Public Works
Department of Regional NSW



Moss Vale Sewage Treatment Plant Upgrade

Review of Environmental Factors

Report Number ISR18129

May 2023

Prepared for Wingecarribee Shire Council

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Certification

This Review of Environmental Factors (REF) has been prepared by NSW Public Works, Department of Regional New South Wales 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 the Moss Vale Sewage Treatment Plant.

Wingecarribee Shire Council is a public authority and a determining authority as defined in the *Environmental Planning and 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 EP&A Act and Section 171 of the *Environmental Planning and Assessment Regulation 2021* (EP&A Reg). It 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 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) / Biodiversity Development Assessment Report (BDAR) 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.

Author & Qualifications	Michelle Moodley BSc (Hons) / Kristen Parmeter BSc (Hons)
Designation	Senior Environmental Scientist
I certify that I have reviewed and endorsed the contents of this REF document and, to the best of my knowledge, it is in accordance with the EP&A Act, the EP&A Regulation and the Guidelines approved under section 170 of the EP&A Regulation, and the information it contains is neither false nor misleading.	
Reviewer & Qualifications	Liz Mathieson BSc
Designation	Principal Scientist
Organisation	NSW Public Works, Department of Regional NSW
Signature	
Date	

Verification and Determination

I have examined this Review of Environmental Factors and the Certification and accept the report on behalf of Wingecarribee Shire Council (the proponent).

Verification

Name	
Designation	
Organisation	Wingecarribee Shire Council
Signature	

Determination

I determine that the activity is approved and may proceed.

Name	
Designation	
Organisation	Wingecarribee Shire Council
Signature	

Executive Summary

Moss Vale is located in the NSW Southern Highlands, approximately 110 km south of Sydney within the Wingecarribee Shire Council (WSC) Local Government Area (LGA). The Moss Vale Sewage Treatment Plant (STP) is located off Kennedy Close in Moss Vale (part Lot 2 DP 187926). According to a recent Integrated Water Cycle Management (IWCM) (PWA, 2018) the projected equivalent person (EP) load for the Moss Vale STP indicates that the load -could potentially increase by over 300% by the year 2046 because of future development. This projection also takes into account the potential significant loads generated within the Moss Vale Enterprise Corridor (MVEC).

To accommodate for the expected additional loads and to improve operational performance, WSC propose to upgrade the treatment infrastructure at Moss Vale STP.

The STP upgrade is proposed to be undertaken in several stages. This REF assesses the Stage 1 scope of works.

Scope of Works

The proposed STP augmentation (Stage 1 works to increase the plant design capacity to 20,000EP) 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, and a vortex style grit removal tank.
- New lift pump station – including wet well, three influent pumps to transfer flows to the bioreactors and two bypass (solids contact) pumps.
- New Storm Detention Ponds (SDP) - by conversion of the current catch/balance ponds, including storm splitter box, two storm return pumps, a return rising main to the screened sewage channel or filter feed control system.
- A new bioreactor splitter box.
- Two new bioreactors - designed as Four Stage Bardenpho (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 control system delivering flows to the tertiary filters.
- 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 (for on-site reuse only).

- 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, new TWAS and scum feed pipes, replacement removable aeration diffusers and control valves 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 and third at ultimate design, if required). 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, two screw press dewatering units, a duty only, horizontal, biosolids cross-conveyor, 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.
- Retention of 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.
- A new carbon storage and dosing system.
- Site provision for future recycled water treatment system.
- Site provision for future tertiary clarifiers for trimming effluent Total Phosphorus (TP) if needed at ultimate design.
- Site provision for a moving bed biological reactor for trimming Total Nitrogen (TN) if needed at ultimate design.

Planning Framework

The proposed Moss Vale STP upgrade works are permissible without consent pursuant to Sections 2.126(1)(a) and 2.126(2) of *State Environmental Planning Policy (Transport and Infrastructure) 2021 (SEPP Infrastructure).* Sections 2.126(1)(a) and 2.126(2) allow 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 Section 2.125 of the SEPP and include SP2 Infrastructure.

This Review of Environmental Factors (REF) has been prepared in accordance with Section 5.5 and 5.7 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and Section 171 of the *Environmental Planning and Assessment Regulation 2021* (EP&A Regulation) which requires a proponent 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, WSC would be the proponent and determining authority for the works.

Approvals

A number of approvals would be required to undertake the proposed Moss Vale 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
- If groundwater dewatering is required during construction works a water supply works approval would be required for pumped dewatering. Consultation should be undertaken with DPE - Water to confirm whether an aquifer interference approval or exemption is required for these works under Section 91 of the *Water Management Act 2000*.

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 capacity and operational reliability of the STP and improve water quality conditions downstream of the effluent discharge location at Whites Creek.

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 Moss Vale STP upgrade works. Therefore, an Environmental Impact Statement would not be required.

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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
cfu / 100mL	Colony forming units per 100 millilitres
COD	Chemical Oxygen Demand
DDWF	Design Dry Weather Flow
DIA	Discharge Impact Assessment
DPI	Department of Primary Industries
DPE	Department of Planning and Environment
EP	Equivalent Persons
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2021*
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FSB	Four Stage Bardenpho
IDEA	Intermittently Decanted Extended Aeration
IWCM	Integrated Water Cycle Management
kL	kilolitre
kW	kilowatt
LEP	Local Environmental Plan
LGA	Local Government Area
LRV	Log Removal Values
Mg/L	milligrams per litre

MHL	Manly Hydraulics Laboratory
NpFI	Noise Policy for Industry
µS/cm	Microsiemens Per Centimeter
MLE	Modified Ludzack-Ettinger
MLSS	Mixed Liquor Suspended Solids
MVEC	Moss Vale Enterprise Corridor
NorBE	Neutral or Beneficial Effect
NSW PW	NSW Public Works
OEMP	Operation Environmental Management Plan
POEO Act	*Protection of The Environment Operations Act 1997*
PQL	Practical Quantitation Limit
PLC	Plants Programmable Logic
PWWF	Peak Wet Weather Flows
SCADA	Supervisory Control and Data Acquisition
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
WTP	Water Treatment Plant

1. Introduction

1.1 Background and Proposal Objectives

Moss Vale is located in the NSW Southern Highlands, approximately 110 km south of Sydney within the Wingecarribee Shire Council (WSC) Local Government Area (LGA). The Moss Vale Sewage Treatment Plant (STP) site is located off Kennedy Close in Moss Vale on part Lot 2 DP 187926.

The Moss Vale STP was upgraded in 1996 to a nominal design capacity of 9,000 equivalent persons (EP). The urban population of Moss Vale in 2016 was approximately 7,900 EP, with an estimated total STP load as high as 10,200 EP. As such, the current load on Moss Vale STP is predicted to exceed the design load.

According to the Integrated Water Cycle Management (IWCM) (PWA, 2018) assessment, the projected EP load to the Moss Vale STP could potentially increase by approximately 300% by the year 2046 due to the projected future development in the area. This projection also takes into account the potential significant loads generated from within the Moss Vale Enterprise Corridor (MVEC) which could result in an additional 19,000 EP.

To accommodate for such future development within the STP catchment, WSC propose to upgrade the treatment infrastructure at Moss Vale STP in stages to provide increased treatment capacity and improve operational performance. The treatment infrastructure would be designed to meet growth projections up to the year 2046 and meet environmental objectives from regulators such as the NSW Environment Protection Authority (EPA).

As the STP upgrade is proposed to be undertaken in several stages, this REF assesses the Stage 1 upgrade works only (20,000 EP). The exact timeframe for the Stage 2 (27,000 EP) and Stage 3 (36,000 EP - ultimate) works are yet to be determined and therefore are not included in this assessment.

A location map and aerial views of the Moss Vale STP are provided in Figure 1.1 to Figure 1.3 and photographic views are provided in Figure 1.4.

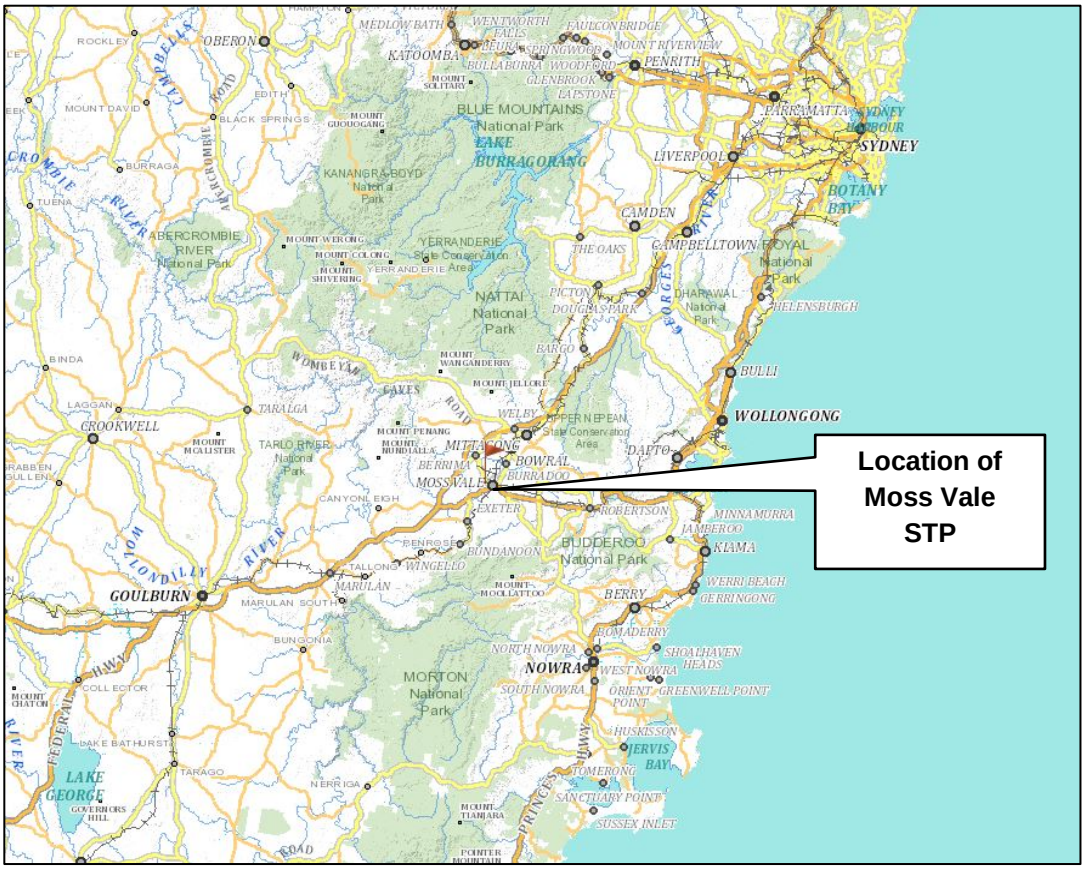


Figure 1.1 Moss Vale location map

Source: SIX Maps, accessed October 2018

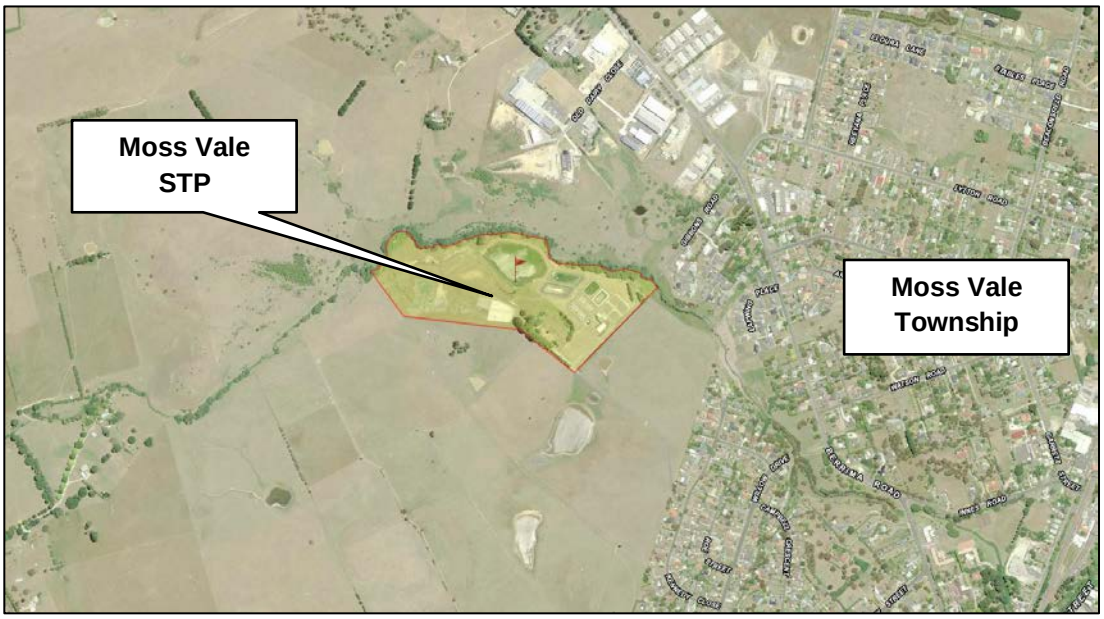


Figure 1.2 Aerial view of Moss Vale STP and surrounds

Source: SIX Maps, accessed October 2018



Figure 1.3 Aerial View of Moss Vale STP and closest residence

Source: Nearmap, accessed February 2023



Existing inlet works (left) and amenities building (right)



Existing Storm Flow Balance Pond



Location of proposed access road. Alum tanks and chemical dosing build on left



Existing Storm balance ponds



Existing sludge drying beds



Existing effluent to Whites Creek

Figure 1.4 Photographic views for Moss Vale STP

Source: NSW PW, October 2018

1.2 Proposal Objectives

The main objectives of the proposed Moss Vale STP Stage 1 upgrade are to:

- provide capacity to 20,000 EP for future development and projected population increase demands within the catchment, as the current design capacity has already been exceeded,
- Provide contingency for future expansion to 36,000 EP, being the projected ultimate population (including development within the MVEC),
- 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, and a vortex style grit removal tank.
- New lift pump station – including wet well, three influent pumps to transfer flows to the bioreactors and two bypass (solids contact) pumps.
- New Storm Detention Ponds (SDP) - conversion of the current catch/balance ponds, including storm splitter box, two storm return pumps, a return rising main to the screened sewage channel or filter feed control system.
- A new bioreactor splitter box.
- Two new bioreactors - designed as Four Stage Bardenpho (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 control system delivering flows to the tertiary filters.
- 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 (for on-site reuse only).
- 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, new TWAS and scum feed pipes, replacement removable aeration diffusers and control valves 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 and third at ultimate design, if required). 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, two screw press dewatering units, a duty only, horizontal, biosolids cross-conveyor, 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.
- Retention of 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.
- A new carbon storage and dosing system.
- Site provision for future recycled water treatment system.
- Site provision for future tertiary clarifiers for trimming effluent Total Phosphorus (TP) if needed at ultimate design.
- Site provision for a moving bed biological reactor for trimming Total Nitrogen (TN) if needed at ultimate design.

The proposed upgrade works would be wholly located within the existing STP site.

1.4 Land Ownership

The proposed works are located on land owned by WSC (Lots 1 and 2 DP 187926).

2. Statutory Planning Framework

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

Zoning

The Moss Vale STP is located within the Wingecarribee LGA. *The Wingecarribee Local Environmental Plan 2010* (LEP) identifies the land use zones relevant to the site. The Moss Vale 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; and
- To prevent development that is not compatible with or that may detract from the provision of infrastructure.

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

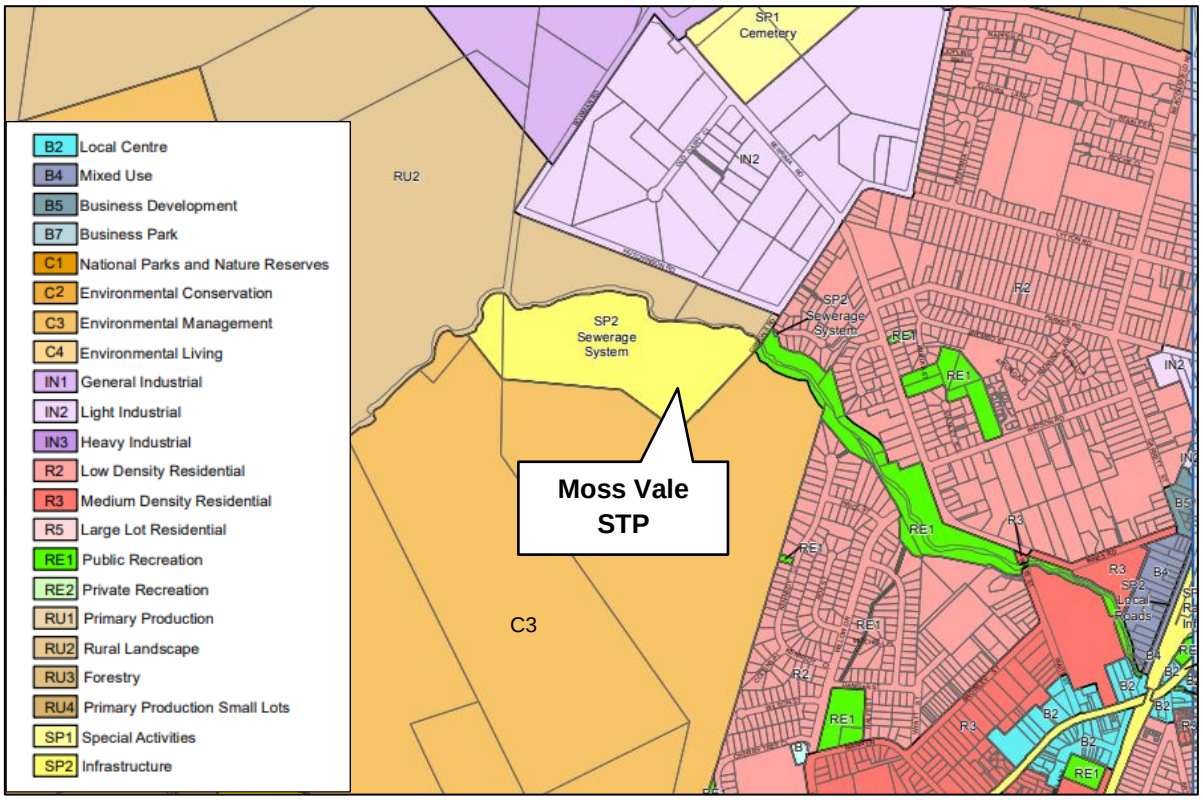


Figure 2.1 Moss Vale STP Zoning Map

Source: Wingecarribee LEP (2010) Zoning Map (Sheet 007D)

It is noted that Section 5.12(1) of the Wingecarribee LEP 2010 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 (Transport and Infrastructure) 2021, Chapter 2. The applicability of *State Environmental Planning Policy (Infrastructure) 2021* 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

Whites Creek runs along the northern boundary of the STP site and is identified as Riparian Land Category 2 - Aquatic and Terrestrial Habitat according to the LEP Natural Resources and Sensitivity Map. In addition, this mapping identifies an unnamed drainage line along the eastern boundary of the STP infrastructure which is identified as Category 3 - Bank Stability and Water Quality Sensitivity (see Figure 2.2). Section 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 5.7 and 5.8.

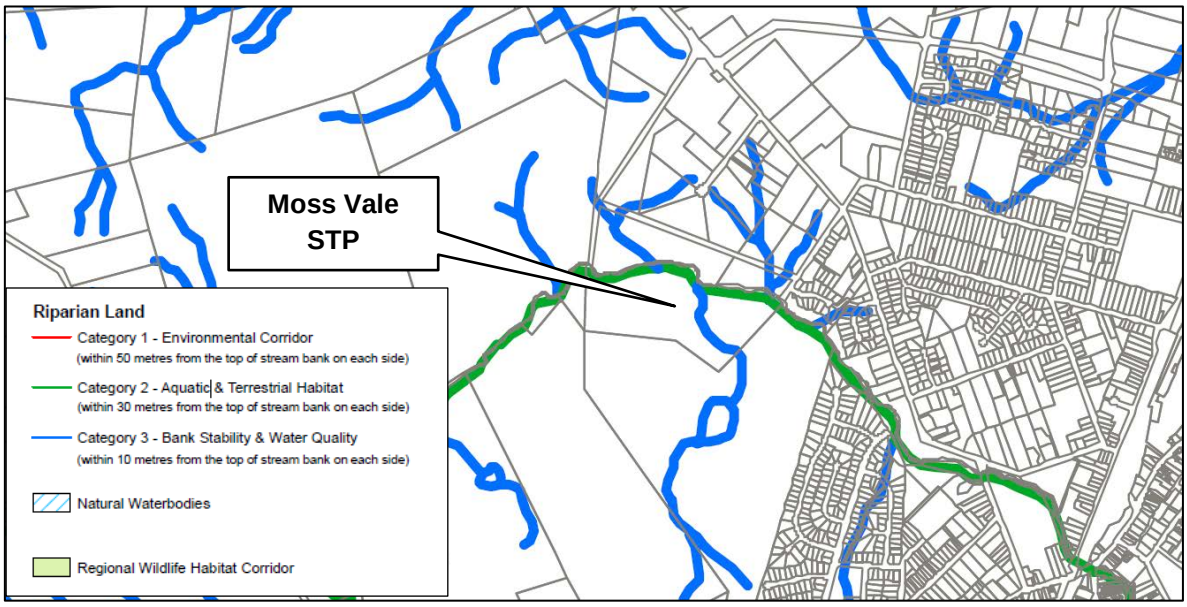


Figure 2.2 Moss Vale STP Natural Resources Sensitivity Map

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

Flood Planning

The Flood Planning Map made under the Wingecarribee LEP identifies the Moss Vale STP as being located in a flood prone area (see Figure 2.3) – albeit the site of the proposed works is not flood affected. An assessment of the impact on flood planning, as well as proposed mitigation measures, are provided in Section 5.7.

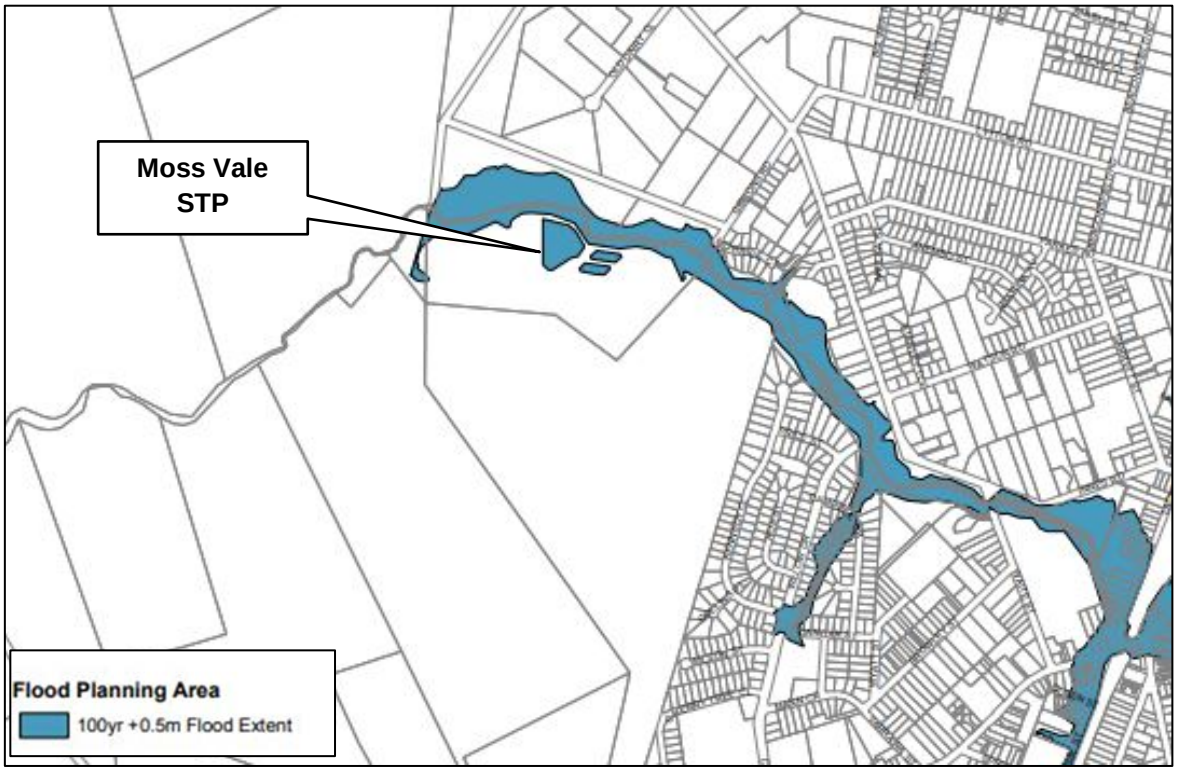


Figure 2.3 Moss Vale STP Flood Planning Map

Source: Wingecarribee LEP (2010) Flood Planning Map (Sheet 007C)

2.1.2 State Environmental Planning Policy SEPP (Transport and Infrastructure) 2021

Chapter 2 of *State Environmental Planning Policy (Transport and Infrastructure) 2021* (SEPP (Transport and Infrastructure) 2021) 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 the environmental assessment and approval process for public infrastructure and services facilities.

Sections 2.126(1)(a) and 2.126(2) of SEPP (Transport and Infrastructure) 2021 allow 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 Section 2.125 and include SP2 Infrastructure.

2.1.3 State Environment Planning Policy (Resilience and Hazards) 2021

Chapter 3 of *State Environment Planning Policy (Resilience and Hazards) 2021* (SEPP (Resilience and Hazards)) 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 nevertheless been considered in relation to the STP upgrade in Section 5.12.

Chapter 4 of SEPP (Resilience and Hazards) 2021 provides for a State-wide planning approach to the remediation of contaminated land. This chapter of the SEPP aims to promote

the remediation of contaminated land for the purpose of reducing the risk of harm to human health or any other aspect of the environment:

(a) by specifying when consent is required, and when it is not required, for a remediation work, and

(b) by specifying certain considerations that are relevant in rezoning land and in determining development applications in general and development applications for consent to carry out a remediation work in particular, and

(c) by requiring that a remediation work meet certain standards and notification requirements."

Two groundwater monitoring wells were installed at the north-western edge and to the south-east of the proposed footprint of the new STP infrastructure by NSW PW (formerly PWA) as part of a Geotechnical investigation (February, 2020). Groundwater monitoring and analysis was subsequently undertaken by Ballpark Environmental (March, 2021a) to assess for potential groundwater contamination due to excavation and potential dewatering works required at the STP site for the Proposal. The analysis found that there is a low potential risk from groundwater contamination to human health or the environment at these two monitoring wells on this site. As such, surplus groundwater from this site may be discharged to the Moss Vale STP or to stormwater during proposed construction activities.

The Geotechnical Investigation undertaken by PWA (February, 2020) at the Moss Vale STP site included asbestos detection testing. The tests detected the presence of chrysotile (White Asbestos) and Amosite (Brown Asbestos) in the soil within the former, demolished trickling filter STP site (location of the proposed Bioreactor, Clarifiers and Tertiary Filters). No Asbestos containing material (ACM) debris was identified during subsequent targeted geotechnical assessment undertaken by D & N Geotechnical (D&N) (April, 2021) which focused on the location of the new STP infrastructure.

