase the sludge age and DWAS thickness and reduce the dewatering time for the Current scenarios if required.
- The screw press wash water flow and operating period is based on supplier advice.
- The polymer carrier (dilution) water flow is based on achieving a polymer concentration of less than 0.1% under all possible conditions. See Section 0 for details.
- The polymer carrier water flow is assumed to be included in the screw press maximum flow. Therefore the dewatering feed pump flow must be lower than the screw press hydraulic capacity. The high carrier water flow adds conservatism to the dewatering run time calculations.
- The solids recovery and biosolids solids content are based on supplier advice and experience.
- The biosolids bulk density is based on experience.

See Table 5-30 for details.

5.25.5 Turndown and Redundancy

The dewatering feed pumps and polymer dosing pumps are provided in duty/standby configuration. Dewatering capacity is unaffected if one of each unit fails. The failure of both will prohibit dewatering. The sludge can be stored in the bioreactors and digester for a significant period while repairs are undertaken. There is significant 'catch up' operating time available if required to process a backlog.

There is a single duty screw press and air compressor. Dewatering cannot continue if either fail. There is a long period each week when dewatering does not occur. Maintenance can occur during these periods. This can also be used to process a backlog after failure or repairs. WAS and DWAS can also be diverted to the existing sludge lagoons in an emergency. Contract dewatering can then be used to process the biosolids.

Each conveyor is duty only. Dewatering can continue if the slewing drive fails. However, the failure of a conveyor will prevent dewatering. As above, this can be accommodated by storage sludge in the bioreactors or digester and then extending the dewatering period to process a backlog.

The system is designed based on digested sludge (DWAS) volume. This is proportional to the digester volume, not the dry sludge production (sludge yield). There is no need for turndown. However, at commissioning (when the sludge yield is less) there are opportunities to vary the throughput. Options are:

- Do nothing. The digester sludge age remains the same (and therefore so does the dewatering feed volume). The dewatering feed is thinner, but dewatering is still run at the hydraulic capacity. There is no change to run times.
- Increase the digester sludge age (reduce TWAS volume) but run at capacity. This reduces the feed volume and increases the dewatering feed thickness. The dewatering time per week is reduced proportionally to EP load.
- Increase the digester sludge age and maintain the hours run per week. The feed volume is reduced, so the dewatering feed flow can also be reduced. This may improve dewatering performance.

The polymer dosing system has much more turndown than necessary to match any solids loading condition.

There is no need for turndown in the conveyors.

5.25.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-30. The worst case for flows is Future, Winter, MLE. The worst case for operating period is Current, Winter, MLE. The operating period does not change with load. The Current and Future scenarios are provided. The conveyors, RE supply and filtrate systems are based on the Future scenario so that a second train can be added in the future.

Table 5-30 Sludge Dewatering Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Current MLE)	Process Design Sizing (Future MLE)
Max Dewatering Operation	h/w	100		
Dewatering Spray Water		50%		
Solids Recovery		95%		
Biosolids Solids Content	w/w	18%		
Bulk Density	kg/m^3	850		
Train Capacity Each	m^3/h	6.5		
Polymer Carrier Water Each	L/s	0.25		
Dewatering Spray Water Each	L/s	2.5		

	Units	Process Design Assumptions	Process Design Sizing (Current MLE)	Process Design Sizing (Future MLE)
Duty Cross Conveyors		1		
Duty Slewing Conveyors		1		
Dewatering Trains			1	2
Typical Dewatering Flow(1)	m^3/h		5.6	11.2
Dewatering Feed Pumps			1	2
Duty Dewatering Units			1	2
Average Carrier Water Use	m^3/d		2.5	5.0
Dewatering Spray Water Total	L/s		12	12
Average Spray Water Use	m^3/d		62	62
Dewatering RE	L/s		2.8	5.5
Average Dry Biosolids	kg/d		511	676
Average Biosolids Wet Mass	Wet T/d		2.8	3.7
Average Biosolids Volume	m^3/d		3.3	4.4
Typical Dewatering Operation	h/w		97	49
Max Dewatering Load	kg/h		39.6	104.4
DWAS Thickness			0.71%	0.94%
VSS:TSS Ratio			49%	49%
Dewatering Feed Pumps Each	L/s		1.8	1.8
Dewatering Feed Pumps Each	m^3/h		6.5	6.5
Dewatering Capacity Each	m^3/h		6.5	6.5
Dewatering Capacity Each	kg/h		39.6	52.2
Max Conveyor Flux	Wet T/h		0.21	0.55
Max Conveyor Flow	m^3/h		0.25	0.65
Biosolids Weekly Storage	Wet T		20.3	26.8
Biosolids Weekly Storage	m^3		23.9	31.5
Average Filtrate Flow	ML/d		0.150	0.149
Maximum Filtrate Flow	L/s		4.6	9.1
Filtrate SS	mg/L		183	243

Note (1) – The maximum carrier water flow is subtracted from the hydraulic capacity to obtain the dewatering feed pump flow.

5.25.7 Control Philosophy

This control philosophy assumes that there is one dewatering train. The control philosophy and control system programming will require modifications if a second dewatering train is added.

There is a single (duty only) fixed speed cross conveyor and a single (duty only) fixed speed inclined conveyor. These start during the Start-up phase and stop during the Shut-down phase. Each conveyor includes a high torque switch and a proximity switch for motion detection. The following conditions lead to the failure of a conveyor.

- Drive failure, or
- High torque, or
- The conveyor is operating and proximity switch is not triggered within a motion detection period.

Failure of either conveyor inhibits the duty dewatering feed pump.

The inclined conveyor has a reversible, fixed speed slewing motor and two position switches. The slewing motor is interlocked with the conveyor motor. It starts when the conveyor starts and stops when the conveyor stops. The motor reverses direction each time a proximity switch is activated. The failure to activate a proximity switch within a time out time leads to the slewing motor failing. An alarm is generated, the slewing motor fails in its current location and latches, but the conveyor motor continues operating. The slewing conveyor can also be placed in manual by the operator and stopped. This has no impact on the dewatering facility operation.

There is a single (duty only) variable speed, reversible screw press and a single (duty only) fixed speed air compressor. The compressor is always available (operating between internal cut-in and cut-out pressure set points set in the field), even if the screw press is not operating. The compressed air solenoid remains open unless an emergency stop is actuated. The screw press cone solenoid valve is a three way valve. It pressurises the cone while the screw press operates, then depressurises the cone based on various screw press alarms and during shut-down.

The screw press starts during the Start-up phase and stops during the Shut-down phase. Failure of the compressor, or low pressure (switch) results in an alarm. The dewatering feed pump is then inhibited, but the screw press continues to operate. Failure of the screw press also inhibits the dewatering feed pump. The speed of the screw press is set by the operator.

The screw press is fitted with a wash water solenoid valve and flow switch. The solenoid opens and closes based on a timer while ever the dewatering system is in the Running phase. It is closed when the dewatering system is in the Stopped phase. The solenoid will also open and close based on a separate timer during the Shut-down phase. If no flow is detected after a time delay after the solenoid opens, then an alarm is generated, and the feed pump is inhibited.

The screw press includes a torque element and a pressure element. These are used for alarming and can also be used for control. There are three control modes for the screw press when running. These are:

- Constant Speed – The screw press operates at an operated preset set point while in the Running phase. This is the default operating mode if the feed thickness is likely to be relatively constant.
- Constant Pressure – The speed of the screw press modulates to try to maintain a constant pressure set point. The speed is bounded by minimum and maximum speed set points.
- Constant Torque – The speed of the screw press modulates to try to maintain a constant torque set point. The speed is bounded by minimum and maximum speed set points.

Regardless of the operating mode, there are a number of screw press alarm states and responses.

An alarm is generated if the torque remains below a low set point for more than a delay time. There is no automated response to this alarm.

If the torque exceeds a high torque set point for more than a delay time, then the feed pump is inhibited, and the cone pressure is released, the screw press slows to a removal speed and the wash water solenoid opens. If the torque falls below the high set point for more than a delay time, then normal operation and feed is resumed. If, however, the torque does not fall within a longer time delay, then the Shut-Down phase commences. A Shut-Down phases also commences if the number of high torque alarms exceeds a set point within a set period of time.

If the pressure increases above a maximum pressure, then the feed pump is inhibited. The feed pump can then automatically restart once the pressure falls below the high pressure for more than a delay time. If the number of high pressure alarms exceeds a maximum set point within a time set point, then a Shut-Down phase is initiated.

Two variable speed dewatering feed pumps operate in duty/standby configuration. The operator can select the duty allocation (2 off) in the SCADA. The failure of a duty or standby pump results in it being allocated as standby. The SCADA will automatically change the duty to each time the duty pump stops. There is a separate cooling fan on each dewatering feed pump drive. This is interlocked with the feed pump drive. The cooling fan operates whenever the pump operates, starting and stopping with the pump drive. The dewatering feed pump can continue to operate if the cooling fan fails.

The speed of each dewatering feed pump can be set separately.

During the Running phase, there are two possible control modes for the dewatering feed pumps:

- Level Mode – The duty dewatering feed pump starts when the level in the dewatering feed tank reaches a dewatering feed pump start level set point. The duty dewatering feed pump stops if the level falls to a dewatering feed pump stop level set point. The pump control automatically switches to Backup mode if the dewatering feed tank level element fails.
- Backup Mode – This is not intended to be a normal operating mode, but rather as an emergency backup if the level element fails. The duty dewatering feed pump starts when the level in the dewatering feed tank rises above the high level switch. The dewatering feed pump stops when the level falls below the low level switch.

The dewatering feed pumps will stop if:

- The level in the dewatering feed tank is below the dry cut-out switch (fail and latch both pumps).
- The level in the dewatering feed tank is below the dewatering feed stop level set point and the operating mode is Level (inhibit feed pump).
- The level in the dewatering feed tank is below the low level switch and the operating mode is Backup (inhibit feed pump).
- The pump high temperature switch is activated (fail and latch the respective pump).
- The pump high pressure switch is activated (fail and latch the respective pump).
- The pressure relief flow switch is activated (fail and latch the duty pump).
- The dewatering feed flow is below the no flow set point after a delay time after pump start (fail and latch the respective pump).
- The duty polymer dosing pump is failed (inhibit feed pump).
- The duty polymer dosing pump stator temperature is high (inhibit feed pump)
- No flow is detected in the polymer dilution water after a time delay after the solenoid opens (inhibit feed pump).
- The screw press is failed (inhibit feed pump).
- The screw press compressor is failed (inhibit feed pump).
- The compressed air low pressure switch is activated (inhibit feed pump).
- The screw compressor torque switch is activated (inhibit feed pump).
- No flow is detected in the screw press wash water after a time delay after the solenoid opens (inhibit feed pump).
- The cross conveyor is failed (inhibit feed pump).
- The cross conveyor torque switch is activated (inhibit feed pump).
- The cross conveyor is operating but the motion detection proximity switch remains deactivated for longer than a motion detection delay time (inhibit feed pump).
- The inclined conveyor is failed (inhibit feed pump).
- The inclined conveyor torque switch is activated (inhibit feed pump).
- The inclined conveyor is operating but the motion detection proximity switch remains deactivated for longer than a motion detection delay time (inhibit feed pump).
- The FWPS is above the inhibit level or overflow level switch (inhibit feed pump).
- The level in the polymer dosing tank is below the stop level (inhibit feed pump).
- The level in the polymer dosing tank is below the dry cut-out level (fail and latch the feed pump).

Two variable speed polymer dosing pumps operate in duty/standby configuration. The operator can select the duty allocation (2 off) in the SCADA. The failure of a duty pump results in it being allocated as standby. The SCADA will automatically change the duty to each time the duty pump stops. There is a separate cooling fan on each polymer dosing pump drive. This is interlocked with the dosing pump drive. The cooling fan operates whenever the pump operates, starting and stopping with the pump drive. The polymer dosing pump can continue to operate if the cooling fan fails.

The speed (dose) of each polymer dosing pump can be set separately.

The duty polymer dosing pump operation is interlocked with the duty feed pump operation. The dosing pump will start as the feed pump starts. The dosing pump will stop when the feed pump stops. The polymer dilution water solenoid valve is also interlocked with the feed pump operation. The solenoid will open when the feed pump starts. The solenoid will close when the feed pump stops. Therefore, any condition above that causes the duty feed pump to be inhibited or failed will also result in the duty polymer dosing pump to stop and the solenoid valve to close.

Other conditions that will stop the polymer dosing pumps are:

- The level in the polymer dosing tank is below the dry cut-out switch (fail and latch both pumps).
- The high stator temperature switch is activated (fail and latch the respective pump).
- The pressure relief flow switch is activated (fail and latch the respective pump).
- The low flow switch is activated after a delay time after pump start (fail and latch the respective pump).

The dewatering equipment operates as an interrelated system. There are four dewatering phases, Start-up, Running, Shut-down and Stopped. These are described below.

Start-up

Start-up is triggered by the following conditions:

- The dewatering system is set to Available, and
- The dewatering system is in the Stopped phase, and
  - The level in the dewatering feed tank is above the dewatering feed pump start level set point (Level mode), or
  - The level in the dewatering feed tank is above the high level switch (Backup mode).

The start-up sequence is then as follows:

- Set the phase to Start-up.
- Start the inclined conveyor (and slewing motor if Available and in Auto).
- Start the cross conveyor.
- Start the screw press at the selected speed or mode.
- Open the cone pressure solenoid valve.
- Start feed / polymer pumps
- Set the phase to Running.

Running

The Running phase starts when the Start-up phase has concluded and continues until the shut-down phase is triggered. The Running phase is as follows:

- The inclined conveyor is running.
- The inclined slewing motor (if Available and in Auto) is running and reversing based on the proximity switches. If the slewing motor fails, then an alarm is generated but the Running phase continues.
- The cross conveyor is running.
- The screw press is running.
- The screw compressor is running.
- The cone pressure solenoid valve is open.
- The screw press wash water solenoid is opening and closing based on timer.
- If the duty feed pump is stopped, then it continues to be stopped unless:
  - The level in the dewatering feed tank is above the dewatering feed start level set point (Level mode), or
  - The level in the dewatering feed tank is above the high level switch (Backup mode).
  - If none of the other inhibit conditions detailed above apply, then the duty dewatering feed pump will then start. This will trigger the polymer dosing pump to start and the polymer dilution solenoid valve to open. The shutdown time delay timer will be set to zero and stop.
- If the duty feed pump is running, then it continues to run unless:
  - The level in the dewatering feed tank is below the feed stop level set point (Level mode), or
  - The level in the dewatering feed tank is below the low level switch (Backup mode), or
  - One of the inhibit conditions listed earlier applies.
  - It will then stop. This will trigger the polymer dosing pump to stop and the polymer dilution solenoid valve to close. The shutdown time delay timer will be set to zero and start.

The dewatering feed tank should remain above the feed start level due to the operation of the DWAS system. Therefore dewatering feed should be continuous.

Shut-down

The Shut-down phase is triggered if:

- The current phase is Running, and
  - The duty dewatering feed pump is stopped and the shut-down delay timer has expired, or
  - The operator sets the dewatering system to Unavailable, or
  - The screw press over pressure or over-torque set points are exceeded for the shutdown time delay, or
  - The number of screw press over pressure or over torque alarms exceed the maximum within the set period of time

The shut-down sequence is then as follows:

- Set the phase to Shut-down.
- Stop the feed pump. This will stop the polymer dosing pump and shut the dilution water solenoid.
- Start the screw press run-on timer.
- Once the screw press run on timer expires, close the cone pressure solenoid valve
- Stop the screw press, reverse the direction and start it again at maximum speed.
- Open the wash solenoid and start the wash timer.
- Once the wash timer expires, close the wash solenoid and stop the screw press.
- Start the conveyor run on timer.
- Once the conveyor run on timer expires, stop the conveyors. This will also stop the slewing motor.
- Set the phase to Stopped.

Stopped

The Stopped phase is as follows:

  - The inclined conveyor is stopped.
  - The inclined slewing motor is stopped.
  - The cross conveyor is stopped.
  - The screw press is stopped.
  - The cone pressure solenoid is closed.
  - The screw compressor is running.
  - The screw press wash water solenoid is closed.
  - If the duty feed pump is stopped, resulting in the duty polymer pump being stopped and the polymer dilution solenoid being closed.

The dewatering facility will always return from power failure as Unavailable and in the Stopped phase.

5.26 Polymer Make-Up Storage and Dosing

5.26.1 Purpose

The purpose of the polymer make-up, storage and dosing system is:

- To flocculate and coagulate solids prior to dewatering.
- To improve dewatering solids capture (increase plant capacity).
- To increase dewatered biosolids solids content, reducing biosolids transport and disposal costs.
- To store dry polymer.
- To make up liquid polymer to a known concentration.
- To continuously supply the polymer necessary for effective and efficient dewatering.

5.26.2 Equipment and Instruments

The polymer make-up, storage and dosing system consists of the following mechanical equipment and instruments. These are based on a Ultromat ULFa 1000 system;

- One (1) level switch in the dry polymer hopper.
- One (1) fixed speed dry polymer screw feeder (subject to supplier configuration).

- One (1) heater for the dry polymer feeder (subject to supplier configuration).
- One (1) potable water wetting solenoid valve (subject to supplier configuration).
- One (1) potable water wetting flow switch (subject to supplier configuration).
- One (1) wetting head high level switch (subject to supplier configuration).
- Three (3) fixed speed polymer mixers (subject to supplier configuration).
- One (1) polymer dosing tank pressure element, doubling as a level element.
- Two (2) polymer dosing tank pressure switches, doubling as level switches (dry and full).
- One (1) polymer dosing eyewash and shower flow switch.
- One (1) level switch in the polymer bund sump.

The polymer dosing system equipment items (pumps and associated instruments) are covered in Section 5.25.2.

5.26.3 Description

Polymer helps to flocculate particles through additional binding and bridging with the long-chained, charged polymers. This improves dewatering performance (solids recovery and biosolids solids content).

Solids recovery is the mass of dry solids in the biosolids cake compared to the dewatering feed. The difference is solids lost in the filtrate. Poor recovery results in solids recycling through the STP, increasing the bioreactor MLSS and reducing the capacity of the bioreactors, clarifiers, digester and even the dewatering facility itself. Improving the recovery through appropriate polymer dosing is therefore a critical objective.

The biosolids solids content is the ratio of dry mass and wet mass of the biosolids. The greater the solids content, the less the moisture content, volume and wet mass of the biosolids. The biosolids solids content has a marked impact on storage capacity and transport and disposal costs.

WSC requested a similar polymer make-up system to that used at Robertson STP (Ultromat ULFa 400) but upsized to cater for the larger polymer consumption at Bowral STP. Polymer is received as a dry powder in 20 kg bags. Operators transfer the polymer powder to the polymer storage hopper manually. A polymer refill level alarm is generated when the hopper drops below the low level switch.

The powdered polymer is batched into a polymer solution of known concentration in the first mixing tank. It overflows through the second mixing tank to the polymer dosing tank. The polymer batching process is initiated by a low level in the dosing tank. The intent is to mix and age polymer in the first two tanks before the previous batch in the dosing tank is depleted. This allows a continuous supply of polymer to be maintained so that dewatering is not interrupted while polymer is batched.

The control of the dosing pumps is interlocked with the operation of the dewatering feed pumps. The dosing rate is fixed by the operator based on the dewatering feed flow and solids content. See Section 5.25.3 for dosing details. A low level in the polymer dosing tank inhibits the dewatering feed pumps, which will eventually lead to dewatering shut-down.

5.26.4 Design Assumptions

The following assumptions have been adopted for the process design.

- Polymer make up and storage system is based on the Ultomat ULFa 1000 system.
- The maximum and typical polymer usage is based on experience and supplier advice. The polymer dry mass dose is assumed to be proportional to dewatering feed dry solids loading.
- The polymer make-up concentration is based on experience and supplier advice.
- The maximum polymer dilution water is based on achieving a diluted polymer concentration of no more than 0.1%. The maximum dilution flow is intentionally conservative.

See Table 5-31 for details.

5.26.5 Turndown and Redundancy

The polymer make up system equipment is all duty only. The failure of the polymer feeder screw, polymer make-up mixer, polymer make up level element or polymer transfer valve prevents the make-up of polymer. This will eventually result in the shut-down of the dewatering facility. This will require dewatering catch up by dewatering for longer hours. Alternatively, it is possible to order liquid polymer and load it directly to the polymer dosing tank (and subsequent dilution), though such loading would be a manual process.

There are sufficient periods when dewatering is not operating to undertake maintenance.

Failure of the polymer dosing level element only effects alarming. Dosing and dewatering can continue until the batch runs out. Another batch can then be manually initiated by the operator. Once batching and ageing is completed, then dewatering can restart.

The dosing pumps have a large turndown and should be suitable across all scenarios. The pumps are provided in a duty / standby arrangement.

Liquid polymer loses its effectiveness over time. However, it is batched just in time on demand. The longest storage time is a few days over the weekend between dewatering runs.

5.26.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-31. Worst case sizing is based on the Future, Winter, MLE scenario. The sizing does not significantly change between the MLE and FSB scenarios. Sizing is provided for single dewatering train (Current) and dual dewatering train (Future) scenarios.

Table 5-31 Polymer Make-Up Storage and Dosing Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Current MLE)	Process Design Sizing (Future MLE)
Maximum Polymer Dose	kg/DST	10.0		
Average Polymer Dose	kg/DST	5.0		
Poly Make-Up Concentration	w/w	0.5%		
Poly Batch Tank Volume	L	1000		
Poly Tank Active Volume		80%		
Poly Dosing Pumps			1	2
Carrier Water Total	L/s		0.25	0.50
Dewatering Feed	DST/week		3.8	5.1
Min Dewatering Operation	h/w		97.1	48.5
Dewatering Feed	DST/h		0.04	0.10
Max Dry Polymer Dose	dry kg/h		0.4	1.0
Average Dry Polymer Use	dry kg/d		2.7	3.6
Max Polymer Use	L/h		79	209
Typical Batching Frequency	h		26.4	10.0
Polymer Dosing Pump Each	L/h		79	104

5.26.7 Control Philosophy

This control philosophy assumes that there is one dewatering train. The control philosophy and control system programming will require modifications if a second dewatering train is added.

This control philosophy is confined to the polymer batching and storage system. The control of the dosing pumps and associated equipment is detailed in Section 5.25.7.

There is a level switch in the polymer bund sump that generates an alarm when activated

There is a flow switch on the polymer dosing area eyewash and shower. An alarm is generated if this flow switch is activated for longer than an alarm delay time.

The dry polymer hopper is fitted with a low level switch. An alarm is generated if the dry polymer falls below this level.

There is a high (overflow) level switch in the polymer dosing tank. If the level is above this switch, then the polymer makeup batching system will be inhibited.

There is a pressure element in the polymer dosing tank. A specific gravity input is used to convert this pressure signal into level in the tank. The calculated level is displayed in the field and transmitted to the SCADA in real time.

A polymer batching sequence is triggered if:

- Requested by the operator, or
- The DWAS system is Available, and
    - The level in the polymer dosing tank falls to the batch start level set point, or
    - The level in the polymer dosing tank falls to the dry cut out switch.

The polymer makeup sequence is controlled by a proprietary controller for the system.

5.27 Biosolids Hardstand

5.27.1 Purpose

The purpose of the biosolids hardstand is:

- To store biosolids if a truck trailer is not available.
- To store biosolids between batch transport and disposal.
- To collect contaminated water and deliver it to the FWPS for treatment.

5.27.2 Equipment and Instruments

There is no equipment or instruments associated with the biosolids hardstand.

5.27.3 Description

Biosolids from the dewatering facility are typically collected and stored in a truck trailer. If a trailer is not available, or there is a desire to store biosolids in the medium term, then they can be stored in the existing biosolids hardstand area.

Biosolids need to be manually transported from the biosolids loading area to the biosolids hardstand. The slewing motor on the inclined conveyor can be stopped without impacting on automated dewatering. This will result in the biosolids being deposited as a single cone in the biosolids loading area. This can be manually transported to the existing biosolids hardstand with the use of a backhoe or similar. The biosolids can be stored in the hardstand until transportation. Manual loading into a truck trailer will then be required.

There is a drain from the hard stand to the FWPS. There is a manual valve on this drain that should be closed if the hardstand is not being used and is clean. This is to reduce stormwater runoff to the FWPS. This valve should be left open when the hardstand is in use or is soiled. Reclaimed effluent can be used to manually wash down the hardstand after use, with the dirty wash-water flowing to the FWPS.

5.27.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The dimensions of the existing biosolids hardstand are as shown in the drawings (DWG 69A).
- The storage volume is assumed to be the contained volume of the hardstand up to wall coping level. In reality, it is more likely to be stored in cones that are higher than the coping level. Therefore the storage volume and duration are an approximation only.

See Table 5-32 for details.

5.27.5 Turndown and Redundancy

The biosolids hardstand is not typically required.

5.27.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-32. The worst case is the Future Winter MLE scenario.

Table 5-32 Biosolids Hardstand Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Existing Hardstands		1		
Existing Hardstand Width	m	15.4		
Existing Hardstand Length	m	15.4		
Existing Hardstand Depth	m	1.0		
Hardstand Storage Volume	m^3		237	237
Average Biosolids Production	m^3/d		4.4	4.5
Hardstand Storage	d		53	53

5.27.7 Control Philosophy

There is no automated control of the biosolids hardstand.

5.28 Foul Water Pump Station

5.28.1 Purpose

The purpose of the Foul Water Pump Station (FWPS) is:

- To collect various foul water streams generated throughout the plant.
- To collect contaminated stormwater from areas around the plant.
- To return foul water to the bioreactors for treatment.
- To minimise the risk of foul water overflow to the emergency storage tank (EST).

5.28.2 Equipment and Instruments

The FWPS consists of the following mechanical equipment and instruments.

- One (1) FWPS level element.
- Four (4) FWPS level switches.
- Two (2) variable speed foul water pumps (duty/standby).
- One (1) foul water flow element.

5.28.3 Description

There are a number of foul water streams generated from processes around the STP. These are:

- Filter backwash from the tertiary filter dirty backwash tank.
- Decanted supernatant from the WAS thickener.
- Filtrate and washdown from the dewatering facility.

In addition to this, the pump station accepts contaminated storm water from the biosolids hardstand.

All these streams drain to the FWPS. The only regular flows during dry weather are the filter backwash, thickener supernatant and dewatering filtrate. The FWPS is designed to have the capacity to pump the worst case flows from these sources. This is pumped to the bioreactor flow splitter for treatment through the plant.

If the level in the FWPS increases above an inhibit level set point or high high level switch, then the following occurs:

- The dirty water backwash pumps are inhibited.
- The dewatering feed pumps are inhibited.

The thickener supernatant is not inhibited because it is a low flow and should typically be of a similar quality to secondary effluent.

Contaminated stormwater from sustained wet weather could exceed the capacity of the FWPS. This could occasionally lead to an overflow from the FWPS to the EST. This will be alarmed and the flow estimated. First flush stormwater will be pumped from the FWPS to the bioreactors, and most solids should settle in the FWPS, so the overflow should be relatively clean stormwater and fully treated water.

Two variable speed foul water pumps are provided in duty/standby configuration. There are two possible control modes for the duty foul water pump.

- Level Mode – The duty foul water pump starts operates to try to maintain a constant level in the FWPS.
- Backup Mode – The duty pump operates at a fixed speed, starting and stopping based on level switches.

Foul water flow is monitored in real time and the daily volume is also calculated and displayed. This is used to calculate the bioreactor feed flow and volume.

5.28.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The foul water pumps are sized to accommodate:
  - The maximum filter dirty backwash pump capacity, plus
  - The maximum supernatant flow (WAS pump flow), plus
  - The maximum dewatering feed pump flow, plus
  - The maximum polymer dilution water flow, plus
  - The maximum screw press wash water flow.
- Other flows are assumed to be negligible.
- The storage capacity in the FWPS is based on control and failure objectives only.
- The storage capacity in the FWPS should also be sufficient to prevent the maximum starts per hour of the duty foul water pump being exceeded.

See Table 5-33 for details.

5.28.5 Turndown and Redundancy

Foul water pumps are provided in duty/standby configuration. The loss of one pump has no impact on operation. The failure of both pumps will lead to a high level inhibition dewatering feed and filter dirty backwash. This could occur for a few days before becoming critical.

Failure of the FWPS level element will lead to a change to Backup control using the level switches.

The flow element is used for monitoring and the calculation of bioreactor feed. There is no process or control consequence to failure.

The FWPS turndown provides some attenuation of foul water returns to the bioreactors. The duty pump will operate at low speed and intermittently most of the time.

5.28.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-33. The worst case is the Future MLE scenario, where there are two parallel dewatering trains.

Table 5-33 Foul Water Pump Station Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Current MLE)	Process Design Sizing (Future MLE)
FWPS Pumps		2		
Duty FWPS Pumps		1		
Number of FWPS Tanks		1		
Active Volume		80%		
Storage at Peak Inflow	mins	5.0		
Maximum Filter Backwash	ML/d		0.944	0.944
Maximum Supernatant	ML/d		0.609	0.609
Maximum Dewatering Filtrate	ML/d		0.394	0.787
Average Foul Water	ML/d		0.943	0.943
FWPS Capacity	L/s		22.5	27.1
FWPS Pumps Each	L/s		22.5	27.1
FWPS Volume Each	m^3		8.4	10.2

5.28.7 Control Philosophy

Two variable speed foul water pumps operate in duty/standby configuration. The operator can select the duty allocation (2 off) in the SCADA. The failure of a duty or standby pump results in it being allocated as standby. The SCADA will automatically change the duty to each time the duty pump stops.

There is a no flow set point for the foul water flow. An alarm will be generated and the pump will be failed and latched if the foul water flow is below the no-flow set point after the duty pump has been running for more than its no flow delay period.

The foul water pump station (FWPS) is fitted with four level switches. The high high level switch indicates that an overflow is occurring (alarm and start the overflow flow estimation). This will also inhibit the dewatering feed and dirty backwash pumps. The high level is also used to start the duty pump if Backup mode is selected. This generates no alarm. The low level switch is used to stop the duty foul water pump, but only if Backup mode is selected. It generates no alarm. If the level falls below the low low level switch, then both pumps fail and latch, regardless of operating mode.

The FWPS is also fitted with a level element. This is used for alarming, pump control and overflow flow and volume estimation. The flow and volume from the FWPS overflow are monitored (estimate only) using the level element and a formula in the SCADA. The overflow flow is set to zero unless the high high level switch is activated. The SCADA calculates and records flow, integrated volume today (since midnight) and integrated volume yesterday (midnight to midnight).

Failure of this level element results in the pump control mode switching to Backup.

The foul water common discharge main is fitted with a flow element. This is used for monitoring. It is added to the influent flow to calculate the bioreactor feed flow. The calculated bioreactor feed flow is used for the control of the MLR pumps, secondary alum dose (to the clarifiers) and RAS pumps. If the foul water flow element fails, then the foul water flow is assumed to be zero for the purpose of this calculation. The real time foul water flow, integrated volume today and integrated volume yesterday are monitored, displayed and recorded.

There are two possible control modes for the foul water pumps:

- Level Mode – The duty foul water pump starts when the level reaches a start level set point. Once started, the duty foul water pump modulates to try to maintain a target level set point in the FWPS. The duty foul water pump stops if the level falls to a stop level set point. Alarms are generated if the level rises to near overflow level set points or the high high level switch is activated. The pump control automatically switches to Backup mode if the FWPS level element fails.
- Backup Mode – This is not intended to be a normal operating mode, but rather as an emergency backup if the level element fails. The duty pump speed is set to a fixed speed set point. The duty pump starts and stops based on the high and low level switches in the FWPS.

The following occurs if the FWPS reaches the inhibit level set point or the overflow switch is triggered:

- The dewatering feed pumps are inhibited. Polymer dilution water is also inhibited (see Section 5.25.7).
- The dirty backwash pumps are inhibited (see Section 5.19.7).

5.29 Alum Storage and Dosing

5.29.1 Purpose

The purpose of the alum storage and dosing system is:

- To store alum, used for phosphorus precipitation (soluble phosphorus removal).
- To accept alum deliveries.
- To capture chemical spills that may result from alum deliveries, storage or maintenance.
- To dose alum to the bioreactors to remove phosphorus.
- To dose phosphorus to the clarifiers or filters to polish phosphorus.
- To flocculate filter feed to assist filtration performance and disinfection.
- To optimise the use of chemicals to save costs.

5.29.2 Equipment and Instruments

The alum storage and dosing system consists of the following mechanical equipment and instruments.

- Two (2) alum storage tank pressure elements, doubling as level elements, one for each tank.
- Four (4) alum storage tank level switches, two for each tank (dry and full).
- One (1) level switch in the alum dosing bund sump.
- One (1) eyewash and shower flow switch on the common eyewash and shower supply main.
- Two (2) variable speed primary alum dosing pumps (duty/standby).
- Two (2) no flow switches, one on each primary dosing pump.
- Two (2) variable speed secondary alum dosing pumps (duty/standby).
- Two (2) no flow switches, one on each secondary dosing pump.
- One (1) alum dosing pressure relief flow switch.

- Three (3) level switches, one for each containment pipe.

5.29.3 Description

Biological treatment removes some phosphorus from sewage. However, some 70% of sewage phosphorus remains in biologically treated secondary effluent. This is in the form of soluble orthophosphate (PO_x-P). PO_x-P can be turned into a solid (chemical precipitant) by adding metal ions. Many different metal ion solutions can be dosed for this purpose. The most common forms of these include:

- Alum or aluminium sulphate ($Al_2(SO_4)_3.16H_2O$).
- PACl or Poly-Aluminium Chloride ($Al_2Cl(OH)_5$ or $AlCl_2OH$, the latter marketed as AlPhos).
- Ferric Chloride ($FeCl_3$).
- Ferrous Chloride ($FeCl_2$).

All perform in similar ways, with the choice of chemical based largely on price (including the cost of any alkalinity correction chemical required). The most common chemical used throughout Australia is alum as it is readily sourced and is well priced. Alum also represents a conservative approach as it has a low metal content (high dose rate and volume usage) and has a large alkalinity consumption (high use of alkalinity correction dosing). Designing for alum means that all other chemicals listed above can be used if the price (and performance following jar testing) is favourable. The design documentation refers to alum for simplicity.

Most phosphorus precipitation chemicals are acidic and remove alkalinity. Of the list above, alum and ferric chloride consume the most alkalinity. PACl removes the least (1/6th that of Alum). AlPhos removes 5/6th of the alkalinity of Alum. The concentration of the active metal (e.g. aluminium) also varies with chemical type and supplier, with Alum being the weakest and PACl being the most concentrated. The intent is to create a metal phosphate precipitant (e.g. $AlPO_4$). Other side reaction precipitants are also formed (e.g. $Al(OH)_3$) which consume metal ions and more alkalinity.

As the concentration of PO_x-P decreases, less of the chemical forms metal phosphates and more is lost to side reactions. Chemical consumption therefore increases exponentially as the target PO_x-P concentration decreases. It is typically more economical to dose in multiple locations, as this reduces overall chemical consumption. There are three possible locations for Alum dosing:

1. To the bioreactors (influent rising main), with precipitants enmeshed in the activated sludge flocs and removed with the WAS.
2. To the clarifiers (ML splitter box), with precipitants enmeshed in the activated sludge flocs, settling in the clarifiers, returned to the bioreactors and removed with the WAS.
3. To the filters (flocculation tank), with precipitants enmeshed in the secondary effluent flocs, removed in the filters and returned to the reactors via the filter dirty backwash so that they may be captured within the WAS.

The intent is to dose the bioreactors and then a choice of either the clarifiers (to take solids loading off the filters and extend the run time) or to the filters (to improve filtration performance and pathogen removal). It should be noted that the pathogen log removal values (LRVs) associated with filters can only be claimed if flocculation (alum) is dosed to the filters. This may be significant for future recycled water compliance.

Phosphorus precipitation chemicals assist in flocculation. They tend to reduce SS in the effluent and can improve sludge settleability. The concentration dosed for phosphorus removal far exceeds that required for flocculation.

Alum is delivered by tanker and stored in the alum storage tanks. Level alarms indicate when the duty storage tank nears empty so that a delivery can be ordered. The level elements are based on pressure. This means that they need a specific gravity input. This must be updated is the specific gravity of the chemical changes.

Deliveries arrive by tanker and are pumped from the tanker to the storage tanks. The delivery filling pump is powered by a local panel at the filling station. The power to the pump is automatically inhibited once the alum tank is full (switch), preventing overflows. The local level indicator panel also assists the tanker delivery operator with filling. Any spills that occur are captured in a bunded area on the road and associated chemical pit. Arrangements must then be made to transfer this chemical spill to a tanker for disposal or back to the storage tank. Rainwater can also fall in this bunded area, in which case it can be manually drained to the EST, from where it can be pumped back for treatment through the STP. The drain valve should normally be open but should be closed manually each time the tanker arrives and before filling commences.

The storage tanks and dosing pumps are located within a bunded area. This is sized to contain more than the volume of one storage tank in case of tank or pipe rupture. The bunded area contains a sump. A portable sump pump can be used to extract and manage spills. A sump pump can also be used to transfer rainwater from the sump to the chemical pit tank and thence the EST.

Two digital dosing pumps in duty/standby configuration are provided for primary (bioreactor) dosing. These dose to the influent main. Therefore the dose is split evenly between the two bioreactors at the feed splitter. The rate of dose can be varied. Typically, the dose rate varies with influent flow (flow paced) so that the alum dose matches the phosphorus mass to be removed. Speed pacing (with the influent pumps) can be used as a backup should the sewage flow element fail. The dose can be capped to prevent overdosing during wet weather.

There is a second set of digital dosing pumps in duty/standby configuration. These can dose to the clarifiers or to the filters, but not both. The rate of dose can be varied. Typically, the dose rate varies with flow (flow paced with the bioreactor feed flow or filter feed flow) so that the alum dose matches the phosphorus mass to be removed. Speed pacing (to the influent pumps or filter feed pumps) can be used as a backup should the flow element fail.

The filter bypass is located upstream of the flocculation tank. This prevents alum precipitants entering the filter bypass.

Flush points are provided for each pump and dosing line. Chemicals should be flushed from the lines prior to maintenance. An eyewash and shower is located in the unloading area, within the bund and near the dosing pumps. The use of these is alarmed.

The use of Alum and other phosphorus precipitation chemicals consumes alkalinity. This can cause the depletion of alkalinity in the process and treated effluent, leading to pH suppression. This is managed through alkalinity dosing. An increase in alum dosing can lead to the need to increase alkalinity dosing.

5.29.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The phosphorus precipitation chemical storage and dosing facility has been based on Alum as this is the most conservative for both sizing and alkalinity consumption.
- Worst case aluminium content and specific gravity has been assumed.
- Default steady state kinetics have been assumed to predict rudimentary biological uptake of phosphorus prior to chemical precipitation.
- The stoichiometric (molar) rates to achieve the desire PO_x-P concentrations are based on experience and are intentionally conservative.
    - 2 for the bioreactors.
    - 5 for the clarifiers or filters.
- The storage tanks have been sized to accommodate the desired delivery frequency, with the active volume being less than the total volume to provide spare capacity.
- The pump capacities are the minimum required. They can be sized identically as the turndown is much more than required.
- Dosing to the filters has been modelled as it is the worst case for filtration design. Dosing to the clarifiers should lead to the same WAS yield and overall sludge production. Both locations lead to identical bioreactor, digester and dewatering sizing.

See Table 5-34 for details.

5.29.5 Turndown and Redundancy

The primary (bioreactor) dosing pumps are provided in duty/standby configuration. The loss of one pump has no impact on operation.

There are an additional two secondary (clarifier or filter) dosing pumps in duty/standby configuration. The loss of one pump has no impact on operation.

The failure of both dosing pumps at one dosing location can be rectified by moving the standby dosing pump from the other location. The loss of three pumps may lead to a slight increase in effluent phosphorus, but this may be mitigated by increasing the primary dose rate and chemical consumption. This is a very high level of redundancy.

There are two storage tanks in duty/standby configuration. If one tank needs to be taken out of service for maintenance (unlikely) dosing can continue.

Failure of the chemical storage level elements only effects filling and alarming. Dosing can continue.

Failure of flow pacing flow elements leads to the control switching to speed pacing. Dosing can continue.

Digital chemical dosing pumps have a very large turndown. The same pumps should be able to meet all scenarios.

Alum has a long effective life. There is little chance that the alum will lose effectiveness even if deliveries are infrequent.

5.29.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-34. Worst case sizing is based the Future, Summer, FSB scenario.

Table 5-34 Alum Storage and Dosing Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Metal Ion		Al		
Aluminium Content	w/w	3.8%		
Specific Gravity		1.3		
PDWF Peaking	:ADWF	2		
Primary Alum Molar Rate		2		
Secondary Effluent (SE) PO_x-P	mg/L	0.5		
Primary Alum Pumps		1		
Secondary Alum Molar Rate		5		
Tertiary Effluent (TE) PO_x-P	mg/L	0.05		
Secondary Alum Pumps		1		
Alum Storage Tanks		2		
Alum Tank Volume Each	m^3	30		
Usable Volume		80%		
Maximum Filter Feed Flow	ML/d		17.817	17.817
Effluent SP Without Dosing	mg/L		7.6	7.5
Max Primary Alum Each	L/h		117.2	117.4
Primary Al Mass Dose	kg/d		69.6	69.7
Primary Precipitants	kg/d		258	258

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Primary Solution Use	kg/d		1820	1813
Primary Solution Use	L/d		1400	1394
Max Secondary Alum Each	L/h		29.4	29.4
Secondary Al Mass Dose	kg/d		10.4	10.4
Secondary Precipitants	kg/d		34	34
Secondary Solution Use	kg/d		274	274
Secondary Solution Use	L/d		211	211
Total Average Alum Usage	L/d		1611	1605
Storage at Average	d		29.7	29.6

5.29.7 Control Philosophy

There are two alum storage tanks (duty/standby). They can be cross connected and their level equalised (duty/duty) as an option. There is a level element and two level switches (overflow and dry) in each tank. The operator must select the duty tank in the SCADA if they are operating as duty/standby.

There is a pressure element in each alum storage tank. A specific gravity input is used to convert pressure into levels in each tank. This occurs in the field. The pressure and level readings are both transmitted to the SCADA and displayed. The level at midnight the previous day is also displayed and recorded.

There are four level set points:

- High High - Overflow (remote alarm).
- High - Full (remote alarm).
- Low - Re-order alum (remote alarm for duty tank only).
- Low Low – Inhibit (remote alarm for duty tank only, with all alum dosing pumps stopped).

The two level switches perform the following functions:

- High - Full (local visual and audible, fill point power supply inhibit and remote alarm).
- Low – Dry (fail and latch all alum dosing pumps).

There is a local indicator panel at the truck fill station that shows various conditions in the field. These are:

- The tank level in each tank as measured by the level elements.
- A visual and audible alarm if the level in either tank reaches the high level switch (full). It is possible to mute the audible alarm from the truck fill panel.

A tanker is used to refill the alum storage tanks. The tanker is located within a bund (common to alum, alkalinity and carbon dosing fill points) that drains to a sump. The sump is not alarmed.

The tanker uses its own pump to transfer alum from the tanker to the alum storage tanks. The power supply for this pump is located on the local indicator panel at the truck fill station. An emergency stop switch on the panel stops the power supply to the pump, stopping filling. The tanker operator can view the alum storage tank levels on the local indicator panel. The level rises as he fills each tank. A local visual and audible alarm is generated if the level reaches the high (full) level switch on either tank. There is a hard wired interlock that inhibits the power supply to the pump if the level in either storage tank is above the high (full) switch.

When the level in the duty storage tank falls below the low (re-order) level, an alarm is generated to remind the operator to order an alum delivery. If the level falls below the low low set point in the duty tank, then all dosing pumps stop and are inhibited. They can automatically restart once the tank fills above this level or the duty tank selection is changed by the operator. If the level in either tank falls to the dry cut-out switch then all dosing pumps fail and latch.

There are three eyewash and showers within the vicinity of the tanker delivery and alum chemical bund. The common main to these eyewash and showers is fitted with a flow switch. An alarm is generated if the switch is activated for longer than a delay time.

There is a high level switch in the sump of the alum dosing bund. An alarm is generated if this switch is activated.

There are three alum dosing points in the plant:

- Point 1 – To the bioreactor (influent main).
- Point 2 – To the clarifiers (ML splitter box).
- Point 3 – To the filters (flocculation tank).

Only two points can be used. The operator must select the secondary dosing point (clarifiers or filters) in the SCADA.

Two alum dosing pumps are provided for each point in duty/standby duty/standby configuration (total of four). Automatic duty/standby changeover occurs upon the failure of a duty pump. Duty changeover will also occur each time the duty pump stops. The duty can also be selected by the operator.

Each dosing pump discharge is fitted with a flow switch. An alarm will be generated and the corresponding pump will be failed and latched if the flow switch is not activated once running for more than a no flow delay period. Once failed, the pump will need to be reset to be able to operate.

Each pump discharge is fitted with a pressure relief valve. These pressure relief lines merge to a common line that returns the pressure relief to the bund. This common line is fitted with a flow switch. An alarm is generated if this flow switch is continuously activated for longer than an alarm delay time. This will fail and latch any operating duty pump(s), instigating duty changeover.

The dosing pumps will stop and not start if the level in the duty alum storage tank falls below the low low level set point. The pumps will be allowed to automatically restart once the level increases above this level, or the other tank is selected as duty by the operator. All four dosing pumps will stop and latch if the level in either alum storage tank falls below the low level switch.

Each of the three dosing lines (to points 1, 2 and 3) is sleaved to provide double containment. There is a level switch located in the low point of the sleeve line to indicate leakage. If one of these level switches is activated, then an alarm is generated and both the corresponding dosing pumps will fail and latch.

The operator selects the appropriate control mode for the primary and secondary dosing pumps. If the operator manually changes the dosing location of the secondary dosing pump, then they must select a corresponding control mode in the SCADA.

Dosing Point 1

There are two possible control modes for the primary alum dosing pump. These are:

- Flow Paced mode
- Speed Paced mode

The flow paced mode relies on the influent flow element. Failure of the influent flow element results in the primary alum dosing pump control switching to Speed Paced mode. Alternatively, the operator can select to use the influent backup flow profile and then select Flow Paced mode. The operating description of each mode is covered hereunder.

Dosing Point 1 Flow Paced Mode

The dosing pump is interlocked with the duty influent pump. The dosing pump starts when the duty influent pump starts and stops when the duty influent pump stops. Under flow paced mode, the speed of the duty dosing pump varies proportionally to the influent flow. The operator sets the flow pacing constant (% per L/s). The SCADA calculates the dosing pump speed target from the influent flow. The duty alum dosing pump operates at the calculated speed whenever operating. The speed is bounded by the maximum and minimum speed. If the influent flow exceeds a maximum flow for alum dosing control, then the maximum flow set point is adopted. Control automatically switches to Speed Paced mode if the influent flow element fails.

Dosing Point 1 Speed Paced Mode

The dosing pump is interlocked with the duty influent pump. The dosing pump starts when the duty influent pump starts and stops when the duty influent pump stops. Under speed paced mode, the speed of the duty dosing pump varies proportionally to the combined influent pump speed. The operator sets the speed pacing constant (% per %). The SCADA calculates the dosing pump speed target from the combined influent pump speed. The duty alum dosing pump operates at the calculated speed whenever operating. The speed is bounded by the maximum and minimum speed. If the influent pump speed exceeds a maximum speed for alum dosing control, then the maximum speed set point is adopted.

Dosing Point 2

There are two possible control modes for the secondary alum dosing pump when dosing to dosing point 2. These are:

- Flow Paced mode
- Speed Paced mode

The flow paced mode relies on the rolling average bioreactor feed flow. This in turn relies on the influent flow element. Failure of the influent flow element results in the primary alum dosing pump control switching to Speed Paced mode. Alternatively, the operator can select to use the influent backup flow profile and then select Flow Paced mode. The operating description of each mode is covered hereunder.

Dosing Point 2 Flow Paced Mode

The duty secondary alum dosing pump (to dosing point 2) will operate continuously. Under flow paced mode, the speed of the duty dosing pump varies proportionally to the calculated, rolling average, bioreactor feed flow. The operator sets the flow pacing constant (% per L/s). The SCADA calculates the dosing pump speed target from the rolling average bioreactor feed flow. The duty alum dosing pump operates at the calculated speed. The speed is bounded by the maximum and minimum speed. If the rolling average bioreactor feed flow exceeds a maximum flow for alum dosing control, then the maximum flow set point is adopted. Control automatically switches to Speed Paced mode if the influent flow element fails.

Dosing Point 2 Speed Paced Mode

The dosing pump is interlocked with the duty influent pump. The dosing pump starts when the duty influent pump starts and stops when the duty influent pump stops. Under speed paced mode, the speed of the duty dosing pump varies proportionally to the combined influent pump speed. The operator sets the speed pacing constant (% per %). The SCADA calculates the dosing pump speed target from the combined influent pump speed. The duty alum dosing pump operates at the calculated speed whenever operating. The speed is bounded by the maximum and minimum speed. If the influent pump speed exceeds a maximum speed for alum dosing control, then the maximum speed set point is adopted.

Dosing Point 3

There are two possible control modes for secondary alum dosing pumps when dosing to dosing point 3. These are:

- Flow Paced mode
- Speed Paced mode

The flow paced mode relies on the filter feed flow. Failure of the filter feed flow element results in the alum dosing pump control switching to Speed Paced mode. The operating description of each mode is covered hereunder.

Dosing Point 3 Flow Paced Mode

The dosing pump is interlocked with the duty filter feed pump. The dosing pump starts when the duty filter feed pump starts and stops when the duty filter feed pump stops. Under flow paced control, the speed of the duty dosing pump varies proportionally to the filter feed flow. The operator sets the flow pacing constant (% per L/s). The duty alum dosing pump operates at the calculated speed whenever operating. The speed is bounded by the maximum and minimum speed.

Dosing Point 2 Speed Paced Mode

The dosing pump is interlocked with the duty filter feed pump. The dosing pump starts when the duty filter feed pump starts and stops when the duty filter feed pump stops. Under speed paced mode, the speed of the duty dosing pump varies proportionally to the combined filter feed pump speed. The operator sets the speed pacing constant (% per %). The SCADA calculates the dosing pump speed target from the combined filter feed pump speed. The duty alum dosing pump operates at the calculated speed whenever operating. The speed is bounded by the maximum and minimum speed.

5.30 Alkalinity Chemical Storage and Dosing

5.30.1 Purpose

The purpose of the alkalinity storage and dosing system is:

- To store chemical used for alkalinity and pH correction.
- To accept chemical deliveries.
- To capture chemical spills that may result from chemical deliveries, storage or maintenance.
- To dose alkalinity to the bioreactors to prevent alkalinity loss and pH suppression.
- To optimise the use of chemicals to save costs.
- To alarm adverse pH conditions in the bioreactors.

5.30.2 Equipment and Instruments

The alkalinity chemical storage and dosing system consists of the following mechanical equipment and instruments.

- Two (2) alkalinity storage tank pressure elements, doubling as level elements, one for each tank.
- Four (4) alkalinity storage tank level switches, two for each tank (dry and full).
- Two (2) level switches, one in each alkalinity dosing bund sump.
- Two (2) variable speed alkalinity dosing pumps (duty/duty), one for each bioreactor.
- Two (2) no flow switches, one on each dosing pump.
- One (1) dosing pressure relief flow switch.
- Two (2) level switches, one for each sodium hydroxide dosing double containment pipe.
- Two (2) combined pH and temperature elements, one for each bioreactor.

5.30.3 Description

Alkalinity is present in sewage. The concentration and load of alkalinity in sewage is dependent on the raw water source and uses within the catchment.

The main processes in sewage treatment that consume alkalinity are:

- Nitrification – The conversion of ammonia to nitrate releases hydrogen ions (acid) which consumes alkalinity. Alkalinity consumption increases as total nitrogen in the sewage increases and effluent ammonia decreases.
- Denitrification – The conversion of nitrate to nitrogen gas releases alkalinity. Therefore alkalinity increases as denitrification increases. Conversely, alkalinity is reduced as effluent nitrate increases.
- Phosphorus precipitation – The dosing of most metal ion solutions (like alum) consumes alkalinity. Alkalinity decreases as target effluent orthophosphate decreases or as sewage phosphorus increases.

Nitrogen removal by itself is not typically enough to cause pH suppression provided significant denitrification occurs. However, combining nitrogen removal and phosphorus precipitation may cause pH suppression unless alkalinity is dosed. If the result is a reduction in effluent alkalinity to low levels, then pH becomes unstable which can cause process instability. If the alkalinity falls further, then the pH can suppress below 6.5. This not only inhibits the nitrification process but can also lead to licence breaches. This can be countered by dosing alkalinity.

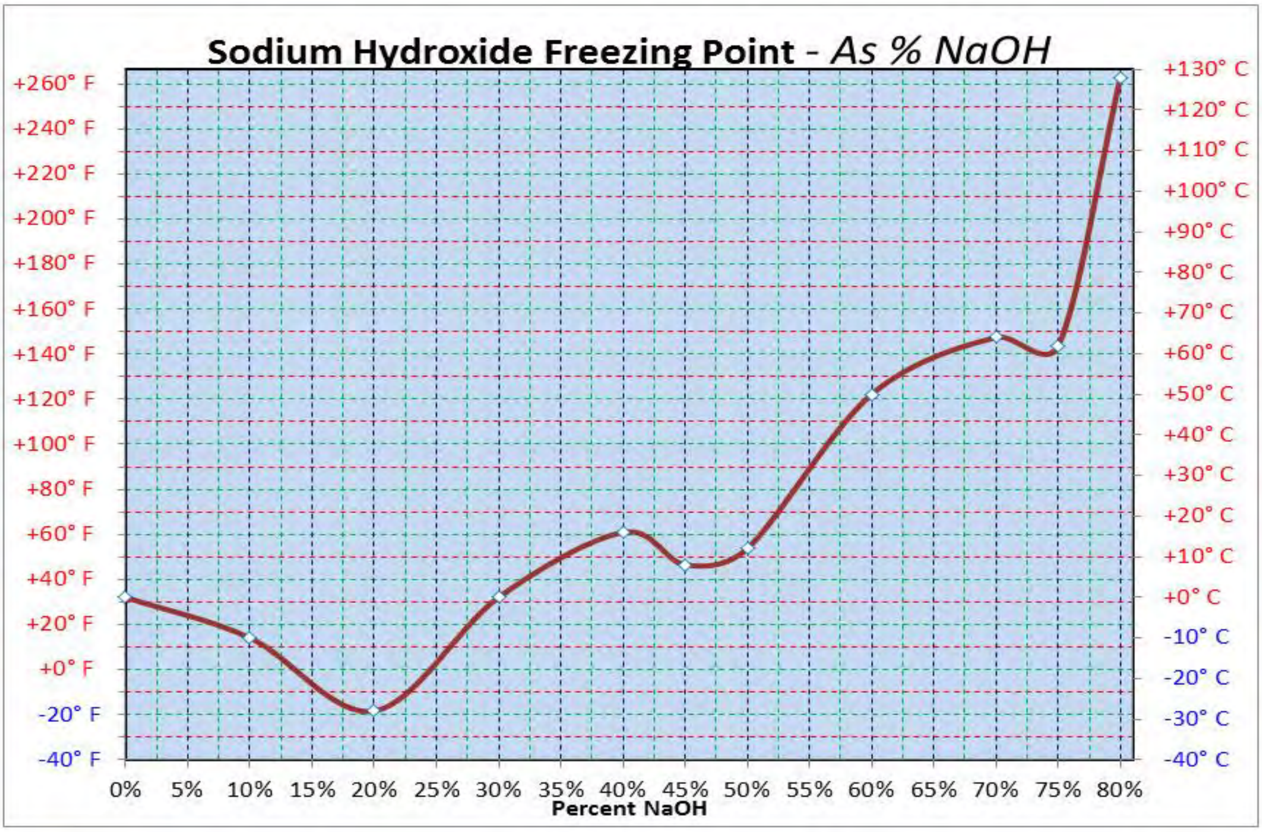
Alkalinity can be dosed in many forms: These include:

- Quicklime (CaO).
- Hydrated or Slaked Lime ($Ca(OH)_2$).
- Sodium hydroxide or caustic soda ($NaOH$).
- Sodium carbonate or soda ash (Na_2CO_3).
- Calcium carbonate ($CaCO_3$).

Alkalinity is measured as the equivalent mass of calcium carbonate.

The most concentrated, liquid form of alkalinity is sodium hydroxide. However, sodium hydroxide crystallises at relatively high temperatures (see Figure 5-2). WSC currently uses a 30% solution and do not report any crystallisation problems. However, Figure 5-2 indicates that the freezing point at 30% solution is about the same as water. There is a risk that crystallisation could occur. Therefore, the system has been designed to allow further dilution if required.

Crystallisation can be avoided by storing and dosing at a 25% solution, which has a freezing point of around -18 °C. The lowest freezing point is at 20% solution (approaching -30 °C), but 20% solution is not a standard supply concentration. If 25% solution cannot be sourced, then potable water can be manually added to the storage tanks to dilute the solution from 30% to 25% or even 20%. This can be done manually based on storage tank levels. Care must be taken when diluting sodium hydroxide as this produces an exothermic reaction, creating heat. The effect should be manageable provided the starting volume is large and water is added gradually.



Source: https://www.doeingalls.com/liquid-sodium-hydroxide-reaches-freezing-point/

Figure 5-2 Freezing Point of Sodium Hydroxide (Caustic Soda) Solution

The design of the sodium hydroxide dosing facility has been based on the worst case assumption of dosing alum or ferric chloride for phosphorus precipitation.

Sodium hydroxide is best dosed to a different location to phosphorus precipitation chemicals (alum) to prevent the two reacting, leading to excess chemical use. Alkalinity is therefore dosed directly to the primary aerobic zone of each bioreactor, which is where alkalinity and pH are at their lowest and where the reactor is well mixed. There is a dedicated alkalinity dosing pump for each bioreactor.

Sodium hydroxide solution is delivered by tanker and stored in the alkalinity storage tanks. Level alarms indicate when the duty storage tank nears empty so that a delivery can be ordered. The level elements are based on pressure. This means that they need a specific gravity input. This must be updated is the specific gravity of the chemical changes.

Deliveries arrive by tanker and are pumped from the tanker to the storage tanks. The pump is powered by a local panel. The power to the pump is automatically inhibited once either sodium hydroxide tank is full, preventing overflows. A local level indicator panel also assists the tanker delivery operator with filling and preventing spills. Any spills that do occur are captured in a bunded area (common to the alum delivery area) on the road. Any spills that occur are captured in a bunded area on the road and associated chemical pit. Arrangements must then be made to transfer this chemical spill to a tanker for disposal or back to the storage tank. Rainwater can also fall in this bunded area, in which case it can be manually drained to the EST, from where it can be pumped back for treatment through the STP.

The storage tanks and dosing pumps are located within two bunded areas. Each bunded area contains a sump. Each sump has a level switch and a drain line with a manual valve. These drain valves can be opened to allow rainwater, washdown water or minor spills to drain to the emergency storage tank. Large spills should be removed by tanker.

Two dosing pumps in duty/duty configuration are provided, one dedicated to each bioreactor. The dosing can be fixed speed or flow paced and can be bounded by limits if the pH elements in the bioreactors are available.

Flush points are provided for each pump and dosing line. Chemicals should be flushed from the lines prior to maintenance. An eyewash and shower is located within the bund and a second shower is located outside of the bund adjacent to the dosing skid. The use of these is alarmed.

A combined pH and temperature element is included in each bioreactor to alarm when the pH is out of the ideal range. These analysers are used for monitoring and alarming, and the pH can be used for control if desired.

5.30.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The alkalinity chemical storage and dosing facility has been based on Alum dosing for phosphorus precipitation as this is the most conservative for alkalinity consumption.
- The alkalinity chemical solution has been assumed to be 25% caustic soda solution to prevent freezing.
- Chemistry has been used to determine alkalinity consumption from nitrogen and phosphorus removal.
- The sewage alkalinity is based on limited sewage measurements.
- The target effluent alkalinity has been based on experience and is above the point where pH suppression typically begins (i.e. is conservative).
- A peaking factor has been chosen to provide additional conservatism.
- The storage tanks have been sized to accommodate the desired delivery frequency, with the active volume being less than the total volume to provide spare capacity.

See Table 5-35 for details.

5.30.5 Turndown and Redundancy

Both dosing pumps are provided in duty only configuration. Dosing may not be required at all or may only be needed from time to time. It is possible that the loss of one or both pumps will have minimal impact on the process or effluent quality. Any impact would be gradual as the alkalinity is slowly depleted from the bioreactor bulk liquid. Even if the loss of one pump resulted in pH suppression in one bioreactor, this could be countered in by increasing the dose to the other bioreactor. The contents of the two bioreactors are mixed at the ML and RAS systems. It may also be possible to dose to both bioreactors using a single pump. A manual cross connection is provided. The back pressure valves at the two dosing points may need to be finely adjusted for dosing to occur to both concurrently.

There are two storage tanks in duty/standby configuration. If one tank needs to be taken out of service for maintenance (unlikely) dosing can continue.

Failure of the chemical storage level elements only effects filling and alarming. Dosing can continue.

Failure of flow pacing flow elements leads to the control switching to fixed speed. Dosing can continue.

The combined pH and temperature elements in the bioreactors are used for monitoring and alarming. Dosing can continue if they fail.

Digital chemical dosing pumps have a very large turndown. The same pumps should be able to meet all scenarios.

Sodium hydroxide loses alkalinity content (turns to soda ash) over time. However, it still contains alkalinity. The operator may need to increase the dose rate over the life of each delivery batch, and then reduce it at the next delivery.

5.30.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-35. Worst case sizing is based on the Future, Summer, MLE scenario.

Table 5-35 Alkalinity Chemical Storage and Dosing Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
Stored NaOH Content	w/w	25%		
Specific Gravity		1.27		
TE Alkalinity	mg/L	80		
Peaking Factor	:1	2		
Dosing Pumps		2		
Dosing Period	h/d	24		
Number of Alkalinity Tanks		2		
Tank Volume Each	m^3	30		
Usable Volume		80%		
Alkalinity Content	w/w		31%	31%
Typical Reactor Flow	ML/d		5.650	5.732
Alkalinity Dosed	mg/L		95.2	98.7
Peak Pump Rate each	L/h		56.6	59.6
Alkalinity Mass Dose	kg/d		538	566
Solution Mass Use	kg/d		1699	1774
Solution Volume Use	L/d		1343	1403
Storage at Average	d		35.3	33.6

5.30.7 Control Philosophy

There are two alkalinity storage tanks (duty/standby). They can be cross connected and their level equalised (duty/duty) as an option. There is a level element and two level switches (overflow and dry) in each tank. The operator must select the duty tank in the SCADA if they are operating as duty/standby.

There is a pressure element in each alkalinity storage tank. A specific gravity input is used to convert pressure into levels in each tank. This occurs in the field. The pressure and level readings are both transmitted to the SCADA and displayed. The level at midnight the previous day is also displayed and recorded.

There are four level set points:

- High High - Overflow (remote alarm)
- High - Full (remote alarm).
- Low - Re-order alkalinity (remote alarm for duty tank only)
- Low Low – Inhibit (remote alarm for duty tank only, with all dosing pumps stopped).

The two level switches perform the following functions:

- High - Full (local visual and audible, fill point power supply inhibit and remote alarm).
- Low – Dry (fail and latch all dosing pumps).

There is a local indicator panel at the truck fill station and shows various conditions in the field. These are:

- The tank level in each tank as measured by the level elements.
- A visual and audible alarm if the level in either tank reaches the high level switch (full). It is possible to mute the audible alarm from the truck fill panel.

There is also a power supply for the tanker pump and an emergency stop switch that cuts power to the power supply. There is a hard wired interlock between the high (full) level switch in each tank and the power supply. This cuts the power to the tanker filling pump when either tank is full, preventing overflows.

When the level in the duty storage tank falls below the low (re-order) level, an alarm is generated to remind the operator to order an alkalinity delivery. If the level falls below the low low set point in the duty tank, then all dosing pumps stop and are inhibited. They can automatically restart once the tank fills above this level or the duty tank selection is changed by the operator. If the level in either tank falls to the dry cut-out switch then all dosing pumps fail and latch.

A tanker is used to refill the storage tanks. It is located within a bund that drains to a sump. The sump is not alarmed.

The tanker uses its own pump to transfer alkalinity from the tanker to the storage tanks. The power supply for this pump is located on the local indicator panel at the truck fill station. An emergency stop switch on the panel stops the power supply to the pump, stopping filling. The tanker operator can view the storage tank levels on the local indicator panel. The level rises as the tank is filled. A local visual and audible alarm is generated if the level reaches the high (full) level switch on either tank. There is a hard wired interlock that inhibits the power supply to the pump if the level in the storage tank is above the high (full) switch on either tank.

There two eyewash and shower units fed by a common potable water main. Alarms are generated if the common eyewash and shower flow switch is activated for longer than a delay time.

There is a high level switch in the sump of the sodium hydroxide dosing bund. An alarm is generated if this switch is activated.

Alkalinity is dosed to the aeration zone of each bioreactor with a dedicated pump and dosing line. Two alkalinity dosing pumps are provided in duty/duty configuration. There is no standby pump and no automated duty changeover.

Each dosing pump discharge is fitted with a flow switch. An alarm will be generated and the pump will be failed and latched if the flow switch is not activated once running for more than no flow delay period. Once failed, the pump will need to be reset to be able to operate.

Each pump discharge is fitted with a pressure relief valve. These pressure relief lines merge to a common line that returns the pressure relief to the bund. This common line is fitted with a flow switch. An alarm is generated if this flow switch is continuously activated for longer than an alarm delay time. This will fail and latch any operating duty pump(s).

The dosing pumps will stop and not start if the level in the duty alkalinity storage tank falls below the low low level set point. The pumps will be allowed to automatically restart once the level increases above this level or the tank with the low level is selected as standby. Both dosing pumps will stop and latch if the level in a duty alkalinity storage tank falls below the low level switch.

Each of the two dosing lines (to bioreactor A and bioreactor B) is sleaved to provide double containment. There is a level switch located in the low point of the sleeve line to indicate leakage. If one of these level switches is activated, then an alarm is generated and the corresponding dosing pump will fail and latch.

There is a combined pH and temperature analyser in each bioreactor. These are used for monitoring and alarming. The pH analyser can be used for control. The average pH and temperature for the previous day is calculated and displayed. Alarms are generated if the pH or temperature is outside high or low limits continuously for more than a delay period.

There are two possible control modes for the alkalinity dosing pumps. These are:

- Flow Paced mode
- Fixed Speed mode

The flow paced mode relies on the bioreactor feed rolling average flow, which relies on the influent flow element. Failure of the influent flow element results in the alkalinity dosing pump mode switching to fixed speed mode. Alternatively, the operator can select the backup influent flow profile and switch the control back to Flow Paced mode. The operating description of each mode is covered hereunder.

Regardless of the operating mode, the dosing pumps can start and stop based on the pH in their respective bioreactor. This automated start and stop function is disabled if the pH element fails but the dosing pumps continue to operate in auto. If the pH of a bioreactor increases above the high set point and the respective dosing pump is operating, then it will stop. If it stops then it will not restart unless the pH falls below the low set point or the pH analyser fails.

Flow Paced Mode

Under flow paced mode, the speed of each dosing pump varies proportionally to the rolling average bioreactor feed flow. If the rolling average bioreactor feed flow increases above a maximum flow for alkalinity dosing, then the maximum flow is adopted. The operator sets the flow pacing constant (% per L/s). The alkalinity dosing pumps operates at the calculated speed whenever operating. The speed is bounded by the maximum and minimum speed.

Fixed Speed Mode

Under fixed speed mode, the speed of the pumps is set to the target speed set point. The operator sets the speed (%). The sodium hydroxide dosing pumps then operates at this fixed speed whenever operating.

5.31 Carbon Chemical Storage and Dosing

5.31.1 Purpose

The purpose of the carbon storage and dosing system is:

- To store chemicals used for enhanced denitrification.
- To accept chemical deliveries.
- To capture chemical spills that may result from chemical deliveries, storage or maintenance.
- To dose carbon to the bioreactors to trim nitrogen from the effluent when required.
- To optimise the use of chemicals to save costs.

Carbon dosing has been allowed for within the design but will only be installed in the future as effluent nitrogen concentration requirements decrease to meet NorBE limits.

5.31.2 Equipment and Instruments

The carbon chemical storage and dosing system is a future system. It has been designed but not included in the initial construction. The future carbon chemical storage and dosing system consists of the following mechanical equipment and instruments.

- One (1) carbon storage tank pressure element, doubling as a level element.
- Two (2) carbon storage tank level switches (dry and full).
- One (1) level switch in the carbon dosing bund sump.
- Two (2) variable speed carbon dosing pumps (duty/duty).
- Two (2) no flow switches, one on each dosing pump.
- Two (2) level switches, one for each dosing line containment pipe.
- One (1) carbon dosing pressure relief flow switch.
- One (1) fixed speed hot water booster pump.

There is also a self-contained hot water tank and heater. This can be manually switched on in the field and utilises its own temperature regulation. It is not connected to the SCADA.

5.31.3 Description

Denitrification involves the conversion of total oxidised nitrogen (NO_x-N) to nitrogen gas. NO_x-N is predominantly in the form of nitrate (NO_3-N). Nitrogen gas is predominantly in the form of molecular nitrogen (N_2). The oxygen released from this process is directly utilised by denitrifying normal heterotrophic organisms

(NHOs) in the activated sludge for respiration and reproduction (growth). The NHOs drive the denitrification process in order to gain access to the oxygen. They will only do this in the absence of DO. Denitrification will not occur where significant DO is present (e.g. aerobic zones). Denitrification occurs only in anoxic zones.

The rate of denitrification is linked directly to the metabolic rate of the NHOs. The faster they feed on carbon, the faster they require oxygen, and the faster they will strip it from NO_x-N. The metabolic rate is dependent on the biodegradability of the carbon upon which the NHOs are feeding. This leads to three different denitrification rates (based on denitrification kinetics theory).

- Rate 1 – This is where soluble biodegradable COD (SBCOD) is present.
- Rate 2 –This is where no SBCOD is present, but particulate biodegradable COD (PBCOD) is present. This is less than 1/7th of the rate of Rate 1.
- Rate 3 – This is where no SBCOD or PBCOD is present. Denitrification occurs only because the biomass is decaying and feeding on itself. This is 1/10th of the rate of Rate 1.

Dosing carbon (SBCOD) to any anoxic zone increases the rate (and amount) of nitrogen removed by up to ten times. A small carbon dose can therefore improve denitrification performance markedly.

There are numerous forms of carbon that can be dosed to STPs to assist with denitrification. The most common are:

- Glycerol
- Sucrose (sugar)
- Acetic Acid
- Methanol
- Ethanol

The relative cost of these is dependent on local availability and supply. In general terms, Methanol and Ethanol are the least costly. However, their fire risk makes storage and dosing installations significantly more costly and risky. Therefore methanol and ethanol use is generally confined to very large STPs where the payback period is short and the operational cost savings outweigh the increased risks. The proposed future carbon dosing facility at Bowral STP is NOT considered suitable for methanol or ethanol storage and dosing.

The facility has been designed for glycerol, sucrose or acetic acid. Glycerol is likely to be the least cost option, but it is not currently used in Australia and the performance has not been confirmed under Australian operating conditions. The facility has been sized based on the standard sucrose solution supply available widely in Australia. The dose rate (L/h) of sucrose and acetic acid is virtually identical. The dose rate of glycerol is less. Therefore a facility designed for sucrose should satisfy any of these chemicals.

Sucrose and glycerol are not hazardous goods. There is no regulated need for containment, signage, eyewash and showers, etc. Acetic acid is a dangerous good. Therefore bunded containment, line flushing and eyewash and shower systems have been included in the design so that acetic acid can be used if ever desirable.

A hot water system has been included. This may or may not be needed depending on the chemical used. Sucrose is the most likely to need hot water to prevent crystallisation and to assist cleaning. It will also assist to reduce the high viscosity of glycerol.

The carbon solution is delivered by tanker and stored in the carbon storage tank. Level alarms indicate when the storage tank nears empty so that a delivery can be ordered. Deliveries arrive by tanker and are pumped from the tanker to the storage tank. The pump is powered by a local panel. The power to the pump is automatically inhibited once the storage tank is full, preventing overflows. A local level indicator panel also assists the tanker delivery operator with filling and preventing spills. Any spills that do occur are captured in a bunded area (common to the alum and sodium hydroxide delivery area) on the road. Any spills that occur are captured in a bunded area on the road and associated chemical pit. Arrangements must then be made to transfer this chemical spill to the plant (slowly) or back to the storage tank. Rainwater can also fall in this bunded area, in which case it can be manually drained to the EST, from where it can be pumped back for treatment through the STP.

The storage tank and dosing pumps are located within a bunded area. This bunded area contains a sump. The sump has a level switch and a drain line with a manual valve. This drain valve can be opened to allow rainwater, washdown water or minor spills to drain to the emergency storage tank. Large spills should be removed by tanker or bled slowly into the EST.

Two dosing pumps in duty/duty configuration are provided, one for each bioreactor. The operator can select the dosing location (primary anoxic zone or secondary anoxic zone) by operating manual valves in the field.

Typically, the location would be the primary anoxic zone in MLE mode or the secondary anoxic zone in FSB mode. The control system is independent of the location. The dosing can be fixed speed or flow paced.

The intent is dose just enough carbon to achieve the desired effluent quality. A small amount of overdosing causes no process issues as the carbon will be readily consumed in subsequent aeration zones. Significant overdosing could lead to greater risks of filamentous bulking (poor settleability). Carbon should not be dosed to the selector zone as there is a risk of forming specialised SBCOD consuming organisms (such as Zooglia) that can also cause severe settling and effluent turbidity issues.

Flush points are provided for each pump and dosing line. Chemicals should be flushed from the lines prior to maintenance, or if the dosing system is not to be used for a significant period. Carbon solution left in the dosing lines can lead to biomass growth in the lines and blockages.

An eyewash and shower is located within the bund and a second shower is located outside of the bund adjacent to the dosing skid. The use of these is alarmed. This may not be required if sucrose or glycerol is used.

The dosing pipelines include double containment. An alarm is raised of the containment pipe level switch is activated.

5.31.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The carbon chemical solution has been assumed to be standard supply sucrose as this is the worst case chemical in terms consumption.
- The typical amount dosed was determined through iteration during denitrification calculations (see Table 5-15).
- The target effluent TN for each scenario as outlined in Section 5.12.
- The equivalent COD content has been determined through first principal chemistry and verified by supplier data sheets.
- The biomass yield is assumed to be that of acetic acid. Sucrose may have a slightly reduced yield, which adds conservatism to usage and sludge production calculations.
- The sucrose content and specific gravity are based on supplier data sheets.
- The peaking factor has been assumed to be DFTF. However, an additional safety factor has been added to account for any errors in the predictions of sewage COD fractions (which cannot be accurately measured).
- The carrier water flow has not been included in the process model or accounted for in the design. The flow should be very low.

See Table 5-36 for details.

5.31.5 Turndown and Redundancy

Both dosing pumps are provided in duty only configuration. Dosing may not be required at all or may only be needed from time to time. The worst case NorBE targets are 50%ile, so elevated TN would be tolerable for some time without exceeding the targets. Any impact would be gradual as the NO_x-N slowly builds in the bioreactor bulk liquid. Even if the loss of one pump resulted in slightly elevated NO_x-N in one bioreactor, this could be countered in by increasing the dose to the other bioreactor. The contents of the two bioreactors are mixed at the ML and RAS systems. It may also be possible to dose to both bioreactors using a single pump. A manual cross connection is provided. The back pressure valves at the two dosing points may need to be finely adjusted for dosing to occur to both concurrently. The carrier water solenoids may also need to be manually opened. A standby dosing pump is provided in store.

There is only one storage tank in duty only configuration. If the tank needs to be taken out of service for maintenance (unlikely) then dosing would be suspended. However, as outlined above, this can be tolerated for an extended period.

Failure of the chemical storage level elements only effects filling and alarming. Dosing can continue.

Failure of flow pacing flow elements leads to the control switching to fixed speed. Dosing can continue.

Digital chemical dosing pumps have a very large turndown. The same pumps should be able to meet all scenarios.

Failure of the hot water system prevents effective cleaning but does not impact plant performance.

5.31.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-36. Worst case sizing is based on the Future, Winter, FSB scenario. The typical dose rates are the typical for the day under these worst case Winter dosing conditions. The typical for the year is less. Dosing is not required for Summer MLE conditions.

Table 5-36 Carbon Storage and Dosing Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Future FSB)	Process Design Sizing (Future MLE)
COD:Sucrose		1.122		
Sucrose Solution Content	w/w	66.5%		
Solution Specific Gravity		1.325		
PDWF Peaking	:ADWF	2.0		
Additional Safety Factor	:1	2.0		
Carbon Dosing Pumps		2		
Carbon Storage Tanks		1		
Carbon Tank Volume Each	m^3	10		
Usable Volume		90%		
Average Bioreactor Flow	ML/d		5.650	5.732
Typical COD Dose	mg/L		37.8	44.0
Typical COD Dose	kg/d		214	252
Typical Sucrose Dose	kg/d		190	225
Typical Carbon Solution Dose	kg/d		286	338
Typical Carbon Solution Dose	L/d		216	255
Peak Dose Rate	L/h		36.0	42.5
Carbon Dosing Pumps Each	L/h		18.0	21.3
Storage at Average	d		41	35

5.31.7 Control Philosophy

There is one carbon storage tank (duty only). There is a pressure (level) element and two level switches (overflow and dry) in the tank.

There is a pressure element in the carbon storage tank. A specific gravity input is used to convert pressure into levels in each tank. This occurs in the field. The pressure and level readings are both transmitted to the SCADA and displayed. The level at midnight the previous day is also displayed and recorded.

There are four level set points:

- High High - Overflow (remote alarm)
- High - Full (remote alarm).
- Low - Re-order alum (remote alarm)
- Low Low – Inhibit (remote alarm, with all carbon dosing pumps stopped).

The two level switches perform the following functions:

- High - Full (local visual and audible, fill point power supply inhibit and remote alarm).
- Low – Dry (fail and latch all carbon dosing pumps).

There is a local indicator panel at the truck fill station and shows various conditions in the field. These are:

- The tank level in each tank as measured by the level element.
- A visual and audible alarm if the level in the tank reaches the high level switch (full). It is possible to mute the audible alarm from the truck fill panel.

There is also a power supply for the tanker pump and an emergency stop switch that cuts power to the power supply. There is a hard wired interlock between the high (full) level switch in the tank and the power supply. This cuts the power to the tanker filling pump when the storage tank is full, preventing overflows.

When the level in the storage tank falls below the low (re-order) level, an alarm is generated to remind the operator to order a carbon delivery. If the level falls below the low low set point in the tank, then all dosing pumps stop and are inhibited. They can automatically restart once the tank fills above this level. If the level in the tank falls to the dry cut-out switch then all dosing pumps fail and latch.

A tanker is used to refill the storage tank. It is located within a bund that drains to a sump. The sump is not alarmed.