The assessment concluded that onsite soils would generally be suitable for use as engineered fill, provided unsuitable materials such as organics, highly plastic material, waste and oversized particles are removed. Laboratory soil analysis by Ballpark Environmental (March, 2021b) as part of the D&N Geotechnical investigation found that no asbestos was identified in any of the soil samples analysed. As such, the Proposal works site is not considered contaminated land requiring remediation.

2.1.4 State Environmental Planning Policy (Biodiversity and Conservation) 2021

The Moss Vale STP site is located within the Warragamba sub-catchment of the Sydney Drinking Water Catchment (SDWC) (see Figure 2.4). The works are therefore subject to the provisions of Chapter 6, Part 6.5 of *State Environmental Planning Policy (Biodiversity and Conservation) 2021* (SEPP (Biodiversity and Conservation) 2021). The objectives of Chapter 6, Section 6.58 of the SEPP (Biodiversity and Conservation) are;

(a) to provide for healthy water catchments that will deliver high quality water to the Sydney area while also permitting compatible development, and

(b) to provide for development in the Sydney Drinking Water Catchment to have a neutral or beneficial effect on water quality.

Under Section 171A(1) of the EP&A Reg, when considering the likely impact on the environment of an activity proposed to be carried out in a regulated catchment, a determining authority must take into account—

(a) the matters a consent authority must consider under SEPP *(Biodiversity and Conservation)*, Sections 6.6(1), 6.7(1), 6.8(1) and 6.9(1), and

(b) the matters of which a consent authority must be satisfied under SEPP (Biodiversity and Conservation), Sections 6.6(2), 6.7(2), 6.8(2) and 6.9(2).

These matters are addressed in Sections 5.7, 5.8 and 5.2 of the REF.

In addition, Section 171A(3) of the EP&A Reg states that when considering the likely impact on the environment of an activity proposed to be carried out in the SDWC, the determining authority must take into account whether the activity will have a neutral or beneficial effect on water quality, and is consistent with the Neutral or Beneficial Effect (NorBE) Guideline under the SEPP (Biodiversity and Conservation) 2021.

WSC has consulted with WaterNSW and the EPA in relation to the Proposal. A Discharge Impact Assessment including a NorBE assessment has been prepared for the proposal to consider the effect on water quality (Manly Hydraulics Laboratory (MHL), 2022). A copy of the report is provided in Appendix F.

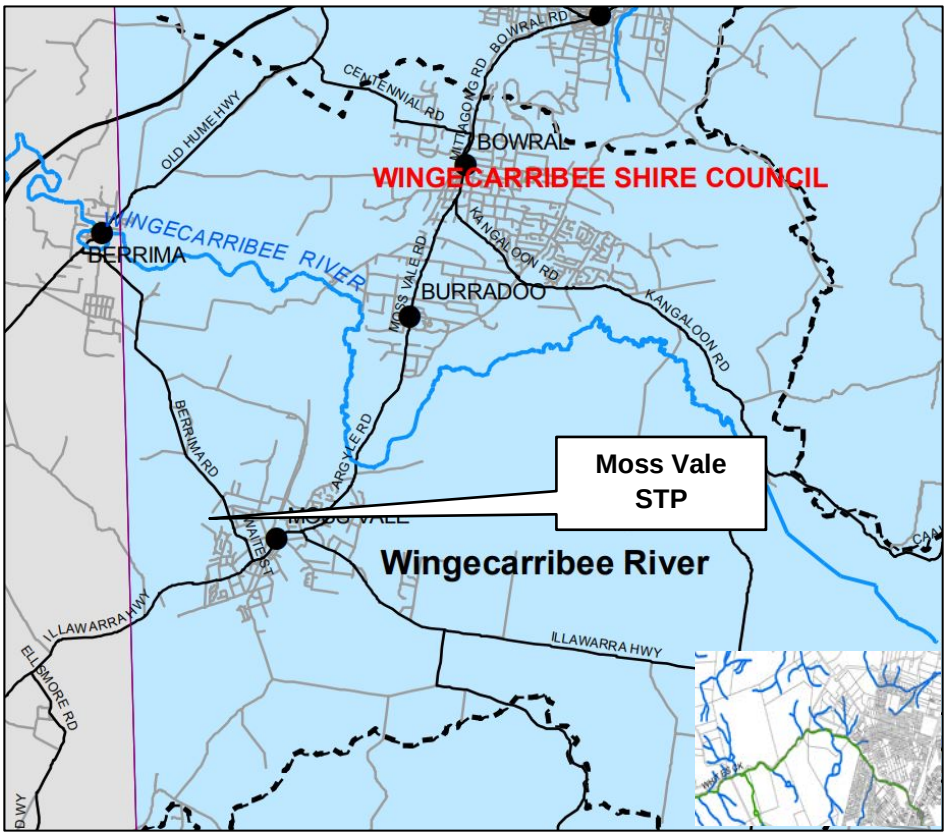


Figure 2.4 Extract from the Sydney Drinking Water Catchment Map (Sheet 015)

Source: NSW Legislation, 2021 SEPP (Biodiversity and Conservation) 2021 Maps

Chapter 4 of SEPP (Biodiversity and Conservation) 2021 aims to encourage the conservation and management of areas of natural vegetation that provide habitat for koalas to support a

permanent free-living population over their present range and reverse the current trend of koala population decline. Schedule 2 of SEPP (Biodiversity and Conservation) 2021 identifies Wingecarribee as an LGA to which this planning instrument applies. It is noted that Chapter 4 of SEPP (Biodiversity and Conservation) 2021 does not apply to proposals assessed under Part 5 of the EP&A Act, nevertheless as a best practice measure consideration of this SEPP has been undertaken as part of the REF.

The proposed vegetation removal associated with the proposed works would comprise mostly exotic conifers (e.g. Monterey Pine and Monterey Cypress) and exotic paddock grasses. Accordingly, the proposed works would not be considered to significantly 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 (NSW)

The applicable environmental planning instrument for the works is SEPP (Transport and Infrastructure) 2021, which provides the permissibility for the proposed development (refer to Section 2.1.2). As the SEPP removes the need for development consent for the proposed STP upgrade works, 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 and 5.7 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 Section 171 of the *Environmental Planning and Assessment Regulation 2021* (EP&A Reg) has been used to assist in assessing the significance of the proposal, and is provided in Appendix A.

2.2.2 Protection of the Environment Operations Act 1997 (NSW)

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 750kL/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 EPA. The existing Moss Vale STP operates under Environment Protection Licence (EPL) No. 1731 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 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, the

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 designed to EPA requirements, 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 Moss Vale 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 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.

Part 7 of the Prote*ction of the Environment Operations (Waste) Regulation 2014* has specific provisions in relation to the transportation and management of asbestos waste (should it be encountered). Part 4 of the Regulation details the requirements to track asbestos waste transported within, out of and into NSW.

The proposed upgrade works including the decommissioning of existing STP components and the disposal of other construction waste including waste classified as general solid waste and special asbestos 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 of Planning and Environment - Water (DPE - 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 Moss Vale STP. WSC has liaised with DPE - 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 Aboriginal sites or places in or near the STP site. Therefore, it is not anticipated that the works would cause harm to any previously recorded Aboriginal sites.

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 5.10).

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.

During geotechnical investigations groundwater was intersected at several of the boreholes during the on-site drilling. Furthermore, the groundwater rose within the short period of monitoring at some locations.

If pumped groundwater dewatering is required for the construction works, a water supply work approval to pump surface water would be required from DPE - Water (NRAR) under Section 91B of the WM Act. If more than 3ML of groundwater dewatering is required during

construction works, an aquifer interference Water Access Licence (WAL) would be required. However, if dewatering of less than 3ML is required for the Proposal, a WAL exemption for aquifer interference activities taking 3ML or less of groundwater per year should be lodged with DPE - 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 BC Act sets out provisions for threatened species and threatened ecological communities.

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 5.8).

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 as listed under the EPBC Act would be significantly impacted by the proposal, as the works would be confined within areas previously disturbed by the existing STP facilities (see Section 5.8). Therefore, a referral under the EPBC Act would not be required.

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 along the banks of Whites Creek, with the riparian area along Whites Creek identified as Key Fish Habitat (see Figure 5.13). 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.

2.2.10 Work Health and Safety Act 2011 & Regulation 2017

The *Work Health and Safety Act 2017* and *Regulation 2017* (WH&S Act, WH&S Reg) are the statutes that direct the control and management of workplace practices and handling of hazardous materials by work teams. Safework NSW is the regulator for the WH&S Act and WH&S Reg in NSW. Hazardous Materials includes asbestos, asbestos containing materials (ACMs), synthetic mineral fibres (SMF), lead in paint, polychlorinated biphenyls (PCBs), and Phenols.

The WH&S Act and Reg includes specific provisions in relation to asbestos management and handling (Chapter 8 of the WH&S Reg). The works would be carried out in accordance with Chapter 8 and all other relevant provisions of the WH&S Act and Reg and with current best practice guides as issued by SafeWork NSW and the Safe Work Australia.

Provisions of the WH&S Reg in relation to asbestos management which may be relevant to the demolition works (if ACM was encountered) include:

- Only suitably certified contractors who hold a current asbestos removal licence would handle and transport asbestos;
- A copy of the asbestos register and management plan to be available and readily accessible to all workers intending to carry out works at the workplace.
- If there is a chance for ACMs to be disturbed, reference needs to be made to the Asbestos Management Plan.
- The Asbestos Management Plan must be controlled by a Nominated Controller of the Asbestos Register for the worksite.

Other documents to be read in conjunction with the WH&S Reg include:

- *Code of Practice: How to Manage and Control Asbestos in the Workplace* (Safe Work Australia 2020) and

- *Code of Practice; How to Safely Remove Asbestos* (Safe Work Australia 2020) prior to demolition works.

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 guideline is largely concerned with reducing overflows from sewerage systems. The Moss Vale 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 (or minimise the risk of) 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 as detailed in 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 Moss Vale 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 to ensure ecologically sustainable development of water resources. The main objective of the Guidelines for fresh and marine water quality is 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.

The proposed Moss Vale 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 5.7 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 (Transport and Infrastructure) 2021, and therefore a WCMS is not required to support a development application. However, in consultation with WaterNSW and the EPA, a Discharge Impact Assessment (DIA) has been prepared by MHL (2022) (refer to Appendix F) 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 2022 (WaterNSW, 2022),

The *NorBE Guideline*, (WaterNSW, 2022) 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 F.

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 Statutory Approvals

Agency	Requirements	Reference
Wingecarribee Shire Council	Determination of the proposal	Part 5 of EP&A Act
EPA	Variation to EPL No. 1731	Section 58 of POEO Act
DPE - Water	Approval to provide sewerage services	Section 60 of LG Act
	Aquifer Interference water access licence (WAL) (if more than 3ML of groundwater is likely to be extracted per annum during construction works). Alternately, a WAL exemption should be lodged with DPE-Water (NRAR) for aquifer interference activities taking 3ML or less of groundwater per year. A water supply work approval would also be required for pumping of surface water if dewatering of groundwater is required for the works.	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 Moss Vale 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 5.7
	• 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 5.7 and Appendix F – Discharge Impact Assessment
	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 5.7

Agency	Summary of Comments	Where Addressed in REF
	• 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. • 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.	Refer to Section 5.7
	• 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.	A DIA has been prepared for the proposal. Refer to Section 5.7 and Appendix F – Discharge Impact Assessment
	• 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 5.7
	• 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)*(repealed - now SEPP(Biodiversity and Conservation) 2021))*. • 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	A DIA including a NorBE test has been prepared for the proposal. Refer to Section 5.7 and Appendix F – Discharge Impact Assessment

Agency	Summary of Comments	Where Addressed in REF
	to accurately define typical loads under average dry weather conditions to be used in the NorBE assessment.	
	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 5.6 and 5.7
	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 5.7 and Appendix F – Discharge Impact Assessment

Agency	Summary of Comments	Where Addressed in REF
	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.	Refer to Section 4
	Impact Assessment - predict impacts and environmental outcomes Describe the nature and degree of impact that any proposed discharges would have on the receiving environment.	Refer to Section 5.6 and 5.7
	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	Refer to Section 5.7

Agency	Summary of Comments	Where Addressed in REF
	mixing zone are demonstrated to be reversible. The proposal should 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 5.7 and Appendix F – Discharge Impact Assessment
	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. .

Agency	Summary of Comments	Where Addressed in REF
	Assess impacts on groundwater and groundwater dependent ecosystems.	Section 5.7 and 5.8.2
	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.	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 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 Moss Vale STP to meet effluent performance criteria agreed with the EPA by the due date - 31 December 2020.	The requirement for the STP upgrade to be completed by the end of 2020 was not achievable. The program does not allow for delays or additional investigations works. WSC has undertaken ongoing consultation with the EPA in relation to the proposed STP upgrade.

Agency	Summary of Comments	Where Addressed in REF
WaterNSW 19 September 2018 (letter)	**State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011** • 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.	Refer to Section 2.1.4 Note that SEPP (Sydney Drinking Water Catchment) 2011 has been repealed and replaced by SEPP (Biodiversity and Conservation) 2021). 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 F).

Agency	Summary of Comments	Where Addressed in REF
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 F)
	• 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
	• Predicted effluent quality for 50, 90 and 100 percentile concentrations for total suspended solids (TSS), BOD, TP, TN and pathogens.	Section 5.7 NB: According to the 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.

Agency	Summary of Comments	Where Addressed in REF
	• 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 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	A DIA including a NorBE assessment has been prepared for the proposal noting WaterNSW comments to consider water quality impacts (provided in - Appendix F) 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 incorporated through the cumulative distribution of concentrations and loads.

Agency	Summary of Comments	Where Addressed in REF
	▪ 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.	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 macroinvertebrate monitoring data is provided in 5.7 A copy of the interim analysis report of is provided in Appendix F. Management of excess inflows have been

Agency	Summary of Comments	Where Addressed in REF
	• Proposed monitoring program including location of proposed monitoring points upstream and downstream of the discharge point.	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.
WaterNSW 22 October 2018 (letter)	**STP Design** • In consideration of the project population, grounds 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.	Refer to Section 4.1
	• Provision for power supply back-up in the event of a power failure at a pumping station or at the STP.	The MSB would include a generator manual transfer switch Refer to Section 4.2.20
	NorBE water quality assessment • Pre- and post-upgrade pollutant loading for 100 percentile pollutant concentrations in effluent	Refer to Section 2.3.3 and 5.7 NorBE has been considered for the Proposal. A DIA including

Agency	Summary of Comments	Where Addressed in REF
		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 • 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 • potential for run-off from any biosolids processing, storage or application areas to enter Whites Creek.	Refer to Section 1.1, 2.3.3, and 5.7 A DIA including water quality modelling has been prepared for the proposal (provided in Appendix F)
	An assessment of the proposed access road, with specific details of any crossing of Whites Creek from Gibbons Road.	N/A -Access road and/or crossing of Whites Creek from Gibbons Road is not proposed.

Agency	Summary of Comments	Where Addressed in REF
	Conceptual Construction Environmental Management plan (CEMP) incorporating a Conceptual Soil & Water Management Plan (SWMP) for the construction phase of the project.	Refer to Section 4.3.3 and 6.1, 6.2
OEH 30 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,* and threatened Paddys River Box (*Eucalyptus macarthurii*) individuals within the vicinity of the subject site. The Whites Creek 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 Whites Creek 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
	<u>Aboriginal cultural heritage</u> 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.	Refer to Section 5.10

Agency	Summary of Comments	Where Addressed in REF
	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 Whites Creek Flood Risk Study & Management Plan (FRSMP). This FRSMP is currently under review, and we suggest you liaise with Sha Prodhan, Council's Floodplain & Stormwater Engineer in this regard. 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,
	• Name of adjacent waterway(s).	Refer to Section 5.7
	• Description of works to be undertaken.	Refer to Section 4
	• Investigations into the options for the reduction in volume of discharge, including beneficial reuse of the treated effluent	Refer to 3.3.4, 4.2.11
	• Description and condition of aquatic habitats (watercourses, wetlands) located on the site and downstream of the site in Whites 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 5.7 and 5.8

Agency	Summary of Comments	Where Addressed in REF
	• 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.	Refer to 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.	Refer to Section 2.2.9
	• Safeguards to mitigate any impacts upon water quality (including impacts downstream in Whites 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.	Refer to Section 3.3 and 5.7 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

Agency	Summary of Comments	Where Addressed in REF
		is minimal (A copy of the report is provided in Appendix F).
	• Details of proposed revegetation of adjacent riparian buffer areas.	Disturbance of riparian buffer areas is not anticipated
Health	No comment received	Not applicable
DPE – Water	No comment received	Not applicable

3. Need for the Project and Option Evaluation

This section reviews the existing sewerage infrastructure at Moss Vale STP, provides the context for the proposed works and describes the option evaluation process. It has been summarised from the *Moss Vale Sewage Treatment Plant Augmentation* Concept Design 2020 – Expanded Staging Strategy (PWA, March 2020) and the and the *Moss Vale Sewage Treatment Plant Upgrade Detailed Design Report* (Hunter H_2O, May2022).

3.1 Existing Infrastructure and Operation

The Moss Vale sewerage scheme services the community of Moss Vale. The collection system is a conventional gravity sewerage system comprising 13 pump stations. The STP receives sewage flows through a trunk gravity main. Moss Vale STP has a design capacity of 9,000 EP and utilises two IDEA reactors for secondary treatment, chemical phosphorus removal and UV disinfection to treat sewage. Treated effluent is discharged to Whites Creek. During storms, sewage is diverted from the inlet works to two wet weather storage ponds. Further overflows from the wet weather storage ponds are drained into two larger downstream storm balance ponds. The STP consists of the following systems:

- Inlet works with mechanical screening and grit removal;
- Two 4,500 EP IDEA reactors; Each including:
    - Twin feed points, one at each end.
    - A centre decanter with a double sided weir.
    - Diffused aeration and associated blowers.
    - Waste activated sludge (WAS) pumping.
- Two decant effluent catch/balance ponds. Alum is dosed into the IDEA decant, creating solids that settle in these ponds. Each can be bypassed for cleaning.
- An alum storage and dosing system for phosphorus precipitation. Alum is also dosed directly to the IDEAs (i.e. as well as the decanted effluent)
- A channel style ultraviolet (UV) disinfection unit sized for faecal coliform inactivation.
- Two sludge lagoons for sludge stabilisation.
- Sludge drying beds for biosolids dewatering. (Noting that 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 effluent/storm pond. This cannot be completely emptied, but provides some storage and return via the catch/balance ponds.

The current STP is currently operating at its design load under EPL 1731. The current effluent quality limits under EPL No 1731 are listed in Table 3-1. The current license arrangement allows for 8.4 ML/day total discharge from the STP. There have been non-conformances at the Moss Vale STP related to wet weather exceedances, , where ammonia, TN and volume exceedance occurred. This has been an ongoing issue over the years.

The upgraded plant has been designed to provide a more consistent and reliable effluent quality.

An aerial view of the current site, the existing site layout and process flow diagram for the STP are shown in Figure 3.1, Figure 3.2 Figure 3.3, respectively.

Table 3-1 Current EPA EPL Effluent Concentration Limits for Moss Vale STP

Pollutant	50 percentile concentration limit	80 percentile concentration limit	90 percentile concentration limit	100 percentile concentration limit
Ammonia Nitrogen (NH_x-N)	-	-	2 mg/L	-
Biochemical Oxygen Demand (BOD)	7 mg/L		10 mg/L	-
Faecal Coliforms	-	200 cfu / 100mL	-	-
Total Nitrogen (TN)	7 mg/L	-	10 mg/L	-
pH	-	-	-	6.5-8.5
Total Phosphorus (TP)	0.5 mg/L	-	1.0 mg/L	-
Total Suspended Solids (TSS)	10 mg/L	-	15 mg/L	-

.



Figure 3.1 Aerial Photograph of Moss Vale STP site

Source: Hunter H_2O, 2022

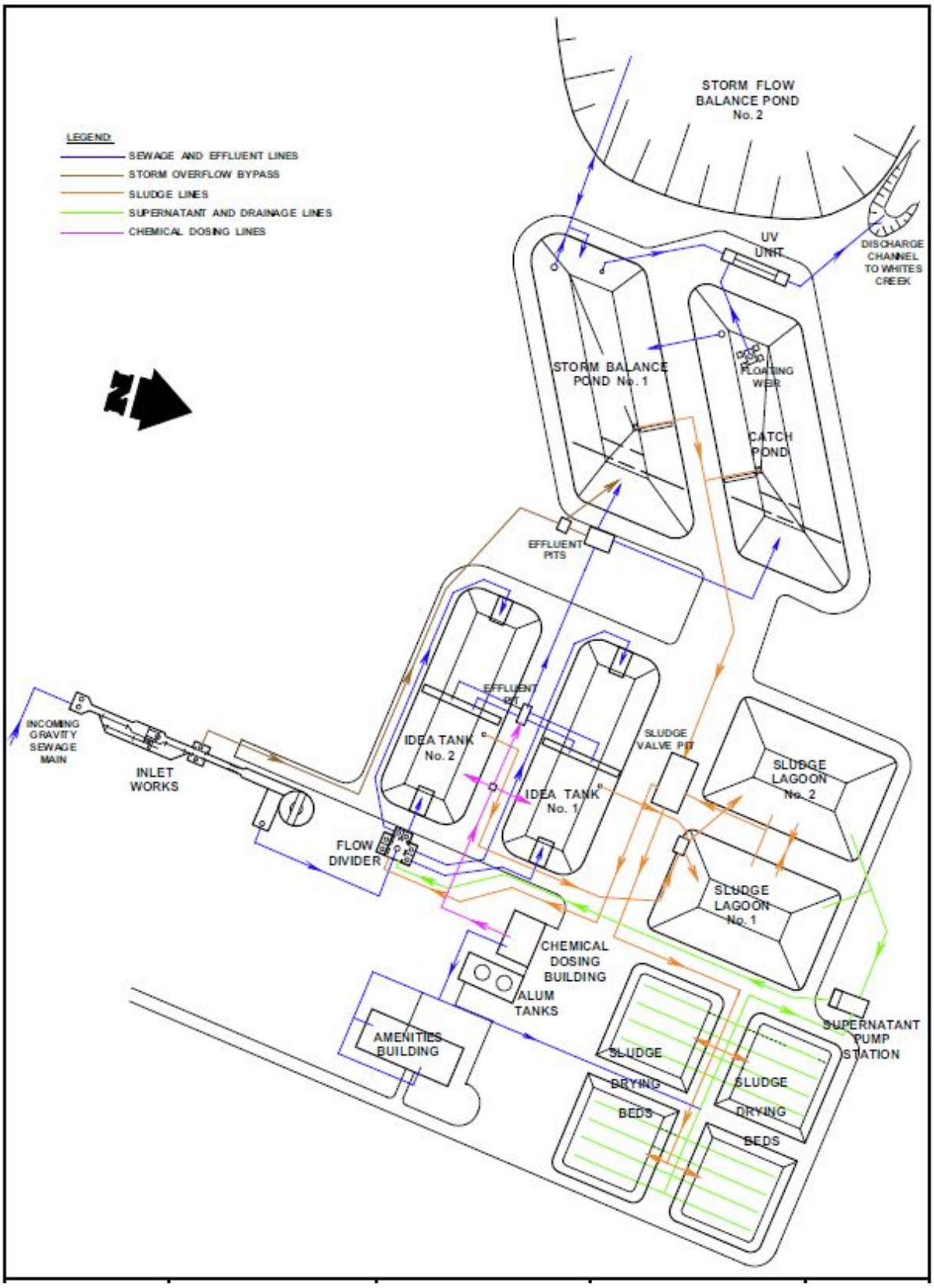


Figure 3.2 Moss Vale STP Current Site Layout

Source: PWA, 2020

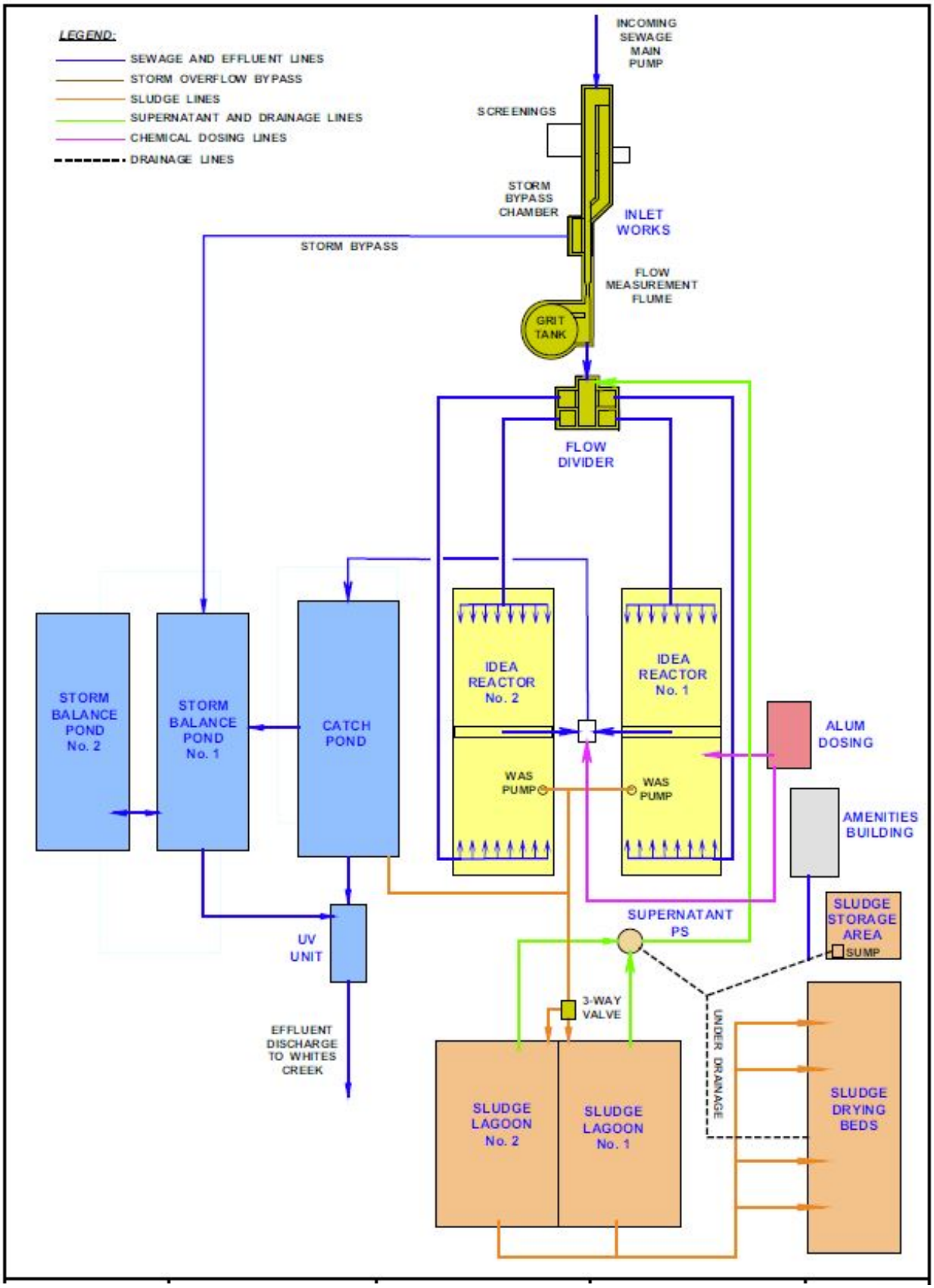


Figure 3.3 Moss Vale STP Current Process Flow Diagram

Source: PWA, 2020

3.2 Basis of Design (Population and Loadings)

3.2.1 Load Projections

The projected equivalent person (EP) growth projections to inform the anticipated load for the STP to the year 2050 has been based on calculations from the recent Detailed Design Report undertaken by HunterH_2O (2022), and is presented in Table 3-2. The projections take into account the potential loads for residential and non-residential flows.

The load projections for the proposed Moss Vale Enterprise Corridor (MVEC) is also included, with the MVEC being a significant area of land between Moss Vale and New Berrima set aside for employment generating development under the Wingecarribee LEP 2010. The MVEC is currently zoned for General Industrial with some Heavy Industrial zoned land to the south of New Berrima (Boral Cement Plant) and the eastern perimeter fronting McCourt Road, Moss Vale. The MVEC has a major influence on projected growth in flows and loads to Moss Vale STP and represents the vast majority of the projected growth in the catchment.

The predicted current (2020) EP is 19% more than the design capacity of the current plant (9000 EP). There is anecdotal evidence (due to insufficient aeration capacity) that the plant is currently overloaded.

Table 3-2 Simplified Moss Vale STP Equivalent Persons (EP) Growth (Load) Projections

Year	Residential	Non-Residential	Total Without MVEC	MVEC	Total With MVEC
2020	8414	2339	10753		10753
2025	9154	2369	11522	8182	19704
2030	9958	2398	12357	12727	25084
2035	10834	2429	13263	17273	30535
2040	11787	2459	14246	19091	33337
2045	12823	2490	15313	19091	34404
2050	13951	2521	16472	19091	35563

Source: HunterH_2O, 2022

3.2.2 EP Mass Loading

STP mass loading values derived from Council sampling and analysis in 2017 and 2018 were considered in order to determine a standard load contribution level as an appropriate adopted basis for the STP upgrade concept design (see Table 3-3).

Table 3-3 Design Mass Load

Parameter	Adopted Design Contributions
Hydraulic Contribution (loading)	230 L/EP/d
Total Suspended Solids (TSS)	65 g/EP/d
Chemical Oxygen Demand (COD)	132 g/EP/d
Biochemical Oxygen Demand (BOD)	60 g/EP/d
Total Nitrogen (TN)	13.0 g/EP/d
Total Phosphorus (TP)	2.2 g/EP/d

Source: HunterH_2O, 2022

3.2.3 Hydraulic Loading

The design basis for the hydraulic load is presented in Table 3-4. The hydraulic loading design has been calculated based on an analysis conducted to compare the hydraulic contribution of various years of data provided by Council dating back to 2014. The EP was based on the IWCM (PWA, 2018) estimates and growth rates (1.7% for residential and 0.25% for non-residential) and the requirements for treatment to meet the EPA quality requirements for the STP EPL.

Table 3-4: Design Hydraulic Loads

	Design/ Factor	Flow rate
Hydraulic Contribution	230 L/EP/day	-
Equivalent Persons (EP)	20,000	-
ADWF (average dry weather flow)	-	4.6 ML/d
MDWF (minimum dry weather flow)	0.3 x ADWF	1.38 ML/d
DFTF (design full treatment flow)	3 x ADWF	13.8 ML/d
DSTF (design storm treatment flow)	6 x ADWF	27.6 ML/d
PDWF (peak dry weather flow)	2 x ADWF	9.2 ML/d
PWWF (peak wet weather flow)	13 x ADWF	59.8 ML/d

Source: Hunter H_2O, 2022

3.3 Option Evaluation

The following information is taken from the *Moss Vale Sewage Treatment Plant Upgrade Detailed Design Report* prepared by Hunter H_20 (2022) for the proposal.

3.3.1 Preliminary Design

In 2017, PWA prepared an IWCM Options Review Paper. PWA modified the following aspects of the upgrade strategy:

- Increase the sludge age of the existing IDEA bioreactors and re-rate them to 7,200 EP total.
- Build a third 3,500 EP IDEA bioreactor.
- Consider omitting the third catch/balance pond.
- Provide an alum flocculation system between the IDEAs and catch/balance ponds.
- Include a suitable sludge extraction system in the catch/balance ponds.
- Install alkalinity storage and dosing (caustic) to counteract the impact of increased alum dosing.
- Install disc filters, including upstream flocculation for phosphorus trimming.
- Consider replacing the UV system with a break point chlorination and de-chlorination system for enhanced total nitrogen (TN) removal for future NorBE requirements.

3.3.2 Concept Design

In 2020, PWA prepared a Concept Design Report (CDR). PWA undertook a more detailed options investigation into the best way to upgrade and amplify the various Moss Vale 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:

- Construct a new 11,300 EP IDEA bioreactor.
- Upgrade one of the existing IDEA bioreactors to provide a capacity of 6,700 EP (total of 18,000 EP).
- Once the capacity is exceeded, upgrade the second existing bioreactor and construct another new bioreactor to provide a total capacity of 36,000 EP.
- Do not construct additional catch/balance ponds.
- Construct a new disc filtration system including a filter feed pump station and polymer dosing system.
- Upgrade the UV disinfection system.
- Include future break point chlorination for TN removal (NorBE), plus de-chlorination.
- Build the future large IDEA early and use it as an aerobic digester. Replace this with a purpose built aerobic digester once the second large IDEA is required.

- Provide permanent mechanical dewatering facilities near the second large IDEA (aerobic digester). Move this dewatering facility to be near the future aerobic digester once it is constructed.
- Provide a new reclaimed effluent system.

3.3.3 Detailed Design

In 2019, WSC awarded Hunter H_2O the detailed design of Bowral STP. This scope of work also included a review of the CDR by PWA. The preferred concept for Bowral STP was similar in treatment style to that proposed for Moss Vale STP. The Design Development Report for Bowral STP was prepared by Hunter H_2O during March to June 2020. This report discussed three secondary treatment options. These were:

- PWA Option & H_2O Option – These were similar to the preferred option for Bowral STP outlined in the CDR. They both retained IDEA bioreactor technology, but utilised more advanced bioreactors for nitrogen removal rather than utilising chlorination/dichlorination. Aerobic digestion and mechanical dewatering were also provided. The differences between these two options was not so much in style, but how to best utilise the existing IDEA (retain as an IDEA or use as the aerobic digester).
- FSB/MLE 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. [This option allows for the plant to initially operate in Modified Ludzack-Ettinger (MLE) configuration].

As part of the detailed design process for the STP upgrade, a *Discharge impact Assessment* (MHL, 2022) 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 FSB/MLE STP upgrade option that was selected for the Bowral STP Upgrade (now with a contract awarded for construction), has also been selected for the Moss Vale STP Upgrade project – to be developed into a detailed design - 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. The practical quantitation limit (PQL) and ANZECC guidelines default trigger values are also included.

	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 of 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.

Source: MHL, 2022

3.3.4 Treated Effluent Management

Options for effluent management are considered to be limited. Accordingly, it is proposed to continue the current practice of treated effluent discharge to Whites Creek. The current STP is a modern standard activated sludge based plant and has been proven to provide a very good level of treatment. The effluent quality from the STP is generally meeting the EPA limits with some exceedances mainly due to wet weather and capacity deficiencies. The augmented plant would improve treatment performance and aim to meet EPA requirements. There is therefore predicted to be limited impact on the receiving water due to continued discharge.

Council is continuing to investigate recycled effluent opportunities and implement where it is of a benefit to the community, however the options being considered appear cost prohibitive and any practical options progressed 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 Moss Vale STP is currently operating at design capacity, therefore the STP requires upgrading as soon as possible.

The preferred MLE/FSB Option involves utilising one of the two existing IDEATs 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 option include:

- It better managed the risk of achieving future effluent quality requirements.
- It carried less risk of sunken assets (especially in future stages).
- It was capital cost neutral or comparable.
- It was simpler to operate and control (no time sequencing and fewer set points).
- It provided equal or better wet weather treatment capacity and performance.
- The FSB plant is also able to initially be operated under the Modified Ludzak Ettinger (MLE) configuration.

In addition, the FSB/MLE Treatment Option is preferred as population (and industrial growth) growth in Moss Vale is likely to be significant, such that the need for highly advanced denitrification bioreactors becomes even more paramount. Given the lack of certainly in MVEC growth, wastewater flow generation and characteristics, it is difficult to plan the staging of Moss Vale STP. The FSB/MLE design is therefore flexible, with the ability to customise the staging and modules to suit MVEC as growth actually occurs.

Furthermore, there are considerable operational advantages in delivering consistent process styles and (where possible) process unit sizes at the Bowral and Moss Vale STPs. Having similar module sizings between plants would lead to benefits around greater operator familiarity between plants. It would also result in many of the equipment items [dewatering units, blowers, ultraviolet (UV) units, clarifier scrapers, etc.] being common between plants, providing greater redundancy and spares or reducing the number of spares in store.

It is considered that the FSB/MLE type treatment system would provide an effective and robust outcome for the proposed Moss Vale 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 the design development and the designers experience in the upgrade of other STPs has led to a design able to 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 Moss vale STP detailed design development for the selected continuous MLE/FSB type treatment plant.

Table 3-6 TP Treatment Process Design Development and Justification

STP Treatment Type/Design Component	STP Design Development and Justification
Intermittent vs Continuous 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 the same order of 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. 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 is no effluent reuse driver at the treatment plant to take advantage of the disinfection log credits offered by the membrane technology.
Concerns with Breakpoint Chlorination (Chlorination/Dechlorination)	The original concept design by PWA suggested chlorination/ dechlorination of effluent as a means to minimise effluent nitrogen concentrations - the design development report by Hunter H_2O discusses 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 de-chlorination dose is required, further increasing cost and very 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 de-nitrify 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.
Further Add On Technologies	• The proposed configuration is operating at the limit of conventional biological processes for nitrogen removal – apart from the addition of carbon to the dual media filters, other options such as side stream treatment (MBBR), activated carbon filters or reverse osmosis come at significant cost for only a marginal improvement in effluent quality. • The same can be said for phosphorus removal where any further improvements are really driven towards clarriflocation and / or membrane treatment. • Such items could be added if required in the future, however the capital and ongoing operational cost of such technologies would be significant (20% of current upgrade costs) and difficult to justify to the local community that are already making a substantial investment to a treatment plant that is on par with current best practice (compared to other NSW regions).
It is also noted that apart from the change from an intermittent to continuous treatment process, HH2O have been innovative throughout the design progression assisting Council in further modifications which will assist plant performance. Some of these changes (from those suggested in the Concept Design Report) include:	
Mechanical Band Screens (in lieu 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 (in lieu of cloth filters)	The Concept Design Report suggested the use of tertiary cloth media disk filters – as currently in use at the Bowral STP. Council has found that the cloth filters at Bowral STP to be operationally difficult with regard to biofouling leading to ineffective backwashing and shortening cloth media life. The Bowral Concept Design Report suggested

	providing an additional cloth filter to reduce the suspended solids (and phosphorus captured in the solids) before effluent is disinfected with the UV unit; and similarly the Moss Vale Concept Design Report suggested installation cloth filters for tertiary treatment. Dual media filters are significantly superior to cloth filters – especially with regard to solids and phosphorus removal. HH2O have suggested that well designed dual media filters should 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 Moss Vale 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 1731 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.

Treated Effluent Discharge Quality

The STP is located in the declared drinking water catchment which is regulated by Chaper 6 of SEPP (Biodiversity and Conservation) 2021 (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 take into account 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 significantly increase from the current load to the ultimate design horizon in 2046 at the Moss Vale 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 development 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 previous consultation with the EPA and WaterNSW to determine what baseline is required and realistic effluent standards for the upgraded STP. Discussions have indicated that it is suitable to use a baseline corresponding to a 2007 benchmark [as per the '*Assessment of Proposed Sewage Treatment Upgrade Projects Within the Sydney Catchment*' by NSW Department of Commerce (NSW Public Works) based upon loads when the Bowral STP was last upgraded.

This approach is not easily translatable to the Moss Vale STP upgrade. The assessment to suggest suitable licence conditions in this case follows an approach of considering historical effluent discharges from the STP so as to appreciate the 'Neutral or Beneficial Effects' (NorBE) of the proposed upgrade on water quality in the catchment. This includes referring to the load based licencing data (i.e. annual returns information back to 2001) published on the EPA Licence Public Register.

From the background investigations undertaken (by MHL in the 'Discharge Impact Assessment' report, 2022) the modelling of the catchment and process treatment scenarios, and from the development of the detailed design for both the proposed Bowral STP Upgrade and the proposed Moss Vale STP Upgrade, there is now a greater understanding of the past and present water quality in these catchments and appropriate EPL conditions.

Based on the comparisons undertaken in the Moss Vale STP Detailed Design Report (HunterH_2O,2022) and other supporting documentation, including the Moss Vale DIA; WSC elected to proceed with the FSB Option. This design option was preferred over the IDEA type plant, as it is more able to meet the expected required future 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 (20,000EP) to the EPA (WSC, 27 January 2023), 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 4-1 and Table 4-3, respectively.

The suggested licence concentration limits for the proposed upgraded Moss Vale STP (to 20,000 EP) are considered a fair and reasonable outcome for a contemporary 'good practice' plant for a regional council in such a catchment and environment. 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 2008 catchment report (PWA, 2008), current licence loads and 2021 annual return loads are summarised below in Table 4-2. It is suggested that the new loads are rounded from these figures where practical for the new EPL.

Table 4-1 Suggested new EPL Licence Concentration Limits for 20,000EP Upgrade

Pollutant	Unit of Measure	90%ile	100%ile
Ammonia	mg/L	2	
BOD	mg/L	10	
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 4-2 Average effluent discharge loads from the 2008 catchment report, current licence loads and 2021 annual return loads

Source	Nitrogen (kg)	Phosphorus (kg)	BOD (kg)	Total Suspended Solids (kg)
Current Licence loads	6,619	414	8,274	12,411
2021 annual return loads #	6,863	267	1,344	7,897
Annual return reported loads April 2007 #	8,121	263	-	3,116
2008 catchment report loads	6,815	166	2,026	3,776

 # Noting that 2007 and 2021 were considered wet years

Table 4-3 Suggested new EPL Effluent Discharge Licence Load Limits for 20,000EP Upgrade

Source	Nitrogen (kg)	Phosphorus (kg)	BOD (kg)	Total Suspended Solids (kg)
50 percentile load and flow	8,500(1)	350(2)	3,500(3)	5,000(4)

(1) At approx. 5 mg/L at full load
(2) At 0.2 mg/L at full load
(3) At the 2 mg/L detection limit at full load
(4) At approx. 3 mg/L at full load (considered reasonable performance for dual media filters)

4.2 Description of the Proposed Works

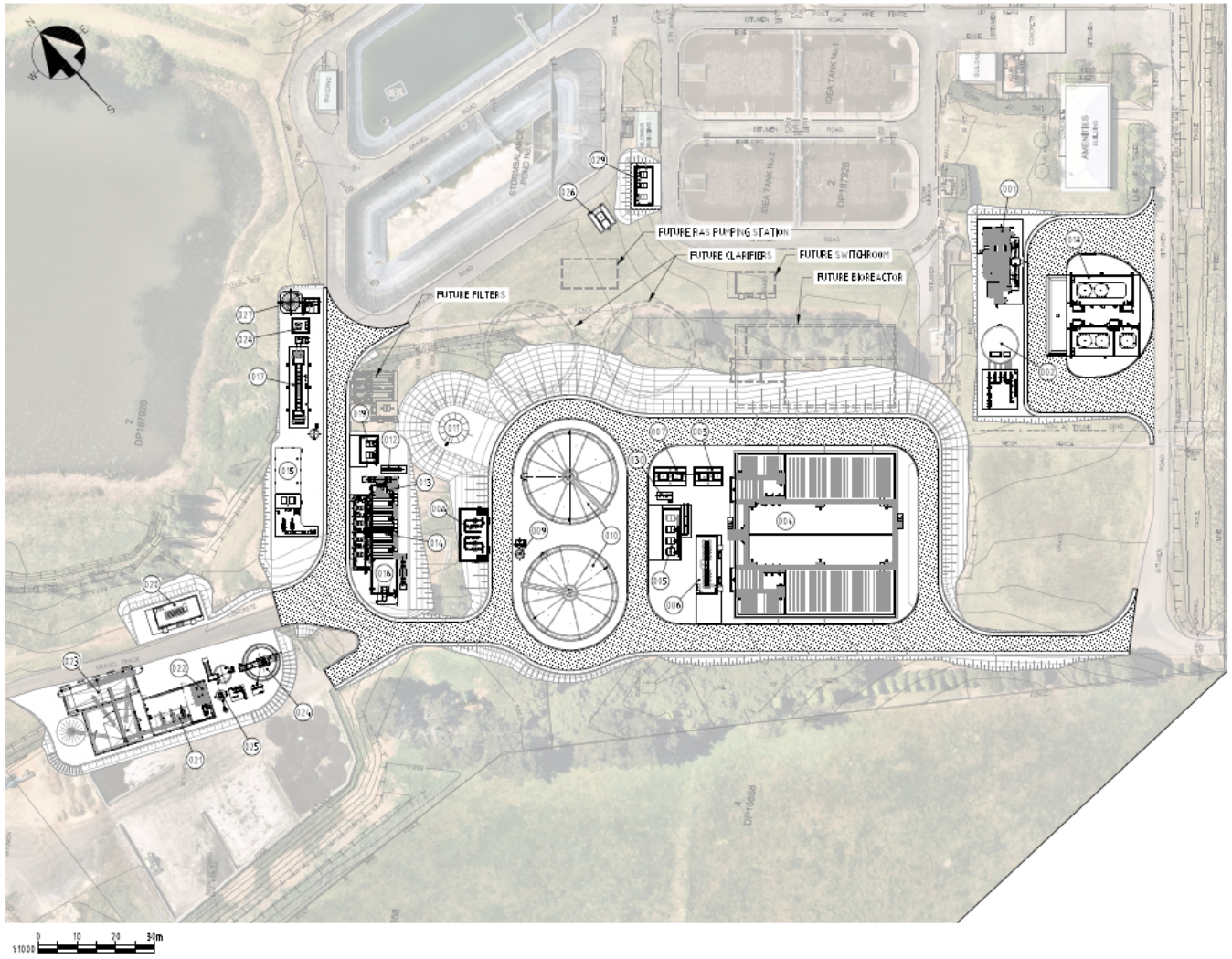
The proposed (Stage 1) upgrade works at the Moss Vale STP would include the following:

- A new inlet works and new lift pump station
- New storm detention ponds (converted from the existing catch/balance ponds)
- A new bioreactor splitter box
- Two new bioreactors designed as FSB (able to be operated as Modified Ludzack-Ettinger (MLE).
- A new bioreactor aeration supply system
- Two new secondary clarifiers each sized for up to 3 ADWF (FSB mode)
- Two RAS pumps in duty/standby configuration
- A new scum pump station
- A new filter feed control 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 (WAS) 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
- A new carbon storage and dosing system
- Site provision for future recycled water treatment system (for on-site use only).
- Site provision for future tertiary clarifiers for trimming effluent TP if needed at ultimate design.
- Site provision for a moving bed biological reactor for trimming TN if needed at ultimate design.

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 G.



STRUCTURE LIST	
ITEM NUMBER	DESCRIPTION
001	INLET WORKS
002	LIFT PUMPING STATION
003	BIOREACTOR FEED SPLITTER
004	BIOREACTOR
005	BIOREACTOR BLOWER ROOM
006	BIOREACTOR SWITCH ROOM
007	CLARIFIER FEED SPLITTER
008	RETURN ACTIVATED SLUDGE (RAS) PUMPING STATION
009	SCUM PUMPING STATION
010	CLARIFIERS
011	FILTER FEED CONTROL STATION
012	FILTER FEED FLOW METER
013	FLOCCULATION TANK
014	TERTIARY FILTERS
015	CLEARWATER BACK WASH TANK
016	DIRTY BACK WASH TANK
017	UV CHANNEL
018	CHEMICAL STORAGE BUNDS
019	AIR SCOUR BLOWER BUILDING
020	TERTIARY TREATMENT & DEWATERING SWITCHROOM
021	DEWATERING BUILDING
022	POLYMER DOSING AREA
023	SLUDGE OUTLOADING FACILITY
024	THICKENER AND TWAS PUMP
025	FOUL WATER PUMPING STATION
026	STORM SPLITTER
027	RE PUMPING STATION
028	SODIUM HYPOCHLORITE DOSING
029	DIGESTER BLOWER BUILDING
030	WAS PUMPING STATION

Figure 4.1: Moss Vale STP Proposed Upgrade Layout Stages (refer to Appendix B for annotations)

Source: Hunter H_2O, 2021

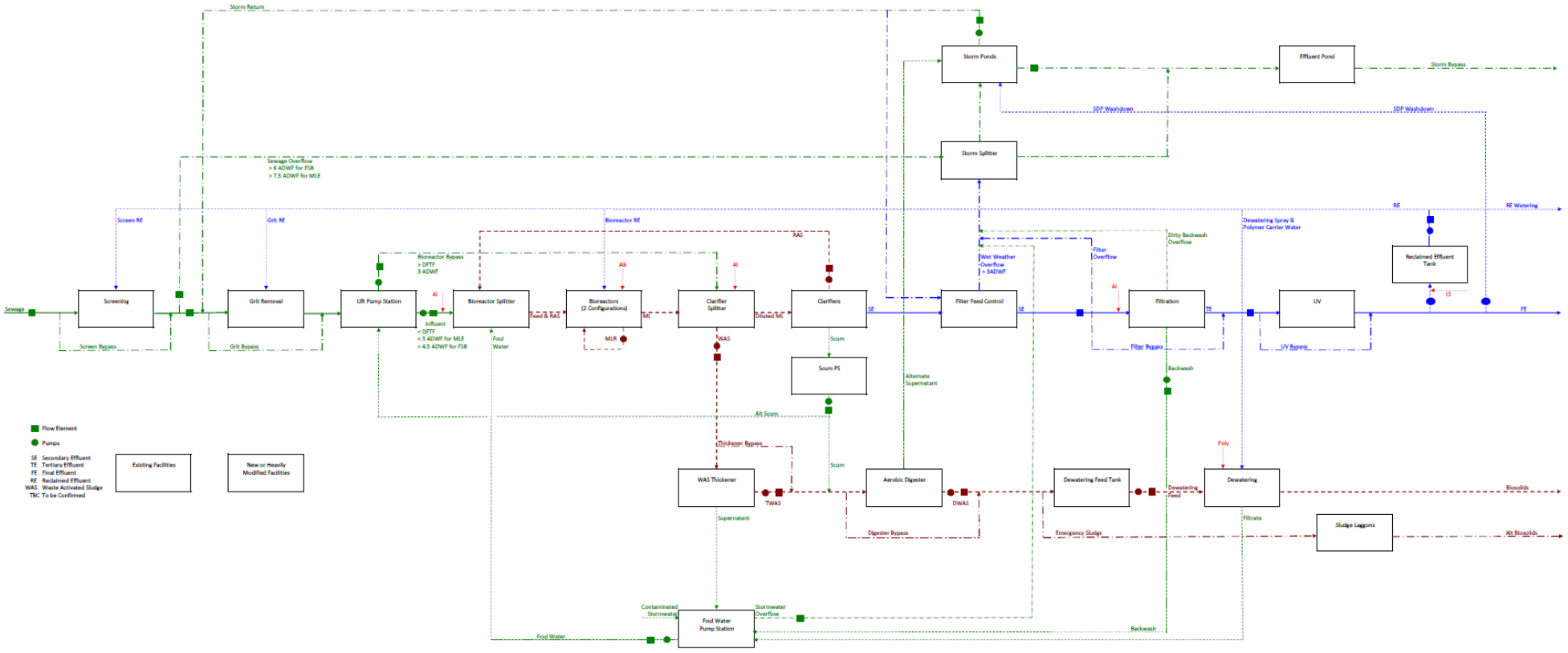


Figure 4.2: Moss Vale STP Proposed Process Flow Diagram

Source: Hunter H_2O, 2023



Figure 4.3 Aerial view of the existing Moss Vale STP site

Source: Nearmap, 2023

4.2.1 Inlet Works

A new inlet works is proposed and would be sized for the equivalent PWWF at 20,000 EP.

The proposed inlet works would include:

- Sewage flow monitoring.
- Two mechanical band screens (duty/duty) each sized for 17 ADWF.
- A bypass channel fitted with a manual screen sized for 10 ADWF.
- Appropriate screen washing and dewatering.
- Screened sewage flow monitoring.
- An overflow to the new storm detention ponds for flows above 7.5 ADWF.
- A single vortex style grit tank sized for 6 ADWF.
- A grit sparge and extraction system (pumped).
- A single fluidised bed classifier for grit washing and dewatering.

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 and Return System

There would be two storm ponds (being the conversion of the existing catch/balance ponds). These can be used to accept screened sewage from the inlet works in excess of Design Storm Treatment Flow (DSTF), or secondary effluent from the filter feed control system in excess of Design Full Treatment Flow (DFTF), or both.

Screened sewage in excess of DSTF overflows a weir in the screened sewage channel of the inlet works and gravitates to the storm splitter. 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 control system, etc).

The converted catch ponds provide over a day's 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).

New storm detention ponds consist of;

- A new storm splitter box allowing the ponds to store overflow sewage or secondary effluent separately or combined, or to allow the ponds to be bypassed to the effluent pond.
- Isolation of the existing overflow from pond A to pond B.
- Isolation of the existing floating weir connection to the decommissioned UV system.
- Retention of the existing overflow weirs and pipes to the existing effluent pond.
- New storm return pumps (one per pond) each sized for 1.5 ADWF.
- New rising mains to the screened sewage channel or filter feed control system.

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:

- 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 with provision for a third bioreactor.
- A Mixed Liquor (ML) splitter accepting ML from the two bioreactors and splitting it to the two clarifiers with provision for four 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.
- A return activated sludge (RAS) splitter accepting flows from the two RAS pump stations (four at ultimate) and splitting it to the two bioreactors (three at ultimate). This mixes with the feed before gravitating to each bioreactor.
- An emergency overflow (alarmed) of 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 FSB (MLE) Bioreactors and aeration system

Two (2) new bioreactors would be installed, designed as FSB but also 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.
- A 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.
- A 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.

The upgraded STP would initially operate under MLE configuration and later operate as an FSB plant. The FSB operational mode would be delayed until it is necessary to achieve NorBe / plant licence limits as there is marginal improvement in nitrogen removal when operating in FSB without sugar dosing. Deferring sugar dosing for as long as practical would assist in the sustainability of the communities investment in the upgraded STP. Furthermore, Operating in FSB mode reduces the hydraulic capacity of the bioreactor – without the improved performance from sugar dosing, the MLE configuration is preferred as it minimises flows to the storm storages (Extract. *Response to EPA comments received on 6th March 2023* .WSC, April 2923).