The tanker uses its own pump to transfer carbon from the tanker to the storage tank. The power supply for this pump is located on the local indicator panel at the truck fill station. An emergency stop switch on the panel stops the power supply to the pump, stopping filling. The tanker operator can view the storage tank levels on the local indicator panel. The level rises as the tank is filled. A local visual and audible alarm is generated if the level reaches the high (full) level switch on the tank. There is a hard wired interlock that inhibits the power supply to the pump if the level in the storage tank is above the high (full) switch.

There are two eyewash and shower units fed by a common potable water main. Alarms are generated if the common eyewash and shower flow switch is activated for longer than a delay time.

There is a high level switch in the sump of the carbon dosing bund. An alarm is generated if this switch is activated.

There is a high level switch in the containment system of each dosing line. An alarm is generated if either high level switch is activated.

Carbon is dosed to the anoxic zone of each bioreactor with a dedicated pump and dosing line. Two carbon dosing pumps are provided in duty/duty configuration. There is no standby pump and no automated duty changeover.

Each dosing pump discharge is fitted with a flow switch. An alarm will be generated and the pump will be failed and latched if the flow switch is not activated once running for more than no flow delay period. Once failed, the pump will need to be reset to be able to operate.

Each pump discharge is fitted with a pressure relief valve. These pressure relief lines merge to a common line that returns the pressure relief the storage tank. This common line is fitted with a flow switch. An alarm is generated if this flow switch is continuously activated for longer than an alarm delay time. This will fail and latch any operating duty pump(s).

The dosing pumps will stop and not start if the level in the duty storage tank falls below the low low level set point. The pumps will be allowed to automatically restart once the level increases above this level. Both dosing pumps will stop and latch if the level in a duty storage tank falls below the low level switch.

There is an electric hot water service supplying wash and carrier water with the pressure boosted by a booster pump that operates whenever there is flow. The heater operates continuously based on internal thermostats. The heater system is connected to a spray system within the sucrose tank to clean the internals of the system and prevent the build-up of crystals and biological growth. The base of the storage tank is conical to assist in the cleaning process. The cleaning process is manual and involves opening the respective valves to the spray head within the tank. The entire contents of the tank must be emptied during a clean and operators need to coordinate deliveries to minimise waste. The pump and heater are not connected to SCADA and are operated in the field.

There is a carrier water solenoid valve and flow switch for each pump. The solenoid valve is interlocked with the operation of the associated pump. The solenoid will open when the pump starts and close when the pump stops. An alarm will be generated if no flow is detected after a valve has been open for a no flow delay time. There is no automated response to this. Dosing can continue.

There are two possible control modes for the carbon dosing pumps. These are:

- Flow paced mode
- Fixed speed mode

The flow paced mode relies on the influent rolling average flow. Failure of the influent flow element results in the pump mode switching to fixed speed mode. Alternatively, the operator can adopt the backup flow profile and switch the control mode back to flow paced. The operating description of each mode is covered hereunder.

Flow Paced Mode

Under flow paced mode, the speed of each dosing pump varies proportionally to the rolling average influent flow. If the rolling average influent flow increases above a maximum flow for carbon dosing, then the maximum flow is adopted. The operator sets the flow pacing constant (% per L/s). The dosing pump operates at the calculated speed whenever operating. The speed is bounded by the maximum and minimum speed.

Fixed Speed Mode

Under fixed speed mode, the speed of the pumps is set to the target speed set point. The operator sets the speed (%). The dosing pumps then operate at this fixed speed.

5.32 Chlorine Chemical Storage and Dosing

5.32.1 Purpose

The purpose of the chlorine storage and dosing system is:

- To provide additional disinfection of reclaimed effluent (RE).
- To assist in the prevention of bacterial and algal growth in the RE system.
- To store the chemical used for RE chlorination.
- To capture chemical spills that may result from chemical handling, storage or maintenance.

5.32.2 Equipment and Instruments

The chlorine chemical storage and dosing system consists of the following mechanical equipment and instruments.

- One (1) level switch in the chlorine storage tank.
- One (1) variable speed chlorine dosing pump (duty only).
- One (1) no flow switch for the dosing pump.
- One (1) dosing pressure relief flow switch.
- One (1) chlorine bund sump level switch.

5.32.3 Description

Chlorine is dosed to the plant RE only. It is not dosed to the storm clean RE system as this system has no retention time so chlorination will have little disinfection effect. The much higher dose rate would also require a much larger dosing system which would be used very few days per year. The storm clean RE relies on UV disinfection alone.

It must also be noted that the RE chlorination system is not verified. It does not include a free chlorine residual analyser (FCR) as part of the alarm or control system. Therefore effective disinfection cannot be continuously verified or guaranteed. The pathogen log removal values (LRVs) associated with chlorination cannot be pre-validated in terms of recycled water guidelines. However, there is no need for verification for recycled water used with STP grounds. Since FCR analysers are costly to purchase, costly to operate and require significant operator attention, they have not been included. This does not preclude the inclusion of an FCR analyser sampling from the RE tank at some later date if WSC so wishes.

Sodium hypochlorite is used for RE chlorination. This is because it is simpler and less risky to handle than gaseous chlorine. The modest usage does not warrant bulk storage. In fact, bulk storage would be disadvantageous as sodium hypochlorite degrades over time. Instead, a small storage tank is provided. Sodium hypochlorite is delivered in intermediate bulk containers (IBCs). These IBCs are manually handled during delivery and their contents are manually transferred into the storage tank via a camlock connection and valve.

There is limited level instrumentation in the storage tank. The operators must inspect the level in the tank periodically. There is a single low level switch that will inhibit dosing pump operation. The flow switch on the dosing pump will also sound an alarm if chlorine is depleted, but this is not a desirable event as it could cause damage to the pump. The operator should refill the storage tank once the level gets low.

The IBCs, storage tank and dosing pump are located within a separate bunded area. This is sized to contain more than the volume of the storage tank in case of tank or pipe rupture. This bunded area contains a sump. The sump has a level switch and a drain line with a manual valve. This drain valves can be opened to allow rainwater, washdown water or minor spills to drain to the emergency storage tank. Large spills should be removed by tanker.

A single dosing pump (duty only) is provided. The dosing is fixed speed at a dose rate set by the operator. The dosing pump operation is interlocked with the duty RE lift pump, starting when the lift pump starts and stopping when the lift pump stops. The RE tank then acts as a chlorine contact tank, be it without instrumentation. Chlorine dosing is suspended if the RE tank level element is failed or the RE lift pump is in Backup mode. This is to minimise chlorine in the RE tank overflow to the discharge.

Flush points are provided for the pump and dosing line. Chemicals should be flushed from the lines prior to maintenance. An eyewash and shower is located within the bund and a second shower is located outside of the bund adjacent to the dosing skid. The use of these is alarmed.

5.32.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The sodium hypochlorite chlorine concentration and specific gravity is based on supplier data sheets.
- The typical and maximum chlorine dose rates have been based on experience.
- The lift pump capacity is as per the existing pump and as outlined in the OEMP.
- The typical RE use is based on individual uses as per the RE system (see Table 5-25).

See Table 5-37 for details.

5.32.5 Turndown and Redundancy

The dosing pump is provided in duty only configuration. If the pump fails then the operator has a number of choices:

- Replace the pump with the standby in store before the RE storage tank is emptied (many hours).
- Continue RE supply with no chlorination, relying on the UV as the disinfection barrier.
- Isolate the RE lift pumps and open the potable water supply to the RE tank.

Dosing does not rely on any elements.

Digital chemical dosing pumps have a very large turndown.

5.32.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-37. Worst case sizing is based on the Future, but there is very little difference between scenarios.

Table 5-37 Chlorine Chemical Storage and Dosing Process Sizing

	Units	Process Design Assumptions	Process Design Sizing
Specific Gravity		1.2	
Stored CL Content	w/w	0.12	
RE Low Lift Pumping Capacity	L/s	7	
Maximum Cl Dose	mg/L	10	
Typical Cl Dose	mg/L	5	
Number of Chlorine Tanks		1	
Chlorine Tank Volume Each	m^3	1.0	
Chlorine Tank Usable Volume		80%	
Average RE Use	ML/d		0.242
Chlorine Solution Mass Use	kg/d		10.1
Chlorine Solution Volume Use	L/d		8.4
Chlorine Peak Dose Rate	L/h		1.8
Chlorine Dosing Pumps			1
Max Chlorine Pump Rate each	L/h		1.8
Chlorine Storage at Average	d		95

5.32.7 Control Philosophy

There is a high level switch in the sump of the sodium hypochlorite dosing bund. An alarm is generated if this switch is activated.

Sodium hypochlorite is dosed to the discharge of the RE lift pumps. A single sodium hypochlorite dosing pump is provided in duty only configuration. There is no standby pump and no automated duty changeover.

The dosing pump discharge is fitted with a flow switch. An alarm will be generated and the pump will be failed and latched if the flow switch is not activated once running for more than no flow delay period. Once failed, the pump will need to be reset to be able to operate.

The storage tank is fitted with a low level switch. The dosing pump will fail and latch if the level falls blow this switch.

There is only one automated control mode for the sodium hypochlorite dosing pump. This is:

- Fixed speed mode

Fixed Speed Mode

The speed of the pump is set to the target speed set point. The operator sets the speed (%). The sodium dosing pumps then operates at this fixed speed whenever the duty RE lift pump is operating. The duty dosing pump starts when the duty lift pump starts. The duty dosing pump stops when the duty lift pump stops.

Chlorine dosing pump operation ceases if the RE lift pump mode is Backup. The dosing pump remains stopped.

6 Upgrade Staging Plan and Interface Strategy

Delivery of the upgrade and augmentation works whilst maintaining effective operation of existing treatment infrastructure presents unique challenges and associated risks. Effective management of these risks is key to successful completion of the project. A high level staging plan has been developed, allowing construction and commissioning of the STP whilst providing continued operation and effective interfacing with existing infrastructure. The staging plan and interface strategy must be developed further by the construction contractor to ensure effective implementation. Details of the developed approach are presented below.

6.1 Staging

Staging has been grouped into a number of logical phases to facilitate construction and transition to the upgraded treatment process. The phases include;

4. Phase 1 – Site establishment
5. Phase 2 – Decommission Eastern sludge lagoon and drying beds
6. Phase 3 – Construct Stage 1 infrastructure (capable of treating commissioning loads)
7. Phase 4 – Pre Commission new infrastructure
8. Phase 5 – Cutover to new treatment processes
9. Phase 6 – Decommission redundant assets
10. Phase 7 – Construct Stage 2 infrastructure
11. Phase 8 – Commission Stage 2 infrastructure and decommission northern sludge lagoons
12. Phase 9 – Finalise earth works, roads, drainage, site fencing, landscaping etc.
13. Phase 10 – Demobilisation.

Each phase is outlined in further detail below;

6.1.1 Phase 1 – Site Establishment

There is minimal available footprint for a site compound within the fence area of the existing treatment plant. It is anticipated that the site compound (including laydown area and parking) will be located in an area between the final pond and Western drying beds as shown in Figure 6-1. Note that a drainage swale crosses and screenings and grit have been historically buried in this area.

Figure 6-1 Proposed Site Compound Location

Temporary power and potable water would be provided from the existing infrastructure within the main treatment plant boundary. It should be noted that this area (as per the rest of the Bowral STP site) is at risk of flooding during major (i.e. 1:100 year) flood events (< 0.5m water depths) and appropriate safeguards (such as elevating site buildings) should be taken.

Access to the Bowral STP crosses dual train lines immediately south of Burradoo Station. Although a dedicated crossing for plant access, there are no signals or automatic gates. Management of the increased vehicle movements utilising this crossing will need to be carefully managed throughout the construction phase and will be the most critical aspect of the Contractors traffic management plan.

6.1.2 Phase 2 - Decommission Eastern Sludge Lagoon & Drying Beds

The sludge lagoon and drying beds between the Pasveer ditches and the existing storm pond occupy real estate required for the new upgrade. Contractors will dewater the sludge lagoon and remove any biosolids from the drying beds prior to works commencing. The infrastructure will then be removed from service, with waste sludge handled via the two northern sludge lagoons and residual drying beds. This allows bulk earthworks to be conducted in the area to accommodate a range of new infrastructure. The design has been completed with offset distances from the Pasveer ditches and storm pond, the Contractor must ensure the excavation embankment stability to prevent any damage to existing structures. There will be a quantity of sludge at the base of the lagoon following dewatering and the Contractor should make allowance to handle this material (including disposal if required) as part of overall bulk earthworks. Ballast at within the drying beds will also have to be removed, nothing that it may be suitable for use within the site compound area.

There are existing electrical cables that run through a conduit system along the north and west of the sludge lagoon to supply the storm return pumps and other smaller miscellaneous loads. The conduit system clashes with the new bioreactor structure and pipework and it will be necessary to provide temporary power / control connections for the return pumps until the new conduit system is installed. The Contractor should also allow for the existing odour masking drums and spray system to be repositioned and to remain in service throughout construction.

6.1.3 Phase 3 – Stage 1 Construction

The location of some upgrade treatment components (Clarifier 1, Storm Pond 1, gravity thickener etc.) is currently occupied by the Pasveer ditches. As the ditches are required to maintain effective treatment it is necessary to deliver the upgrade in two stages. The staged approach also allows conversion of the existing IDEA reactor to an aerobic digester with minimal non-compliance risk.

The staged approach relies on commissioning of new structures capable of replacing the existing secondary treatment capacity before they are decommissioned in preparation of the required civil works. New structures required as part of Stage 1 include;

- Inlet works (new inlet works provides superior screenings and grit removal compared to existing inlet works, minimises contamination of new structures with gross solids / grit)
- Storm bypass pipework (required to direct flows from the inlet works to SDP2 – pipework is designed to allow SDP1 to be bypassed to allow for construction and future operational activities). There are clashes with this pipework associated with the existing bypass pipework from the lift pump station and the IDEA tank feed pipework. The design allows for the lift pump station pipework to discharge into the new pipework and for local redirection of IDEA feed pipework to resolve this issue. The intent is to lay a majority of the new bypass pipework then lay the lay the section that clashing with the existing overflow pipework during a period of dry weather.
- Odour control (odour control system is required once the inlet works becomes operational to ensure sufficient air changes for both odour control and corrosion protection
- Inlet lift pump station (required to feed the new bioreactors)
- Flow Splitter / Bioreactor (connections to Clarifier 2 to be capped)
- Clarifier 1 (single clarifier is able to cater for greater than PDWF at commissioning loads – operators can cap bioreactor flow rate to clarifier capacity)
- RAS pump stations (required for effective clarifier operation)
- WAS pump station (WAS transferred to the existing northern sludge lagoons via existing pipework)
- Scum pump station (required for effective clarifier operation)
- Filter feed pump station (required to accept clarified effluent and lift to the new filters (if installed))
- Blower building (housing the bioreactor blowers)

- New switchroom (required to run new treatment equipment).
- Associated pipework, noting the major pipework corridor to the south of Clarifier 1. Temporary connections may be required from the RE and chemical systems to service the new infrastructure.

There are also a range of other items that can be constructed across both stages. The Contractor can nominate when these items are completed to suit their program, available resources etc;

- Tertiary Treatment – Refers to the dual media filters, UV disinfection system and RE infrastructure. If the tertiary treatment component is not installed during Stage 1, clarified effluent would pass through to the filter feed pump station and then overflow to the EST. The existing filter feed pump station will then draw effluent from the EST for treatment via the cloth filters and existing UV system. The existing RE system would be used to service new plant components as required. If the new tertiary treatment components are constructed during Stage 1, the outlet of the new UV system can be connected to the existing outfall allowing the existing tertiary treatment components to be decommissioned.
- Sludge Handling – Refers to the feed tank, RSP, polymer dosing and outloading systems. The sludge handling equipment is required once the IDEA is converted to a digester but can be constructed prior to this as required. Until IDEA conversion is complete, WAS will be directed to the remaining sludge lagoons for stabilisation such that dewatering contractors will be used for sludge handling.
- Chemical Systems – The existing chemical systems can be used (fixed speed dose and temporary pipework) to dose the bioreactor and filters (if required). Sodium hypochlorite is not required from a licence compliance perspective and can also be deferred as required. The construction methodology for the chemical systems is as follows;
  - New Alum dosing (dual tank) Sodium Hydroxide (single tank) systems are constructed
  - New Alum system is commissioned and tanks are filled
  - Alum dosing relies exclusively on the new systems
  - Existing alum tank is decommissioned, cleaned and placed into the new Sodium Hydroxide bund allowing new dosing equipment to be installed
  - The single Caustic tank is then commissioned, filled and brought into service.
  - The existing Caustic tank is refurbished / fit out with new equipment
  - The dual bund Caustic system is then commissioned.
  - The western Caustic bund is then repurposed with Hypo dosing equipment.
- Storm Pond 2 Modifications – The existing overflow weir is to be replaced with a new internal overflow bellmouth connected to the outflow from the existing EST. The existing return pumps are also to be replaced with larger capacity units and associated instrumentation. This works can be completed at any time when the risk of wet weather flows filling the pond can be effectively managed.

Figure 6-2 presents the Stage 1 infrastructure.

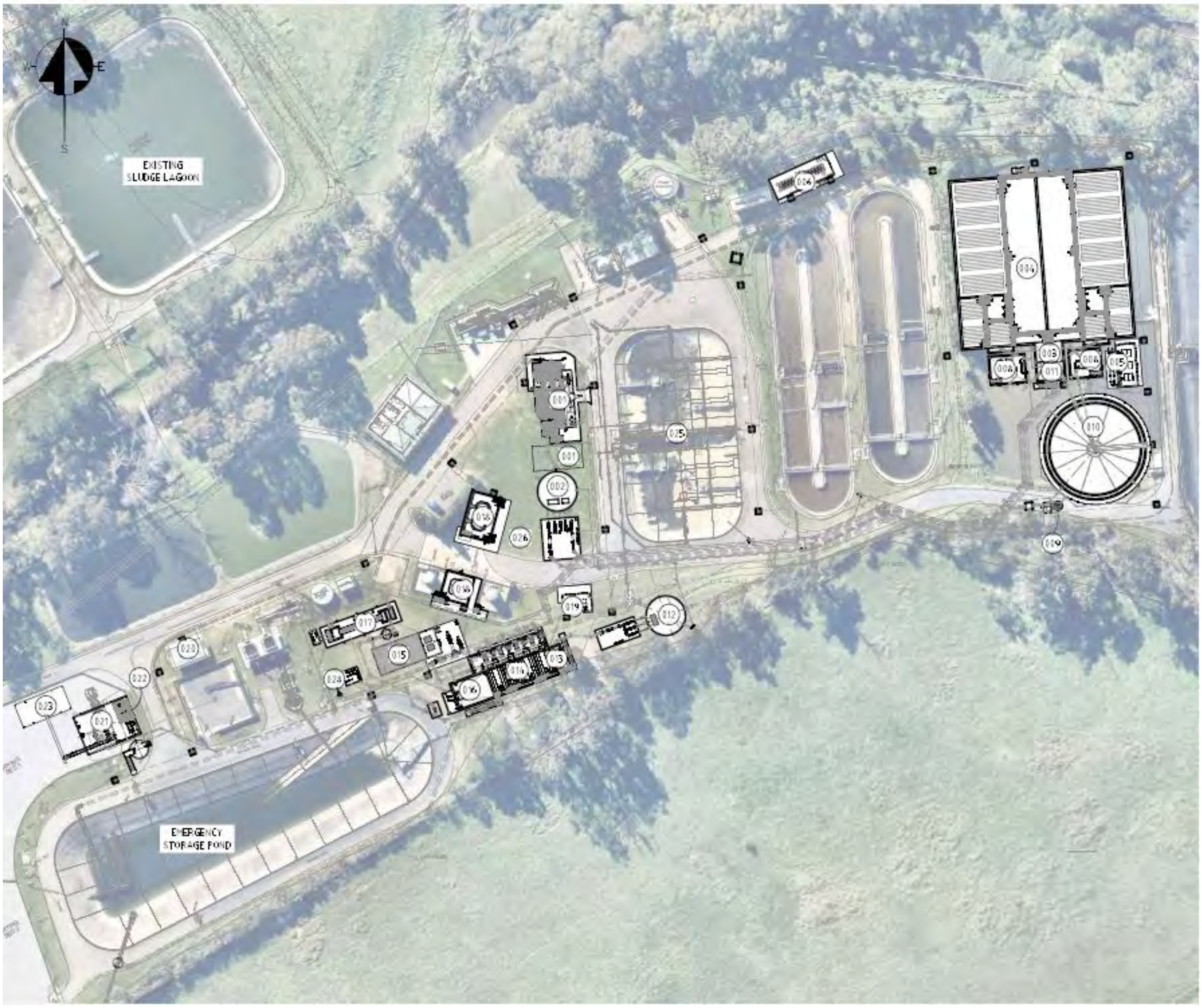


Figure 6-2 Stage 1 Infrastructure

6.1.4 Phase 4 – Pre Commission Stage 1 Works

Once the Stage 1 infrastructure has been constructed, pre commissioning can commence. This involves a number of phases to prepare and then the new equipment to accept raw sewage.

1. Testing to demonstrate the necessary performance, including both manufacturer and site testing
2. Checking of installed equipment, electrical, PLC and SCADA systems
3. A range of specific equipment tests (aeration system, mixers, pump etc.)
4. Water function testing (recirculation of water to confirm control system and equipment reliability in preparation of cutover)

The intent is to provide all Stakeholders reassurance that the new infrastructure will be able to accept raw sewage with minimal risk. Once the complete the Stage 1 works will be ready to accept raw sewage.

6.1.5 Phase 5 – Cut Over to New Treatment Process

This phase involves connecting incoming gravity and sewer mains to the new inlet works. Diverting the rising main from the existing inlet works is relatively straight forward and can be completed within a normal shutdown window from the upstream pump station. The new pipework will be laid from the inlet works back to the designated interface point ahead of the shutdown and then cutover when required. Connection to the incoming gravity system is much more complex.

The design allows for as much of the incoming pipework as possible to be constructed ahead of the cutover. The two mains are also combined within a common pit outside of the existing plant boundary to minimise the quantity of pipework / crossing required. The arrangement had to accommodate a number of constraints;

- Had to avoid the drip line of the tree adjacent to the existing inlet lift pump station, zone of influence of the existing power pole and edge of the existing chemical bund.
- The East Bowral Main has to cross the Bowral Main on grade
- Had to cross the gravity feed pipes from the existing inlet works to existing secondary process
- Had to cross the ring road on grade into the new inlet works.

The configuration is shown in Figure 6-3. Unshaded pipework and all manholes can be constructed prior to any shutdowns. The yellow shaded pipework requires shutdowns but can then be isolated (pipe bladders / bungs, sandbags etc) such that the existing flow path through the existing inlet works can be maintained.

The red shaded pipework crosses gravity pipework on similar grades (Bowral Trunk Main, gravity pipework from the existing inlet works to the secondary process and inlet works bypass pipework) and once work commences on these sections it will not be possible to revert back to the existing operational configuration (i.e. works must be completed within a single shutdown).

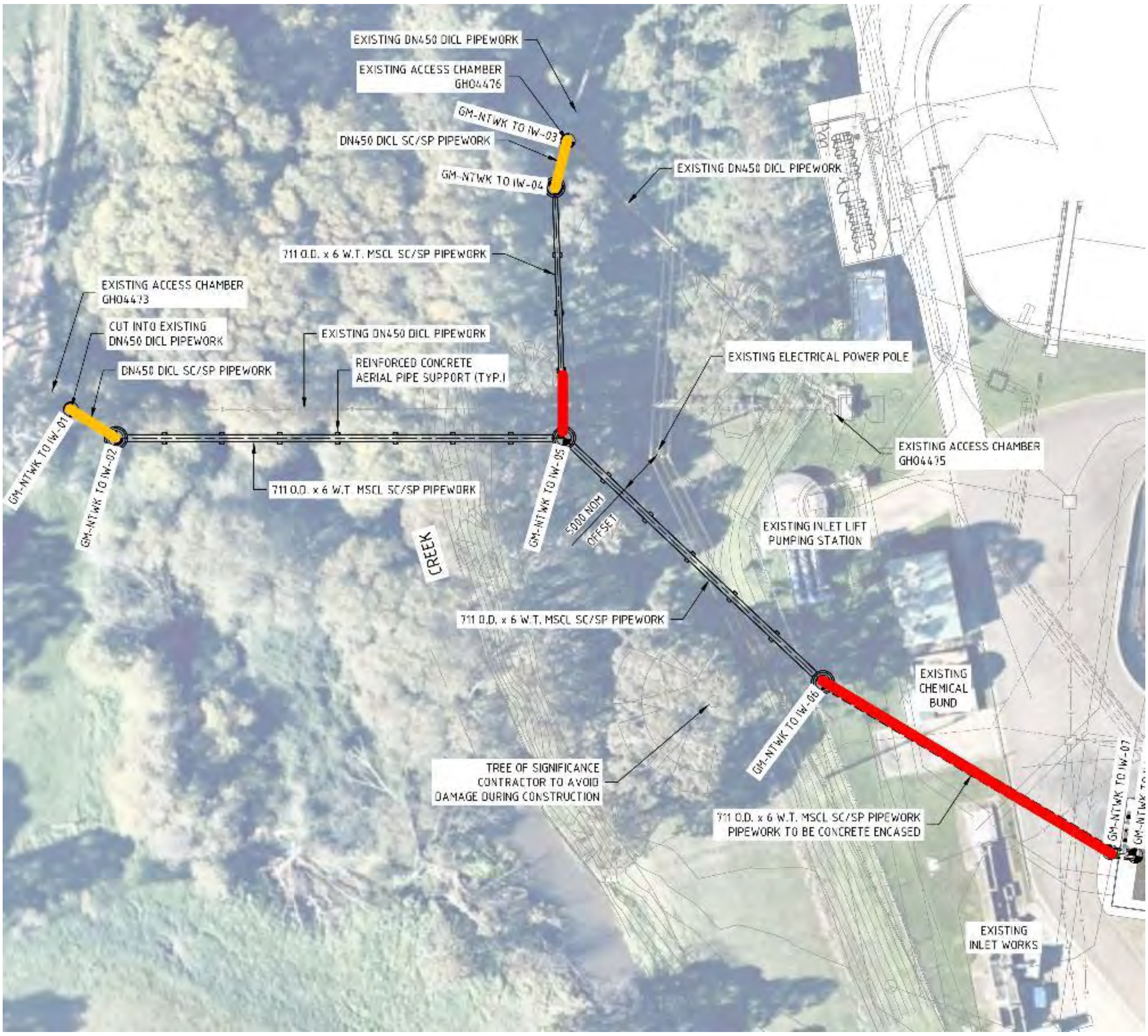


Figure 6-3 Incoming Gravity Main Arrangement

These cutover works (especially for the two red shaded mains) require careful planning and effective execution to mitigate non-compliance risks (i.e. avoid any sewage spills). It is expected that the Contractor will develop detailed cutover plans and consult extensively with WSC and other stakeholders to effectively mitigate risks. It is envisaged that a number of approaches will be utilised to safely complete these works, including but not limited to;

- Night works (to coincide with low flow periods)
- Catchment management (utilising inherent storage available within mains and pump stations)
- Use of temporary pumping (to divert around gravity sections of pipe)
- Use of multiple work crews (to shorten required shutdown periods)
- Use of available storage within the storm detention pond

Once the incoming diversions are complete, the new primary and secondary treatment processes will be online and wholly responsible for achieving effluent quality objectives. As mentioned previously new chemical dosing, RE and tertiary treatment systems may or may not be online at this stage.

It is envisaged that biomass from the existing reactors will be used to seed the new reactor and will occur in conjunction with the cutover (the MLSS should be transferred via the new inlet works to remove entrained screenings and grit). WAS will not be generated for some time until the MLSS has built up to sufficient levels. Once required WAS will be directed via the new pump to the remaining sludge lagoons.

6.1.6 Phase 6 – Decommission Existing Secondary Process

With the new secondary treatment infrastructure online, existing Pasveer Ditches and IDEA tank can be decommissioned. This provides the necessary footprint for the outstanding infrastructure and for conversion of the IDEA into the digester. Residual biomass from the existing reactors will be transferred to the sludge lagoons. The Pasveer Ditches will be cleaned out and demolished, with waste streams managed appropriately. This will allow the necessary earthworks to be completed within this area. The IDEA will be repurposed, including removal of the decanter and provision of a fixed overflow down to the EST.

6.1.7 Phase 7 – Stage 2 Construction

With the existing secondary process decommissioned, outstanding items can be constructed, including;

- Clarifier 2
- Storm Detention Pond 1
- Thickener & TWAS pump station
- Addition of new EST Return Pump
- The IDEA reactor is also converted during this stage.

Any other items not constructed as part of the Stage 1 construction phase are also to be completed. This includes the dewatering system that must be available shortly after the new digester begins accepting WAS.

Addition of the new EST Return pump can be completed any time when the EST tank can be emptied to allow installation into the existing sump. It is envisaged that this is undertaken once the new tertiary system is online (such that clarified effluent flows straight from the filter feed pump station through the new tertiary system and the outfall), although provision temporary pumping and pipework (utilising the existing tertiary treatment infrastructure) is also an option.

6.1.8 Phase 8 – Residual Commissioning & Decommission of Redundant Assets

Once the Stage 2 constructions works are completed, pre-commissioning can begin. This involves the same process as per Phase 4. Commissioning can then begin, where the process fluid is introduced to the unit processes and the entire treatment plant can operate as a hole. Following a stabilisation period, the performance of the treatment plant will be verified over an intensive daily sampling program. Proof of performance testing on specific equipment (odour control, inlet works residuals handling, disinfection system, dewatering systems etc.) will also be undertaken during this phase.

Once the new UV system is commissioned it will be necessary to connect to the existing effluent main and isolate the connection to the existing UV system. It is envisaged that the EST can provide the necessary storage to facilitate the pipework connection / modification.

Once the new process has been proved, any remaining redundant treatment processes can be decommissioned. This includes the existing tertiary treatment infrastructure and the sludge lagoons.

6.1.9 Finalisation

The finalisation phase sees completion of earthworks, roadworks, stormwater and drainage, site fencing and landscaping. These works may be completed in conjunction with Phase 8. Submission of Operations and Maintenance (O&M) Manuals, Work as Executed (WAE) documentation and operator training should be completed during this time in preparation of full handover of the site to WSC.

6.1.10 Demobilisation

With works complete, the Contractor will then demobilise from site. Noting that attendance will still be required to meet requirements of the defects period. This may require retention of a site shed and a small compound to allow coordination and completion of any necessary rectification works.

As WSC will remain responsible for effective operation of existing treatment infrastructure throughout the entire upgrade it will be necessary to develop a Site Co-Operative Use Plan (SCUP) with the construction contractor to ensure construction and operational activities can be undertaken effectively concurrently. The SCUP should contain the following details as a minimum;

- Clearly defined construction and operational areas – including detailed plans
- Procedures required for entering / undertaking work in delineated areas
- Communication and notification protocols
- Dedicated parking, laydown and no go zones
- Traffic management plans
- Nominated contact persons including for emergencies and provision of emergency response plans

6.2 Interfaces

The design attempts to minimise the interfaces between the existing and new infrastructure wherever possible. There are however a number of key interfaces associated with the project are outlined below;

1. Incoming Mains – As described in Phase 5 above the interfaces associated with the existing incoming mains are complex and must be carefully managed. The existing admin building waste is to be rediverted to the foul water pump station.
2. Effluent Discharge Main – The outlet from the new UV disinfection channel connects to the existing effluent discharge main. This connection can occur once the new system is effectively commissioned, with the EST providing the necessary storage to complete the works.
3. Inlet Works Bypass – Overflow from the existing lift pump station to SDP2 follows a similar route to the new bypass pipework. The new alignment clashes with existing pipework for a small length. The design intent is to install the new pipework and then complete the new pipework by removing the existing pipework as required. This work would be completed during a forecasted dry period and include connection of the existing overflow to the new pipework, to be in service until the new works are commissioned. Depending on the length of time required to complete the works, it may be necessary to run a temporary bypass line from the existing receival chamber to effective manage the risk of surcharge during wet weather events.
4. IDEA Inlet and WAS Pipework – This pipework also clashes with the new bypass pipework from the inlet works. The invert of the inlet pipework will be locally lowered to clear the new pipework. Sub-optimal flow conditions within these lines during construction are considered acceptable and can be managed through flushing flows. The WAS rising main will be redirected accordingly. The Pasveer inlet pipework crosses beneath the new bypass line.
5. EST Inlet – The existing inlet is utilised to accommodate a range of additional EST feeds. This approach minimises penetrations within the EST concrete works
6. EST Overflow – A new overflow from SDP2 will connect with the existing EST overflow pipework. The connection point is adjacent to the plant boundary and should remain relatively clear of other services
7. EST Return Pump – The existing EST return pump will be replaced with a larger unit installed within the existing sump. This work can be completed once flows can be diverted from the EST for sufficient periods to complete the installation works.

8. Sludge Lagoons – The two northern sludge lagoons will be retained for redundancy purposes. WAS pipework will be connected to the existing inlets, with the supernatant line diverted to the inlet works.
9. Storm Detention Pond 2 – Modifications are required to the existing storm detention pond. These include removal of the existing overflow weir, installation of an internal overflow pipe and replacement of the existing storm return pumps. These works can be completed when sufficient construction windows are available within the pond (i.e. pond can remain empty for sufficient time). It is also necessary to redirect the return main to avoid clashes with road drainage and overflow lines.
10. Chemical Bunds – Drainage from the chemical bunds will be connected to existing drainage pipework that discharges to the EST
11. Hardstand Drainage – The existing hardstand will be configured to drain to the foul water pump station
12. Roadways – The new roadways will interface with the existing access at the front gate
13. Potable Water – A new potable water metering point will be provided at the entrance gate and connect to the incoming main
14. Storm Pond Ring Main – The existing storm pond RE main will be maintained and connected to the dedicated storm clean pump. A new section of main will be provided to service SDP1
15. Power – Power is required to pre-commission the new treatment infrastructure (i.e. power is required simultaneously at the new and existing plants). As the entire new plant is not required to operate in conjunction with the existing secondary process, the new transformer should provide sufficient power to service both needs. Transitioning the power supply will require input from the service provider and should be scheduled with sufficient lead time to avoid delays.
16. Electrical Conduits – There are a number of clashes associated with new infrastructure and electrical cables associated with existing infrastructure. Of note is the supply to the storm return pumps that will have to be temporarily relocated to allow installation of the bypass pipework and the supply to the IDEA and Pasveers that will have to be crossed perpendicularly when laying the new bypass line. The Contractor will be responsible for identifying all existing infrastructure prior to undertaking any excavations.
17. Telemetry – A telemetry SCADA pack Telemetry RTU and Trio data radio has been included in the design to communicate with the WSC Mt Gibraltar Sewer Telemetry network via the repeater at Mt Gibraltar. The RTU will communicate with the local PLC system to provide peer comms to SPS sites and send a subset of status data for the Bowral STP for display on the WSC Sewer SCADA system.

7 Hydraulics

The treatment plant hydraulics are governed by three key factors;

1. All inflows are to be screened before entering the process or the storm ponds.
2. Treated effluent is to utilise the existing effluent discharge main
3. All new infrastructure is to be above the 1 in 100 year flood level.

The Bowral STP site is relatively flat, dictating that at least one lift pump station is required (the existing process has two). To minimise the size of the inlet lift pump station and to protect the lift pumps from gross solids (minimising blockage issues encountered with the current upstream lift pump station), WSC preference was to locate the first lift pump station downstream of the inlet works.

Given the invert of the incoming gravity main, this requires lowering of the TWL within the storm ponds. This allows incoming flows to gravitate through the screens and into the storm storages. The CDR assumed that the height of the existing overflow weir within SDP2 could be lowered to accommodate this gravity flow. Following a storm in late 2020 it was observed that the level within the Mittagong Rivulet rose and flowed into the existing storm pond at its current height. Comparing the current weir level to available flood mapping information indicated that lowering the weir (to the height assumed within the CDR) would result in backflow even under minor flood conditions.

In the existing arrangement, once the rivulet level exceeds the existing storm pond, the hydraulic capacity of the incoming gravity mains is dependent on the rivulet level. There is a level (somewhere between the current overflow of RL659.1m and the invert of the incoming main – RL659.7m) where gravity inflow will be restricted and sewage will back up within the reticulation work, potentially leading to surcharge. A number of options were considered, including;

- Provision of a dedicated overflow point from the incoming manholes – this removes the need for a dedicated overflow from the storm storage but results in storm flows discharging to the swollen rivulet during extreme flood events.
- Locating the incoming lift pump station upstream of the inlet works – removes the hydraulic restriction but requires a larger pump capacity and reintroduces potential blockages (as currently experienced).
- Relocation of the storm pond – the 1 in 100 year flood level is significantly (> 3m) lower on the western edge of the site. This allows for an overflow to be incorporated without impacts from the swollen rivulet.
- Reconfigure the storm pond overflow to discharge to the rivulet further downstream.

In consultation with WSC, it was decided that a new bellmouth overflow would be constructed within the existing storm pond. New overflow pipework would then connect with existing overflow pipework from the EST and discharge to the final effluent pond. The lower flood level around the maturation pond provides the necessary head to accommodate screening of all gravity flows whilst accommodate PIF through the new bypass pipework and retaining the same volume within the storm pond as the concept design (i.e. pond TWL ~ RL658.3m). The existing overflow point would be sealed to prevent river water entering the storm pond during major flood events (decoupling performance of the gravity network from the river height).

Headloss associated with the secondary treatment process and the preferred dual media filtration arrangement requires a second lift pump station (filter feed pump station) to then allow tertiary effluent to gravitate into the existing effluent discharge main.

The existing main discharges into the Wingecarribee River via a weir over an energy dissipation device at RL648.13m. At PFTF plus recycle rates less peak RE demand (~195 L/s), one of the manholes is expected to be close to overtopping. This overtopping risk could be solved by increasing the height of the manhole, however as these flows are not expected until the plant is at design capacity there is little driver to undertake any works based on standard conditions. However, available 1 in 100 year flood information for the river indicates that the discharge weir would be submerged by more than 6m. The reduction in available driving head reduces the capacity of the main to around 2.3 x ADWF if the manholes are sealed.

Raising the UV system by 6m to provide the necessary driving head was deemed impractical, however a number of solutions were considered:

- Cap the filter feed pump station once the level within the RE pump station approaches the maximum tailwater depth. This will force the remaining secondary and solids contact treated effluent to overflow the EST to the old maturation pond and ultimately the rivulet.
- Raise and place grating on one of the effluent main manholes (most likely manhole 1). The modified manhole acts as a surcharge point directly into the rivulet to prevent surcharge at the RE / UV system.

- Provide an additional effluent pump station and pressurise the effluent main to increase capacity.
- Duplicate the main and provide actuated valves to allow mains to be isolated during normal flow conditions to assist with self-cleaning velocities.

In consultation with WSC, it was agreed that the design could be completed assuming that either a treated effluent flow cap or dedicated surcharge point within the main (separate scope of works) would be provided. Additional capital works associated with duplicate mains and pump stations were found to come at considerable cost and would be required very infrequently. Discharging treated effluent into the rivulet as opposed to the river during major flood conditions is likely to have negligible impact. It would be possible to increase effluent main capacity at a later stage as the plant approaches design capacity if required.

Other key components of the hydraulic design are summarised below;

- FSL of all structures is above the 1 in 100 year flood level.
- The reticulation network can discharge up to PIF / 13 x ADWF (695 L/s) to the inlet works.
- The TWL within the inlet works has been capped at the TWL within the existing inlet lift pump station to retain current hydraulic conditions within the incoming gravity mains.
- Manually raked bypass screen is designed to pass PIF when fully blind. The height of the manual screening channel floor is set to eliminate tail water (i.e. remains dry) during dry weather flows.
- The inlet works flow measurement flume provides a number of functions;
    - Provides the hydraulic restriction necessary to maintain required tailwater levels downstream of the band screens.
    - Provides the hydraulic restriction necessary to cap flows through to the grit chamber and inlet lift pump station to 7.5 x ADWF + RE flows. The remainder of flow overtops the upstream bypass weir and flows to the storm ponds.
    - Provides flow monitoring of the flow passing through to the gravity system.
- The length of the bypass weir ensures that most of the flows above the grit chamber capacity are directed to the storm pond. The height of the bypass weirs can be adjusted to accommodate different bioreactor configurations (i.e. allow 7.5 x ADWF through to the grit chamber when in MLE mode or cap inflow to 6 x ADWF when in FSB mode).
- The capacity of the storm pond inlet pipework has been sized for PIF (i.e. inlet lift pump station is also offline). The bypass weirs will become flooded under such scenarios; however, flow is still able to pass without surcharge.
- Pipework has been provided to isolate SDP1 as required (i.e. flows pass directly to SDP2).
- Overflow pipework from SDP2 is sized to accommodate PIF.
- The grit chamber is sized for 7.5 x ADWF plus RE flows.
- The operating volume of the inlet lift pump station has been selected to provide sufficient flow attenuation to achieve smooth / gradual changes in flow directed to the flow splitter.
- Flow distribution structure has been configured to allow chambers to overtop to the ML splitter (i.e. feed to the clarifiers). High level switch within the ML splitter is used to inhibit contributing pump stations under such scenarios.
- The level of the bioreactor has been set based on WSC preference to provide access from the external walls when standing on the roadway. This requires the water level within the clarifiers to be below the FSL of the site.
- Gravity pipework between structures has been sized to achieve self-cleansing velocities at PDWF. This requires the inflow from the lift pump station to be capped if a bioreactor or clarifier is taken offline to ensure sufficient hydraulic carriage (i.e. pipework from single bioreactor / clarifier unable to accept full flow).
- Bioreactor pipework is set to achieve 4.5 x ADWF plus Recycle Flows to accommodate MLE operation.
- The submerged weirs between each of the bioreactor zones are designed to maximise zone integrity (i.e. prevent contamination with DO / nitrate etc.) whilst minimising headloss.
- The clarifier gravity pipework is designed to accept up to 7.5 x ADWF + Recycle Flows to facilitate solids contact operation.
- The top of the scum pump station is above the clarifier water level to prevent surcharge upon pump failure or scum beach fault.
- Flows that exceed the filter capacity are overflowed to the EST via a bellmouth that is sized to accept peak clarifier effluent flows.
- An overflow within the flocculation tank serves two purposes;
    - Prevent surcharge of the structure.
    - Allows the filters to be bypassed with flow diverted directly to the UV disinfection channel (default location). Alternatively, a manual valve can be opened to direct overflow to the EST.

- Filter control valves work to maintain a level within the filters (i.e. there is no individual flow control on the filter cells).
- Filtered effluent enters the clean backwash tank before overflowing a fixed weir to the UV system. The height of the fixed weir is set to ensure the filter sand remains submerged during drain down.
- An overflow is provided within the dirty backwash tank to the EST to prevent surcharge.
- A separate bypass is provided around the UV disinfection system to prevent surcharge.
- The height within the UV disinfection chamber is governed by an actuated penstock.
- The Foul Water Pump Station includes an overflow to the EST to prevent surcharge.
- A minimum operational freeboard allowance of greater than 300mm for unaerated structures and 500mm for aerated structures has been provided.

An overview of the hydraulic carriage through the plant is provided below.

The inlet works accepts all gravity and pump inflow to the STP. The inlet works is capable of accepting up to 13 x ADWF and comprises dual bands screens, mechanical bypass screen, grit chamber, flow measurement flume, bypass weirs and residuals handling equipment. Each band screen is capable of treating 13 x ADWF providing 100% redundancy. In the event of dual screen unavailability, flow overtops an upstream weir and enters a manual bypass screen channel. The installed manual bypass screen provides coarse screening of inflows until it becomes fully blind and inflows pass through to the flume channel unscreened. Operators must manually rake collected screenings from the manual screen once flows subside.

Screened flows pass through a flow measurement flume before entering a vortex style grit chamber. The flume provides a hydraulic restriction to maintain the necessary screen tailwater depths and limit grit chamber flows below the peak treatment flow of 7.5 x ADWF (plus recycle flows). Flows above 7.5 x ADWF overtop fixed bypass weirs upstream of the flume and pass through to SDP1. Once the capacity of SDP1 is reached, storm flows overtop a weir and continue through top SDP2. Once the storage capacity within SDP2 is exceeded, flow bypasses directly to the old maturation pond. It is possible to isolate SDP1 (direct flows straight to SDP2) if required for maintenance purposes. Pump stations within each pond return storm flows to the inlet works downstream of the flow measurement flume once inflows subside.

The inlet lift pump station receives degritted flow from the vortex grit chamber. The pump station contains five pumps, three of which are dedicated bioreactor / influent pumps and the remainder storm pumps. The influent pumps direct flows to the feed splitter, where equal length weirs distribute inflow between the bioreactors. The storm pumps direct flows to the solids contact splitter, where equal length weirs distribute storm flows between the clarifiers. Each of the lift pumps has a capacity of 1.5 x ADWF. The number of operational influent pumps is dependent on the configuration of the bioreactor (i.e. 2 pumps in FSB and 3 pumps in MLE). The maximum capacity of the storm pumps (i.e. solids contact mode) is 3 x ADWF.

Inflows to the bioreactor are combined with RAS from the clarifiers within a common chamber before gravitating into the bioreactor. This combined flow passes through the bioreactor and overflows a fixed wear at the end of the secondary aerobic zone before gravitating to the ML splitter. MLR pumps within the bioreactors establish an internal recycle rate much greater than the combined outflow, however this only influences the hydraulic losses between each of the bioreactor zones. Equal length weirs within the ML splitter is combined with flow from the storm pumps (when flows are above capacity of bioreactors) and distributed equally between the two clarifiers. Internal dividing walls within the RAS and feed splitters overtop to the ML splitter to limit the risk of surcharge.

Clarified effluent enters the clarifier launders and gravitates to a common pit. Combined effluent then passes through to the filter feed pump station. The filter feed pump station contains three pumps (duty / assist / standby) to lift 3 x ADWF plus recycle flows to the flocculation tank. Flow in excess of the filter feed capacity overflows the pump station to the EST (existing catch pond). Flocculated effluent enters a feed channel and then enters online filter cells via an actuated valve and pipe upstand. The filter inlet is set above the design operating level such that the height of the discharge pipe governs flow distribution through the online cells (i.e. the height of each discharge pipe is identical). An overflow pipe within the flocculation tank inlet allows the filter cells to be bypassed (directly to the UV channel) and prevent surcharge in the event of multiple filter cell failures.

Clarified effluent flows through the filter control valves to the clean backwash tank. The filter control valves work to maintain a target level within the filter cells (there is no flow control mode available for filter control). During normal operation, filtered effluent overtops a fixed weir and flows to the UV disinfection system. The height of the fixed weir is set to keep the filter sand submerged under normal operation. The clean backwash tank provides sufficient storage volume for two consecutive backwashes. Similarly, the dirty backwash tank can accommodate two consecutive backwashes. The operator can elect to override interlocks associated with backwash tank high level and conduct additional backwashes; however backwash water will overflow to the EST rather than being pumped back to the foul water pump station.

Filtered effluent enters the UV receival pit and passes through a manual penstock to the UV channel. The UV channel contains three banks operating in a duty / assist / assist arrangement and is able to treat 3 x ADWF plus recycle flows with all banks available. Provision is made for a fourth bank in the future if required (i.e. to provide redundancy). A modulating penstock on the channel outlet works to maintain optimal channel levels despite changing flow rates. Disinfected effluent overtops the modulating penstock and enters the RE lift pumping station. An overflow is provided around the UV system directly to the RE lift pumping station tank if the UV system is unavailable.

A RE lift pump within the RE lift pumping station transfers disinfected effluent to the RE tank where it is available for onsite reuse. A separate storm clean pump services a storm pond cleaning ring main that is used to clean the storm ponds following wet weather events. Tertiary effluent beyond the demands of the RE and storm pump overflows the RE lift pumping station and connects to the existing effluent main. The TWL within the RE lift pumping station is set to allow unhindered operation of the modulating weir (i.e. discharge over the weir is unimpeded).

The foul water pump station accepts flow from a number of plant process (predominantly dewatering and filter backwash). The foul water is then returned to the feed flow splitter for treatment within the bioreactors. Foul water flows are exposed to some storm water and flows may increase during wet weather. In the event inflows exceed pump capacity, flow will overflow to the EST. The EST receives flow from a number of other locations on site (chemical bunds, pump station overflows, digester etc.) A single pump with 1.5 x ADWF capacity is provided within a sump at the base of the storage and returns flows to the either the inlet works or the filter feed pumping station for retreatment. Once the storage of the EST is exceeded, flows overtop an overflow bellmouth and flow to the existing maturation pond.

Further details are available within the flow balance (Appendix D) and the hydraulic profile (Appendix F).

8 Civil Design

8.1 Site Layout

The site layout (provided in Appendix G and Figure 8-1) has been developed in consideration of the existing Bowral STP site and provided survey from WSC and further survey by HH2O. Identified and known underground services are presented on the survey and have been considered in the layout of the site.

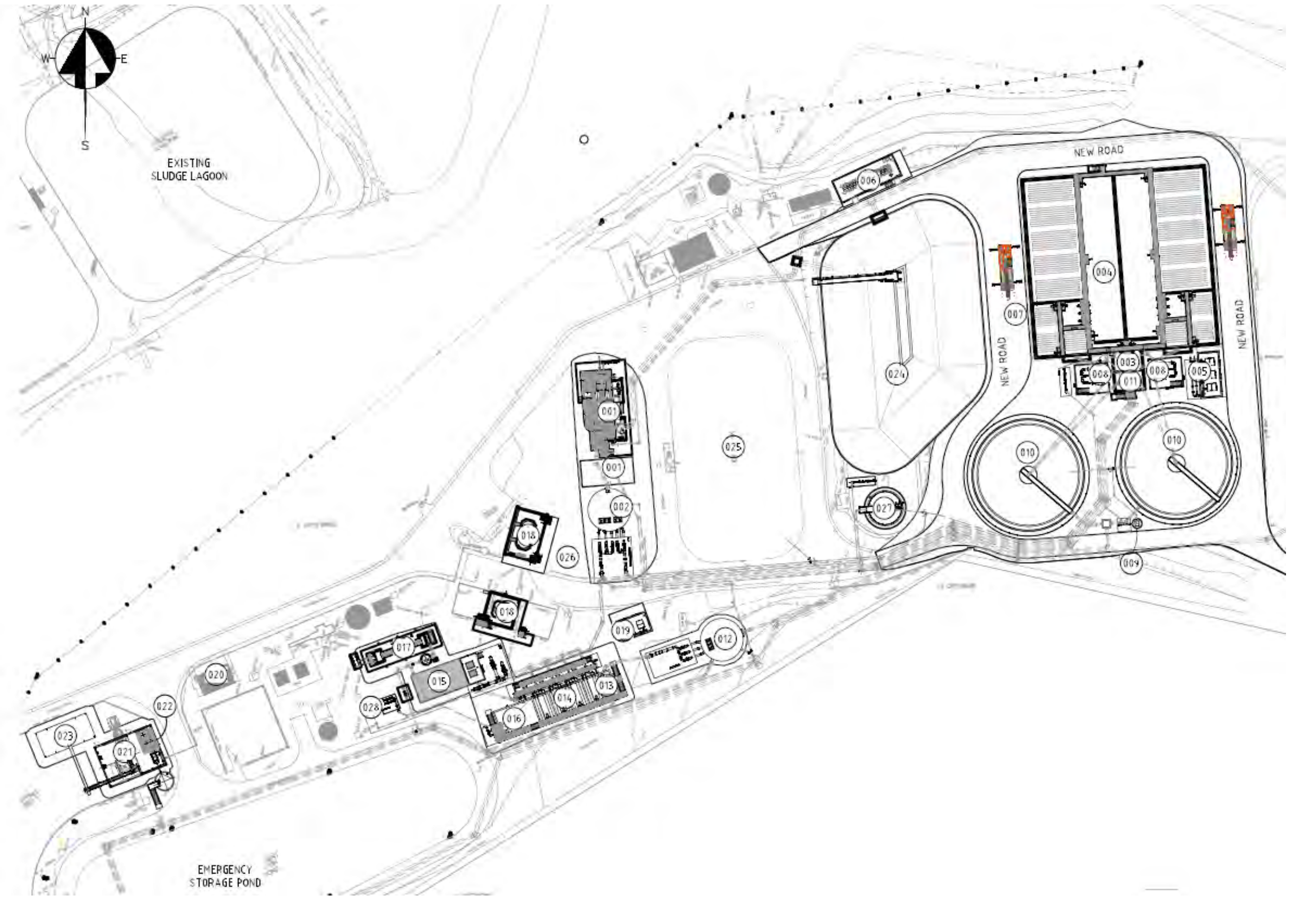


Figure 8-1 Site Arrangement

The influent receival area (inlet works, odour control and inlet pumping station) are located between the existing amenities building and sludge digester (which is to be converted to an IDEA reactor). The location of these structures is alongside an existing access road that allows for suitable vehicles to collect the solids from the inlet works bins, for removal from the site.

The storm pond, bioreactor and associated blower room, RAS pumping station, clarifiers and thickener are located to the East of the influent receival area. Construction of additional access roads is required to access these elements of the STP.

The filter feed pumping station, filters, clear water backwash tank and UV process units are located to the south-west of the influent receival area, in a position that is towards the existing effluent discharge main. This area also comprises an air scour blower building and foul water pumping station.

Routine heavy vehicle movements are required for chemical deliveries and sludge removal. Vehicle movements for both of these are limited to the western portions of the site. Two new chemical bunds are located adjacent to the two existing chemical bunds to consolidate the location of the chemical facilities on the site. The dewatering facility is located towards the western end of the site, situated alongside the incoming road. These vehicle movements will be required to sign-in at the amenities building which is situated along the proposed vehicle movement path utilising the loop road alongside the proposed influent receival area.

A new switchroom is located towards the Northern edge of the site, located between the inlet works and bioreactor, to minimise cable run lengths to each of the main motor drives. New switchboards are to be located within the existing switchroom, located adjacent to the dewatering facility.

The layout allows the provision of semi-trailers and cranes to access the necessary areas of the site to carry out routine deliveries and ongoing maintenance / operation of the STP. Crane pads are provided adjacent to the bioreactor to enable crane outriggers to be placed on the concrete hardstand and for aeration grids to be placed on the hardstand for cleaning purposes.

8.2 Geotechnical

For the purposes of this project, WSC provided existing geotechnical reports for three previous phases of geotechnical investigation, associated with historical upgrades and proposed designs (dated 1979, 2003 and 2018).

Subsequently in 2021, Hunter H2O engaged D&N Geotechnical on behalf of WSC to conduct further geotechnical investigations and reporting for Bowral STP following the development of the preliminary detailed design for this upgrade, targeting boreholes based on the anticipated site layout and associated structural / hydraulic requirements. It is noted that the test location plan was developed considering the presence of available information but was also limited by the presence of existing structures preventing subsurface investigation in the vicinity of some of the proposed structures.

The historic and recent geotechnical reports are provided in Appendix H.

The 2021 geotechnical investigation comprised the drilling of seven boreholes, installation of two groundwater monitoring wells, in-situ and laboratory testing, in addition to reporting on the following:

- Subsurface conditions, including depth to rock and depth to groundwater (if encountered);
- Foundations design parameters and considerations;
- Earthworks:
  - Excavatability / rippability;
  - Excavation and trench support requirements, including shoring, benching and batter slope requirements;
  - Construction methodology including site preparation measures;
  - Suitability of excavated material (site-won) for re-use;
- Geotechnical risks;
- Groundwater:
  - Results of groundwater level monitoring over a period of three months.
  - Results of permeability testing for soil and rock units along with the seepage analysis to provide sufficient information to adequately inform dewatering requirements.
- Pavement thickness design (flexible and rigid) for internal site pavements in accordance with RMS, Austroads and Council standards;
  - Design traffic loading: designed for heavy vehicles unrestricted, adopting traffic loading of one rigid truck (2.1 ESAs) per day for a 25yr design life. In addition, a designated crane pad loading of 270 kPa over 2.5m^2 was assessed at designated crane set-down areas.

The 2021 geotechnical report is summarised as follows:

- The regional topography comprises slightly undulating hillsides, with the site located between two topographic rises towards the base of a shallow valley associated with the formation of Mittagong Creek.
- The site is underlain partially by quaternary alluvium within the flood plain adjacent to Mittagong Creek, which is further underlain by the predominant geological unit across the remainder of the site: sedimentary rocks of the Liverpool subgroup of the Wianamatta Group.
- Typical subsurface conditions can be summarised as follows:

Unit[1]	Material Origin	Material Description	Depth Range to Top of Unit (m)[2]	Range of Unit Thickness (m)[2]
1	Topsoil/Fill - General	Sandy CLAY/sandy SILT/silty CLAY, medium plasticity clay fines, brown, fine to medium sand, with some fine to coarse, sub-rounded to sub-angular gravel, trace fragments of brick and asphalt (≤50 mm diameter), with some fine roots in landscaped areas.	0	0.2 to >2.0
2	Alluvium	Clayey SAND, fine to medium grained, grey, off-white, mottled orange-brown, medium plasticity clay fines, with fine to coarse, sub-angular gravel, typically medium dense	1.1	2.6
3	Residual Soil	Sandy/Silty CLAY, medium to high plasticity, grey, mottled orange-brown, fine to medium grained sand, with some fine to medium grained, sub-angular gravel. Typically, stiff to very stiff consistency.	0 to 0.9	1.4 to 3.3
4a	Interlaminated Siltstone and Sandstone Bedrock	Extremely to highly weathered, inferred soil strength to low strength.	1.6 to 4.2	1.9 to 2.2
4b		Highly to moderately weathered, low to medium strength	3.8 to 5.6	0.3 to 1.2
4c		Slightly weathered to fresh, medium to high strength	5.0 to 5.9	unproven

Notes:

1. Units were not encountered at every borehole location, reference should be made to specific engineering boreholes logs, included in the geotechnical report
2. The depths and unit thicknesses are based on information at the borehole locations and may not represent the maximum or the minimum values at other locations

- Groundwater was encountered during auger drilling within BH105 at about 2.5 m depth but not observed during auger drilling within any of the remaining boreholes advanced as part of this investigation. Note, groundwater observations are obscured during rock coring. Further, groundwater levels fluctuate in response to the prevailing climatic conditions and will therefore vary with time.
- Site classification to AS2870-2011: the site is classified as Class M with up to 30 mm seasonal movements due to climatic effects.
- Earthquake design parameters to AS1170.4-2007:
  - Seismic Hazard Factor (Z): 0.09
  - Sub-Soil Class: Ce.
- Excavatability:
  - Large (20 to 30 tonne) hydraulic excavators, equipped with ripping buckets or ripping tynes, would feasibly excavate the material up to at least the depth of auger TC-bit refusal (refer to geotechnical logs).
  - Heavier excavation equipment, or ripping equipment, may be required to extend bulk excavation, or trenching works below the level of auger refusal, likely to be within predominantly moderately to slightly weathered, medium strength (or better) sandstone and/or siltstone. Ripping of rock materials encountered in the cored borehole intervals (below the depth of auger refusal) would require “easy ripping” to “hard ripping”, typically using D8 dozers equipped with ripping tynes.
- Re-use of site-won materials:
  - Site soils should generally be suitable for use as engineered fill, provided unsuitable materials such as organics, highly plastic material, waste and oversized particles are removed.
  - Unit 3 Residual Soil, generally comprising low to medium plasticity sandy clay, may be considered for re-use as compacted clay liner material subject to suitable blending, moisture conditioning and further laboratory testing to confirm plasticity, dispersiveness and permeability.
  - It is not expected that material directly won from the geotechnical units encountered would be suitable for pipe bedding material.

The following additional information that is relevant to this project can be drawn from the previous geotechnical reports:

- Subsurface conditions summarised as uncontrolled fill overlaying firm to stiff or better cohesive deposits, underlain by variably weathered shale bedrock.
- Site Class varies from Class S (slightly reactive clay site) to Class H1 (highly reactive clay site), or Class P where > 0.4 m of filling is present. Approximate seasonal movements therefore estimated to range from 15 mm to 50 mm.
- Shallow footings, allowable bearing pressures:
  - Cohesive deposits: 100 kPa
  - Shale bedrock:
    - Up to TC-bit refusal: 300 kPa
    - Beyond TC-bit refusal: 700 kPa.
- Design subgrade CBR of 7% (2003) and 4% (2018) recommended.
- Permeability coefficient of cohesive deposits: between 1 x 10^{-8} m/s to 7.7 x 10^{-10} m/s. For use as clay liner in an in-ground water retaining structure, a minimum thickness of 600 mm would be required, for which there is insufficient volume expected to be site-won.

8.3 Survey and Services

WSC provided a survey of Bowral STP, with additional detail survey and services location carried out by Hunter H2O to locate interfacing constraints associated with the detailed design, extend the survey boundary and validate services plans where possible. The design has been developed in consideration of the provided survey and identified services, however there is a residual risk of damaging existing services during construction and causing environmental discharge for services that have not been identified.

Of importance is the fact that the incoming rising main from the south (Burradoo Rising Main – 225 mm DICL) was not able to be located by electronic scanning or ground-penetrating radar (GPR) scanning; it is recommended that this will need to be located by potholing prior to construction.

8.4 Structural Design

The structural design has been developed predominantly using STRAND7 software, considering the imposed design loads and earthquake loads in accordance with Australian Standards, in particular "AS3735 Concrete Structures for Retaining Liquids". The design drawings provide the outcomes of the concrete and reinforcement design that has been completed during the course of the design.

8.5 Access Platforms / Handrails

Access platforms are provided to work area to provide access to equipment and control panels etc., enabling operators to conduct day to day operational and maintenance tasks.

Aluminium platforms / handrails have been provided for corrosive areas such as the inlet works, flow splitter and reactor structure, whilst hot dipped galvanised platforms / handrails are provided for other areas where the rate of corrosion is typically reduced. This provides GMC with a long term cost effective and durable product specifically targeting each facet of the project.

8.6 Roadworks

The location of the existing access road near the intersection of Burradoo Rd and Railway Rd is to be retained. The access road crosses the main railway line adjacent and to the south-west of Burradoo Train Station, with manual gates on either side of the railway to enable vehicle access to the site. This is considered a construction and operational risk that needs to be carefully managed both during construction and for ongoing operation / maintenance of the STP, with a traffic management plan being established to mitigate this risk.

The existing access road to the site is to be retained, with new access roads provided within the site to provide appropriate access to the process units and facilities across the site. The access roads have been provided to enable heavy vehicle and crane movements to appropriate areas for construction and operational purposes.

8.7 Storm Water Drainage

Site storm water collected from buildings (i.e. blower room, switchroom, dewatering facility and chemical facility) and roadworks will be directed to a storm water drainage system discharging to the nearby watercourse.

The storm water drainage hydrologic assessment adopts the requirements of the Australian Rainfall Runoff (ARR) method for a 5% Annual Exceedance Probability (AEP). The adoption of the 5% AEP peak design flow indicates that there is a 5% chance every year that design flows through the catchment will be exceeded. Implementing a 5% AEP (Average Recurrence Interval or ARI = 20 years) has been taken from AS 3500.3:2003 Plumbing and drainage - Stormwater drainage.

8.8 Reclaimed Effluent System

The treated effluent from the UV supplies the existing RE storage tank via a RE lift pumping station. A high level outlet from the existing RE storage tank enables flows to return to the RE lift pumping station if the water level in the RE tank reaches the overflow level. The RE effluent system comprises an existing RE storage tank and a proprietary pumping station comprising 3 off RE transfer pumps and a pressure vessel, along with pipelines / fittings around the site to supply onsite RE demands. Connections to the existing RE pipelines are required to provide RE water to new process units as required.

A storm cleaning pump is also located within the RE lift pumping station connecting to existing pipework to facilitate cleaning of the storm ponds. The residual UV treated water that does not get pumped to the RE system or storm pond is discharged to the river via the existing effluent main.

8.9 Fire Fighting Requirements

Firefighting requirements are to comply with the requirements of AS2419.1, which require a demand of 10 L/s @ 150 kPa. As per AS2419.1 this demand needs to be met for a minimum duration of 4 hours. It is suggested that WSC confirm whether the firefighting requirements can be met by the existing potable water supply network system. If the existing potable water supply network cannot achieve the firefighting requirements, then an onsite storage and / or booster pump set may be required to meet the firefighting flow and head conditions. This would typically include the following:

- Provide a dedicated 200 m^3 storage tank for storing firefighting water.
- Provide dedicated 2 x 10 L/s pumps to provide pressure of 150 kPa (diesel pump set to enable firefighting when power outage occurs).
- The need for dedicated firefighting water storage and pumps may become redundant if GMC upgrades the water supply to the site to provide additional water supply of 10 L/s at minimum pressure of 15 m.

Firefighting requirements for diesel storage would need to comply with the requirements of AS1940. The requirements set out for storages less than 60,000 L in AS1940 (Table 11.4) include the following:

- At least one powder-type extinguisher shall be provided if a single tank installation, otherwise two powder type extinguishers plus a hose reel with foam shall be provided.

It is recommended that WSC undertakes a fire risk assessment prior to construction by a BCA consultant to confirm the need for fire hydrants and fire fighting for the site.

8.10 Landscaping

Backfilling of all excavated areas is to be carried out in such a way that the site will be returned to pre-construction conditions where possible. All disturbed soil areas will be reinstated to minimise erosion. Vegetation will be left where possible or revegetation conducted to maintain visual screen around the sites.

8.11 Bushfire

It is understood that Bowral STP does not lie within a bushfire prone area as mapped by the rural fire service and therefore does not require further bushfire risk assessment. However, fire risk is to be considered when landscaping the facility. Water for firefighting to be provided from potable water network or alternatively be available from a water storage tank and diesel pump system. All vegetation screens to be established in regard to the provision of the Planning for Bushfire Protection 2006 and consist of predominantly fire-retardant species.

All firefighting requirements are to be addressed as per the relevant Australian standards or BCA during or prior to construction.

8.12 Onsite Amenities and Testing Room

WSC have advised that the existing amenities building on site will be retained as part of the upgrade.

9 Electrical Design

9.1 Overview

As noted in the introduction to this report, the Bowral STP is being amplified and upgraded to increase the capacity from 14,600 EP to 21,000 EP and improve the plant performance to meet NorBE..

To achieve this much new plant infrastructure will be installed replacing most of the existing plant. What existing equipment does remain in service will be replaced and the associated electrical equipment will also be replaced

An increase in power supply capacity is required for the new plant, and a new dedicated substation and new main switchroom will be installed to supply all new and existing equipment.

The upgraded electrical system will include a new main switch room, new main switchboard, and a new tertiary treatment switchboard. New PLC panels will be installed in each switchroom as well as new remote I/O panels in the filter and bioreactor area blower rooms. The PLCs, SCADA system and all other instruments and electrical equipment required to supply and distribute power and monitor and control the new plants.

9.2 Existing Electrical Infrastructure

The Bowral STP is supplied by an 11kV overhead high voltage line, running past the northern boundary of the site, from a pole located outside the property boundary, to the dedicated Endeavour Energy 500kVA pad mount substation (No. 24435), which is located on the STP site.

It is located to the west of the existing site administration office building. The existing 400VAC runs from the transformer in an underground conduit to the existing switchroom within the amenities building. A standby generator connection point is located outside the switchroom.

The main switchboard distributes power to several other switchboards located around the STP. These switchboards will be redundant and decommissioned at completion of the project.

A submain from the new main switchboard will be installed to supply power to the amenities building switchroom at the completion of the project.

Figure 9-1 Existing Pad mount Substation, HV Connection & HV Powerline

There is insufficient space in the existing amenities building main switchroom to house the new equipment so a new main switchroom and switchboard have been included in the design. The new substation and pad mount substation will be located across the road from Storm Detention pond 1 & adjacent to the existing brick building.

9.3 Power Supply Upgrade

An upgrade to the plant power supply will be required to meet the increased load requirements and large quantity of new drives and instruments for the new plant.

A new 1000kVA pad mount substation, new main switchroom, new main switchboard MCC-1001 and new tertiary treatment switchboard MCC-2001 (installed in the existing tertiary treatment switchroom) have been included in the design.

The existing 500kVA transformer is insufficient for the upgraded power demand and will need to be replaced as part of this project. It will be decommissioned and removed at the end of the project, once the new switchroom and power supply are in place and all existing equipment that will remain in service has been repowered from the new supply.

The contractor will include all works required to complete the upgrade in the construction contract. This will include application and liaison with Endeavour Energy and payment of any required fees to gain approval and a design information pack (DIP) for the upgrade. An ASP3 designer will need to be engaged to complete the certified design, and an ASP1 construction contractor will need to be engaged to complete the works.

Power supply upgrade, temporary power supply and decommissioning of the existing power supply will need to be coordinated with WSC to minimise disruption and ensure there is no interruption to operations during the upgrade.

As noted below the route for the new LV power supply will need to be finalised during the ASP3 design.

Figure 9-2 New Switchroom, Pad Mount Substation & Power Supply Modifications

The location of the proposed new and existing substations and new switchroom are shown in Figure 9-2 above. The HV connection point for the new substation will be confirmed as part of the ASP3 design development during construction.

Both the new pad mount substation and new switchroom will be located closer to the new bioreactor area, reducing the cable run length to equipment in this area. This will provide maximum flexibility for the site and will also allow for continued operation of the existing plant during plant construction and commissioning.

The existing amenities building distribution will be resupplied by a feeder in the new main switchboard, and once the new plant is commissioned the old power supply and existing pad mount substation will be decommissioned.

9.4 Maximum Demand

The maximum demand for the upgraded plant has been calculated assuming duty loads are at nameplate capacity, standby loads are not using any power, and an overall diversity factor of 0.85 has been applied. The maximum demand for the new plant is calculated to be 693kVA.

Based on the results, a new 1000kVA pad mount substation is recommended for the site to meet the increased demand, and to allow for future growth.

A 750kVA substation would exceed the calculated demand requirement however this is not recommended as this capacity is not enough to allow for future growth.

The detailed maximum demand calculation is attached as Appendix I.

9.5 Power Quality

The upgrade design includes many variable speed drives (38 in MCC-1001, and 21 in MCC-2001) to provide efficient process control.

The VSDs have very good power factors compared to traditional starting methods, but adversely affect the power quality of the electrical distribution due to the harmonics they generate as part of their operation. Harmonics affect the entire electrical distribution system, and can lead to poor equipment performance, reliability issues and equipment failures.

The generated harmonics associated with the non-linear VSD loads have been calculated as ~300 Amps for MCC-1001 and ~150 Amps for MCC-2001, based on a typical VSD THDi unit rating of 40%.

Active Harmonic Filters (AHFs) are used to counteract and compensate for this harmonic content, and have been estimated as follows:

- For MCC-1001 a 300 Amp AHF will counteract the harmonics with ~35% spare capacity
- For MCC-2001 a 200 Amp AHF will counteract the harmonics with 35% spare capacity

Spare capacity of the AHF units will be used in each switchboard for power factor correction and phase balancing.

Verification by the VSD vendor of the AHF size required is required prior to design completion of detailed design.

The active harmonic filter will be configured and tuned during the commissioning process in a dual mode operation. This is achieved by limiting the harmonic correction to reduce the harmonics to acceptable levels, and then setting the AHF to allow additional capacity will be used for power factor correction. Using the AHF in the way, prevents the risks of resonance between VSDs and traditional capacitor banks.

9.6 Lightning and Surge protection

An AS1768 lightning risk assessment has been undertaken as part of the detailed design for the major structures, using a direct strike protection level of PL III, ground flash density of 3, and a suburban service line density. An unacceptable risk level was calculated with respect to the "Loss of Essential Services" category and therefore triggering the requirement for direct strike protection.

Under this scenario the detailed design of the direct strike lightning protection system is required to be undertaken as part of the upgrade works for the main Switchroom and transformer area, blower facility, UV facility and chemical dosing facility. Details of the direct strike protection requirements are to be reviewed with WSC prior to design completion.

9.7 Switchrooms

A new main switchroom will be constructed as part of the upgrade works and will house the main switchboardMCC-1001. Wall mounted L&P DB, process DB, AHF, VSDs and network communication cabinet will be installed in the room.

The Switchroom has been sized to house a back-to-back main switchboard located in the centre of the room, allowing sufficient spare space in the room for future extension of the main switchboard by one tier, and spare wall space for future use by WSC.

The Switchroom flooring will be raised computer style type, to allow cables to be easily run under the floor and exit the Switchroom into underground pits and conduits that run to motors, instruments and equipment located in the field.

Cable ladders will be installed under the computer flooring to route cables from external pits to the MCC and between the MCC and wall mounted equipment

The Switchroom is air-conditioned, to provide a constant environment for the PLC and electrical equipment, and to compensate for the heat generated by the Variable Speed Drives and other hardware.

Switchboard layout and construction is detailed in the civil drawing set for the project.

The tertiary treatment switchroom will be upgraded during the project, and will house the new Tertiary Treatment MCC-2001, and associated wall mounted L&P DB, process DB VSD's and network communications cabinet

9.8 Main Switchboards

Two (2) new switchboards will be constructed as part of the upgrade works. These are:

- MCC-1001 Main Switchboard, housed in the new main switchroom
- MCC-2001 Tertiary Treatment Switchboard, housed in the existing tertiary treatment switchroom.

Both new Switchboards will be a Form 4A design, and will utilise modular, Type Tested Assemblies (TTA) to AS61439 for short circuit faults, heat rise and arcing faults to improve safety and reliability.

MCC-1001 is a double-sided design, and incorporates:

- A withdrawable Air Circuit Breaker (ACB) for the consumer mains as the main Service Protection Device (SPD)
- A mechanically interlocked Automatic Transfer Switch (ATS) for changeover to the permanent standby generator. The ATS will provide the ability to automatically changeover to the standby generator during extended power outages
- Moulded case circuit breakers for supply to outgoing motor, distribution, and feeder circuits.
- Submain feeders to the Tertiary Treatment MCC-2001, the existing admin building distribution board, and the Bioreactor Blower room Process DB.
- Power and control circuits for all motors, and distribution of power.
- A PLC section in the MSB contains the PLC remote IO hardware, and marshalling for all motor and MCC controls.

MCC-2001 is a single-sided design, and incorporates:

- A moulded case incoming circuit breaker for the supply submain from MCC-1001
- Moulded case circuit breakers for supply to outgoing motor, distribution, and feeder circuits.
- A submain feeder tot the Filters Blower room Process DB.
- Power and control circuits for all motors, and distribution of power.
- A PLC section in the MSB contains the PLC remote IO hardware, and marshalling for all motor and MCC controls.

In addition to the main switchboards in the main and tertiary treatment switchrooms, Process DBs and L&P DBs will be installed in the bioreactor and blower rooms. DC UPS systems will also be installed in the blower rooms to provide power to the RIO panels and instrument distribution in each area.

9.9 Motor Starters

There are two main motor starter types used for Bowral; these are: Variable Speed Drive (VSD) and Direct Online (DOL) starters. Each of these types have various configurations dependant on the I/O and control requirements of the connected equipment, however the main features are:

The DOL starter is the traditional hardwired design and includes:

- Door interlocked moulded case circuit breaker (magnetic only), 24VDC line contactor and thermal overload combination to meet the Schneider NSX type 2 co-ordination charts.
- 24VDC control wiring and relays.
- Hardwired interface to the PLC IO for automatic control and monitoring.
- Door mounted indicators for fault and running.
- Door mounted manual/off/auto selector switch.
- Proprietary protection relays (over torque, seal fail/overload) where required.
- Local control station with whole current isolator and field start/stop buttons.

The VSD starter design includes an Ethernet communications interface to control and monitor the drive. The inbuilt VSD IO is used to monitor the drive controls and includes:

- Door interlocked moulded case circuit breaker (magnetic only) and 24VDC line contactor.
- 24VDC control wiring and relays.
- Hardwired interface to the VSD for automatic control and monitoring via an Ethernet communications link to the PLC.
- Door mounted indicators for fault and running.
- Door mounted manual/off/auto selector switch.
- Proprietary protection relays (over torque, seal fail/overload) where required.

Each motor starter includes a local control panel to provide the facility for local starting and stopping of the motor when selected to manual control at the MSB, and a field isolator for local isolation. Decontactors are used for selected submersible drives.

An emergency stop has only been provided where required in accordance with the risk assessment. Where required these have been designed to meet the associated AS4024 category rating.

9.10 Emergency Stops and Safety Limit Switches

A risk assessment was undertaken on each motor, with only motors that presented a risk during normal operation undertaking a further AS4024 risk assessment to define the emergency stop category.

The risk assessment did not consider operation with guards removed and assumed that in the event that this was required as part of a maintenance/operations activity that the motor would be electrically isolated, and the works performed under a standard operating procedure (SOP) which had been risk assessed.

Majority of the motors are either fully guarded, or not accessible during normal operation due to their location of installation (submersible pumps, mixers etc.). A select number of motors/equipment did include access hatches which present a risk of entanglement to operations if accessed whilst the motor was in operation. An AS4024 risk assessment was undertaken for all equipment that presented a significant risk to operations/maintenance personnel and a Category 3 emergency stop system implemented.

9.11 Low Voltage System Modelling & Discrimination

A PowerCAD model has been developed for the site to finalise the cable sizing to ensure let-through energies, voltage drop, and earth fault loop impedance requirements are addressed.

Further to this a discrimination study was undertaken to ensure discrimination was maintained between all devices in accordance with the requirements of AS/NZS3000. The study considered the discrimination from the supply authority fuses, incoming breakers and then the next largest circuit breakers. It not considered necessary to examine lower level circuit breakers as they will automatically discriminate with upstream.

Generally, the lower level circuit breakers were Magnetic only trip (for motor starters with overload protection), and simple distribution curves (TM-D) for distribution circuit breakers. The only exception is the 100A power supply feeder to the Dewatering area, which needed an electronic circuit breaker to achieve discrimination, and ground fault protection was included due to distance.

The two main concerns for discrimination is the clearance between the incomer and the following feeders and largest drives:

- Tertiary treatment switchroom submain feeder
- Light & Power distribution board feeder
- Process distribution board feeder

- Bioreactor Blower Drive

These larger circuit breakers are modelled in the PowerCAD software to confirm discrimination. Settings and discrimination curves are detailed in the PowerCAD report.

9.12 PLC Systems

Wingecarribee Shire Council has standardised on the Omron PLC platform and use the Omron PLCs across multiple sites. The Bowral STP site currently uses the Omron CS1 PLC platform however this range has been in service for over 10yrs, lifespan for the system is now limited, and hardware costs are high in comparison to the newer NX/NJ PLC platform.

A comparison of the Omron PLC ranges was completed during design development for review by WSC, and the NJ/NX range has been selected for Bowral

There are two (2) PLC systems on site, one in the main switchroom and one in the tertiary treatment switchroom. Each of these PLC systems will include NJ/NX Ethernet connected PLC and remote I/O racks as per Table 3-1 below :

Table 9-1 PLC Panel Details and Locations

Panel	Location	Installation	Type	Connected Equipment
MAIN SWITCHROOM				
PNL-1001	Main switchroom	Standalone panel	Main panel – CPU rack	Instrument & control loops
RIO-1001	Main switchroom	Tier in MCC-1001	Remote I/O	Drive & MCC controls
RIO-1101	Bioreactor blower room	Standalone panel	Remote I/O	Instrument & control loops
TERTIARY TREATMENT SWITCHROOM				
PNL-2001	Tertiary treatment Switchroom	Standalone panel	Main panel – CPU rack	Instrument & control loops
RIO-2001	Tertiary treatment Switchroom	Tier in MCC-2001	Remote I/O	Drive & MCC controls
RIO-2101	Filters blower room	Standalone panel	Remote I/O	Instrument & control loops

A Redlion DSPLE gateway module is configured on the PLC network in each switchroom to provide protocol conversion between connected devices and the PLC where required.