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 Control System

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 control system (FFCS). Emergency storage return flows could also be pumped directly to the FFCS as an option.

The new filter feed control system would include:

- Secondary effluent pipes from each clarifier.
- A balance tank sized for ultimate.
- A filter feed control valve and flow element controlling the gravity flow to the filters.
- An overflow from the filter feed control system to the storm ponds.
- An optional return pipe from the storm ponds.

4.2.9 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 gravity main from the filter feed control system.
- A new feed splitter including a filter bypass weir and pre flocculation tanks. The filter bypass can be directed to the storm ponds or the UV facility.
- An alum dosing point to the flocculation tank.
- Four deep bed, dual media filter cells.
- An air scour system including duty/standby blowers.
- A clean backwash tank and duty/standby pumps.
- A dirty backwash tank and duty/standby pumps.
- An overflow from the dirty backwash tank to the storm ponds.
- A new dirty backwash rising main from the dirty backwash tank to the FWPS.

4.2.10 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 storm ponds 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 E-Coli licence limits and assist in the disinfection of reclaimed effluent (RE) used around the STP.

A new UV disinfection system will 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.

4.2.11 Effluent Reuse System

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

- New RE lift pump (duty only) to downstream of the new UV system.
- A new 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). This system will be replaced with a larger system at Ultimate.
- A chlorine dosing point to the RE tank feed line.

Treated effluent would be utilised on-site at the STP for a number of purposes including:

- 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 storm ponds after they empty.

4.2.12 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.
- Provision for two future digester loading control valves, to switch loading between the two digesters.

4.2.13 Aerobic Digester

One of the existing IDEA bioreactors 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.
- New submerged baffle walls dividing the digester into three cells.
- Replacement removable aeration diffusers and control valves. The control valves switch aeration between the first cell and the last two cells (in parallel), as well as modulating to control DO.
- 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 storm ponds via existing pipework. From there is can be returned to the head of works via the storm return pumps.
- Retention of existing instrumentation plus an additional DO element.
- 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 last digester cell is aerating.

4.2.14 Sludge Dewatering Facility

The sludge dewatering facility would dewater biosolids to reduce transport and disposal costs and convey biosolids to an out loading system. It will consist of a new mechanical dewatering facility featuring 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, sized for ultimate, complete with mixer/aerator
- A polymer make-up, storage, dosing and dilution system. Two dosing pumps in duty/duty configuration (duty/standby initially), with provision for a third at Ultimate.
- Two dewatering feed pumps in duty/duty configuration (duty/standby initially), with the provision for a third at Ultimate.
- A polymer dosing point to each feed line.
- Two screw press dewatering units in duty/duty configuration (duty only initially), with provision for a third at Ultimate.
- A filtrate collection system delivering filtrate to the FWPS.
- A duty only, horizontal, biosolids cross-conveyor, designed for Ultimate.
- A slewing, inclined biosolids conveyor delivering biosolids to a truck trailer, designed for Ultimate.
- A building including acoustic insulation and ventilation.
- A bunded truck trailer hard stand.
- An awning over the truck trailer hard stand.

4.2.15 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 storm ponds.

4.2.16 Alkalinity Storage and Dosing System

A new alkalinity 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 new alkalinity storage and dosing system would be installed, including:

- Two new alkalinity storage tanks (with provision for a third at Ultimate), cross connected and used for alkalinity storage (based on 25% sodium hydroxide).

- Two new alkalinity dosing pumps (duty/duty) with provision for a third at Ultimate, one dosing to the primary aerobic zone of each bioreactor.
- New unloading and bunded storage areas.

4.2.17 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 (with provision for a third at Ultimate).
- Two new (duty/standby) alum dosing pumps to dose to the bioreactor feed splitter (via the influent rising main), sized for Ultimate.
- Two new (duty/standby) alum dosing pumps dosing to the ML splitter box (via the common ML gravity main) or the filter feed, sized for Ultimate.
- New unloading and bunded storage areas (combined with alkalinity dosing)

4.2.18 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:

- A duty only storage tank, manually filled from intermediate bulk containers (IBC).
- A new chlorine dosing pump (duty only), dosing to the feed to the existing RE storage tank.

4.2.19 Carbon Storage and Dosing System

A new carbon storage and dosing system is required to store chemicals used for enhanced denitrification, to accept chemical deliveries and to dose carbon to the bioreactors to trim nitrogen from the effluent when required.
The new carbon storage and dosing system (sized for sucrose solution) would consist of:

- One new carbon storage tank.
- Two new (duty/duty) carbon dosing pumps (with provision for a third at Ultimate) to dose to each bioreactor primary anoxic zone (MLE) or secondary anoxic zone (FSB).
- A hot water cleaning system with duty only booster pump and residential hot water service.
- New unloading and bunded storage areas.

4.2.20 Electrical Systems

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 substation is currently being designed. However, a new 1000kVA pad mount substation is recommended to meet the increased demand, allow for future loads, and provide an additional 10% spare capacity.

The upgraded electrical system will include a new main switchroom, new tertiary treatment switchroom and Inlet/digesters switchroom. New switchboards and Plants Programmable Logic (PLC) panels will be installed in each switchroom as well as a new remote I/O panels in the filter blower room. The design will include new PLCs, remote I/O, SCADA system, as well as all other instruments and electrical equipment required to supply and distribute power and monitor and control the new plant.

The new main switchroom is required as there is insufficient space and capacity in the existing amenities building main switchroom, and its location is not suited for the supply of the new equipment required for the upgrade, hence the upgrade of the power supply is required and will include:

- A new main switchroom SWRM-1001 and main switchboard MCC-1001 located in the bioreactor area. The main switchboard will be provided with a 'generator manual transfer' switch.
- A new tertiary treatment switchroom SWRM-2001 and switchboard MCC-2001 located near the sludge outloading facility, as well as a new LV supply cable from MCC-1001.
- A new inlet/digesters switchroom SWRM-3001 and switchboard MCC-3001 located between the digesters and existing amenities building, as well as a new LV supply cable from MCC-1001.
- A new LV supply cable from MCC-3001 to the existing amenities building.
- An upgraded Endeavour Energy power supply in accordance with the ASP3 certified design including:
    - A new 1000kVA pad mount substation installed adjacent to the new main switchroom.
    - Replacement of existing HV power pole 3K1662 (near the existing amenities building) with a new pole and underground to overhead cable.
    - A new HV underground cable will run from pole 3K1662 to the new substation via the south-eastern and south-western boundaries of the site, following the site access roadways, and including road crossing under the access road at the site southern corner.
    - Decommissioning of the existing HV power supply and 400kVA transformer at completion of cutover to the new system.

4.2.21 Control Network and Communications

The Moss Vale STP control system architecture will use an Ethernet network topology. There are three plant PLCs. 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 servers would be used for the site. ClearSCADA rack mounted servers will be installed in the main switchroom and administration building communication panels. These 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 and switchrooms to provide the operator interface to the plant control system.

4.3 Construction Issues

4.3.1 Construction Methodology

The exact construction methodology is unknown at this stage and would be determined by the successful contractor. A proposed preliminary 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 *Moss Vale STP Upgrade Detailed Design Report* prepared by HunterH_2O (2022) 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 G). 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 – Construct new treatment infrastructure
3. Phase 3 – Pre Commission new infrastructure
4. Phase 4 – Cutover to new treatment processes
5. Phase 5 – Decommission redundant assets
6. Phase 6 – Augment and/or retrofit retained infrastructure
7. Phase 7 – Finalise earthworks, roads, drainage, landscaping etc.
8. Phase 8 – 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 to maintain sewage service and treatment requirements, 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 (but not limited to) the following:

- Truck mounted auger
- Air compressor
- Excavator / Rock breaker
- Concrete agitators and pumps
- Rollers
- Backhoe
- Pumps for dewatering (e.g. pumps, filters)
- Crane
- Water trucks
- 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; and
- 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 Moss Vale 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 Moss Vale 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 2011* and the *Work Health and Safety Regulation 2017*.

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 the new 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 the 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 Proposal. 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:

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

5.2 Location and Land Use

Moss Vale STP is located in the suburb of Moss Vale in the Southern Highlands of NSW, approximately 122 km south-west of Sydney. The STP site is located off Kennedy Close within Lots 1 and 2 DP 187926.

The existing STP site is located on cleared and disturbed land on the southern bank of Whites Creek (see Figure 1.2). The STP site is fenced. Surrounding land to the east and north is generally zoned for rural uses while land to the south is zoned for environmental management. Land zoned for public recreation and the residential areas of Moss Vale are located to the east of the STP site.



Figure 5.1 Moss Vale STP Locality Map

Source: Nearmap, March 2023

5.2.1 Construction Impacts

The construction works may result in some minor disruptions to the community, especially other users of Kennedy Close and the residential areas to the east and north-east of the site. Whilst impacts to the general amenity would be expected over the 18 month construction program for the works, these are not predicted to adversely affect surrounding land use. Potential noise, traffic and dust impacts are discussed further in Sections 5.3, 5.4 and 5.5 below. The construction of the works would be designed to avoid interruptions to the delivery of sewage services.

Overall, as the proposed upgrade works would be located entirely within the STP site, no significant impacts to land use within adjoining properties are anticipated during construction works.

It is considered that a long term positive impact to the community through improved sewage management and treatment services would outweigh the temporary construction impacts. 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 the current land use and zoning (SP2 Infrastructure) of the site.

During the operation of the upgraded STP, minimal impacts to surrounding land uses are anticipated, with any impacts likely to be similar to those from the existing STP operations. The predicted noise and odour impacts associated with the increased STP capacity are discussed in Sections 5.3 and 5.5 below.

The Proposal would result in a positive, long term benefit to the local community through improved sewage management and treatment services to meet projected future population growth in the region and provide increased opportunities for development of the surrounding land.

5.2.3 Mitigation Measures

Construction

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

Operation

- An OEMP for the upgraded Moss Vale 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 receptor is a residential property located at 4 Morrice Court, within the residential area of Moss Vale, approximately 60 m to the north-east of STP property boundary, along the northern bank of Whites Creek (see Figure 1.3).

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 receptor 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. It is not anticipated that construction works would be required outside of standard working hours.

Noise impacts were estimated based on the *Interim Construction Noise Guideline* and *AS 2436 – 2010 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 60 m and 100 m from the source are also shown in Table 5-1. The maximum predicted noise levels at the property boundary of the closest residence located 60 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 60 m	Sound Pressure Level dB at 100m
Hand tools (electric)	102	55	51
Excavator	107	60	56
Backhoe	104	57	53
Air compressor	101	54	50
Dump truck	117	70	66
Crane (mobile)	104	57	53
Concrete agitator truck	109	62	57
Light commercial vehicle	78	59	27
Rock breaker	118	71	67
Generator	99	52	48
Vibratory roller	108	61	57

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 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 namely the aeration blowers associated with the new FSB/MLE plant (bioreactors) and various pumps. No formal operational noise assessment was undertaken as part of the REF.

The *Noise Policy for Industry (NPfI)* (EPA, 2017) 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 and implementation 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 both intrusive noise is limited and amenity is protected and 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. 60 m to the north east)	Day (7am – 6pm)	45	50	50
	Evening (6pm – 10pm)	40	45	45
	Night (10pm – 7am)	40	40	40

The upgraded STP would generate some additional noise compared to the existing STP. This is a result of the additional drives and processes required.

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 5 dB. Noise generating components such as blowers would be housed within acoustically designed enclosures or buildings, and the plant layout and screening would be designed to mitigate operational noise emissions.

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, 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 Measures

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; and 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 *Noise Policy for Industry* (Npfl) 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

Moss Vale has a moderate population and moderate traffic volumes, with Argyle Street being the main road through the township. The STP is accessed via Willow Drive, Kennedy Close and a private road which traverses a privately owned paddock, with the latter used mainly by STP operators and the owners of the paddock. Traffic on Kennedy Close and Willow Drive is expected to be limited to those vehicles accessing the STP and the residents within the local area and is therefore anticipated to have low traffic volumes travelling at low to moderate speeds. Currently livestock enter the STP 'right of way' access road outside normal controlled movements between paddocks.

5.4.1 Construction Impacts

Increased heavy vehicle traffic levels are expected during the construction works, particularly during the early stages of construction works as fill material may be required to be imported onto the site. Construction vehicles and staff would enter the STP site via Willow Drive and Kennedy Close and the sealed STP site 'right of way' access road. The STP 'right of way' access road would be fenced for the duration of construction works in order to protect livestock from construction traffic.

The construction workforce would vary according to the work being carried out, the construction method and contractor's program. Indicative average numbers during

construction would be in the order of 15 – 50 employees (based on the construction of a similar sized STP).

It is estimated that the construction works would involve an average of 20 (30t) truck deliveries per day over 8 weeks during fill delivery if imported from offsite (anticipated to sourced be from the Bowral STP site or alternately won from an onsite location) and approximately 6 truck deliveries plus additional traffic associated with construction employees during the remainder of the construction period. Additional particular short duration construction operations may require more frequent heavy vehicle movements (e.g. concreting operations), which would require deliveries of large quantities of materials in addition to 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 including a plan for delivery of the imported fill material. The TMP would be developed in accordance with the *TfNSW's Traffic Control at Work Sites Manual, Issued February 2022,* 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 using Kennedy Close and Willow Drive and owners of the farmland (paddocks) adjoining the two-way STP site access road. 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 site access road, Kennedy Close and Willow Drive in the vicinity of the STP should be assessed prior to construction, including the provision of any erosion and sedimentation controls, to withstanding the anticipated heavy vehicle movements during construction.

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 trucks removing dewatered sludge (from the treatment process). 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 Measures

Construction

- Prior to the commencement of works, existing access tracks, road and culverts that would be used by heavy vehicles would be assessed for adequacy and upgrade 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 nearby waterways.

- Prior to the commencement of works, the contractor would prepare a dilapidation report for Kennedy Close and Willow Drive and the STP 'right of way' access road to identify areas of existing damage and the right of way should be fenced for the duration of construction works.
- The contractor would prepare a Traffic Management Plan as part of the CEMP, including a specific plan for delivery of imported fill material, to be reviewed by WSC prior to commencement of works. The Traffic Management Plan would include measures to minimise traffic impacts ensure public safety and would be prepared in accordance with:
    - *TfNSW's Traffic Control at Work Sites Manual, Issued February 2022, and*
    - *Australian Standard 1742.3 - 2009 Traffic Control for Works on Roads.*
- Any disturbance to landowners due to vehicle movements and associated noise would be minimised by adhering to the working hours outlined in Section 5.3.3.
- The contractor would ensure access to properties are not impacted (and/or managed).
- 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 *Moss Vale Sewage Treatment Plant Upgrade Odour Impact Assessment* (SLR, 2022). A copy of the assessment is provided in Appendix H.

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 6.3 km east of the Moss Vale STP. Long term wind data (2001 – 2021) recorded by the Moss Vale AWS are presented as wind roses in Figure 5.2Figure 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% of the time over the 20-year period reviewed. The seasonal wind roses show that typically:

- In summer, winds predominantly blow from the northeast and southeast quadrants with a very low frequency of winds from the northwest and southwest quadrants. On average, calm winds are experienced 3.1% 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 9.1% 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 7.4% of the time during winter.
- In spring, winds predominantly blow from the west and northeast quadrants. On average, calm winds were experienced 4.4% of the time during spring.

Only two odour complaints relating to the operation of the existing Moss Vale STP have been received since 2017. This indicates that the existing operations at the STP are generally performing well in relation to odour emissions.

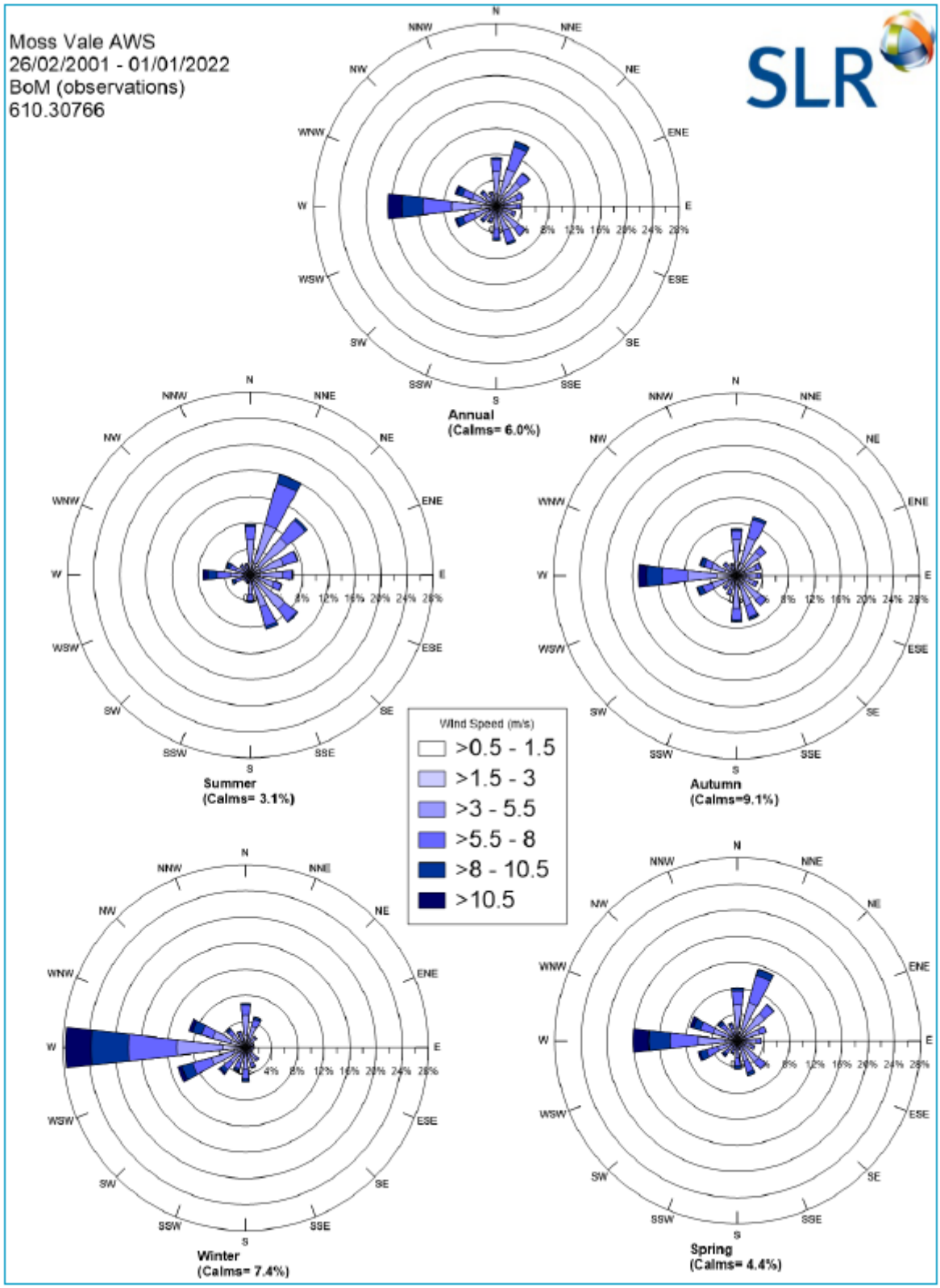


Figure 5.2 Rose of Wind Direction Vs Wind Speed for Moss Vale AWS (2001 -2021)

Source: SLR, May 2022

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 Moss Vale STP include:

- Inlet works
- Lift pump station
- Stormwater detention ponds
- Aerobic Digester
- Bioreactor and splitter
- Clarifiers and feed splitter
- Sludge drying beds
- Dewatering building
- Thickener & TWAS Pump
- Sludge outloading 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 SLR OIA modelling indicates that the overall emissions from the existing STP operations has a Raw Odour Emission Rate (OER) of 5,452 odour units (ou).m^3/s and post upgrade the STP's operational Raw OER would be reduced to 3,410 ou.m^3/s.

Figure 5.3 illustrates the location of the surrounding sensitive receptors in relation to the Moss Vale STP. Predicted concentrations of odour were assessed at each of these receptors, for the operational scenarios modelled.

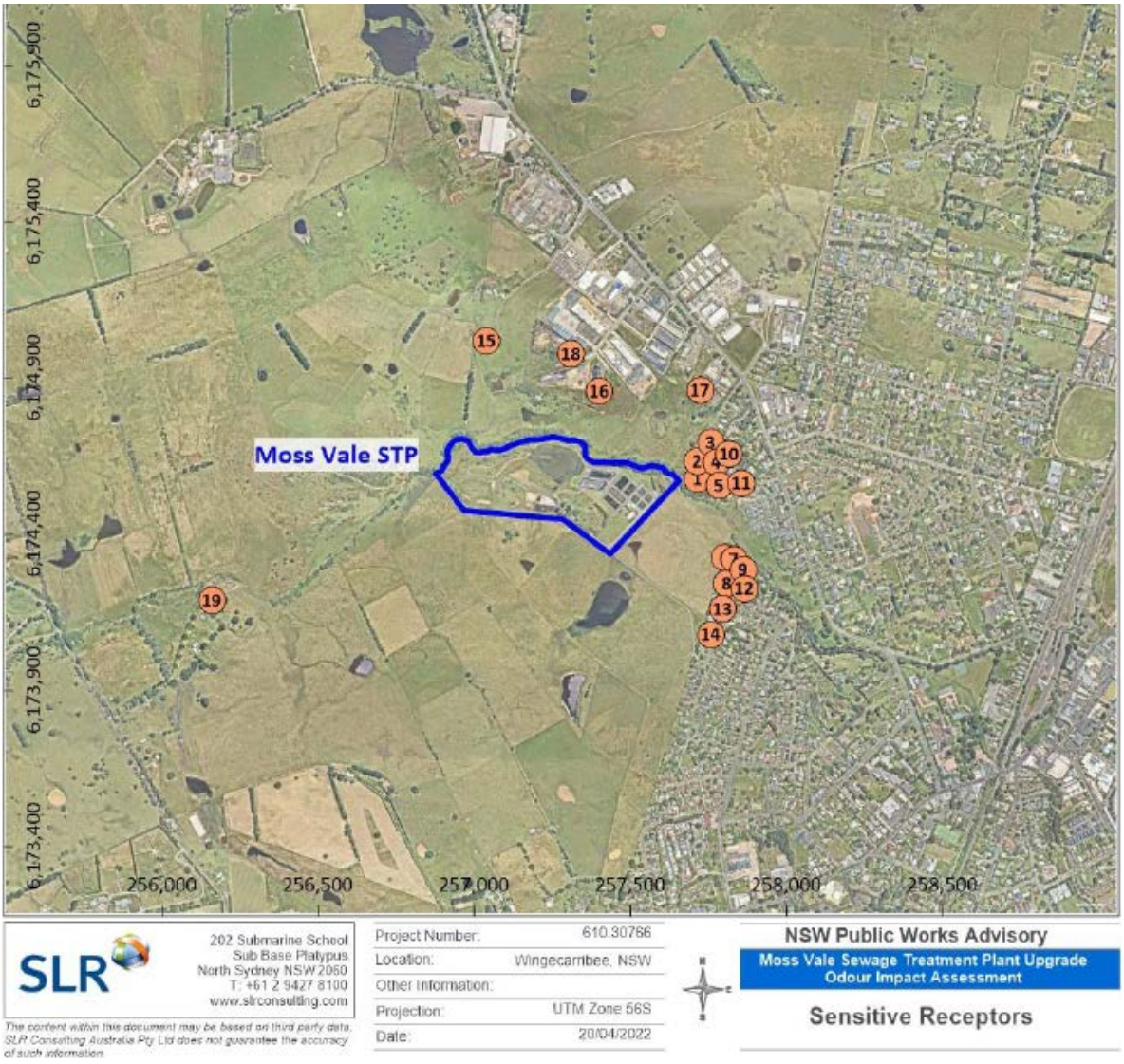


Figure 5.3 Location of Identified Sensitive Receptors

Source: SLR, 2022

As illustrated in Figure 5.4, the area predicted to be affected by the existing and proposed operations at the Moss Vale STP (i.e. the area within the 2 ou contour line) is 0.39 km^2 and 0.28 km^2 respectively. It is noted that as a conservative measure, these areas include the area occupied by the Moss Vale STP (approximately 0.16 km^2) as well as areas to the north and northeast of the Moss Vale STP where residential development is constrained due to flooding impacts. Dispersion modelling was performed to predict worst-case impacts associated with the existing and proposed operations at the Moss Vale STP.

Based on 2016 ABS Census data, it is estimated that a population of approximately 16 people may be affected by the cumulative emissions from the existing operations at the Moss Vale

STP. It is predicted that the affected population would decrease to three 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 operations; and
- 6 ou for the assessment of odour impacts due to proposed STP upgrade operations.

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

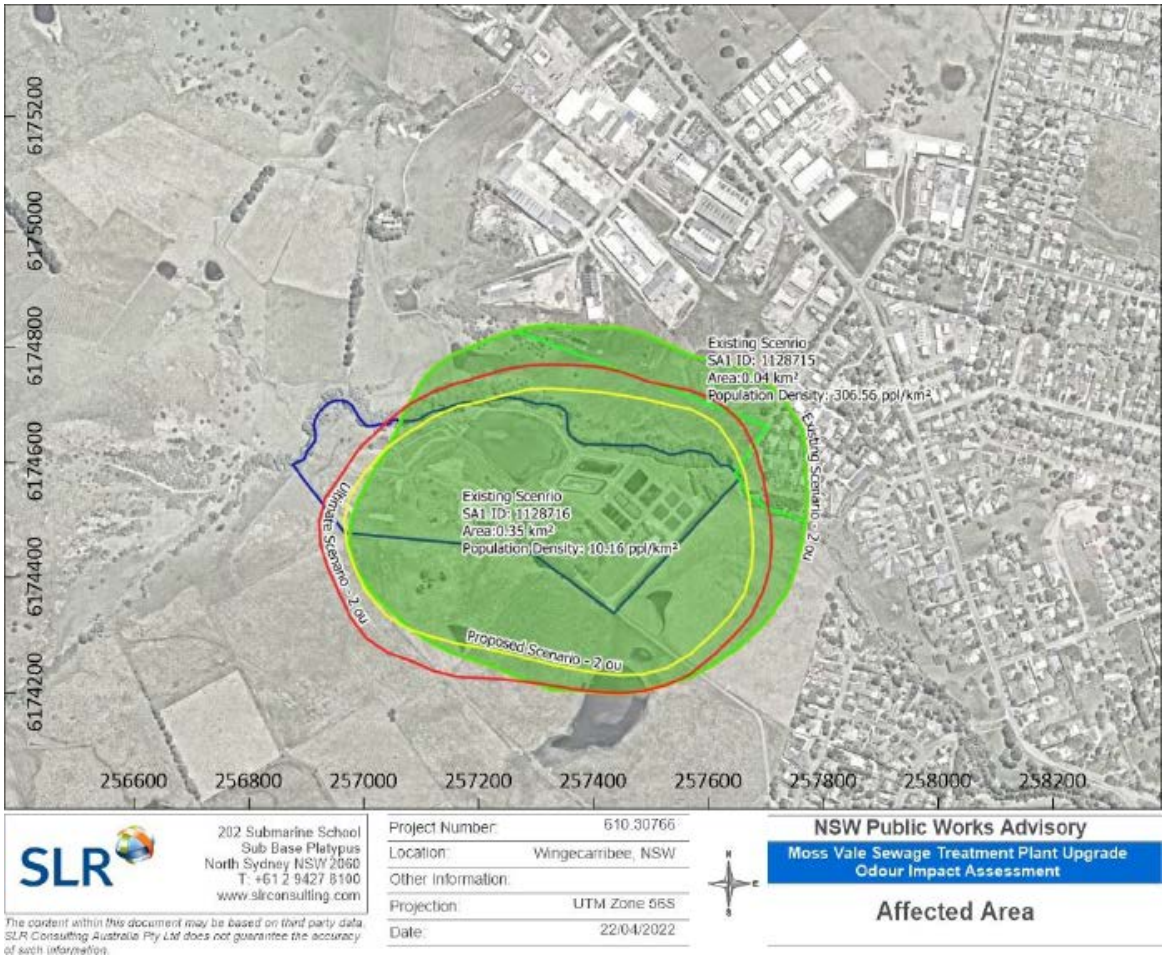


Figure 5.4 Affected area for Odour Modelling (atmospheric dispersion modelling)

Source: SLR, 2022

Atmospheric dispersion modelling was undertaken to predict worst-case odour impacts associated with the existing and upgraded Moss Vale STP operations as well as the Southern Regional Livestock Exchange (SRLX) saleyards.

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 operations as compared to existing normal operations. The results indicate that after the upgrade, the predicted 99th percentile odour concentrations, which range between 0.2 ou and 1.7 ou, would be well below the adopted criterion of 6 ou at all of the discrete receptors modelled for the modelled proposed and ultimate scenarios.

The predicted 1-hour average 99th percentile (nose response time) odour concentrations for the existing and proposed normal STP operations are shown as contour plots in Figure 5.5 and Figure 5.6**,** 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 after the proposed STP upgrade indicates that odour concentrations are predicted to decrease by an average of 45 % across the sensitive receptors. The total odour emissions from the proposed operations is estimated to be 3,410 ou.m^3/s which is approximately 37 % lower than the emissions estimated for the existing operations.

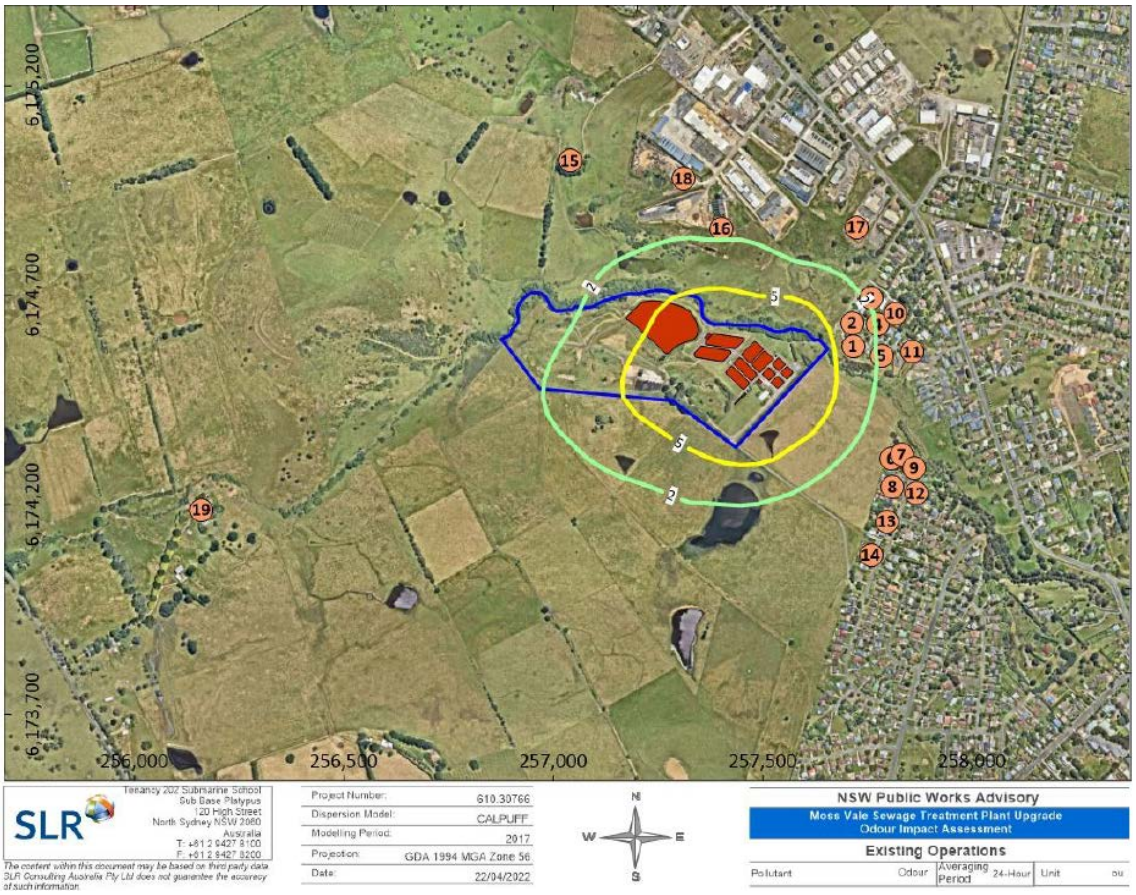


Figure 5.5 Predicted 99th Percentile (Nose Response Time) Odour Concentrations (ou) – Existing Normal Operations

Source: SLR, 2022

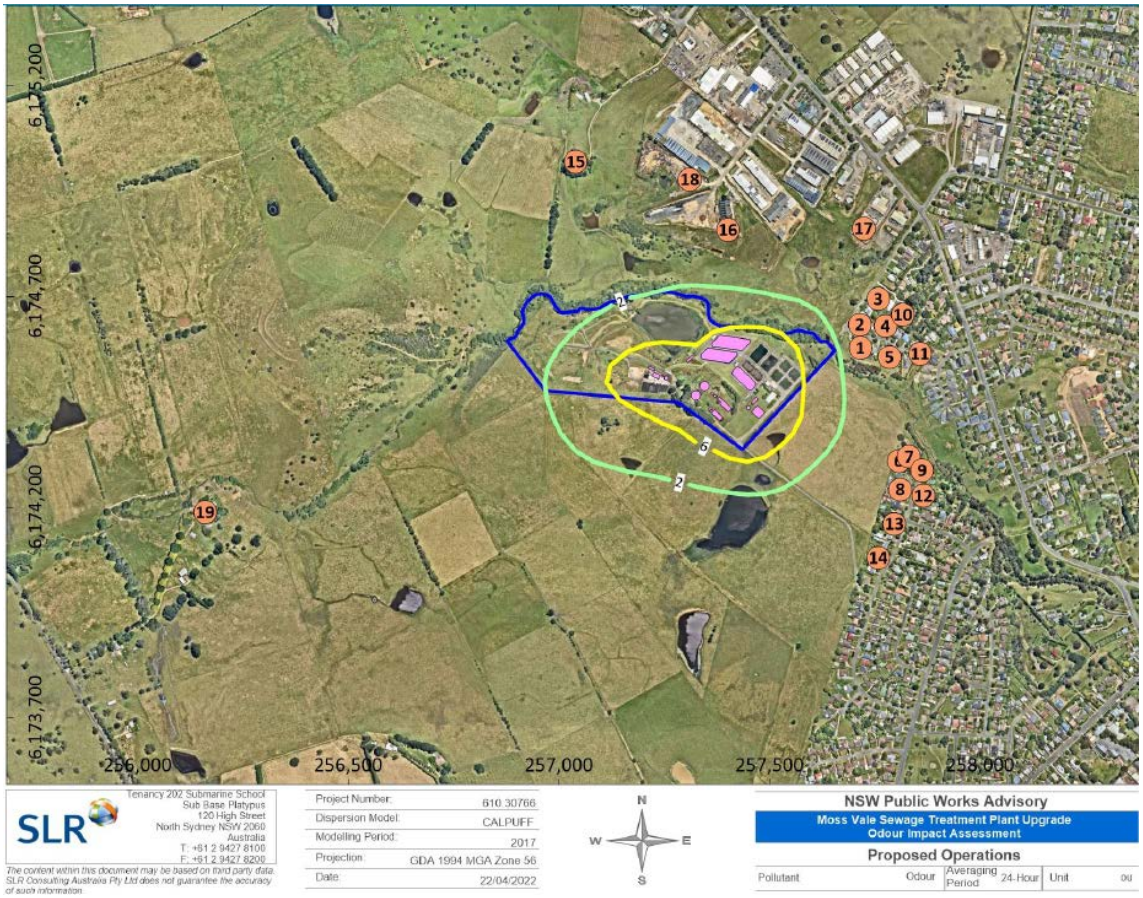


Figure 5.6 Predicted 99th Percentile (Nose Response Time) Odour Concentrations (ou) – Proposed Operations

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 proposed STP upgrade 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 but the predicted concentration at all sensitive receptors would be below 2.0 ou.

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

- The modelling of odour emissions from all identified sources associated with the existing and upgraded operations at the Moss Vale STP showed that predicted 99th percentile odour concentrations at all nearby sensitive receptors would be below the adopted odour impact criterion of 6 ou (nose response time) as a result of the upgrade. According to the modelling predictions, the proposed upgrade will result in a 45% decrease (compared to

the existing operations) in the 99th percentile odour concentrations at the nearby sensitive receptors for proposed STP operations.

- The proposed STP design 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. However, the predicted concentration at all sensitive receptors is below 2.0 ou.
- Given the proposed capacity of the STP and site limitations, emissions from all sources may need to be captured and treated before discharge to the atmosphere in order to achieve the 2.0 ou odour design criterion at the boundary of the SP2 lot.

Full 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.

Full compliance with the odour design criterion recommended by the draft DoP Odour Guideline would most likely involve enclosure of significant areas of the STP, which is not considered to be feasible by the design team. However, given that the 99$_{th}$ percentile odour concentration is predicted to be well below the adopted odour impact criterion of 6.0 ou (designed to preserve amenity in communities neighbouring odour-emitting activities) at the worst impacted sensitive receptor (1.7 ou), ongoing odour issues at the surrounding residential dwellings are highly unlikely. Furthermore, as odour concentrations at the nearby sensitive receptors are predicted to decrease as a result of the upgrade, a decrease in any existing odour issues associated with the current STP operations is expected.

To further reduce the potential for odour emissions, it is recommended that management measures including an Odour Management Plan, good neighbour procedures and a complaints register be adopted in line with the recommendations of the DoP Odour Guideline.

The OIA odour emissions results 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.

5.5.3 Mitigation Measures

Construction

- Construction vehicles and equipment would be suitably serviced within the six-month period prior to commencement of construction activities and all necessary maintenance undertaken during the construction period to meet EPA air quality requirements.
- 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

- 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.
- An Odour Management Plan (OMP) should be adopted for the Moss Vale 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 should adopt 'good neighbour' procedures and complaints register in line with the recommendations of the DoP Odour Guideline.
- 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 *Moss Vale Sewerage Sewage Treatment Plant Geotechnical Investigation* (D & N Geotechnical, 2021), which was undertaken to assess the subsurface conditions at the proposed site of the new STP infrastructure to support design and construction of the STP upgrade.

Topography

Regionally the site topography comprises gently undulating hillsides. The site is located with locally lower lying terrain (when compared with the surrounding topography), associated with the southern bank of Whites Creek, which forms the northern site extent, and flows towards to the west.

The site has been formed through modification to the existing Whites Creek alignment and construction of several lagoons of varying geometry, constructed through excavation and cut to fill on the southern and northern creek banks.

The overall site surface across the STP area is generally flat, with a slight reduction in surface elevation of about 1 to 2 m across the general site footprint. Our investigation included assessment of subsurface conditions within a local depression associated with former use as a pond area, which appears to have been partially backfilled.

Geology and Soils

Regional geological mapping indicates that the site is underlain by Quaternary Residual Deposits, associated with weathering of the parent geology, described as comprising *"unconsolidated clayey SAND (fine to coarse grained), to weakly consolidated sandy CLAY layers, poor to extensive soil development*".

The underlying solid geology is expected to comprise of Bringelly Shale of the Tertiary aged Wianamatta Group, described as light to dark grey, sideritic claystone to siltstone, dark grey carboniferous claystone, sandstone to siltstone, and quartz lithic, very fine to medium grained sandstone. This unit is shown to represent the surface geology beyond the northern and southern site extents.

The subsurface profiles encountered in the borehole investigations at the Moss Vale STP site are described in terms of distinct geological units. Table 5-4 below provides a summary of the main geotechnical units observed across the STP site.

Table 5-4: Summary of the Main Geotechnical Units at the Moss Vale STP

Unit[1]		Material Origin	Material Description	Depth Range to Top of Unit (m)[2]	Range of Unit Thickness (m)[2]
1		Topsoil/Fill	Sandy/silty CLAY, medium plasticity, brown, fine to medium sand, with rootlets, trace fine to medium, sub-angular gravel	0	0.2 to 0.3
2		Fill - General	Gravel and cobbles, fine to coarse grained, subangular basalt fragments (ballast), dark grey Or Sandy gravelly CLAY/SILT, low and medium plasticity, pale brown, fine to coarse sand	0	0.25 to 2.6
3		Alluvium	Sandy CLAY/Clayey SAND, medium plasticity orange-brown, mottled grey, fine to coarse sand, trace fine roots, typically firm consistency, or loose with some soft organic clay layers towards the base of the unit	0 to 2.6	1.2 to 1.6
4		Colluvium	orange-brown, mottled brown, grey, fine to medium sand, typically firm to stiff consistency	0 to 0.6	1.1 to 2.7
5		Residual Soil	Sandy CLAY/CLAY, medium to high plasticity, orange-brown, mottled yellow-brown, grey, fine to medium sand, trace fine to medium, sub-angular gravel. Typically, stiff to very stiff consistency, hard in parts.	0.3 to 2.7	0.5 to 5.2
6	a	Siltstone Bedrock	Extremely to highly weathered, inferred soil strength to low strength.	1.9 to 5.5	0.7 to Unproven
	b		Highly to moderately weathered, low to medium strength	3.1 to 7.3	0.4 to Unproven
	c		Moderately weathered or better, medium strength	4.0 to 5.2	Unproven

Notes:
1. Units were not encountered at every borehole location, reference should be made to specific engineering boreholes logs.
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

Fill was observed at most borehole locations to depths of typically between 0.3 m and 2.6 m as described in Table 5-4.

Given the nature of the site, it is expected that other areas of previous filling are likely to be present across the site footprint, associated with previous site development, trenching and disposal of waste materials.

The main fill thickness was encountered within BH04 to BH08 associated with likely partial backfill of a former pond within this part of the site, generally comprising of gravel and cobbles with some building waste such as ceramic/terracotta pipe fragments.

From a geotechnical viewpoint, 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. Re-used material should be screened for such physical contaminants, reworked, and compacted as controlled fill.

Acid Sulfate Soils

The dataset for Acid Sulfate Soils (State of NSW and Department of Planning, Industry and Environment, eSPADE tool) indicates that the site is not underlain by Acid Sulfate Soils (ASS). The site geology is not commensurate with the development of actual or potential acid sulfate soils.

Soil Waste Classification

A Preliminary In-situ Waste Classification Assessment was undertaken by Ballpark Environmental (2021) concurrently with the geotechnical investigation. The assessment was undertaken to assess the in-situ waste classification by chemical assessment of soils proposed to be excavated during the planned STP upgrade works in accordance with the NSW EPA *Waste Classification Guidelines, Part 1: Classifying Waste (2014).* Results of the assessment are discussed in Section 5.14

5.6.1 Construction Impacts

Earthworks

Approximately 17,000 m^3 of clean imported fill (Virgin excavated natural material (VENM) or excavated natural material (ENM)) would be required for the foundation works at the site. The fill is anticipated to be sourced from an onsite borrow pit which would be restored post-works (including shaping the ground surface, covering it with topsoil excavated from the site and re-establishing an appropriate vegetation cover), or from the nearby Bowral STP site. The imported fill material must be tested and pre-classified as either VENM or ENM in accordance with EPA waste classification requirements prior to being utilised as fill at the Moss Vale STP site for the STP Upgrade construction.

Unless records confirm that the existing fill has been compacted in accordance with an engineering specification, where present, this material should be classified as uncontrolled and is not considered suitable as a foundation for structures or pavements due to the potential for differential settlement. Therefore, it is recommended that the existing fill materials be subject to excavation and recompaction (if suitable) or replaced with engineered fill.

Where natural soils are exposed and no filling is required, subgrade and foundations for structures and/or pavements should consist of bulk excavation to design level(s) (including to the underside of any fill encountered on the site) followed by a geotechnical assessment of the exposed stratum. General guidelines for earthworks and foundations during construction are

provided in Section 5.1 and 5.5 respectively, of the D & N Geotechnical Investigation report (2021) (refer to Appendix I).

All fill placement and subgrade preparation should be constructed under Level 1 Geotechnical Inspection and Testing as defined in A*S3798-2007 Guidelines on Earthworks for Commercial and Residential Developments*. The extent of subgrade treatment will largely depend on preceding weathering conditions and construction methodology and should be treated as advised by the project geotechnical consultant.

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 Whites Creek 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 allow the existing STP components to remain 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.

5.6.3 Mitigation Measures

Construction

- All fill placement and subgrade preparation should be constructed under Level 1 Geotechnical Inspection and Testing as defined in *AS3798-2007 Guidelines on Earthworks for Commercial and Residential Developments.*
- Re-used onsite fill material should be screened for such physical contaminants, reworked, and compacted as controlled fill.
- All imported fill material must be tested and pre-classified as either VENM or ENM in accordance with EPA waste classification requirements prior to being utilised as fill onsite for the STP upgrade construction.

- A detailed Erosion and Sediment Control Plan (ESCP) shall be prepared as part of the CEMP. The ESCP 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 ESCP 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 (including any borrow pits) 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 EPA requirements.

5.7 Water Quality

The following information has been taken from the *Discharge Impact Assessment for the Moss Vale Sewerage Scheme* (DIA*)* (Manly Hydraulics Laboratory (MHL), 2022). A copy of the report is provided in Appendix F.

Catchment Water Quality

Moss Vale STP discharges treated effluent into Whites Creek, which is located within Sydney's 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 Moss Vale 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 livestock effluent and ongoing adverse impacts. 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 experienced poor water quality across a range of parameters during the audit period (MHL,2022).

Whites Creek

Treated effluent from the Moss Vale STP is discharged into Whites Creek, adjacent to the STP. Whites Creek, a tributary of the Wingecarribee River, commences approximately 3 km upstream of the STP and runs through the township of Moss Vale before passing along the northern boundary of the STP and then joins the Medway Rivulet, approximately 3.5 km downstream, then the Wollondilly River and Lake Burragorong.

Under wet weather conditions, treated effluent is discharged to Whites Creek, Point 2 (the Emergency Stormflow Discharge Point) (see Figure 5.7). 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 Figure 5.7 and Table 5-5. Locations that are owned and operated by WaterNSW are for the purposes of auditing the quality of Sydney's drinking water supply.

The primary land use zones surrounding Whites Creek downstream of the STP include residential, dryland agriculture and natural environments. Historic algal blooms have caused issues at the Medway Water Treatment Plant (WTP) which have led to long-term ceasing of operations. It has been postulated that some of the nutrient loading which contributes to the Medway Dam's algal blooms comes from the upstream STP at Moss Vale (MHL, 2022). However, Medway WTP is not anticipated to be utilised as a potable water source in the future, as WSC's adopted Integrated Water Cycle Management (IWCM) strategy supported the decommissioning Medway WTP and supply the Medway service area from the Wingecarribee WTP.

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 3-5 together

with water quality monitoring data for Wingecarribee River in the vicinity of the STP (MHL, 2022).

Existing STP Impacts on River Water Quality

To assess the existing conditions in Whites Creek, a temporal trend analysis (including catchment modelling and monitoring) was undertaken as part of the Moss Vale Sewerage Scheme DIA (MHL, 2022) with the concurrence of EPA representatives, using the data collected as part of the WaterNSW long-term measurement program.

The current impact of the STP on the receiving waterways was estimated based on the historic data between 2013 and 2019. Historical water quality data for Whites Creek was limited, with the existing water quality data available limited to total nitrogen and total phosphorus. As a result, the impacts of the existing STP on the receiving waterway was estimated on historic data. 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:

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

- The largest concentrations of total nitrogen and total phosphorus occur in the treated effluent at the STP discharge point. The next largest concentrations occur at the location immediately downstream of the STP (Point 5). Concentrations at the STP and Point 5 are significantly greater than those at the other two locations.
- This suggests that impacts from the STP discharge can be detected immediately downstream of the discharge point (as might be expected). Total phosphorus concentrations at Point 4 (2 km downstream) are not statistically different from the upstream concentrations. However, total nitrogen concentrations at Point 4 still appear elevated, compared with the upstream concentrations. This may suggest a source(s) of nitrogen entering Whites Creek between the STP discharge point and Point 4.
- Trends in total nitrogen concentration at, and downstream of, the STP are decreasing over time. However, for half of these results, the slope of the trend line is not statistically, significantly different from a slope of zero.
- Trends in total phosphorus from the STP are increasing, although the slopes of these trend lines are not statistically, significantly different from a slope of zero.

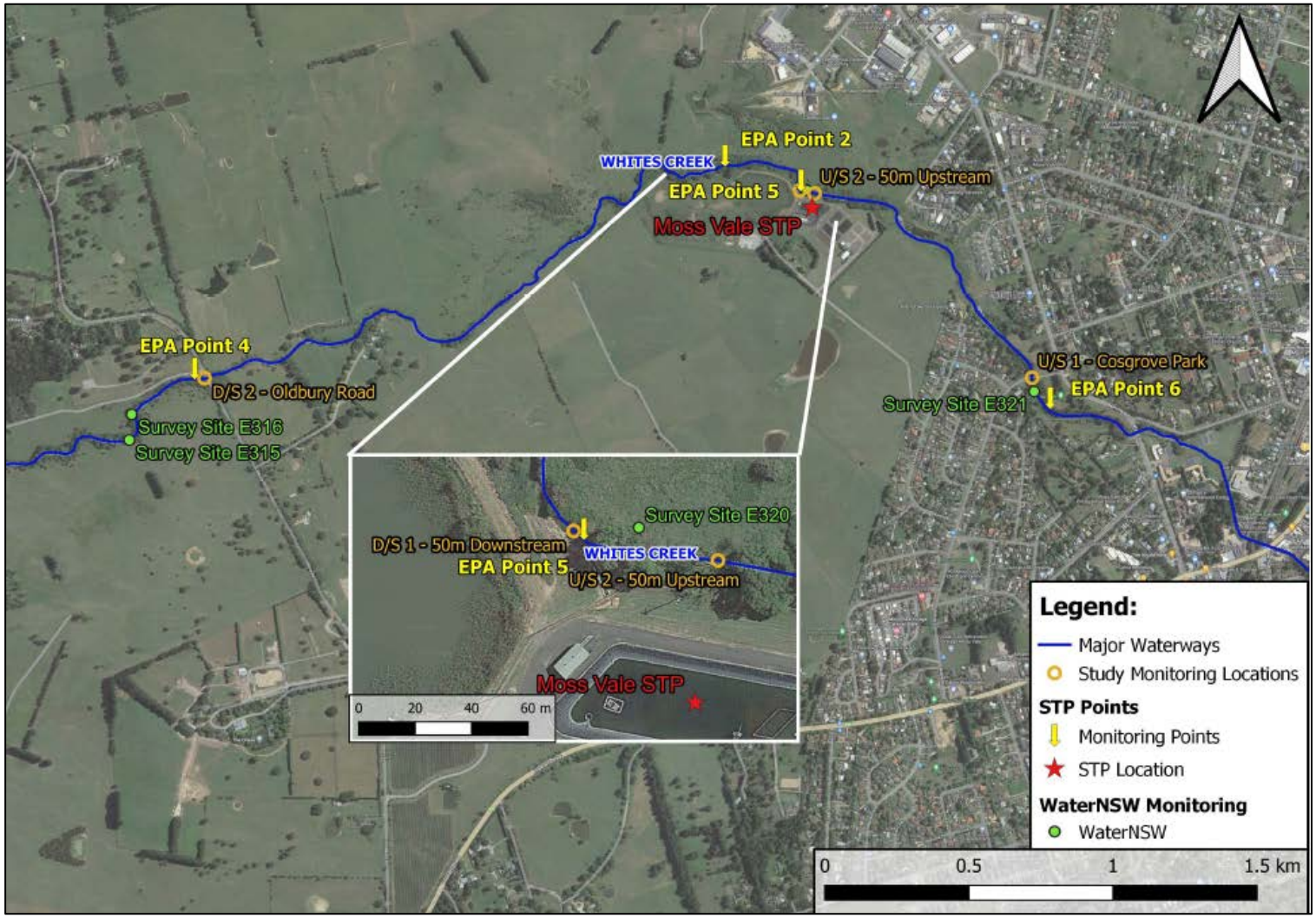


Figure 5.7 Moss Vale STP and receiving waters.

Source MHL, 2022b

Table 5-5 Long-term monitoring locations and variables measured

WaterNSW code	Site Description and Variables Measured	Latitude (° S)	Longitude (° E)	Period of Record
2122520	Whites Creek (at Oldbury Road) (Q, EC, turbidity, T, pH, DO)	-34.54592	150.33737	2014-2020
STP licences	**Site Description and Variables for Licencing**	**Latitude (° S)**	**Longitude (° E)**	**Dates Analysed**
Moss Vale STP EPA Point 1	Main monitoring location (Q, BOD, FC, NH3, TN, TP, pH, TSS)	-34.541389	150.356111	2013-2019
Moss Vale STP EPA Point 2	Wet weather discharge	-34.541111	150.353889	2013-2019
Moss Vale STP EPA Point 3	Volume monitoring (Q)	-34.543056	150.356667	2013-2019
Moss Vale STP EPA Point 4	Whites Creek (at Oldbury Road) (Q, EC, turbidity, T, pH, DO, TN, TP)	-34.546111	150.337500	2013-2019
Moss Vale STP EPA Point 5	Whites Creek immediately downstream from discharge (TN, TP)	-34.541111	150.355833	2013-2019
Moss Vale STP Point 6	Cosgrove Park, 800m upstream Whites Creek (TN, TP)	-34.546111	150.363333	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.

Source: MHL, 2022b

Upstream and Downstream Water Quality

The following information has been taken from the *Discharge Impact Assessment for the Moss Vale Sewerage Scheme* (DIA) (Manly Hydraulics Laboratory (MHL), 2022). A copy of the report is provided in Appendix F.