All variable speed drives (VSDs) for the project are wall mounted and located in the switchrooms, and communication to the plant PLC will be via Cat 6 Ethernet cables connected to the Control network. VSDs are controlled over the Ethernet CONTROL network, sending basic status signals to the PLC as well as additional information and status via the Ethernet communications.

Connections to field equipment for VSDs are hardwired to VSD IO and will be monitored by the PLC via the Ethernet communications interface.

All connections to field equipment such as valves and instruments are via hardwired I/O to the PLC, using digital, or 4-20mA analogue signals as required. Instrument and sensor cabling is marshalled in field junction boxes and run via multicore cables to the PLC panels in switchrooms or the RIO panels.in the blower rooms.

9.13 Control Network and Communications

The Bowral STP control system architecture will use an Ethernet network topology. There are 2 plant PLCs as noted above. The plant PLCs will directly control all STP field and process equipment, and a ClearSCADA SCADA system communicating with the plant PLCs will provide the operator interface for the plant.

SCADA workstations are installed in the administration building control room, the main switchroom and the tertiary treatment switchroom buildings for operator access.

9.13.1 Fibre Optic Control Network and Communication Panels

A single mode fibre optic cable network will be established for the new plant. Fibres will be run between major plant areas to communications panels installed in each area, arranged in a ring to provide redundant network paths in the event of a communications failure.

The communications panels will house the fibre optic termination modules as well as any communications and network hardware required for that area. For the larger floor standing panels network switches and server hardware will 19" rack mounted units. For the smaller wall mounted and remote I/O panels network switches will be din rail mounted.

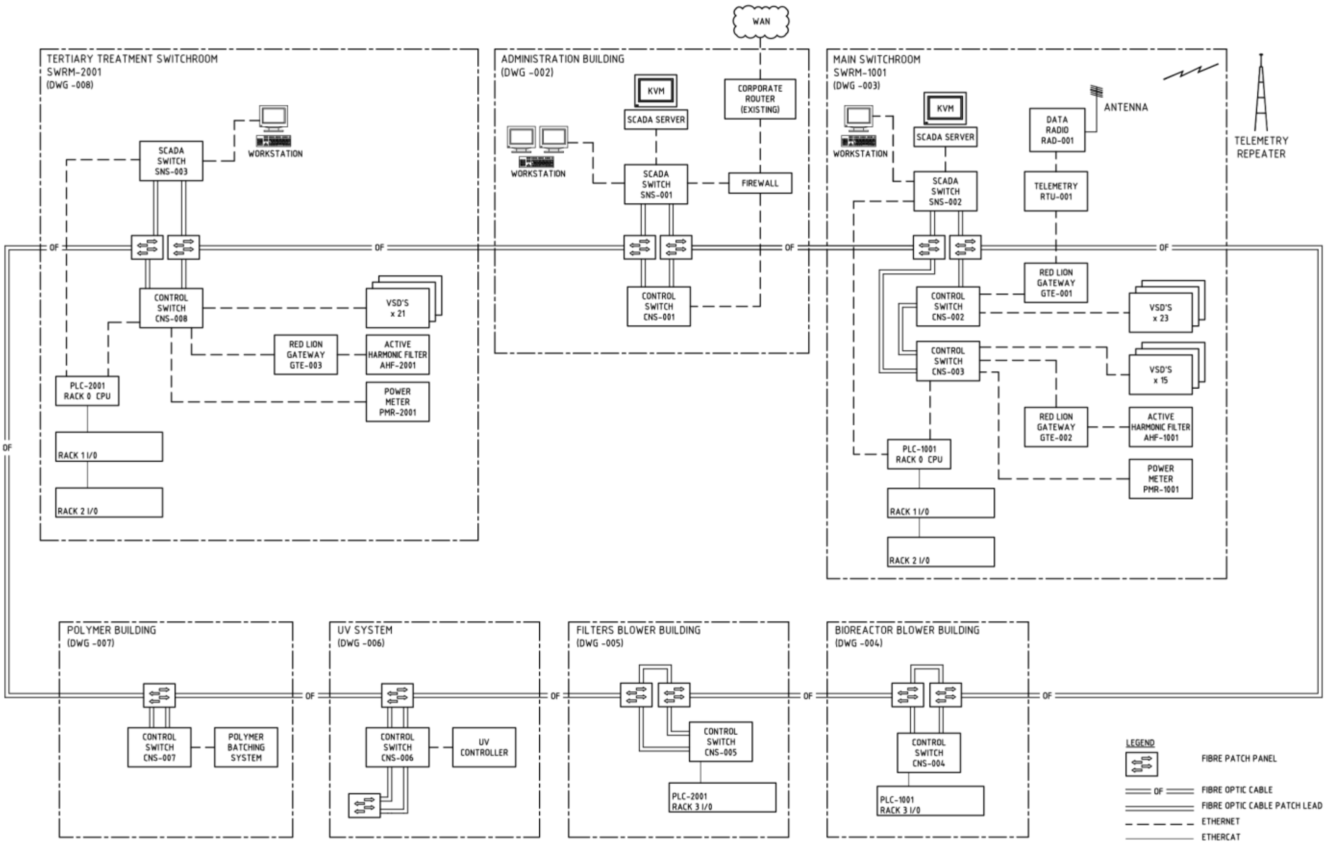


Figure 9-3 Fibre Optic Communications Network Overview

Communication between the control panels in each area will be via a single mode 24 core fibre optic cable, with FOBOTS installed in each panel. A minimum of 12 cores shall be terminated in each FOBOT to allow for future corporate and other network connections (e.g. fire, security, camera) where required.

9.13.2 Network Topology

The plant control system Ethernet network has been designed to provide PLC control and communication to all plant control equipment and instrumentation, and segregation (by physical separation) between the process & PLC control (CONTROL) networks and operations management level (SCADA) networks. A firewall and a corporate network switch (existing) have been included in the design to control communications and provide an interface between the corporate network and the local Control and SCADA networks.

The SCADA network will use a ring topology, utilising the single mode fibre optic network to connect and provide SCADA communications to all areas. The SCADA network will be used for communication between:

- SCADA servers to server
- SCADA server to workstation
- SCADA-PLC communications.

The CONTROL network will use a ring topology, utilising the fibre optic network to provide PLC communications to all areas. The CONTROL network will be used for:

- PLC to PLC Peer communications
- PLC to VSD Communications
- PLC to Remote I/O Ethernet communications
- PLC to local I/O rack connections within switchrooms will use direct EtherCAT communications
- PLC to RTU communications (for connection to the WSC Sewer Telemetry and SCADA System)

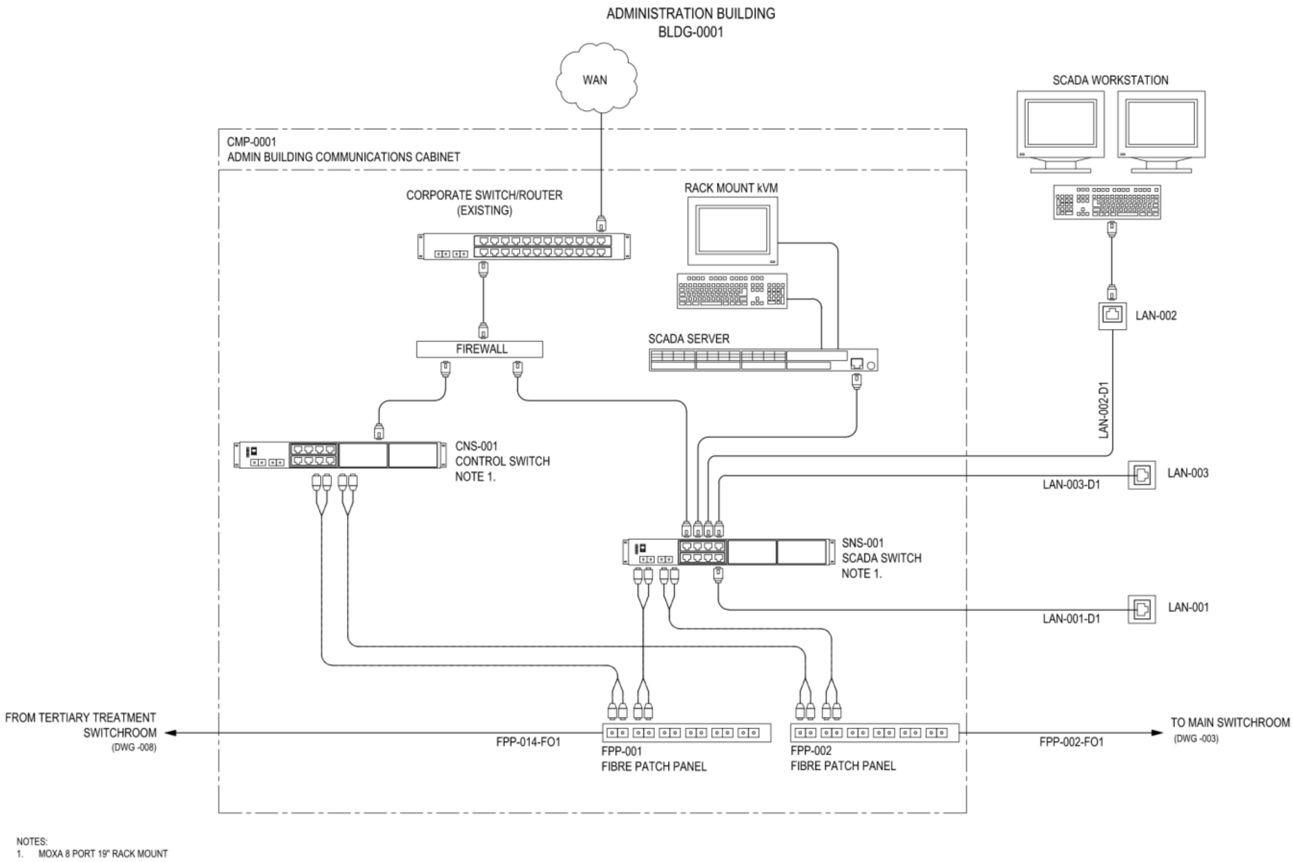


Figure 9-4 Admin Building Communications Network Connections

The diagram above is for the Administration Building and shows the SCADA, CONTROL and corporate network interfaces and connections

Layer 2 Moxa managed Ethernet switches that support the selected protocols and provide ring topologies for increased reliability have been specified for the project. Modular 24 port switches have been used, allowing expansion to the maximum ports required for the control network and connection of VSDS.

A firewall has also been included to control traffic between the corporate and control & SCADA system networks, and a corporate router has been included for remote WSC access to the site for SCADA and Engineering requirements. Our design assumes that the corporate router would be specofoed, supplied and configured by the WSC IT department to communicate with the new system

Five (5) communications cabinets and two (2) remote I/O cabinets will be installed to house network communications, SCADA and PLC equipment.

Each switchroom communications panel contains a dedicated local UPS which is supplied from the Process Distribution Board, as these are critical communications equipment.

Table 9-2 Communications Panel and Fibre Optic Cable Details

Location	Panel No.	Type	Network Components	FOBOTs	Fibre Optic Cable
Administration Building	CMP-0001	42RU Floor	1 x corporate Switch 2 x 24pt rack mount switches 1 x firewall 1 x SCADA Server & KVM	FPP-001 FPP-002	FPP-002-FO1
Main Switchroom	CMP-1001	42RU Floor	3 x 24pt rack mount switches 1 x firewall 1 x SCADA Server & KVM 1 x Rack mount 230V UPS	FPP-003 FPP-004	FPP-004-FO1
Bioreactor Blower Building	RIO-1102	Within RIIO Panel	1 x 8 port din rail mount switch	FPP-005 FPP-006	FPP-006-FO1
Fliters Blower Building	RIO-2102	Within RIIO Panel	1 x 8 port din rail mount switch	FPP-007 FPP-008	FPP-008-FO1
UV System	CMP-2002	18RU Wall mount IP56	1 x 8 port din rail mount switch	FPP-009 FPP-010	FPP-010-FO1
Dewatering Building	CMP-2003	18RU Wall mount IP56	1 x 8 port din rail mount switch	FPP-011 FPP-012	FPP-012-FO1
Tertiary Treatment Switchroom	CMP-2001	42RU Floor	3 x 24pt rack mount switches 1 x Rack mount 230V UPS	FPP-013 FPP-014	FPP-014-FO1

9.13.3 SCADA System

Two (2) ClearSCADA servers will be used for the site. ClearSCADA rack mounted servers will be installed in the main switchroom and administration building communication panels and will communicate with the plant PLCs via the SCADA Ethernet network.

Three (3) ClearSCADA Client desktop workstations will be provided and installed in the administration building and switchrooms to provide the operator interface to the plant control system.

10 Safety in Design

The purpose of the Safety in Design Report (refer to Appendix J) is to describe any project-specific safety issues that have been identified during the design.

This report is prepared specifically to discharge duties of the designer to provide a safety report under the following legislation:

- the Work Health and Safety Act 2011 – section 22 and/or;
- Work Health and Safety Regulation 2011 – regulation 295.

This report only describes project-specific safety hazards. This report does not comprehensively address all safety hazards associated with the construction and operation of this project. Contractors are responsible for carrying out their own risk assessments for all construction activities.

The safety in design report identifies project-specific risks which HH2O is reasonably aware of that may be encountered during the works.

The Safety in Design process involved the following workshops:

- CHAIR-1 to address construction, operation and maintenance safety risks (Safety in Design) at the concept design stage;
- HAZOP to address process risks;
- CHAIR 2/3 to address construction, operation and maintenance safety risks (Safety in Design) during the detail design stage.

The Safety in Design Report covers the HAZOP, CHAIR 1 and CHAIR 2/3 components of the risk management approach. The CHAIR-1 workshop was conducted as part of the concept design, whilst the HAZOP and CHAIR 2/3 workshops were conducted as part of the detail design. The studies were conducted on the design drawings available at the time of the workshops and is limited to the risks identified during the workshop using the drawings provided.

Appendix A: Detailed Sewage Characteristics

H2Options Version: 6/08/2021

Bowral STP - Sewage Characterisation

 V6.20

Wastewater Treatment Process Design and Operations Modelling

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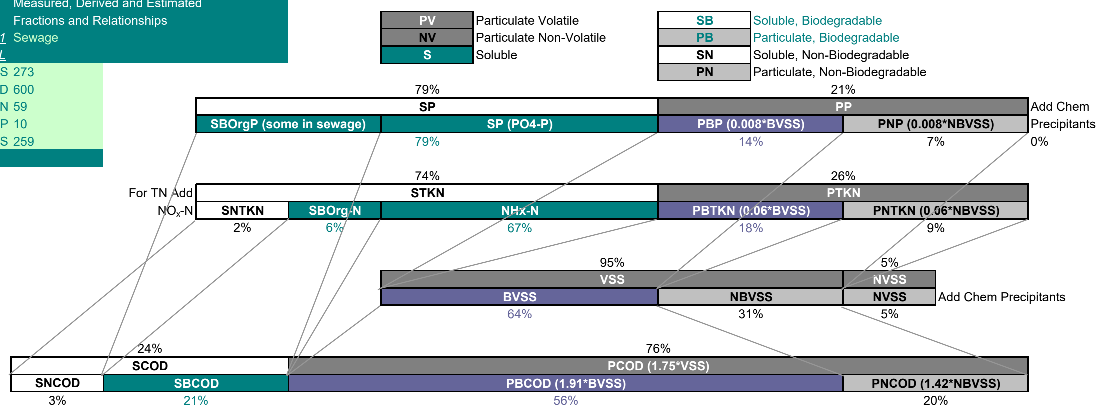
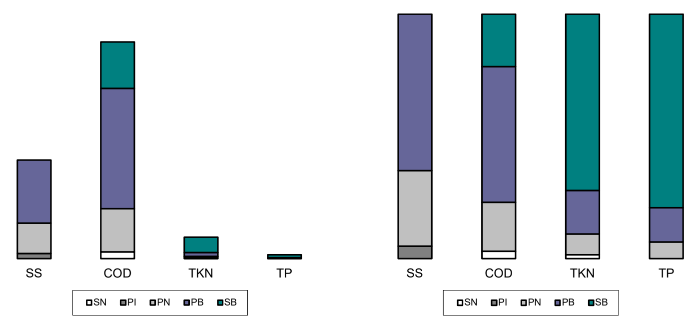
Sewage Characterisation			01
In	Measures	Out	Sewage
Avg ML/d	4.620		
Peak ML/d	46.200		
Peak to Avg	10.00		3.00
EP Loadings	Actual	Estimate	Default
Flow L/EP/d	220	220	250
SS g/EP/d	60.0	60.0	65.0
COD g/EP/d	132.0	132.0	140.0
TKN g/EP/d	13.0	13.0	14.0
TP g/EP/d	2.2	2.2	2.5
Loading		0	
EP	21000	21000.0	40000
Avg ML/d	4.620	4.620	
Priority 1 mg/L			
SS	272.7	272.7	
COD	600.0	600.0	
TKN	59.1	59.1	
TP	10.0	10.0	
Priority 2 mg/L			
VSS	259.1	259.1	
SCOD	146.6	146.6	
STKN	43.5	43.5	
SP	7.9	7.9	
Alk	250.0		220
Priority 3 mg/L			
SNCOD	18.0	18.0	
SNTKN	0.9	0.9	
NHx-N	39.4	39.4	
NOx-N	0.0		0.0
DO	0.0		0.0
Solids Ratios			
PNCOD:VSS	1.420		1.420
PNCOD:COD	0.200	0.200	
PIP:NVSS	0.000		0.000
Solids Ratios			
VSS:SS	0.950	0.950	0.850
NBVSS:VSS	0.326	0.326	0.360
PCOD:VSS	1.750	1.750	1.750
PBCOD:BVSS	1.910		1.885
PTKN:VSS	0.060	0.060	0.060
PP:VSS	0.008	0.008	0.008
Soluble Ratios			
SNCOD:COD	0.030	0.030	0.050
SBCOD:BCOD	0.278		0.343
PNCOD:COD	0.200		0.195
SNTKN:TKN	0.015	0.015	0.020
NHx-N:TKN	0.667	0.667	0.667
SBOrg-N:TKN	0.055		0.077

Fractionation

Measured, Derived and Estimated
Fractions and Relationships
01 Sewage
mg/L

SS 273
COD 600
TKN 59
TP 10
VSS 259





01 mg/L	Sewage Total	Soluble Non Bio (SN)	Particulate Inorganic (PI)	Particulate Non Bio (PN)	Particulate Bio (PB)	Soluble Bio (SB)
SS	273		14	85	175	
COD	600	18		120	333	129
TKN	59	1		5	10	43
TP	10		0	1	1	8

mg/L	01 Sewage	Fractions mg/L Soluble Non Biodegradable	Particulate Non Biodegradable	Particulate Biodegradable	Soluble Biodegradable	Biodegradable
ML/d	4.620					
SS	273		36%	64%		64%
COD	600	3%	20%	56%	21%	77%
TKN	59	2%	9%	18%	72%	90%
TP	10		7%	14%	79%	93%
VSS	259		33%	67%		67%
NHx-N	39				100%	100%
NOx-N	0				0%	0%
DO-N	0				0%	0%
Alk	250				100%	100%

Appendix B: Dewatering Technology Assessment

To:	Richard Batty Senior Project Manager Wingecarribee Shire Council Victoria Longley Manager Sewer Services Wingecarribee Shire Council	From:	Michael Collins Hunter H2O (HH2O) Principal Process Engineer Emily Hyde Hunter H2O (HH2O) Process Engineer
CC:		Date:	12/05/2020

Subject: Dewatering Options - Technical Memo

1 Introduction

Bowral Sewage Treatment Plant (STP) is owned and operated by Wingecarribee Shire Council (WSC). WSC have engaged Hunter H2O to undertake the detailed design of the Bowral STP upgrade. The aim of the upgrade is to address both capacity and performance based risks into the future.

As part of the upgrade, WSC require a new sludge dewatering facility to be constructed at Bowral STP to cater for current and future loads.

The current plant uses sludge drying beds and Geobags for biosolids dewatering. It was noted in the Concept Design Report (CDR) that operators find this system difficult to maintain the required dewatering schedule, especially in winter due to the cold and wet climate.

The first stage of the detailed design project involves the review and finalisation of the concept design for the upgrade. The scope of works proposed in 2019 Concept Design Report (CDR) prepared by Public Works Advisory (PWA) recommended a volute dehydrator or screw press for dewatering.

This memorandum explores the technology options available for the dewatering facility in order for Council to make an informed selection of the preferred equipment to be taken forward in the design. The dewatering equipment has implications to the sizing of process units upstream due to return streams, therefore it is important this equipment is selected early to allow progression of the design.

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2 Design Basis for Costing Assumptions

This section outlines the design basis used for the sizing of the dewatering technologies for cost comparison of options.

Parameter	Value	Units	Comments
Sludge Type	Aerobically digested sludge		
Unit Redundancy	Duty Only		Existing sludge lagoons will provide emergency storage.
Amount of Sludge Generated	1,000	kg/d	
Concentration of Solids in Sludge	1 %	(w/v) solids	Based on an estimated dry solids concentration of 1-1.5% leaving the aerobic digester as per the CDR.
Assumed Operating Hours	48	hr/wk	Operating 12 hours per day, 4 days per week
Solids Loading	150	kg/hr	Calculated from 7000 kg/wk assuming an operating time of 48 hours per week.
Design Hydraulic Loading	5	L/s	Calculated as 15 kL/hr based on the solids loading (150 kg/hr), solids concentration (1%) and assumed sludge density of 1000 kg/m^3. 15 kL/hr = 4.2 L/s which was rounded up for conservatism to 5 L/s.

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3 Dewatering Technologies

A range of technology options are explored in the memo, including;

- Belt filter press (BFP)
- Centrifuge
- Rotary screw press (RSP)
- Volute dehydrator.

3.1 Belt filter press

3.1.1 Components

A belt filter press (BFP) is comprised of two porous conveyor belts that travel around a series of rollers that exert pressure and shear sludge between the belts. The typical BFP configuration consists of three zones that include a gravity feed zone, a wedge zone and a shear/pressure zone.

3.1.2 Configurations

There are numerous configurations available for the gravity feed zone. The following examples are illustrated below, however many other configurations are available:

- Feed zone at the bottom of the filter (Figure 3-1)
- Feed zone at the top of the filter (Figure 3-2)
- Provision of gravity drainage deck prior to feed gravity zone of BFP (Figure 3-3).

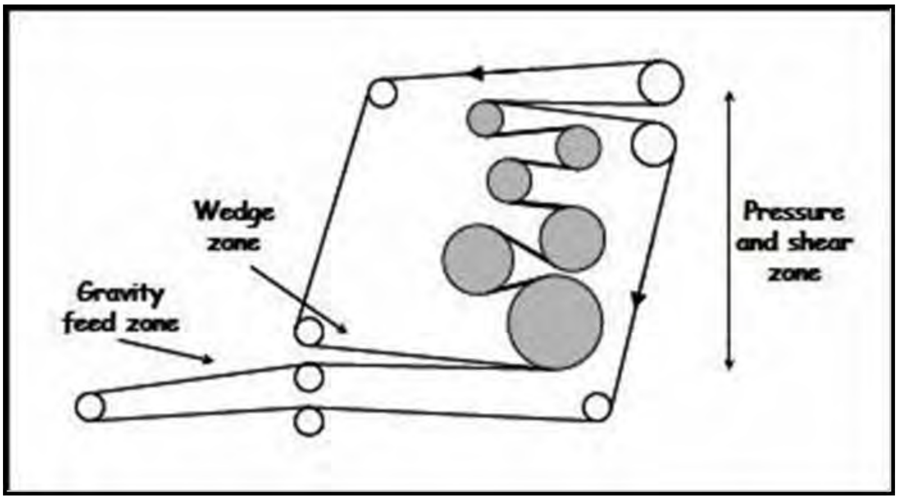

Figure 3-1 BFP with gravity feed zone at bottom

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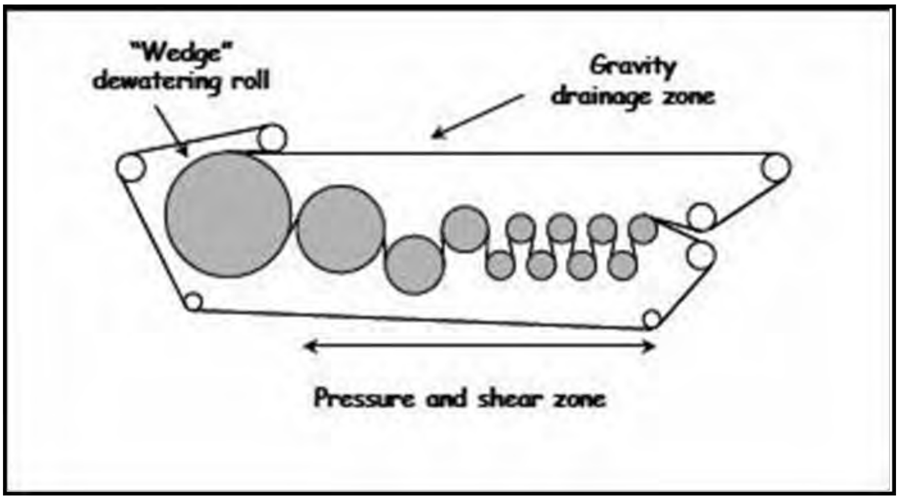

Figure 3-2 BFP with gravity feed zone at top

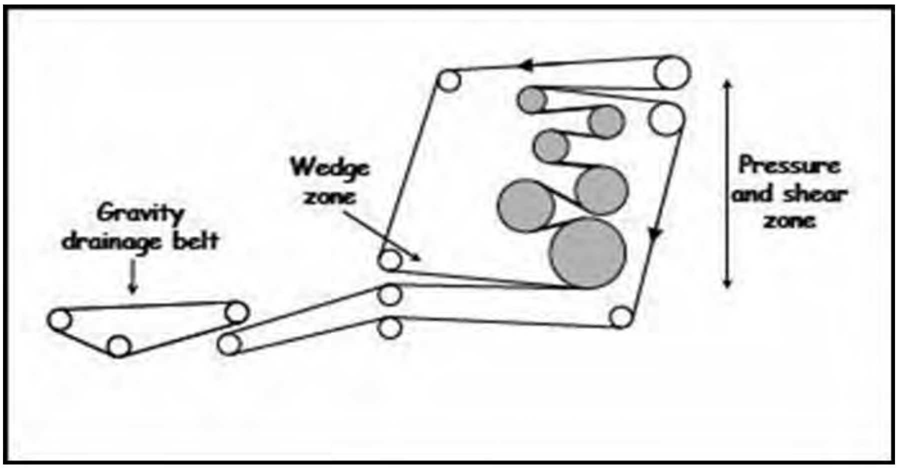

Figure 3-3 BFP with gravity drainage deck feeding the gravity zone of the BFP

3.1.3 Operation

Thickened sludge is flocculated via the addition of polymer and fed onto the bottom belt. The free water drains away under gravity and this region is known as the gravity drainage zone. It is common for "ploughs" to be used in the gravity drainage zone to break up the continuous gel formed by the flocculated solids and provide a pathway for free water to drain away

From the gravity drainage zone, the sludge enters a wedge zone formed by the two belts coming together. Slight pressure is applied on the sludge encouraging more water to drain. The sludge is then held between the two belts as it travels around a series of rollers with decreasing diameters. This increases the pressure on the sludge and is called the pressure zone. Shearing occurs as the belts travel at the same speed over slightly different path lengths. At the end of this pressure zone, the belts come apart leaving a cake on the lower belt that is discharged from the filter onto a conveyor system with the use of fixed scrapers.

3.2 Centrifuges

3.2.1 Components

As shown in Figure 3-4, the components of a decanter centrifuge include:

- A hollow cylinder forming a solid-bowl where sedimentation and clarification takes place

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- A conical beach where expression and compression take place
- Screw-conveyor that fits the profile of the solid-bowl.

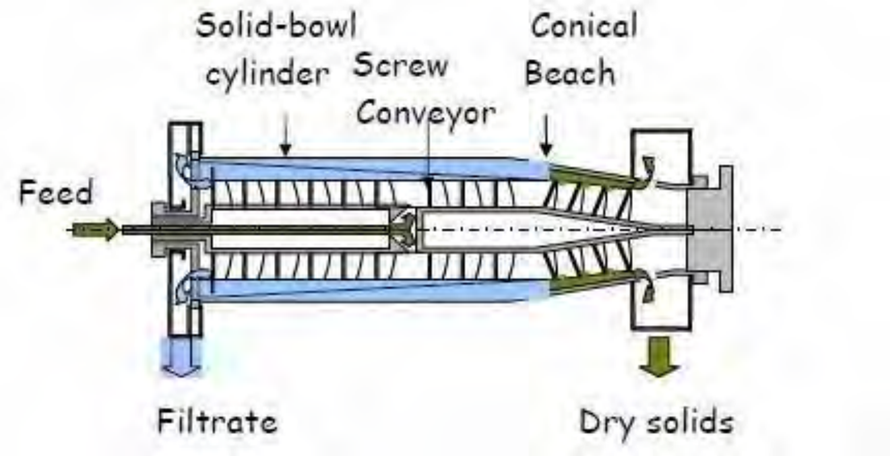

Figure 3-4 Typical solid bowl or decanting centrifuge

3.2.2 Operation

3.2.2.1 Solid bowl centrifuge

In a decanter centrifuge, sludge and flocculant are mixed in the rotating feed chamber running parallel to the bowl and conveyor. Feed enters the bowl often mid-way along the cylinder or near the intersection of the cylinder and conical beach. The centrifugal force pushes the feed into a pool of wet cake that undergoes sedimentation on the bowl wall. The liquid forms a supernatant layer on top of the solids.

At steady state, the liquid level is constant and supernatant overflows a weir at the opposite end of the cylinder which is discharged as centrate. The differential speed of the conveyor with respect to the bowl (indicatively < 6 rpm) pushes the cake into the conical beach zone. For a solid bowl centrifuge, the throughput is limited by the rate of sedimentation in the pool of liquor in the cylinder.

3.2.2.2 High solids centrifuge

The high solids decanter centrifuge, illustrated in Figure 3-5 , has an increased angle and residence time in the conical beach section thereby increasing the extent of expression of the sludge. Higher feed solids contents and better flocculation produce faster settling sludge with a lower liquid to solids ratio. This means that for a given feed rate, the hydraulic load is lower, the solids capture is higher and the number of solids entering the conical beach zone is higher.

In the high solids decanter centrifuge, the sludge in the conical beach zone almost completely fills the annular space between the conveyor shaft and bowl, which results in the throughput being dependent on the rate of water release from the compacting cake in the bowl.

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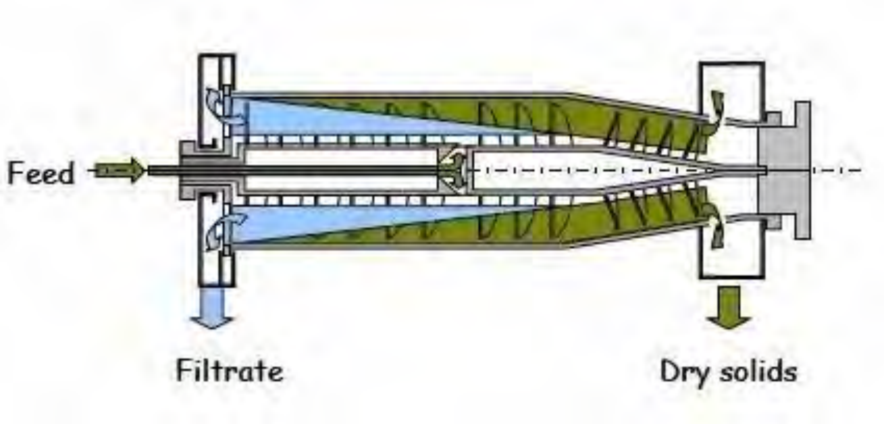

Figure 3-5 Typical high solids decanter centrifuge

3.3 Rotary screw press

3.3.1 Components

The rotary screw press is comprised of a rotating helical screw inside a cylinder formed from a perforated sheet or longitudinal bars. To increase pressure as sludge passes through the press, the distance between the cylinder and screw decreases. The solids are discharged through a throttle that can exert high pressure on the solids exiting the press.

3.3.2 Configurations

The distance between the cylinder and screw can be reduced by:

- a cone-shaped cylinder (Figure 3-6)
- increasing the diameter of the screw (Figure 3-7)
- reducing the spacing or pitch of the screw flight or windings.

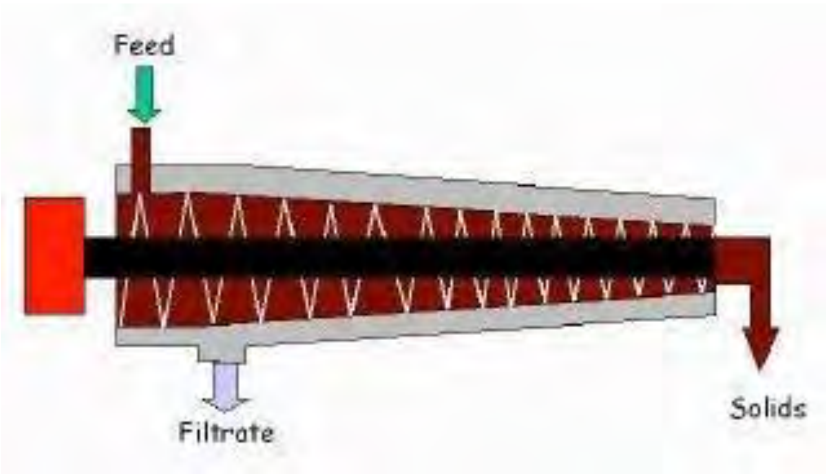

Figure 3-6 Rotary screw press showing cone-shaped cylinder

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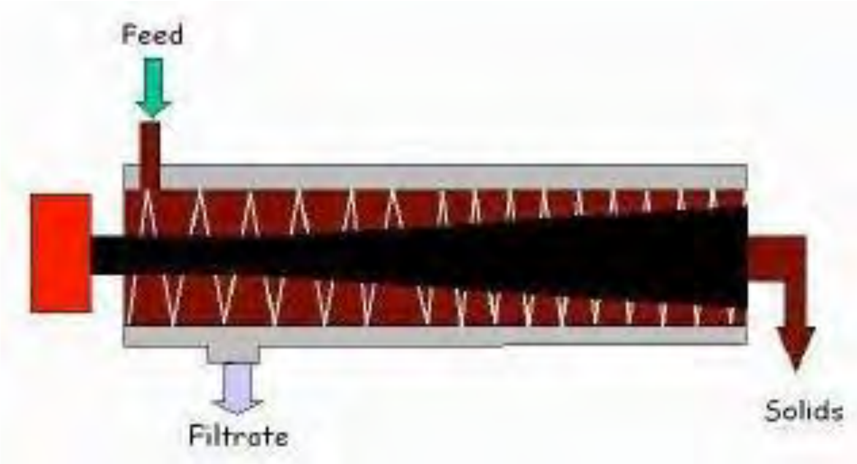

Figure 3-7 Rotary screw press showing tapered shaft

3.3.3 Operation

The operating mechanism of a screw press involves high pressure and shearing. If the press is fed with dilute materials, the solids throughput needs to be low to produce high solids contents.

As with the BFP and centrifuges, sludge is conditioned with polymer before being pumped into the rotary screw press. Inside the screw press, the sludge sits inside a cylindrical screen that acts as a filter allowing water from the sludge to drain through to the outlet. A screw within the cylinder operates in the order of 0.5-2 rpm, slowly moving the sludge up and on an incline to the outlet. A compression head at the end of the screw pushes 'down' along the line of the screw, thus increasing the cake solids content by adding additional pressure before being discharged from the outlet as shown in

Figure 3-8.

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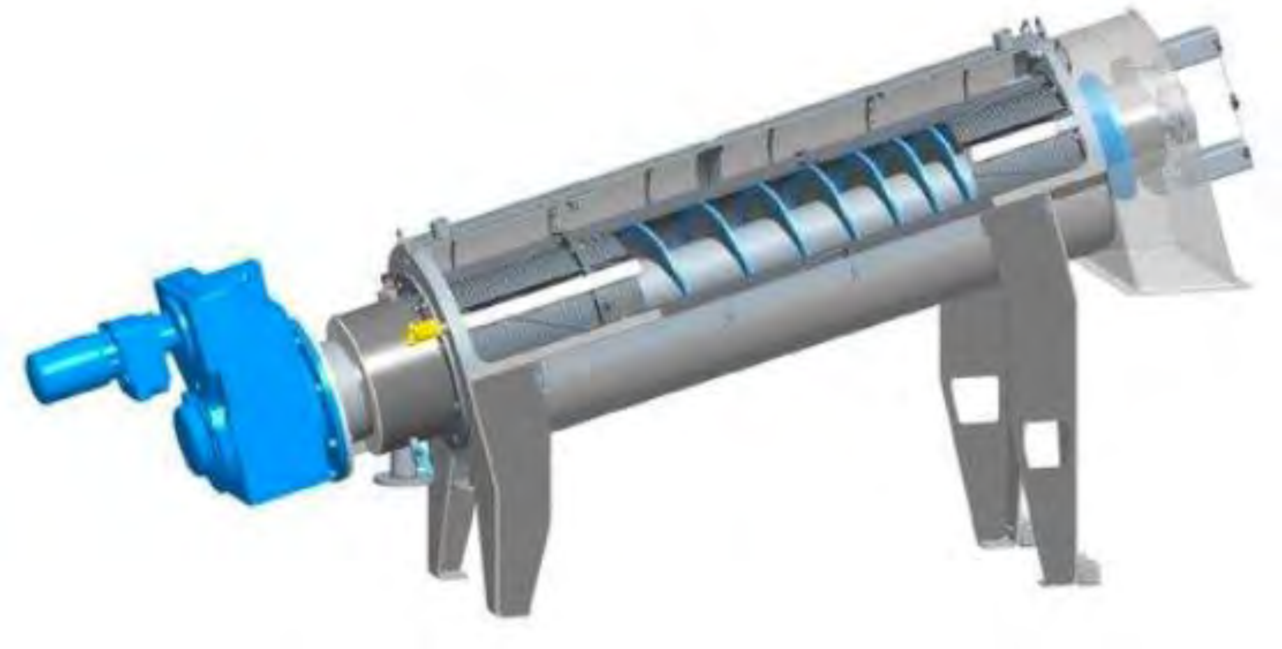

Figure 3-8 Rotary screw press

3.4 Volute Dehydrator

3.4.1 Components

The volute dehydrator consists of a flocculation tank, a thickening zone along the volute and a dewatering zone. In the dewatering zone, a variable pitch auger rotating at a constant speed under a layer of fixed and movable rings is separated by spacers. The fixed rings have an internal diameter larger than the diameter of the auger. The movable rings have an internal diameter slightly less than the auger and move in an orbital motion as the auger turns. The screw pitch also narrows causing increasing pressure as the volume increases.

3.4.2 Operation

Dilute sludge and polymer solution are mixed in a flocculation tank at the rear of the unit to produce flocs. The flocs overflow the tank into a thickening barrel where free water is initially drained. As the volute rotates it pushes the edges of the movable rings that continuously move in the gaps between the fixed rings. This causes the sludge water to drain while the solids are collected along the volute. As the screw pitch narrows the pressure increases to encourage final dewatering before discharge of the cake.

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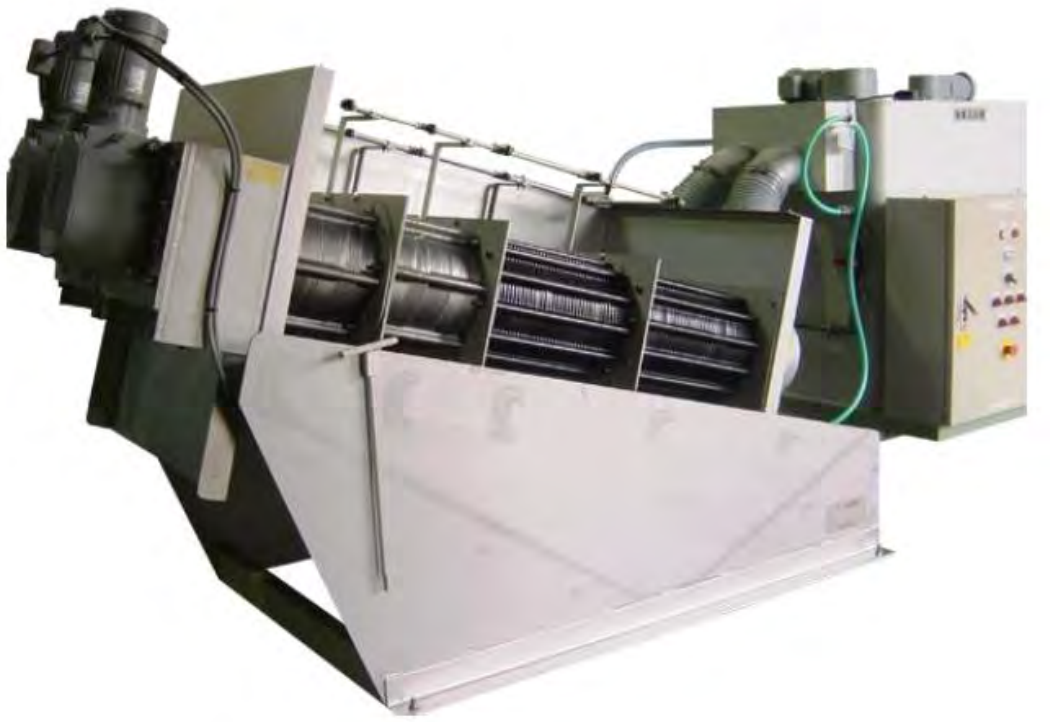

Figure 3-9 Volute Dehydrator

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4 Dewatering Technology Comparison Summary

Indicative costs and sizing based on unit capacity of 1000 kg/d at 1% solids (for 4 days per week / 12 hours per day operation).

Table 4-1 Dewatering technology comparison summary table

Parameter	Belt Filter Press	Centrifuge	Rotary Screw Press	Volute Dehydrator
Dewatering Mechanism	Pressure and shear	High G force and shear	Pressure and shear	Pressure and shear
Indicative Cake Solids	13-15%	17-24%	17-20%	14-18%
Capital cost / unit (Excl. GST)	$170,000	$170,000*	$195,000	$133,000
Continuous operation	Yes	Yes	Yes	Yes
Performance sensitivity	Sensitive to variations in feed composition	Adaptive control to system torque adjusts for feed variations	Adaptive back pressure control accommodates varying loads	Uncertain
Labour	High	Low	Low	Low
Totally enclosed	No	Yes	Yes	Yes
Polymer Usage	5-8 kg/t DS (power) 10-15 L/t DS (liquid)	5-12 kg/t DS (powder)	9-12 kg/t DS (liquid required)	6-10 kg/t DS
Power Consumption	~3.8 kW	~21 kW	~2.3 kW	~3.3 kW
Noise level	Medium	High	Low	Low
Temperature and Vibration	N/A	Critical	N/A	N/A
Startup/shutdown procedure	Complex – Number of steps required	Less steps than BFP, however can take some time to reach production and produces thin sludges initially	Simple – limited steps	Simple - limited steps
Footprint (W/L/H) (m) /unit	Larger 2.4 x 6.2 x 2.5	Smaller 0.6 x 2.7 x 1.4	Moderate 1.2 x 5.1 x 2.5	Moderate 1.7 x 4.4 x 2.1
Washwater Consumption	11,000 L/h	5,000-10,000 L/h	300 L/h	180 L/h

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		(for 10 mins only during start-up/shutdown)		
Maintenance	Low	High cost – wear components and high speed drives requiring specialist service capability	Low	Low
Operation Intensity (over system lifetime)	Higher	Moderate	Lower	Unknown
Operator Familiarity	Common in Australia	Common in Australia	Limited WW installations in Australia but numerous worldwide	Limited WW installations in Australia
Expansion	No requires installation of additional machine	No requires installation of additional machine	No requires installation of additional machines	Volute can be expanded with its Cylinder Unit
Examples in NSW	Shortland WWTW, Boulder Bay WWTW, Morpeth WWTW	Cessnock WWTW, Kurri Kurri WWTW	Muswellbrook STP, Gunnedah, Farley WWTW, (under construction)	Mudgee STP, Nambucca Heads STP

*The supplier indicated in practice a smaller machine (handling flows up to 12 kL/h) would likely be selected in design for a budgetary price of ~$160 K, the current selection has been made largely for comparison purposes however would likely be oversized in practice.

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5 Summary

Aligning with the findings of the CDR, the volute dehydrator technology represents the least capital cost option. The volute dehydrator option is also advantageous in its low washwater usage, relatively low operational maintenance requirements and the relative simplicity of its start up/shut down procedure.

A major disadvantage of the volute dehydrator is performance (i.e. how wet the produced biosolids is). When considering the volume of sludge produced from the plant, even a 1 -2% difference in performance translates to considerable increases in annual operational costs. Figure 5-1 presents the biosolids disposal costs for varying dewatering system performance across a wide range of disposal costs ($50 - 150 / wet tonne)

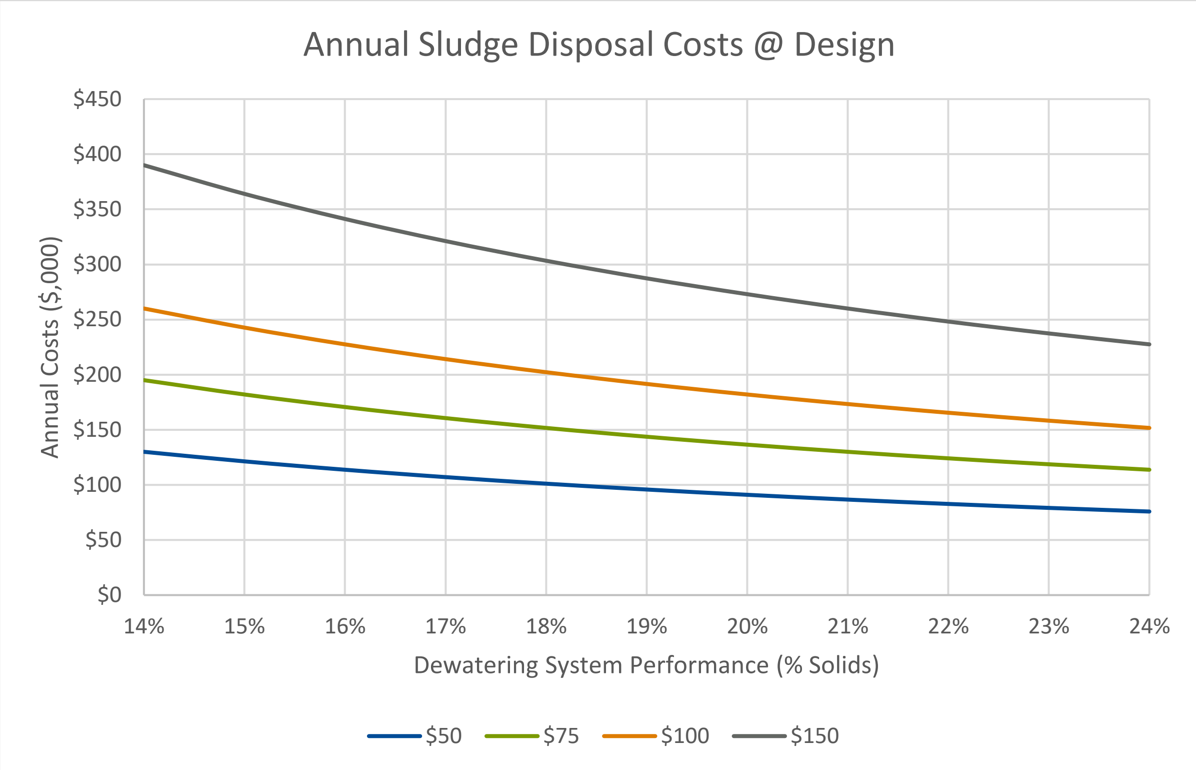

Figure 5-1 Biosolids Disposal Costs vs Dewatering System Performance

Moving from 15% solids to 18% solids at $50/wet tonne disposal cost equates to an annual difference in operating cost in the order of $20,000 per annum. At $75 / wet tonne this increase to $30,000 per annum. This results in a likely payback period of less than three years between a volute dehydrator and both centrifuge and RSP technology. It should be noted that other capital cost items associated with the dewatering system (building, polymer system, out loading conveyors, hardstand) are all relatively independent of the technology adopted.

Another key operational cost consideration is power. The estimated power costs for each machine at design loads is presented in Figure 5-2. There is little difference between the BFP, RSP and the volute dehydrator (although the RSP consumes the least amount of power), however the centrifuge options consumes considerably more power. Although the centrifuge likely out performs all technology, it is likely that the significant increase in power demand offset these operational costs savings, especially when compared to an RSP that is expected to perform only marginally below a centrifuge option.

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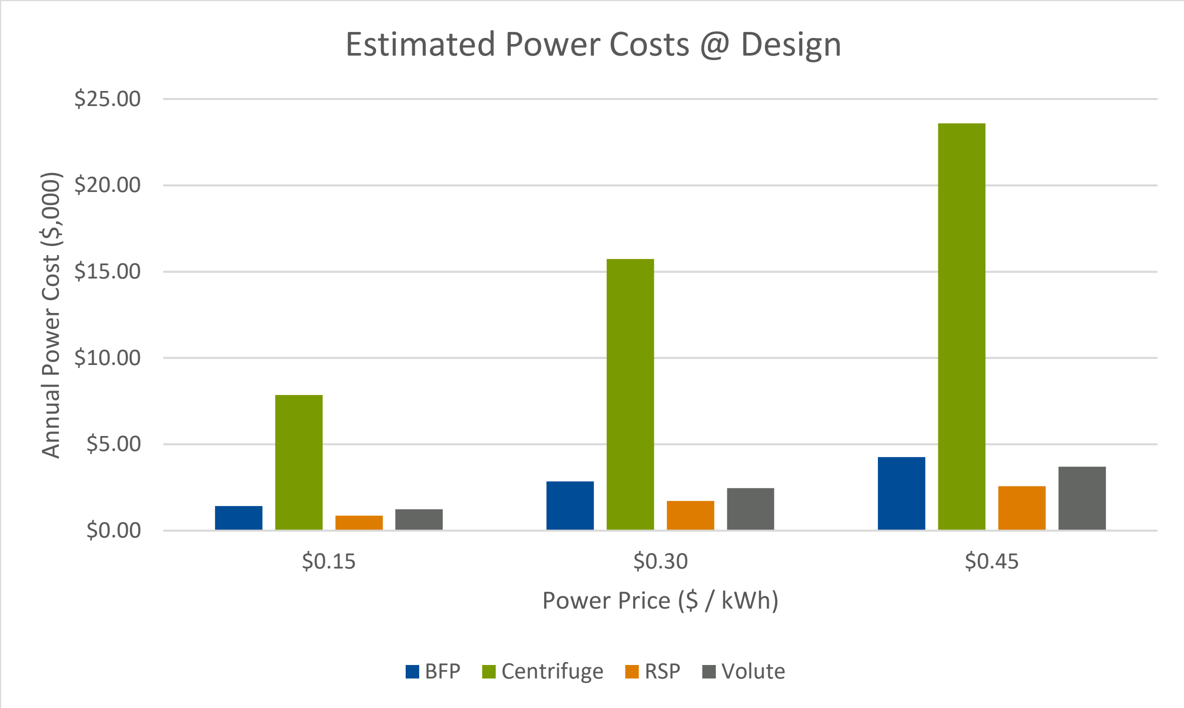

Figure 5-2 Estimated Power Costs for Dewatering Technologies

The belt filter press is not recommended for further consideration, due to poorer performance, high recycled water demand and greater operational requirements.

Although the volute dehydrator represents the cheapest capital cost, it is likely that these capital savings are quickly offset by the reduced biosolids disposal costs with other options. This technology is also relatively unproven in Australia and is not recommended for further consideration.

The centrifuge option will most likely produce the driest cake, has the smallest footprint and is well proven in the Australian water industry. That said, this approach consumes the most electricity by far, produces considerable noise and requires specialist servicing for the high speed components.

The RSP will likely perform slightly below the centrifuge, however without the high electricity and noise concerns. This is an emerging technology, however there are a number of successful installations throughout NSW that can act as reference sites.

In our opinion, the RSP likely represents the lowest lifecycle cost for the project and is well suited for this size and type of plant. That said, centrifuge technology will also perform well provided the risks are appropriately managed.

We are able to assist in organising a site visit / discussion with reference site if of benefit.

We await confirmation of the preferred technology so that we can integrate these components into our design and are willing to hold a separate workshop to discuss if required.

Regards,

Michael Collins

Principal Process Engineer

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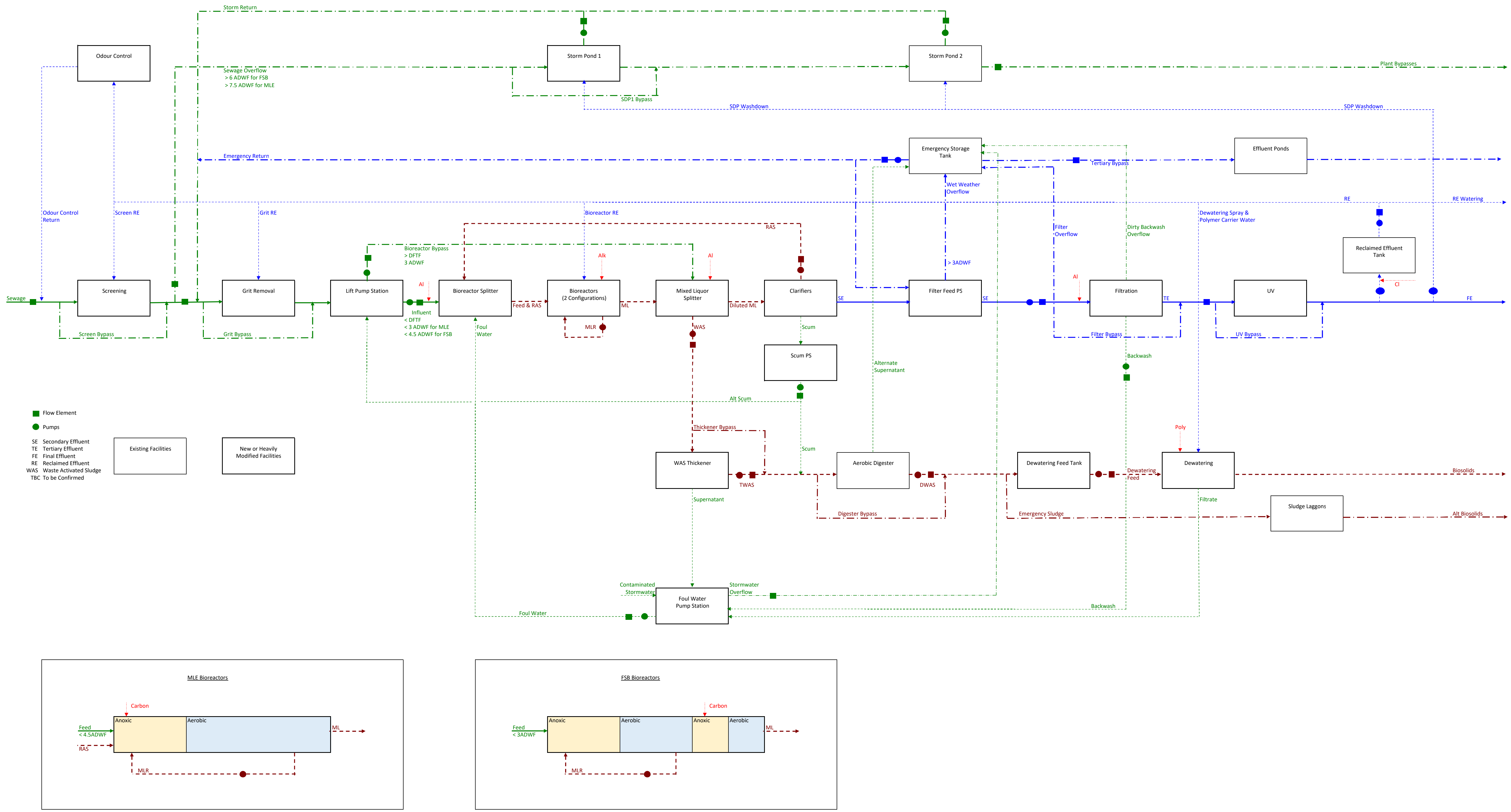
Appendix C: Process Flow Diagram

Process Flow Diagram

Version: 210223

Bowral STP



Appendix D: Mass & Flow Balance

Process Flow and Mass Balance Diagram Bowral STP Future MLE Winter

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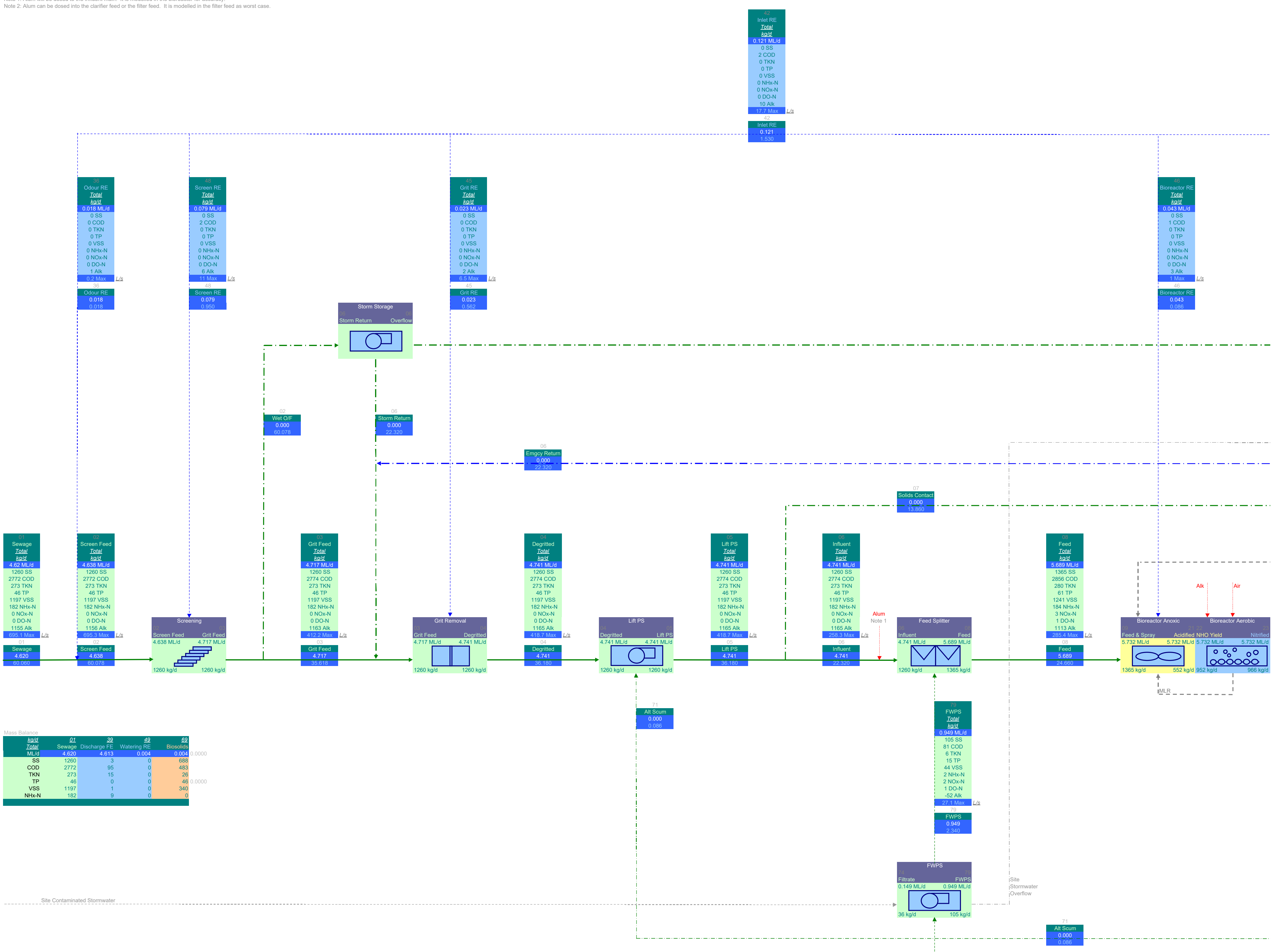
Process Flow and Mass Balance Diagram

All flows ML/d unless otherwise indicated
All mass kg/d
All concentrations mg/L
Grey lines are not included in the process model

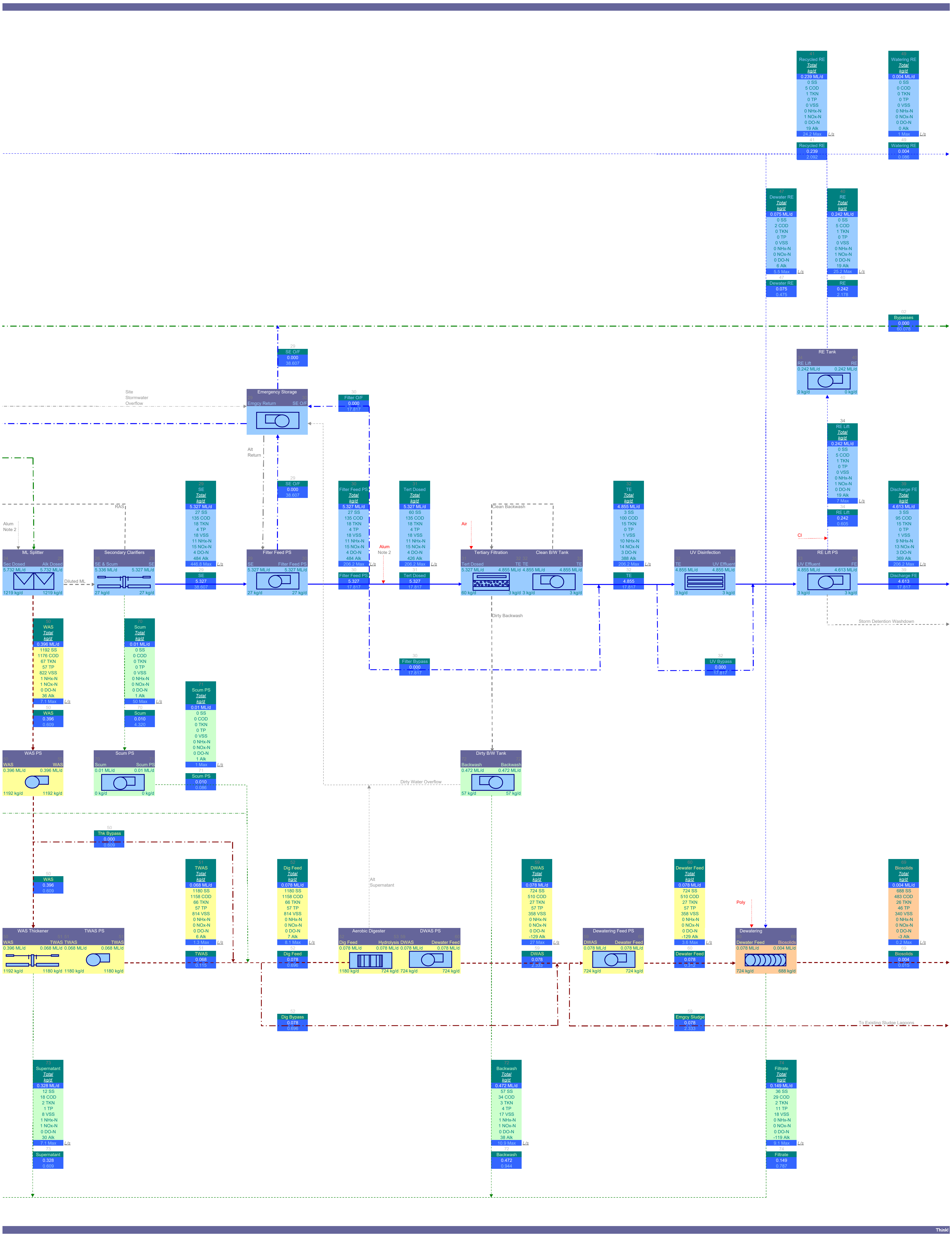
Note 1: Alum will be dosed to the influent main. It is modelled in the bioreactor for accuracy.
Note 2: Alum can be dosed into the clarifier feed or the filter feed. It is modelled in the filter feed as worst case.



Mass Balance

kg/d Total	01 Sewage	39 Discharge FE	49 Watering RE	69 Biosolids	
ML/d	4.620	4.613	0.004	0.004	0.0000
SS	1260	3	0	688	
COD	2772	95	0	483	
TKN	273	15	0	26	
TP	46	0	0	46	0.0000
VSS	1197	1	0	340	
NHx-N	182	9	0	0	

Measurements	01 Sewage mg/L	08 Feed mg/L	29 SE mg/L	32 TE mg/L	50 WAS mg/L	59 DWAS mg/L
ML/d	4.620	5.689	5.327	4.855	0.396	0.078
Max ML/d	60.060	24.660	38.607	17.817	0.609	2.333
SS	272.7	240.0	5.0	0.6	3011.1	9325.1
COD	600.0	502.0	25.3	20.7	2970.1	6571.0
TKN	59.1	49.2	3.4	3.2	170.0	353.3
TP	10.0	10.8	0.7	0.1	144.9	729.0
VSS	259.1	218.1	3.4	0.2	2077.2	4612.5
SCOD	146.6	122.9	20.4	20.4	20.4	21.3
STKN	43.5	35.9	3.2	3.2	3.2	2.1
SP	7.9	8.0	0.5	0.0	0.5	111.3
Alk	250.0	195.6	90.9	80.0	90.9	-1654.6
SNCOD	18.0	18.0	18.0	18.0	18.0	18.0
SNTKN	0.9	0.9	0.9	0.9	0.9	0.9
NHx-N	39.4	32.4	2.0	2.0	2.0	1.2
NOx-N	0.0	0.5	2.9	2.9	2.9	0.0
DO-N	0.0	0.1	0.7	0.7	0.7	0.3



Recycled RE
Watering RE
Dewater RE
RE
Bypasses
RE Tank
Emergency Storage
Site Stormwater Overflow
SE O/F
Filter O/F
Alt Return
ML Splitter
Secondary Clarifiers
Filter Feed PS
Tertiary Filtration
Clean B/W Tank
UV Disinfection
RE Lift PS
SE
Filter Feed PS
Tert Dosed
TE
RE Lift
Discharge FE
Alum Note 2
Air
Cl
Clean Backwash
Dirty Backwash
Diluted ML
RAS
Filter Bypass
UV Bypass
Storm Detention Washdown
WAS
Scum
Scum PS
WAS PS
Dirty B/W Tank
Dirty Water Overflow
Thk Bypass
WAS Thickener
TWAS PS
TWAS
Dig Feed
Aerobic Digester
DWAS PS
DWAS
Dewatering Feed PS
Dewater Feed
Dewatering
Biosolids
Poly
Alt Supernatant
Dig Bypass
Emgcy Sludge
To Existing Sludge Lagoons
Supernatant
Backwash
Filtrate

H2Options — Process Flow and Mass Balance Diagram — Bowral STP — Future FSB — Winter

Version: 210223

Wastewater Treatment Process Design and Operations Modelling

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Process Flow and Mass Balance Diagram

All flows ML/d unless otherwise indicated
All mass kg/d
All concentrations mg/L
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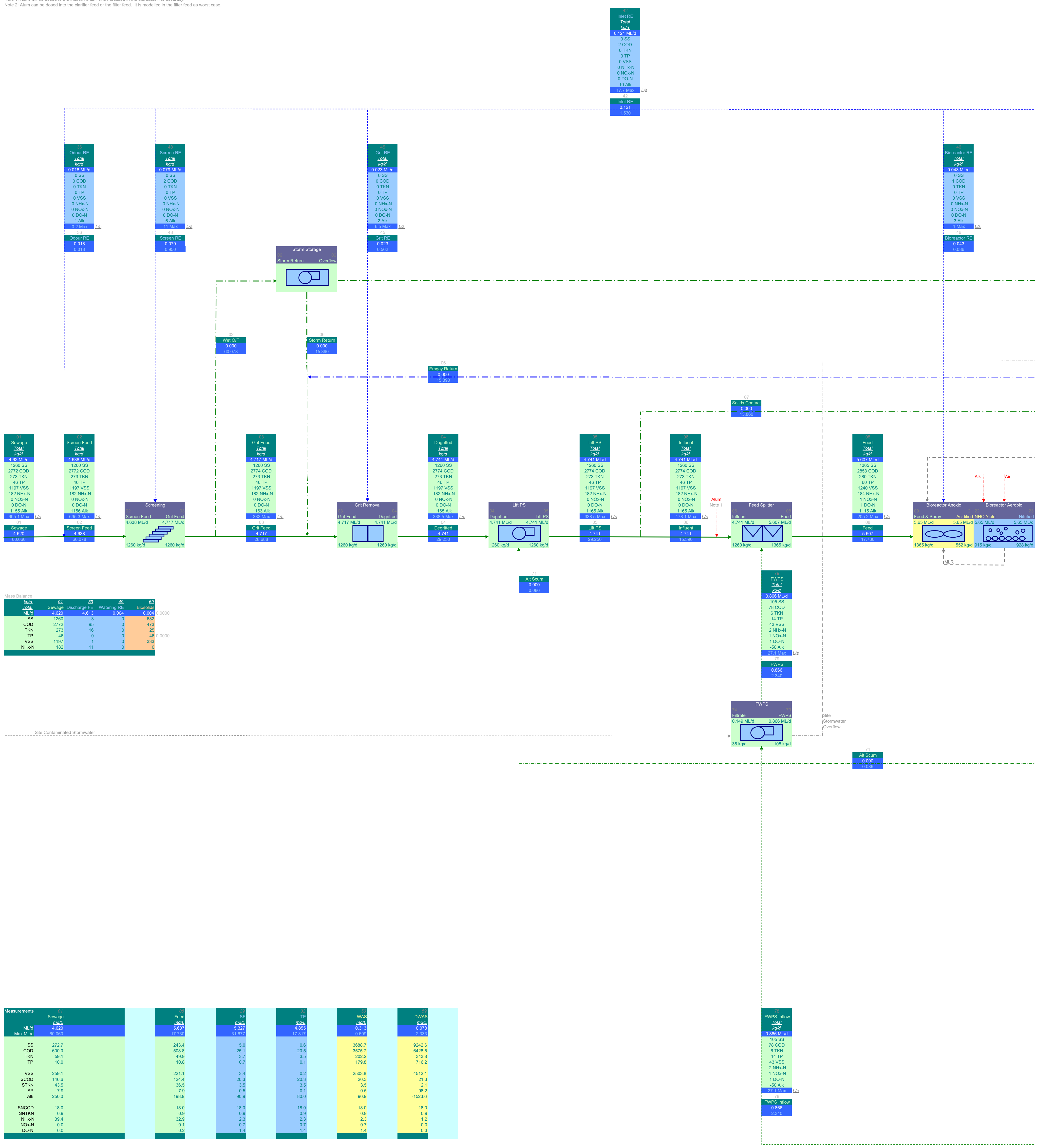
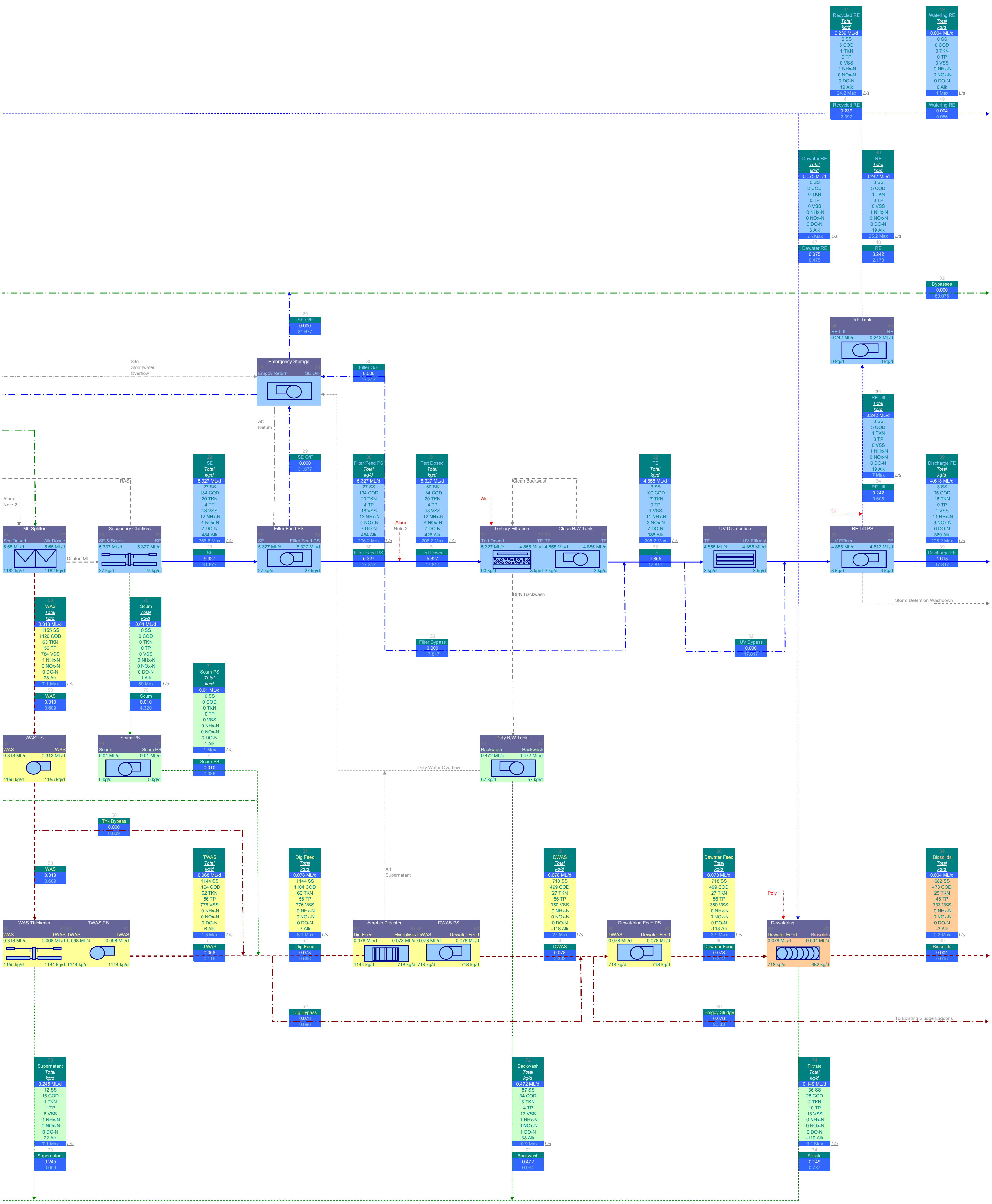


Mass Balance

kg/d Total	01 Sewage	39 Discharge FE	49 Watering RE	69 Biosolids	
ML/d	4.620	4.613	0.004	0.004	0.0000
SS	1260	3	0	682	
COD	2772	95	0	473	
TKN	273	16	0	25	
TP	46	0	0	46	0.0000
VSS	1197	1	0	333	
NHx-N	182	11	0	0	

Measurements	01 Sewage mg/L	08 Feed mg/L	29 SE mg/L	32 TE mg/L	50 WAS mg/L	59 DWAS mg/L
ML/d	4.620	5.607	5.327	4.855	0.313	0.078
Max ML/d	60.060	17.730	31.677	17.817	0.609	2.333
SS	272.7	243.4	5.0	0.6	3688.7	9242.6
COD	600.0	508.8	25.1	20.5	3575.7	6428.5
TKN	59.1	49.9	3.7	3.5	202.2	343.8
TP	10.0	10.8	0.7	0.1	179.8	716.2
VSS	259.1	221.1	3.4	0.2	2503.8	4512.1
SCOD	146.6	124.4	20.3	20.3	20.3	21.3
STKN	43.5	36.5	3.5	3.5	3.5	2.1
SP	7.9	7.9	0.5	0.1	0.5	98.2
Alk	250.0	198.9	90.9	80.0	90.9	-1523.6
SNCOD	18.0	18.0	18.0	18.0	18.0	18.0
SNTKN	0.9	0.9	0.9	0.9	0.9	0.9
NHx-N	39.4	32.9	2.3	2.3	2.3	1.2
NOx-N	0.0	0.1	0.7	0.7	0.7	0.0
DO-N	0.0	0.2	1.4	1.4	1.4	0.3



Recycled RE
Watering RE
Dewater RE
RE
Bypasses
SE O/F
Site Stormwater Overflow
Emergency Storage
Emgcy Return
Filter O/F
RE Tank
RE Lift
Alt Return
Alum Note 2
RAS
ML Splitter
Sec Dosed
Alk Dosed
Diluted ML
Secondary Clarifiers
SE & Scum
SE
Filter Feed PS
Filter Feed PS
Tert Dosed
Alum Note 2
Air
Clean Backwash
Tertiary Filtration
Clean B/W Tank
TE
UV Disinfection
UV Effluent
RE Lift PS
Cl
Discharge FE
Dirty Backwash
Storm Detention Washdown
Filter Bypass
UV Bypass
WAS
Scum
Scum PS
WAS PS
Dirty B/W Tank
Dirty Water Overflow
Thk Bypass
Alt Supernatant
TWAS
Dig Feed
DWAS
Dewater Feed
Biosolids
Poly
WAS Thickener
TWAS PS
Aerobic Digester
Hydrolysis DWAS
DWAS PS
Dewatering Feed PS
Dewatering
Dig Bypass
Emgcy Sludge
To Existing Sludge Lagoons
Supernatant
Backwash
Filtrate