Upstream monitoring is required as part of the EPA licence conditions at Point 6 in Whites Creek (near Cosgrove Park, Moss Vale). Downstream monitoring is undertaken at Point 5 (just downstream of the STP discharge into Whites Creek) and at Point 4 (at Oldbury Road, about

2 km downstream from the STP discharge point. Only analyses for total nitrogen and total phosphorus are undertaken at these locations.

Trend analysis for the water quality parameters monitoring data was undertaken using effluent data collected from the Moss Vale STP for two time periods between 2013 and 2019 (MHL, 2021). 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. 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). Cells that are shaded indicate that the trend line is, statistically, significantly different from a slope of zero. Trends in river water quality parameters are shown in Table 5-6.

For most variables, the slope of the regression line was negative, and not significantly different from a slope of zero. A statistically significant increasing trend was identified for suspended solids (for the 2013-2019 period) and for faecal coliforms (for the 2017-2019 period). BOD, nitrite, faecal coliforms and alkalinity showed a reversal in the slope of the linear trend line for the two time periods examined. This may suggest short period fluctuations in those variables. Assuming the increasing 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.

Contaminant concentrations under dry and wet weather conditions were also compared. In general, the contaminant concentrations in the wet weather discharge ponds exceeded those at the dry weather monitoring location.

Table 5-6: Temporal Trends in the Moss Vale STP data

Variable	2013-2019		t-calc	2017-2019	
	Slope (concentration change)	significance	t-crit= +/-1.97	Slope (concentration change)	significance
BOD	↓	SIG	-12.06	↑	NSD
TSS	↑	SIG	2.72	↑	NSD
Conductivity	↓	NSD	-1.12	↓	SIG
Ammonia	↓	NSD	-0.58	↓	NSD
Nitrite	↑	NSD	1.19	↓	NSD
Nitrate	↓	SIG	-2.56	↓	NSD
Oxidised nitrogen	↓	SIG	-2.50	↓	NSD
Total nitrogen (TN)	↓	SIG	-3.87	↓	SIG
Total phosphorus (TP)	↑	NSD	1.51	↑	NSD
pH	↓	NSD	-0.42	↓	SIG
Oil and grease	Insufficient data above limit of reading (LOR) for reliable statistics				
Faecal coliforms	↓	NSD	-1.93	↑	SIG
Alkalinity	↑	NSD	0.48	↓	SIG

Results from an ANOVA assessment of Total Phosphorus (TP) and Total Nitrogen (TN) (see Table 5-7) confirmed that the highest concentrations occur at the STP discharge point and that there is no statistically significant difference between the data collected from Point 5 and those collected at the STP. Concentrations of TP and TN at these two locations are significantly greater than the concentrations at Points 4 and 6. There is no significant difference between Point 4 and Point 6 for TP, however TN concentrations are significantly greater at Point 4 than at Point 6

Trends at each of the four locations are shown in Table 5-7. Two times periods were used: 2013-2019 and 2017-2019. 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.

There is a significant decreasing trend in TN at the STP over time. The trend patterns over the two time periods are similar, with the exception of Point 6, which shows a reversal in the slope of the trend line in the two time periods.

Table 5-7: TN and TP Trends for the Point 1 (STP), Point 4, Point 5 and Point 6.

	2013-2019		t-calc	2017-2019	
	Slope	significance	t-crit= +/-1.99	Slope	significance
Total Nitrogen (mg/L)					
Point 6 (upstream)	↓	NSD	-1.03	↑	NSD
STP	↓	SIG	-2.66	↓	SIG
Point 5 (downstream)	↓	NSD	-0.93	↓	NSD
Point 4 (far down stream)	↓	NSD	-1.41	↓	SIG
Total Phosphorus (mg/L)					
Point 6 (upstream)	↓	NSD	-0.31	↑	SIG
STP	↑	NSD	0.49	↑	NSD
Point 5 (downstream)	↑	NSD	1.33	↑	SIG
Point 4 (far down stream)	↑	NSD	1.76	↑	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.
TN = total nitrogen, TP = total phosphorus.
Source: MHL, 2021

Existing STP Impacts on River Water Quality

Due to the lack of water quality data for Whites Creek, existing water quality data is limited to total nitrogen and total phosphorus. The current impact of the Moss Vale STP on the receiving waterways was estimated based on the historic data 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 at the Moss Vale STP site:

- Concentrations of nutrients, ions and aluminium from the Moss Vale STP appear to be elevated compared with the upstream concentrations. Some elevated metal concentrations were identified at locations upstream of the STP discharge location, suggesting an upstream source of metals. Concentrations of bacteria in the receiving waters were highly variable, largely depending on the sampling day. This may suggest upstream sources of bacteria, although the variable results make this assertion difficult to verify.
- The largest concentrations of TN and TP occur in the treated effluent at the STP. The next largest concentrations occur at the location immediately downstream of the STP (Point 5). Concentrations at the STP discharge point and at Point 5 are significantly greater than those at the other two locations.

- This suggests that impacts from the STP discharge can be detected immediately downstream of the discharge point (as might be expected). Total phosphorus concentrations at Point 6 (2 km downstream) are not statistically different from the upstream concentrations. However, total nitrogen concentrations at Point 6 still appear elevated, compared with the upstream concentrations. This may suggest a source(s) of nitrogen entering Whites Creek between the STP discharge point and Point 6.
- Temporal trend analysis was undertaken using long term data sets. Only limited long term water quality data was available. Results from temporal trends between 2013 and 2019 indicate decreasing concentrations of TN in both the effluent and river, while increasing trends were observed for TP. However, it is noted that the slopes of the trend lines were, generally, not statistically different from a slope of zero.
- Concentrations of most contaminants sampled during wet weather exceed those sampled during dry weather.
- Upstream concentrations of TN and TP 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.

University of Newcastle (2020) carried out analysis of xenoestrogens in effluent samples taken from several WSC-operated STPs including Moss Vale 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 this (memo) report is provided in Appendix F.

The *Southern Highlands Biological Monitoring Report* was undertaken to assess aquatic ecosystem health both upstream and downstream of the STP, by employing the use of multiple biotic indices' (Sydney Water Monitoring Services, 2022. Refer to Appendix D of the DIA, provided in Appendix F). The report concluded that:

- All upstream and downstream sites display some level of impact from urban and/or agricultural pollution.
- While STP discharges would no doubt contribute to pollution to some degree, differences observed between test sites could not be attributed specifically to STP discharges and are most likely also impacted due to urban/ agricultural runoff from the surrounding townships and natural variation.

Groundwater

Groundwater inflows were encountered during auger drilling for the D & N Geotechnical (2021) investigation within BH104 to BH107 at between about 0.3 m to 1.6 m depth, However, groundwater was not observed during auger drilling within any of the remaining boreholes advanced as part of the investigation. Subsequent groundwater observations during diamond core drilling within bedrock were not possible as water was added to each borehole to facilitate coring.

Groundwater levels may increase in response to rainfall. It is possible that groundwater may be temporarily perched above the rock level during and after heavy or sustained rain events.

The standing water level at the NSW Public Works Advisory (2020) boreholes B20 and B25 was measured on Monday, 12 April 2021 as:

- 2.8 m below ground level at B20 and
- 0.5 m below ground level at B25.

These levels vary significantly from the NSW Public Works Report measurements on 10 May 2019 as:

- 4.2 m below ground level at B20 and
- 2.5 m below ground level at B25.

The locations of these boreholes are shown on Figure 5.8 below (NSW Public Works Advisory, 2020).

The difference in water levels between 2019 and 2021 may be ascribed to drier conditions during 2019 in comparison to 2021. This difference shows that a significant range in groundwater levels is possible in response to rainfall, seasonal and climatic effects.

As part the geotechnical investigation, the two groundwater monitoring wells (B20 and B25) at the STP site were gauged and sampled for a Preliminary Groundwater Quality Assessment (Ballpark Environmental, March 2021a). The depth to groundwater was recorded as 3.53 m (BH20) and 0.9 m (BH25) below ground surface.

The groundwater samples were analysed by a National Association of Testing Authorities (NATA) accredited laboratory and the results reviewed to assess if groundwater contamination was present. The laboratory results found that metals; copper, nickel and zinc recorded concentrations above the adopted applicable groundwater investigation levels (GILs) in the National Environment Protection (Assessment of Site Contamination) Measure 1999 (Amended April 2013), EPHC 2013, Canberra (ASC NEPM, 2013) (ASC NEPM).

It was concluded that the presence of these metals may be attributed to natural mineralisation in local soils and rock and is assessed to be a low risk. It was assessed that there is a low potential risk from groundwater contamination to human health or the environment in groundwater at these two monitoring wells on the site.

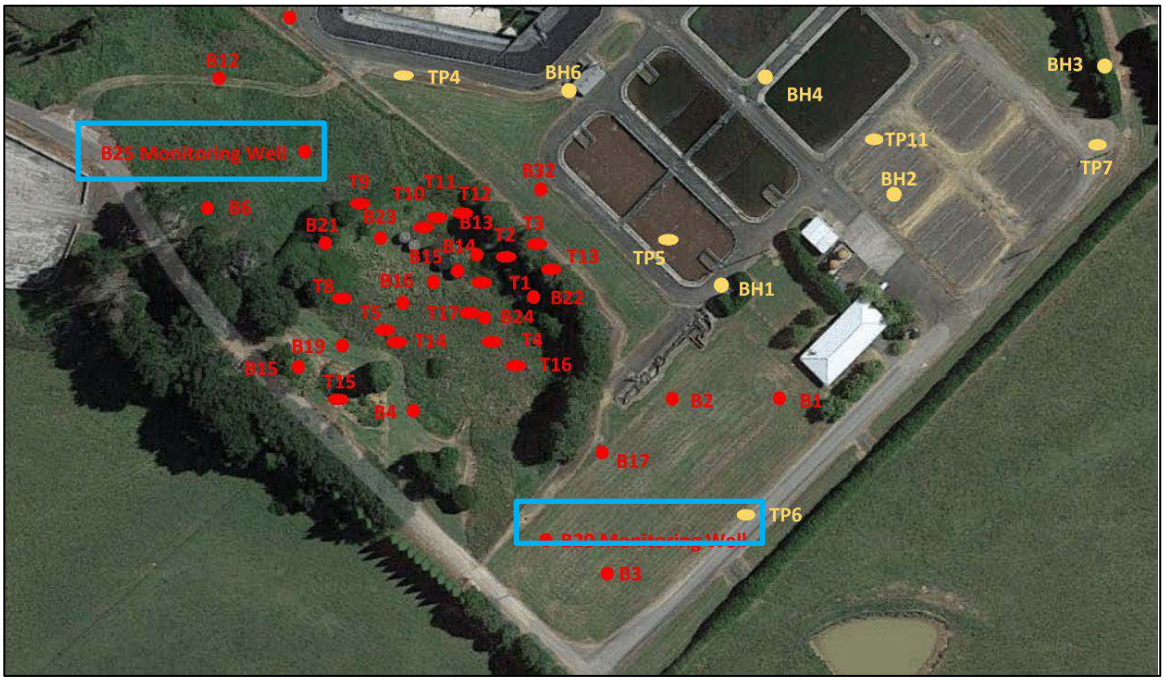


Figure 5.8: NSW Public Works Advisory geotechnical investigation report showing location of Groundwater Monitoring Wells B20 and B25 (in blue)

Source: NSW Public Works Advisory, 2020

Flooding

The STP site is located on the southern bank of Whites Creek. Council have indicated that the site of the proposed works is above the 1 in 100 year flood level, as shown in Figure 5.9. The finish level of all in-ground components proposed would be located above the natural surface level by at least 100 mm to avoid overland run-off.

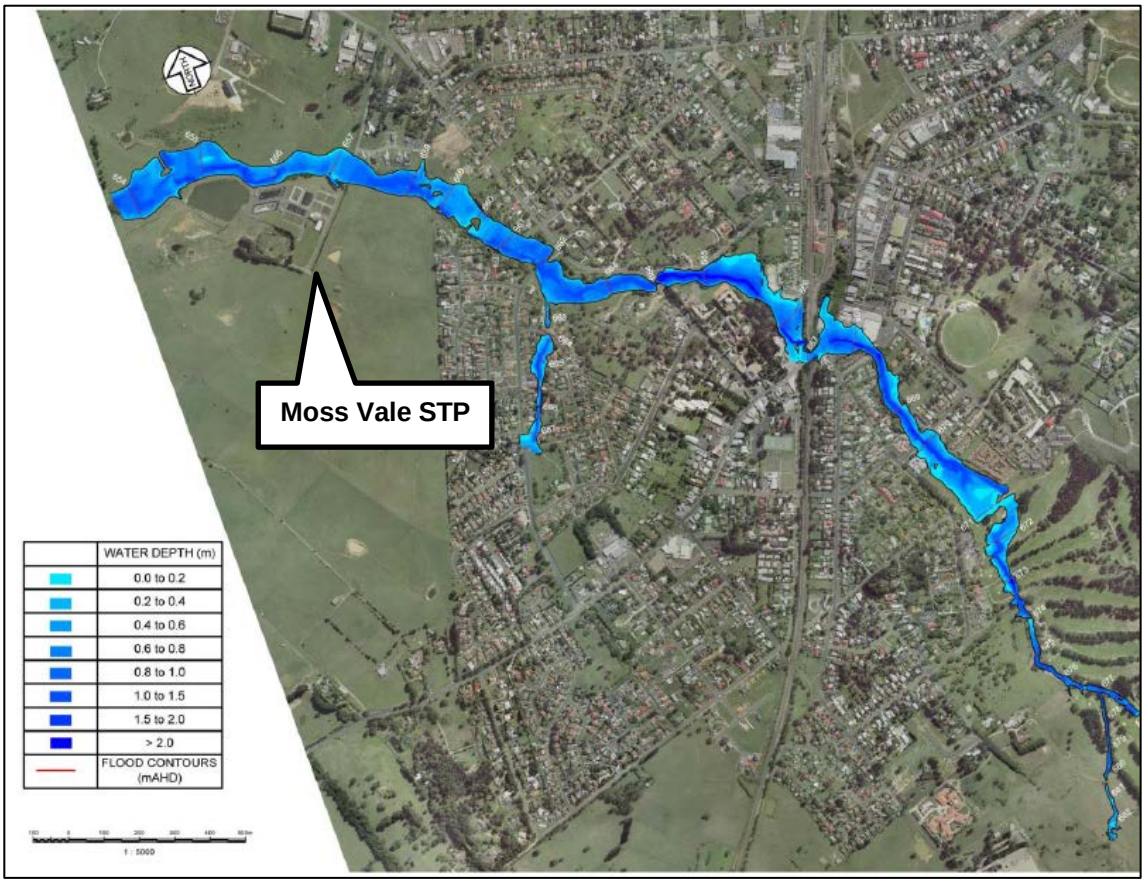


Figure 5.9 Whites Creek Flood Contours

Source: URS and Wingecarribee Shire Council, 2018

5.7.1 Construction Impacts

Groundwater

Based on prior geotechnical investigations at the STP site, groundwater and seepage may be expected to be encountered during the construction works.

The results of the Preliminary Groundwater Quality Assessment (Ballpark Environmental, 2021a) analysis found that subject to obtaining all the necessary approvals, surplus groundwater from the site may be permitted to be discharged to the nearby Moss Vale Sewage Treatment Plant or to stormwater during proposed construction activities.

Groundwater should be managed during the construction of the proposed STP upgrade works to prevent groundwater and surface water quality impacts. Generally, where required, dewatering of the excavations may best be achieved by sumping or pumping techniques.

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 DPE - 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 and as such, it is recommended that the volume of water extracted during

the course of the works each day be recorded and an aquifer interference activity WAL exemption and associated water supply work approval for pumped dewatering of groundwater should be lodged through DPE - Water 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.

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.

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

5.7.2 Operational Impacts

Stormwater

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

Groundwater

There is limited potential for the STP to impact groundwater. The 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 is predicted.

Effluent Discharge

Following the proposed upgrade works, treated effluent produced at the STP would continue to be discharged to the Whites Creek where it is joined by the Medway Rivulet, as per the current arrangement. The upgrade of the Moss Vale STP has been designed to meet the NSW EPA licence conditions and with due consideration of WaterNSW's Neutral or Beneficial Effects (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, reliable and improved effluent quality.

The results of discharged effluent contaminant concentration modelling indicate that FSB/ MLE plant type options for the proposed upgraded STP (EP 20,000) would result in downstream

contaminant concentrations at equal or lower levels than the existing STP contaminant concentrations.

MHL's DIA analysis results (such as the results shown in Table 5-8 below) were based on 18,000 EP 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 better effluent quality than cloth filters for tertiary treatment (especially for TSS and TP concentrations) and therefore, lower discharged effluent contaminant concentrations than the results from the modelling shown in Table 5-8.

The initial STP upgrade works planned comprise construction of a plant with a designed treatment capacity of 20,000EP. Table 5-8 shows that a MLE/FSB treatment process design is justified as suitable to achieve the required effluent discharge so as not to have environmental impacts to the receiving waters.

Table 5-8: STP Downstream Contaminant Concentrations at DS 1 and DS 2 locations for each scenario (design load of 18,000 EP)

	Concentrations (mg/L)					
	TSS		TN		TP	
ANZECC	25		0.25		0.02	
Background (50%ile)			2.0		0.10	
	50%	90%	50%	90%	50%	90%
DS-1						
Existing	13	73	3.5	5.5	0.26	1.23
IDEA	13	65	5.5	8.0	0.25	1.03
MLE	13	66	4.2	5.9	0.19	0.99
FSB	13	67	3.0	4.7	0.18	0.96
DS-2						
Existing	9	69	3.4	5.6	0.25	1.13
IDEA	10	60	5.7	8.5	0.24	0.92
MLE	9	64	4.3	6.2	0.17	0.95
FSB	13	67	3.0	4.7	0.18	0.96

Source: MHL, 2022

Note: Cells shaded green indicate an improvement in water quality compared with the existing conditions.

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.

ANZECC Guidelines Water Quality Modelling

A discussed in Section 4.1, modelling undertaken as part of the DIA by MHL (2022) (refer to Appendix F) 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 TSS, TN and TP based on the use of cloth filters for tertiary treatment, rather than the proposed dual media filters which are anticipated to result in even lower contaminant concentrations to that of the modelling results.

In all cases, the 50%ile background (i.e. upstream) concentration already lies close to or above the relevant ANZECC guideline. 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 from the STP 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 (Point 4) exceed those at DS-1 (Point 5). Overall:

- Statistically, there is no significant difference in the concentrations between the two downstream locations. This is a direct result of low dilutions in Whites Creek.
- Patterns at DS-1 (Point 5) and DS-2 (Point 4) are similar. Concentrations at DS-2 (Point 4) are generally less than (but not statistically significantly different from) those at DS-1 (Point 5).
- The STP concentration for TSS does not change for the different scenarios (the slight differences observed are due to the random inputs into the Monte Carlo simulations).
- Downstream nutrient concentrations are greatest for IDEA, thence MLE and the lowest concentrations are from FSB. Upstream concentrations of TN and TP are well in excess of the ANZECC guidelines (a factor of 2 or more) 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 which 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.

NorBE Assessment

The Neutral or Beneficial Effects (NorBE) assessment tool is used to determine the likely impact of a development on Sydney's drinking water catchment. New activities and developments carried out without development consent by public authorities under Part 5 of the EP&A Act are required to take into account, whether the activity is consistent with the NorBE Guideline (WaterNSW, 2022) and current recommended practices.

It is noted that the NorBE Guideline (WaterNSW, 2022) explicitly refers to 'new developments'. As a result, it is unclear how or whether, NorBE applies to upgrades to existing developments, such as the upgrade to the Moss Vale STP .

Furthermore, the NorBE Guideline (WaterNSW, 2022) does not explicitly define the 'pre-development' concentrations of contaminants. There has been a reduction in annual loads of (at least some) contaminants since 2013. If the pre-development concentrations are based on 2013 data then the likelihood of meeting NorBE requirements would be greater than that if the 2018 data (which has lower concentrations) is used. This would discourage a 'continual improvement' process. Therefore, in the context of this , compliance with NorBE has been used as a guide rather than a requirement.

There are two major components to meeting NorBE requirements. 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 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 Moss Vale STP at the future (18,000 EP) 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 Moss Vale plus MVEC (EP = 18,000): 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	4,350	3,810	4.0	7.0	1.6	3.1
TN	4,000	3,540	3.90	6.95	1.56	2.68
TP	260	220	0.240	0.496	0.086	0.206

Source: MHL, 2022

Exceedance plots comparing simulations of the three treatment type scenarios with the existing concentrations for Moss Vale (EP = 18,000) are shown in Figure 5-10 with key results are summarised below in Table 5-10 and Figure 5-10. 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 than the now proposed dual media filters, which would provide a better outcome with respect to meeting the NorBE concentration requirements.

TN concentrations are considerably less than the existing conditions for FSB, while MLE concentrations are slightly above the existing conditions. TP concentrations are generally less than the existing concentrations for all scenarios. TSS concentrations are close to, but slightly above those for the existing conditions.

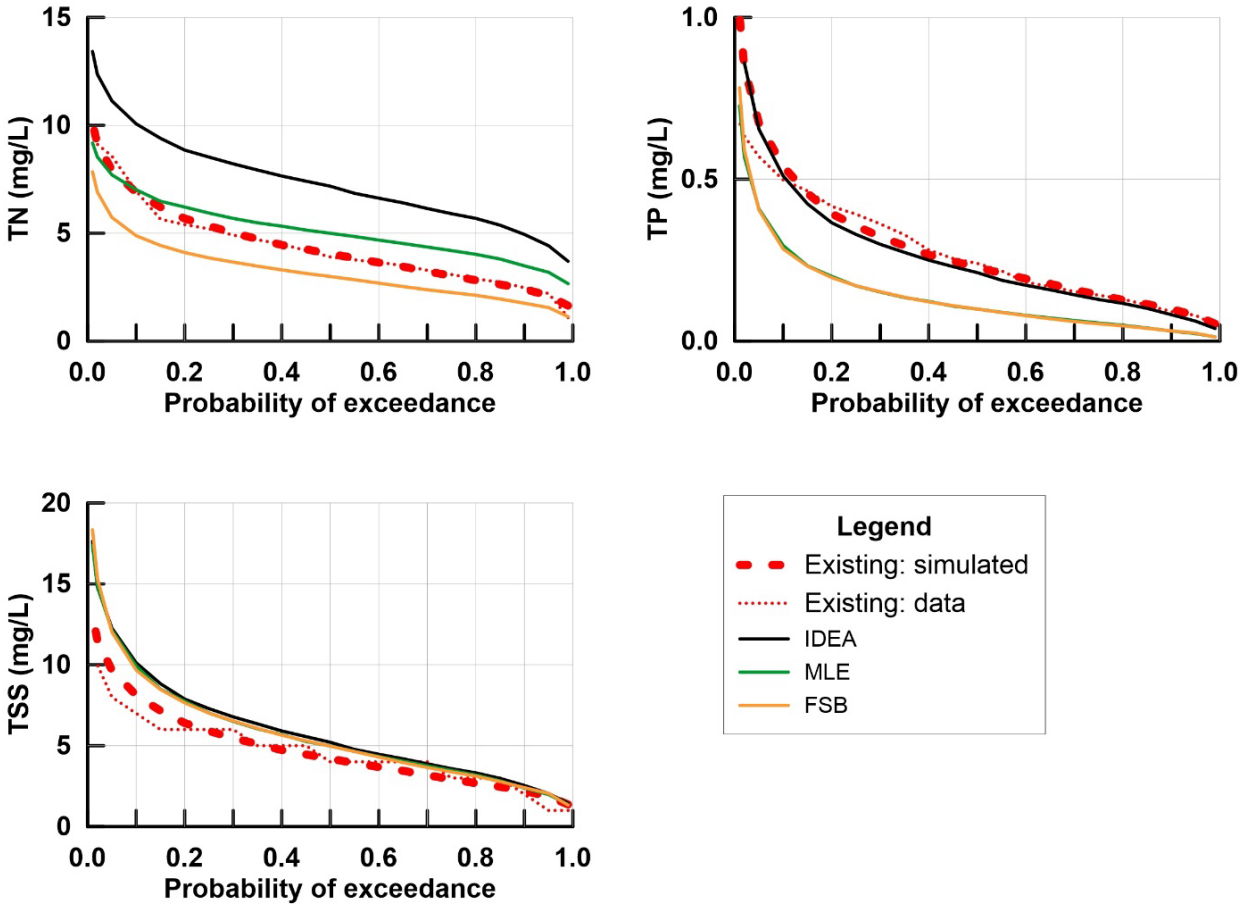


Figure 5-10 Moss Vale STP exceedance plots (EP=18,000) for concentrations simulated from the three scenarios and under existing conditions

Source: MHL, 2022

Table 5-10 Moss Vale STP (EP+18,000): NorBE concentrations for three treatment type scenarios (with the 10% improvement based on existing loads)

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

Source: MHL, 2022

Annual loads were estimated by averaging the annual loads for each of the 5 years that comprise the simulation period and multiplied by 1.1. Results are provided in Table 5.11. The scaled annual loads for TSS exceed the existing conditions. However, it is noted that the design concentrations are conservative and the actual loads will be less than those presented here. The MLE and FSB loads for TP are close to the existing load values. All other scenarios exceed the NorBE annual load requirements.

Table 5-11 Moss Vale (EP=18,000): NorBE annual loads

Annual load		Scenario treatment type		
(kg/year)	Existing	IDEA	MLE	FSB
TSS	4,350	11,900	11,800	11,800
TN	4,000	15,130	10,700	6,700
TP	260	530	290	290

Source: MHL, 2022

Generally, it is the annual loads (rather than the concentrations) that govern compliance with NorBE. None of the three proposed scenarios would meet NorBE. The FSB treatment option comes closest, however it only meets some of the NorBE requirements. Although, 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) of the scenarios. In general, this means that the NorBE concentration and/or load requirements will not be met. However, it is noted that the design criteria are conservative, and the actual performance will be substantially better. 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) and this is the basis for the suggested licence conditions, rather than the existing loads which were modelled 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. A comparison to historical load data and recent return loads was undertaken to substantiate proposed practical load limits. This was suggested to be used as a variation to the discharge licence conditions (which has been discussed with EPA representatives (*Moss Vale STP upgrade correspondence to EPA*. WSC, 27.1.23; *EPA comments on Moss Vale STP upgrade*. EPA, 6.3.23.).

The Discharge Impact Assessment (MHL, 2022) undertaken for the STP upgrade indicates that complete treated effluent mixing occurs within a few hundred metres of the STP discharge point. As such, there is limited opportunity to mitigate the extent of the mixing zone due to the several factors outlined below.

Further treatment to reduce pollutant concentrations in the effluent is limited as the technology proposed to be used in the upgraded STP upgrade is 'best practice' for a plant of this proposed size, and there is a point of diminishing returns to achieve incremental reductions in effluent concentrations. In addition, due to the STP site configuration there appears to be no benefit to move the discharge point further downstream and a 'reuse opportunities' report (BECA,HunterH_2O, 2023) found that the options to significantly reduce the effluent discharge

to Whites Creek were impractical or cost prohibitive. Furthermore, discharges timed to coincide with specific receiving waterway flow conditions are impractical given that the receiving waterway flow conditions are weather dependent and storing effluent on site prior to discharge would not be achievable given the excessive volumes of effluent that would be generated between rainfall events (*Moss Vale STP upgrade correspondence to EPA.* WSC, 27.1.23; EPA comments on Moss Vale STP upgrade. EPA, 6.3.23.)..