Appendix E: Process & Instrumentation Diagrams

PROCESS AND INSTRUMENTATION DIAGRAMS

DRG. NUMBER	DRG. TITLE
5804-P-000	TITLE PAGE
5804-P-001	DRAWING LIST
5804-P-002	INDEX SHEET 1
5804-P-003	INDEX SHEET 2
5804-P-004	INDEX SHEET 3
5804-P-005	INDEX SHEET 4
5804-P-006	PROCESS FLOW DIAGRAM
5804-P-007	INLET WORKS 1 OF 2
5804-P-008	INLET WORKS 2 OF 2
5804-P-009	LIFT PUMP STATION
5804-P-010	SPLITTER & WAS THICKENER
5804-P-011	BIOREACTOR A
5804-P-012	BIOREACTOR B
5804-P-013	CLARIFIER A
5804-P-014	CLARIFIER B
5804-P-015	FILTER FEED PS & SCUM PS
5804-P-016	FILTER FEED SPLITTER
5804-P-017	TERTIARY FILTER A
5804-P-018	TERTIARY FILTER B
5804-P-019	TERTIARY FILTER C
5804-P-020	TERTIARY FILTER D
5804-P-021	BACKWASH SYSTEM
5804-P-022	UV SYSTEM
5804-P-023	RE SYSTEM
5804-P-024	RE RING MAIN AND STORM CLEAN RE MAIN
5804-P-025	EMERGENCY STORAGE
5804-P-026	STORM RETURN PUMPING STATION AND DETENTION POND 2
5804-P-027	STORM DETENTION POND 1
5804-P-028	BIOREACTOR AIR BLOWERS
5804-P-029	ALUM DOSING SYSTEM - SHEET 1 OF 2
5804-P-030	ALUM DOSING SYSTEM - SHEET 2 OF 2
5804-P-031	SODIUM HYDROXIDE DOSING SYSTEM - SHEET 1 OF 2
5804-P-032	SODIUM HYDROXIDE DOSING SYSTEM - SHEET 2 OF 2
5804-P-033	SODIUM HYPOCHLORITE DOSING SYSTEM
5804-P-034	POLYMER BATCHING AND DOSING SYSTEM
5804-P-035	SUCROSE DOSING SYSTEM
5804-P-036	DIGESTER
5804-P-037	DEWATERING FEED SYSTEM
5804-P-038	SLUDGE DEWATERING
5804-P-039	BIOSOLIDS HARDSTAND (EXISTING)
5804-P-040	FOUL WATER PUMPING STATION
5804-P-041	FILTER AIR BLOWERS
5804-P-042	ODOUR CONTROL
5804-P-043	ODOUR DUCTWORK

A3

AMENDMENTS

Ver	Date	Description	Drawn
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA

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HH2O Project Number 5804	

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WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
DRAWING LIST

Scale: N.T.S. at A3
Document No: **5804- P - 001**
Status: **TENDER**
Version: **C**

LINE SYMBOLS

- MAIN PROCESS LINE
- MINOR PROCESS LINE
- PROCESS LINE (EXISTING)
- INSTRUMENT SUPPLY OR CONNECTION TO PROCESS
- UNDEFINED SIGNAL
- PNEUMATIC SIGNAL
- ELECTRICAL SIGNAL
- ELECTRIC BINARY SIGNAL
- HYDRAULIC SIGNAL
- LIMIT OF VENDOR SUPPLY
- OTHERS / CLIENT — LIMIT OF VENDOR SUPPLY
- FLOW ARROW
- FUTURE (NOT PART OF THIS UPGRADE)
- PRIMARY OPEN CHANNEL OR HYDRAULIC LINK
- PRIMARY OPEN CHANNEL OR HYDRAULIC LINK (EXISTING)
- JACKETED LINE (DOUBLE CONTAINMENT)
- INSULATED LINE

PIPE FITTINGS

- REDUCER
- BLIND FLANGE
- NOZZLE
- FLANGED JOINT
- DISMANTLING JOINT (DJ)
- HOSE COUPLING
- HOSE REEL
- FLEXIBLE HOSE
- EXPANSION JOINT
- ELASTOMER EXPANSION JOINT
- EXPANSION CHAMBER
- CALIBRATION CYLINDER
- PULSATION DAMPENER

SELF ACTUATED REGULATORS AND VALVES

- CONTINUOUS VENTING VALVE
- ANGLE PRESSURE RELIEF OR SAFETY VALVE
- BACKFLOW PREVENTER (RPZD)
- PRESSURE RELIEF OR SAFETY VALVE
- PRESSURE REGULATING
- PRESSURE SUSTAINING
- VAC / PRESS — PRESSURE & VACUUM RELIEF VALVE

PIPING VALVES

- VALVE, GENERAL (NOTE 1)
- GATE
- BALL
- GLOBE
- NEEDLE
- DIAPHRAGM
- BUTTERFLY
- PLUG
- NON RETURN VALVE
- PINCH
- ANGLE
- HOSE BIB
- THREE PORT VALVE
- TELESCOPIC VALVE
- ECCENTRIC PLUG
- KNIFE GATE VALVE

VALVE FITTINGS

- PNEUMATIC ACTUATOR
- MODULATING PNEUMATIC ACTUATOR
- SPRING - FOR PRESSURE RELIEF OR SAFETY VALVE ONLY
- HAND ACTUATED OR HANDWHEEL
- ELECTRIC ACTUATOR (M)
- MANUAL GEARBOX (G)
- SOLENOID ACTUATOR
- WEIGHT
- FLOAT

GENERAL ITEMS

- PUMP, CENTRIFUGAL
- PUMP, GENERAL
- AIR DIAPHRAGM PUMP
- SAMPLING PUMP
- PUMP, DIGITAL DOSING
- PUMP, RECIPROCATING
- PUMP, PROGRESSIVE CAVITY
- PUMP, ROTARY VANE
- PUMP, LOBE
- FAN OR BLOWER
- AIR COMPRESSOR
- EJECTOR OR EDUCTOR
- SILENCER
- STRAINER, FILTER CARTRIDGE TYPE
- BASKET STRAINER
- AUTOMATIC CONDENSATE DRAIN TRAP
- AUTOMATIC CONDENSATE DRAIN TRAP WITH FILTER
- C.A.S. FILTER
- AIR OR GAS FILTER
- HEAT EXCHANGE
- CONTROL VALVE
- SIGHT GLASS (TUBE)
- DRAIN
- SLIDE GATE VALVE
- Y STRAINER

GENERAL ITEMS

- PENSTOCK
- STOPBOARD
- CROSSFLOW FILTER
- HEATER
- AUDIBLE ALARM
- FUTURE EQUIPMENT
- EXHAUST FAN
- EDUCTOR / INJECTOR
- ORIFICE PLATE
- DAMPER
- STATIC MIXER
- DUST FILTER
- INLINE MIXER
- DIAPHRAGM SEAL
- MF XXXXX — ELECTRIC MOTOR - FIXED SPEED
- MV XXXXX — ELECTRIC MOTOR - VARIABLE SPEED
- MO XXXXX — ELECTRIC MOTOR - XXX
- MFR XXXXX — ELECTRIC MOTOR - FIXED SPEED REVERSING
- DOSING LANCE / DOSING SYPHON
- AGITATOR, FAN PROPELLER
- VENTURI
- WEIR
- OPEN VENT, GIVE NOTE IF RUN TO GRADE
- VENT - SCREENED

GENERAL ITEMS

- RUPTURE DISK (or BURSTING DISK)
- TRAPPED DRAIN e.g. AUTO CONDENSATE RELEASE
- TRAPPED VENT e.g. AUTO AIR RELEASE
- BELLMOUTH
- SPARGE PIPE
- SHOWER & EYE WASH
- SG — SIGHT GLASS
- TANK
- PRESSURE VESSEL
- PI XXXXX — PRESSURE ELEMENT
- XX XXXXX — INSTRUMENT TX
- LE XXXXX — LEVEL ELEMENT
- RADAR/ULTRASONIC LEVEL SENSOR
- FLOAT SWITCH

GENERAL INSTRUMENT OR FUNCTION SYMBOLS

- I/P — ELECTRO-PNEUMATIC SIGNAL CONVERTER
- FO — FAIL OPEN
- FC — FAIL CLOSED
- FCV — FLOW CONTROL VALVE
- LO — LOCK OPEN
- LC — LOCK CLOSED
- NC — NORMALLY CLOSED
- Σ — SUMMING
- ULTRA SONIC SIGNAL
- BEA — INDICATOR BEACON
- I — INTERLOCK

PRIMARY FLOW ELEMENTS & INSTRUMENTS

- FE — VARIABLE AREA FLOWMETER
- AVERAGING PILOT TUBE FLOWMETER
- TARGET FLOWMETER
- MAGNETIC FLOWMETER
- ULTRASONIC FLOW METER
- m3 — MASS FLOW METER
- TURBINE or PROPELLER METER
- T — THERMAL MASS FLOW METER
- FLUME
- ROTAMETER (FLOW INDICATOR)
- FE — FLOW ELEMENT, ORIFICE TYPE
- VORTEX FLOWMETER

SPECIAL FIELD INSTRUMENTATION (OTHER)

- AC - AIR COMPRESSOR
- AT - ANALYSER
- AV - AIR VENT
- B - BLOWER
- BPV - BACKFLOW PREVENTION VALVE
- DPI - DIFFERENTIAL PRESSURE GAUGE
- DPS - DIFFERENTIAL PRESSURE SWITCH
- DPT - DIFFERENTIAL PRESSURE TRANSMITTER
- DR - AIR DRYER
- F - FILTER
- HTR - HEATER
- MDP - MOISTURE DETECTION PROBE
- PU - PUMP
- ZSC - LIMIT SWITCH CLOSE
- ZSO - LIMIT SWITCH OPEN

LCP FUNCTIONS

- HC - HAND CONTROL MODULATING
- HS - ON/OFF CONTROL

INSTRUMENTATION IDENTIFICATION LETTER CODE FOR USE WITH INSTRUMENTS AND CONTROL

LETTER	FIRST LETTER MEASURED VALUE	SECOND LETTER MODIFIER	THIRD LETTER DISPLAY OR OUTPUT
A	ANALYSIS	ALARM	ALARM
B	BURNER, FLAME	---	STATE OR STATUS DISPLAY
C	CONDUCTIVITY	CONTROL	CONTROL
D	DENSITY	DIFFERENCE	---
E	VOLTAGE	SENSING ELEMENT	SENSING ELEMENT
F	FLOW	RATIO	---
G	GAUGE POSITION OR LENGTH	GAUGE	GLASS
H	HAND OPERATED	HIGH	HIGH
I	CURRENT	INDICATING	INDICATOR
J	POWER	SCAN	---
K	TIME	---	BARRIER
L	LEVEL	LOW	LOW
M	MOISTURE AND HUMIDITY	INTERMEDIATE	---
N	LRV	---	---
O	---	---	---
P	PRESSURE OR VACUUM	PRESSURE OR VACUUM	TEST POINT CONNECTION
Q	QUANTITY	INTEGRATE OR TOTALIZE	INTEGRATING OR SUMMATING
R	RADIOACTIVITY	---	RECORDING
S	SPEED OR FREQUENCY	SWITCH	SWITCH
T	TEMPERATURE	TRANSMITTER	TRANSMITTER
U	MULTIVARIABLE	---	MULTIFUNCTION UNIT
V	VIBRATION	VALVE	VALVE, DAMPER, LOUVRE
W	WEIGHT OR FORCE	---	WELLS
X	---	---	CATHODE RAY TUBE, ETC
Y	EVENT	CONVERTER	COMPUTING RELAY, RELAY
Z	POSITION	---	EMERGENCY AND SAFETY ACTING

A3

AMENDMENTS

Ver	Date	Description	Drawn
B	10/08/21	TENDER	RR
A	01/09/20	DRAFT	MA

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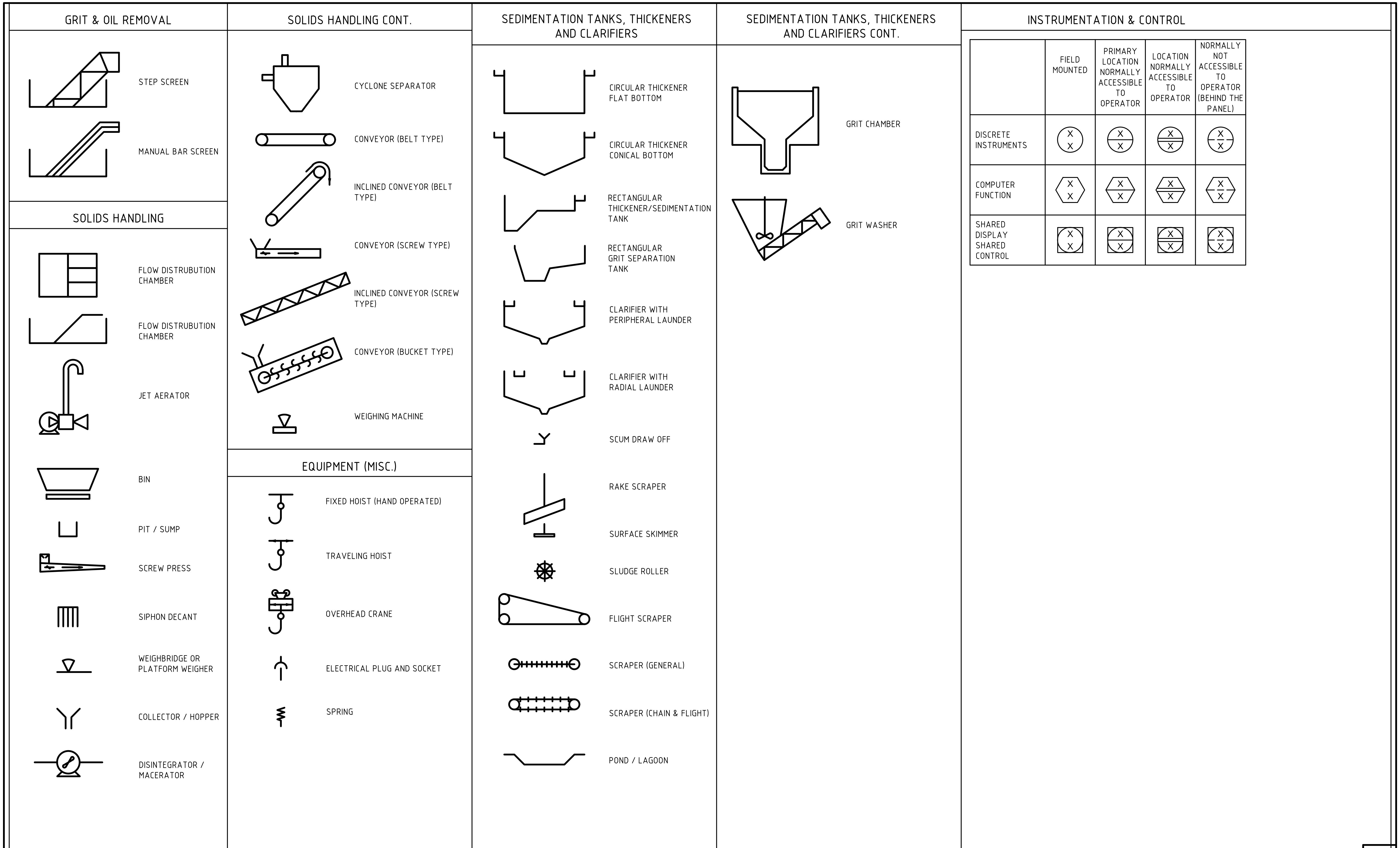
HH2O Project Number 5804

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
INDEX SHEET 1 OF 4

Scale N.T.S. at A3
Document No **5804- P - 002**
Status **TENDER**
Version **B**

Plot Date: 10/08/21 - 13:35 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-002 - INDEX SHEET 1.dwg



A3

AMENDMENTS			
B	10/08/21	TENDER	RR
A	01/09/20	DRAFT	MA
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ISO 4801 SGS ISO 9001 SGS ISO 14001 SGS

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Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
INDEX SHEET 2 OF 4

Scale: **N.T.S.** at A3
Document No: **5804- P - 003**
Status: **TENDER**
Version: **B**

Plot Date: 10/08/21 - 13:35 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-003 - INDEX SHEET 2.dwg

ANALYSER AND FUNCTIONAL ABBREVIATIONS	
CODE	ANALYSER
NH3	AMMONIA
COD	CHEMICAL OXYGEN DEMAND
COND	CONDUCTANCE
DO	DISSOLVED OXYGEN
EC	ELECTRICAL CONDUCTIVITY
F	FLUORIDE
FC	FAECAL COLIFORMS/E.COIL
CL2	CHLORINE
H2S	HYDROGEN SULPHIDE
IRON	IRON (SOLUBLE)
MN	MANGANESE (SOLUBLE)
NOX	NITRATE
PH	PH
OP	ORTHO PHOSPHORUS
ORP	REDOX POTENTIAL
SB	SLUDGE BLANKET
SS	SUSPENDED SOLIDS
TEMP	TEMPERATURE
TN	TOTAL NITROGEN
TP	TOTAL PHOSPHORUS
TURB	TURBIDITY
UVI	UV INTENSITY
UVT	UV TRANSMISSIVITY
RTN	ROTATION
VIB	VIBRATION

INSTRUMENT AND FUNCTIONAL ABBREVIATIONS	
CODE	INSTRUMENT
AE	ANALYSER ELEMENT
AIT	ANALYSER INDICATOR TRANSMITTER
CT	CHLORINATOR
FE	FLOW ELEMENT
FI	FLOW INDICATOR
FIT	FLOW INDICATING TRANSMITTER
FQ	FLOW TOTALISER
FS	FLOW SWITCH
FSH	FLOW SWITCH - HIGH
FSHH	FLOW SWITCH - HIGH HIGH
FSL	FLOW SWITCH - LOW
FSLL	FLOW SWITCH - LOW LOW
FT	FLOW TRANSMITTER
HS	HAND SWITCH
LC	LEVEL CONTROLLER
LE	LEVEL ELEMENT
LIT	LEVEL TRANSMITTER
LSH	LEVEL SWITCH - HIGH
LSHH	LEVEL SWITCH - HIGH HIGH
LSL	LEVEL SWITCH - LOW
LSLL	LEVEL SWITCH - LOW LOW
MD	MOISTURE DETECTION
PDE	PRESSURE DIFFERENTIAL ELEMENT
PDI	PRESSURE DIFFERENTIAL INDICATION
PDT	PRESSURE DIFFERENTIAL TRANSMITTER
PE	PRESSURE ELEMENT
PI	PRESSURE INDICATOR/GAUGE
PIT	PRESSURE INDICATING TRANSMITTER
PS	PRESSURE SWITCH
PSH	PRESSURE SWITCH - HIGH
PSHH	PRESSURE SWITCH - HIGH HIGH
PSL	PRESSURE SWITCH - LOW
PSLL	PRESSURE SWITCH - LOW LOW
PT	PRESSURE TRANSMITTER
SSH	SPEED SWITCH - HIGH
SSL	SPEED SWITCH - LOW

INSTRUMENT AND FUNCTIONAL ABBREVIATIONS	
CODE	INSTRUMENT
TE	THEMPERATURE ELEMENT
TIT	TEMPERATURE INDICATING TRANSMITTER
TS	TEMPERATURE SWITCH
TSH	TEMPERATURE SWITCH - HIGH
TSHH	TEMPERATURE SWITCH - HIGH HIGH
TSL	TEMPERATURE SWITCH - LOW
TSLL	TEMPERATURE SWITCH - LOW LOW
WE	WEIGHT ELEMENT
WI	WEIGHT INDICATING
WIT	WEIGHT INDICATING TRANSMITTER
WQ	WEIGHT TOTALISER
WS	WEIGHT/TORQUE SWITCH
WSH	WEIGHT/TORQUE SWITCH - HIGH
WSHH	WEIGHT/TORQUE SWITCH - HIGH HIGH
WSL	WEIGHT/TORQUE SWITCH - LOW
WSLL	WEIGHT/TORQUE SWITCH - LOW LOW
WT	WEIGHT/TORQUE TRANSMITTER
ZIT	POSITION INDICATING TRANSMITTER
ZS	POSITION SWITCH
ZSB	POSITION SWITCH - BACKWARD
ZSC	POSITION SWITCH - CLOSE
ZSF	POSITION SWITCH - FORWARD
ZSL	POSITION SWITCH - LEFT
ZSO	POSITION SWITCH - OPEN
ZSP	POSITION SWITCH - PARKED
ZSR	POSITION SWITCH - RIGHT

EQUIPMENT AND FUNCTIONAL ABBREVIATIONS	
CODE	EQUIPMENT
AD	AIR DRYER
AG	AGITATOR
AH	ANTI-ARCHING HAMMER
ARV	AIR RELEASE VALVE
AS	AUTO SAMPLER
BA	BIN ACTIVATOR
BE	BELLOWS
BN	BIN
BL	BLOWER
BS	BAR SCREEN
CL	CLARIFIER
CM	COMPRESSOR
CR	CRANE
CT	CALIBRATION TUBE
CV	CONTROL VALVE
DE	DUST EXTRACTOR
DEB	DEBUBBLER
DN	DRAIN OR BUND
DS	DOSING SIPHON
DW	DECANTER WEIR
EJ	EJECTOR/EDUCTOR/INJECTOR
EV	ELECTRIC VALVE (CHLORINATOR)
EW	EYEWASH / SAFETYSHOWER
FCV	FLOW CONTROL VALVE
FDC	FLOW DISTRIBUTION CHAMBER
FIL	FILTER
FL	FLOCCULATOR
FM	FLOW METER
FN	FAN
FS	FLOAT SWITCH
FV	FLOW CONTROL VALVE
GW	GRIT WASHER
HE	HEATER
HJ	ELECTRIC HOIST
HR	HOSE REEL
HS	HAND SWITCH
HV	HAND VALVE
IT	INCLINED TROUGH
JA	JET AERATOR
KL	KAMLOCK FITTING
MF	MOTOR FIXED SPEED
MFR	MOTOR FIXED SPEED REVERSING
MO	MOTOR
MS	MOTOR SOFT START

EQUIPMENT AND FUNCTIONAL ABBREVIATIONS	
CODE	EQUIPMENT
MV	MOTOR VARIABLE SPEED
MI	MIXER
NRV	NON-RETURN VALVE
PD	PULSATION DAMPENER
PK	PENSTOCK
PO	POND OR LAGOON
PP	PNEUMATIC PUMP
PREV	PRESSURE REGULATOR / REGULATING
PRV	PRESSURE RELEASE VALVE
PSV	PRESSURE SUSTAINING VALVE /LOADING VALVE
PTT	PIT
PU	PUMP
PV	PRESSURE VESSEL
RD	RAKE DRIVE
ROT	ROTAMETER
RPZ	REDUCED PRESSURE ZONE VALVE
RS	RADAR SENSOR
RTU	RADIO TELEMETRY UNIT
RV	ROTARY VALVE
SA	SURFACE AERATOR
SB	STOP BOARD
SC	SCREW CONVEYOR
SD	SIPHON DECANT
SLD	SLUDGE DETECTOR
SCP	SCRAPER
SF	SCREW FEEDER
SG	SLIDE GATE
SIL	SILENCER
SM	STATIC MIXER
SP	SCREW PRESS
SPL	SPLITTER
SR	STEP SCREEN OR MANUAL BAR SCREEN
ST	STRAINER
SU	SURGE VESSEL
SV	SOLENOID VALVE
TAR	TURBO AERATOR
TK	TANK
US	ULTRASONIC SENSOR
UV	UV BANK
VB	STOPBOARD
VE	VENTURI
VP	PENSTOCK
VS	VARIABLE SPEED DRIVE
VT	VENT
WR	WEIR

A3

AMENDMENTS

Ver	Date	Description	Drawn
B	10/08/21	TENDER	RR
A	01/09/20	DRAFT	MA

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BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
INDEX SHEET 3 OF 4

Scale N.T.S. at A3
Document No **5804- P - 004**
Status **TENDER**
Version **B**

PIPELINE TAG

PIPE NOMINAL DIAMETER (SIZE)
PIPE LINE NUMBER
450-RE-DI1-0001
FLUID DESCRIPTORS (SERVICE)
PIPING MATERIAL (SPEC)

EQUIPMENT TAG

TRAIN NUMBER
SUB AREA NUMBER
AREA NUMBER
TAG NUMBER
VA-3 1 0 30
EQUIPMENT ITEM ABBREVIATION

FLUID DESCRIPTORS (NOTE 1)

GENERAL

AA	COMPRESSED AIR
AIR	BLOWER AIR
ASC	AIR SCOUR
BR	BRINE
BW	BACKWASH
CCT	CHLORINE CONTACT TANK
CFF	CONSTANT FLOW FITTING
CIP	CLEAN IN PLACE
D	DRAIN - GRAVITY
FIL	FILTRATE
FW	FOUL WATER
MIT	MIT AIR
NS	NEUTRALISED SOLUTION
OF	OVERFLOW
OS	OFF SPEC
PA	FIXED AERATION AIR
PER	PERMEATE
PW	PRODUCT WATER
SE	SECONDARY EFFLUENT
SEW	SEWAGE
SW	STORMWATER
RE	RECYCLED EFFLUENT
TD	TANK DRAIN (NON CHEMICAL)
TE	TREATED EFFLUENT
V	VENT

CHEMICALS

AAM	AQUEOUS AMMONIA
ALS	ALUMINIUM SULPHATE
AS	ANTISCALANT
CA	CITRIC ACID
CHL	CHLORAMINES
CO2	CARBON DIOXIDE
CS	CAUSTIC SODA
EDTA	EDTA
FCC	FERRIC CHLORIDE
FCS	FERRIS SULPHATE
FSC	FERROUS CHLORIDE
HCL	HYDROCHLORIC ACID
HDL	HYDRATED LIME
HYDR	SODIUM HYDROXIDE
HYPO	SODIUM HYPOCHLORITE
POL	POLYMER
ROC	RO CLEANING
SBS	SODIUM BISULPHITE
SA	SULPHURIC ACID
PAC	POWDER ACTIVATED CARBON
PP	POTASSIUM PERMANGANATE

PLANT WATER

FW	FIRE HYDRANT SUPPLY
W1	POTABLE WATER
IW	PLANT SERVICE WATER (INDUSTRIAL)
RE	RECLAIMED EFFLUENT

PIPING MATERIAL DESIGNATION (NOTE 1)

COP	COPPER, AS 1432, TYPE B, ANNEALED TEMPERED
CS0	CARBON STEEL EPOXY COATED
CS1	CARBON STEEL
SS0	GRADE 316 STAINLESS STEEL, SEAM WELDED, SCHEDULE 10S
SS1	GRADE 316 STAINLESS STEEL, SEAM WELDED, SCHEDULE 5S
SS2	GRADE 316 STAINLESS STEEL, SEAM WELDED, SCHEDULE 40S
DI1	DUCTILE IRON, CEMENT LINED (HEAVY), BITUMEN COATED
DWV	DRAIN WASTE VENT
MSCL	MILD STEEL CONCRETE LINED
PVC0	PVCU, SCHEDULE 80 ASTM-D-1785
PVC1	PVCU, AS 1254, STORMWATER PIPES/SEWER PIPES
PVC2	PVC-M GLUED JOINT PN16, AS 1477
PVC3	CPVC SCH 80 ASTM F441
PVC4	OPVC RRJ PN16
ABS	PLASTIC ABS, AS 3518, PN 15
GRP	GRP POLYESTER BASED, 2R-2RK65
PE1	POLYETHYLENE AS 4130, PN 16 (PE 100)
PE2	POLYETHYLENE PN 8 (PE100)
PE3	POLYETHYLENE AS4130 PN12.5 (PE80B) (TUBE) SDR11
PE4	POLYETHYLENE AS 430 PN10 (PE100)
POLY	POLYPROPYLENE PIPE
RCP	REINFORCED CONCRETE PIPE
SS3	GRADE316 STAINLESS STEEL TUBE
CC	CONCRETE CHANNEL

INSTRUMENT DESCRIPTORS

INSTRUMENTATION ID CODE
GENERAL INSTRUMENT SYMBOL
AB
XYZ
XXXX
HH
H
L
LL
ALARM OUTPUT (IF PRESENT)
TAG NUMBER

NH_3	=	AMMONIA
CL_2 FREE	=	CHLORINE RESIDUAL FREE
CL_2 TOTAL	=	CHLORINE RESIDUAL TOTAL
COND	=	CONDUCTIVITY
FI	=	FLUORIDE
CHLORAMINE	=	MONOCHLORAMINE (NH2CL)
NO_X	=	NITRATE
ORP	=	OXIDATION REDUCTION POTENTIAL
pH	=	pH
TURB	=	TURBIDITY

PROCESS FLOW CONTINUATION .... PROCESS WATER
TAG NUMBER 001
DRAWING NUMBER FROM/TO PI-001

A3

AMENDMENTS			
Ver	Date	Description	Drawn
B	10/08/21	TENDER	RR
A	01/09/20	DRAFT	MA

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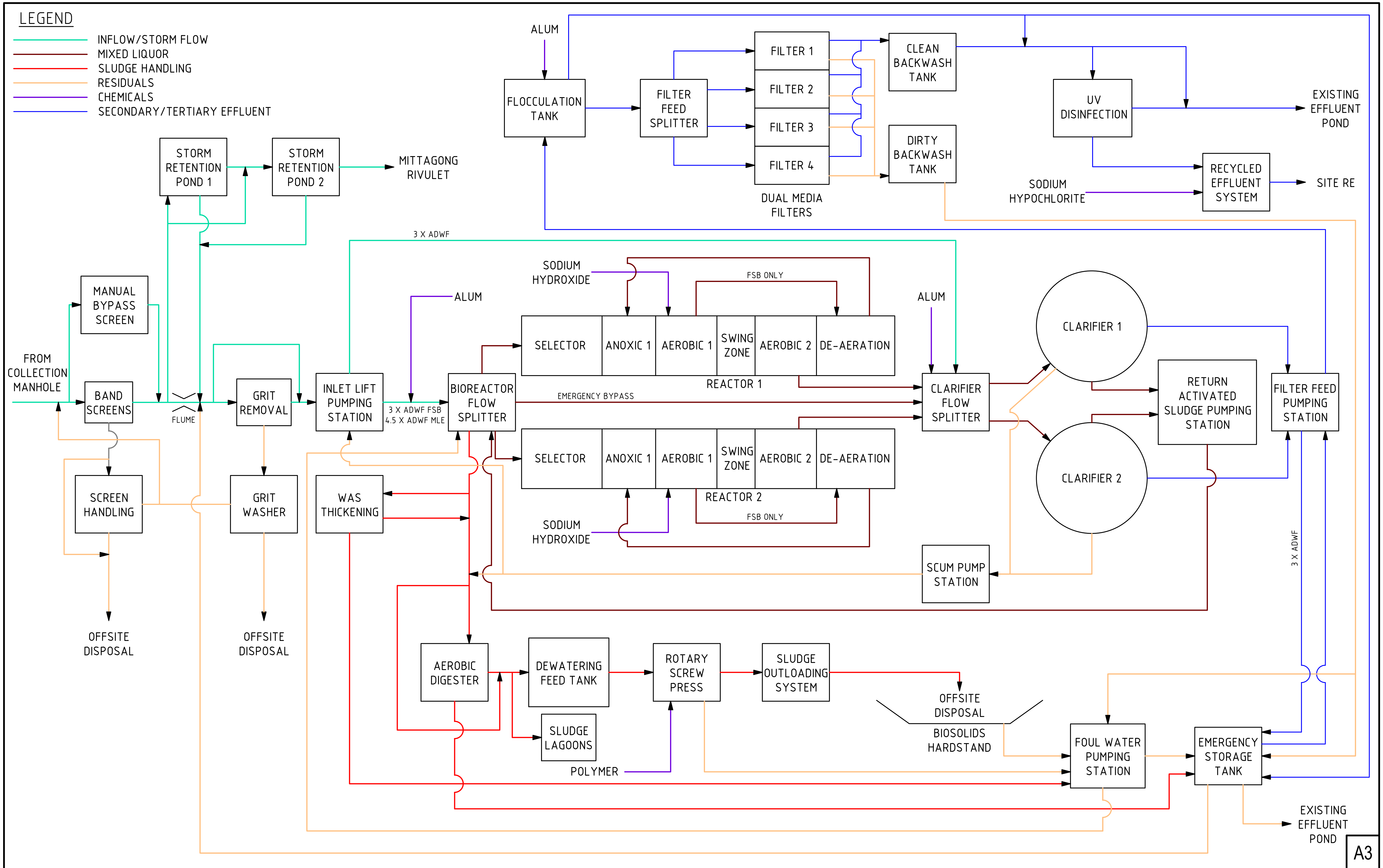
ISO 14001 SGS · ISO 9001 SGS · ISO 45001 SGS

Designed MC	Checked AR
Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
INDEX SHEET 4 OF 4

Scale: N.T.S. at A3	Document No: 5804- P - 005
Status: TENDER	Version: B



A3

AMENDMENTS			
B	10/08/21	TENDER	RR
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

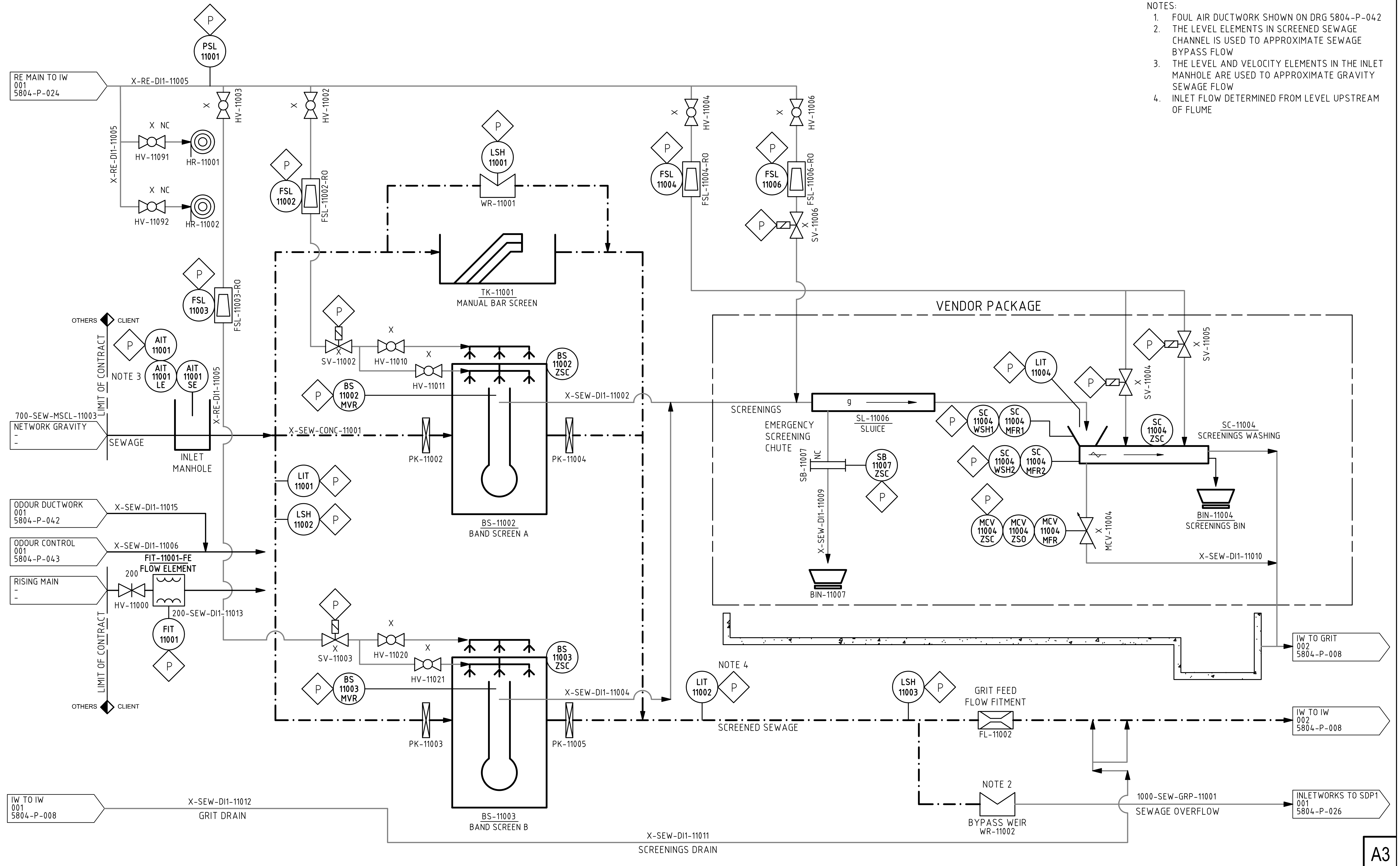
Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
PROCESS FLOW DIAGRAM

Scale: N.T.S. at A3
Document No: 5804- P - 006
Status: **TENDER**
Version: B

Plot Date: 10/08/21 - 13:37 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-006 - PROCESS FLOW DIAGRAM.dwg

NOTES:
1. FOUL AIR DUCTWORK SHOWN ON DRG 5804-P-042
2. THE LEVEL ELEMENTS IN SCREENED SEWAGE CHANNEL IS USED TO APPROXIMATE SEWAGE BYPASS FLOW
3. THE LEVEL AND VELOCITY ELEMENTS IN THE INLET MANHOLE ARE USED TO APPROXIMATE GRAVITY SEWAGE FLOW
4. INLET FLOW DETERMINED FROM LEVEL UPSTREAM OF FLUME



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AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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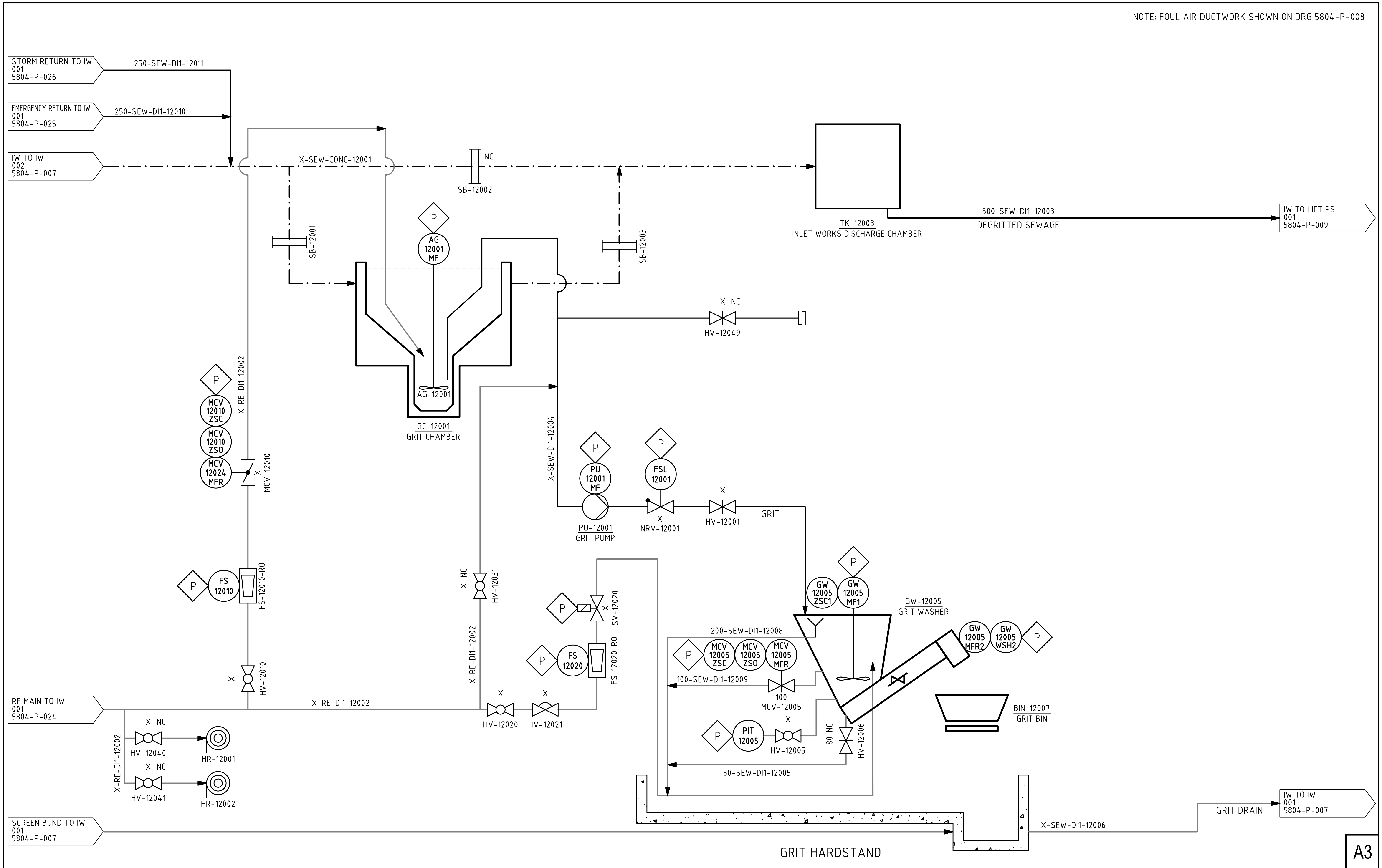
Approved	J.L.SMITH		
Date	10/08/21		
HH2O Project Number	5804		

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
INLET WORKS 1 OF 2

Scale: N.T.S. at A3
Document No: 5804- P - 007
Status: TENDER
Version: C

Plot Date: 10/08/21 - 13:37 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-007 - INLET WORKS 1 OF 2.dwg



AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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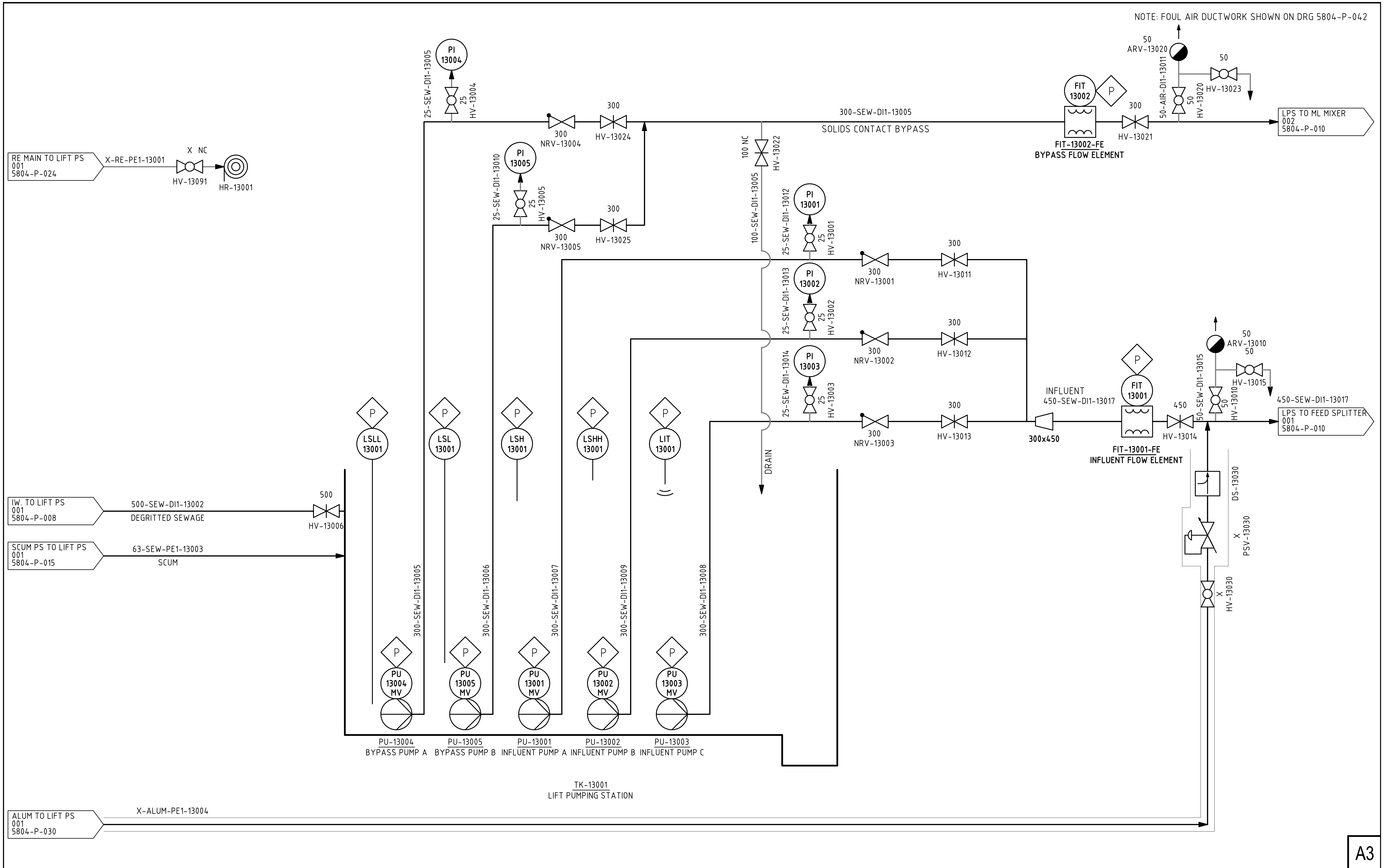
Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
INLET WORKS 2 OF 2

Scale: N.T.S. at A3
Document No: 5804- P - 008
Status: **TENDER**
Version: C

Plot Date: 10/08/21 - 13:38 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-008 - INLET WORKS 2 OF 2.dwg



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AMENDMENTS

Ver	Date	Description	Drawn
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA

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Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
LIFT PUMPING STATION

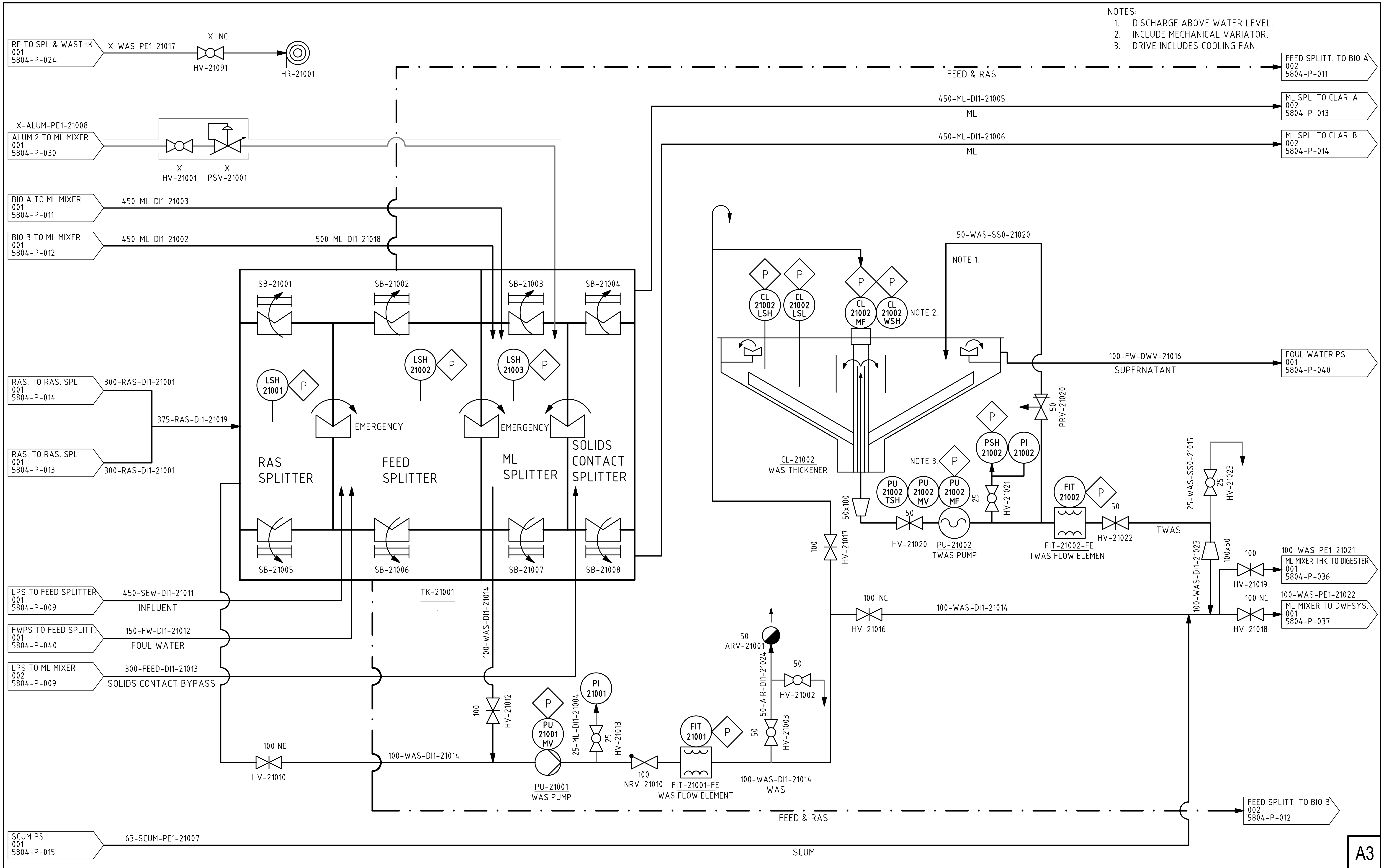
Scale N.T.S. at A3

Document No **5804- P - 009**

Status **TENDER**

Version **C**

Plot Date: 10/08/21 - 13:39 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-009 - LIFT PUMPING STATION.dwg



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AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
SPLITTER & WAS THICKENER

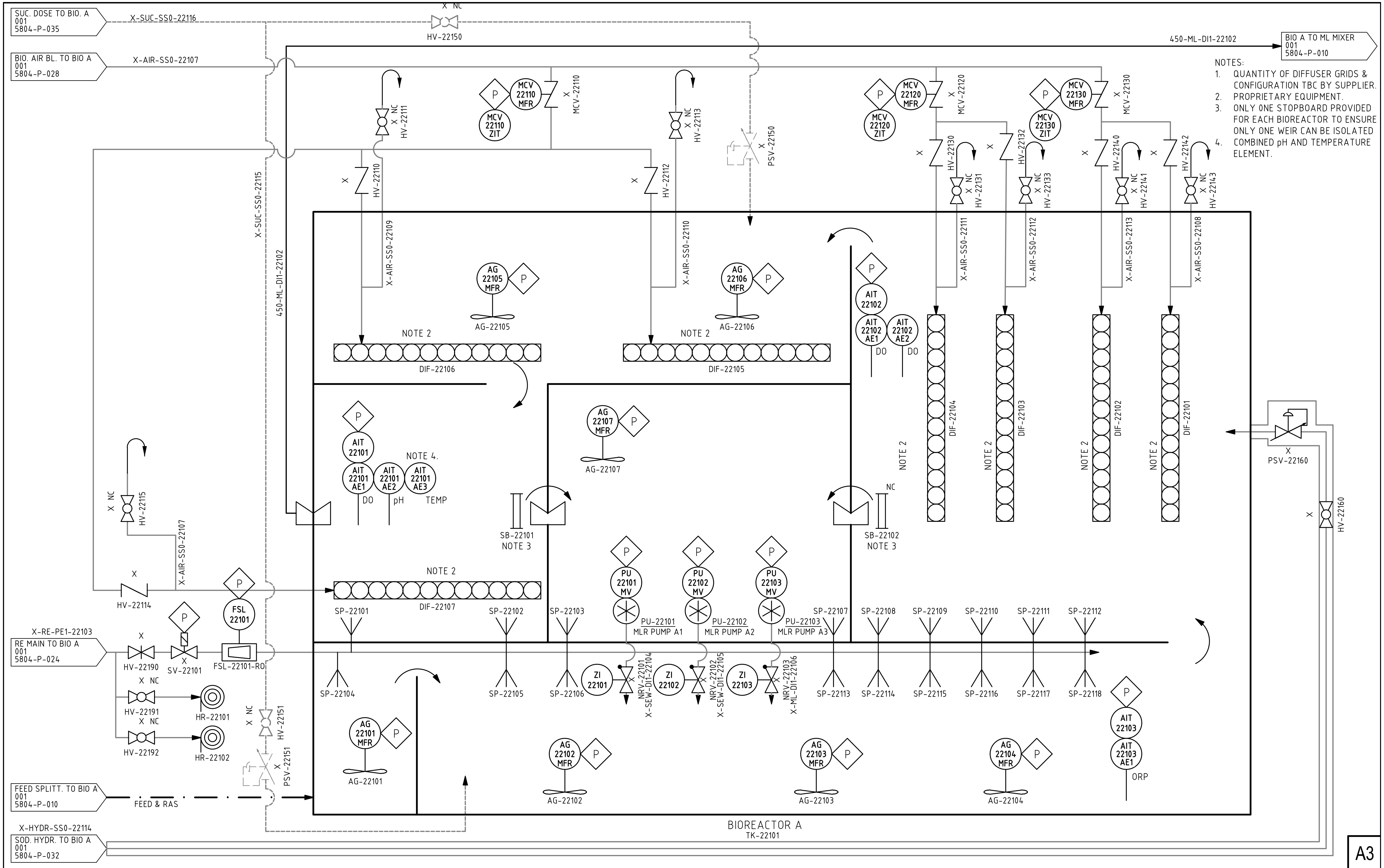
Scale N.T.S. at A3

Document No **5804- P - 010**

Status **TENDER**

Version **C**

Plot Date: 10/08/21 - 13:39 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-010 - FEED SPLITTER AND ML SPLITTER.dwg



AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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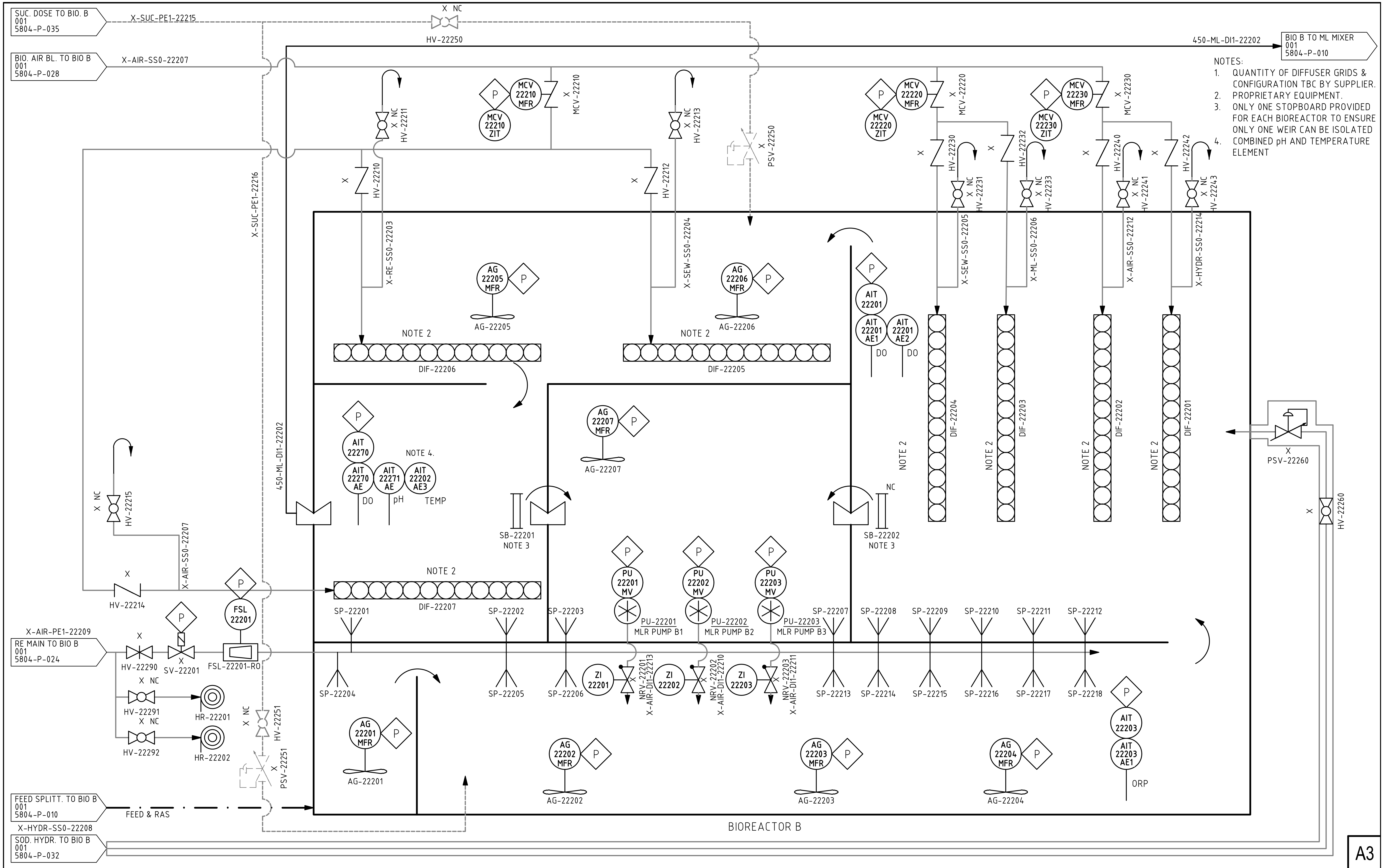
Drawn	MA	Checked	MC
Approved	J.L.SMITH		
Date	10/08/21		
HH2O Project Number	5804		

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
BIOREACTOR A

Scale: N.T.S. at A3
Document No: 5804- P - 011
Status: **TENDER**
Version: C

Plot Date: 10/08/21 - 13:40 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-011 - BIOREACTOR A.dwg



AMENDMENTS

Ver	Date	Description	Drawn
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA

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Approved	J.L.SMITH		
Date	10/08/21		
HH2O Project Number	5804		

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
BIOREACTOR B

Scale: N.T.S. at A3

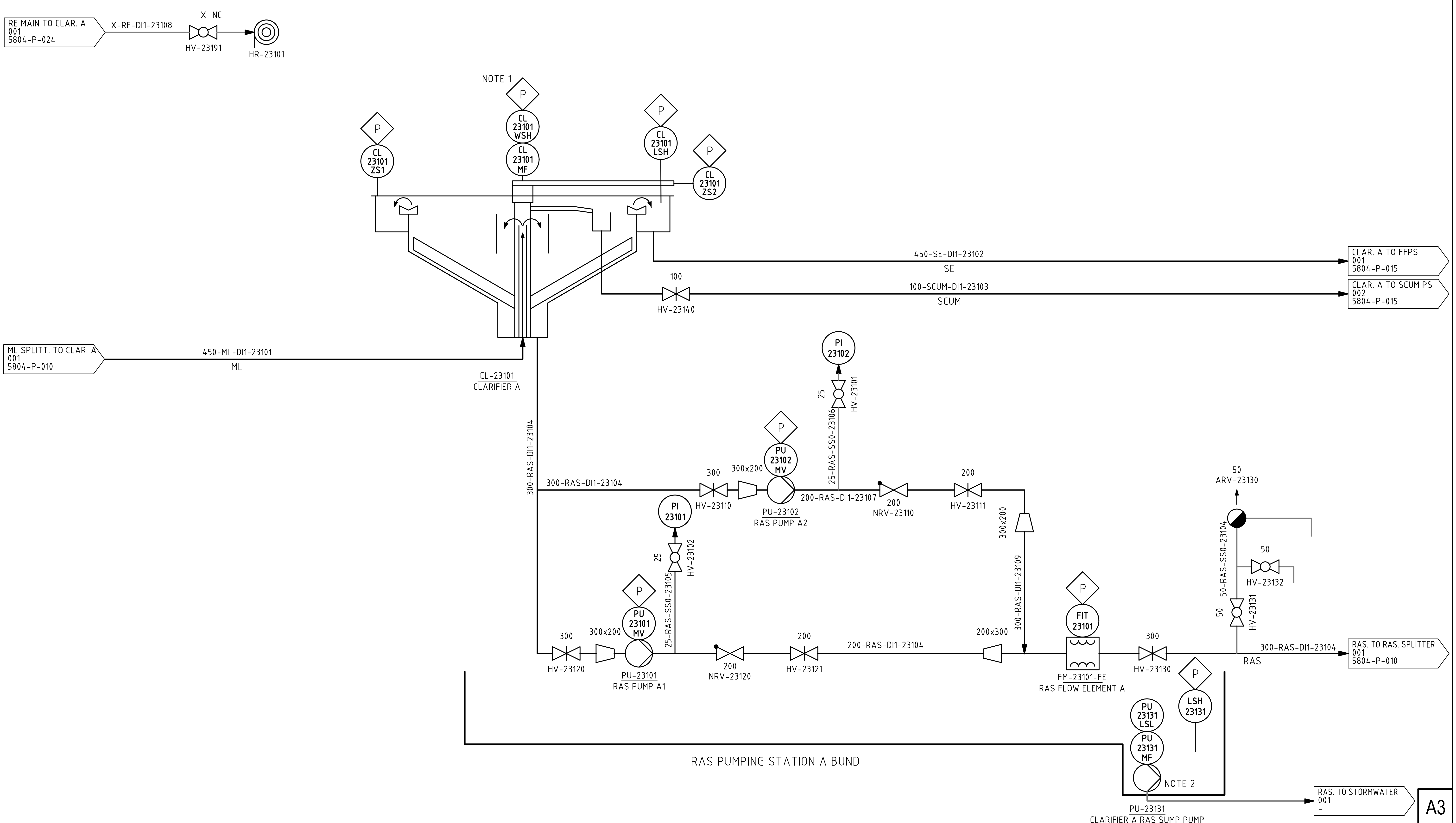
Document No: **5804- P - 012**

Status: **TENDER**

Version: **C**

Plot Date: 10/08/21 - 13:40 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-012 - BIOREACTOR B.dwg

NOTES:
1. INCLUDE MECHANICAL VARIATOR
2. SELF CONTAINED 240V SUMP PUMP WITH FLOAT SWITCH



A3

AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

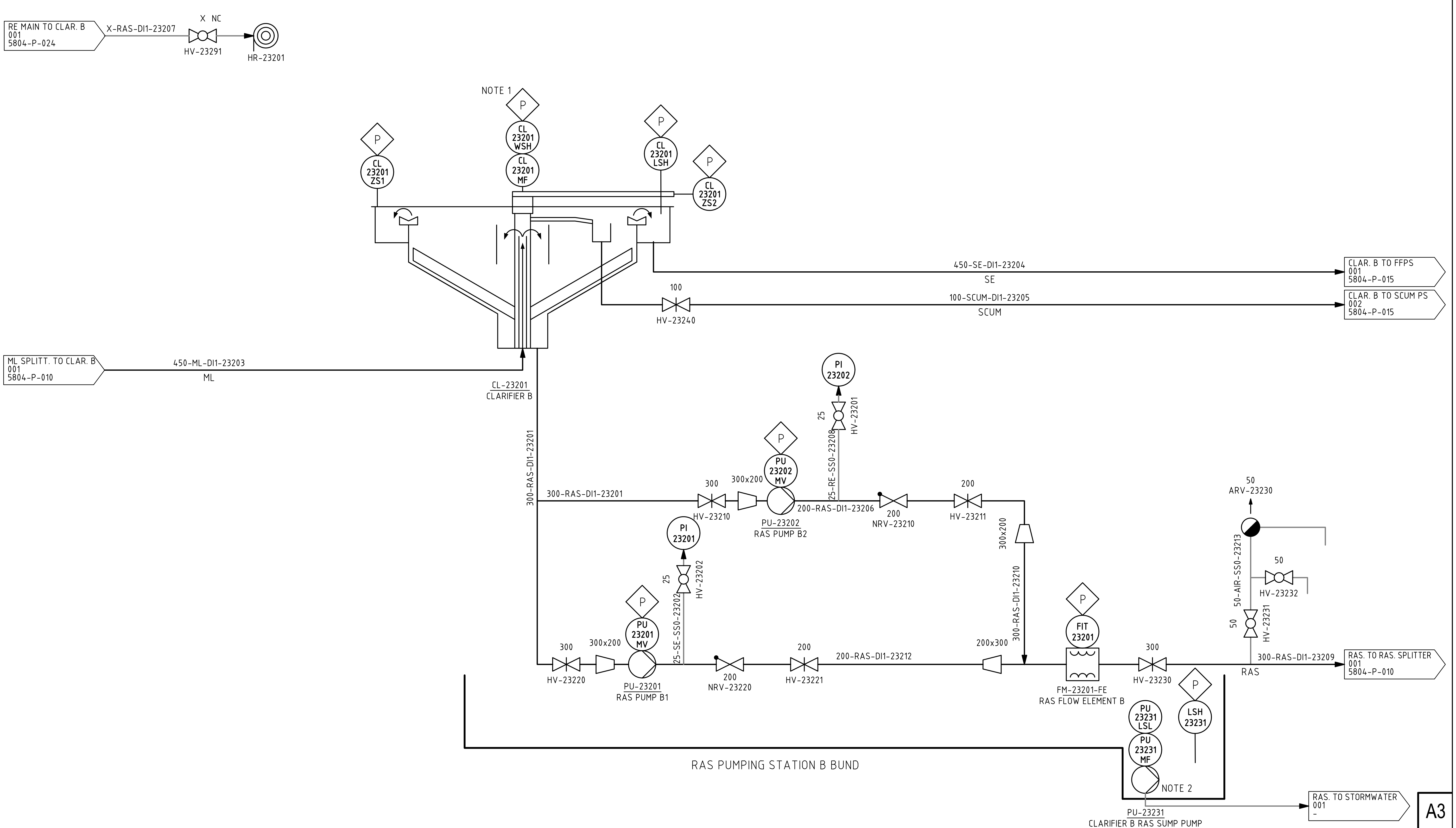
Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
CLARIFIER A

Scale: N.T.S. at A3
Document No: 5804- P - 013
Status: TENDER
Version: C

Plot Date: 10/08/21 - 13:41 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-013 - CLARIFIER A.dwg

NOTES:
1. INCLUDE MECHANICAL VARIATOR
2. SELF CONTAINED 240V SUMP PUMP WITH FLOAT SWITCH



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AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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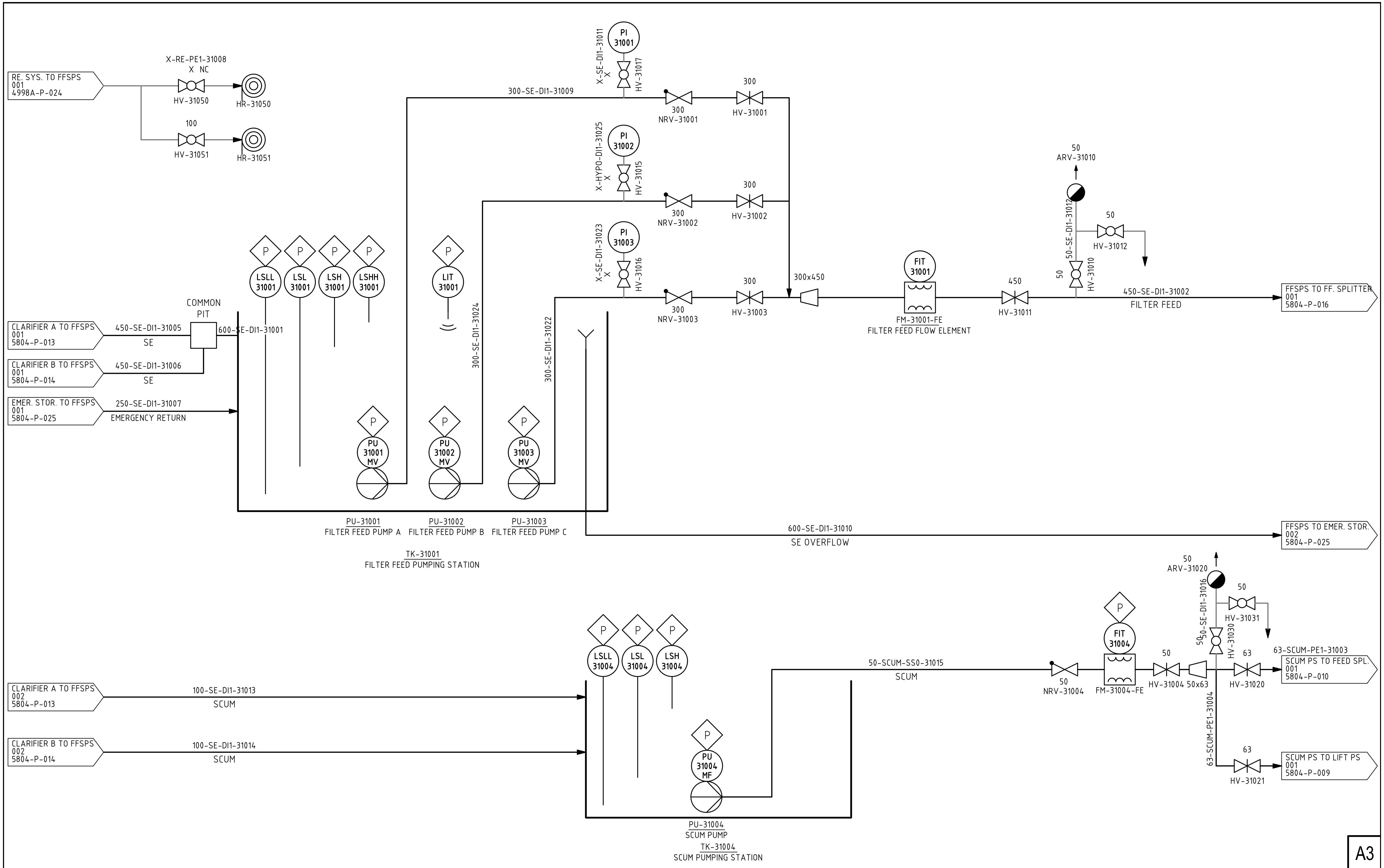
Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
CLARIFIER B

Scale N.T.S. at A3
Document No **5804- P - 014**
Status **TENDER**
Version **C**

Plot Date: 10/08/21 - 13:41 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-014 - CLARIFIER B.dwg



A3

AMENDMENTS

Ver	Date	Description	Drawn
C	10/08/21	REVISED DRAFT	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA

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Designed MC	Checked AR
Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
FILTER FEED PS & SCUM PS

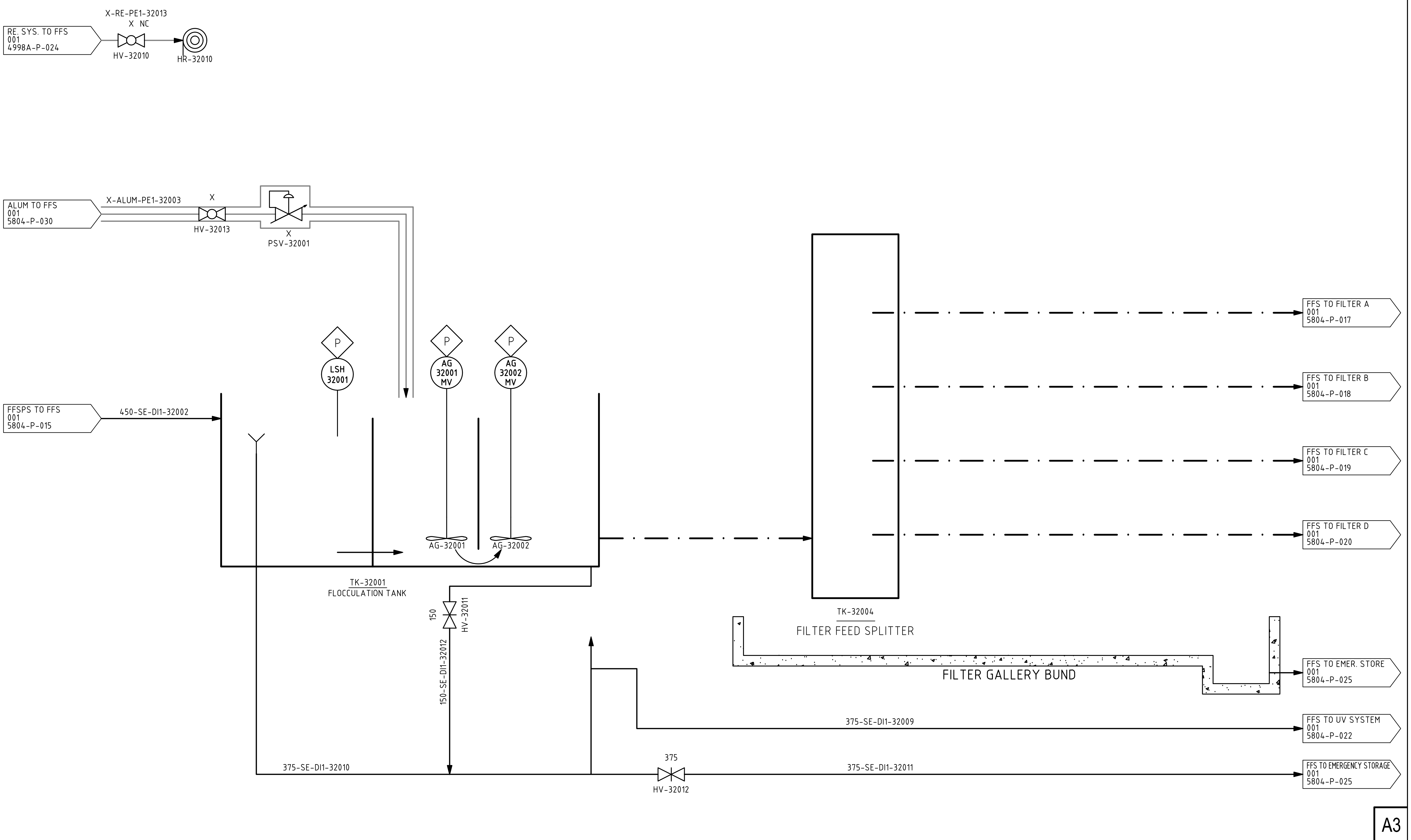
Scale N.T.S. at A3

Document No **5804- P - 015**

Status **TENDER**

Version **C**

Plot Date: 10/08/21 - 13:42 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-015 - FILTER FEED PS & SCUM PS.dwg



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AMENDMENTS

Ver	Date	Description	Drawn
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA

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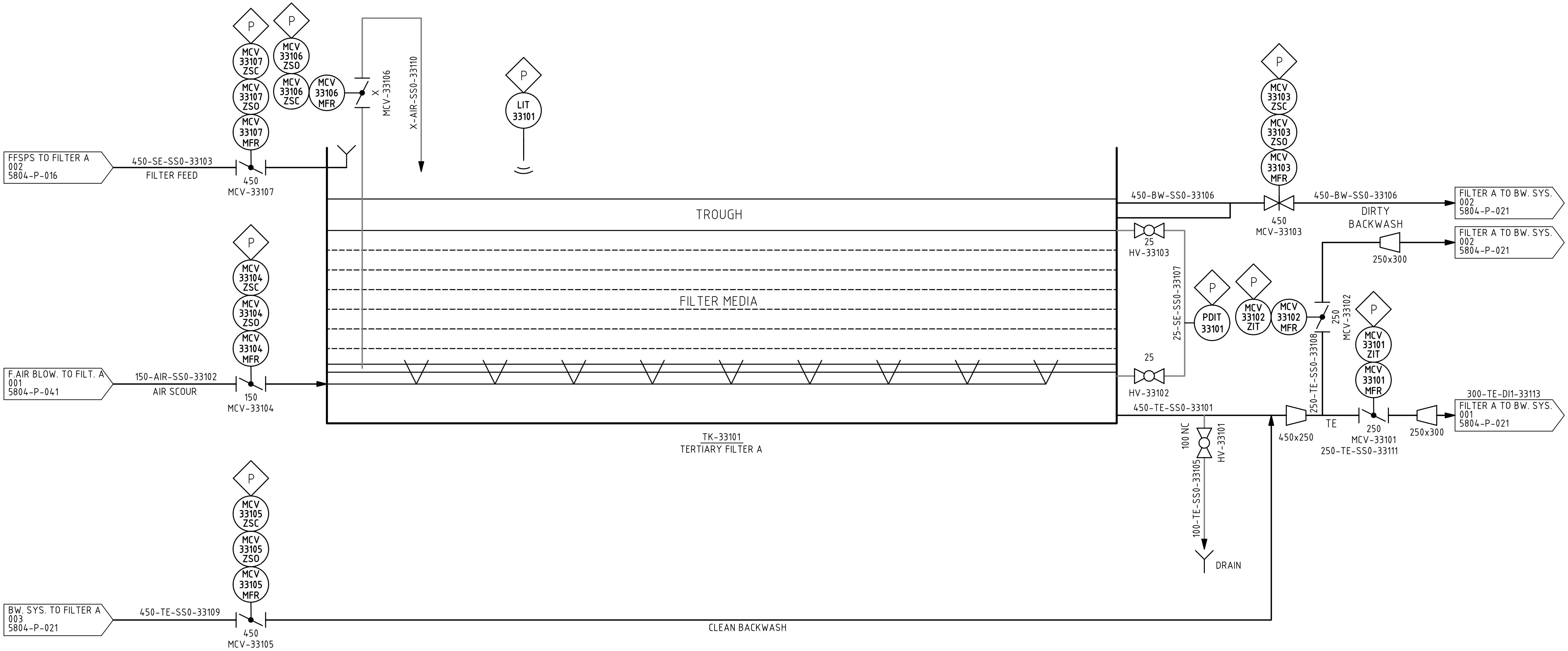
Designed MC	Checked AR
Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
FILTER FEED SPITTER

Scale: N.T.S. at A3
Document No: **5804- P - 016**
Status: **TENDER**
Version: **C**

Plot Date: 10/08/21 - 13:42 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-016 - FILTER FEED SPLITTER.dwg



A3

AMENDMENTS			
C	10/08/21	REVISED DRAFT	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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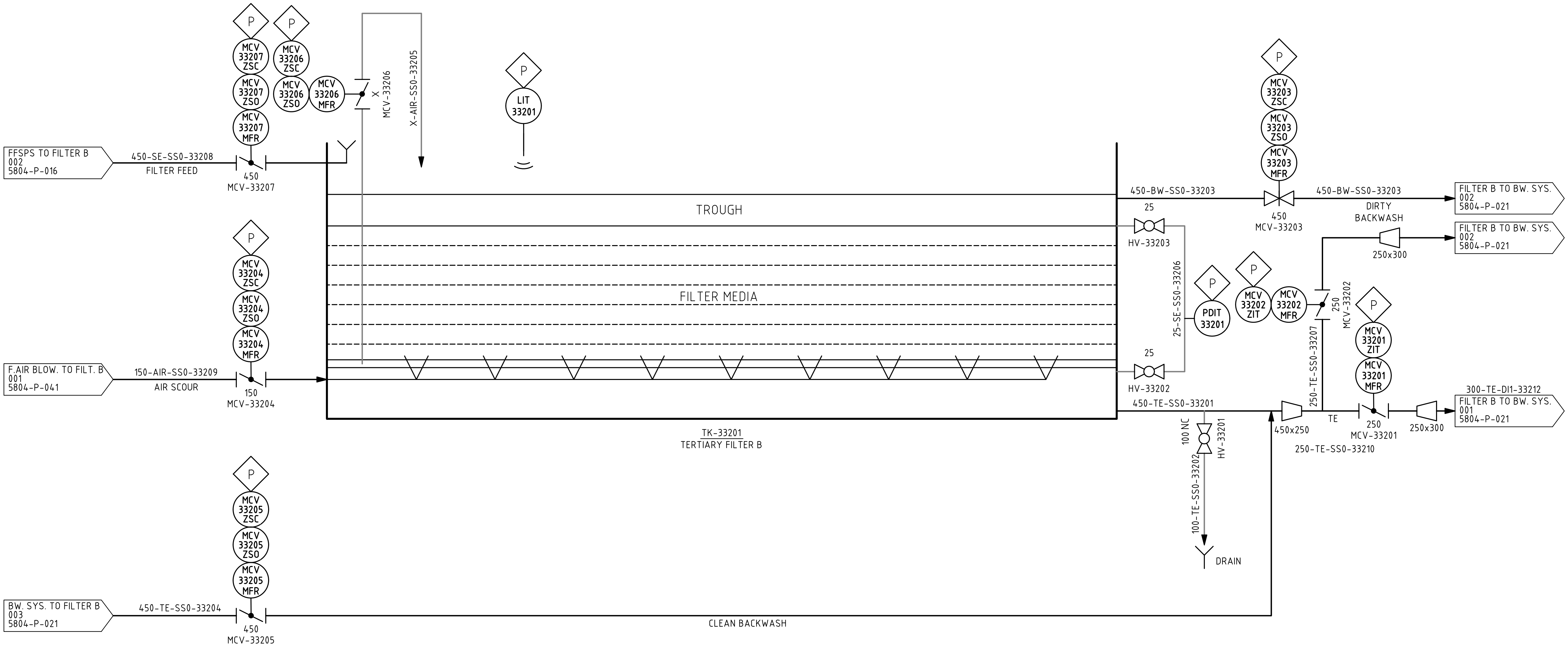
Designed MC	Checked AR
Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
TERTIARY FILTER A

Scale N.T.S. at A3
Document No 5804- P - 017
Status **TENDER**
Version C

Plot Date: 10/08/21 - 13:43 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-017 - TERTIARY FILTER A.dwg



A3

AMENDMENTS

Ver	Date	Description	Drawn
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA

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Designed MC	Checked AR
Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

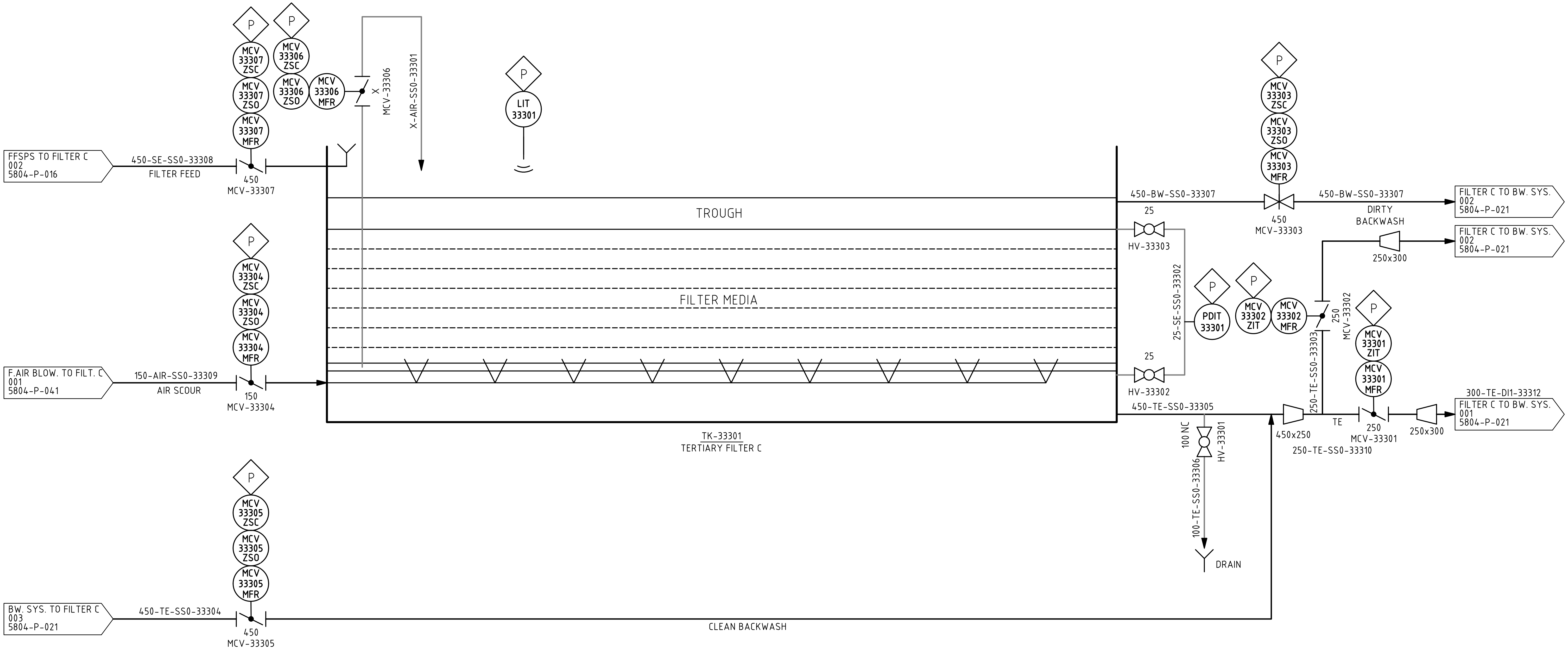
Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
TERTIARY FILTER B

Scale	Document No
N.T.S. at A3	5804- P - 018

Status	Version
TENDER	C

Plot Date: 10/08/21 - 13:43 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-018 - TERTIARY FILTER B.dwg



AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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ABN 16 602 201 552

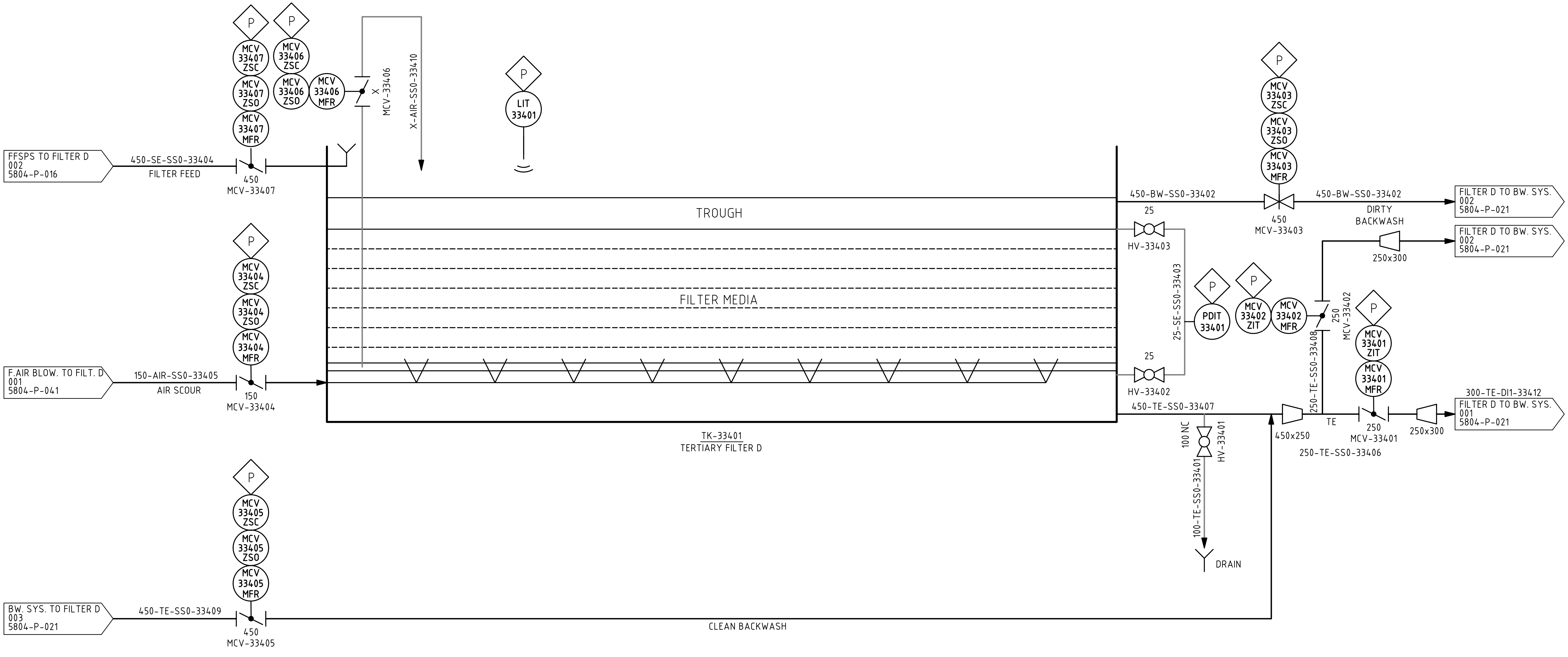
Designed MC	Checked AR
Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
TERTIARY FILTER C

Scale	Document No
N.T.S. at A3	5804- P - 019
Status: TENDER	Version: C

Plot Date: 10/08/21 - 13:44 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-019 - TERTIARY FILTER C.dwg



A3

AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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Designed MC	Checked AR
Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
TERTIARY FILTER D

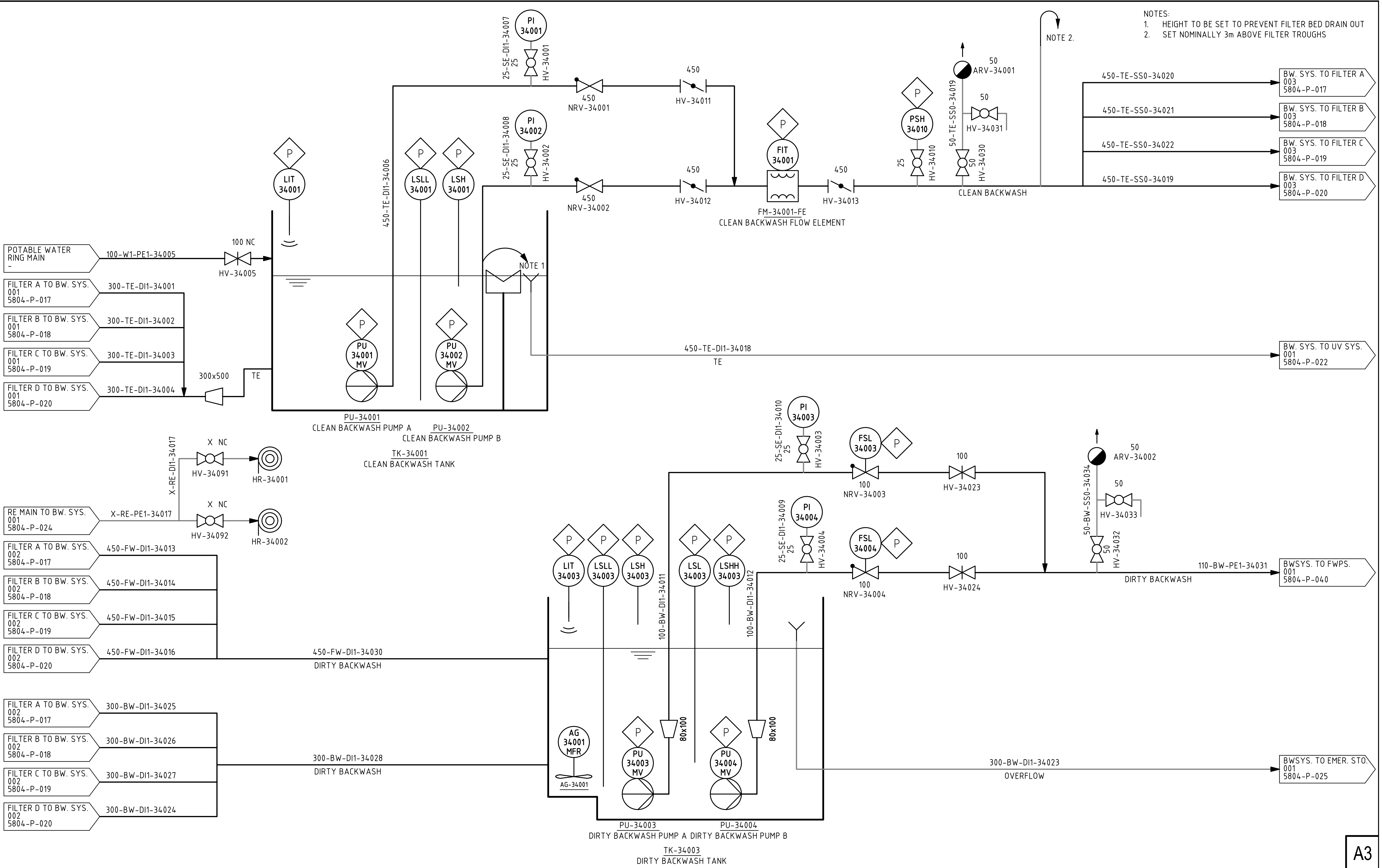
Scale N.T.S. at A3

Document No **5804- P - 020**

Status **TENDER**

Version **C**

Plot Date: 10/08/21 - 13:44 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-020 - TERTIARY FILTER D.dwg



A3

AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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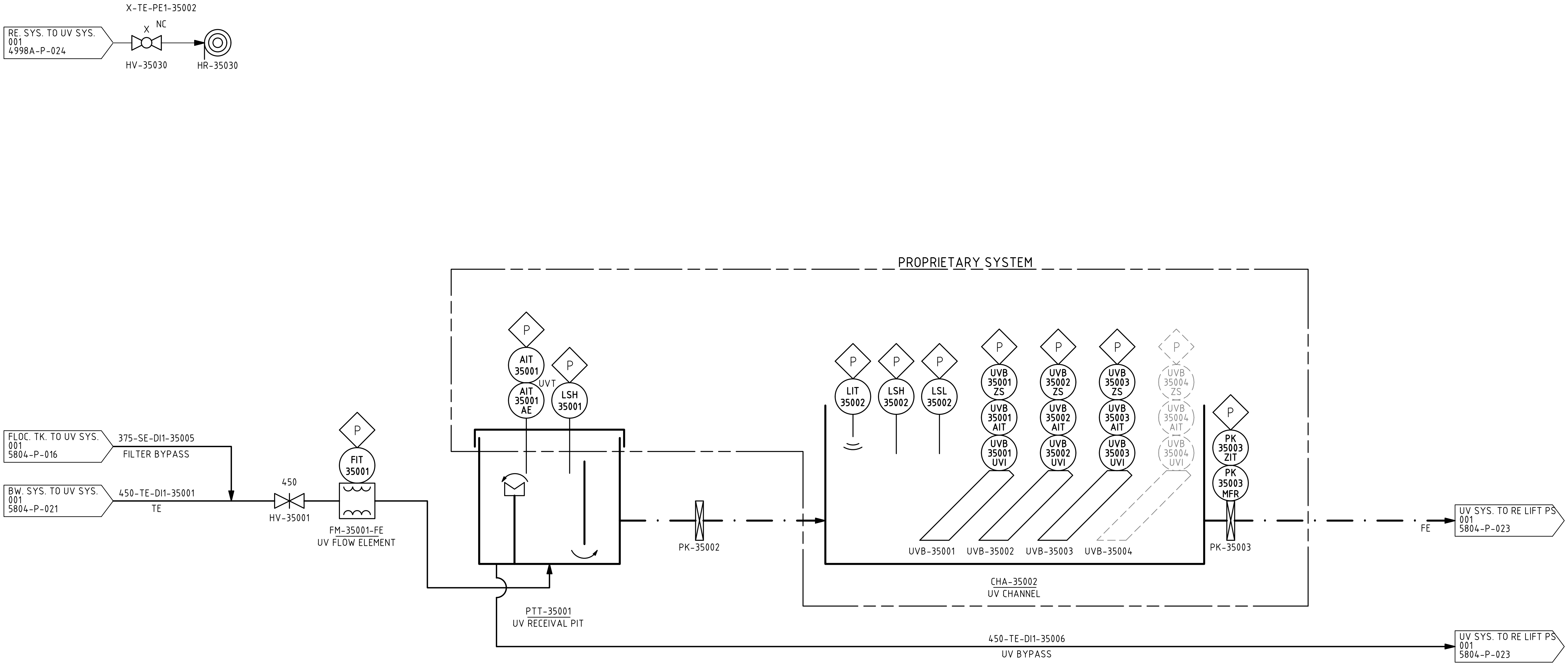
Designed MC	Checked AR
Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
BACKWASH SYSTEM

Scale N.T.S. at A3
Document No **5804- P - 021**
Status **TENDER**
Version **C**

Plot Date: 10/08/21 - 13:45 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-021 - BACKWASH SYSTEM.dwg



A3

AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

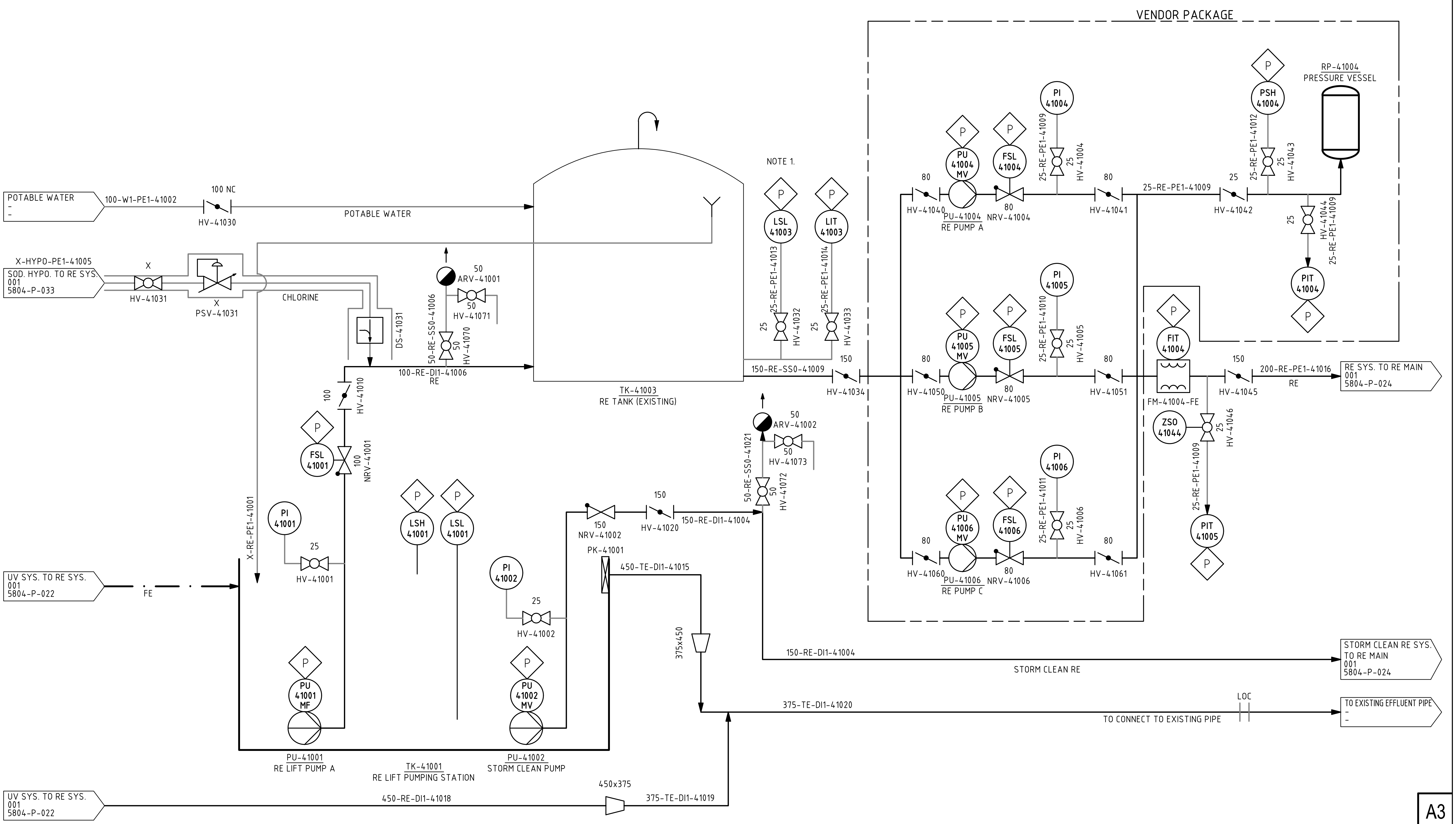
Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
UV SYSTEM

Scale	Document No
N.T.S. at A3	5804- P - 022
Status: TENDER	Version: C

Plot Date: 10/08/21 - 13:45 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-022 - UV SYSTEM.dwg

NOTES:
1. THE PRESSURE INSTRUMENTS ON THE RE TANK ACT AS LEVEL INSTRUMENTS.



A3

AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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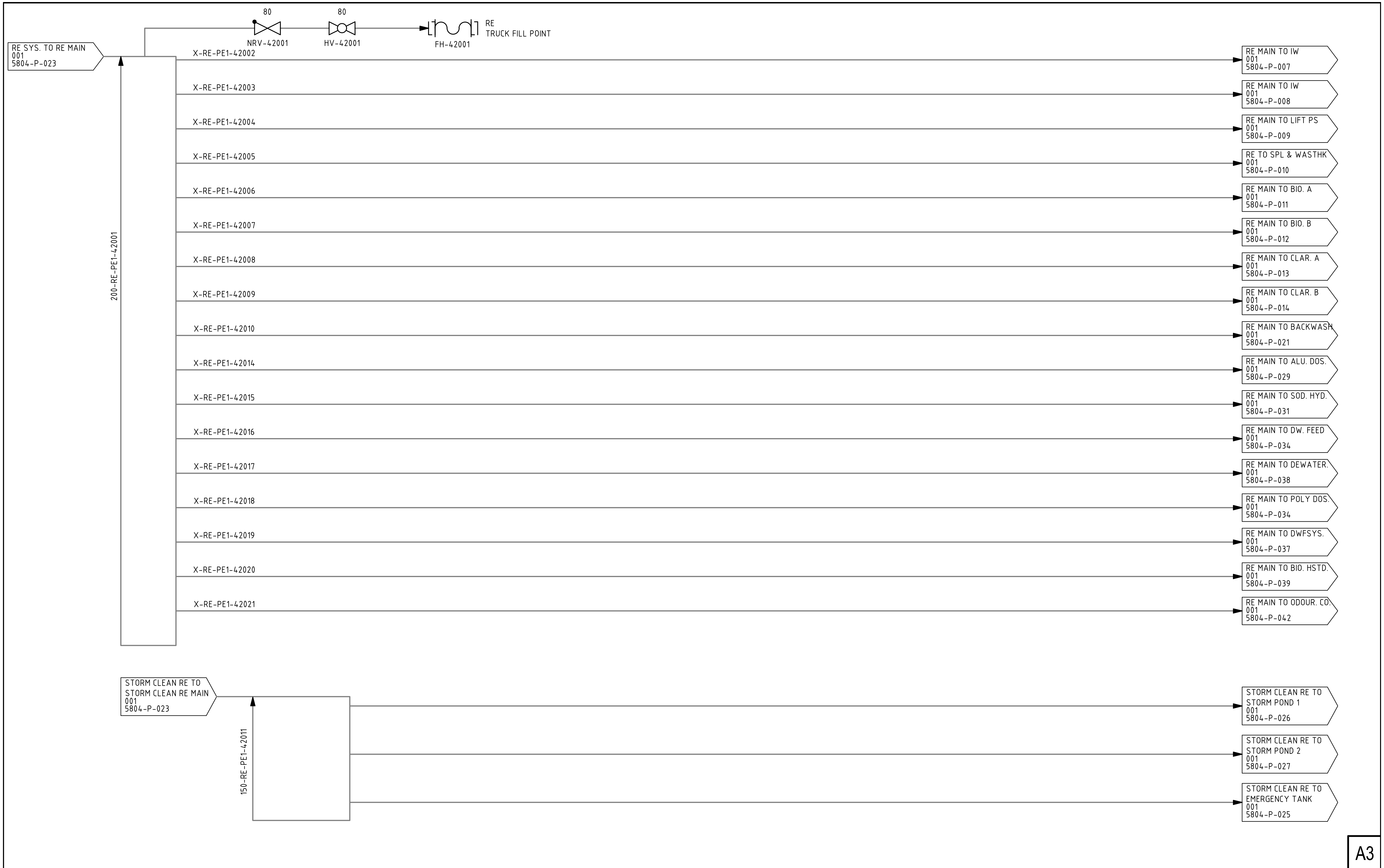
Approved	J.L.SMITH		
Date	10/08/21		
HH2O Project Number	5804		

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
RE SYSTEM

Scale: N.T.S. at A3
Document No: 5804- P - 023
Status: TENDER
Version: C

Plot Date: 10/08/21 - 13:46 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-023 - RE SYSTEM.dwg



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AMENDMENTS

Ver	Date	Description	Drawn
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA

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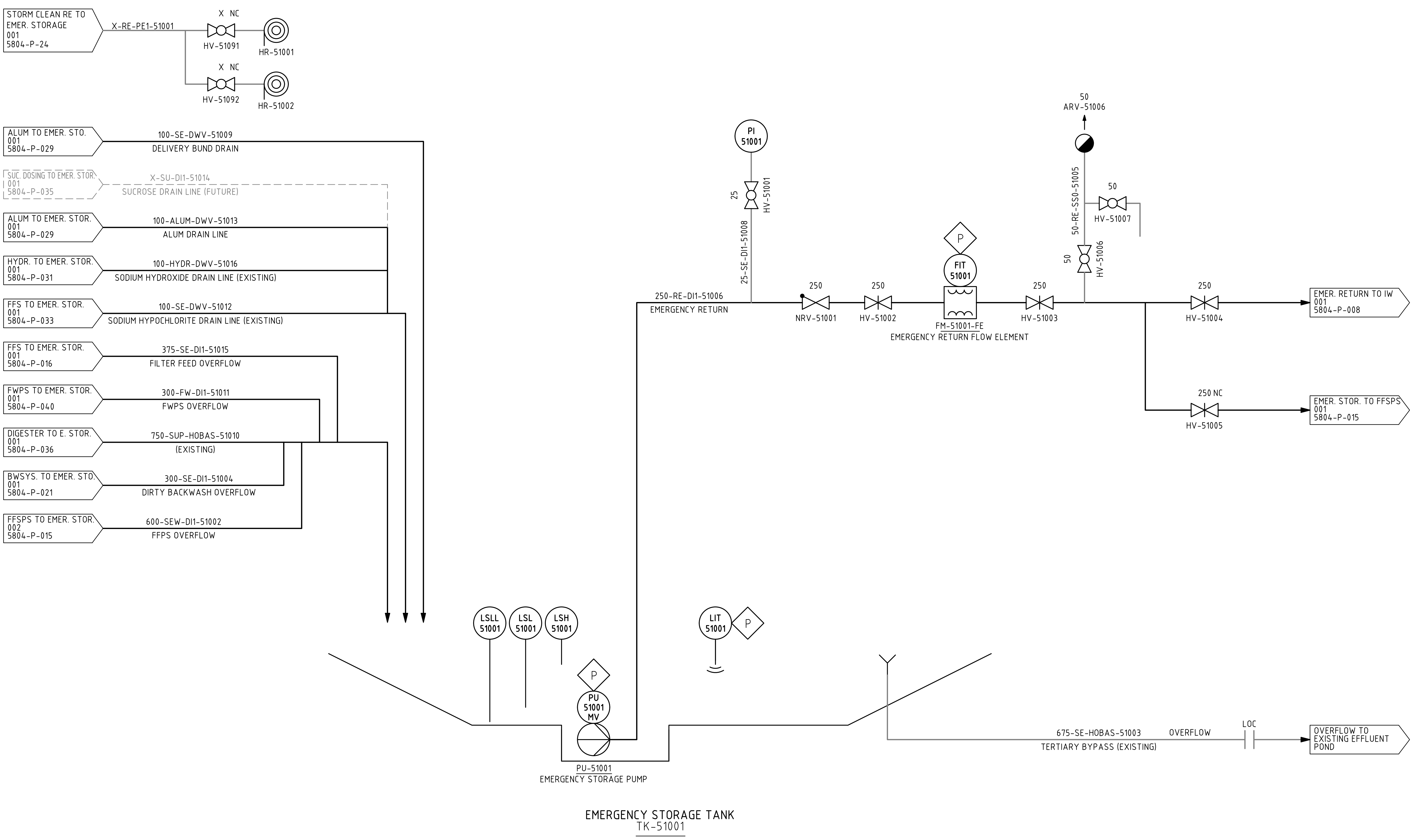
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
RE RING MAIN AND
STORM CLEAN RE MAIN

Scale: N.T.S. at A3
Document No: 5804- P - 024
Status: **TENDER**
Version: **C**

Plot Date: 10/08/21 - 13:46 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-024 - RE RING MAIN.dwg



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AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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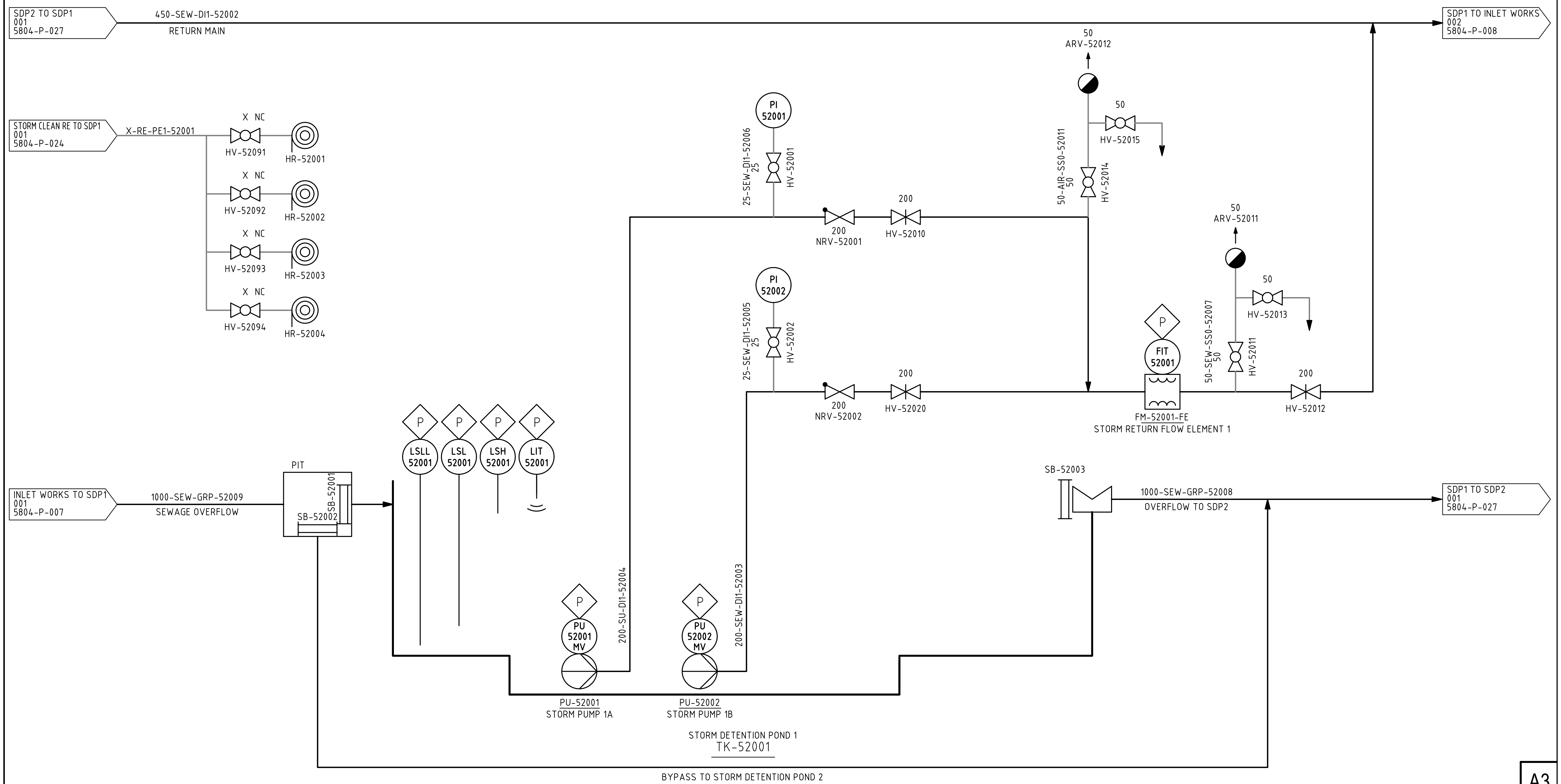
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
EMERGENCY STORAGE

Scale: N.T.S. at A3	Document No: 5804- P - 025
Status: TENDER	Version: C

Plot Date: 10/08/21 - 13:47 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-025 - EMERGENCY STORAGE.dwg



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AMENDMENTS

Ver	Date	Description	Drawn
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA

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Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
STORM DETENTION POND 1

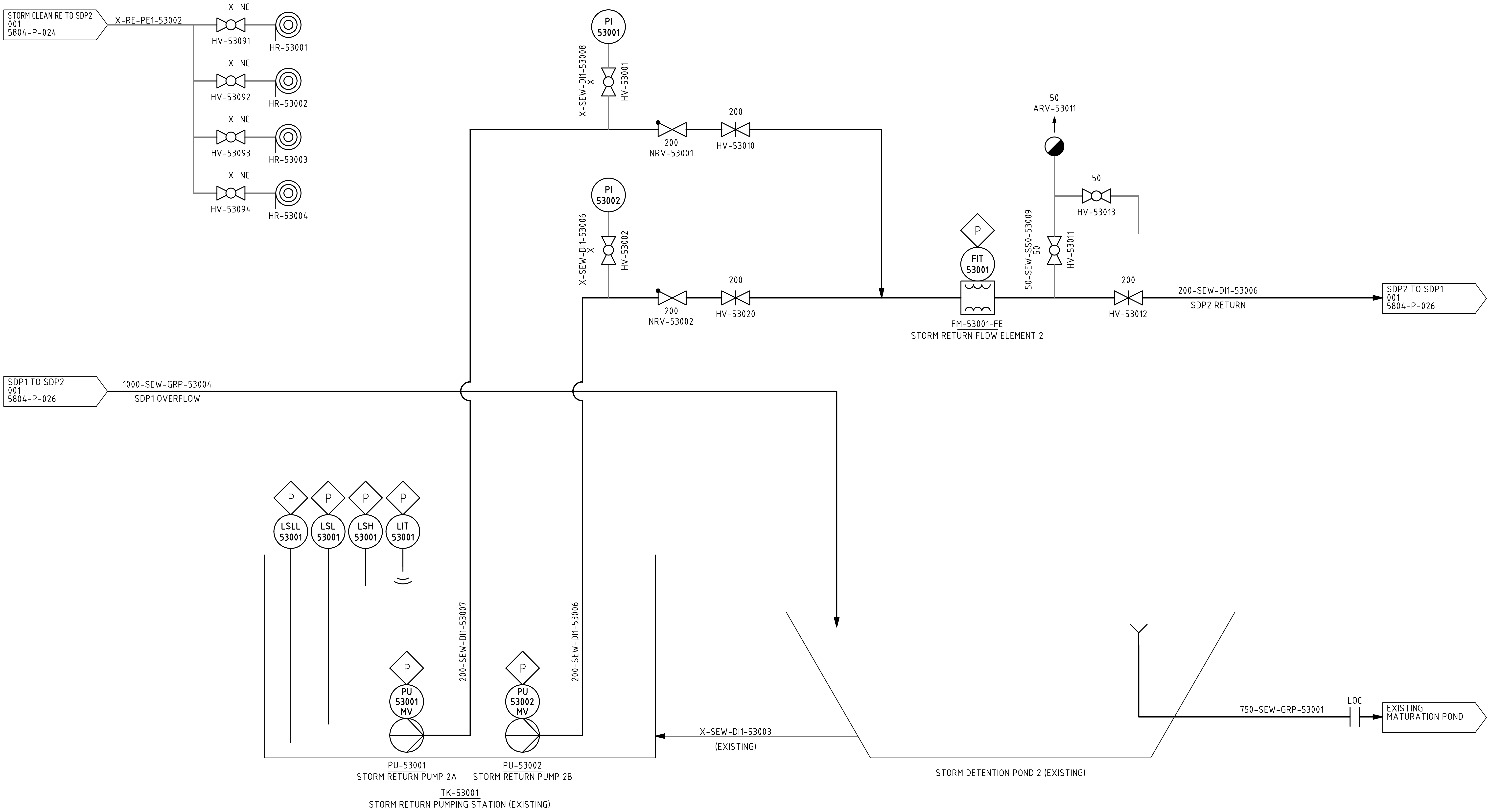
Scale N.T.S. at A3

Document No **5804- P - 026**

Status **TENDER**

Version **C**

Plot Date: 10/08/21 - 13:47 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-026 - STORM DETENTION POND 1.dwg



A3

AMENDMENTS

Ver	Date	Description	Drawn
B	10/08/21	TENDER	RR
A	01/09/20	DRAFT	MA

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HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
STORM RETURN PS & DETENTION POND 2

Scale: N.T.S. at A3

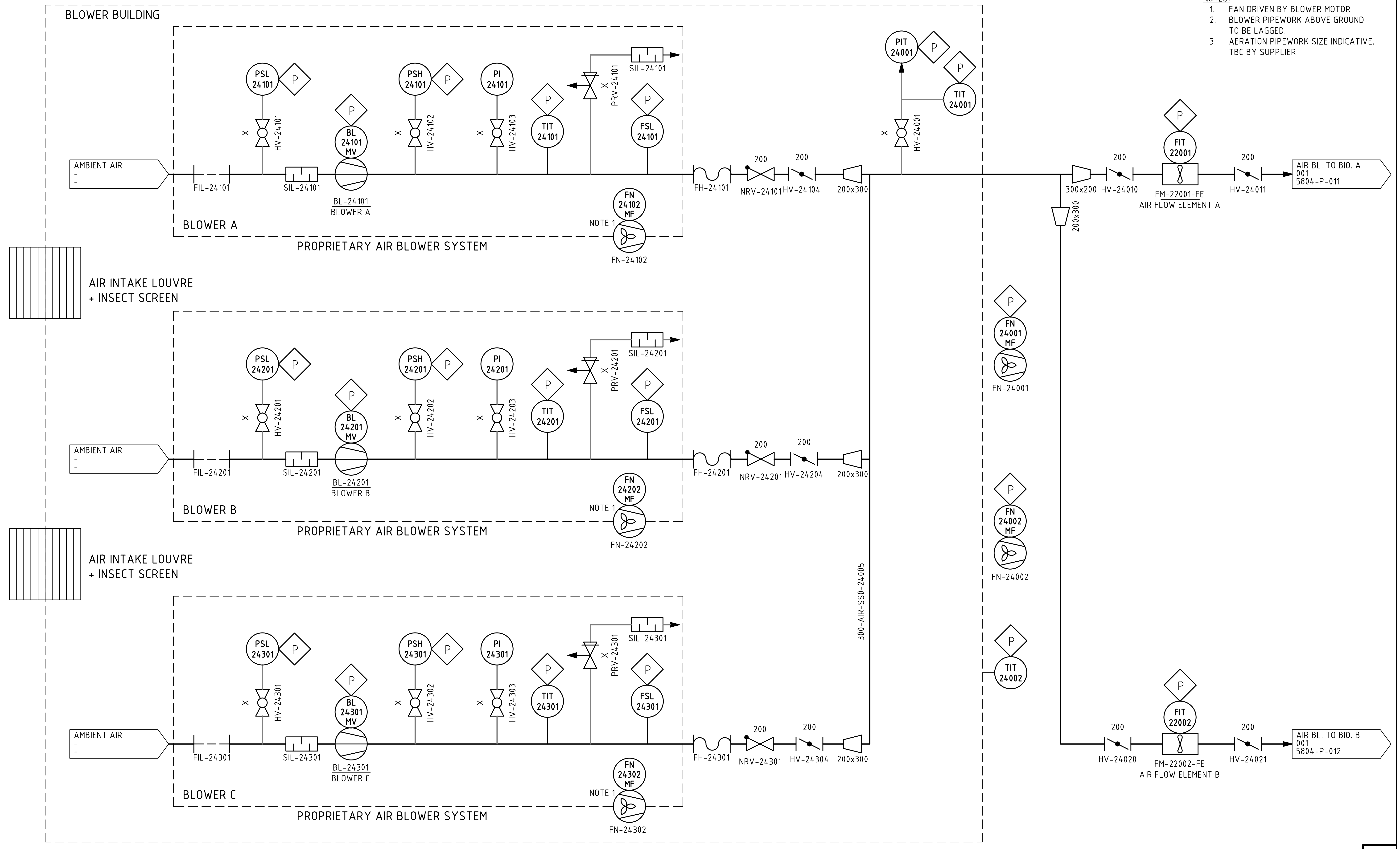
Document No: 5804- P - 027

Status: **TENDER**

Version: **B**

Plot Date: 10/08/21 - 13:48 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-027 - STORM RETURN PS & DETENTION POND 2.dwg

NOTES:
1. FAN DRIVEN BY BLOWER MOTOR
2. BLOWER PIPEWORK ABOVE GROUND TO BE LAGGED.
3. AERATION PIPEWORK SIZE INDICATIVE. TBC BY SUPPLIER



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AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

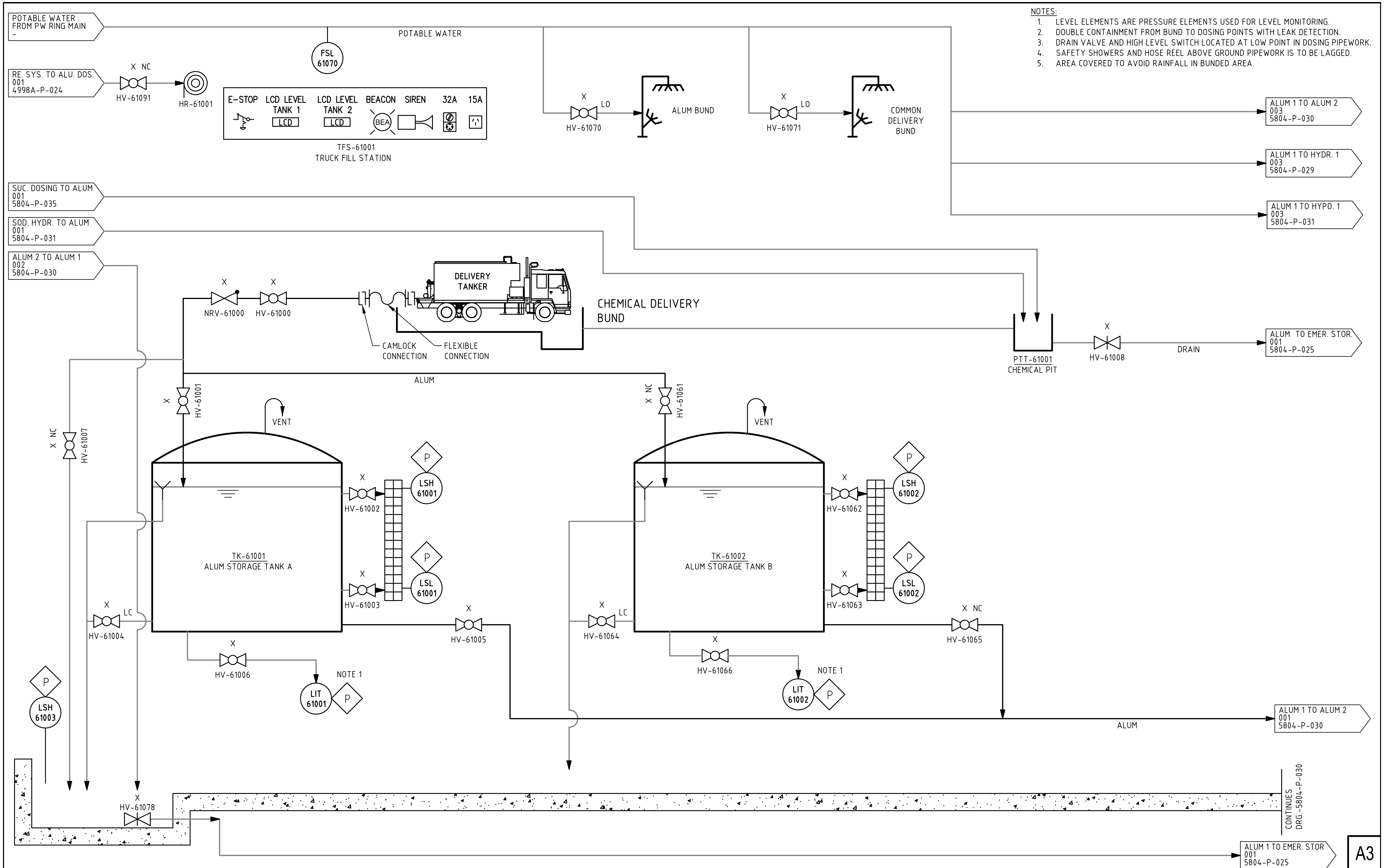
Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
BIOREACTOR AIR BLOWERS

Scale N.T.S. at A3
Document No **5804- P - 028**
Status **TENDER**
Version **C**

Plot Date: 10/08/21 - 13:48 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-028 - BIOREACTOR AIR BLOWERS.dwg

NOTES:
1. LEVEL ELEMENTS ARE PRESSURE ELEMENTS USED FOR LEVEL MONITORING.
2. DOUBLE CONTAINMENT FROM BUND TO DOSING POINTS WITH LEAK DETECTION.
3. DRAIN VALVE AND HIGH LEVEL SWITCH LOCATED AT LOW POINT IN DOSING PIPEWORK.
4. SAFETY SHOWERS AND HOSE REEL ABOVE GROUND PIPEWORK IS TO BE LAGGED.
5. AREA COVERED TO AVOID RAINFALL IN BUNDED AREA.



AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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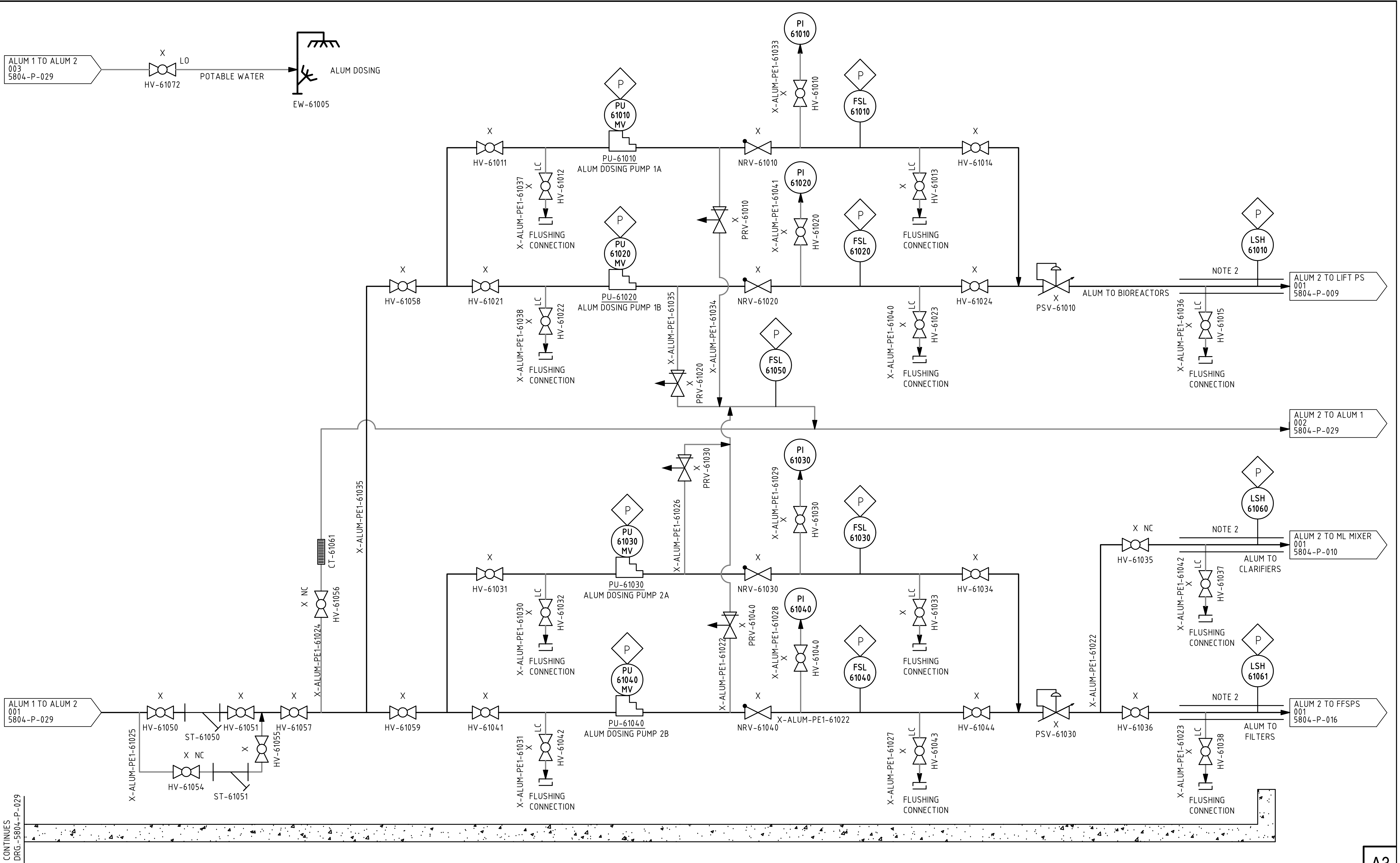
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
ALUM DOSING SYSTEM
SHEET 1 OF 2

Scale N.T.S. at A3
Document No **5804- P - 029**
Status **TENDER**
Version **C**

Plot Date: 10/08/21 - 13:49 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-029 - ALUM DOSING SYSTEM 1.dwg



A3

AMENDMENTS			
B	10/08/21	TENDER	RR
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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Designed MC	Checked AR
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Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

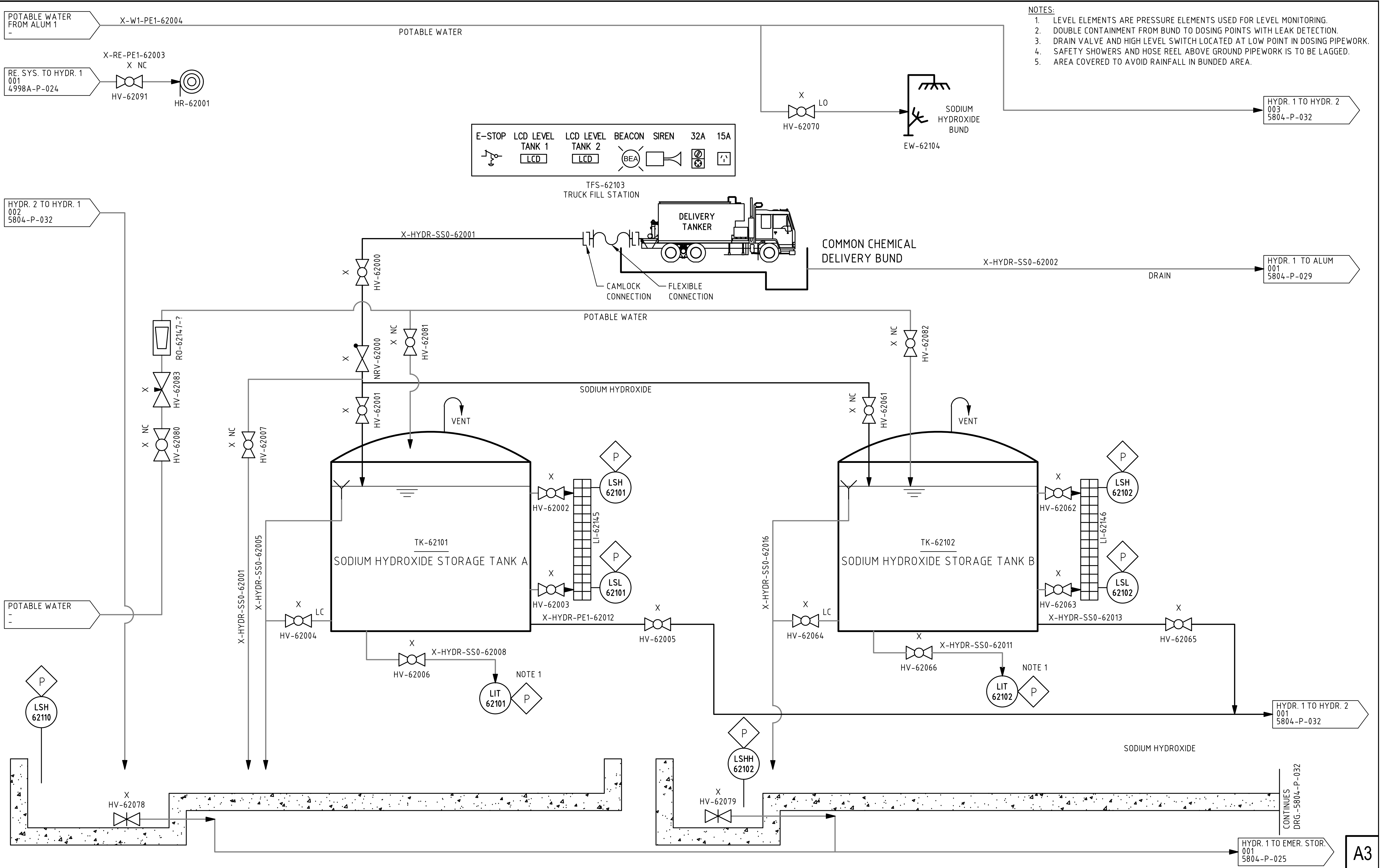
Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
ALUM DOSING SYSTEM
SHEET 2 OF 2

Scale N.T.S. at A3
Document No 5804- P - 030
Status **TENDER**
Version **B**

Plot Date: 10/08/21 - 13:50 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-030 - ALUM DOSING SYSTEM 2.dwg

NOTES:
1. LEVEL ELEMENTS ARE PRESSURE ELEMENTS USED FOR LEVEL MONITORING.
2. DOUBLE CONTAINMENT FROM BUND TO DOSING POINTS WITH LEAK DETECTION.
3. DRAIN VALVE AND HIGH LEVEL SWITCH LOCATED AT LOW POINT IN DOSING PIPEWORK.
4. SAFETY SHOWERS AND HOSE REEL ABOVE GROUND PIPEWORK IS TO BE LAGGED.
5. AREA COVERED TO AVOID RAINFALL IN BUNDED AREA.



AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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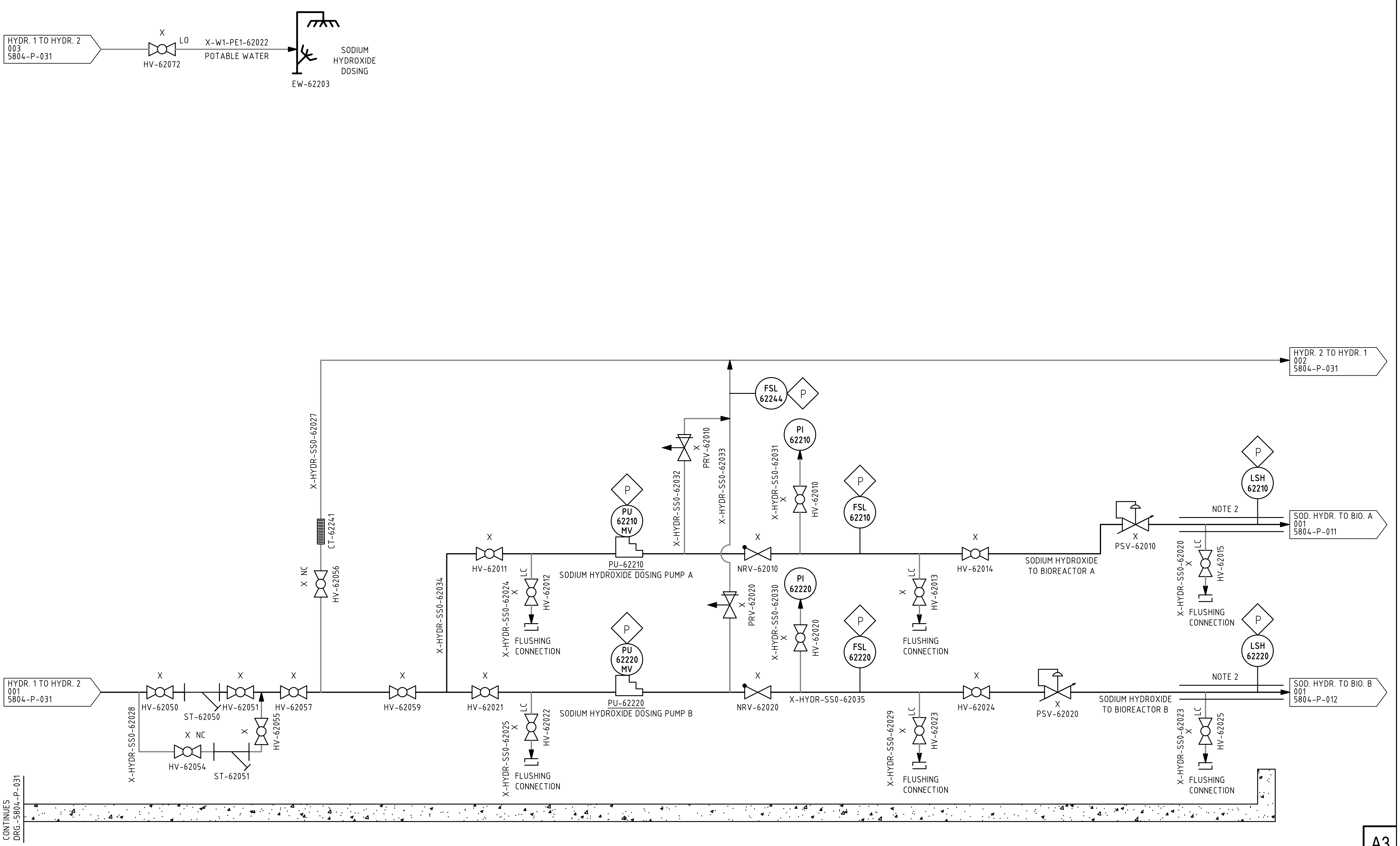
Approved	J.L.SMITH		
Date	10/08/21		
HH2O Project Number	5804		

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
SODIUM HYDROXIDE DOSING SYSTEM
SHEET 1 OF 2

Scale: N.T.S. at A3
Document No: 5804- P - 031
Status: **TENDER**
Version: C

Plot Date: 10/08/21 - 13:50 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-031 - SODIUM HYDROXIDE DOSING SYSTEM 1.dwg



A3

AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
SODIUM HYDROXIDE DOSING SYSTEM
SHEET 2 OF 2

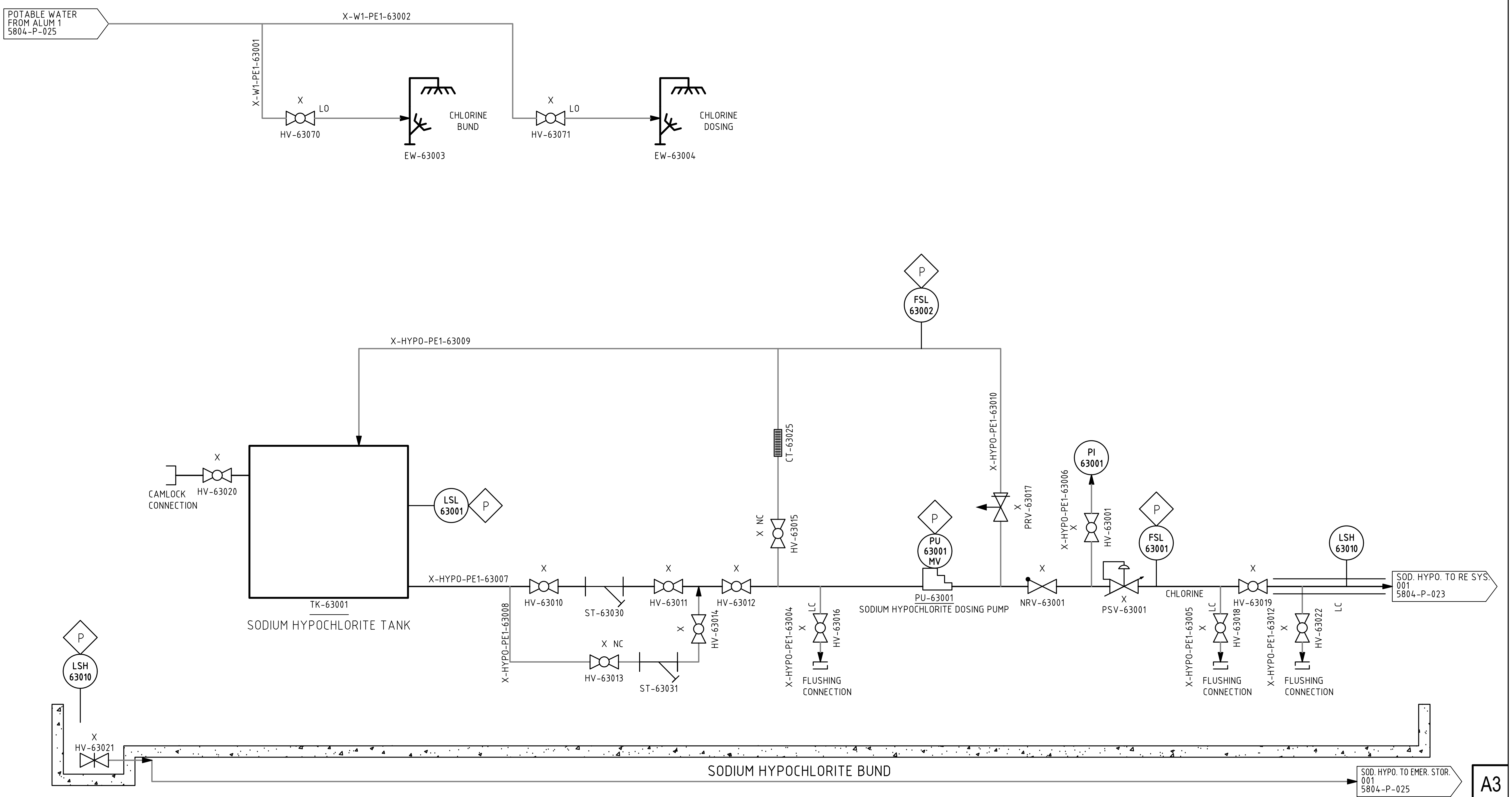
Scale N.T.S. at A3

Document No 5804- P - 032

Status **TENDER**

Version C

Plot Date: 10/08/21 - 13:51 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-032 - SODIUM HYDROXIDE DOSING SYSTEM 2.dwg



A3

AMENDMENTS			
B	10/08/21	TENDER	RR
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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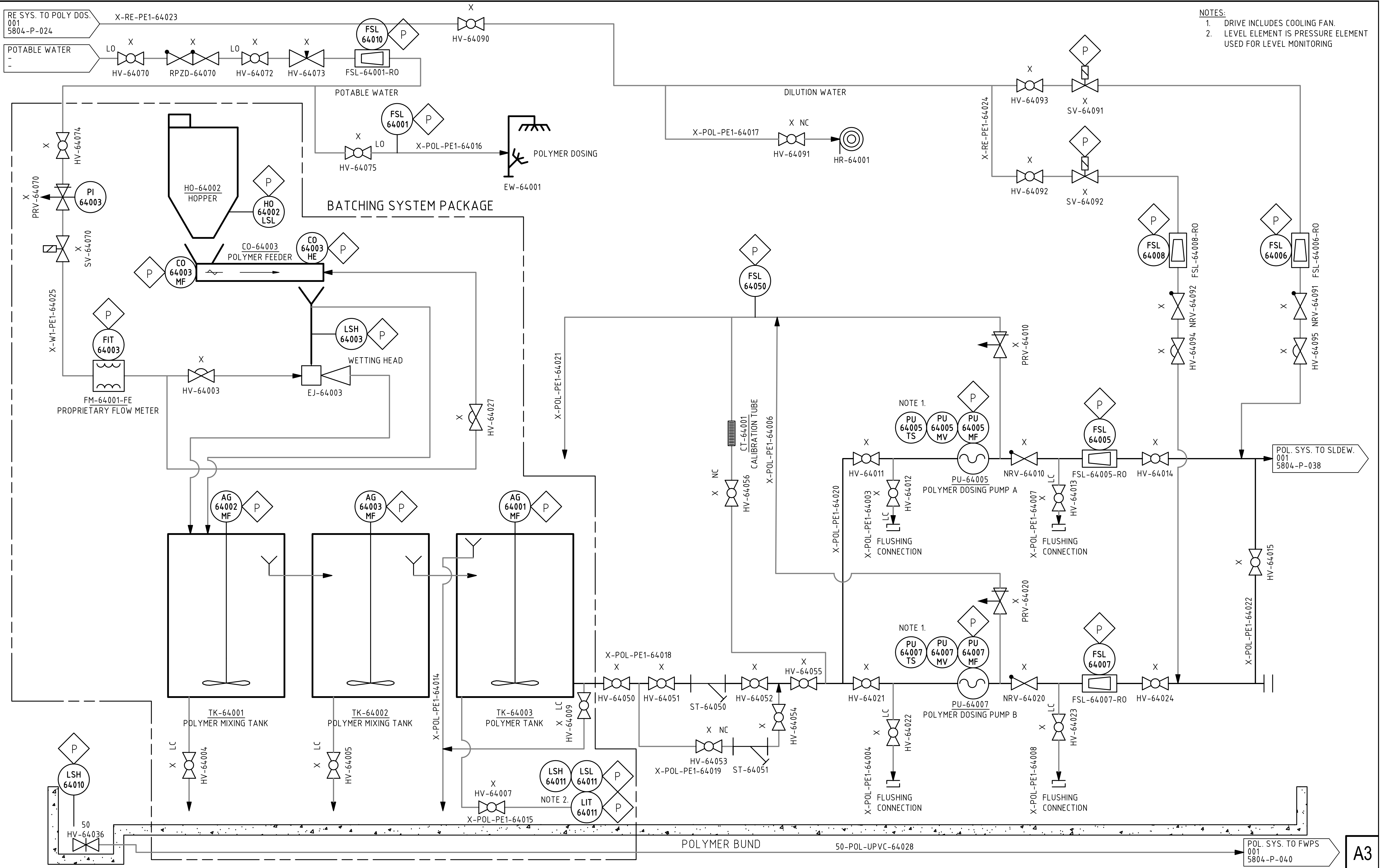
Designed MC	Checked AR
Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee
SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
SODIUM HYPOCHLORITE DOSING SYSTEM

Scale	Document No
N.T.S. at A3	5804- P - 033
Status	Version
TENDER	B

Plot Date: 10/08/21 - 13:51 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-033 - SODIUM HYPOCHLORITE DOSING SYSTEM.dwg



AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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Designed	MC	Checked	AR
Drawn	MA	Checked	MC
Approved	J.L.SMITH		
Date	10/08/21		
HH2O Project Number	5804		

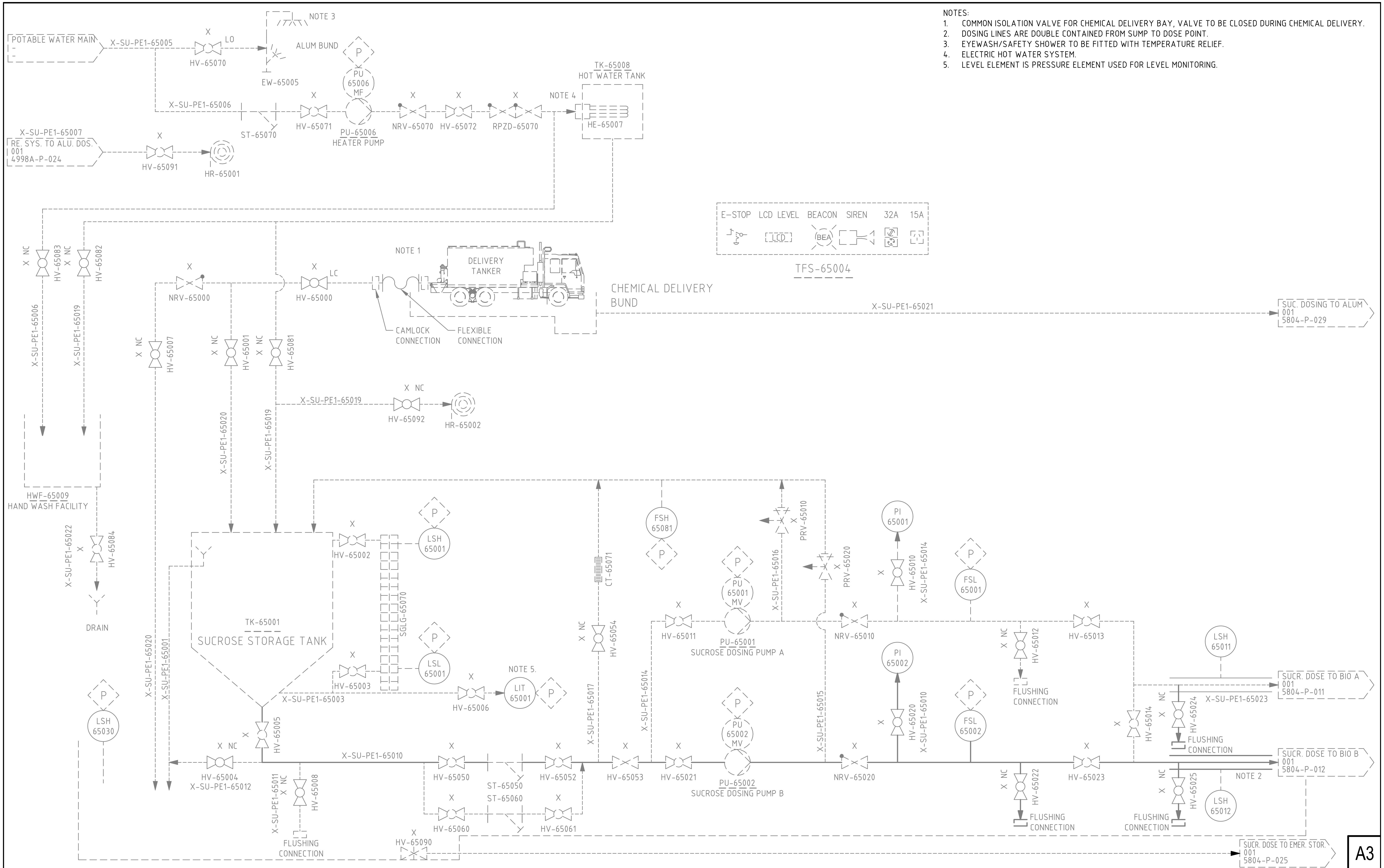
Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
POLYMER BATCHING AND DOSING SYSTEM

Scale	Document No
N.T.S. at A3	5804- P - 034
Status	Version
TENDER	C

Plot Date: 10/08/21 - 13:52 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-034 - POLYMER DOSING SYSTEM.dwg

NOTES:
1. COMMON ISOLATION VALVE FOR CHEMICAL DELIVERY BAY, VALVE TO BE CLOSED DURING CHEMICAL DELIVERY.
2. DOSING LINES ARE DOUBLE CONTAINED FROM SUMP TO DOSE POINT.
3. EYEWASH/SAFETY SHOWER TO BE FITTED WITH TEMPERATURE RELIEF.
4. ELECTRIC HOT WATER SYSTEM.
5. LEVEL ELEMENT IS PRESSURE ELEMENT USED FOR LEVEL MONITORING.



A3

AMENDMENTS			
B	10/08/21	TENDER	RR
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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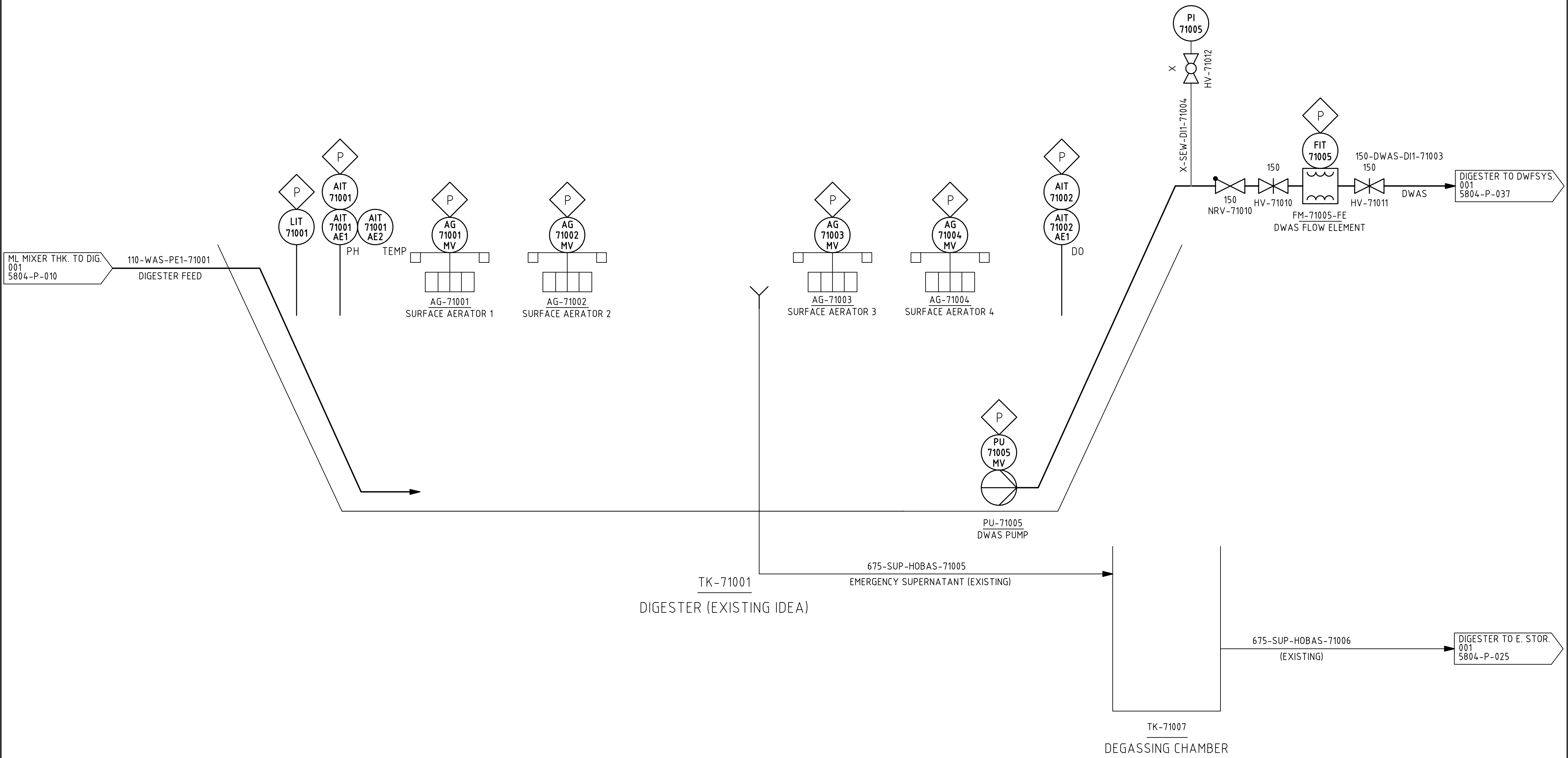
Drawn	MA	Checked	MC
Approved	J.L.SMITH		
Date	10/08/21		
HH2O Project Number	5804		

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
SUCROSE DOSING SYSTEM (FUTURE)

Scale: N.T.S. at A3
Document No: 5804- P - 035
Status: TENDER
Version: B

Plot Date: 10/08/21 - 13:52 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-035 - SUCROSE DOSING SYSTEM.dwg



A3

AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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Designed MC	Checked AR
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Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

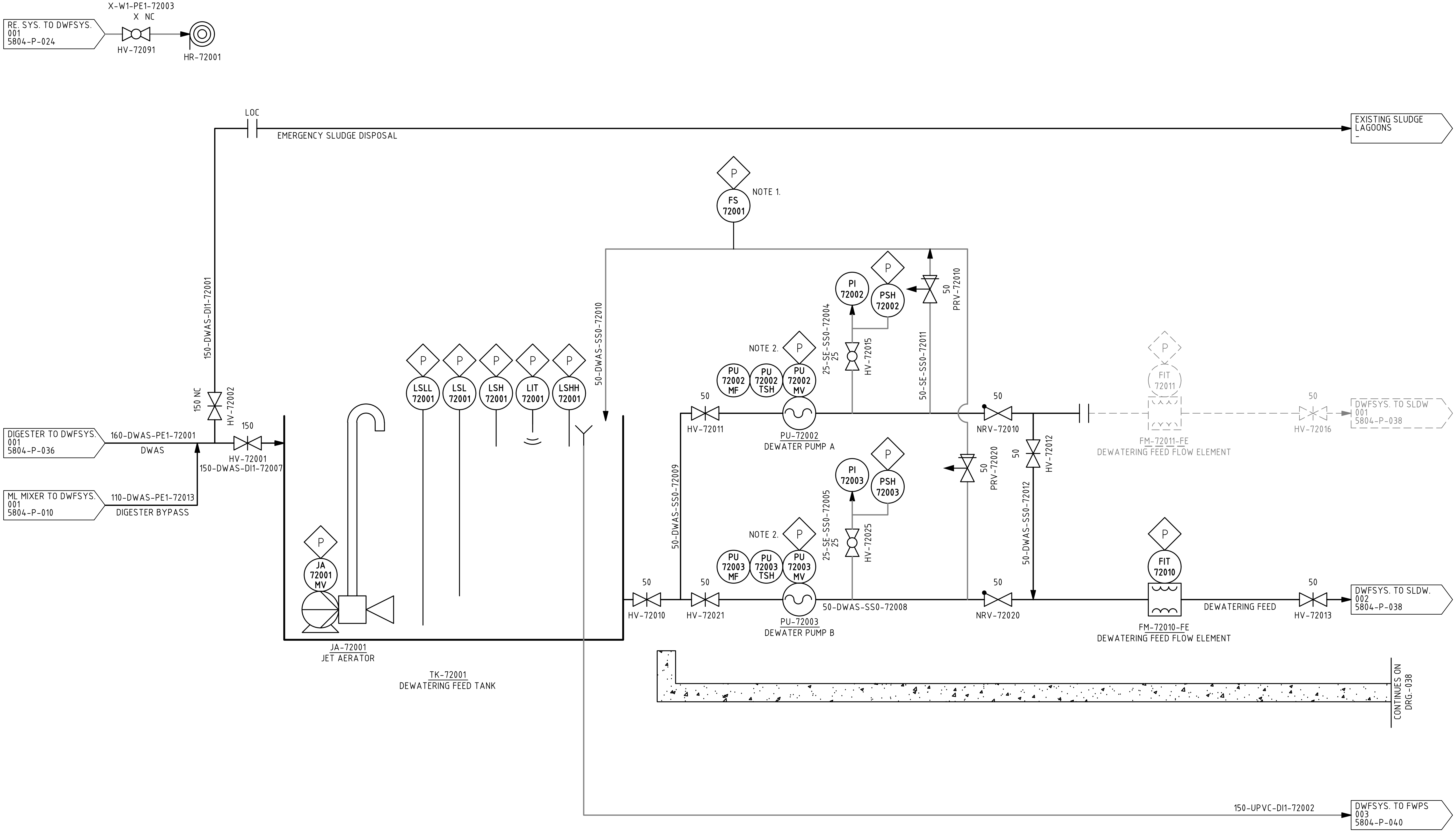
Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
DIGESTER

Scale N.T.S. at A3	Document No 5804- P - 036
Status **TENDER**	Version C

Plot Date: 10/08/21 - 13:53 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-036 - DIGESTER.dwg

NOTES:
1. SUBJECT TO SOURCING AN APPROPRIATE FLOW SWITCH.
2. DRIVE INCLUDES COOLING FAN.