Overall, despite the increased capacity, the proposed upgrade of the Moss Vale STP is predicted to result in an overall positive impact on water quality and reduce the contribution of pollutant levels to the Whites Creek 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

Council engaged Beca/Hunter H_2O to conduct a review of opportunities to reuse treated effluent from all six of WSC's STPs. The findings were provided in the *'Wingecarribee Recycled Effluent – Review of Reuse Opportunities' report* (Beca/Hunter H_2O, February 2023).

Longlisted reuse options were initially screened through a Go/No Go assessment then the selected options developed through a Multi Criteria Analysis (MCA). The MCA ranked the non-cost components of a range of potential reuse options, with the highest ranked further developed for the cost component.

The developed options included:

- Combined municipal irrigation scheme including the Moss Vale Golf Club plus additional municipal reuse locations (potentially Community Oval and Seymour Park, ~56 Ha). Estimated to have a capital cost of $6.19M and a 10-year projected cost normalised to estimated reuse volume of $5.80 per kL.
- Agricultural irrigation of pasture for livestock grazing/feedstock production (third party operated). Estimated to have a capital cost of $13.07M and a 10-year projected cost normalised to estimated reuse volume of $3.43 per kL.
- A standpipe for council water cart use. Estimated to have a capital cost $0.68M. However, there is limited opportunity for significant reuse volumes which was reflected in the 10-year projected cost per kL of $52.23.
- Potential industrial reuse (future) – Moss Vale Enterprise Corridor. Estimated to have a capital cost of $15.83M and a 10-year projected cost normalised to estimated reuse volume of $2.73 per kL. Noting that the estimated price of the scheme and recycled effluent usage were based on 2022 data for the purpose of comparison.

Based on the MCA, the standpipe for council reuse was the highest rated option which was largely due to the low cost of implementation. However, there is limited opportunity for significant reuse volumes which was reflected in the 10-year projected cost per kL of $52.23.

Large scale reuse opportunities would have benefit WSC by making NorBE targets more achievable. However, given the climatic constraints (i.e. being a reasonably high rainfall region) it would be expected that there would be little interest for third party take up for simple

agricultural reuse, and the cost of Council buying agricultural land and the providing infrastructure for the other schemes investigated are considered cost prohibitive (Extract. *Response to EPA comments received on 6th March 2023* .WSC, April 2923).

During STP operation, 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. The effluent would be pumped to a reuse tank from the chlorine contact tank, before the dechlorination dosing point.

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 Measures

- 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 and water supply works approval (for pumping water) should be lodged through DPE - 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 DPE-Water prior to the commencement of works.

- Mitigation measures to manage groundwater (should it 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 in the event that 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 Biodiversity

The Moss Vale STP site is predominantly cleared of vegetation and is subject to routine maintenance such as slashing and mowing. The vegetation onsite consists of mostly exotic planted conifers (e.g. Monterey Pine and Monterey Cypress) and assorted landscaping trees, ground cover comprising shrubs and exotic grasses (see Figure 5.14).

In response to consultation regarding this project, DPE - Biodiversity and Conservation (formerly OEH) has advised that:

- Mapped areas of Southern Highlands Shale Woodland (SHSW) ecological community, listed as endangered under the BSW *Biodiversity Conservation Act 2016* (BC Act) and critically endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (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 5.11);

- 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; and
- Whites Creek is identified on the Biodiversity Values Map supporting the BC Act (see Figure 5.12).

Treated effluent from the STP is discharged into Whites Creek, 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).

NSW Department of Primary Industries (DPI) Fisheries Spatial Data Portal mapping identifies Whites Creek as Key Fish Habitat (see Figure 5.13). However, the waterway is not mapped as habitat for any threatened freshwater fish species.

A search of DPE - Biodiversity and Conservation's Atlas of NSW Wildlife indicates 24 threatened species protected under the BC Act or EPBC Act have previously been recorded within a 10km x 10km square area of the site, including seven threatened flora species, 12 threatened bird species and five mammal species. An EPBC Act Protected Matters Report with a 10 km buffer surrounding the site identified 5 listed threatened ecological communities, 66 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 E.

Overall, the area of the site to be affected by the upgrade works has very limited terrestrial habitat potential due to its highly disturbed nature, and 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.

In addition to the sampling described above, a 2-year macroinvertebrate monitoring program was carried out by Sydney Water Monitoring Services (2022) to determine the ecological impact of the STPs on the receiving waterways. Macroinvertebrate sampling was conducted in autumn and spring in 2020 and 2021 in accordance with AUSRIVAS protocols for New South Wales (Turak & Waddell, 2004) and Sydney Water's in-house test methods and was used as a primary indicator for biodiversity and ecological health of the riverine systems.

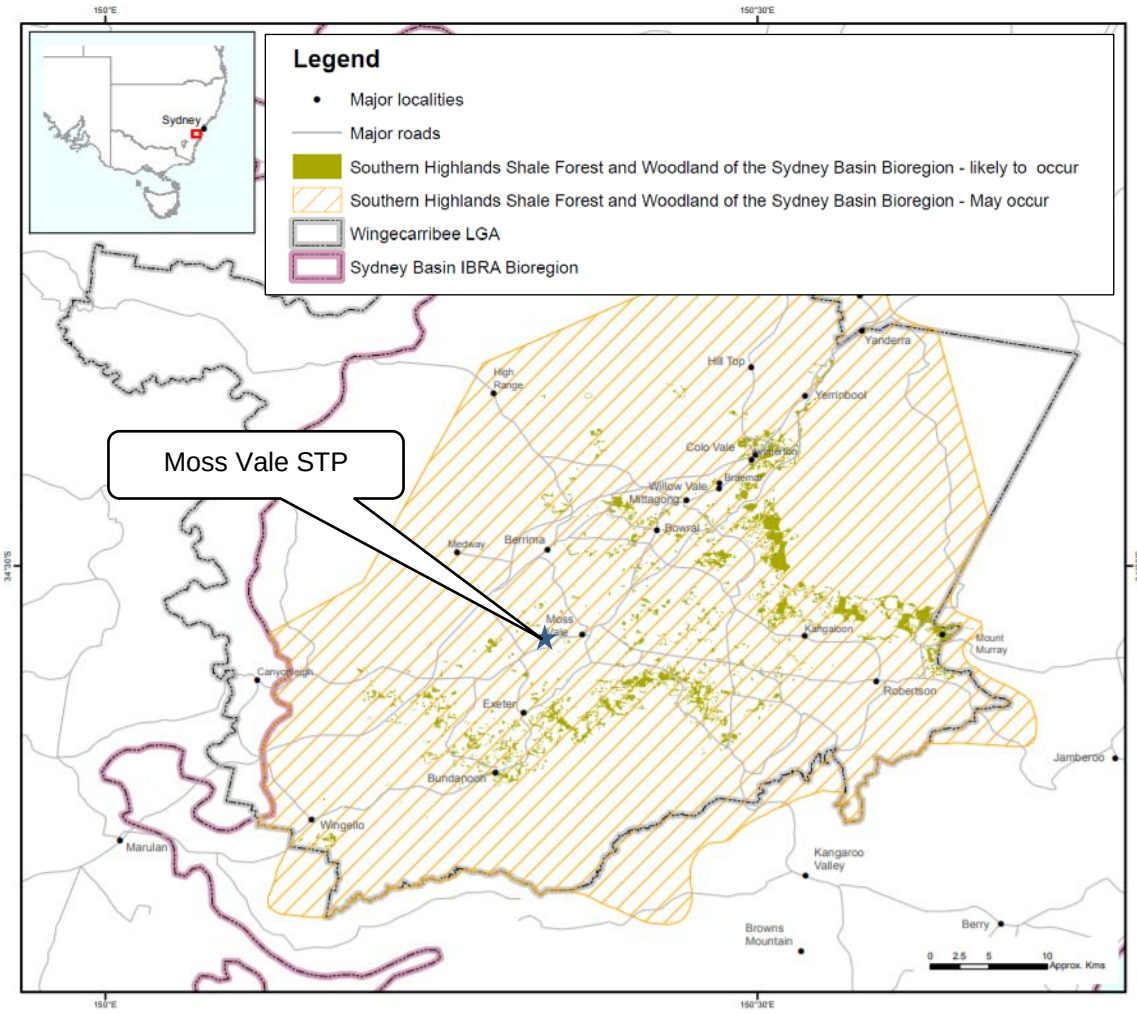


Figure 5.11 Southern Highlands Shale Forest and Woodland of the Sydney Basin Bioregion Map Extract

Source: Department of Environment and Energy, March 2017

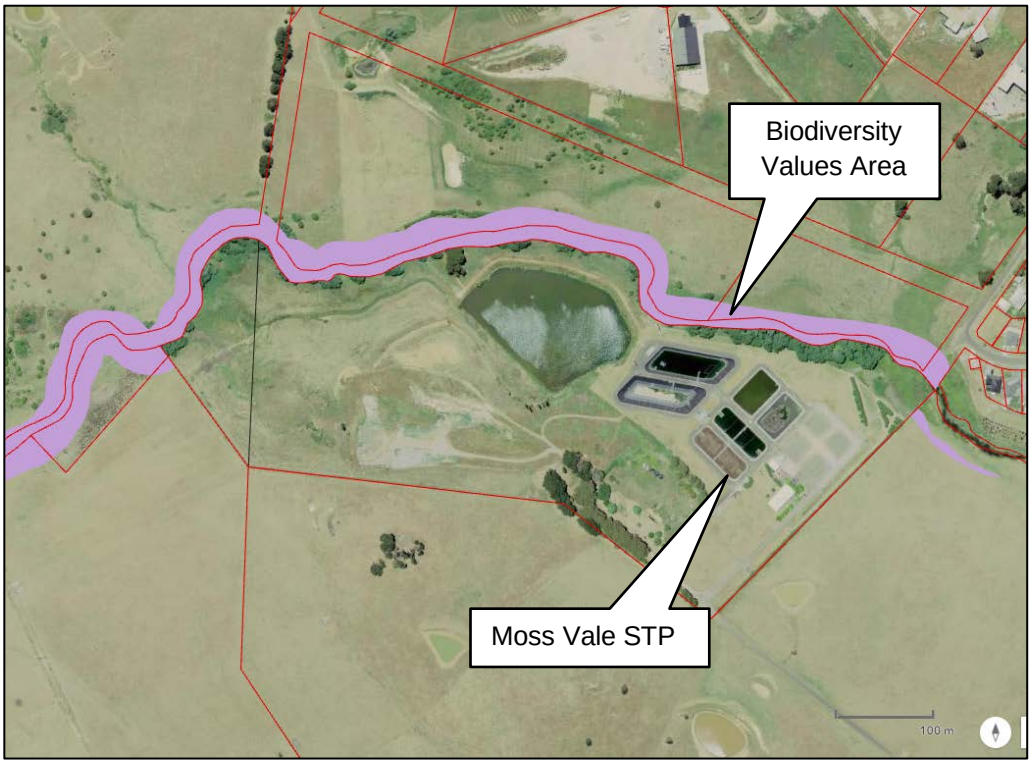


Figure 5.12 Biodiversity Values Map Extract

Source: NSW Planning Portal Spatial Viewer - Biodiversity Values Map later, accessed March 2023

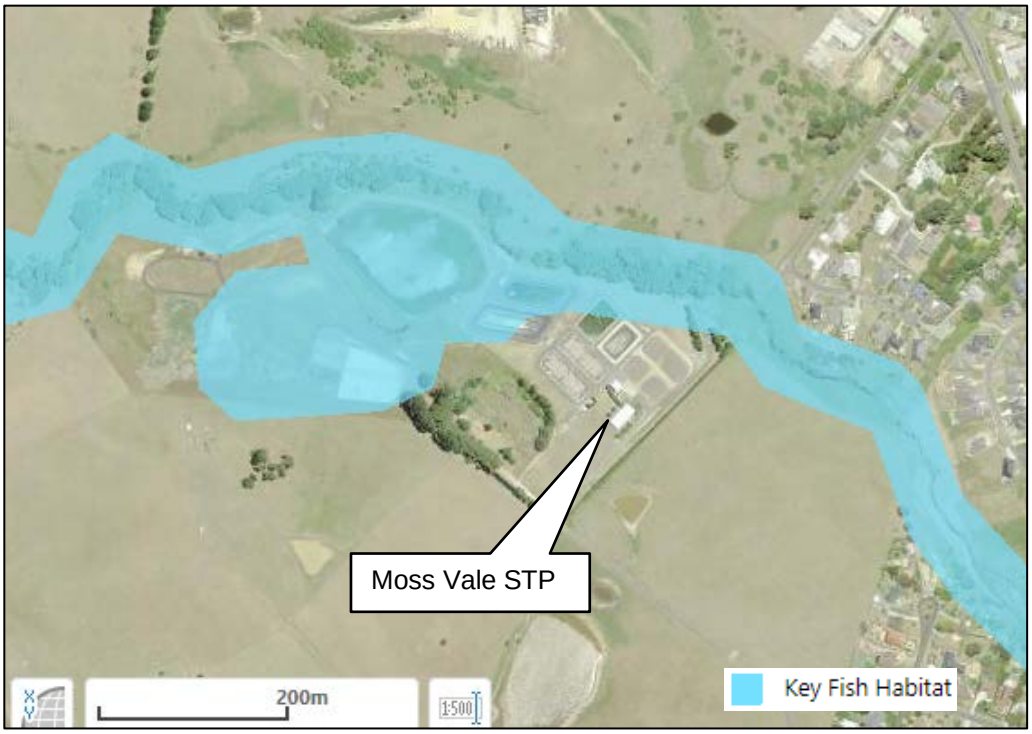


Figure 5.13 Hawkesbury Nepean Key Fish Habitat Map Extract

Source: Key Fish Habitat Maps, NSW Department of Primary Industries, Fisheries Spatial Data Portal, accessed March 2023



Figure 5.14 Moss Vale STP Typical ground cover and landscape trees

Source: NSW PW, 2020



Figure 5.15 Moss Vale STP site in area of upgrade works

Source: NSW PW, 2020

5.8.1 Construction Impacts

The proposed works would require tree removal and some minor vegetation removal, comprising several planted conifers and exotic grasses. 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 proposed development 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 the BC Act.

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 Whites Creek.

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 macroinvertebrate water monitoring assessment was undertaken by Sydney Water Monitoring Services (2022) comprising a monitoring program across two years, to determine the ecological impact of the Moss Vale STP discharges on Whites Creek. The following information is taken from the report. A copy of the report is provided in Appendix F.

The macroinvertebrate sampling for Moss Vale STP was carried out at two sites (shown in Figure 5.16) which are located upstream (MOS_US) and downstream (MOS_DS) of the 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 assessment found that taxa richness was similar between the upstream and downstream Moss Vale STP sampling sites and the overlapping ranges indicated no significant difference in the number of macroinvertebrate families between the sites. There was no clear seasonal trend between sites; in both autumn sampling occasions, the upstream site displayed slightly higher mean taxa richness, while in both spring sampling occasions the downstream site displayed higher mean taxa richness, although differences were small.

The biggest difference present between the two sites was in Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa. The upstream site only recorded EPT taxa on one occasion (Autumn 2021), while the downstream site consistently recorded EPT taxa at low levels. Leptoceridae,

Baetidae, Caenidae, and Hydroptiliae were all the families of EPT taxa found at these sites, all are relatively tolerant taxa. This difference could be due to a natural variation between sites. Stream Invertebrate Grade Number Average Level – National scores (SIGNAL2) and bi-plot placement for both sites indicated urban and/or agricultural pollution which is consistent with the surrounding land use for both sites. Stream Invertebrate Grade Number Average Level – Sydney Family (SIGNAL SF) scores were indicative of possible mild organic pollution for both sites, while Australian River Assessment System (AUSRIVAS) OE50 placed both sites within Band C which indicates a severe impact.

These results indicate both sites are under stress from pollutants. The upstream site is based in a more rural setting and would receive runoff from the surrounding area, and a stormwater pipe that discharges into the creek was observed. The downstream site is situated adjacent to a road and surrounded by primarily agricultural land with land clearing and bank erosion appearing to be issues. The road would also be a source of high runoff being an impervious surface that leads directly to the creek. This along with the Moss Vale STP discharge upstream would all contribute to a polluted waterway.

The assessment concluded that the differences between the upstream and downstream sampling 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.



Figure 5.16 Location of macroinvertebrate sampling sites including upstream (MOS US) and downstream (MOS DS) of the Moss Vale STP site.

Source: Sydney Water Monitoring Services, 2022

The water quality of the treated effluent discharged to Whites Creek would improve post STP upgrade compared to the current treated effluent quality. Based on the disturbed nature of the

STP site and above 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 5.7.

5.8.3 Mitigation Measures

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 the STP Upgrade works areas footprints as far as practical. 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 Whites Creek riparian corridor.
- The works area should be monitored for the spread of weeds.

5.9 Waste Management

5.9.1 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 waste management facility (or other suitably licenced landfill facility).

Excess cut material (spoil) would be produced during construction in the area of the bioreactor, southern clarifier, tertiary filters and UV channel. The cut would be reused for fill onsite as part of the cut/fill foundation works and any unsuitable materials such as organics, highly plastic material, waste and oversized particles would be removed and disposed of offsite at a licensed waste disposal facility (unless it can be reincorporated into the project works).

Soil testing undertaken on samples taken from the site detected the presence of chrysotile (white asbestos) and Amosite (brown asbestos) (associated with the previously demolished and covered trickling filter plant). However, no Asbestos containing material (ACM) debris was identified during subsequent targeted geotechnical assessment undertaken by D & N Geotechnical (D&N) (April, 2021) which focused on the location of the new STP infrastructure.

Any surplus spoil that is reused on the site 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).

Decommissioning and/demolition of Existing Facilities

Existing STP facilities associated with the former 1939 trickling filter STP may be encountered during the works. Demolition waste may include ACM (if the old trickling filter was encountered – albeit that they are expected to be below the datum of the foundations for the proposed new works).

Other demolition waste including electrical and mechanical equipment, steel, bricks and concrete is predicted to be the main source of waste materials to be generated by the Proposal. Demolition waste would 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 unsuitable material would be disposed to a licensed waste disposal facility in accordance with its waste classification.

Provided the implementation of recommended management measures, no adverse impacts associated with the waste is predicted during the construction works.

5.9.2 Operational Impacts

Waste solids generated during the operation of the Moss Vale STP would include:

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

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 bio-solids guidelines (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 truck trailer for disposal – with the truck trailer parked on a bunded hard stand area.

5.9.3 Mitigation Measures

Construction

- 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 shall be 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.
- Cleared vegetation (devoid of weeds) would be mulched and re-used on site as part of site stabilisation and revegetation. Excess mulch would be removed off site and disposed of in accordance with EPA requirements.
- If practicable, surplus excavated material/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 and excess spoil 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 waste disposal facility in accordance with its waste classification.
- Any waste or contaminated products (sewage, bio-solids, contaminated soil, etc.) are appropriately managed either within the STP site or by transport to a suitable approved landfill disposal site.

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 for the Use and Disposal of Biosolids Products* (EPA, 2000).
- Land application of biosolids (if proposed) would be controlled to prevent any off-site migration.

5.10 Heritage

A search of the Aboriginal Heritage Information Management System did not identify any Aboriginal sites or places within 200m of the STP site (refer to Appendix D).

The site is located within 200m of Whites Creek however the site has been heavily disturbed for the construction of the existing STP and access roads.

There are no State or local heritage listings that apply to the STP site. “Willow Grange” house and grounds (I1192) is the nearest listed heritage item to the site, located approximately 250m north-east of the STP on 34 Berrima Road (Lot 9 DP 1138934).

5.10.1 Construction Impacts

Works would be contained wholly within the STP site and therefore will not cause harm to any 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 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, the construction works would cease and safeguards listed below would be applied.

5.10.2 Operational Impacts

No impacts are predicted.

5.10.3 Mitigation Measures

- 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.

5.11 Greenhouse Gas Emissions

Existing Greenhouse Gas Emissions (GHG) from the STP are related to current energy usage, which is generated from conventional fuel sources.

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, tertiary treatment and inlet/digesters switchrooms and associated switchboards would also be required for the proposal.

5.11.1 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.

5.11.2 Operational Impacts

During operation of the upgraded Moss Vale 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 substation would meet the upgraded STP's power demands and allow capacity for future upgrades when required.

5.11.3 Mitigation Measures

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

- Council should consider the use of green energy or the installation of solar panels as part of any future sustainability projects.
- Energy efficient equipment or functions would be used where possible for the operation of the STP.
- STPs lighting to be minimised where possible.
- STP equipment and machinery would be suitably serviced and maintained during operation.

5.12 Chemical Management and Public Health

5.12.1 Operational Impacts

Chemical spills may occur as a result of the storage and use of alum, chlorine and carbon at the upgraded STP. This could result in offsite impacts. In order to avoid these impacts, liquid alum, chlorine and carbon would be stored in new bulk storage tanks within suitably bunded areas. The bunded areas would contain dosing pumps, sump pump, safety shower and eyewash facilities and would have a minimum storage volume of 110% of the total chemical volume stored.

The design features of these tanks are detailed in Section 4.2.17, 4.2.18 and 4.2.19. These design features 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. Safety Data Sheets would be available on site at all times. The risks associated with chemical management at the plant are considered low. No off-site impacts are anticipated to occur in relation to the use or handling of chemicals. Emergency response plans and procedures would be incorporated into the OEMP.

5.12.2 Mitigation Measures

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 an 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 impacts.

5.13 Visual Amenity

All of the proposed upgrade works would be located within the boundary of the 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 with planted trees screening the site, some distance from the town centre.

5.13.1 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.

5.13.2 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.

5.13.3 Mitigation Measures

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

5.14 Contamination

Ballpark Environmental (2022b) carried out a Preliminary In-Situ Waste Classification Assessment as part of the D & N Geotechnical Investigation (2022) for the Proposal to provide an in-situ waste classification by chemical assessment of the fill soils present within the site in general accordance with the NSW EPA W*aste Classification Guidelines, Part 1: Classifying Waste* (2014). A copy of the report is provided in Appendix I.

The waste classification assessment was undertaken as previous geotechnical investigation undertaken by PWA (2020) had encountered extensive fill material during the test pitting program within the location of the original STP trickling filters (constructed circa 1939). Waste material observed included terracotta pipes, geotextile, bituminous gravel and road base, bricks, steel pipe, reinforced concrete slabs, fibre fragments, wet waste, sludge and cement pipes and cobble and gravel sized trickling filter media. The PWA (2020) assessment also comprised asbestos detection testing. The tests detected the presence of chrysotile (White Asbestos) and Amosite (Brown Asbestos) in the soil adjacent to the location of the proposed new STP upgrade infrastructure.

The new STP clarifiers may be located within an area where there is buried trickling filters from the original STP. These trickling filters have previously been demolished and ballast media from the filter tanks was likely to have been buried in-situ and was observed to be present on this site. The buried ballast media may require excavation and removal; these materials may potentially be contaminated due to the prior contact with effluent.

Field investigation for the current works undertaken by D&N Geotechnical included the drilling of 13 boreholes, 9 within the location of the former tickling filter area and 3 to the west and 1 to the north of the site. The stratigraphy encountered during the geotechnical field investigation consisted of areas of fill, overlain residual soils overlying bedrock. The fill appeared to be associated with basalt ballast likely to have been previously used in the former trickling filters previously located within the site.

No ACM debris was identified during the D & N Geotechnical (2022) drilling program; however borehole drilling can limit the ability to fully observe the presence of buried fill materials and reduces the likelihood of discovery of ACM debris when compared to a test pitting investigation.

A total of 13 primary soil samples were submitted to a NATA accredited chemical laboratory for analysis of the adopted contamination suite for the Preliminary In-Situ Waste Classification Assessment (Ballpark Environmental,2022b).

The following outcomes were noted from the soil sample laboratory analysis results:

- Concentrations of metals were below the SCC1 – General Solid Waste or the laboratory's limit of reporting (LOR).
- Concentrations of TRH were below the SCC1 or the laboratory's limit of reporting (LOR).
- Concentrations of BTEX, PAH, OCP and PCB compounds were below the laboratory's LOR in the samples analysed.
- Concentrations of metals and BTEXN were below the values for leachable concentration, TCLP1 – General Solid Waste.
- No asbestos was identified in the soil samples analysed.

Based on the laboratory analysis results for the samples analysed, the in-situ fill soil material is classified as *General Solid Waste.* However, as ACM debris has previously been identified and confirmed by laboratory analysis at various locations within the site of the former trickling filters the fill material at this location is classified as *Special Waste – Asbestos Waste.*

As the underlying soils beneath the fill material are natural soils they may potentially be classified as Virgin Excavated Natural Material (VENM). However, additional investigation would be required to satisfy the NSW EPA requirements for VENM classification.

5.14.1 Construction Impacts

There is a possibility that ACM debris will be found at the STP site during excavation works in the vicinity of the original STP infrastructure this would impact on the ability to reuse the material on site. The buried original STP infrastructure materials may be contaminated due to the prior contact with effluent. Accordingly, during construction works the upper fill materials would need to be carefully excavated and stockpiled separately from the underlying natural soil materials to avoid cross contamination, as this fill material does not meet the requirements for VENM classification.

Implementation of an Unexpected Finds Protocol is recommended as part of the CEMP or as a stand-alone document if potentially contaminated fill material, ACM or buried unexpected finds are encountered during construction earthworks on the site.

5.14.2 Operational Impacts

No operational impacts predicted.

5.14.3 Mitigation measures

- An Unexpected Finds Protocol is recommended as part of the CEMP or as a stand-alone document if potentially contaminated fill material, suspected ACM or buried unexpected finds are encountered during construction earthworks on the site.
- If any previously unidentified contaminated material is encountered, or unknown materials are encountered, work will cease pending further sampling, the site secured and a safe work method statement(s) and appropriate documented practices would be implemented.
- During construction works the upper fill materials would need to be carefully excavated and stockpiled separately from the underlying natural soil materials to avoid cross contamination, as this fill material does not meet the requirements for VENM classification.
- Additional investigation will be required to pre-classify the natural soil materials at the site to satisfy the NSW EPA requirements for VENM classification.
- As ACM debris has previously been identified and confirmed by laboratory analysis at various locations within the site of the former trickling filters, the fill material at this location is classified as *Special Waste – Asbestos Waste.* Such material cannot be reused on the site and must be disposed of to a suitable waste facility.
- The CEMP would include measures to ensure compliance with all legislative requirements for the management and disposal of hazardous waste from the site during construction works. In particular, any asbestos removal work must comply with the relevant statutory requirements and current standards, codes and guidelines as published by SafeWork NSW and the National Occupational Health and Safety Commissions and be disposed at a waste disposal facility licenced to receive *Special Waste – Asbestos Waste.*
- The CEMP would include an asbestos management plan (AMP) to be prepared prior to work.
- Where practicable, all asbestos containing materials would be removed from the Site prior to any construction works.
- Classify any contaminated material encountered, after which the material would be stored, transported and disposed of in accordance with EPA requirements at an appropriately licensed waste disposal facility.