A3

AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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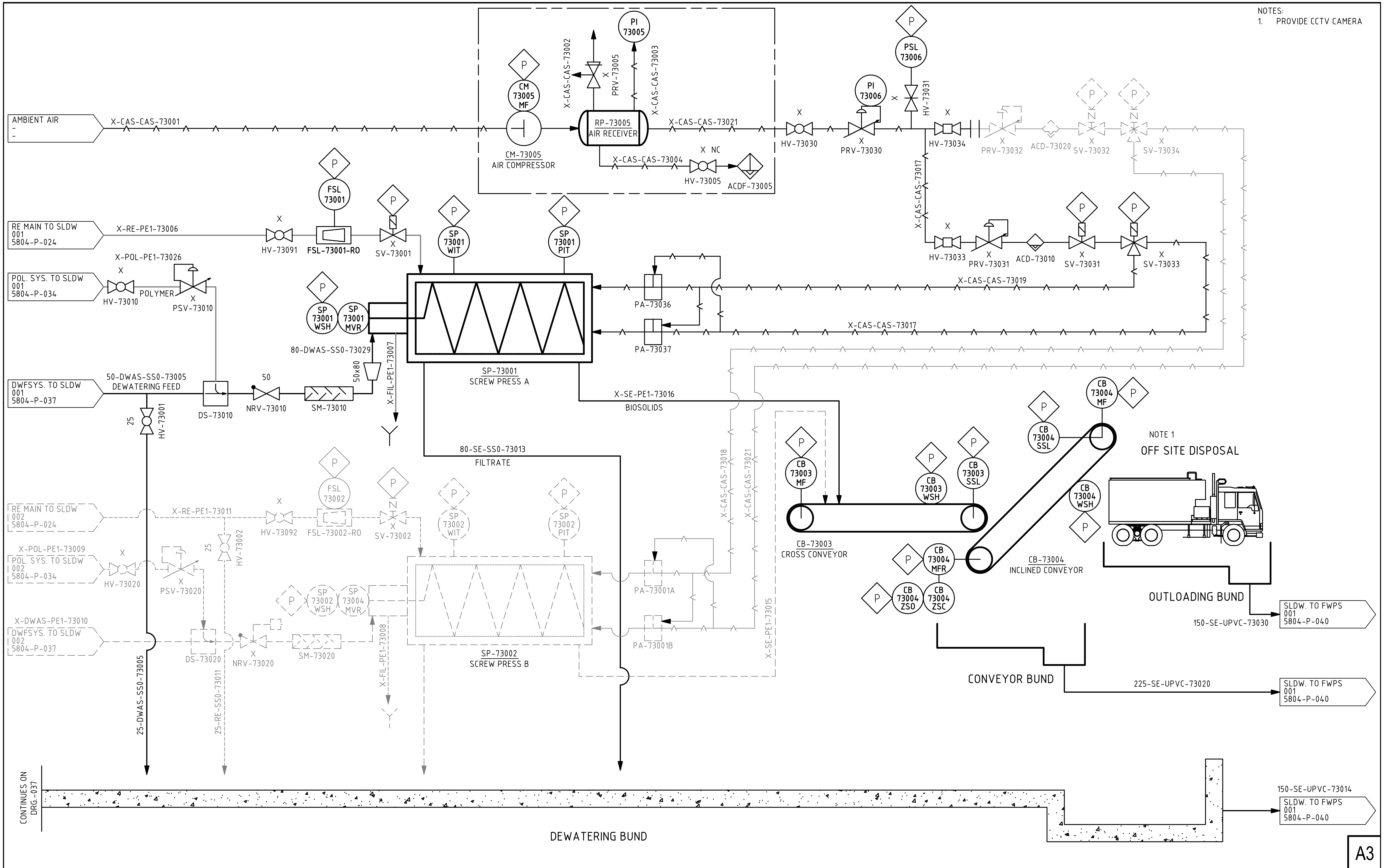
Drawn MA	Checked MC
Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
DEWATERING FEED SYSTEM

Scale	Document No
N.T.S. at A3	5804- P - 037
Status: TENDER	Version: C

Plot Date: 10/08/21 - 13:54 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-037 - DEWATERING FEED SYSTEM.dwg



AMENDMENTS

Ver	Date	Description	Drawn
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA

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HH2O Project Number 5804

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BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
SLUDGE DEWATERING

Scale N.T.S. at A3
Document No 5804- P - 038
Status **TENDER**
Version C

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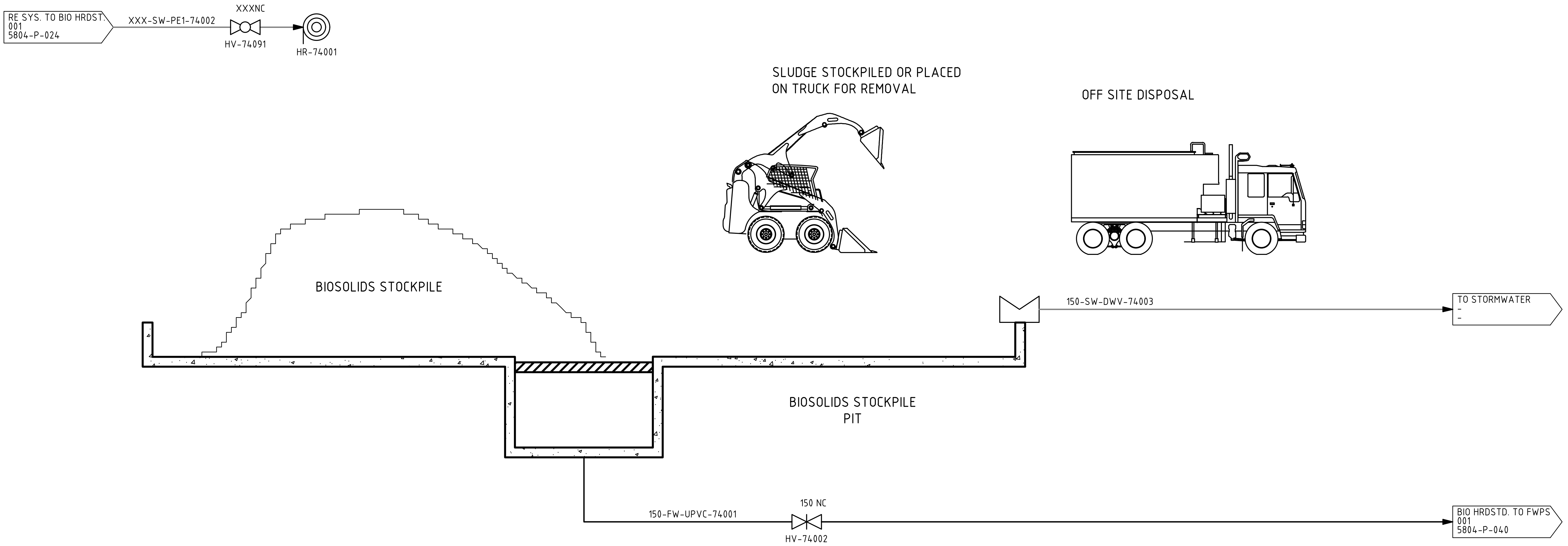

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AMENDMENTS

Ver	Date	Description	Drawn
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA

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Approved J.L.SMITH	
Date 10/08/21	
HH2O Project Number 5804	

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SHIRE COUNCIL

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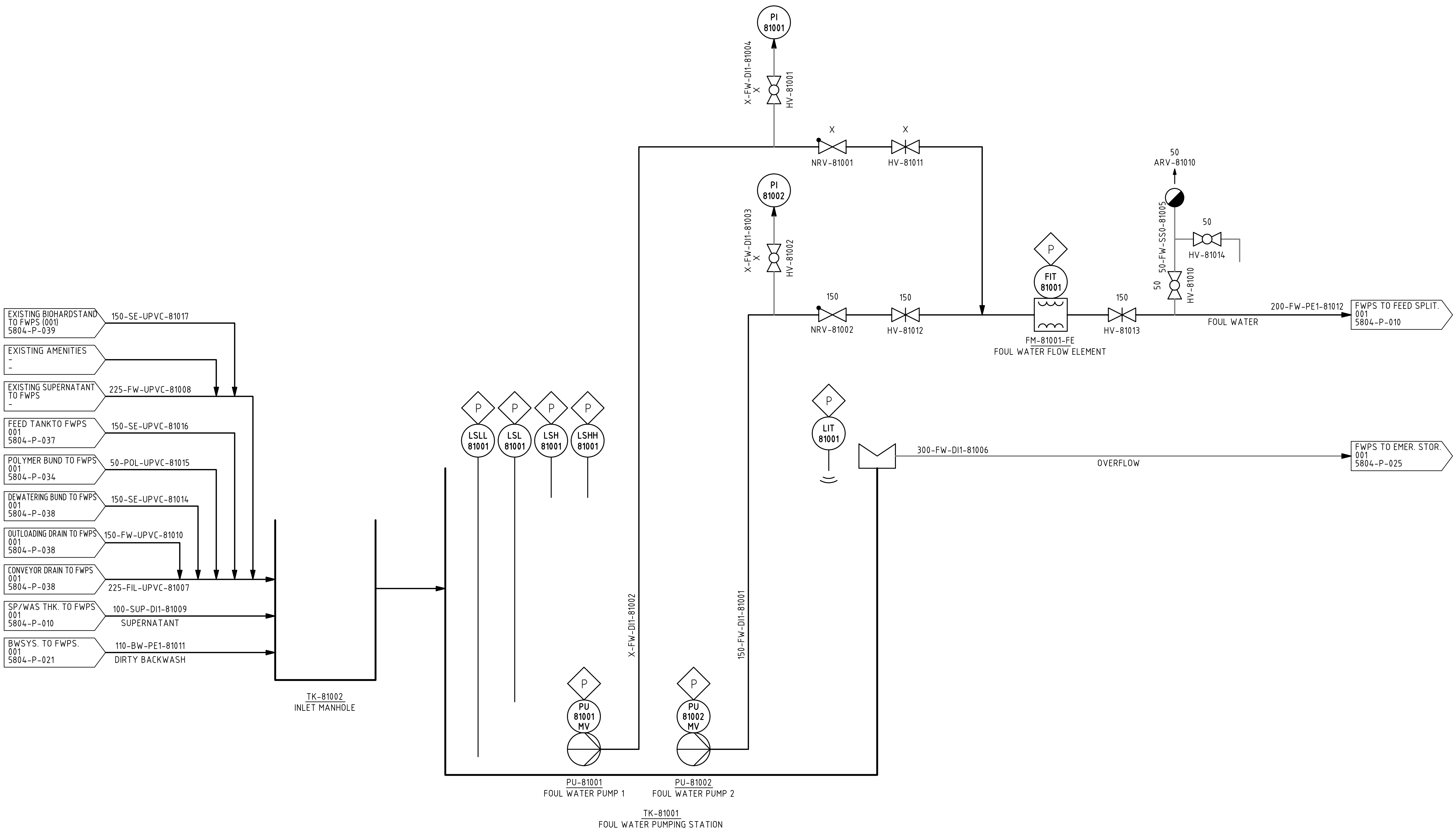
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
BIOSOLIDS HARDSTAND (EXISTING)

Scale	Document No
N.T.S. at A3	5804- P - 039

Status	Version
TENDER	C

Plot Date: 10/08/21 - 13:57 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-039 - BIOSOLIDS HARDSTAND (EXISTING).dwg



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AMENDMENTS			
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA
Ver	Date	Description	Drawn

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Date 10/08/21	
HH2O Project Number 5804	

Wingecarribee SHIRE COUNCIL

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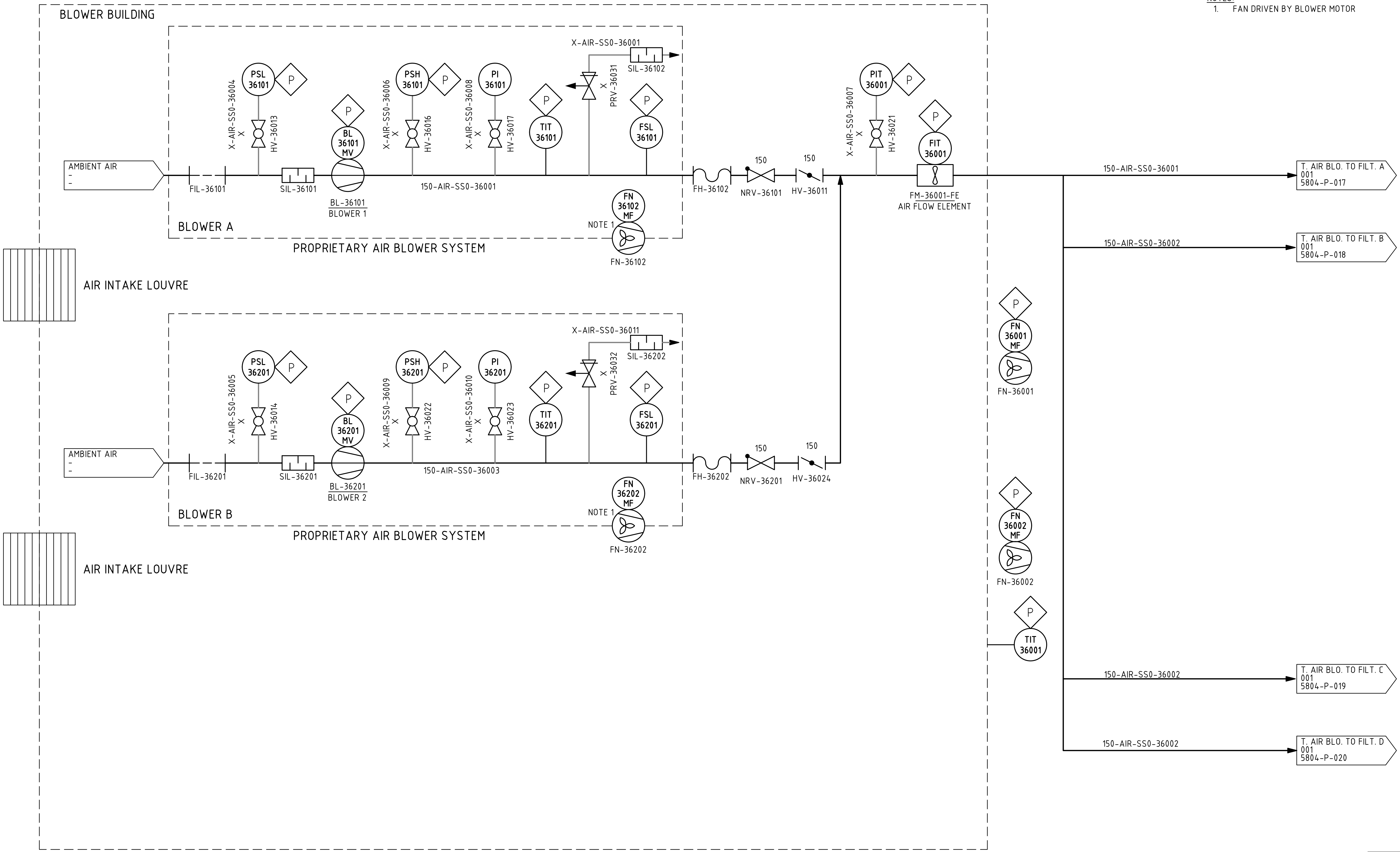
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
FOUL WATER PUMPING STATION

Scale	Document No
N.T.S. at A3	5804- P - 040
Status: **TENDER**	Version: C

Plot Date: 10/08/21 - 13:57 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-040 - FOUL WATER PUMPING STATION.dwg

NOTES:
1. FAN DRIVEN BY BLOWER MOTOR



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Ver	Date	Description	Drawn
C	10/08/21	TENDER	RR
B	06/11/20	REVISED DRAFT	MA
A	01/09/20	DRAFT	MA

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HH2O Project Number 5804

Wingecarribee SHIRE COUNCIL

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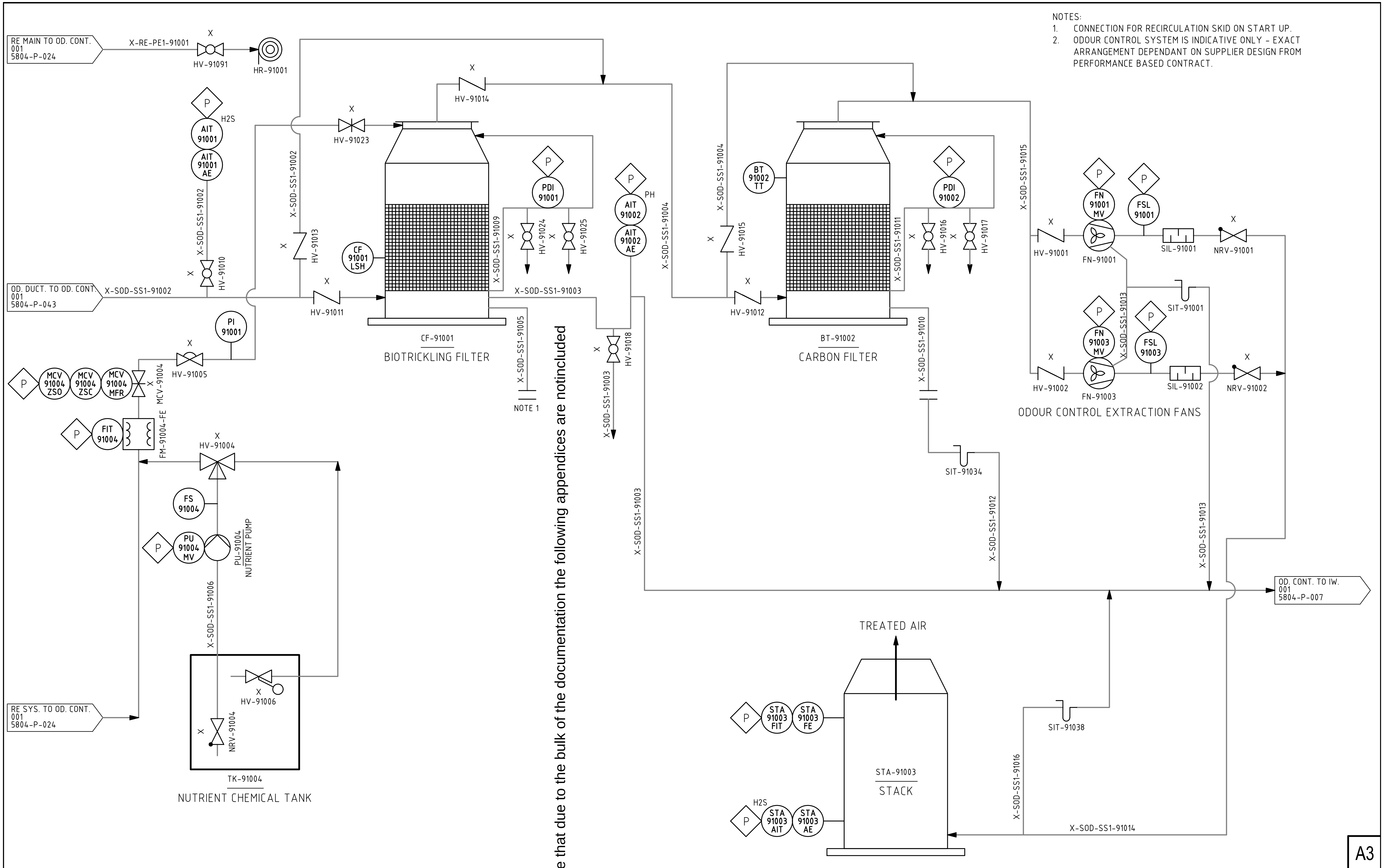
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
FILTER AIR BLOWERS

Scale N.T.S. at A3
Document No 5804- P - 041
Status **TENDER**
Version C

Plot Date: 10/08/21 - 13:58 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-041 - FILTER AIR BLOWERS.dwg



Note that due to the bulk of the documentation the following appendices are notincluded

AMENDMENTS			
B	10/08/21	TENDER	RR
A	06/11/20	DRAFT	MA
Ver	Date	Description	Drawn

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Date 10/08/21	
HH2O Project Number 5804	

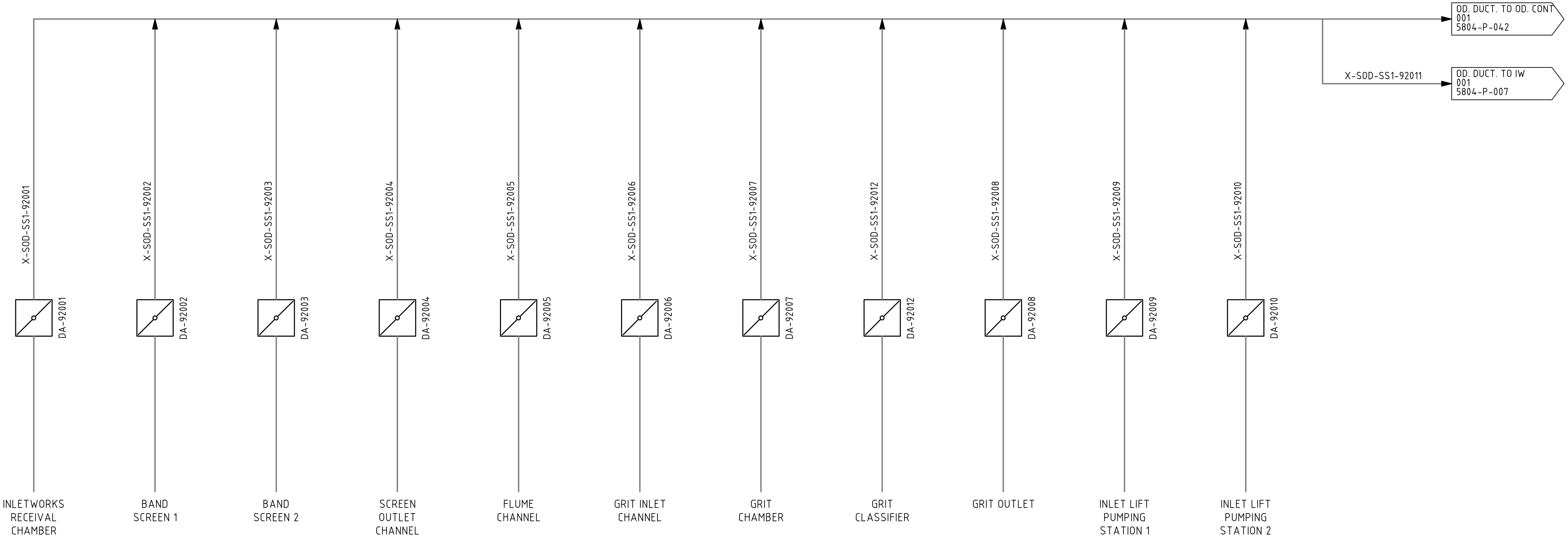
Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
ODOUR CONTROL

Scale: N.T.S. at A3
Document No: 5804- P - 042
Status: TENDER
Version: B

Plot Date: 10/08/21 - 13:59 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-042 - ODOUR CONTROL.dwg

NOTE: ODOUR DUCTWORK IS INDICATIVE, EXACT ARRANGEMENT DEPENDANT UPON SUPPLIER DESIGN.



A3

AMENDMENTS			
B	10/08/21	TENDER	RR
A	06/11/20	DRAFT	MA
Ver	Date	Description	Drawn

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Date 10/08/21	
HH2O Project Number 5804	

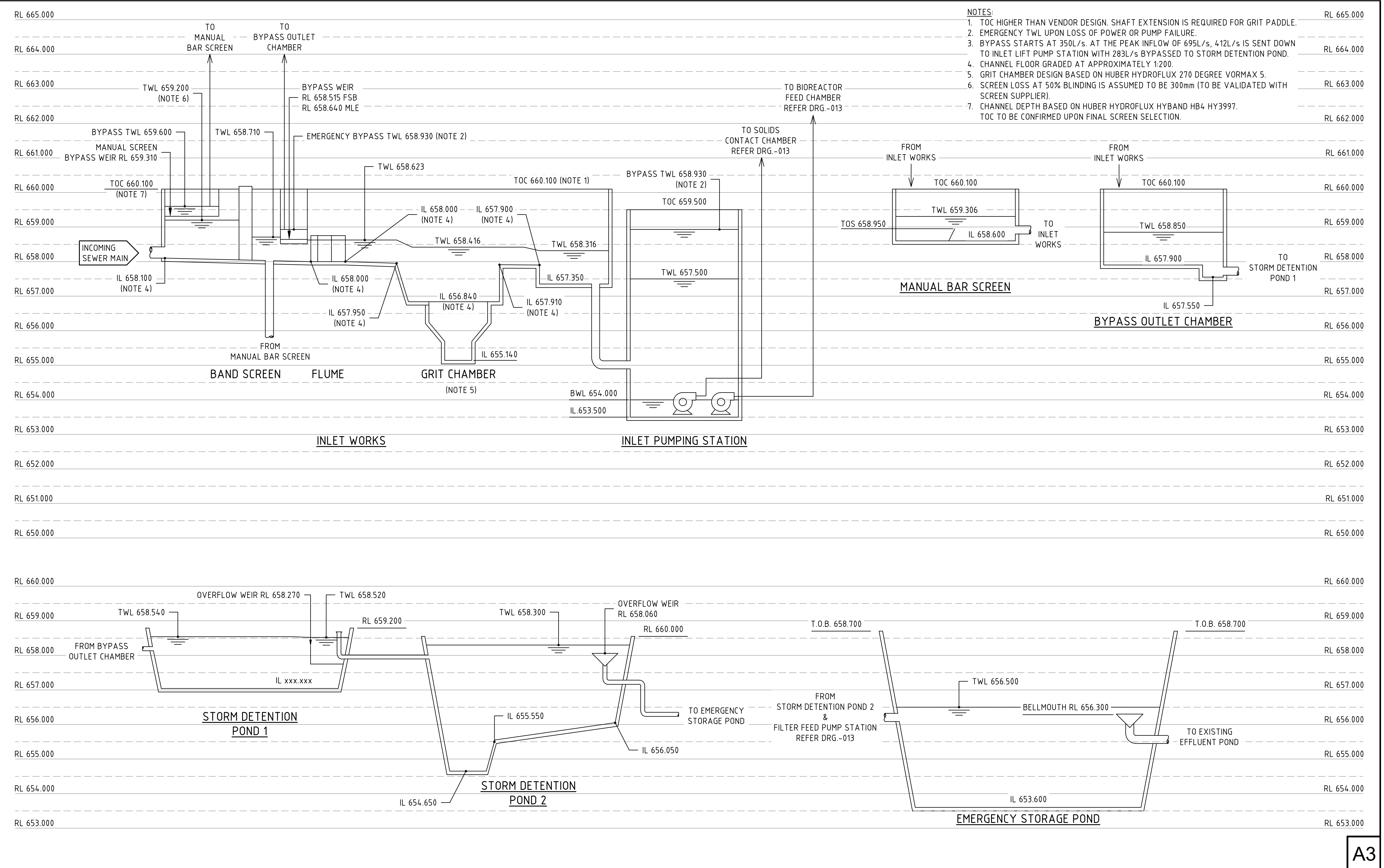
Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
PROCESS & INSTRUMENTATION DIAGRAM
ODOUR DUCTWORK

Scale: N.T.S. at A3
Document No: **5804- P - 043**
Status: **TENDER**
Version: **B**

Plot Date: 10/08/21 - 13:59 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\2 P&ID's\1 - CURRENT WORKING\Bowral STP Upgrade\PID DWG\5804-P-043 - ODOUR DUCTWORK.dwg

Appendix F: Hydraulic Profile



NOTES:
1. TOC HIGHER THAN VENDOR DESIGN. SHAFT EXTENSION IS REQUIRED FOR GRIT PADDLE.
2. EMERGENCY TWL UPON LOSS OF POWER OR PUMP FAILURE.
3. BYPASS STARTS AT 350L/s. AT THE PEAK INFLOW OF 695L/s, 412L/s IS SENT DOWN TO INLET LIFT PUMP STATION WITH 283L/s BYPASSED TO STORM DETENTION POND.
4. CHANNEL FLOOR GRADED AT APPROXIMATELY 1:200.
5. GRIT CHAMBER DESIGN BASED ON HUBER HYDROFLUX 270 DEGREE VORMAX 5.
6. SCREEN LOSS AT 50% BLINDING IS ASSUMED TO BE 300mm (TO BE VALIDATED WITH SCREEN SUPPLIER).
7. CHANNEL DEPTH BASED ON HUBER HYDROFLUX HYBAND HB4 HY3997. TOC TO BE CONFIRMED UPON FINAL SCREEN SELECTION.

AMENDMENTS

Ver	Date	Description	Drawn
A		PRELIMINARY	

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Approved	
Date	
HH2O Project Number 5804	

HORIZONTAL
Co-ordinate System -
BM Adopted -
East - North -

VERTICAL
Datum -
BM Adopted -
Reduced Level -

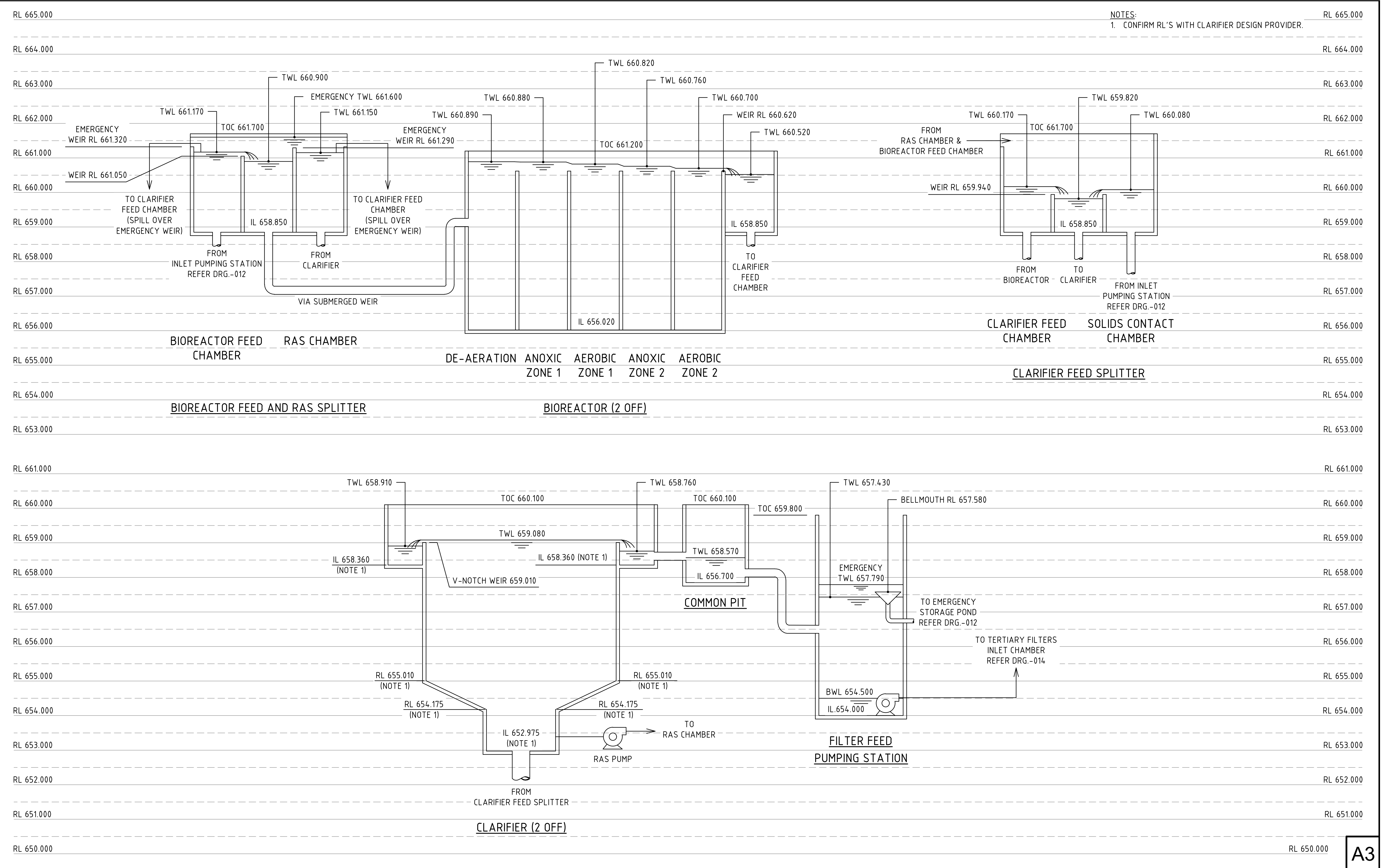
Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
INLET WORKS & BYPASS

HYDRAULIC PROFILE - SHT. 1 of 3

Scale: N.T.S. at A3
Document No: 5804- C - 012
Status: **PRELIMINARY**
Version: A

Plot Date: 27/07/21 - 17:42 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\CIVIL DWGS\1 - CURRENT WORKING\5804-C-012 (Hydraulic Profile).dwg Ver.0314



AMENDMENTS			
A		PRELIMINARY	
Ver	Date	Description	Drawn

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Drawn TJS	Checked
Approved	
Date	
HH2O Project Number 5804	

HORIZONTAL
Co-ordinate System -
BM Adopted -
East - North -

VERTICAL
Datum -
BM Adopted -
Reduced Level -

Wingecarribee SHIRE COUNCIL

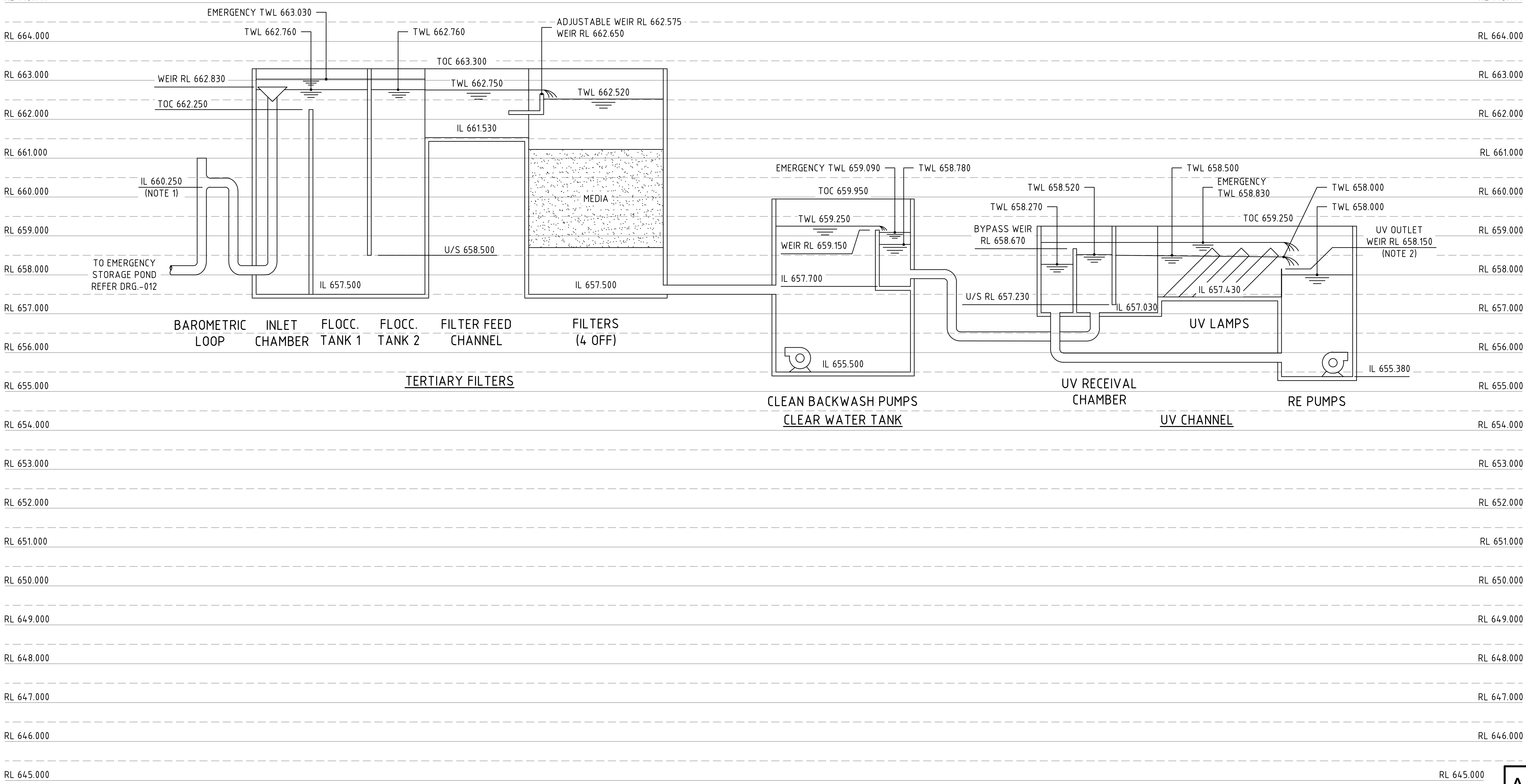
WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
INLET WORKS & BYPASS

HYDRAULIC PROFILE - SHT. 2 OF 3

Scale: N.T.S. at A3
Document No: 5804- C - 013
Status: **PRELIMINARY**
Version: A

Plot Date: 27/07/21 - 17:42 Cad File: P:\Wingecarribee Shire Council\5804 Bowral STP Detailed Design\2. Tasks\CIVIL DWGS\1 - CURRENT WORKING\5804-C-012 (Hydraulic Profile).dwg
Ver.0314

NOTES:
1. BAROMETRIC LOOP TO PREVENT FILTER BYPASS SURCHARGING INTO UV FEED BACKFLOWING INTO EMERGENCY POND.
2. PENSTOCK POSITION AT PEAK FLOW (i.e. LOWEST POSITION). DOWNWARD OPENING PENSTOCK IS PART OF VENDOR SUPPLY.



A3

AMENDMENTS			
A		PRELIMINARY	
Ver	Date	Description	Drawn

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Designed	Checked
Drawn TJS	Checked
Approved	
Date	
HH2O Project Number 5804	

HORIZONTAL
Co-ordinate System -
BM Adopted -
East - North -

VERTICAL
Datum -
BM Adopted -
Reduced Level -

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE
BIOREACTOR & FILTER FEED PUMP STATION
HYDRAULIC PROFILE - SHT. 3 OF 3

Scale: N.T.S. at A3
Document No: 5804- C - 014
Status: **PRELIMINARY**
Version: A

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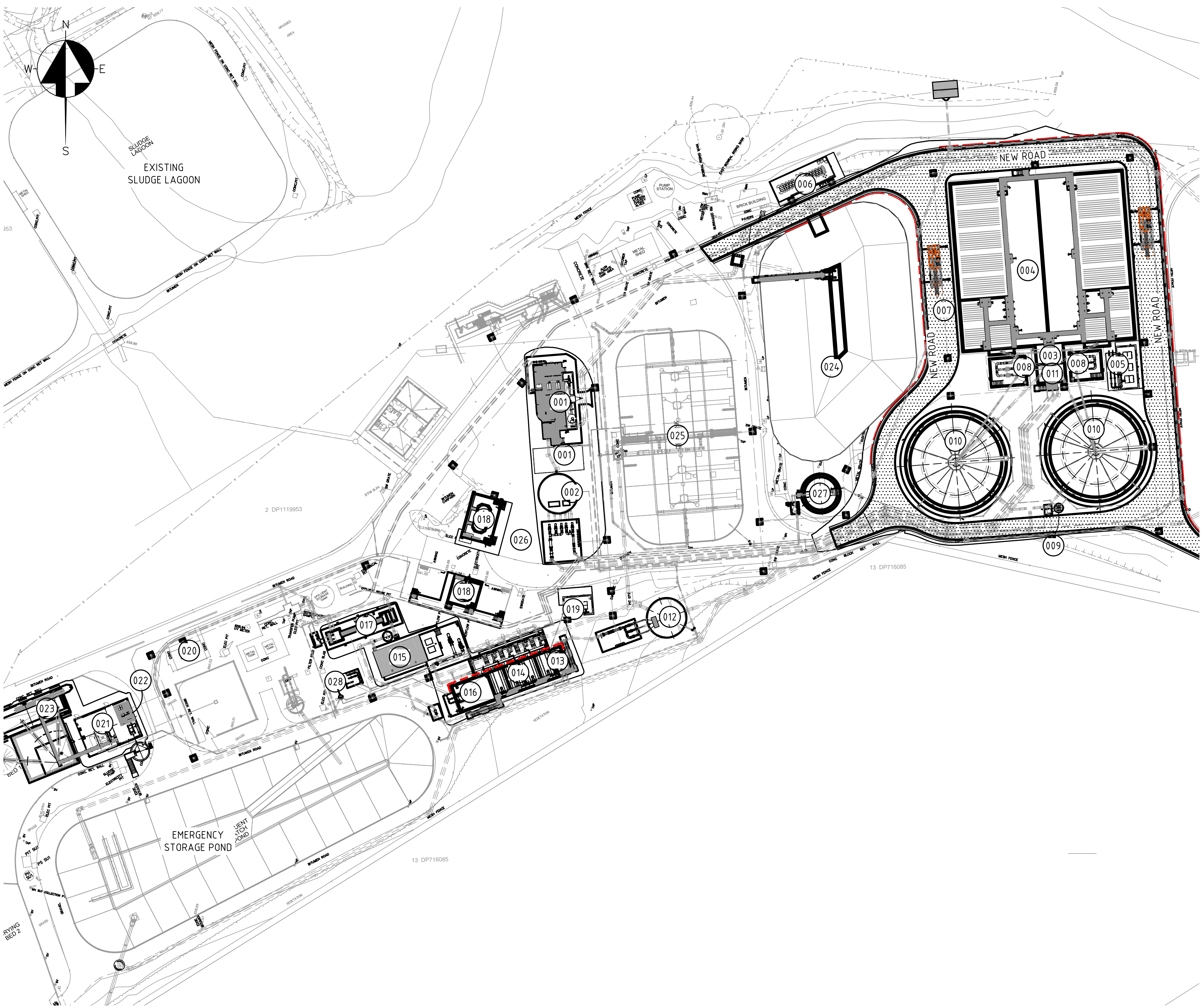
Ver.0314

Appendix G: Site Layout



STRUCTURE LIST

ITEM NUMBER	DESCRIPTION	DRAWING NUMBER
001	INLET WORKS & ODOUR CONTROL	5804-C-035
002	INLET PUMPING STATION	5804-C-070
003	BIOREACTOR FLOW SPLITTER	5804-C-085
004	BIOREACTOR	5804-C-085
005	BIOREACTOR BLOWER ROOM	5804-C-605
006	BIOREACTOR SWITCH ROOM	5804-C-585
007	CRANE PAD	
008	RETURN ACTIVATED SLUDGE (RAS) PUMPING STATION	5804-C-180
009	SCUM PUMPING STATION	5804-C-165
010	CLARIFIERS	5804-C-135
011	CLARIFIER FLOW SPLITTER	5804-C-085
012	FILTER FEED PUMPING STATION	5804-C-200
013	FLOCCULATION TANK	5804-C-215
014	TERTIARY FILTERS	5804-C-215
015	CLEARWATER BACK WASH TANK	5804-C-260
016	DIRTY BACK WASH TANK	5804-C-215
017	UV CHANNEL	5804-C-285
018	CHEMICAL STORAGE BUNDS	5804-C-530 5804-C-550
019	AIR SCOUR BLOWER BUILDING	5804-C-620
020	TERTIARY TREATMENT & DEWATERING SWITCHROOM	
021	DEWATERING BUILDING	5804-C-335
022	POLYMER DOSING AREA	5804-C-352
023	SLUDGE OUTLOADING FACILITY	5804-C-360
024	STORM DETENTION POND 1	5804-C-305
025	SLUDGE DIGESTER (CONVERTED IDEA REACTOR)	
026	FUTURE CARBON DOSING	
027	THICKENER	5804-C-170
028	FOUL WATER PUMPING STATION	5804-C-390

A3

AMENDMENTS

Ver	Date	Description	Drawn
C	04/06/21	PRELIMINARY	TJS
B	26/03/21	PRELIMINARY	TJS
A	26/02/21	PRELIMINARY	TJS

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Drawn CT | Checked
Approved
Date
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HORIZONTAL
Co-ordinate System -
BM Adopted -
East - North -

VERTICAL
Datum -
BM Adopted -
Reduced Level -

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
BOWRAL STP UPGRADE

SITE ARRANGEMENT

Scale 1:750 at A3

Document No **5804- C - 010**

Status **PRELIMINARY**

Version **C**

Appendix H: Geotechnical Reports

Note that due to the bulk of the documentation the following appendices are not included in the REF version of the Detailed Design Report:

- Appendix H: Geotechnical Reports
- Appendix I: Maximum Demand Calculations
- Appendix J: Safety in Design Report

Appendix G – Odour Impact Assessment

BOWRAL SEWAGE TREATMENT PLANT UPGRADE

Odour Impact Assessment

Prepared for:

NSW Public Works Advisory
Level 4, 66 Harrington Street
Sydney NSW 2000

SLR Ref: 610.18382-R02
Version No: -v1.0
April 2021

SLR

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PREPARED BY

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with NSW Public Works Advisory (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.18382-R01-v1.0	21 August 2019	Ali Naghizadeh	K Lawrence	K Lawrence
610.18382-R02-v1.0	7 April 2021	Danroy Dsouza	J Meline	Ali Naghizadeh

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DOCUMENT REFERENCES

TABLES

FIGURES

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APPENDICES

1 Introduction

The Bowral Sewage Treatment Plant (STP) receives sewage from Bowral and surrounds via the Bowral, East Bowral and the Burradoo sewage pump stations (SPS). The existing Bowral STP, which was last upgraded in 2006, has a design capacity of 14,600 Equivalent Persons (EP).

In order to ensure treatment capacity is sufficient to accommodate present and expected future loads as well as to improve process and operational performance improvements and provide treatment infrastructure that meets state environmental objectives, Wingecarribee Shire Council (the Council) is currently planning for the upgrade of the Bowral STP.

To assess potential odour impacts from the proposed operations, the New South Wales Public Works Advisory (PWA) commissioned SLR Consulting Australia Pty Ltd (SLR Consulting) to prepare an Odour Impact Assessment (OIA) to support the Review of Environmental Factors (REF) being prepared for the proposed upgrade. This report includes assessment of updated plant design and is an update of the original assessment performed in 2019 (SLR Consulting Pty Ltd, 2019).

This OIA has been performed in accordance with the New South Wales Environment Protection Authority (NSW EPA) document '*Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*' (NSW EPA, 2017), hereafter referred to as 'the Approved Methods'. For the assessment of potential odour emissions, this report also refers to the NSW Department Office of Environment and Heritage (OEH) 2006 document, *Technical Framework: Assessment and management of odour from stationary sources in NSW* (NSW DEC, 2006a) (hereafter the Odour Framework) and the *Technical Notes: Assessment and management of odour from stationary sources in NSW* (NSW DEC, 2006b) (hereafter the Technical Notes).

In addition to the above, the draft *NSW Best Practice Odour Guideline - Sewerage systems including sewage treatment plants, water recycling facilities, sewage reticulation systems and sewer mining* (DoP NSW, 2010) hereafter referred to as the Odour Guideline has also been referred to in this report.

The assessment methodology included the modelling of local meteorology and the dispersion of odour emissions from the Bowral STP to predict the level of concentrations that may be experienced in the surrounding environment. The sections of this report where the requirements of the Approved Methods are met are as follows:

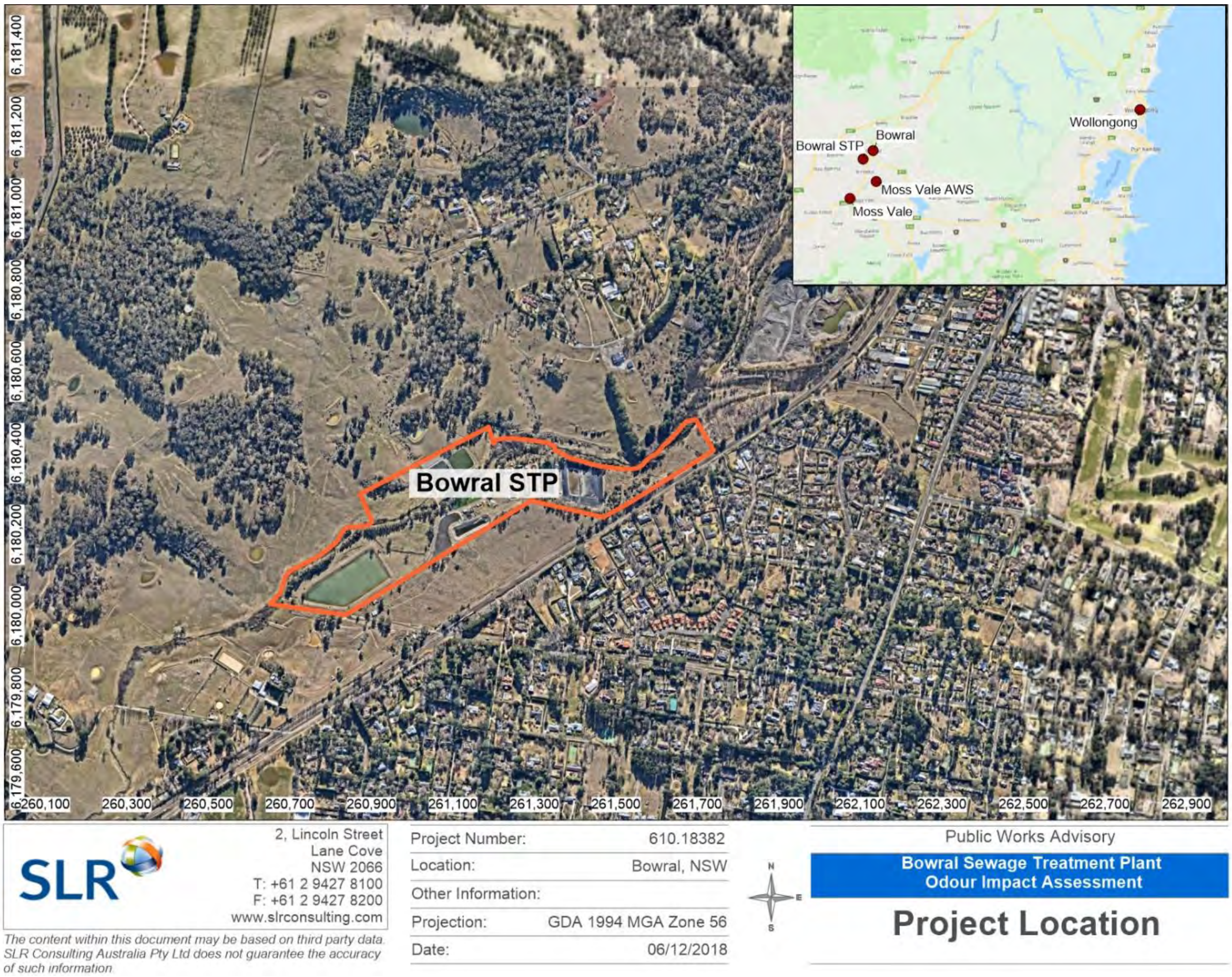
- Description of local topographic features and sensitive receptor locations (**Section 2.4**).
- Description of existing air quality environment (**Section 2.5**).
- Establishment of air quality assessment criteria (**Section 3.4.2**).
- Analysis of climate and dispersion meteorology for the region (**Sections 4** and **6.2**).
- Compilation of an emissions inventory for the existing and proposed activities (**Section 5.3**).
- Completion of atmospheric dispersion modelling and analysis of results (**Sections 6** and **7**).
- Description mitigation measures recommended for the Bowral STP (**Section 8**).

2 Project Overview

2.1 Project Location

The Bowral STP is located near Bowral in the Southern Highlands of New South Wales (NSW), in the Wingecarribee Shire Local Government Area (LGA). The Bowral STP is approximately 2 kilometres (km) southwest of Bowral, 6 km north of Moss Vale and 40 km west of Wollongong. A location plan and an aerial view of the Bowral STP are illustrated in **Figure 1.**

Figure 1 Location of the Bowral STP



2.2 Project and Site Description

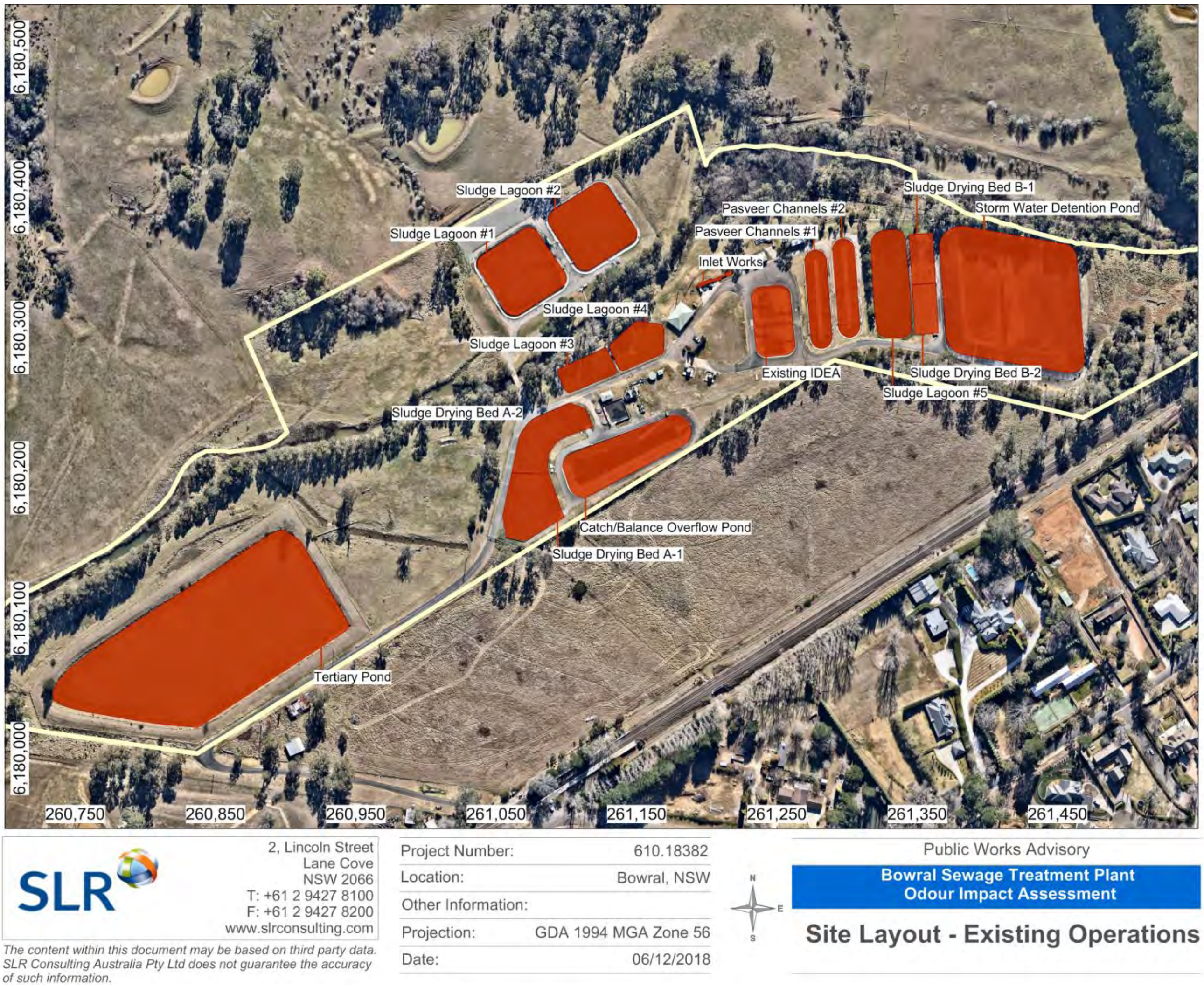
2.2.1 Existing Operations

The existing Bowral STP has a nominal design capacity of 14,600 EP. The plant comprises the following process units:

- Inlet works including coarse screening, grit arrestor, flow splitting and diversion structures;
- Pasveer channels and intermittently decanted extended aeration (IDEA) systems;
- A catch/balance overflow pond;
- Four sludge drying beds;
- Five sludge lagoons, three of which are not in active use;
- A stormwater detention pond (SDP2) for temporary storage of inlet works emergency overflow in significant rain events; and
- Filtration and disinfection units.

Final treated effluent from the Bowral STP is discharged into Mittagong Creek. The layout of the existing Bowral STP is provided in **Figure 2**.

Figure 2 Bowral STP Site Layout – Existing Operations



2.2.2 Proposed Operations

The layout of the proposed Bowral STP is provided in **Figure 3** and is designed for a capacity of 21,000 EP.

The FSB concept to be taken to detailed design consists of the following:

- An augmented sewage main (flow measurement to be confirmed).
- A new inlet works consisting of:
  - Two mechanical screens (duty/duty) each sized for 10 ADWF. The preference is for band screens if the hydraulic profile allows.
  - A bypass channel to SDP1 fitted with a manual screen sized for 10 ADWF.
  - Appropriate screen washing and dewatering (to be confirmed).
  - A single vortex style grit tank sized for 10 ADWF (if turndown permits).
  - A grit sparge and extraction system (pumped).

    - A single grit classifier for grit washing and dewatering
    - Inlet works will be enclosed
    - Installation of an odour control unit.
- A new lift pump station consisting of:
    - A new wet well.
    - Three feed pumps in duty/assist/standby configuration, each sized for 1.5 ADWF. Can be operated as duty/assist/assist under the MLE configuration.
    - Two solids contact (i.e. clarifier feed) pumps in duty/assist configuration, each sized for 1.5 ADWF.
    - An overflow to new storm detention pond (SDP1).
    - The lift pump station will be enclosed
- A new SDP1 located at the site of the current Pasveers. This consists of:
    - An inlet receiving overflows from the lift pump station.
    - A settling zone to contain the majority of the settled solids and the return pump in a sump.
    - A structural baffle wall with overflow to a second zone.
    - A return pipe (with non return flap) returning flow to the settling zone as it drains.
    - A duty only return pump sized for 1.5 ADWF. Provision for future pumps if required.
    - A return rising main to the screenings inlet chamber.
    - An overflow from the second zone to SDP2.
- The existing storm detention pond (SDP2) consisting of:
    - The existing SDP with floor modifications to assist cleaning.
    - A replacement, duty only return pump sized for 1.5 ADWF. Provision for future pumps if required.
    - Modifications to the existing return rising main to the screenings inlet chamber.
- A new bioreactor splitter box consisting of:
    - A bioreactor feed splitter, accepting feed from the lift pump station and foul water from the FWPS and splitting it to the two bioreactors.
    - An alum dosing point to the feed splitter (or to the feed rising main for better mixing).
    - A mixed liquor (ML) box accepting ML from the two bioreactors plus solids contact bypass flow from the lift pump station.
    - An alum dosing point to the ML box. Mixing will occur in this box and the ML gravity main to the ML splitter.
    - A return activated sludge (RAS) splitter accepting flows from the two RAS pump stations and splitting it to the two bioreactors.
- Two (2) new bioreactors designed as FSB but able to be operated as MLE. Each of the bioreactors includes the following:
    - A selector zone fed with dosed feed and RAS. This zone may be self-scouring or it may require a mixer.

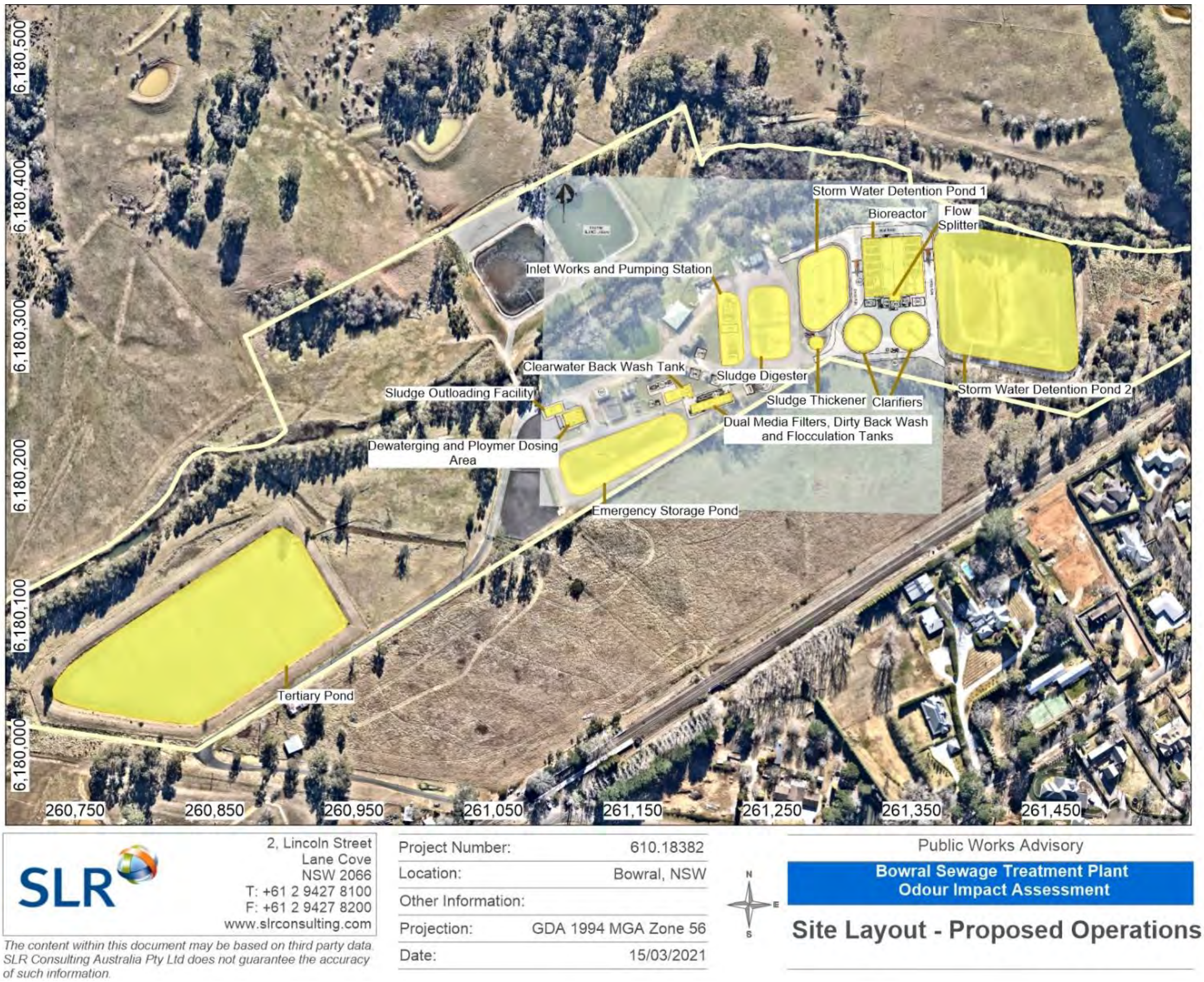
  - A future carbon dosing point to the selector zone.
  - A primary anoxic zone accepting flows from the selector and the MLR. This zone is likely to require three mixers and an Oxygen Reduction Potential (ORP) element.
  - A primary aerobic zone that accepts flows from the primary anoxic zone. This zone will include removable aeration diffuser grids, two dissolved oxygen (DO) elements and two aeration control valves.
  - An alkalinity dosing point to the primary aeration zone. This zone will also contain a combined temperature and pH element.
  - A secondary anoxic zone that accepts flows from the primary aerobic zone. This can be aerated (MLE) or mixed (FSB). It will include two mixers (can be deferred) plus removable aeration grids.
  - A future carbon dosing point to the secondary anoxic zone.
  - A secondary aerobic zone that accepts flows from the secondary anoxic zone. This zone will include a removable aeration grid plus a DO element and an aeration control valve (which also controls air to the secondary anoxic zone when aerated).
  - A de-aeration zone that accepts flows from the primary aerobic zone (FSB) or secondary aerobic zone (MLE). Stop boards are used to select the flow path. This zone is fitted with a mixer but should remain aerobic under most conditions.
  - Three (3) MLR pumps in duty/assist/assist configuration pumping ML from the de-aeration zone to the primary anoxic zone.
  - A ML outlet weir from the secondary aerobic zone to the ML box, where the ML from both bioreactors is combined.
- A new ML flow splitter, splitting the combined ML from the two bioreactors to the two secondary clarifiers.
- Two new secondary clarifiers each consisting of:
  - ML feed pipes.
  - An energy dissipating inlet (EDI). This will require advanced design to dissipate the high DSTF velocities.
  - A feed well.
  - A rotating sludge and scum scraper with peripheral drive (to be confirmed).
  - Self-flushing scum boxes intermittently delivering scum to the scum pump station.
  - In-board effluent launders that also act as Stamford baffles.
  - An effluent pipe to the filter feed pump station.
  - Two RAS pumps in duty/standby configuration. These extract RAS from the central floor of the clarifier and deliver to a common rising main to the RAS splitter. The RAS flow from each clarifier is individually monitored and controlled to ensure a perfect RAS split.
- A new scum pump station, with two scum pumps (duty/standby) accepting scum from the two clarifiers and delivering it to the aerobic digester, bioreactors or dewatering feed tank (to be confirmed).
- A new filter feed pump station consisting of:
  - Secondary effluent pipes from each clarifier.

  - Three filter feed pumps in duty/assist/standby configuration (to be determined) delivering flows up to 3ADWF to the tertiary filters.
  - An overflow from the filter feed pump station to the emergency storage tank.
- An emergency storage tank (EST). This will consist of:
  - The existing catch/balance pond to store overflows from the filter feed pump station (typically flows in excess of 3ADWF and below 6ADWF).
  - Possible benching or a sump to allow the EST it to be fully drained between events.
  - The existing filter feed pump station converted to an emergency return pump station.
  - An existing overflow to the existing emergency storage lagoon.
  - A rising main returning stored effluent to the inlet works or back to the filter feed pump station (to be confirmed)
- Tertiary filters consisting of:
  - A new rising main from the filter feed pump station.
  - An optional alum dosing point to the filter feed.
  - Provision for a future rapid mix flocculator (to be confirmed).
  - The existing two disk filters, refurbished and upgraded based on supplier advice. This is likely to include backwash flow and pressure elements at a minimum.
  - One or two additional disk filters, similar to the existing filters (number to be confirmed, but two additional filters is the current default).
  - A dedicated backwash and sludge withdrawal systems for each new filter.
  - A new backwash return rising main from the filters to the FWPS.
  - A tertiary effluent collection chamber.
- A new UV system to replace the existing UV system. The style of system is yet to be determined.
  - A new or augmented reclaimed effluent (RE) system. This will consist of:
  - Relocation of the existing RE lift pumps to downstream of the new UV system. Alternatively, a new set of lift pumps (duty/assist) may be required.
  - The existing RE storage tank.
  - A replacement, amplified RE pumping system (proprietary) to service the increased RE pressure and flow requirements (particularly dewatering).
- A new WAS pumping system with a duty only WAS pump drawing from the ML splitter or the RAS splitter and delivering WAS to the aerobic digester.
- An aerobic digester consisting of:
  - A new WAS feed pipe to one end of the digester.
  - The existing IDEA bioreactor with added baffle walls.
  - The existing IDEA surface aerators (or replace them with smaller aerators if they are beyond their economic life).

  - The existing IDEA decanter fitted with a new 10:1 reduction gearbox to reduce supernatant decant flows. This is necessary to reduce the risk of scouring and so as not to overload the FWPS.
  - Diversion of the supernatant (old effluent) pipe to the FWPS.
  - Retention of existing instrumentation.
  - Relocation of the existing WAS pump to act as the new digested WAS (DWAS) pump.
  - DWAS is pumped from the digester during dewatering periods, but only while the digester is aerating.
  - A new DWAS main to the new mechanical dewatering facility.
- A new mechanical dewatering facility consisting of:
  - A new dewatering feed tank, complete with mixer/aerator, to store DWAS between digester draws (to be confirmed)
  - A polymer make-up, storage, dosing and dilution system. Dosing pumps in duty/standby configuration. Connection to a new or existing potable (industrial) water supply.
  - Dewatering feed pumps in duty/standby configuration.
  - A duty only screw press dewatering unit.
  - A filtrate collection system delivering filtrate to the FWPS. This may be able to gravitate or may require pumping. If pumping is required, then the filtrate could be delivered directly to the bioreactor feed splitter, bypassing the FWPS.
  - A horizontal biosolids conveyor.
  - A pivoting, inclined biosolids conveyor delivering biosolids to a truck trailer (default).
  - A building including acoustic insulation and ventilation.
  - A bunded truck trailer hard stand.
  - An awning over the truck trailer hard stand.
  - A separate, bunded biosolids storage hard stand as a backup.
- Retain at least one sludge lagoon as emergency liquid sludge storage.
- A foul water pump station (FWPS) consisting of:
  - Either the existing supernatant pump station or a new pump station.
  - The existing foul water pumps (duty/assist) or new foul water pumps (duty/standby).
  - The existing or new filter backwash main connection.
  - A new digester supernatant connection.
  - A new dewatering filtrate connection (unless pumped directly to the bioreactors).
  - Contaminated stormwater and washwater connections from various hardstands.
  - A new foul water main to the bioreactor feed splitter.
  - A stormwater overflow to an appropriate location (to be determined).
- An alkalinity storage and dosing system consisting of:

    - The existing alkalinity and alum storage tanks, cross connected and used for alkalinity storage (based on 50% sodium hydroxide).
    - Two new alkalinity dosing pumps (duty/duty), one dosing to the primary aerobic zone of each bioreactor.
    - The existing unloading and bunded storage areas.
- A new alum storage and dosing facility consisting of:
    - Two new alum storage tanks.
    - Two new (duty/standby) alum dosing pumps to dose to the bioreactor feed splitter.
    - Two new (duty/standby) alum dosing pumps dosing to the ML box or the filter feed.
    - A new storage bund and tanker delivery area.
- Site provision for future carbon storage and dosing (sucrose solution used for sizing).
- Site provision for future recycled water treatment system.
- Site provision for future deep bed tertiary filters and backwash system

Figure 3 Bowral STP Site Layout – Proposed Operations



2.3 Surrounding Land Use and Sensitive Receptors

Sensitive receptors are locations where the general population can be adversely impacted by exposure to pollution from atmospheric emissions. These locations include hospitals, schools, day care facilities and residential housing. The area surrounding the Bowral STP include land zoned as Environmental Management, Primary Production Small Lots, Public Recreation, Low Density Residential and Large Lot Residential as zoned by the *Wingecarribee Local Environmental Plan 2010* (refer **Figure 4**).

The Bowral STP is situated in an area surrounded by scattered residential properties to the north and west and higher density residential to the south and east. A list of existing sensitive receptor points identified in the immediate vicinity of the Bowral STP is provided in **Table 1**, along with the respective distances of each of these receptor points to the Bowral STP boundary. **Figure 5** illustrates the location of the surrounding receptors in relation to the Bowral STP. Predicted concentrations of odour have been assessed at each of these receptors, for the operational scenarios modelled. It is noted that closest receptors in all directions were identified for this assessment. Impacts at sensitive receptors located further away in each direction will be less than the modelling results presented in this report.

Figure 4 Surrounding Land Zoning

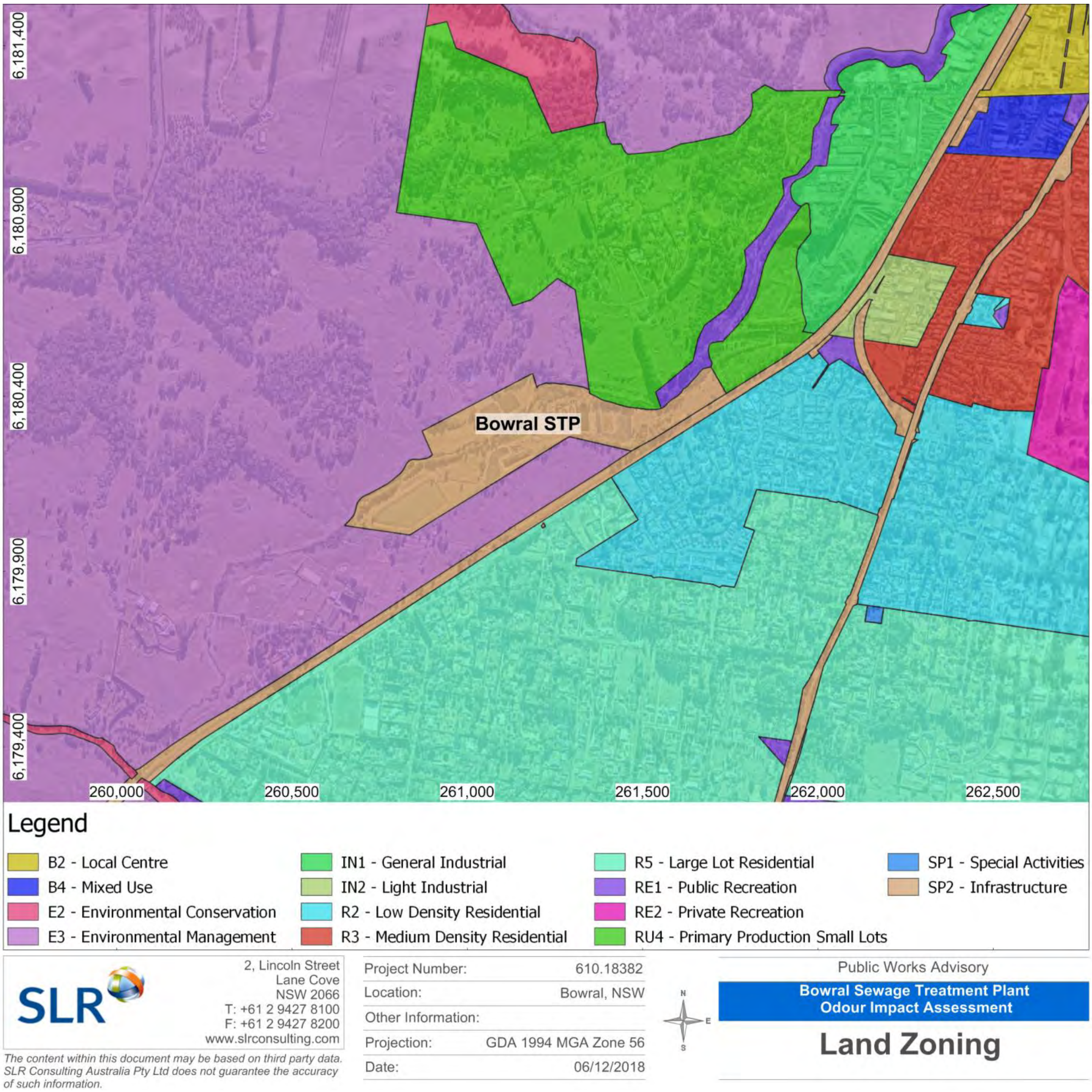
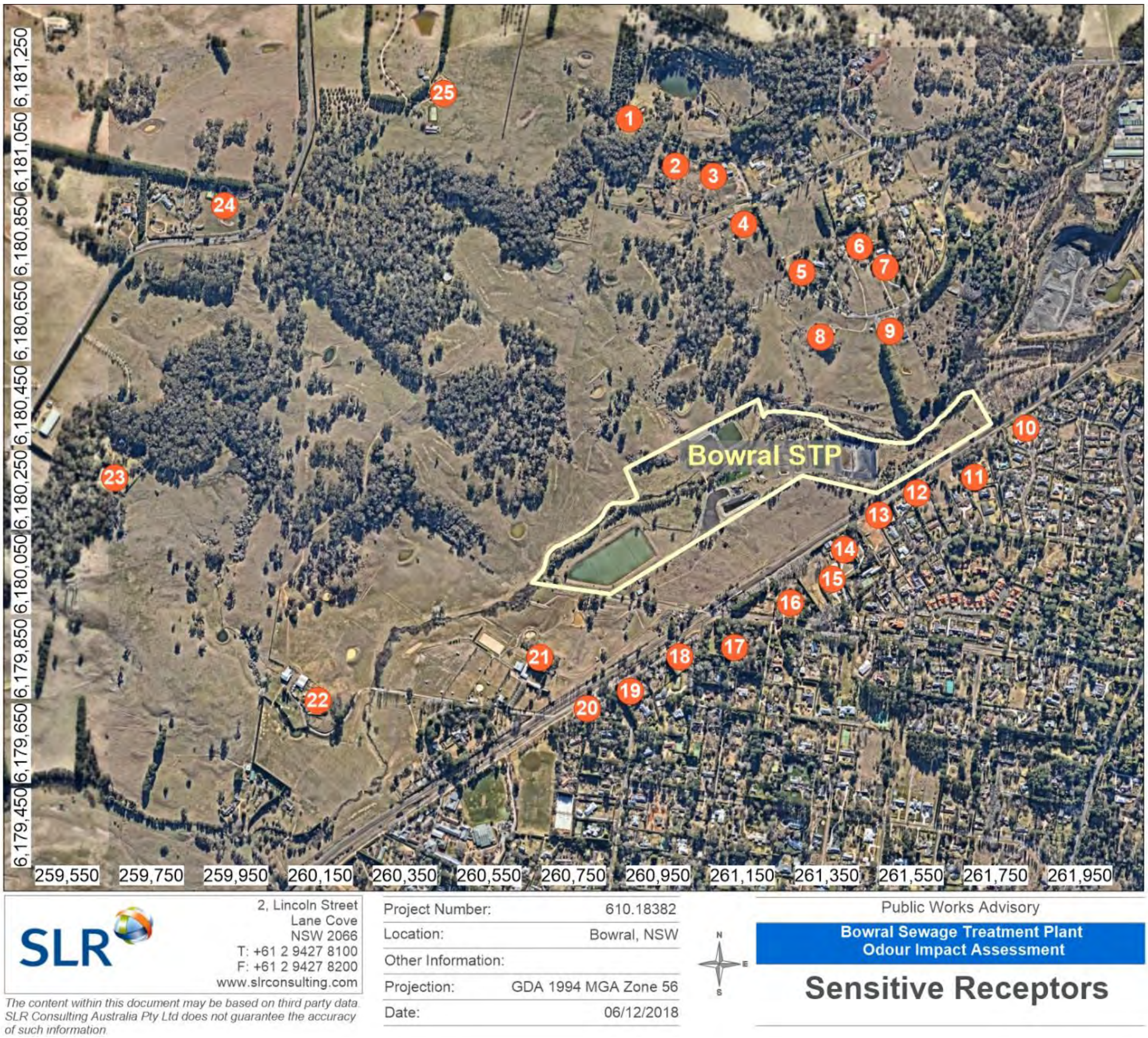


Table 1 Details of Identified Sensitive Receptors

Receptor ID	Location (m, UTM)		Approximate Distance from Nearest Boundary (m)	Elevation (m, AHD)
	Northing	Easting		
R1	6,181,129	260,882	760	768
R2	6,181,017	260,991	630	739
R3	6,180,992	261,081	570	733
R4	6,180,880	261,152	430	720
R5	6,180,765	261,290	330	698
R6	6,180,826	261,427	400	712
R7	6,180,778	261,487	380	705
R8	6,180,612	261,335	190	683
R9	6,180,625	261,500	250	689
R10	6,180,396	261,821	75	663
R11	6,180,280	261,699	80	666
R12	6,180,244	261,563	40	665
R13	6,180,190	261,473	55	664
R14	6,180,109	261,391	155	663
R15	6,179,982	261,263	250	663
R16	6,180,038	261,363	240	663
R17	6,179,878	261,131	250	666
R18	6,179,855	261,001	210	664
R19	6,179,773	260,884	230	663
R20	6,179,733	260,782	270	662
R21	6,179,853	260,670	175	658
R22	6,179,751	260,144	570	670
R23	6,180,279	259,663	1,020	752
R24	6,180,924	259,923	1,120	813
R25	6,181,190	260,442	980	796

Figure 5 Locations of the Identified Sensitive Receptors

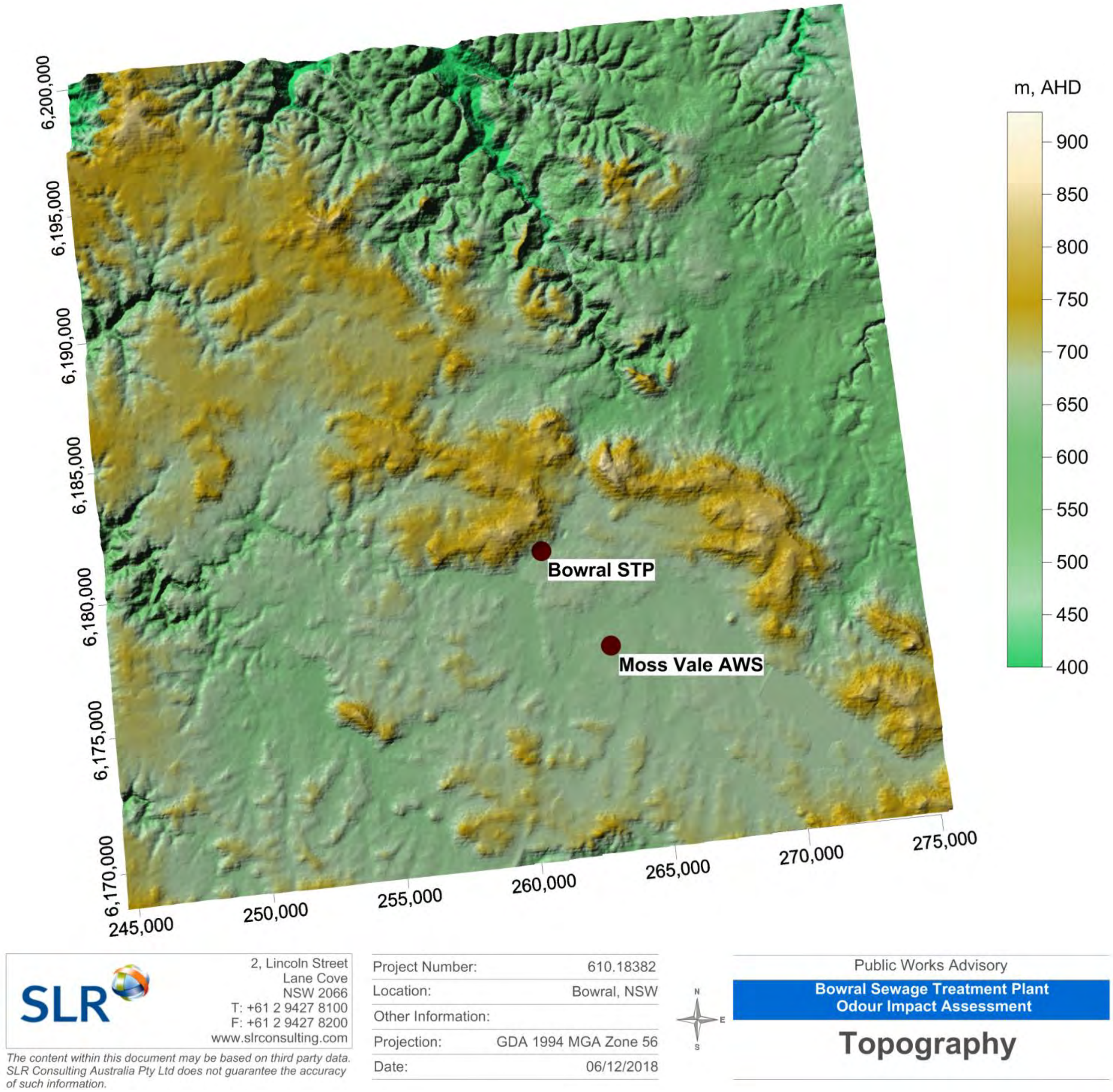


2.4 Surrounding Topography

Topography is important in air quality studies as local atmospheric dispersion can be influenced by night-time katabatic (downhill) drainage flows from elevated terrain or channelling effects in valleys or gullies.

A three dimensional representation of the topography surrounding the Bowral STP is presented in **Figure 6**. The ground elevation within the area illustrated in **Figure 6** ranges from approximately 400 m to 900 m Australian Height Datum (AHD). There are a number of significant topographical features in the surrounding area that are expected to influence local wind patterns and affect the dispersion of air emissions from the Bowral STP. This has been taken into consideration in the selection of the model and modelling grid resolution used for the study.

Figure 6 Local Topography Surrounding the Bowral STP



Note: Vertical exaggeration applied

2.5 Existing Odour Environment

The existing air quality was investigated by desktop mapping of industrial sites in the area regulated by EPA and those that are required to report to the National Pollutant Inventory (NPI).

Environment Protection Licences (EPLs) are issued under the POEO Act and are regulated by the NSW EPA. EPLs stipulate emission limits to water, land and/or air and provide operational protocols to ensure emissions/operations comply with relevant standards.

The NPI database provides details on industrial emissions of over 4,000 facilities across Australia. The requirement to return annual reports on emissions to the NPI is determined by the activities/processes being undertaken at the facility, and also whether those processes exceed process-specific thresholds in terms of activity rates (i.e. throughput and/or consumption). It is not intended to make a statement that impacts associated with those activities will be significant in terms of their potential for impact, generation of complaint, however it provides a tool to identify potentially significant emission sources in a specific area that then may be investigated further to assess their potential to impact on local air quality.

A search of the EPA public register and NPI database returned four records within a 4 km radius of the Bowral STP. Of these four records, the EPLs of three (namely Bowral Brickworks, Berrima Feed mill And Dux Manufacturing), do not identify a potentially offensive odour as an issue. The fourth facility, ie Southland Waste, which is located approximately 500 m to the northeast of the Bowral STP is considered to be a potentially odour-generating industry in the vicinity of the Bowral STP. However, the odours from this facility will have a different characteristic compared to odours from the Bowral STP operations. Therefore, it is not appropriate to assume that the odours from this facility are directly additive. The Technical Notes only requires:

> *"Where it is likely that two or more facilities with **similar odour character** will result in cumulative odour impacts, the combined odours due to emissions resulting from all nearby facilities should also be assessed against the odour assessment criteria."*

Similarly, the Queensland EHP Guideline *Odour Impact Assessment from Developments* (2013) states:

> *One of the drawbacks of dispersion modelling with multiple sources of odour is that the model assumes that the odours are additive. While this is correct for single chemical contaminants, it is not correct for odour units because the actual downwind odour concentration will depend on the various concentrations of the chemical constituents in the odour mixture. If the two sources were of quite different make-up, then the combined, diluted mixture of these two odour sources can have quite a different cumulative impact on the receiving environment. In some cases the effects may be additive and in other cases it may be positively or negatively synergistic. The modelling of multiple odour sources is quite complex and a little is currently understood about the cumulative impacts of multiple odour sources. It is reasonable to expect multiple sources of the same type of odorant (eg. multiple sheds on a poultry farm) to be additive in nature. An example of different type of odorant would be the rendering plant cooking odour via a chimney and the diffuse source odour from a wastewater treatment system.*

On this basis, only odour-emissions from the Bowral STP have been assessed within this report.

2.5.1 Odour Complaints

PWA has advised the following recent odour complaints have been recorded -

- Two odour complaints in the 2018-19 annual return period; and
- One odour complaint in the 2020-21 annual return period.

It is noted that all of these complaints were recorded at the time of mixing operations being performed at the sludge lagoons. As mentioned in **Section 2.2**, sludge lagoons are to be decommissioned as part of the proposed upgrade.

3 Air Quality Policy and Guidance

The following air quality policy and guidance documents have been referenced within this assessment and have been used to identify the relevant air quality criteria (see **Section 3.4**).

3.1 Approved Methods for Modelling and Assessment

State air quality guidelines adopted by the NSW EPA are published in the NSW EPA's *Approved Methods for Modelling and Assessment of Air Pollutants in NSW* publication (NSW EPA, 2017), hereafter referred to as the Approved Methods.

The Approved Methods lists the statutory methods for modelling and assessing air pollutants (including odour) from stationary sources and specifies criteria which reflect the environmental outcomes adopted by the EPA. The Approved Methods are referred to in the *POEO (Clean Air) Regulation 2002* for assessment of impacts of air pollutants.

The odour impact assessment criteria set out in the Approved Methods relevant to the Bowral STP are reproduced and discussed in **Section 3.4.2**.

3.2 Odour Technical Framework and Notes

The EPA's *Assessment and Management of Odour from Stationary Sources in NSW (Technical Framework and Technical Notes)* publications provide a policy framework for assessing and managing activities that emit odour and offer guidance on dealing with odour issues. These documents are required to be referenced when assessing any odour issue in NSW.

3.3 NSW DoP Best Practice Odour Guideline

The draft *NSW Best Practice Odour Guideline - Sewerage systems including sewage treatment plants, water recycling facilities, sewage reticulation systems and sewer mining* published in April 2010 (DoP NSW, 2010) hereafter referred to as the Odour Guideline, covers sewerage system infrastructure in urban areas including sewage treatment plants (STP), water recycling facilities, sewage reticulation systems and sewer mining. It is noted that the Odour Guideline is a draft document that is not legally enforceable and is not official government policy, but provides best practice guidance for managing odour for existing, new and expanding sewage treatment plants.

The following guidance provided in the Odour Guideline is relevant to expanding STPs:

- The odour design criteria to be adopted during the engineering design stage for an expanding STP is the achievement of a 2 odour unit (ou) odour assessment criterion at the boundary of the Industrial Zone or the Rural or infrastructure (SP2) lot(s).
- Adoption of good operational practices such as an Odour Management Plan (OMP). An OMP would specify odour operational and management standards and practices, and set out strategies and measures for minimising the risks of odour incidents and contingency actions for managing odour issues if they occur.
- Adoption of 'good neighbour' procedures and practices and encouraging staff to:
  - communicate and consult with neighbours;
  - seek opportunities to explain and interpret management practices;

- provide detailed information about proposed activities or works in progress;
- actively participate in community forums on issues relating to the sewerage system, its management and community values;
- be responsive to neighbour's concerns and professionally conciliate any issues; and
- cooperate with neighbours to resolve concerns.

3.4 Air Quality Criteria

3.4.1 Odour Concentration and Emission Rate Definitions

Odour concentration is measured in terms of odour units (ou). 1 ou is the concentration of odour-containing air that can just be detected by 50% of members of an odour panel (persons chosen as representative of the average population sensitivity to odour). This process is defined within Australian Standard AS4323.3: *Stationary Source Emissions – Part 3: Determination of Odour Concentration by Dynamic Olfactometry (Standards Australia 2001).*

The Specific Odour Emission Rate (SOER) is a measure of odour released from an area source and is expressed in odour units emitted per surface and time unit (ou. m^3/ m^2/s or ou. m^3/ m^2/min).

An Odour Emission Rate (OER) is the product of the odour concentration (ou) and the volumetric flow rate (e.g. m^3/s or m^3/min), and is often annotated as ou.m^3/s, or ou.m^3/min. For area sources, the SOER is multiplied by the area of the source to obtain the OER.

3.4.2 Odour Impact Assessment Criteria

Impacts from odorous air contaminants are often nuisance-related rather than health-related. Odour performance goals guide decisions on odour management, but are generally not intended to achieve "no odour".

The detectability of an odour is a sensory property that refers to the theoretical minimum concentration that produces an olfactory response or sensation. This point is called the *odour threshold* and defines 1 ou. An odour goal of less than 1 ou would theoretically result in no odour impact being experienced.

In practice, the character of a particular odour can only be judged by the receiver's reaction to it, and preferably only compared to another odour under similar social and regional conditions. Based on the literature available, the level at which an odour is perceived to be a nuisance can range significantly depending on a combination of the following factors:

- *Odour Quality*: whether an odour results from a pure compound or from a mixture of compounds. Pure compounds tend to have a higher threshold (lower offensiveness) than a mixture of compounds.
- *Population sensitivity:* any given population contains individuals with a range of sensitivities to odour. The larger a population, the greater the number of sensitive individuals it may contain.
- *Background level:* whether a given odour source, because of its location, is likely to contribute to a cumulative odour impact. In areas with more closely-located sources it may be necessary to apply a lower threshold to prevent offensive odour.

- *Public expectation:* whether a given community is tolerant of a particular type of odour and does not find it offensive, even at relatively high concentrations. For example, background agricultural odours may not be considered offensive, particularly in a rural or semi-rural environment, until a higher threshold is reached than for odours from a landfill facility.
- *Source characteristics:* whether the odour is emitted from a stack (point source) or from an area (diffuse source). Generally, the components of point source emissions can be identified and treated more easily than diffuse sources. Emissions from point sources can be more easily controlled using control equipment.
- *Health Effects:* whether a particular odour is likely to be associated with adverse health effects. In general, odours from agricultural activities are less likely to present a health risk than emissions from industrial facilities.

Experience gained through odour assessments from proposed and existing facilities in NSW indicates that an odour performance goal of 7 ou is likely to represent the level below which "offensive" odours should not occur (for an individual with a 'standard sensitivity' to odours). The OEH recommends within the Odour Framework that, as a design goal, no individual be exposed to ambient odour levels of greater than 7 ou. This is expressed as the 99th percentile value, as a nose response time average (approximately one second).

Odour performance goals need to be designed to take into account the range in sensitivities to odours within the community, and provide additional protection for individuals with a heightened response to odours. In NSW this is done using a statistical approach which depends on the size of the affected population. As the affected population size increases, the number of sensitive individuals is also likely to increase, which suggests that more stringent goals are necessary in these situations. In addition, the potential for cumulative odour impacts in relatively sparsely populated areas can be more easily defined and assessed than in highly populated urban areas. It is often not possible or practical to determine and assess the cumulative odour impacts of all odour sources that may impact on a receptor in an urban environment. Therefore, the proposed odour performance goals allow for population density, cumulative impacts, anticipated odour levels during adverse meteorological conditions and community expectations of amenity.

The equation used by the OEH to determine the appropriate impact assessment criteria for complex mixtures of odorous air pollutants, as specified in the Approved Methods, is expressed as follows:

$$\text{Impact assessment criterion (ou)} = (\log_{10}(\text{population})-4.5)/-0.6$$

A summary of the impact assessment criteria given for various population densities, as drawn from the Approved Methods, is given in **Table 2**. This factor has been used to derive a project specific odour criterion.

Table 2 OEH Impact Assessment Criteria for Complex Mixtures of Odorous Air Pollutants

Population of Affected Community	Impact Assessment Criteria for Complex Mixtures of Odours (ou) (nose-response-time average, 99th percentile)
Urban area (≥ 2000)	2.0
~500	3.0
~125	4.0
~30	5.0
~10	6.0
Single residence (≤ 2)	7.0

Source: The Approved Methods (NSW EPA, 2017)

The Approved Methods states that the impact assessment criteria for complex mixtures of odorous air pollutants must be applied at the nearest existing or likely future off-site sensitive receptor(s).

The incremental impact (predicted impact due to the pollutant source alone) must be reported in units consistent with the impact assessment criteria (ou), as peak concentrations (i.e. approximately 1 second average) and as the:

- 100th percentile of dispersion model predictions for Level 1 impact assessments; or
- 99th percentile of dispersion model predictions for Level 2 impact assessments.

It is noted that a Level 2 odour impact assessment as defined by the Approved Methods is equivalent to a Level 3 odour impact assessment as defined by the Technical Framework.

Based on previous discussions with the NSW EPA for similar facilities, the odour impact assessment criterion was determined by identifying the area within the two odour unit contour for the worst case scenario and multiplying this area by the relevant average population density obtained from the Australian Bureau of Statistics (2016 Census data). Refer to **Section 7** for details on the odour impact assessment criterion adopted for the Bowral STP.

3.4.3 Peak to Mean Ratios

It is a common practice to use dispersion models to determine compliance with odour goals. This introduces a complication because dispersion models are typically restricted by the meteorological data inputs to predicting concentrations over an averaging period of 1-hour or greater. The human nose, however, can respond to odours over periods of the order of one second. During longer periods, odour levels can fluctuate significantly above and below the mean depending on the nature of the source.

To determine the ratio between the 1-second peak concentrations and longer period average concentrations (referred to as the peak to mean ratio) that might be predicted by a dispersion model, the EPA commissioned a study by Katestone Scientific Pty Ltd [(Katestone Scientific, 1998), (Katestone Scientific, 1995)]. This study recommended peak to mean ratios for a range of circumstances. The findings of these studies have been adopted in the Approved Methods and Technical Framework.

For area sources, the peak to mean ratio is dependent on atmospheric stability and the distance from the source. Given the separation distance and topographical features between the odour sources at the Bowral STP and the nearest sensitive receptors, a Peak-to-Mean Ratio (P/M60) of 2.3 for stability classes A, B, C and D and 1.9 for stability classes E and F applies. However, as a conservative measure, a P/M60 of 2.3 has been applied to all area sources for all stability classes at the Bowral STP. Similarly a P/M60 of 2.3 is recommended for volume source and wake-affected point sources for all stability classes.

The estimated odour emission rates used in the modelling study have accounted for the above peak to mean ratio to enable direct comparison of the results against the goals shown in **Section 3.4.2**, which are based on nose-response time.

4 Climate and Meteorology

The nearest active Automatic Weather Station (AWS) collecting data suitable for use in a quantitative air dispersion modelling study operated by the Bureau of Meteorology (BoM) is located at Moss Vale, approximately 4 km southeast of the Bowral STP.

Moss Vale AWS (Station 68239, elevation 678 m), has data available for the following parameters:

- Temperature (°C);
- Rainfall (mm);
- Relative humidity (%);
- Wind speed (m/s); and
- Wind direction (degrees).

The details of Moss Vale AWS are summarised in **Table 3**.

Table 3 Meteorological Monitoring Station Details

Station Name	Location (m, MGA)		Distance / Direction from Bowral STP	Elevation (m, AHD)
	Easting	Northing		
Moss Vale AWS	263,346	6,176,578	4.3 km / Southeast	678

A review of the long term data collected by this station is provided in the following sections.

4.1 Temperature

Long-term temperature statistics for Moss Vale AWS are summarised in **Figure 7**. Mean maximum temperatures range from 11.9°C in winter to 26.3°C in summer, while mean minimum temperatures range from 2.4°C in winter to around 14.1°C in summer. Maximum temperatures of 40°C and minimum temperatures less than -6°C have been recorded.

4.2 Rainfall

Long-term rainfall statistics for Moss Vale AWS are summarised in **Figure 8.** The average monthly rainfall is relatively high between early summer and early winter, reducing from mid-winter to late spring with the lowest average of 37.1 mm/month recorded during September. No months recorded an average of less than ten days of rain days per month. The highest average monthly rainfall of 99.4 mm/month occurs in February, with an average of 14 rain days recorded in this month. The highest monthly rainfall recorded over the time period examined was 318 mm recorded in June 2016.

4.3 Relative Humidity

Long-term humidity statistics (9 am and 3 pm monthly averages) for Moss Vale AWS are summarised in **Figure 9**. Morning humidity levels range from an average of around 63% in mid spring to around 83% in early autumn to mid-summer. Afternoon humidity levels are lower, at around 63% in late summer and dropping to a low of 51% in spring.

Figure 7 Long Term Temperature Data for Moss Vale AWS

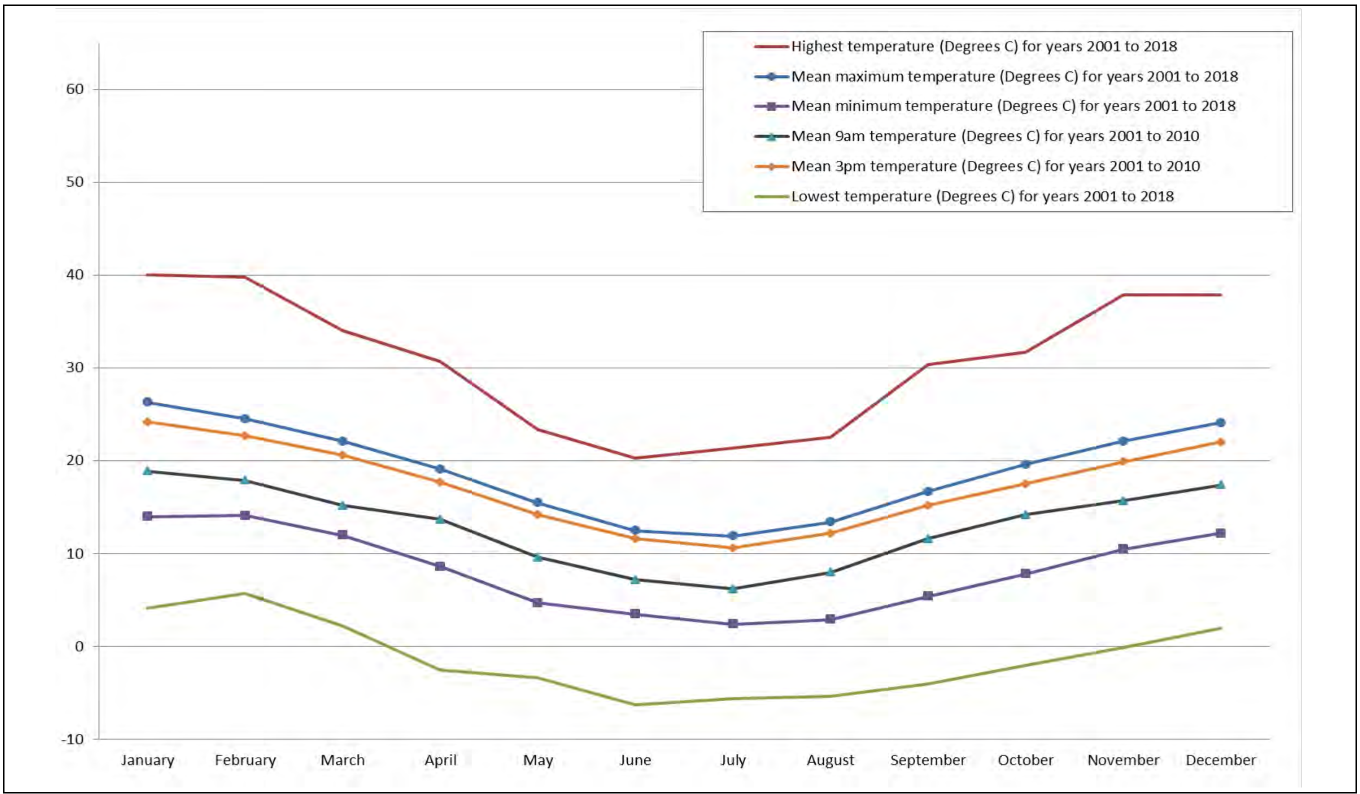


Figure 8 Long Term Monthly Rainfall Data for Moss Vale AWS

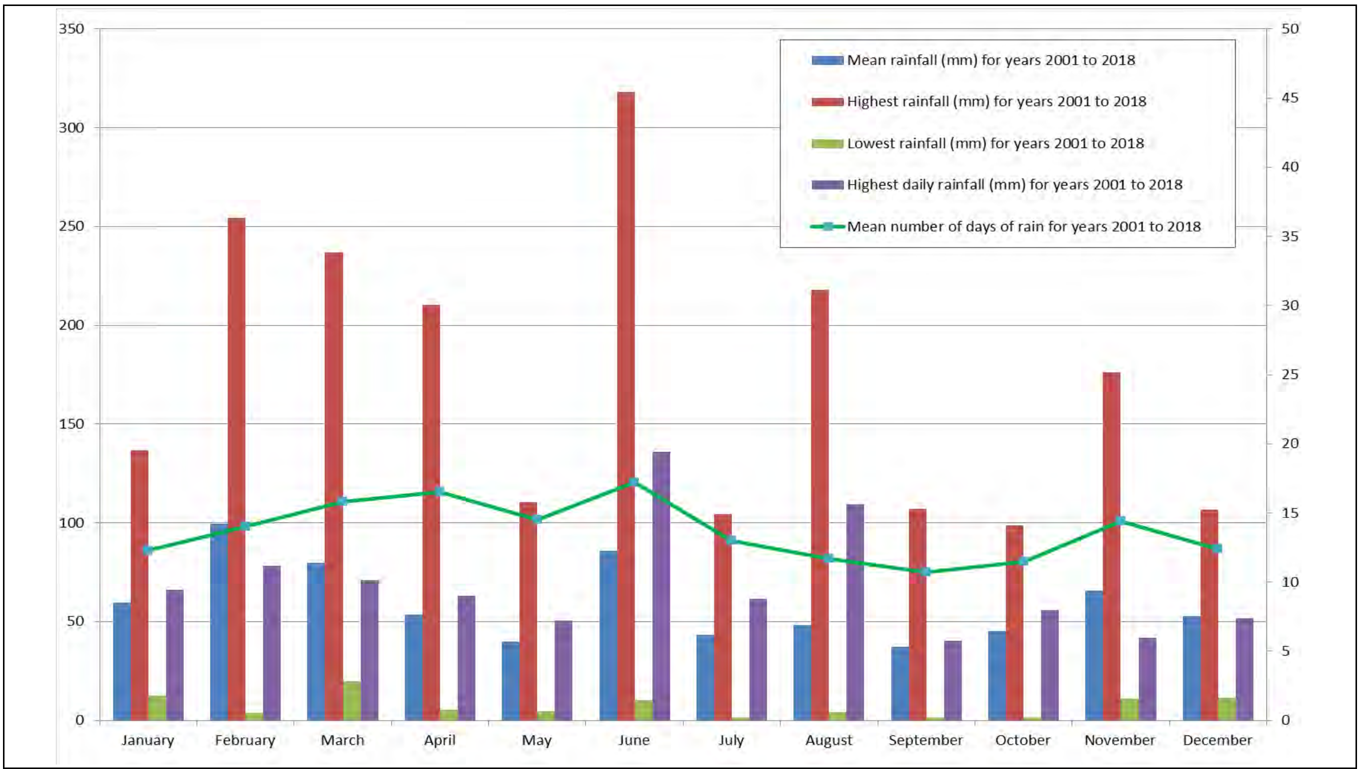
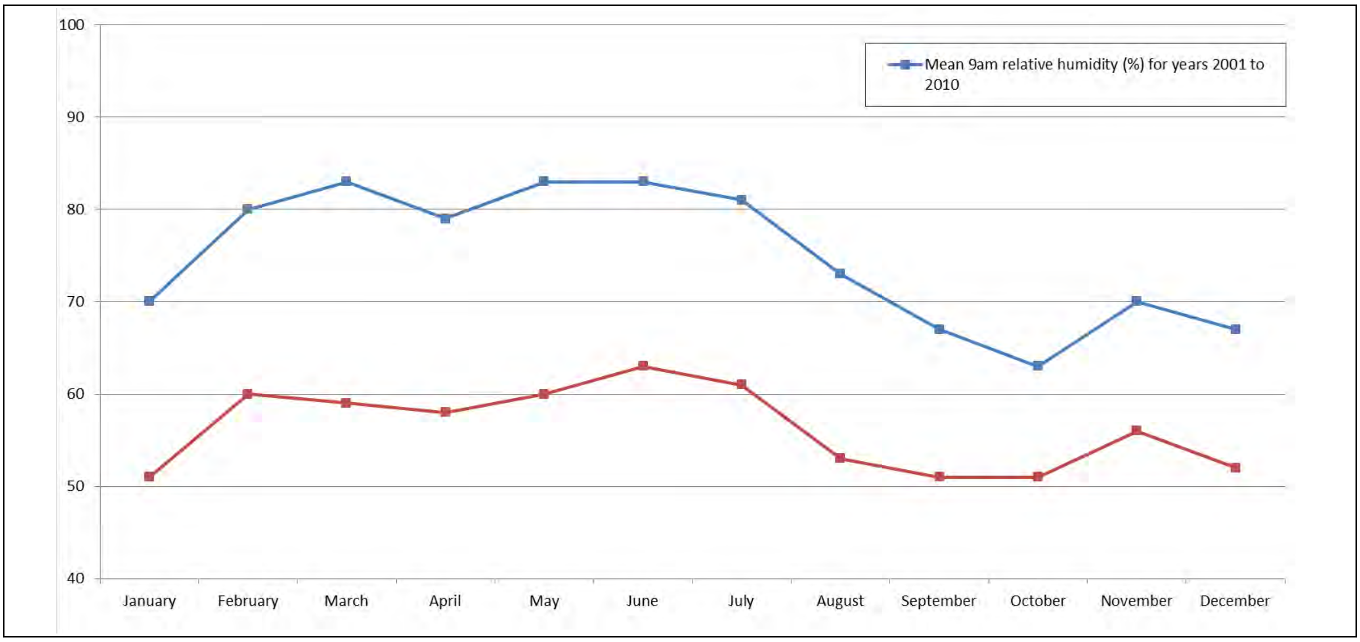


Figure 9 Long Term Humidity Data for Moss Vale AWS



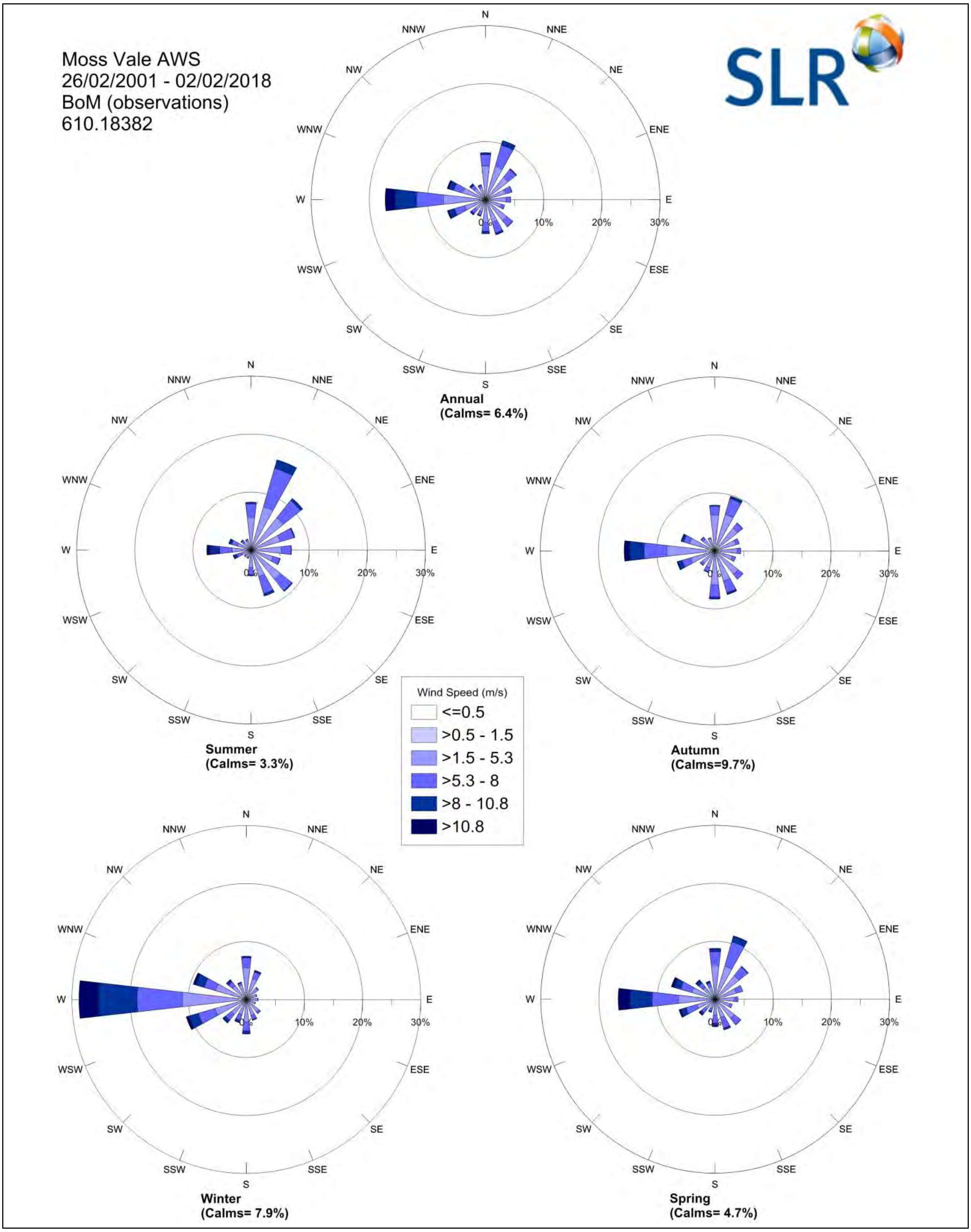
4.4 Wind Speed and Direction

Long term wind data (2001 – 2018) recorded by the Moss Vale AWS are presented as wind roses in **Figure 10**. The wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points (degrees from north). The direction of the bar shows the direction from which the wind is blowing. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds. Thus it is possible to visualise how often winds of a certain direction and strength occur over a long period, either for all hours of the day, or for particular periods during the day. There are times when the wind is calm (defined as being from zero to 0.5 metres/second), and the percentage of the time that winds are calm are shown as a note on the wind rose.

Figure 10 shows prevailing westerly winds at Moss Vale AWS. Calm wind conditions were predicted to occur approximately 6.4% of the time over the 17 year period reviewed. The seasonal wind roses indicate that typically:

- In summer, winds predominantly blow from the north-northeast and northeast with a very low frequency of winds from the northwest and west quadrants. On average, calm winds are experienced 3.3% of the time during summer.
- In autumn, winds predominantly blow from the west, with the lowest frequency of winds from the northwest and southwest. On average, calm winds are experienced 9.7% of the time during autumn.
- In winter, winds predominantly blow from the west quadrant, with the lowest frequency of winds from the northeast and southeast quadrants. On average, calm winds are experienced 7.9% of the time during winter.
- In spring, winds predominantly blow from the west and north-northeast. On average, calm winds were experienced 4.7% of the time during spring.

Figure 10 Rose of Wind Direction Vs Wind Speed for Moss Vale AWS (2001 -2018)



5 Estimation of Air Emissions

5.1 STP Odour Sources

The odour sources at the existing and proposed Bowral STP include:

- **Inlet works** –The existing inlet works is proposed to be replaced with a higher capacity system as part of the proposed upgrades. The proposed new inlet works facilities will be enclosed and will include an odour control unit. Inlet works have the potential for releasing fugitive emissions while the odour control system includes a stack emission source. Waste collected in the fully enclosed and automated grit and screenings waste bins is frequently (at least daily) transferred for off-site disposal.
- **Stormwater detention ponds** – The existing stormwater detention pond (SDP2) will be retained and a new stormwater detention pond (SDP1) added by converting the existing Pasveer reactors. During wet weather conditions, overflow from the inlet works as diluted sewage will be bypassed to SDP1. SPD2 will be used as an overflow pond from SDP1. This could be a significant source of odour, however the frequency of use of the SDPs is low and estimated to be in the order of 20 days per year.
- **IDEA reactor and Sludge Digester** – As part of the proposed upgrades, the existing IDEA reactor will be modified to be used as an aerobic sludge digester.
- **Sludge lagoons** – Existing sludge lagoons are a potential major source of odour. Currently, the sludge is stabilised for several months, and only mixed in the week before the lagoons are emptied. This allows trapped odorous gases to escape. Sludge lagoons will be decommissioned as part of the proposed upgrade.
- **Sludge drying beds** - These will be decommissioned as part of the proposed upgrade.
- **Bioreactor –** There are two (2) new bioreactors proposed in the upgraded plant design.
- **Clarifiers –** Two (2) new secondary clarifiers are proposed in the upgraded plant design.
- **Catch / balance tanks and Emergency Storage -** The existing balance pond will become an emergency storage pond for process storage.
- **Sludge dewatering building –** Sludge processed on site will be dewatered before transport off site. Fugitive odour emissions from the sludge dewatering building are expected.
- **Other sources –** Other smaller sources of odours included in the proposed design are**:**
    - Flocculation tanks;
    - Dual media filters;
    - Clear water backwash tank;
    - Dirty water backwash tank and;
    - Sludge loadout facility.

The following components of the existing and proposed design have been excluded as odour emissions from these sources are considered to be negligible -

- **Tertiary pond –** Excluded on the basis of storage of treated water (no odour emissions as relevant for cumulative assessment with odours from STPs).
- **Filter Feed Pumping Station –** Excluded as a minor source
- **Foul water Pumping Station -** Excluded as a minor source

- **RAS pump station** - Excluded as a minor source
- **Scum pump station** - Excluded as a minor source
- **Clarifier flow splitter** - Excluded as a minor source

The locations of these sources are illustrated in **Figure 2** and **Figure 3** above.

5.2 Emission Estimation Methodology

No odour sampling has been performed for the existing Bowral STP. A literature review of publicly available odour emission testing reports and impact assessments for STPs in Australia was performed to identify odour emission rates relevant for the existing and proposed operations. Two relevant STP odour impact assessment reports were available and reviewed as part of this study, which were:

- Rosebery Wastewater Treatment Plant (WWTP) – Air Quality Impact Assessment (MWH, 2013); and
- Farley Wastewater Treatment Works (WWTW) - Odour Impact Assessment (Vipac Engineers and Scientists, 2016).

The SOERs used in the above assessments for processing units relevant to the Bowral STP were identified and are presented in **Table 4**.

Table 4 Surface Odour Emission Rates Identified from the Literature Review

Material Type	SOER* ($ou.m^3/m^2/s$)	Reference
Inlet Works	7.59	Rosebery WWTP
Inlet Works	6.13	Farley WWTW
Sludge Holding Tank	0.69	Rosebery WWTP
Sludge Lagoon	1.150	Farley WWTW
Clarifiers	0.230	Farley WWTW
Biosolids Stockpile	0.529	Farley WWTW
Biosolids Area	0.529	Farley WWTW
Aerobic Digester	0.1932	Farley WWTW
Oxidation Ditch	1.288	Farley WWTW
Decant / Balance Tank	0.414	Rosebery WWTP
IDEA Reactor - Aeration Phase	0.644	Rosebery WWTP
IDEA Reactor - Settling Phase	1.38	Rosebery WWTP
IDEA Reactor - Decant Phase	0.414	Rosebery WWTP

* includes Peak to Mean Ratio of 2.3

Note –conservative odour emission rates were estimated for the Bowral STP using highest reported values shown above

The adopted surface odour emission rates for this assessment are presented in **Table 5**. In order to estimate conservative odour emission rates from the Bowral STP, for sources with multiple emission rates available in the literature, the highest reported values have been used for the purpose of this assessment.

Table 5 Surface Odour Emission Rates Adopted for Bowral STP

Activity	SOER ($ou.m^3/m^2/s$)*	Reference
Inlet Works	7.59	Rosebery WWTP
Pasveer Channels	1.38	Assumed similar to IDEA Reactor
Catch/Balance Tanks	0.414	Rosebery WWTP
IDEA Reactor	1.38	Rosebery WWTP
Bioreactor flow splitter	7.59	Assumed similar to inlet works
Bioreactor	0.644	Conservatively assumed similar to aeration phase of IDEA Reactor
Clarifiers	0.23	Farley WWTW
Flocculation tank	0.23	Conservatively assumed similar to clarifiers, as involves further removal of solids from clarifiers
Dual media filters	0.23	Conservatively assumed similar to clarifiers, as involves further removal of solids from clarifiers
Clearwater backwash tank	0.23	Conservatively assumed similar to clarifiers, as involves further removal of solids from clarifiers
Dirty backwash tank	0.23	Conservatively assumed similar to clarifiers, as involves further removal of solids from clarifiers
Stormwater Detention Ponds (SDP2-Existing, Proposed)	0.414	Existing - Assumed similar to Catch/Balance tank Proposed - Conservatively assumed similar to existing operations. It is noted that for the proposed scenario, by-pass from inlet works is proposed to have a bar screen to capture larger solids
Stormwater Detention Ponds (SDP1-Proposed)	0.414	Conservatively assumed similar to Catch/Balance tank, as by-pass from inlet works is proposed to have a bar screen to capture larger solids
Emergency Storage Pond	0.23	Assumed similar to clarifier
Sludge Lagoons	1.15	Farley WWTW
Aerobic Digester	0.1932	Farley WWTW
Sludge Digester	0.1932	Assumed similar to Aerobic Digester
Biosolids Stockpile	0.529	Farley WWTW
Sludge loadout facility	0.529	Assumed similar to biosolids stockpile
Sludge Storage Area	0.529	Conservatively assumed similar to biosolids stockpile
Sludge Thickener	0.69	Assumed similar to sludge holding tank

* includes Peak to Mean Ratio of 2.3

Note –conservative odour emission rates were estimated for the Bowral STP using highest reported values shown **Table 4.**

It is noted that previously conducted OIA (SLR Consulting Pty Ltd, 2019) for the Bowral STP considers an SOER of 7.59 $ou.m^3/m^2/s$ for the Stormwater Detention Ponds. However, this has been updated in the current modelling study based on updated sources as presented in **Table 5**.

Additionally, as shown in **Table 6** the odour emission concentration for the inlet works odour control unit were adopted from the *'Odour Control Unit Standard Specifications'* (Sydney Water, 2011). Stack parameters and flow rate were provided in the Public Works Advisory (Public Works Advisory, 2021).

As a conservative assumption, 10% of the odours associated with the Odour Control Unit were assumed to be emitted as fugitives from inlet works and pump station.

Table 6 Odour Control Unit – Stack Emission Parameters

Source	Height (m)	Flow rate (m3/s)	Exit Velocity (m/s)	Temperature	Odour Concentration (ou)	OER ($ou.m^3/s$)*
Odour Control Unit (Stack)	12	1.3	20	Variable (set to ambient)	500	1,597

* includes Peak to Mean Ratio of 2.3

Odour emissions from the sludge dewatering building were estimated based on sludge building odour concentration data from the Sydney Water and assumptions on building size and a potential ventilation rate as presented in **Table 7**.

Table 7 Sludge Dewatering Building – Emission Parameters

Source	Estimated Building Volume (m^3)	Hourly ventilation volume (m^3/hr)#	Odour Concentration	OER (ou/s)*
Sludge Dewatering Building	700	3,500	500	1,150

* includes Peak to Mean Ratio of 2.3

Based on assumed 5 air exchanges per hour

5.3 Estimated Emissions

The odour emission rates and source parameters used in the modelling for the existing and proposed upgraded operations are presented in **Table 8** and **Table 9** to **Table 11**, respectively. The total odour emissions from the proposed operations is estimated to be 10,014 $ou.m^3/s$ which is approximately 42% lower than the emissions estimated for the existing operations.

Considering the relative proportion of emissions from the stormwater detention and emergency storage ponds and that these sources are rarely in use[1] these sources were modelled separately so that results could be presented for both normal operations (without inlet works overflow to stormwater detention and emergency storage ponds) and with the use of the stormwater detention and emergency storage ponds. For the scenarios with these sources included emissions were assumed as continuous which is conservative considering the low likelihood of an overflow event co-occurring with peak impact dispersion conditions.

[1] It was estimated from inlet data that SDP1 may be in use 20 days per year and overflow to SDP2 may occur on 15 of these days (Public Works Advisory, 2021).

Table 8 Odour Emission Rate and Source Parameters – Existing Operations Area Sources

Source	Area (m^2)	Height (m)	SOER ($ou.m^3/m^2/s$) *	OER ($ou.m^3/s$) *
Pasveer Channels 1	1,025	0.5	1.380	1,415
Pasveer Channels 2	1,025	0.5	1.380	1,415
Catch/Balance Overflow Pond	1,800	0.5	0.414	745
Existing IDEA	1,339	0.5	1.380	1,848
Inlet Works	60	0.5	7.59	455
Sludge Drying Bed B-1	601	0.5	0.529	318
Sludge Drying Bed B-2	601	0.5	0.529	318
Sludge Drying Beds A-1	1,569	0.5	0.529	830
Sludge Drying Beds A-2	1,471	0.5	0.529	778
Sludge Lagoon #1	2,436	0.5	1.150	2,801
Sludge Lagoon #2	2,436	0.5	1.150	2,801
Stormwater Detention Pond	8,265	0.5	0.414	3,422
Total STP Odour Emissions				**17,146**

* includes Peak to Mean Ratio of 2.3

Table 9 Odour Emission Rate and Source Parameters – Proposed Operations Stack Source

Source	Stack Diameter (m)	Height (m)	Flow rate (m^3/s)	OER ($ou.m^3/s$)*
Odour control (inlet works)	0.3	12	1.39	1,597

* includes Peak to Mean Ratio of 2.3

Table 10 Odour Emission Rate and Source Parameters – Proposed Operations Volume Source

Source	Source Height (m)	OER ($ou.m^3/s$)*
Inlet works (fugitive)	1.5	160
Intel pump station (fugitive)	0.25	160
Bioreactor flow splitter	1.5	273
Flocculation tank	1.5	4
Dual media filters	1.5	5
Clearwater back wash tank	1.5	21
Dirty back wash tank	1.5	14
Sludge dewatering building	1.5	1,150
Sludge load out facility	1.5	41
Sludge thickener	1.5	27

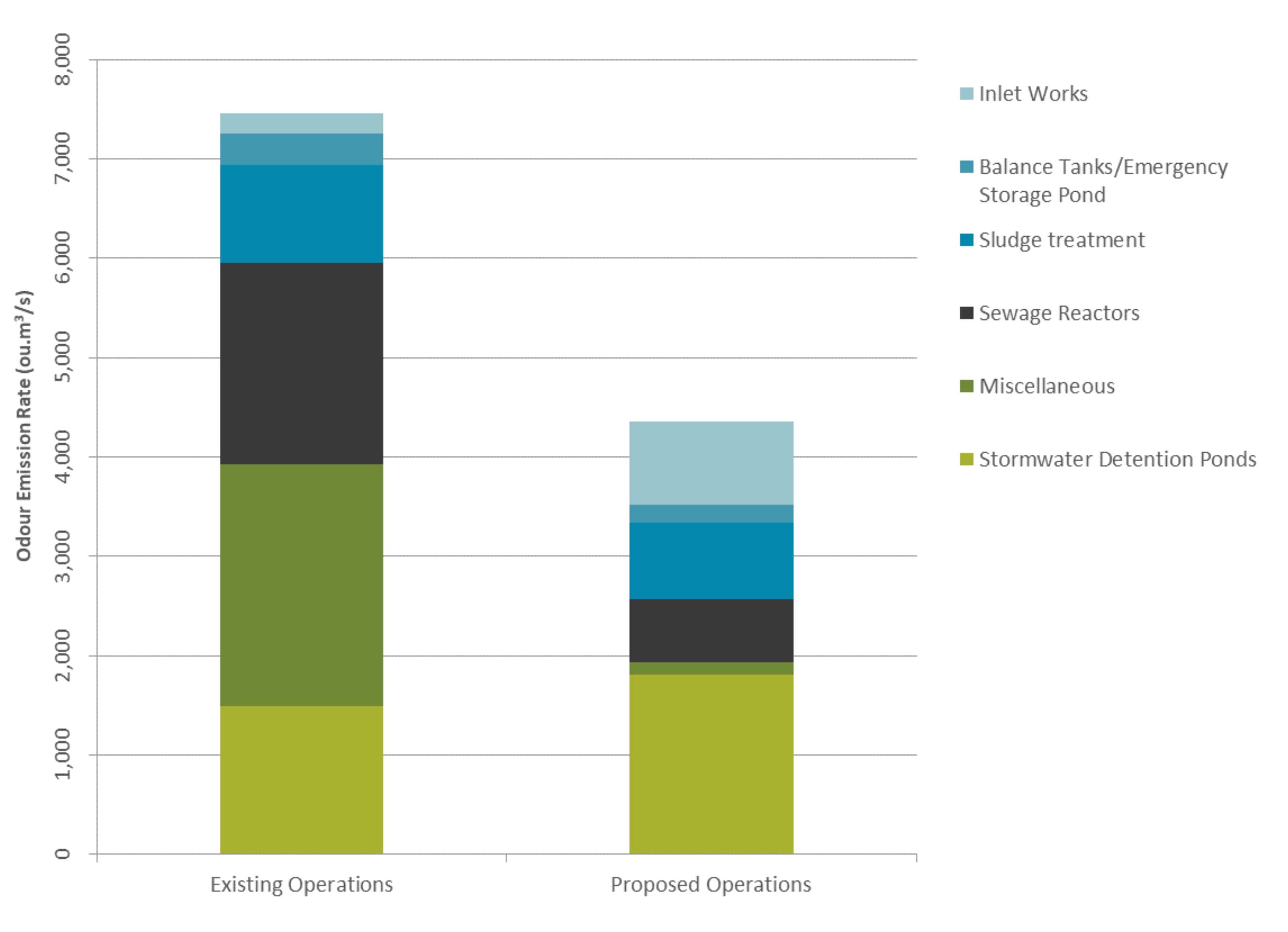
* includes Peak to Mean Ratio of 2.3

Table 11 Odour Emission Rate and Source Parameters – Proposed Operations Area Source

Source	Area (m^2)	Height (m)	SOER ($ou.m^3/m^2/s$)*	OER ($ou.m^3/s$)*
Bio reactor (MLE)	1,840	0.5	0.64	1,185
Clarifiers	1,061	0.5	0.23	244
Storm pond (inlet overflow) SDP1	1,800	0.5	0.41	745
Storm pond (inlet overflow) SDP2	8,265	0.5	0.41	3,422
Filter feed overflow pond	1,800	0.5	0.23	414
Sludge digester (aerobic)	1,339	0.5	0.41	554

* includes Peak to Mean Ratio of 2.3

Figure 11 Source Odour Emission Contributions



Note - Peak to mean ratio not included

Note 2 – The increase in inlet works odour emission rates from the existing to the proposed operations are predominantly due to the conservative odour emission rates adopted for the proposed inlet works.

6 Atmospheric Dispersion Modelling Methodology

6.1 Model Selection

Odour emissions from the Bowral STP were modelled using a combination of the TAPM, CALMET and CALPUFF models. CALPUFF is a transport and dispersion model that ejects "puffs" of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so, it typically uses the fields generated by a meteorological pre-processor CALMET, discussed further below. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain either hourly concentration or hourly deposition fluxes evaluated at selected receptor locations. The CALPOST post-processor is then used to process these files, producing tabulations that summarise results of the simulation for user-selected averaging periods.

6.2 Meteorological Modelling

6.2.1 Selection of Representative Year for Meteorological Modelling

In order to determine a representative meteorological year for use in dispersion modelling, five years of meteorological data (2013-2017) from the closest meteorological monitoring station (i.e. Moss Vale AWS) were analysed against the five year average meteorological conditions. Specifically, the following parameters were analysed:

- Frequency and distribution of the predominant wind directions;
- Monthly average wind speeds observed; and
- Monthly average temperatures.

Based on this analysis, it was concluded that the year 2015 was representative of the last five years of meteorological conditions experienced at the Bowral STP and hence the 2015 calendar year was adopted for use in this OIA. A summary of the analysis is presented in **Appendix A**.

6.2.2 Meteorological Data Availability

To adequately characterise the dispersion meteorology of the Bowral STP, information is needed on the prevailing wind regime, atmospheric stability, mixing depth and other meteorological parameters. Hourly meteorological data from the Moss Vale AWS (refer **Section 4**) were used in the meteorological modelling study for the study area.

6.2.3 TAPM

The TAPM prognostic model, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), was used to generate the upper air data required for CALMET modelling.

TAPM predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate one full year of hourly meteorological observations at user-defined levels within the atmosphere.

Additionally, the TAPM model may assimilate actual local wind observations so that they can optionally be included in a model solution. The wind speed and direction observations are used to realign the predicted solution towards the observation values. In this study, data from the BoM's Moss Vale AWS and High Range AWS (Wanganderry) were used to nudge (i.e. influence) the TAPM predictions. **Table 12** details the parameters used in the TAPM meteorological modelling for this assessment.

Table 12 Meteorological Parameters Used for this Study - TAPM

TAPM (v 4.0)	
Number of Grids (spacing)	4 (30 km, 10 km, 3 km and 1 km)
Number of Grid Points	25 x 25 x 25
Year of Analysis	2015
Centre of Analysis	247,807 m E 6,031,864 m S
Data Assimilation	Moss Vale AWS, High Range AWS (Wanganderry)

6.2.4 CALMET

In the simplest terms, CALMET is a meteorological model that develops hourly wind and other meteorological fields on a three-dimensional gridded modelling domain that are required as inputs to the CALPUFF dispersion model. Associated two dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, sea breeze, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final hourly varying wind field thus reflects the influences of local topography and land uses.

The CALMET domain was modelled with a resolution of 0.05 km. The TAPM-generated 3-dimensional meteorological data (1 km resolution) was used as the 'initial guess' wind field and the local topography and available surface weather observations in the area were used to refine the wind field predetermined by TAPM. **Table 13** details the parameters used in the meteorological modelling to drive the CALMET model.

Table 13 Meteorological Parameters Used for this Study – CALMET (V 6.1)

CALMET Domain	
Meteorological Grid	6.5 km × 6.5 km
Meteorological Grid Resolution	0.05 km
Initial Guess Filed	3D output from TAPM modelling
Topography	SRTM-derived 1 Second data sourced from Geosciences Australia
Surface station data	Moss Vale AWS

6.3 Meteorological Data Used In Modelling

To provide a summary of the meteorological conditions predicted at the Bowral STP using the methodology described in **Section 6.2**, a single-point, ground-level meteorological dataset was 'extracted' from the 3-dimensional dataset at the Bowral STP and is presented in this section.

6.3.1 Wind Speed and Direction

A summary of the annual wind behaviour predicted by CALMET for 2015 (extracted at the Bowral STP) is presented as wind roses in **Figure 12** and as a wind speed distribution plot in **Figure 13**. These plots show that winds in the study area were predicted to be predominantly of gentle to moderate strength with average windspeed predicted to be 4.4 m/s during 2015. Calm wind conditions were predicted to occur approximately 2.6% of the time throughout the modelling period. It is noted that the moderate winds and low percentage of calm wind conditions will assist pollutant dispersion, resulting in lower odour concentrations at the surrounding receptors.

The seasonal wind roses indicate that typically:

- In summer, winds predominantly blow from the north-northeast with a very low frequency of winds from the northwest and southwest quadrants. On average, calm winds are experienced 1.6% of the time during summer.
- In autumn, winds predominantly blow from the west, with the lowest frequency of winds from the east. On average, calm winds are experienced 2.8% of the time during autumn.
- In winter, winds predominantly blow from the west quadrant, with the lowest frequency of winds from the east quadrant. On average, calm winds are experienced 3.8% of the time during winter.
- In spring, winds predominantly blow from the north-northeast quadrant. On average, calm winds were experienced 2.1% of the time during spring.

A comparison of the wind roses presented in **Figure 12** with the Moss Vale AWS wind roses presented in **Figure 10** shows a similar distribution of wind directions, however the frequency of calm conditions is lower at the Bowral STP. This may be due to the influence of night-time drainage flows from the elevated terrain to the north increasing the night-time wind speeds. Based on the wind roses, the seasons with the greatest potential for odour impacts at the nearest sensitive receptors (R12-R16 south of the site) would be summer.

Figure 12 CALMET-Predicted Seasonal Wind Roses for the Bowral STP – 2015

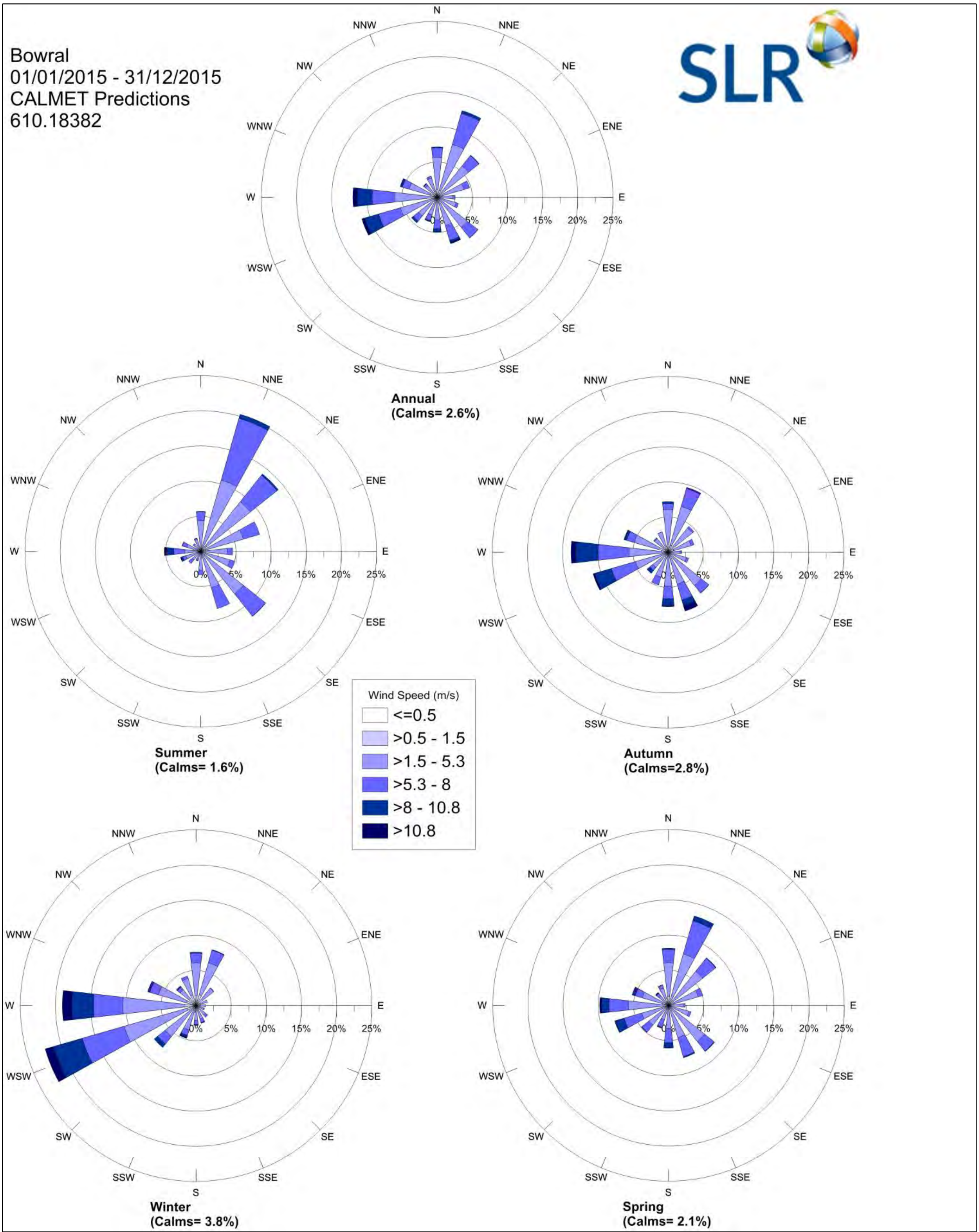
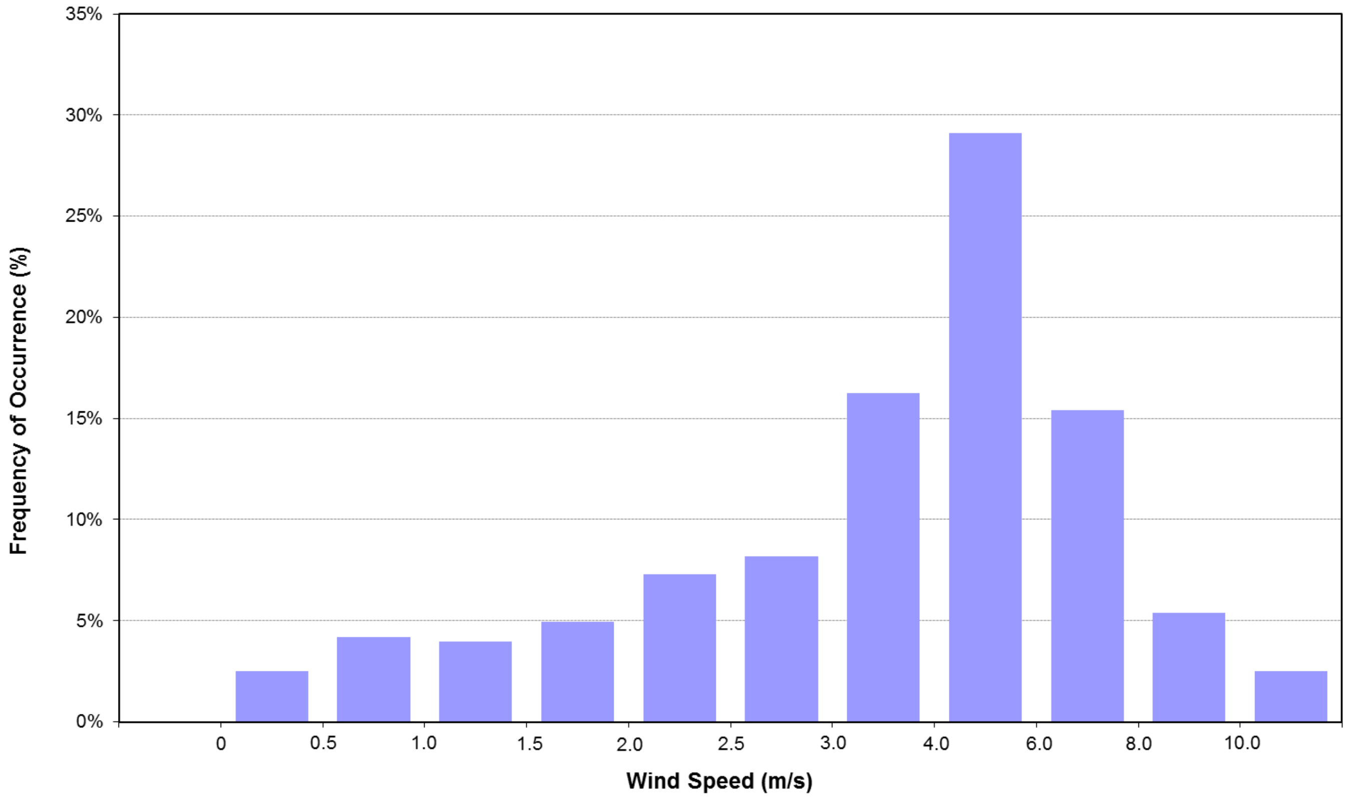


Figure 13 Annual Wind Speed Frequencies at the Bowral STP (CALMET Predictions, 2015)



6.3.2 Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Gifford-Turner (PGT) assignment scheme identifies six stability classes, A to F, to categorise the degree of atmospheric stability as follows:

- A = Extremely unstable conditions
- B = Moderately unstable conditions
- C = Slightly unstable conditions
- D = Neutral conditions
- E = Slightly stable conditions
- F = Moderately stable conditions

The meteorological conditions defining each PGT stability class are shown in **Table 14**.

Table 14 Meteorological Conditions Defining PGT Stability Classes

Surface Wind Speed (m/s)	Daytime Insolation			Night-Time Conditions	
	Strong	Moderate	Slight	Thin overcast or > 4/8 low cloud	<= 4/8 cloudiness
< 2	A	A - B	B	E	F
2 - 3	A - B	B	C	E	F
3 - 5	B	B - C	C	D	E
5 - 6	C	C - D	D	D	D
> 6	C	D	D	D	D

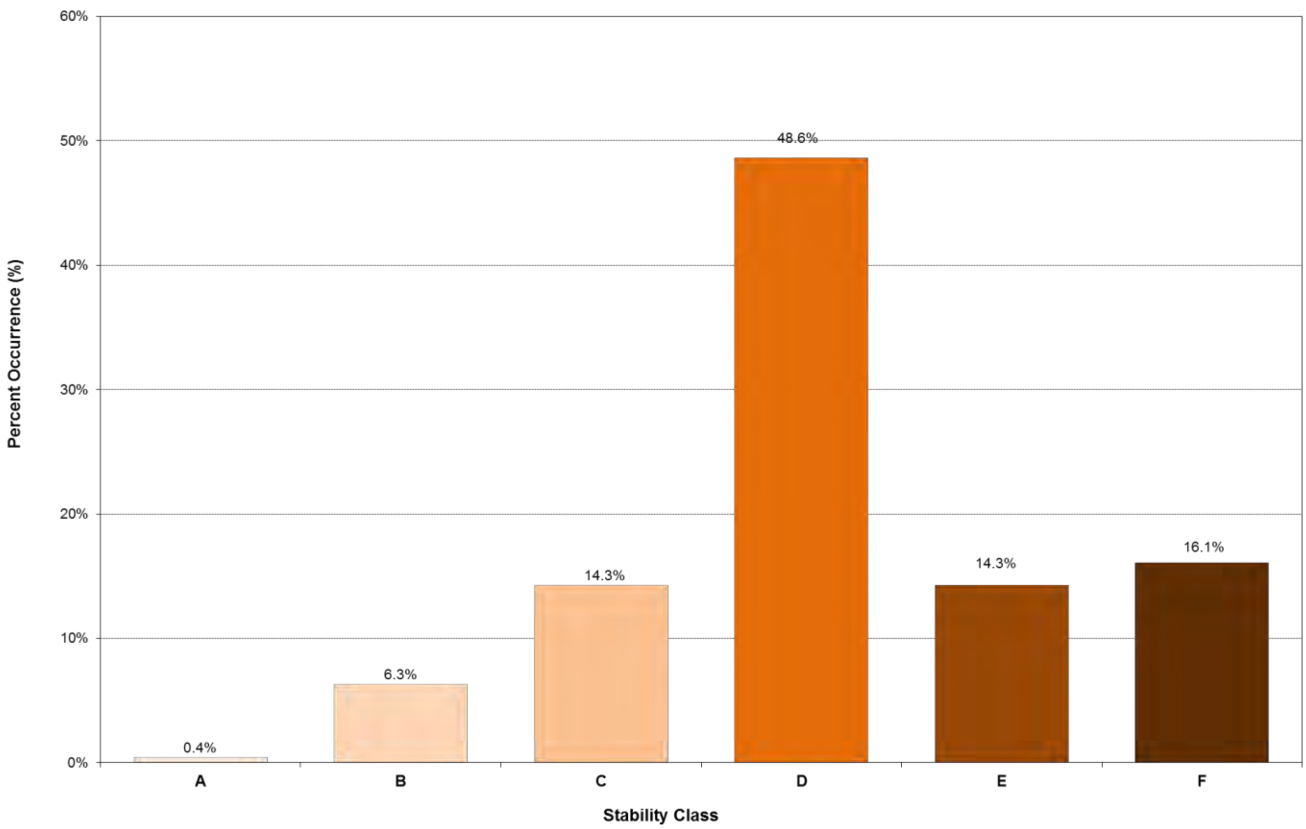
Source: (NOAA, 2018)

Notes:

1. Strong insolation corresponds to sunny midday in midsummer in England; slight insolation to similar conditions in midwinter.
2. Night refers to the period from 1 hour before sunset to 1 hour after sunrise.
3. The neutral category D should also be used, regardless of wind speed, for overcast conditions during day or night and for any sky conditions during the hour preceding or following night as defined above.

The frequency of each stability class predicted by CALMET at the Bowral STP during the modelling period is presented in **Figure 14**. The results indicate a high frequency of conditions typical to Stability Class D. Stability Class D is indicative of neutral conditions, conducive to a moderate level of pollutant dispersion due to mechanical mixing.

Figure 14 Predicted Stability Class Frequencies at the Bowral STP (CALMET predictions, 2015)

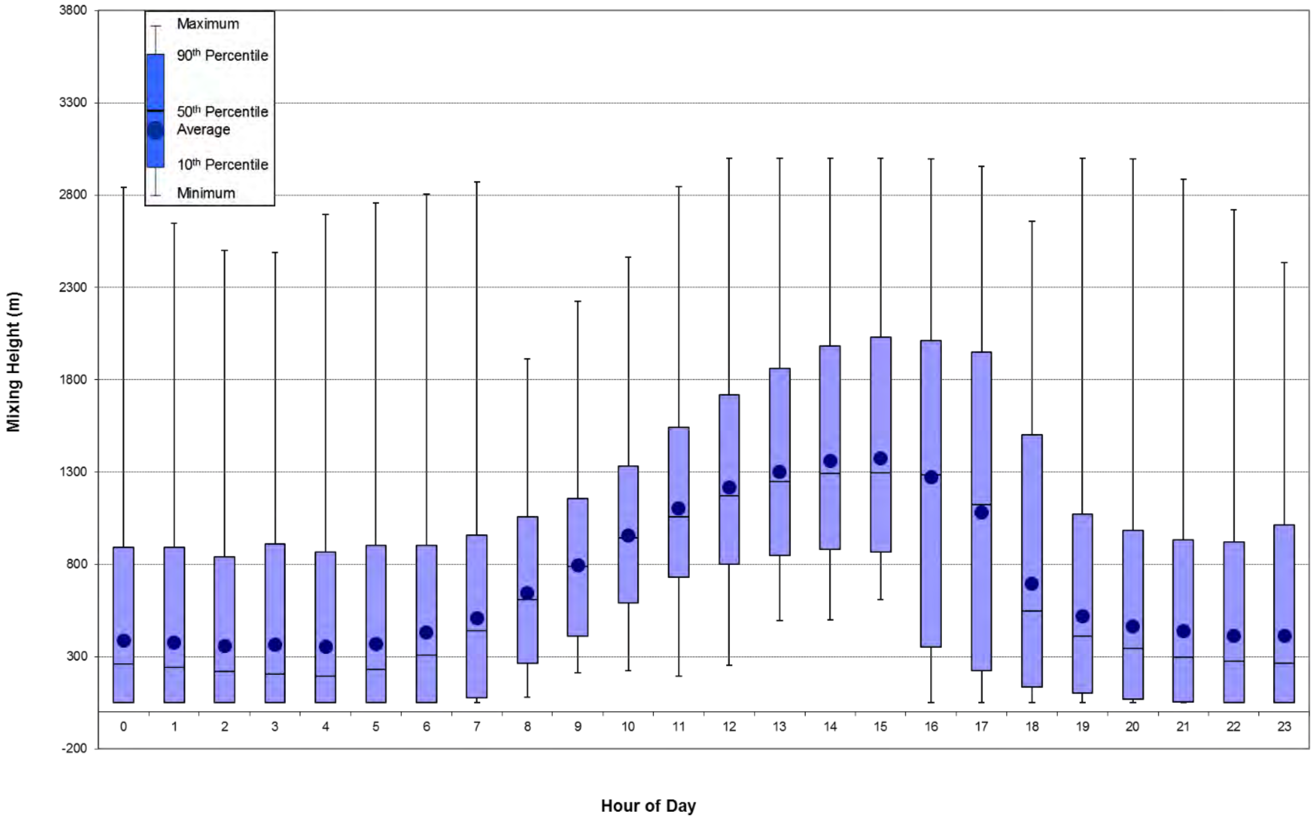


6.3.3 Mixing Heights

Diurnal variations in maximum and average mixing heights predicted by CALMET at the Bowral STP during the 2015 modelling period are illustrated in **Figure 15**.

As would be expected, an increase in mixing depth during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground based temperature inversions and growth of the convective mixing layer.

Figure 15 Predicted Mixing Heights at the Bowral STP (CALMET predictions, 2015)



6.4 Dispersion Model Configuration

As discussed in **Section 6.1**, dispersion modelling was conducted using the CALPUFF dispersion model and three-dimensional meteorological data output from CALMET. This study utilised the CALPUFF dispersion model in full 3D mode, incorporating the 3D meteorological output from CALMET and the CSIRO prognostic meteorological model TAPM. Conservative assumptions have been made in deriving the odour emission rates to provide worst case assessment of odour impacts.

In order to appropriately analyse the various operational scenarios on site, the following modelling scenarios were used in this study:

- **Existing Normal Operations** – this scenario is designed to represent the existing operations and includes all existing odour sources except for those reserved for emergency use (i.e. emergency catch/balance pond, storm water detention pond -SDP2).

- **Proposed Normal Operations** - this scenario is designed to represent the proposed operations on site and includes all proposed odour sources except for those reserved for emergency use (i.e. storm water detention ponds -SDP2, SDP1 and the Emergency Storage Pond).
- **Existing Operations with Emergency Storage–** this scenario is designed to represent the existing operations on site and includes all existing odour sources including those reserved for emergency use (i.e. emergency catch/balance pond, storm water detention pond -SDP2).
- **Proposed Operations with Emergency Storage** - this scenario is designed to represent the existing operations on site and includes all proposed odour sources including those reserved for emergency use (i.e. storm water detention ponds -SDP2, SDP1 and the Emergency Storage Pond).

7 Odour Impact Assessment

7.1 Adopted Odour Impact Assessment Criterion

This section identifies an appropriate odour impact assessment criterion for the Bowral STP and presents a summary of the odour impacts predicted by the modelling at the sensitive receptors identified in **Section 2.3**.

As illustrated in **Figure 16**, the area predicted to be affected by the existing and proposed operations including emergency storage at the Bowral STP (ie the area within the 2 ou contour line) is 0.48 km^2 and 0.21 km^2 respectively. It is noted that as a conservative measure, these areas include the area occupied by the Bowral STP (approximately 0.18 km^2).

According to the 2016 ABS Census data, the area affected by the existing and proposed operations is located within the Statistical Area Level 1 (the smallest geographic unit for the release of Census data) SA1:1128433 and SA1:1128430 (refer **Figure 16**). **Table 15** presents the population densities for these statistical areas based on the 2016 ABS Census data as well as the area predicted to be affected by the existing and proposed operations of the Bowral STP.

Table 15 Potential Affected Population

Statistical Area	Population Density (ppl/km^2)	Existing Operations with Emergency Storage (km^2)	Proposed Operations with Emergency Storage (km^2)
1128430	362.0	0.08	0.01
1128433	7.75	0.4	0.2

ppl/km^2 = people per square kilometre

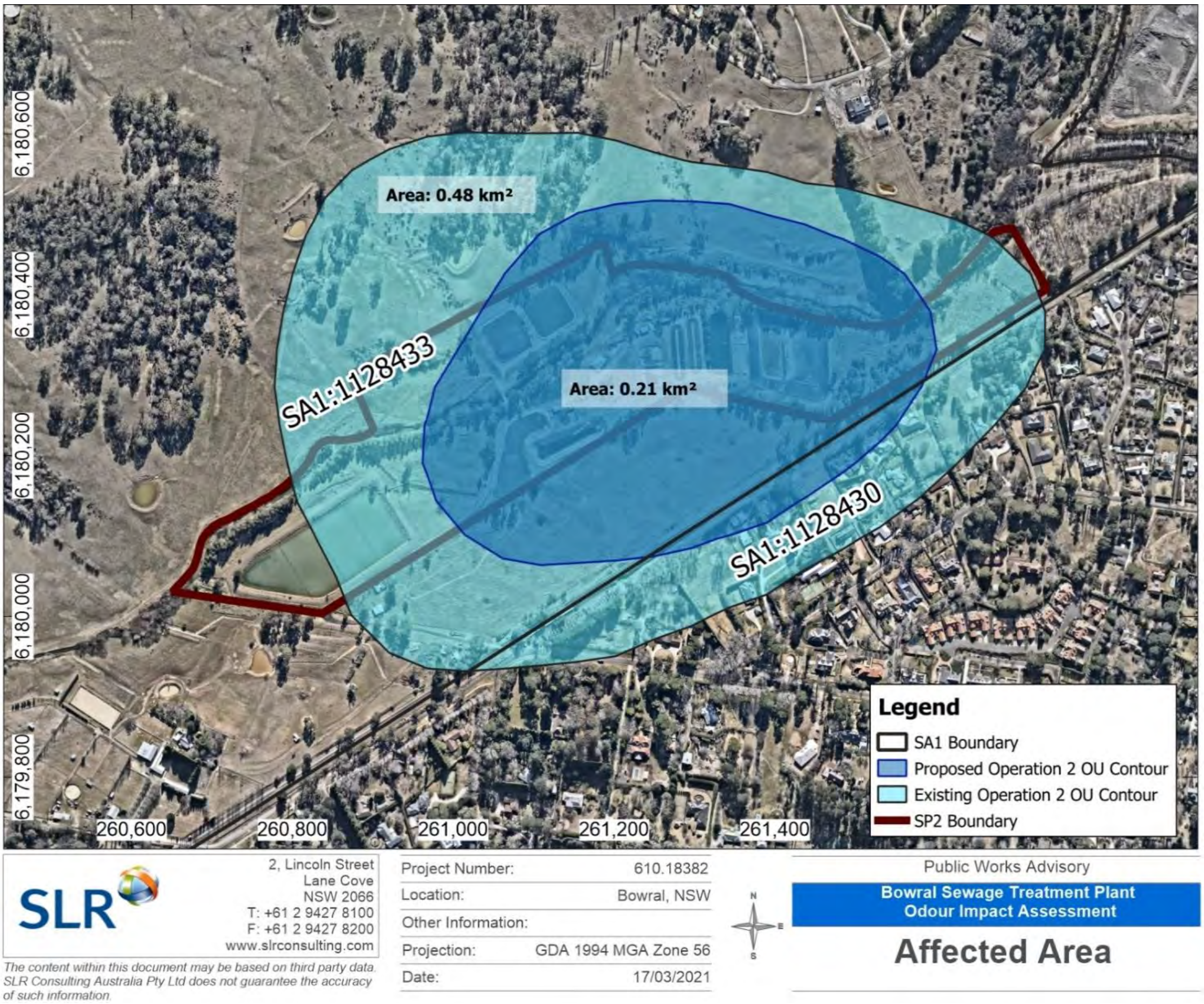
Based on the data presented in **Table 15**, it is estimated that a population of approximately 32 people may be affected by the existing operations at the Bowral STP. It is predicted that the affected population would decrease to 5 people as a result of the proposed upgrades.

Therefore, the following odour impact assessment criteria (expressed as the 99^{th} percentile for a nose response average, i.e. 1-second average) have been adopted (refer **Table 2**):

- 5.0 ou for the assessment of odour impacts due to existing normal operations and existing operations with emergency storage; and
- 6.0 ou for the assessment of odour impacts due to proposed normal operations and proposed operations with emergency storage.

Note – Criteria for operations with emergency storage have been applied to normal operations as well in order to provide conservative results.

Figure 16 Affected Area for Modelled Scenarios



7.2 Dispersion Modelling Results

Dispersion modelling was performed to predict worst-case impacts associated with the existing and proposed operations (as described in **Section 6.4**) at the Bowral STP. The following sections presents results for this study.

7.2.1 Existing Normal Operations

The 99th percentile nose-response-time odour concentrations predicted for the existing operations at the Bowral STP at the surrounding sensitive receptors are presented in **Table 16**. The results show that no exceedances of the adopted criterion of 5 ou are predicted by the 99th percentile odour concentrations at any of the receptors. The maximum sensitive receptor odour concentration of 2.3 ou was predicted for R13.

7.2.2 Proposed Normal Operations

A significant decrease in the 99th percentile 1-hour average odour concentrations (average of 62% reduction across receptors modelled) has been predicted at all receptors modelled for proposed normal operations as compared to existing normal operations. The results indicate that after the upgrade, the predicted 99th percentile odour concentrations, which range between 0.1 ou and 1.0 ou will be in compliance with the adopted criterion of 6 ou at all of the sensitive receptors modelled. Predicted 99th percentile odour concentrations at the surrounding receptors are presented in **Table 16**.

The predicted 1-hour average 99th percentile odour concentrations for the existing and proposed operations are presented as a contour plots in **Figure 17** and **Figure 18** respectively. It is noted that odour contour plots do not reflect odour concentrations occurring at any particular instant in time, but rather illustrate a compilation of the predicted 99th percentile (88th highest) odour concentrations at all locations downwind, taking into account all combinations of meteorological conditions modelled across the modelling period.

Table 16 Predicted Odour Concentrations at Sensitive Receptors – Normal Operations

Receptor ID	Predicted 99th Percentile Odour Concentrations at Sensitive Receptor Locations (ou, nose-response time)	
	Existing Operations	Proposed Operations
R1	0.3	0.1
R2	0.4	0.2
R3	0.5	0.2
R4	0.6	0.2
R5	0.7	0.3
R6	0.5	0.2
R7	0.6	0.2
R8	1.3	0.5
R9	1.0	0.4
R10	1.0	0.4
R11	1.3	0.5
R12	1.9	0.8
R13	2.3	1.0
R14	2.1	0.8

Receptor ID	Predicted 99th Percentile Odour Concentrations at Sensitive Receptor Locations (ou, nose-response time)	
	Existing Operations	Proposed Operations
R15	1.7	0.6
R16	1.7	0.7
R17	1.4	0.5
R18	1.4	0.5
R19	1.1	0.3
R20	0.9	0.3
R21	0.9	0.3
R22	0.4	0.1
R23	0.2	0.1
R24	0.3	0.1
R25	0.3	0.1
Criterion	**5.0**	**6.0**

7.2.3 Existing Operations with Emergency Storage

The 99th percentile nose-response-time odour concentrations predicted for the existing operations including emergency storage at the surrounding sensitive receptors are presented in **Table 17**. The results show that no exceedances of the adopted criterion of 5 ou are predicted by the 99th percentile odour concentrations at any of the receptor. The maximum sensitive receptor odour concentration of 3.5 ou was predicted for R13.

7.2.4 Proposed Operations with Emergency Storage

A significant decrease in the 99th percentile 1-hour average odour concentrations (average of 40% reduction across receptors modelled) has been predicted at all receptors modelled for proposed operations including emergency storage as compared to existing operations with emergency storage. The results indicate that after the upgrade, the predicted 99th percentile odour concentrations, which range between 0.1 ou and 2.2 ou will be in compliance with the adopted criterion of 6 ou at all of the discrete receptors modelled. Predicted 99th percentile odour concentrations at the surrounding receptors are presented in **Table 17**.

The predicted 1-hour average 99th percentile odour concentrations for the existing and proposed operations are presented as contour plots in **Figure 19** and **Figure 20** respectively. It is noted that odour contour plots do not reflect odour concentrations occurring at any particular instant in time, but rather illustrate a compilation of the predicted 99th percentile (88th highest) odour concentrations at all locations downwind, taking into account all combinations of meteorological conditions modelled across the modelling period.

Table 17 Predicted Odour Concentrations at Sensitive Receptors –Emergency Storage

Receptor ID	Predicted 99th Percentile Odour Concentrations at Sensitive Receptor Locations (ou, nose-response time)	
	Existing Operations with Emergency Storage	Proposed Operations with Emergency Storage
R1	0.4	0.3
R2	0.5	0.3
R3	0.5	0.3
R4	0.7	0.4
R5	0.9	0.6
R6	0.7	0.4
R7	0.8	0.5
R8	1.5	1.0
R9	1.3	0.9
R10	1.5	0.8
R11	2.1	1.2
R12	3.4	1.9
R13	3.5	2.2
R14	2.8	1.9
R15	2.0	1.3
R16	2.1	1.4
R17	1.6	1.0
R18	1.6	0.9
R19	1.2	0.7
R20	1.0	0.6
R21	1.1	0.5
R22	0.4	0.2
R23	0.3	0.1
R24	0.3	0.2
R25	0.3	0.2
Criterion	**5.0**	**6.0**

Figure 17 Predicted 99th Percentile (Nose Response Time) Odour Concentrations – Existing Normal Operations

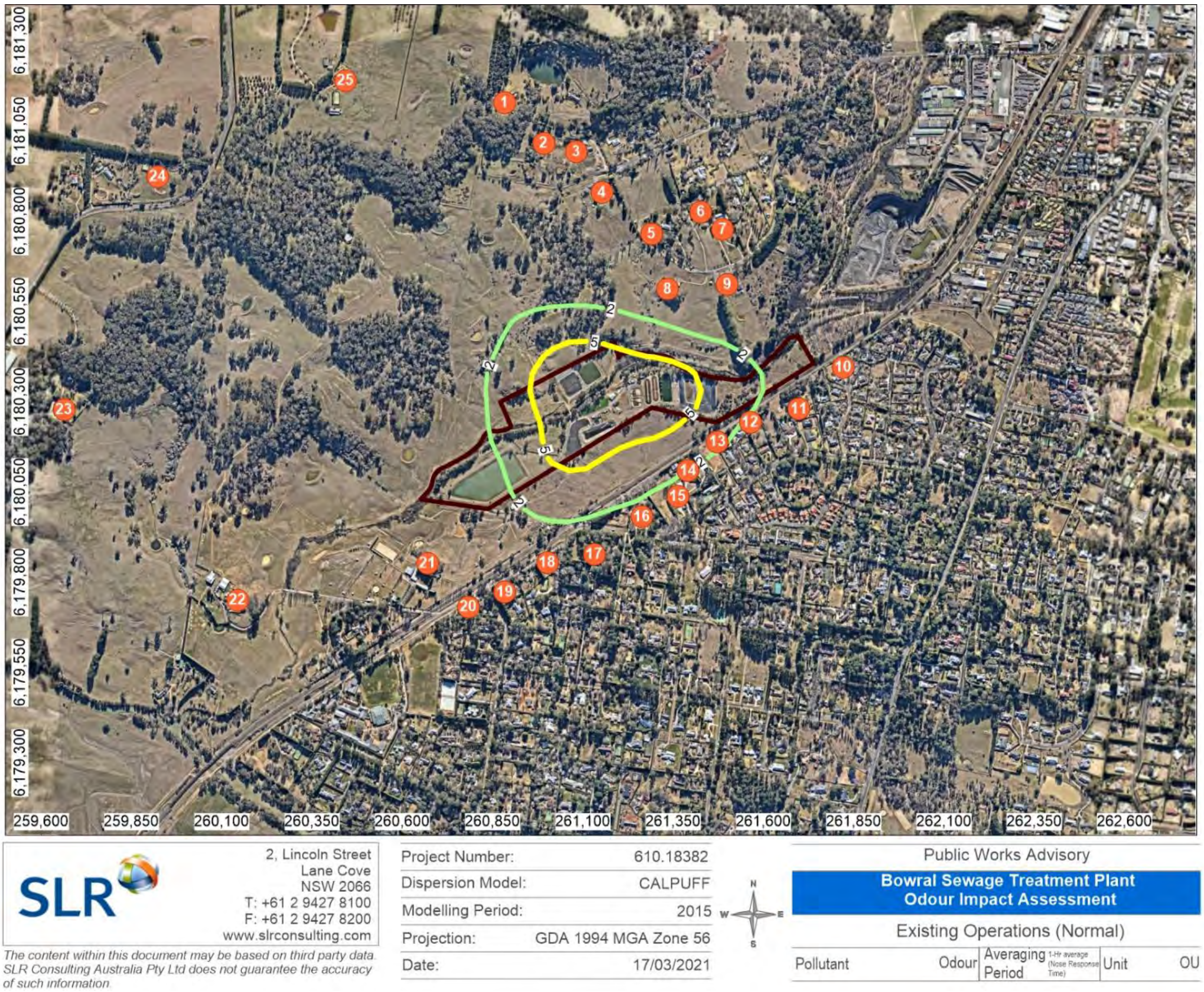


Figure 18 Predicted 99th Percentile (Nose Response Time) Odour Concentrations – Proposed Normal Operations

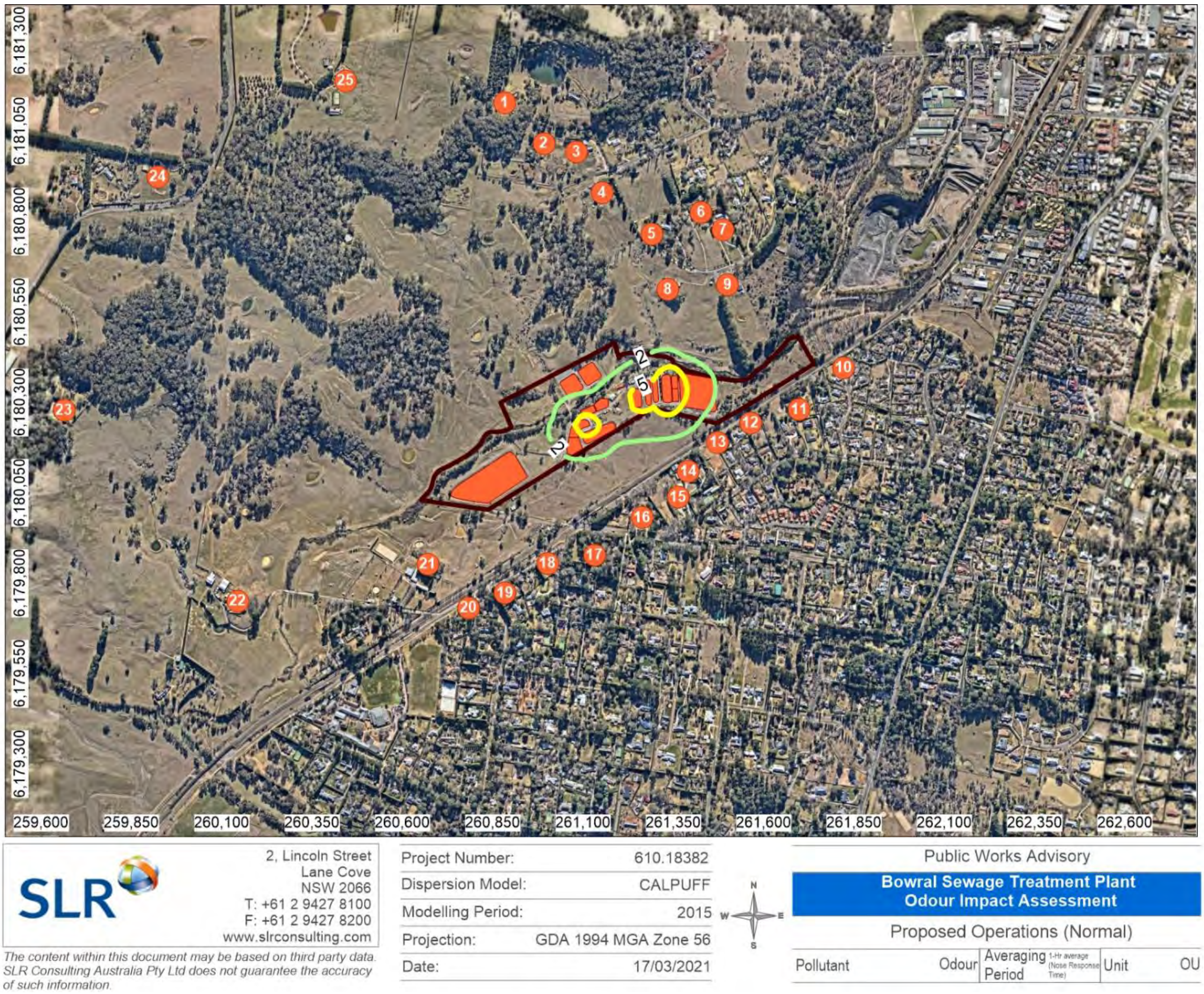


Figure 19 Predicted 99th Percentile (Nose Response Time) Odour Concentrations – Existing Operations with Emergency Storage

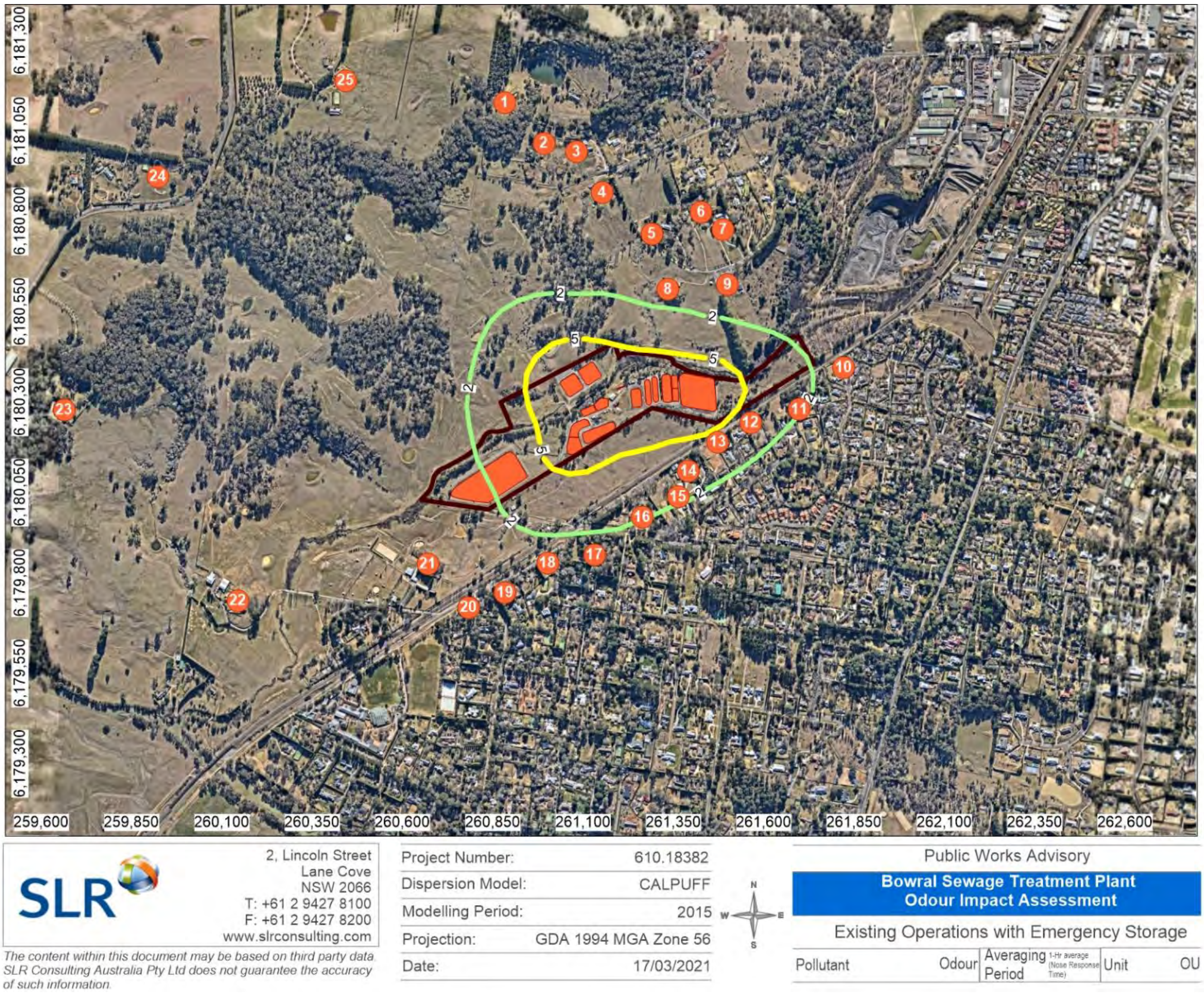


Figure 20 Predicted 99th Percentile (Nose Response Time) Odour Concentrations – Proposed Operations with Emergency Storage

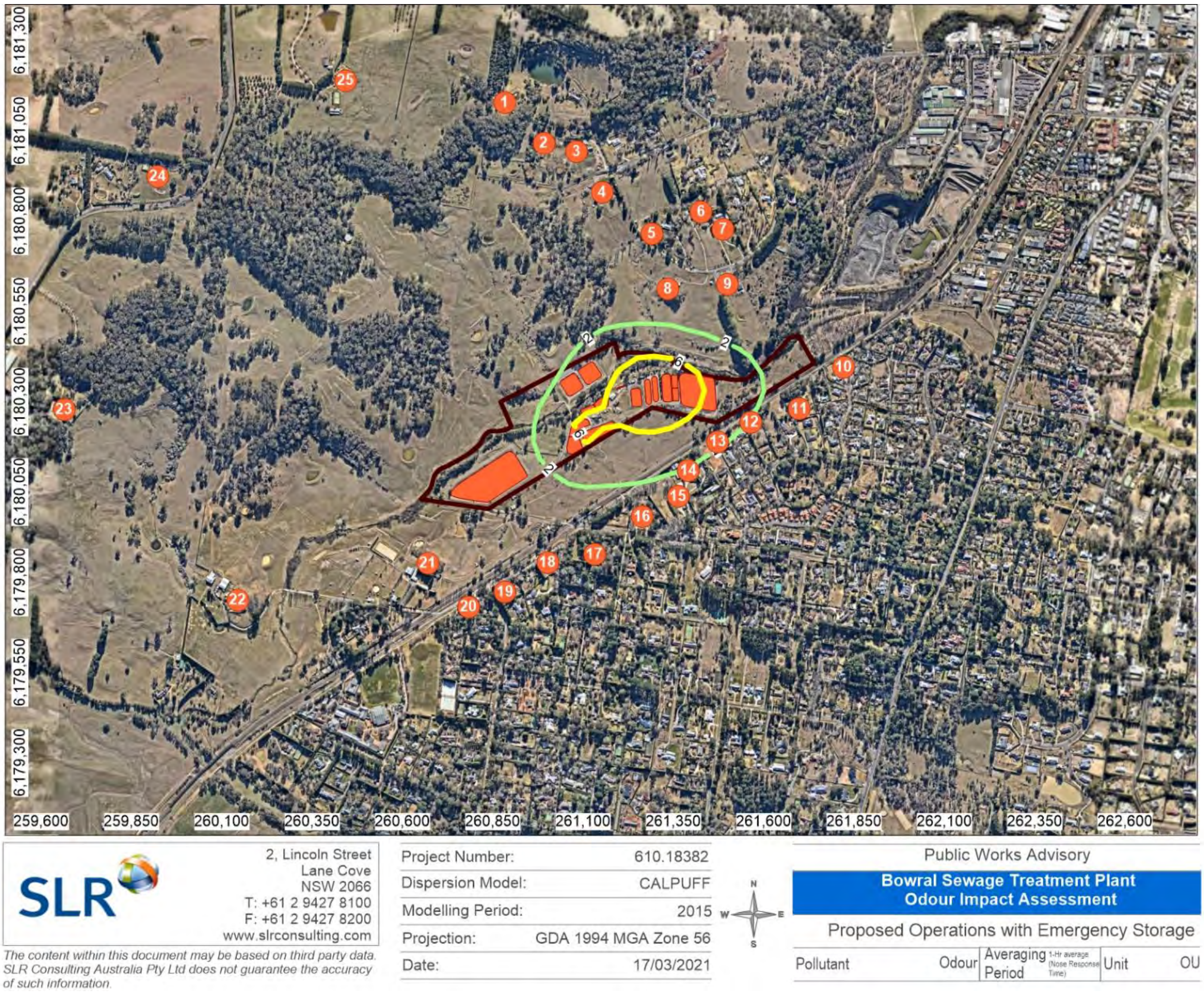


Figure 21 and **Figure 22** present the odour concentrations predicted along the Bowral STP SP2 boundary for the proposed upgraded operations with and without the use of emergency storage to assess compliance with the DoP Best Practice Odour Guideline requirement (see **Section 3.3**) of:

> *The odour design criteria to be adopted during the engineering design stage for an expanding STP is the achievement of a 2 odour unit (ou) odour assessment criterion at the boundary of the Industrial Zone or the Rural or infrastructure (SP2) lot(s).*

These plots shows that the proposed design does not meet the odour design criteria recommended by the Odour Guideline, as the predicted 99th percentile odour concentrations at the SP2 boundary range between 0.3–5.5 ou, with an average of 1.3 ou for normal operations and 0.6-13.1 ou, with an average of 2.9 ou for operations with emergency storage across all boundary receptors.

Figure 21 Predicted 99th Percentile (Nose Response Time) Odour Concentrations at the SP2 Boundary – Proposed Normal Operations

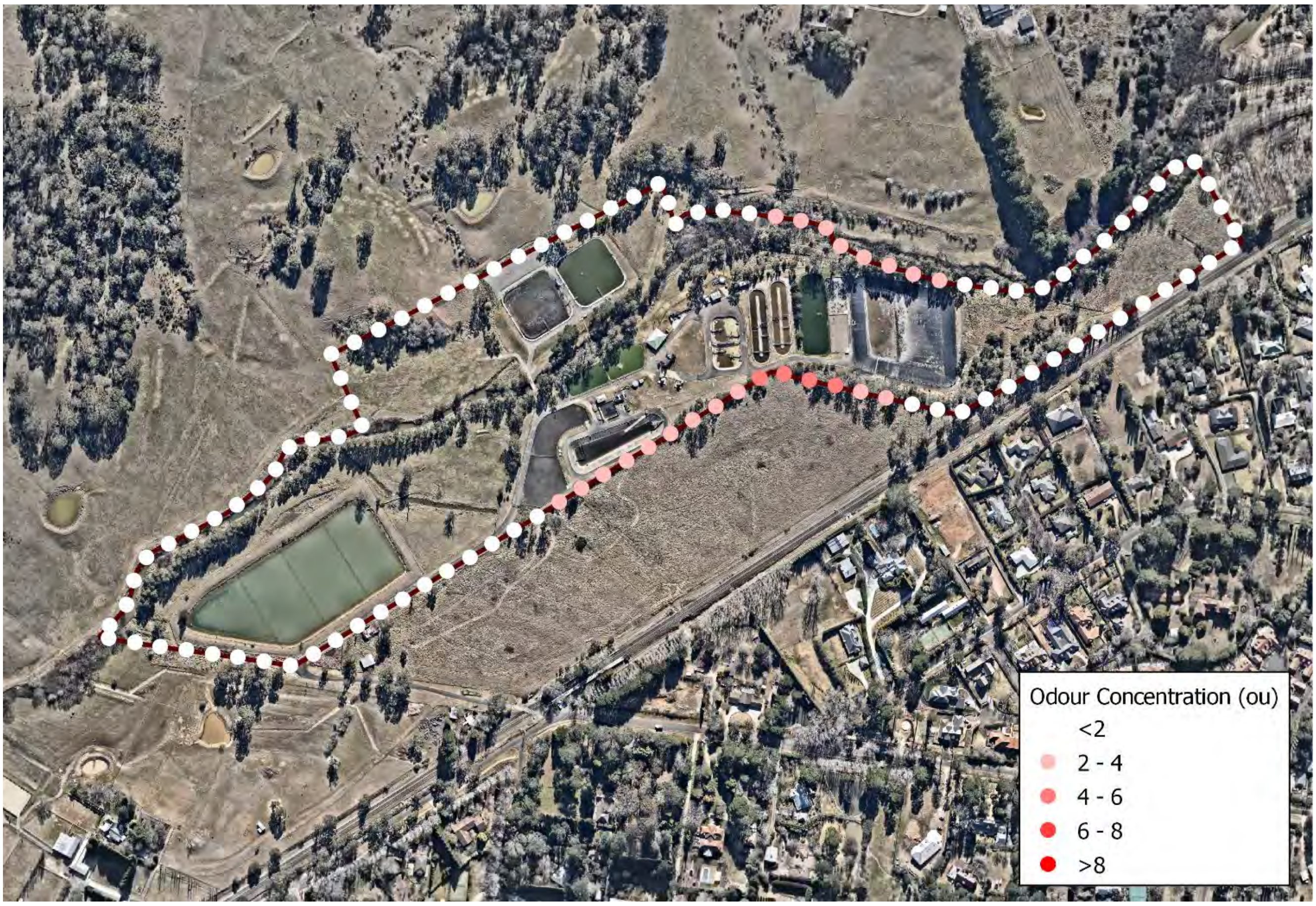
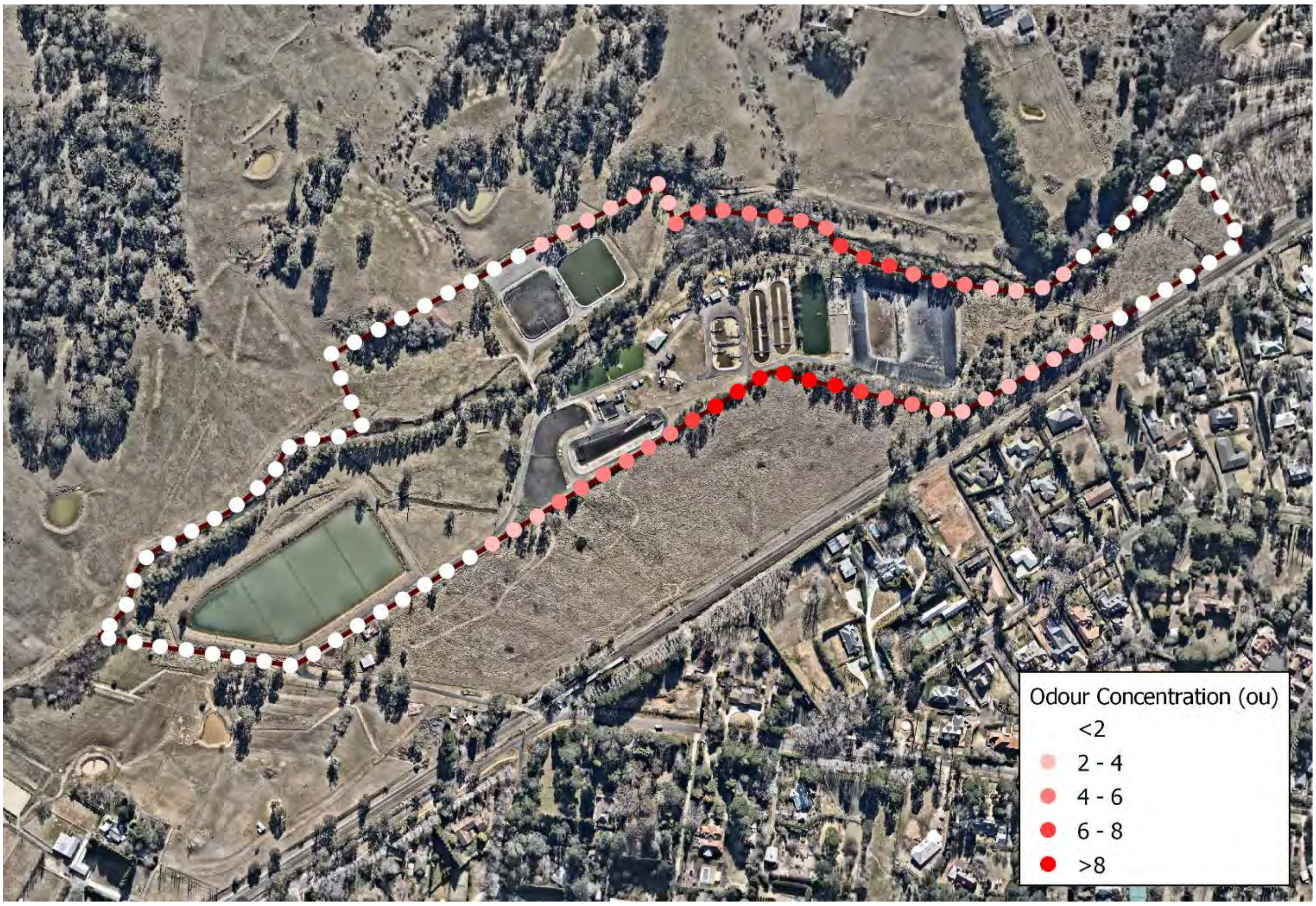


Figure 22 Predicted 99th Percentile (Nose Response Time) Odour Concentrations at the SP2 Boundary – Proposed Operations with Emergency Storage



8 Mitigation Measures

As outlined in **Section 7**, the 99th percentile odour concentrations are predicted to decrease by an average of 62% across the receptors modelled for normal operations and 40% for operations with emergency storage due to the proposed upgrades. Furthermore, the 99th percentile odour concentrations at all nearby sensitive receptors are predicted to be below the adopted odour impact criterion of 6 ou (nose response time) for the proposed concept design. However, the Bowral STP upgrade is predicted to exceed the 2 ou odour design criterion (at the boundary of the SP2 lot) recommended by the Odour Guideline.

As illustrated in **Figure 3**, given the proximity of the various odour sources to the SP2 boundary, compliance with the 2 ou design criterion at the boundary would require significant additional odour controls. While some reductions may be achievable through optimising the site layout to provide maximum buffer distance between the odour emission sources and the SP2 boundary, it is unlikely that compliance with the 2 ou design criterion could be achieved by changes to the layout alone.

Additionally, good management procedures can however be adopted to ensure that impacts on off-site air quality are minimised. It is recommended that an Odour Management Plan (OMP) is adopted for the Bowral STP. The OMP should outline the management structure and strategies for odour performance during the operation of the STP. It is recommended that the OMP be developed as per the recommendations of the Odour Guideline and that it includes procedures for registration and investigation of complaints.

Complaints monitoring is a useful tool in assessing whether nuisance is being caused. It is therefore recommended that any complaint be investigated as soon as possible so that effective appraisal of the complaint can be carried out by subjective assessment. Where odour complaints are verified, engineering, and operational or other odour reduction measures may be considered.

9 Conclusions

Wingecarribee Shire Council is currently planning to upgrade the Bowral STP in order to ensure treatment capacity is sufficient to accommodate present and expected future loads, improve process and operational performance improvements and provide treatment infrastructure that meets state environmental requirements.

SLR Consulting was commissioned by the New South Wales Public Works Advisory (PWA) to conduct an OIA for the proposed upgrade of the Bowral STP to support a Review of Environmental Factors (REF) which is being prepared for the proposed augmentation.

Emissions of odour from existing and proposed on-site activities were conservatively estimated using publicly available data wherein highest reported values were considered for the Bowral STP.

The calculated emissions were modelled using the CALMET/CALPUFF modelling software to investigate the transport of emitted odour from the Bowral STP to predict the impact upon the nearest identified sensitive receptor locations.

Based on the modelling results, the following conclusions have been drawn:

- The modelling of odour emissions from all identified sources associated with the existing operations at the Bowral STP showed that predicted 99th percentile odour concentrations at all nearby sensitive receptors are predicted to be below the adopted odour impact criterion of 5 ou (nose response time) for existing normal operations as well as existing operations with emergency storage.
- The modelling of odour emissions from all identified sources associated with the proposed operations at the Bowral STP showed that predicted 99th percentile odour concentrations at all nearby sensitive receptors are predicted to be below the adopted odour impact criterion of 6 ou (nose response time) as a result of the upgrade. Based on the modelling predictions, the proposed upgrades will result in a 55% to 69% decrease (compared to the existing normal operations) and a 31% to 50% decrease (compared to existing operations with emergency storage) in the 99th percentile odour concentrations at the nearby sensitive receptors for the respective scenarios.
- The proposed concept does not achieve the 2.0 ou odour design criterion (at the boundary of the SP2 lot) recommended by the relevant draft Odour Guideline published by DoP.

Compliance with 2 ou at the plant boundary would be unlikely without significant additional plant odour controls, which is not considered to be feasible by the design team, considering the proximity of the SP2 lot boundary from the treatment processes. Furthermore, the design of the proposed works has included reasonable and practical methods to address potential odour issues, including enclosing inlet works and lift pump station as well as an inclusion of an odour control unit. However, as demonstrated, the plant upgrade will achieve a significant improvement in odour performance with good margins to the assessment criteria (2.2 ou for R13 compared to the assessment criterion of 6 ou).

These results suggest low risk in relation to odour complaints. The three odour complaints received since 2018 have all been related to operation of the sludge lagoons which will be decommissioned as part of the plant upgrade.

As a recommendation for ongoing operations to best practice it is recommended that an Odour Management Plan be prepared and implemented in line with the recommendations of the Odour Guideline

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APPENDIX A

Selection of Representative Meteorological Data

A.1 SELECTION OF REPRESENTATIVE METEOROLOGICAL DATA

Once emitted to atmosphere, emissions will:

- Rise according to the momentum and buoyancy of the emission at the discharge point relative to the prevailing atmospheric conditions;
- Be adverted from the source according to the strength and direction of the wind at the height which the plume has risen in the atmosphere;
- Be diluted due to mixing with the ambient air, according to the intensity of turbulence; and
- (Potentially) be chemically transformed and/or depleted by deposition processes.

Dispersion is the combined effect of these processes.

Dispersion modelling is used as a tool to simulate the air quality effects of specific emission sources, given the meteorology typical for a local area together with the expected emissions. Selection of a year when the meteorological data is atypical means that the resultant predictions may not appropriately represent the most likely air quality impacts. Therefore, in dispersion modelling, one of the key considerations is the representative nature of the meteorological data used.

The year of meteorological data used for the dispersion modelling was selected by reviewing the most recent five years of historical surface observations at Moss Vale AWS (2013 to 2017 inclusive) to determine the year that is most representative of average conditions. Wind direction, wind speed and ambient temperature were compared to averages for the region to determine the most representative year.

Data collected from 2013 to 2017 is summarised in **Figure A1** to **Figure A3**. Examination of the data indicates the following:

- **Figure A1** indicates relatively similar wind roses for all years analysed. It is noted that the most significant difference in observed for the year 2017 ;
- **Figure A2** indicates that 2015 exhibit wind speeds that are closest to the long term average; and
- **Figure A3** shows that temperatures in 2014 and 2015 more closely reflect the long term average.

Given the above considerations, the year 2015 was selected as the representative year of meteorology.

Figure A1 Frequency of Winds at Moss Vale AWS for 2013 – 2017

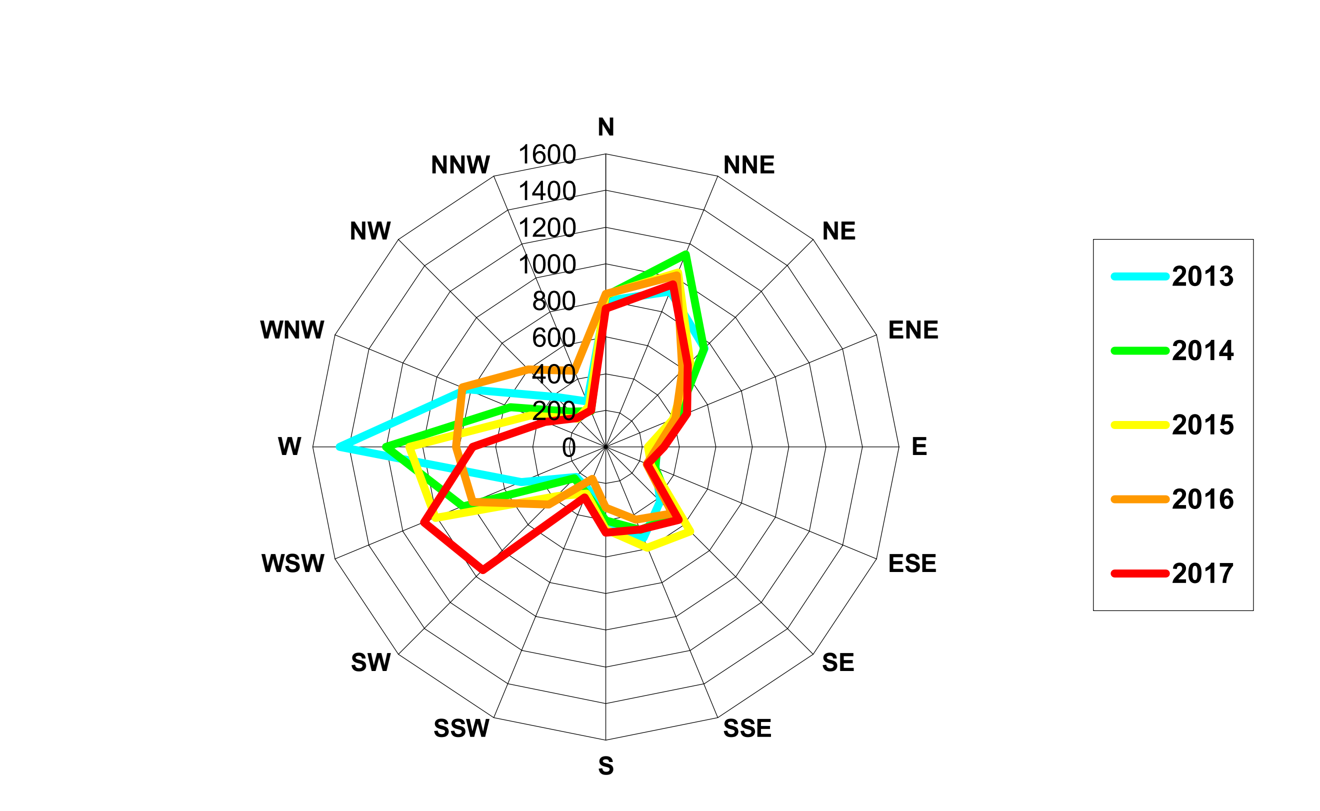


Figure A2 Monthly Average Wind Speed at Moss Vale AWS for 2013 – 2017

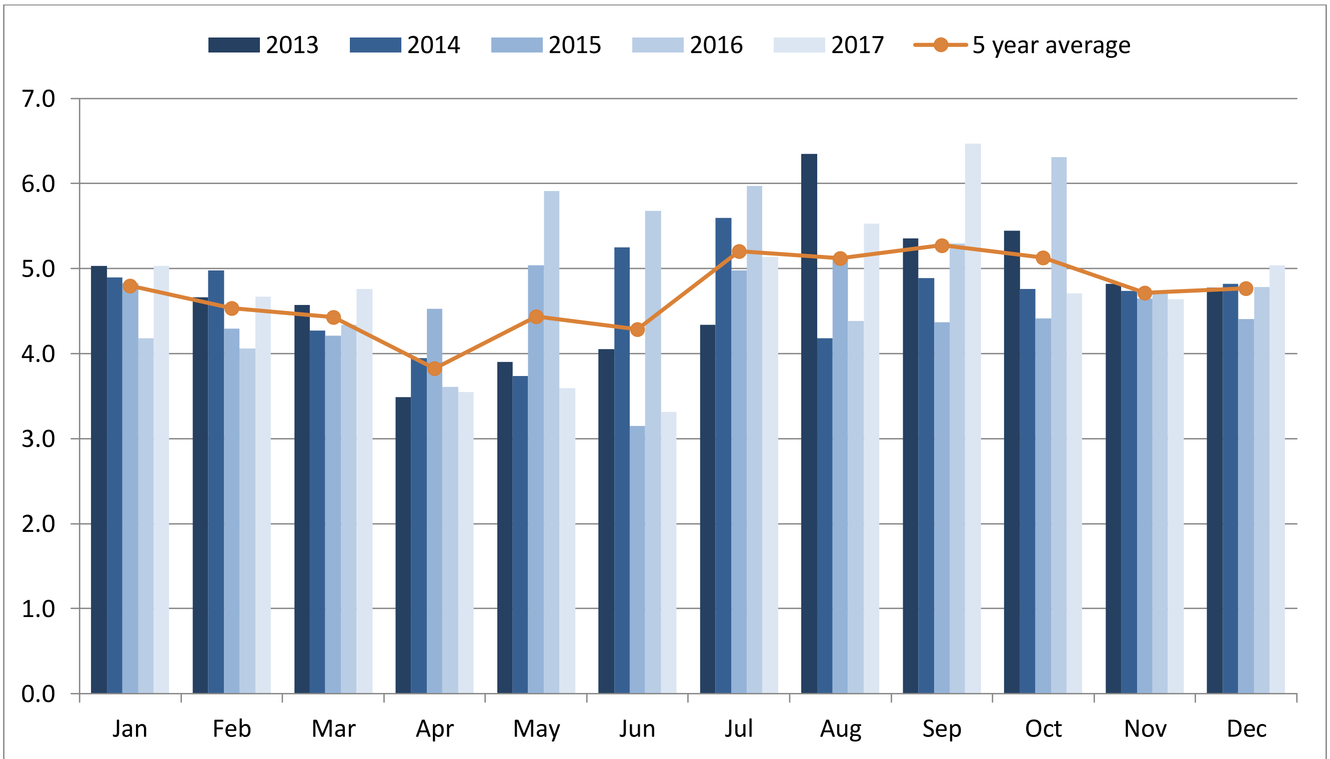
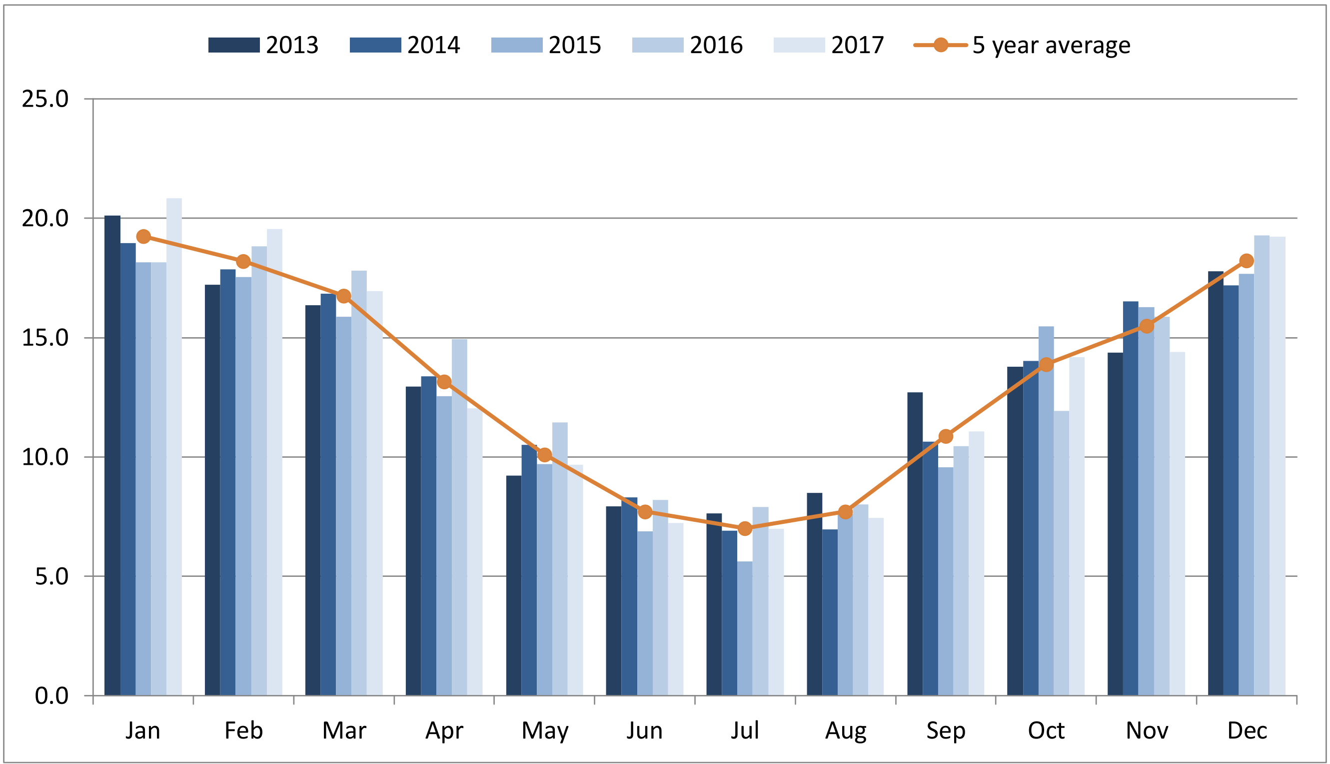


Figure A3 Monthly Average Temperature at Moss Vale AWS for 2013 – 2017



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Appendix H – Interim Macroinvertebrate Monitoring Report

MHL – Southern Highlands Interim Biological Monitoring Report Bowral STP

August 2021

Sydney Water Monitoring Services™

Analytical Services, 51 Hermitage Road, West Ryde NSW 2114

PO Box 73 West Ryde NSW 2114

Report version: August 2021

Report Name: MHL – Southern Highlands Interim Biological Monitoring Report Bowral STP

August 2021

Authors: Harrison Ritchie

Aquatic Ecologist

Reviewed by: Mark Hopkins

Laboratory Supervisor

Cover image: Wingecarribee River, Burradoo

1. Table of contents

Figures

Tables

2. Glossary

Item	Meaning
Abundance	The total number of individual specimens; in a sample, community, ecosystem etc.
Aquatic ecosystem	Community of aquatic plants and animals together with the physical and chemical environment in which they live.
Anthropogenic	Impacts on an environment that are produced or caused by humans
AUSRIVAS	AUSRIVAS is a rapid prediction model used to assess the biological health of Australian rivers.
Catchment	The area that is drained by a river, lake or other water body.
Community	Assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another.
Diversity (Biological)	The measure of the number and/or degree of available organisms in an environment.
Edge habitat	The edge habitat is an area of unbroken water surface that is within 2 m of the bank.
Effluent	A waste product that is discharged to the environment, usually in reference to waste water discharged from sewage treatment plants.
Ethanol	Alcohol used to preserve macroinvertebrates for long-term reference and identification.
Habitat	The place where a population lives and its surroundings, both living and non-living.
Indicator	A parameter (chemical, biological or geological) that can be used to provide a measure of the quality of water or the condition of an ecosystem.
Invertebrate	Animal lacking a dorsal column of vertebrae (backbone) or a notochord.
Macroinvertebrate (Aquatic)	Animals without backbones that when mature are greater than 1 millimetre; live in the water column, on the water surface or on the bottom of a waterway.
Macrophyte	Plant species that are adapted to growing in or on permanent water and have a definite life form related to the aquatic environment.
Sensitive organism	An organism that's survival is highly susceptible to shifts in environmental conditions.
Sewage	The waste water from homes, offices, shops, factories and other premises discharged to the sewer. Is usually 99% water.
SIGNAL	SIGNAL (Stream Invertebrate Grade Number Average Level) is a biotic index using aquatic macroinvertebrates to assess stream health.
Taxon	(plural taxa) The definite entity and classification formally recognised by taxonomists of any given organism.

Item	Meaning
Taxonomic Level	Refers to the classification type of an organism; kingdom, phylum, class, order, family, genus, species.
Tolerant organism	Is an organism that can survive in highly variable environmental conditions.
Turbidity	A measure of the amount of suspended solids (usually fine clay or silt particles) in water and thus the degree of scattering or absorption of light in the water.
Univariate Analyses	Refers to the statistical analysis of data containing one variable.

3. Acronyms and abbreviations

Acronyms/ Abbreviation	Meaning
AUSRIVAS	Australian River Assessment System
EPT	Ephemeroptera, Plecoptera, Trichoptera
LGA	Local Government Area
NATA	National Association of Testing Authorities of Australia
SIGNAL-SF	Stream Invertebrate Grade Number Average Level – Sydney Family
SIGNAL2	Stream Invertebrate Grade Number Average Level – National scores (2003)

4. Introduction

4.1 Study Area

4.1.1 Catchment

The Wingecarribee River catchment located in the Southern Highlands of NSW and covers an area of approximately 225km^2. The Wingecarribee River extends from Near Glenquarry and flows down into Bangadilly National Park. The surrounding catchment is dominated by agricultural and urban land use. Our sampling sites were situated upstream and downstream of the Bowral STP discharge and situated near the townships of Burradoo and Bowral.

4.1.2 Sampling sites

Two sites sampled for macroinvertebrates are shown in Table 2 and **Error! Reference source not found.**. Sites were sampled for macroinvertebrates across Autumn and Spring 2020 and Autumn 2021. The upstream site (BOW_US) is located near the end of Sullivan Rd, Burradoo while the downstream site (BOW_DS) is located downstream of the bridge along Railway Rd, Burradoo.

Figure 3 Map of macroinvertebrate and water quality sampling sites

Table 2 Macroinvertebrate sampling sites

Site code	Site name	Latitude / Longitude
BOW_DS	Wingecarribee River d/s Bowral STP	-34.499491, 150.3862904
BOW_US	Wingecarribee River u/s Bowral STP	-34.5041935, 150.3936639

5. Methods

All field sampling and laboratory methods adhered to internal methods and ISO/IEC 17025 requirements. NATA accreditation details are summarised in Table .

Table 2 Sydney Water laboratories' NATA accreditation numbers

Field of Testing	Number	Accredited	Standard
Biological Testing	610	1966	ISO/IEC 17025

5.1 Sampling methods

5.1.1 Macroinvertebrate sampling and identifications

Macroinvertebrate sampling was completed in accordance with AUSRIVAS protocols for New South Wales (Turak et al. 2004) and Sydney Water in-house test methods. For each sampling site, two edge habitats were sampled with a hand-held dip net. Edge habitats were defined as areas with little to no current. The sampling net was swept across the habitat, to the length of 10 m. In the process, silt and detritus on the bottom of the stream were stirred up so that benthic animals were suspended and captured.

The contents of the net were emptied into a large white sorting tray with a small amount of water. The live macroinvertebrate specimens were extracted with fine forceps and pipettes for a minimum period of 40 minutes (**Error! Reference source not found.**). If new taxa were collected between 30 and 40 minutes, sorting continued for a further 10 minutes, if not, picking ceased. If new taxa were found, the 10-minute processing cycle continued up to a maximum of 60 minutes. There is not a set maximum number of animals to be collected under the NSW AUSRIVAS protocols (Turak et al. 2004).

Specimens were preserved in small glass specimen jars containing 85% un-denatured ethanol with a label indicating site code, location, date, habitat, replicate number, name of sampler and name of picker.

Macroinvertebrates were identified and enumerated to the family taxonomic level, except the family Chironomidae, which were identified to sub-family. For AUSRIVAS analysis specimens were combined for Oligochaeta at class and Acarina at order level.

Figure 4 Sample jars and a picked specimen, Hemipteran, Notonectidae *Enithares* (Back-swimmer)

5.2 Data analysis methods

5.2.1 Macroinvertebrate Analyses

Macroinvertebrate data was analysed per the five methods listed below. Descriptions of these analyses are introduced briefly at the start of each respective results section.

Univariate Analyses;

- Taxa Richness
- EPT Taxa Richness

Biological Indices;

- SIGNAL2
- SIGNAL-SF
- AUSRIVAS

6. Rainfall results and interpretation

Rainfall information provides context for water quality and macroinvertebrate data. Rainfall plays an important role in driving water quality in urban streams through input of pollutants and increased flow.

Rainfall events can cause bank erosion, resulting in a loss of habitat and altered channel complexity (Walsh 2005). Urban catchments often have a high amount of connected impervious surfaces, such as roads and building. This results in increased storm water runoff, which often discharges into streams. This can cause an increase in turbidity, nutrients and other pollutants.

Daily rainfall data recorded from Hoskins St Moss Vale between March 2020 and May 2021 and sampling dates are presented in **Error! Reference source not found.**. There were large rainfall events within the analysed period. Most notable was the storm event in May 2021 which recorded 93.2mm in one day and 211mm over the whole event. March 2020 to May 2020 had relatively low rainfall levels, while late October and November 2020 recorded some moderate rainfall events around 20 – 30mm.

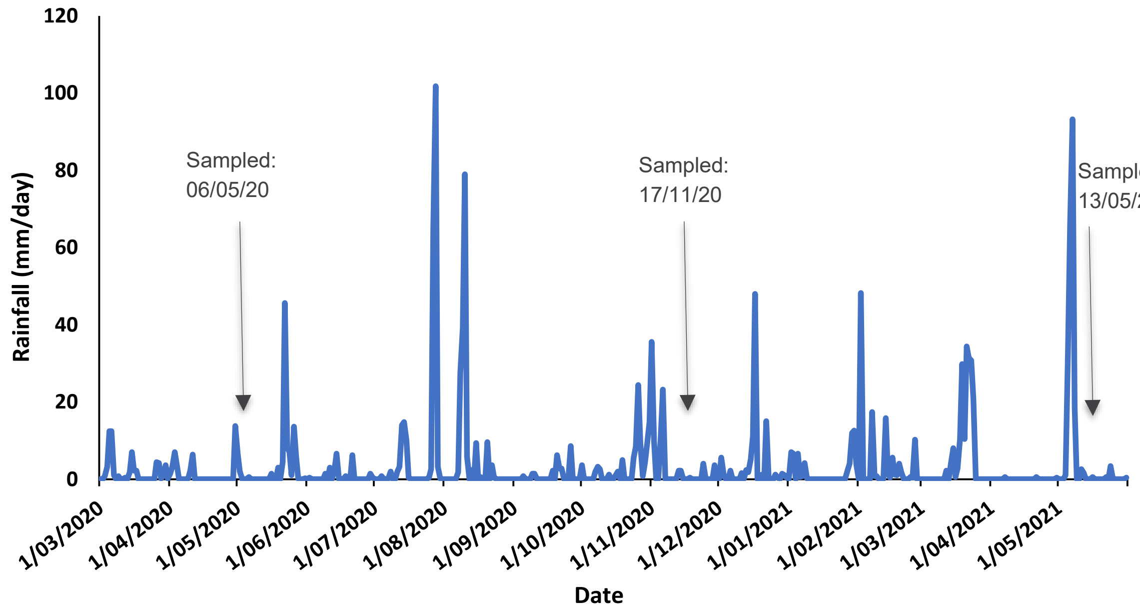

Figure 3 Daily rainfall data 1st March 2020 – 31st May 2021 and sampling dates for each season.

7. Macroinvertebrate results and interpretation

7.1 Results

7.1.1 Taxa richness

Taxa richness is the overall variety (total taxa) of macroinvertebrates in a given community assemblage. It is an indicator of ecosystem health that can be measured at any specific taxonomic level and operates under the assumption that taxa richness will be higher in healthy systems and lower in systems of poor health.

Taxa richness results presented as the average number of macroinvertebrate families per site across three sampling seasons are graphed below in Figure 3.

Taxa richness was similar between upstream and downstream sites, the overlapping ranges indicated no significant difference in the number of macroinvertebrate families between the sites. BOW_US displayed the highest taxa diversity each season with averages of 13, 15.5 and 11.5, this was only slightly higher than BOW_DS which displayed averages of 11.5, 13.5 and 8.5 for each respective season. Both sites display the same seasonal trend, recording higher taxa richness in spring and lower taxa richness in autumn.

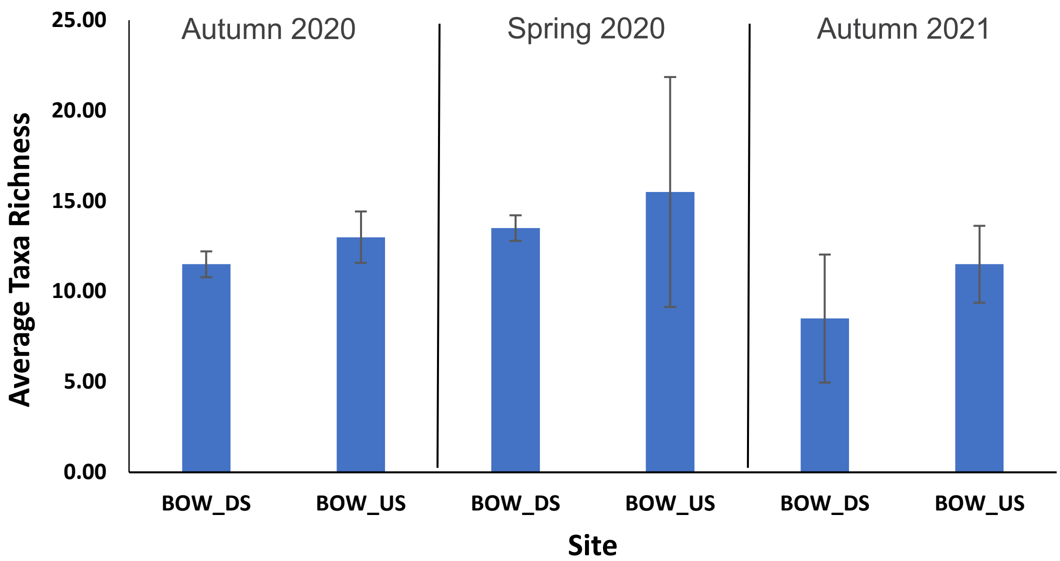

Figure 4 Mean ± SD taxa richness per site between Autumn 2020 – Autumn 2021.

7.1.2 EPT taxa richness

EPT taxa richness shows the abundance of highly sensitive Ephemeroptera (mayfly) Plecoptera (stonefly) and Trichoptera (caddisfly) orders. High EPT richness indicates increased health of an aquatic ecosystem.

EPT taxa were recorded at both sites across all sampling seasons (Figure 4). The lowest average EPT taxa displayed among all sites and seasons was 1 while the highest was 3.5. As with taxa richness, the upstream site consistently displayed a higher average of EPT taxa across each season, however the only significant difference occurred in Spring 2020. Differences in average EPT taxa between sites ranged from 0.5 in Autumn 2020 to 2 in Spring 2020.

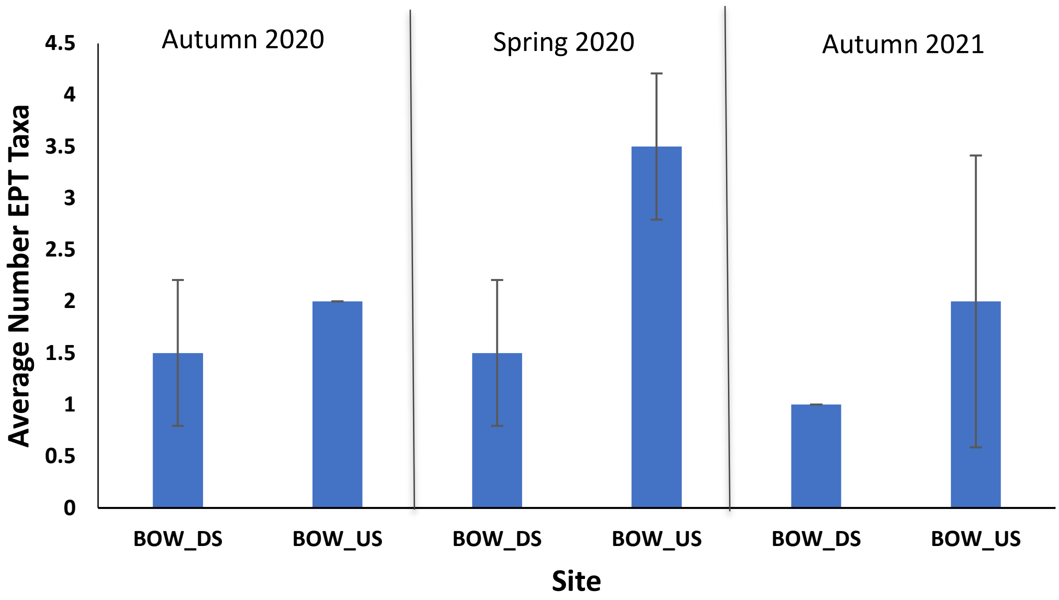

Figure 5 Mean ± SD EPT taxa collected at each site between Autumn 2020 – Autumn 2021.

7.1.3 Signal2

SIGNAL2 (Stream Invertebrate Grade Number Average Level) biotic index is a relatively simple method used to assess the health of an aquatic ecosystem. This index assigns 'sensitivity scores' to macroinvertebrate taxa. A final SIGNAL score combined with the total taxa then places a sample within a quadrant based on potential pollution type.

Mean SIGNAL2 scores are presented in Figure 5 with associated bi-plot placement in Figure 6. Both upstream and downstream sites were within the range of 2.7 and 3.6 across all seasons with no real trends present. Bi-plot placement for all sites across seasons is indicative of sites experiencing agricultural and/or urban pollution.

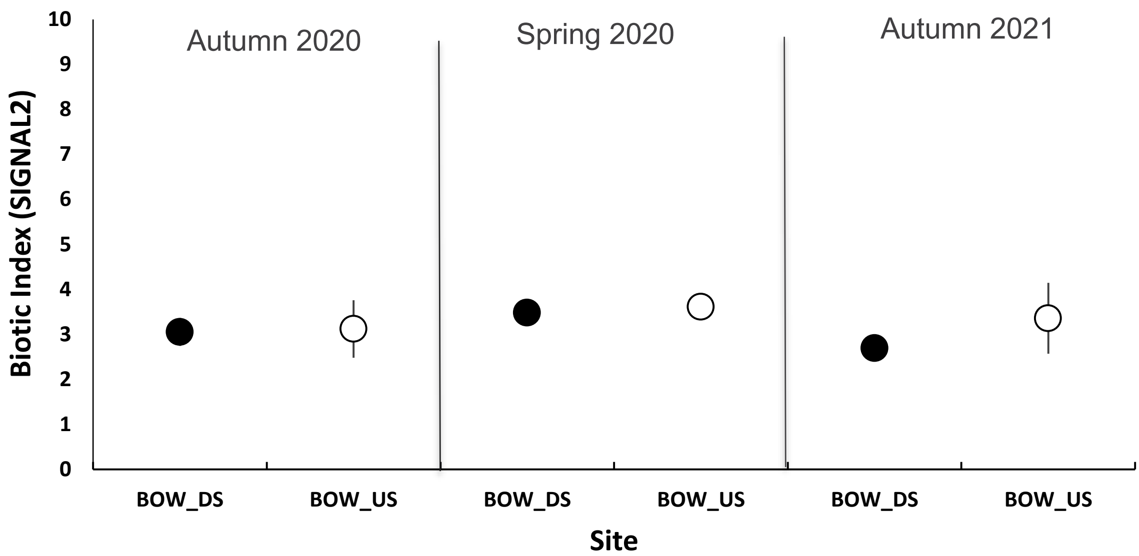

Figure 6 Mean ± SD SIGNAL2 scores across sites and sampling seasons.

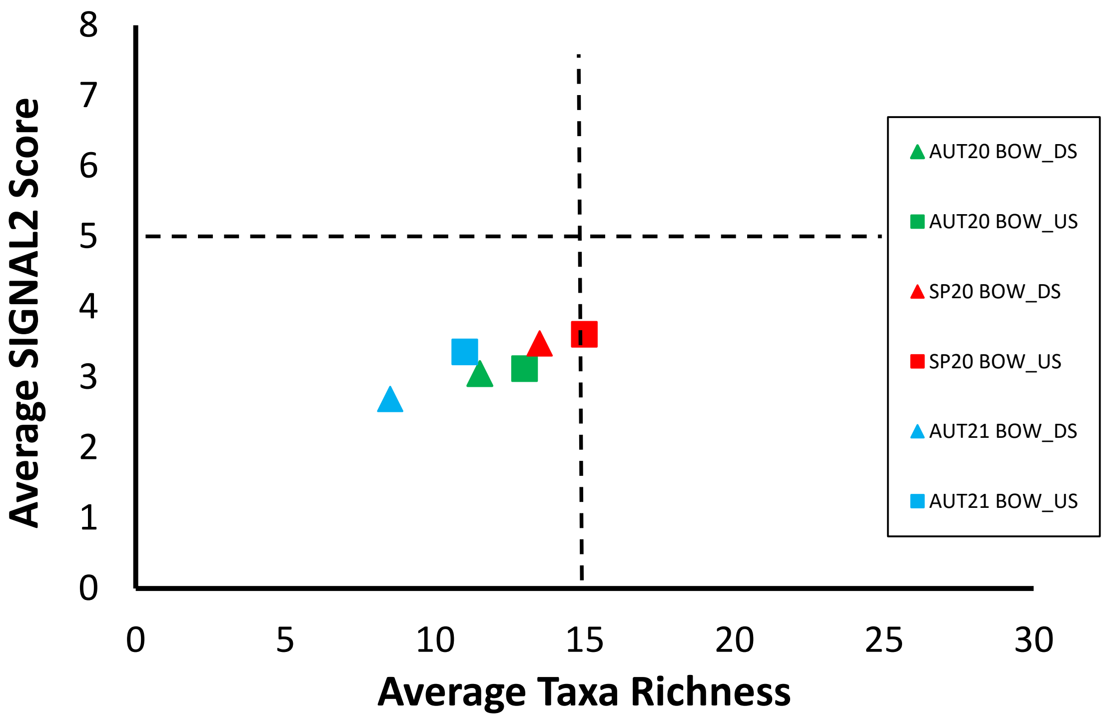

Figure 7 **Mean SIGNAL2 bi-plot for upstream and downstream sites across seasons.**

7.1.4 Signal-SF

SIGNAL-SF *Stream Invertebrate Grade Number Average Level - Sydney Family* biotic index is a relatively simple method used to assess the health of an aquatic ecosystem. This index assigns 'sensitivity scores' from 1 being tolerant to 10 being very sensitive to each individual macroinvertebrate taxa.

SIGNAL-SF results for both upstream and downstream sites across all sampling seasons are shown in Figure 7. Average SIGNAL-SF scores were between 4.8 and 5.8 for both sites across all seasons with no strong trends between sites. All SIGNAL-SF scores are below the "natural water quality" level of 6.5 indicating possible mild organic pollution at all sites (Table 3).

Table 3 **Interpretation of SIGNAL-SF scores (Chessman et al., 2007)**

SIGNAL-SF score	Water quality status
> 6.0	Clean water
4.6-6.0	Possible mild organic pollution
3.2-4.6	Probable moderate organic pollution
< 3.2	Probable severe organic pollution

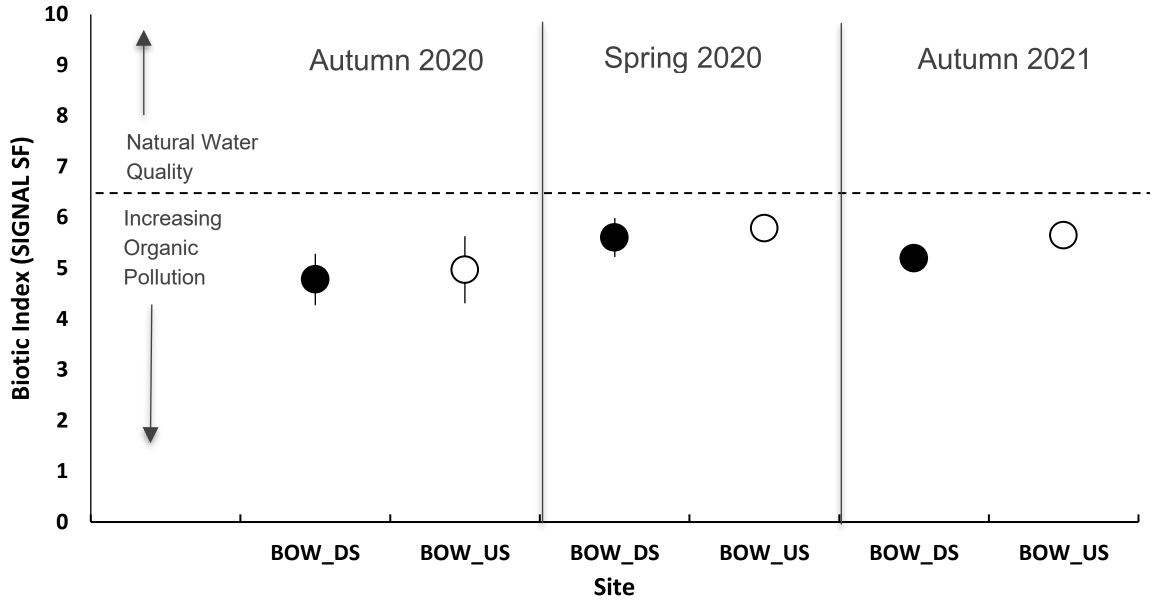

Figure 8 **Mean ± SD Signal-SF scores for upstream and downstream sites across sampling seasons.**

7.1.5 AUSRIVAS

AUSRIVAS OE0 SIGNAL

AUSRIVAS OE0 SIGNAL is an index calculated from the AUSRIVAS predictive model, comparing the macroinvertebrates from a current assessment site to macroinvertebrate data previously collected from reference sites with similar physical and chemical characteristics. The OE0 SIGNAL index is a ratio of the observed SIGNAL (Chessman, 1995) values from the assessment site to the expected taxa from the reference sites. The ratio uses all (100%) of the observed and expected taxa in the calculation. This comparison can also help determine the 'condition' or 'health' of the aquatic ecosystem.

The AUSRIVAS OE0 SIGNAL scores ranged between 0.53 and 0.8 for the downstream site, while the upstream scores ranged between 0.66 and 0.8 (Figure 8). Across the three sampling seasons a consistent trend was present with the upstream site displaying slightly higher OE0 SIGNAL scores, although scores for both sites mostly fell within the 0.6-0.7 range.

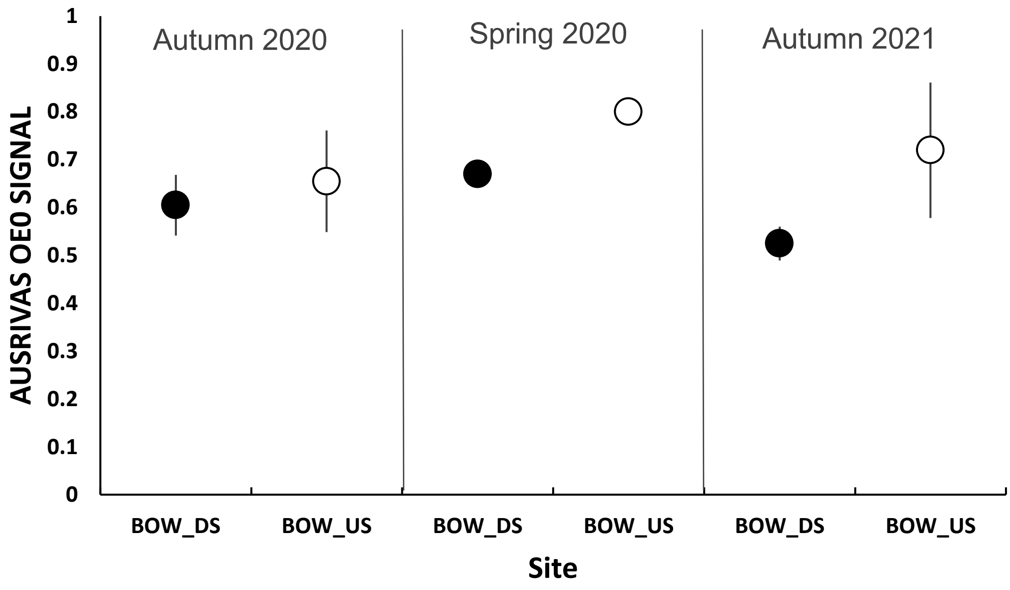

Figure 9 **Mean ± SD OE0 Signal scores for upstream and downstream sites across sampling seasons.**

AUSRIVAS OE50

AUSRIVAS OE50 is an index calculated from the AUSRIVAS predictive model, comparing the macroinvertebrates from a current assessment site to macroinvertebrate data previously collected from reference sites with similar physical and chemical characteristics. The OE50 index compares only the macroinvertebrates from the assessment site with a greater than 50% chance of occurring at the reference site. This comparison can help determine the ‘condition’ or ‘health’ of the aquatic ecosystem.

AUSRIVAS OE50 scores are presented in Figure 9. The OE50 scores for both sites fell within Band C, except for the upstream site for Spring 2020 which fell within Band B on that one occasion. OE50 scores again displayed the same trend of slightly higher scores at the upstream site across the three seasons. OE50 scores for the downstream site range from 0.22 to 0.38, while the upstream ranged from 0.30 to 0.52.

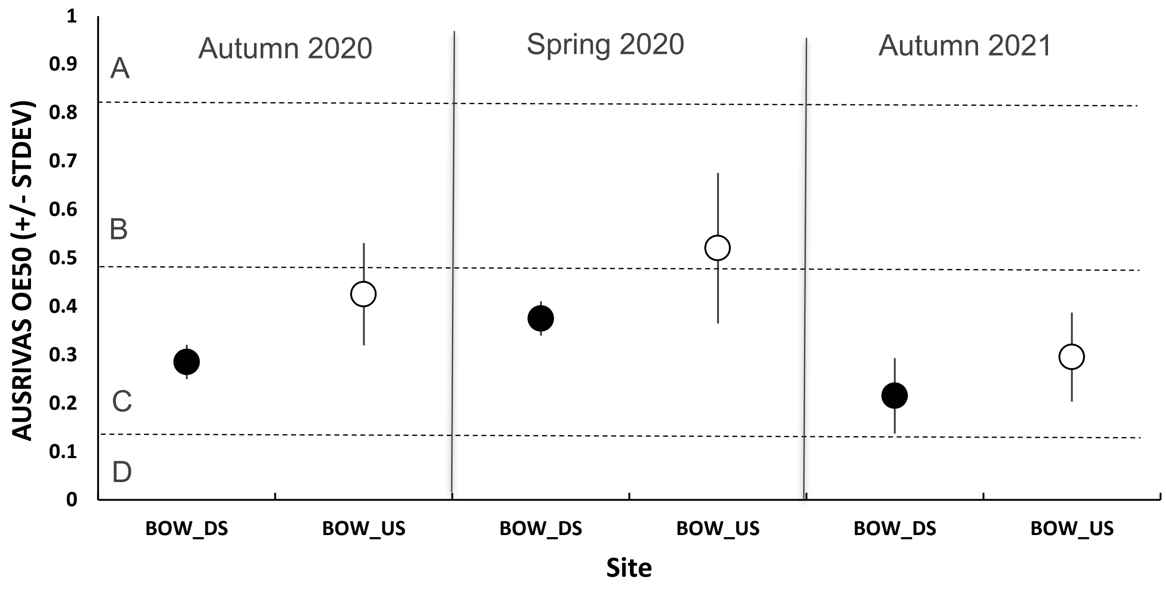

Figure 10 **Mean ± SD AUSRIVAS OE50 score for upstream and downstream sites across sampling seasons.**

7.2 Macroinvertebrates interpretation

Macroinvertebrates are widely recognised as key indicators because their presence or absence is a result of their exposure to changing water quality over periods of time. They also reflect changes in physical habitats, including sediment deposition and altered hydrology, as well as changes in biological interaction such as the introduction of pest plant and animal species. Macroinvertebrates are also ubiquitous, they are found in almost all water bodies and as such, the type and diversity of macroinvertebrates present can indicate what stressors may be acting upon a given aquatic system.

Taxa Richness across both sites fluctuate seasonally, there is a consistent trend of a slightly higher taxa richness at the upstream site, although the differences between sites are not significant and could be due to natural variation in the sampling habitat. Both upstream and downstream sites have community assemblages dominated by pollution tolerant taxa indicative of impacted waterways. The most populous taxa that were consistently collected across both sites across all seasons were Acarina, Atyidae, Corixidae, Coenagrionidae, Chironomidae (sub families Chironominae and Orthocladiinae) and Leptoceridae.

The number of EPT taxa across both sites fluctuate seasonally, there is again a consistent trend of a slightly higher number at the upstream site in autumn with quite a distinct difference in the spring sampling occasion. Overall there were seven EPT families collected over the three sampling occasions: Baetidae, Caenidae, Leptophlebiidae, Ecnomidae, Hydropsychidae, Hydroptilidae, Leptoceridae. Four taxa were only found at the upstream site; Caenidae, Leptophlebiidae,Ecnomidae and Hydropsychidae, while one taxa was only found at the downstream site: Baetidae. The rest of the taxa were found at both sites. Leptoceridae were by far the most populous and consistently present EPT taxa, the rest of the taxa were found in low numbers and often in only one sampling season.

Although EPT taxa are thought to be more sensitive to organic pollution than some other taxa, within some families there are genera which are quite tolerant to pollution. EPT and other taxa diversity-based indices are influenced by several natural factors other than pollution. These include stream size, substrate variability, current, water temperature, food resources and life cycles (Hilsenhoff, 1998). The large rainfall event in May 2021 which occurred prior to sampling could be contributing to the lower levels of taxa richness and EPT collected that season.

SIGNAL 2 scores were similar at both the upstream and downstream site across all three sampling seasons. The SIGNAL 2 biplot placed both sites in the quadrant which indicates agricultural or urban impacted waterways (Chessman, 2003). Both sites were present in the quadrant across all seasons with upstream and downstream sites closely clumped together indicating similar levels of impact. The placing in this quadrant is consistent with the surrounding land use of the catchment and shows both sites are under similar levels of agricultural/urban pollution impacts.

SIGNAL SF scores are very similar between the upstream and downstream site and remain consistent across seasons. Both sites sit just below the 6.5 level which is indicative of natural water quality. This indicates that water quality at both upstream and downstream sites are impacted by mild organic pollution.

AUSRIVAS results indicated that both upstream and downstream sites were of a similar ecological condition. OE50 SIGNAL scores display similar levels at both upstream and downstream sites, with the upstream remaining slightly higher than the downstream site across seasons. OE50 scores for both sites fell within Band C, except for the upstream site in spring which fell into Band B. The trend of the upstream site remaining at a higher level across seasons was consistent. The fact that the upstream and downstream displayed values in Band C and lower Band B indicate that both sites are under a similar amount impact. Changes in values across seasons could be explained by natural variation which is common in dynamic environmental systems such as waterways, for example the large rainfall event in May 2021 could be contributing to the lower OE50 scores recorded in Autumn 2021. AUSRIVAS Band C is indicative of a severely impacted system, while Band B is indicative of a moderately impacted system.

The results of all biotic indices indicate a water way which is moderately impacted by pollution both upstream and downstream. This is consistent with land use in the wider catchment, which is dominated by agricultural and urban land use, both of which have been shown to have adverse impacts on aquatic ecosystems. There is a consistent trend throughout the results of the upstream site being in slightly better condition than the downstream, although the difference is minor and could be due to natural variation and site-specific features. BOW_US has a slightly thicker surrounding of riparian vegetation along with increased amount of emergent macrophyte within the stream edge. These environmental variables may assist in decreasing the amount of nutrients and urban run-off entering the creek and provide better habitat diversity for macroinvertebrates. BOW_DS is located downstream not only of the STP effluent discharge, but also of a busy roadway and railway bridge which passes directly over the river. These impervious surfaces leading right up to the river may increase the amount of urban runoff entering the river at this point, impervious surfaces have been found to increase the amount of urban run-off entering urban waterways (Walsh et al, 2005).

8. Key findings summary

- All community indices and biological indices indicate that both sites are at least moderately impacted by urban and agricultural pollution.
- All sites were placed in AUSRIVAS Band C, except for BOW_US in Spring 2020 which fell within Band B.
- SIGNAL SF scores for both sites fell within the range of 4.8 to 5.8 indicating possible mild organic pollution.
- SIGNAL2 bi-plot indicated both sites are under similar levels of agricultural/urban impact with sites clumped in the same quadrat.
- BOW_US consistently had slightly higher values each sampling season for some indices, although scores for both sites fall within a similar range overall.
- Differences between sites could be due to natural variation in site specific habitat and/or characteristics. There is no clear impact on macroinvertebrate communities that can be specifically attributed to STP discharge based on the analyses undertaken.

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