6. 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 regard 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

Action/Phase	Responsibility
Operation	
An OEMP for the upgraded Moss Vale 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; and 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

Action/Phase	Responsibility
Operation	
Operational noise emissions would be verified to demonstrate selected plant and equipment complies with Noise Policy for Industry (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 access tracks, road and culverts that would be used by heavy vehicles would be assessed for adequacy and upgrade 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 nearby waterways.	WSC /Contractor
Prior to the commencement of works, the contractor would prepare a dilapidation report for Kennedy Close and Willow Drive and the STP 'right of way' access road to identify areas of existing damage and the 'right of way' should be fenced for the duration of construction works.	Contractor
Construction	
The contractor would prepare a Traffic Management Plan as part of the CEMP, including a specific plan for delivery of imported fill material, to be reviewed by WSC prior to commencement of works. The Traffic Management	Contractor

Action/Phase	Responsibility
Plan would include measures to minimise traffic impacts ensure public safety and would be prepared in accordance with: • *TfNSW's Traffic Control at Work Sites Manual, Issued February 2022, and* • *Australian Standard 1742.3 - 2009 Traffic Control for Works on Roads.*	
Any disturbance to landowners due to vehicle movements and associated noise would be minimised by adhering to the working hours outlined in Section 5.3.3 of the REF.	Contractor
The contractor would ensure access to properties are not impacted (and/or managed).	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
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.	Contractor

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 machinery and vehicle emissions.

Actions

Action/Phase	Responsibility
Construction	
Construction vehicles and equipment would be suitably serviced within the six-month period prior to commencement of construction activities and all necessary maintenance undertaken during the construction period to meet EPA air quality requirements.	Contractor
All construction machinery would be turned off when not in use to minimise emissions.	Contractor
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	
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.	Contractor/WSC
An Odour Management Plan (OMP) should be adopted for the Moss Vale 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
WSC should adopt 'good neighbour' procedures and complaints register in line with the recommendations of the DoP Odour Guideline.	WSC

Action/Phase	Responsibility
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	
All fill placement and subgrade preparation should be constructed under Level 1 Geotechnical Inspection and Testing as defined in *AS3798-2007 Guidelines on Earthworks for Commercial and Residential Developments.*	Contractor
Re-used onsite fill material should be screened for such physical contaminants, reworked, and compacted as controlled fill.	Contractor
All imported fill material must be tested and pre-classified as either VENM or ENM in accordance with EPA waste classification requirements prior to being utilised as fill onsite for the STP upgrade construction.	Contractor
• A detailed Erosion and Sediment Control Plan (ESCP) shall be prepared as part of the CEMP. The ESCP 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 ESCP 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.	Contractor

Action/Phase	Responsibility
• 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 (including any borrow pits), 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 EPA requirements.	Contractor
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.	Contractor

Action/Phase	Responsibility
• 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 and water supply works approval (for pumping water) should be lodged through DPE - 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 DPE- Water prior to the commencement of works.	Contractor
Mitigation measures to manage groundwater (should it 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 in the event that 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	
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	WSC

Action/Phase	Responsibility
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.	WSC
The community would be notified of any incident with the potential to result in public health impacts.	WSC

6.2.6 Biodiversity

Objective

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

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 the STP Upgrade works areas footprints as far as practical. 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 Whites Creek riparian corridor.	WSC
The works area should be monitored for the spread of weeds.	WSC

6.2.7 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	
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	Contractor

Action/Phase	Responsibility
practices shall be 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.	
Cleared vegetation (devoid of weeds) would be mulched and re-used on site as part of site stabilisation and revegetation. Excess mulch would be removed off site and disposed of in accordance with EPA requirements.	Contractor
If practicable, surplus excavated material/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 and excess spoil 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 waste disposal facility in accordance with its waste classification.	Contractor/WSC
Any waste or contaminated products (sewage, bio-solids, contaminated soil, etc.) are appropriately managed either within the STP site or by transport to a suitable approved landfill disposal site.	Contractor
Operation	
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 for the Use and Disposal of Biosolids Products* (EPA, 2000).	WSC
Land application of biosolids (if proposed) would be controlled to prevent any off-site migration.	WSC

6.2.8 Heritage

Objective

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

Actions

Action/Phase	Responsibility
Construction	

Action/Phase	Responsibility
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

6.2.9 Greenhouse Gases Emissions

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
Reduce the number of traffic movements required.	Contractor
Energy efficiency requirements would be included in the site environmental induction.	Contractor/WSC
Operation	
Council should consider the use of green energy or the installation of solar panels as part of any future sustainability projects.	WSC
Energy efficient equipment or functions would be used where possible for the operation of the STP.	WSC
STPs lighting to be minimised where possible.	WSC
STP equipment and machinery would be suitably serviced and maintained during operation.	WSC

6.2.10 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
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 an 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

Action/Phase	Responsibility
The community would be notified of any incident with the potential to result in public health impacts.	WSC

6.2.11 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.	Contractor/WSC

6.2.12 Contamination

Objective

- Identify and adequately manage contaminated materials
- Compliance with *SafeWork NSW and the National Occupational Health and Safety Commissions and Protection of the Environment Operations Act 1997*

Actions

Action/Phase	Responsibility
Construction	
An Unexpected Finds Protocol is recommended as part of the CEMP or as a stand-alone document if potentially contaminated fill material, suspected ACM or buried unexpected finds are encountered during construction earthworks on the site.	Contractor
If any previously unidentified contaminated material is encountered, or unknown materials are encountered, work will cease pending further sampling, the site secured and a safe work method statement(s) and appropriate documented practices would be implemented.	Contractor
During construction works the upper fill materials would need to be carefully excavated and stockpiled separately from the underlying natural soil	Contractor

Action/Phase	Responsibility
materials to avoid cross contamination, as this fill material does not meet the requirements for VENM classification.	
Additional investigation will be required to pre-classify the natural soil materials at the site to satisfy the NSW EPA requirements for VENM classification.	Contractor
As ACM debris has previously been identified and confirmed by laboratory analysis at various locations within the site of the former trickling filters, the fill material at this location is classified as *Special Waste – Asbestos Waste.* Such material cannot be reused on the site and must be disposed of to a suitable waste facility.	Contractor
The CEMP would include measures to ensure compliance with all legislative requirements for the management and disposal of hazardous waste from the site during construction works. In particular, any asbestos removal work must comply with the relevant statutory requirements and current standards, codes and guidelines as published by SafeWork NSW and the National Occupational Health and Safety Commissions and be disposed at a waste disposal facility licenced to receive *Special Waste – Asbestos Waste.*	Contractor
The CEMP would include an asbestos management plan (AMP) to be prepared prior to work.	Contractor
Where practicable, all asbestos containing materials would be removed from the Site prior to any construction works.	Contractor
Classify any contaminated material encountered, after which the material would be stored, transported and disposed of in accordance with EPA requirements at an appropriately licensed waste disposal facility.	Contractor

7. Conclusions

WSC propose to upgrade the existing Moss Vale STP to increase the plant's capacity during the peak loads period and improve effluent discharge quality, in compliance with EPA requirements. It is proposed to upgrade the STP in stages, with the initial stage to accommodate peak loads up to 20,000 EP and to overcome current operational issues identified at the plant. The treatment infrastructure would be designed to meet growth projections with subsequent staged upgrades up to the year 2046 and meet environmental objectives from regulators such as the NSW Environment Protection Authority (EPA).

The proposed works would involve new inlet works, new pump stations, storm ponds (converted), two new bioreactors, new clarifiers, 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

Modelling has demonstrated that the design and operation of the upgraded plant and treatment capacity is sufficient for present and future peak loads while producing effluent that would meet expected EPA's discharge requirements.

Pursuant to the provisions of the EP&A Act, and EP&A Regulation, an environmental assessment of the proposed Moss Vale 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, and upon adoption of the safeguards identified, 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) / Biodiversity Development Assessment Report (BDAR) 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.

References

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Sydney Water Monitoring Services, 2022. *MHL – Southern Highlands Biological Monitoring Report.*

University of Newcastle, 2020. *Effluent samples - Oestrogens Analysis Memo Report to MHL.* Author. Dr. Geoff Macfarlane.

WaterNSW, 2022. Neutral or Beneficial Effect on Water Quality Assessment Guideline.

Appendix A – Consideration of Section 171

Section 171 of the EP&A Regulation 2021 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) the environmental impact on the 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 improved wastewater treatment services including reduced odour and noise impacts.

(b) the transformation of the locality

The works would be constructed wholly within the existing STP site and would be consistent with the existing use of the site. Any disturbance to ground surfaces during construction would be rehabilitated post construction.

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

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

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

The quality of treated effluent discharged to White Creek from the STP would be improved post-upgrade.

(e) the effect on any locality, place or building that has –

(i) aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance, or

(ii) other special value for present or future generations

No impacts identified.

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

The proposal would not impact habitat of protected fauna within the meaning of the *Biodiversity Conservation Act 2016*

(g) the endangering of a 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 *Environment Protection and Biodiversity Act* 1999, given the proper implementation of mitigation measure provided in Section 5.8.

(h) long-term effects on the environment

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

(i) degradation of the quality of the environment

Temporary minor impacts may occur during the construction works. However, the site would be appropriately landscaped/restored as part of construction works.

(j) risk to the safety of the environment

No impacts anticipated

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

No impacts anticipated

(l) pollution of the environment,

Asbestos removal may be required during the proposed works. Personal protective equipment and decontamination procedures to be implemented. If required, appropriate management measures would be implemented construction works and any ACM waste disposed of at an appropriately licensed waste disposal facility.

The reliability of the quality of treated effluent discharges would be more consistent compared to the existing treated effluent discharged to White Creek. The discharges would continue to meet EPA licence conditions.

(m) 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. All construction and operational waste would be disposed of at an appropriately licensed waste disposal facility.

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

None identified.

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

The Proposal has been designed in consideration of future population projections for the region and Moss Vale Enterprise Corridor (MVEC)

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

The Proposal site is not located in the coastal zone.

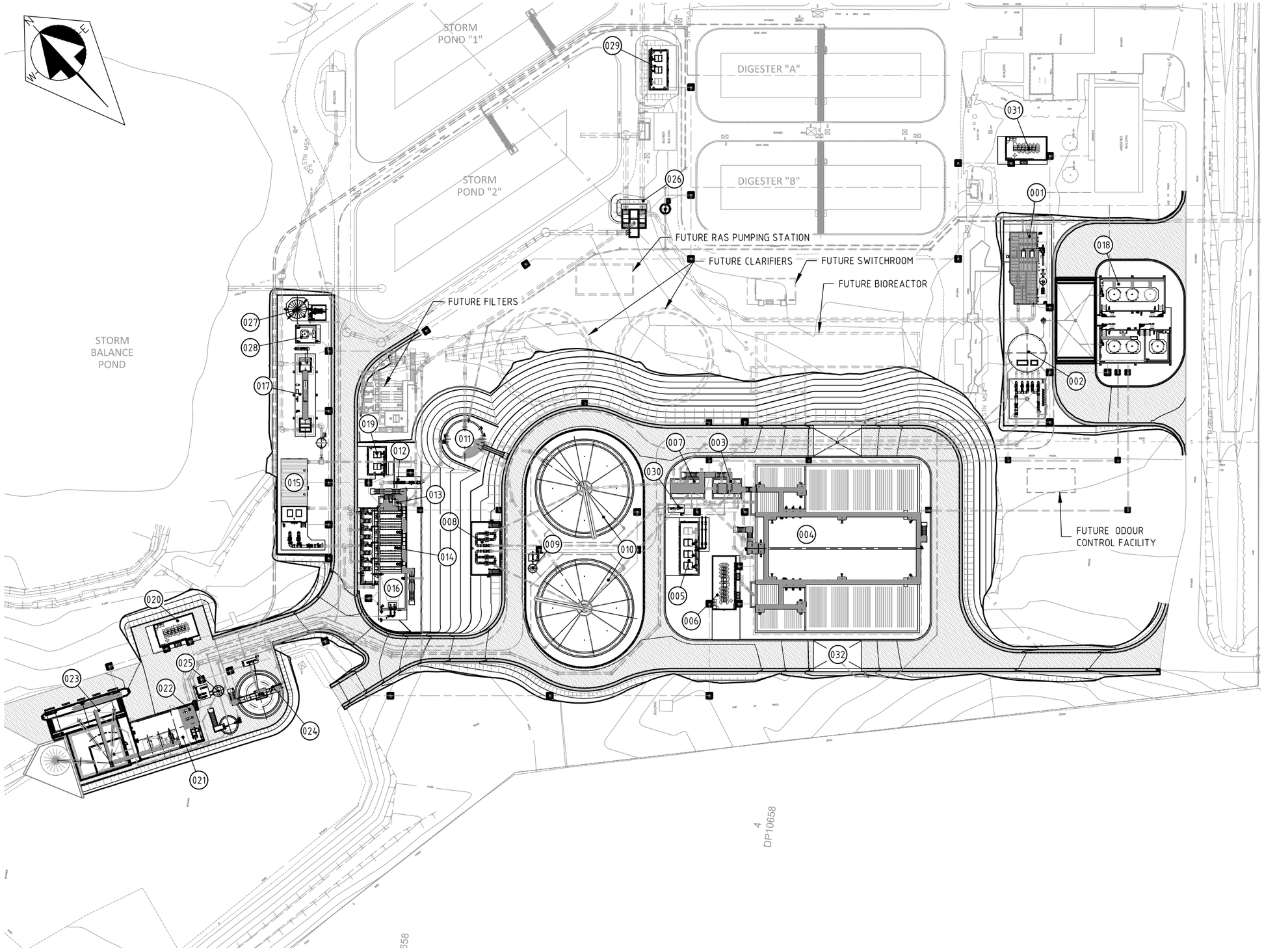
(q) applicable local strategic planning statements, regional strategic plans or district strategic plans made under the Act, Division 3.1,

The Proposal aligns with Objective 22: 'Strengthen cross-border connectivity and infrastructure coordination' of the *Draft South East and Tablelands Regional Plan 2041 (DPE,2022)* and Strategy 3.4: 'We have safe, maintained and effective assets and infrastructure' of the *Wingecarribee Shire Community Strategic Plan 2031 (WSC, 2017).*

(r) other relevant environmental factors.

None identified.

Appendix B – Plans



STRUCTURE LIST

ITEM NUMBER	DESCRIPTION	DRAWING NUMBER
001	INLET WORKS	C-045
002	LIFT PUMPING STATION	C-075
003	BIOREACTOR FEED SPLITTER	C-090
004	BIOREACTOR	C-130
005	BIOREACTOR BLOWER ROOM	C-470
006	BIOREACTOR SWITCHROOM	C-485
007	CLARIFIER FEED SPLITTER	C-110
008	RETURN ACTIVATED SLUDGE (RAS) PUMPING STATION	C-190
009	SCUM PUMPING STATION	C-355
010	CLARIFIERS	C-170
011	FILTER FEED CONTROL STATION	C-210
012	FILTER FEED FLOW METER	C-220
013	FLOCCULATION TANK	C-225
014	TERTIARY FILTERS	C-225
015	CLEARWATER BACK WASH TANK	C-270
016	DIRTY BACK WASH TANK	C-225
017	UV CHANNEL	C-295
018	CHEMICAL STORAGE BUNDS	C-560
019	AIR SCOUR BLOWER BUILDING	C-535
020	TERTIARY TREATMENT & DEWATERING SWITCHROOM	C-515
021	DEWATERING BUILDING	C-390
022	POLYMER DOSING AREA	C-407
023	SLUDGE OUTLOADING FACILITY	C-415
024	THICKENER AND TWAS PUMP	C-360
025	FOUL WATER PUMPING STATION	C-440
026	STORM SPLITTER	C-330
027	RE PUMPING STATION	C-315
028	SODIUM HYPOCHLORITE DOSING	C-590
029	DIGESTER BLOWER BUILDING	C-500
030	WAS PUMPING STATION	C-350
031	INLETWORKS SWITCHROOM	C-581
032	AERATION GRID WASHDOWN PAD	C-445

A3

AMENDMENTS			
A	20/05/22	PRELIMINARY	TJS
Ver	Date	Description	Drawn

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Designed	-	Checked	-
Drawn	TJS	Checked	-
Approved	-		
Date	-		
HH2O Project Number	5949		

HORIZONTAL
Co-ordinate System -
BM Adopted -
East - North -

VERTICAL
Datum -
BM Adopted -
Reduced Level -

Wingecarribee SHIRE COUNCIL

WINGECARRIBEE SHIRE COUNCIL
MOSS VALE STP UPGRADE

SITE ARRANGEMENT

Scale: **1:1000** at A3

Document No: **5804- C - 010**

Status: **PRELIMINARY**

Version: **A**

Appendix C – Consultation Responses

WINGECARRIBEE SHIRE COUNCIL

Our Ref: 7602, 7621, 7631
Contact: Jon Hook

16 November 2018

Mr Peter Bloem
Environmental Protection Authority
PO Box 513
WOLLONGONG NSW 2520

Dear Mr Bloem

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

In relation to the Environment Protection Authority's letters dated 19/9/18, Council provides the following responses in relation to the matters raised:

Bowral and Moss Vale

Council is currently undertaking the development of concept designs for the Moss Vale and Bowral STP's with the services of Public Works Advisory (PWA). It is anticipated that the draft concept reports for both of these projects will be available for the review and comment by representatives of the EPA, WaterNSW and Dept of Industries – Water in the coming weeks. Council has recently provided review comments to PWA on the first draft of the Bowral concept report and there is a meeting scheduled at the end of November to discuss the first draft of the Moss Vale concept report.

PWA is also preparing a preliminary Review of Environmental Factors as part of their scope of works for both the Moss Vale and Bowral projects as part of the concept development which should include the relevant considerations. PWA have been provided with a copy of the EPA's letter and in relation to the "Specific Considerations for Environmental Assessment of Moss Vale and Bowral STP Upgrades".

Council understands that representatives of Department of Industries – Water are currently coordinating a meeting with Council, PWA and representatives of the EPA to discuss the projects.

Council is advising that the proposed timing for the completions of the upgrades for Bowral and Moss Vale as suggested (End of 2020), is unachievable. Council advises that it has limited capacity to deliver large capital works projects at the same time. Council is intending to develop a proposed construction timeline as part of the concept development, in consultation with the various authorities, to assist in informing all parties of the proposed upgrade completions. A first draft of the possible Bowral Upgrade

timeline is attached for information, which suggests completion of the Bowral project by February 2022.

Council's concept design consultants, PWA, have reviewed the EPA letter in relation to Moss Vale and Bowral and have provided the separate comments that are attached for information.

The EPA are also advised that PWA are currently engaged for the development of concept designs of these two projects only and may not continue as the detailed design consultant into the future.

Mittagong

The release of the brief for the concept design of the Mittagong plant has been delayed while Council rewrites the brief to incorporate the considerations included in the EPA's letter. The EPA's letter will be included as part of the project scope for the consideration of consultants.

The project scope has been modified to enable consultant's to provide consideration of an "Aquatic Health Monitoring Program" as part of their submission, including their proposed methodology for discussion with the EPA prior to engagement of a consultant. Testing of the receiving waters will involve an extended delay to the delivery of the STP Upgrade and any improvements to outflow quality. Based on the draft Mittagong Pollution Reduction Program, it would appear the EPA is anticipating submission of the report for the Aquatic Health Monitoring Program in 18 months from agreement of the program of assessment. Following assessment of the outcomes of the report and any redesign of the treatment process and Section 60 approval, is essentially adding 2 years to the delivery of the upgrade project. But Council believes that by including the monitoring program as part of the concept development it can move to address the requirements of PRP1 more rapidly.

Development of a preliminary Review of Environmental Factors has been included as part of the scope of works for the Mittagong STP concept project.

Council is suggesting that the proposed timing for the completion of the upgrade of Mittagong as suggested (End of 2022), is unachievable, particularly if it is to follow the "Aquatic Health Monitoring Program". Council is intending to develop a proposed construction timeline as part of the concept development, in consultation with the various authorities, to assist in informing all parties of the proposed upgrade completions.

In relation to PRP2, Council will include the EPA letter as part of the project scope for the concept design and therefore feel that it will be in a better position to address these requirements, provide better informed comment and commit to a realistic delivery date once a suitable consultant is engaged and has had time to consider the project requirements.

Council's current upgrade strategy for Mittagong is to initially undertake an upgrade of the inlet works and storm flow diversion prior to the overall capacity upgrade. This should provide improved process operation and improved outflow quality in the short term and could be undertaken prior to the outcomes of the Aquatic Health Monitoring Program.

If you require additional information in relation to this matter please contact Council's Manager Water and Sewer, Jonathan Hook on jonathan.hook@wsc.nsw.gov.au or phone (02) 4868 0888.

Yours sincerely

Barry W Paull
Deputy General Manager Operations, Finance & Risk

(Enclosure)

Attachment 1: PWA Comments

EPA Items – 1-5 - Receiving Environment and Background Conditions

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". As per Table 3.3.3 the associated low risk trigger levels provided for this classification are provided in Table 2.

Council's ongoing instream testing shows that the receiving waters, Wingecarribee River (Bowral STP) and Whites Creek (Moss Vale STP), are impacted from 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. Council's testing is for the last five years at Bowral (134 records) and last three years at Moss Vale (39 records). The assessment covers dry and wet results (43 at Bowral).

Additional testing could be undertaken, especially at Moss Vale, however this may delay the delivery of the project. Further data from additional sources, such as WaterNSW, may be available for review.

Of interest is that the upstream water quality 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 3x the trigger level prior to receiving STP releases. The Total Nitrogen (TN) instream quality is around 3-4x the trigger level prior to receiving STP release. This is shown in Table 2.

Based on the assessment of the results it is shown 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.
- Phosphorus in the STP discharge from the Moss Vale STP has a slight impact on the instream quality of the Whites Creek with downstream values being 6% higher 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)
- Nitrogen based impacts are higher at Moss Vale with Total Nitrogen (TN) levels doubling due to the STP discharge. This may be indicative of the lower flows in White Creek as compared to the STP release volume (i.e. lower dilution potential).

Further detailed environmental assessment would need to be undertaken by specialists to determine the current river health, upstream and downstream of the STP releases, the extent that the STP impacts the waterways and downstream users. An investigation of this nature would be expected to take approximately 3-6 months to be undertaken and would likely involve further testing especially in Whites Creek which has had the least testing to date.

Table 1 – Comparison of ANZECC Low Risk Trigger Values, US and DS quality with STP Discharges

Bowral STP (fortnightly testing 2013-2018)				
Parameter	**ANZECC Default Trigger Value**	**U/S EPA Pt 11 Wingecarribee River**	**D/S EPA Pt 12 Wingecarribee River**	**STP EPA Pt 1**
Total Phosphorus:	20 µg/L	89 90 %ile 58 50 %ile	82 90 %ile 42 50 %ile	249 90 %ile 100 50 %ile
Total Nitrogen:	250 µg/L	1632 90 %ile 980 50 %ile	1431 90 %ile 1000 50 %ile	6800 90 %ile 5600 50 %ile
NOx	15	505 90 %ile 52 50 %ile	420 90 %ile 140 50 %ile	5146 90 %ile 3700 50 %ile
Ammonium NH4	13	94 90 %ile 50 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		
Moss Vale STP (monthly Testing 2015-2018)				
Parameter	**ANZECC Default Trigger Value**	**U/S EPA Pt 6 Whites Creek**	**D/S EPA Pt 12 Whites Creek**	**STP EPA Pt 1**
Total Phosphorus:	20 µg/L	165 90 %ile 64 50 %ile	124 90 %ile 68 50 %ile	44 90 %ile 19 50 %ile
Total Nitrogen:	250 µg/L	1400 90 %ile 630 50 %ile	4600 90 %ile 1330 50 %ile	6640 90 %ile 3220 50 %ile
NOx	15			6065 90 %ile 1970 50 %ile
Ammonium NH4	13			1588 90 %ile 700 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 7.2 50 %ile
Salinity:	30-350 µg/L	No testing results		
FC	Secondary contact - < 1000 FC/100mL			77 90 %ile 5 50 %ile
Aluminium	27-150µg/L pH>6.5	No testing results		

EPA Items – 6-8 Describe Proposal

Need for Upgrading

The upgrades are being undertaken to address the following areas:

- Capacity increases for future development
    - Bowral STP
        - Nominal capacity – 14,600 EP
        - Current load – 2.9 ML/d and 14,000 EP
        - Future load – 21,000 EP in 2046
    - Moss Vale STP
        - Nominal capacity – 9,000 EP
        - Current load – 2.8 ML/d and 11,600 EP
        - Stage 1 – 24,700 EP
        - Stage 2 – 36,000 EP (With Berrima and MVEC) in 2046
- Improved nutrient removal
    - Improved ammonia removal by increasing sludge age, provision of more efficient aeration and from chlorination/de-chlorination
    - Alum dosing for TP removal
- Wet weather handling facilities – All storm flows stored will receive screening and degritting prior to storage and return for treatment or release. Return pumping facilities at Bowral and Moss Vale STP.
- Catch/Balance pond modifications – To improve operations to allow better cleaning.
- Liquid alum dosing facility upgrade – For capacity increases
- Filtration upgrades
    - Bowral STP – Augmentation of cloth filters to enable full treatment to DDWF (3xADWF)
    - Moss Vale STP – Provision of cloth filters to enable full treatment to DDWF (3xADWF)
- Disinfection upgrades - For capacity. Full, validated disinfection for 3 x ADWF.
- Biosolids handling upgrade – sludge stabilisation and dewatering

The proposed Scope of Works is as follows for Bowral STP;

The concept developed for the plant augmentation includes the following proposed facilities:

- Reticulation network – Upgrade of the 450 mm section of the incoming gravity mains and the rising main into the STP (TBA);
- New inlet works incorporating mechanical fine screening and a grit removal system upstream of the lift pumping station;

- Conversion of the existing raw sewage lift pump station into a screened sewage pump station;
- Reconstruction of the storm detention pond to improve drainage and cleanup operations;
- Conversion of the Pasveer Channels into an intermediate storm detention pond;
- De-rating of existing IDEA reactor by the use of a more conservative criteria;
- New IDEA reactor for the secondary treatment with either a box configuration or a lagoon type to ensure that the total IDEA treatment capacity will be 21,000;
- New alum and caustic storage and dosing systems for the increased load;
- New catch/balance tanks. The existing balance pond will become an emergency storage pond and the existing overflow to the tertiary pond will be continued to be used;
- A return pump station from the tertiary ponds to the inlet works to treat effluent during low flow periods;
- Upgraded filtration system;
- Upgraded UV disinfection system;
- Chlorination/de-chlorination to meet future NorBE requirements;
- Conversion of the sludge lagoon in to an aerobic digester to replace the sludge lagoons – an alternative would be to provide a 3rd sludge lagoon;
- Mechanical dewatering machines, volute dehydrator or similar, sited where the existing sludge dewatering area is;
- A telemetry system upgrade to cover new elements, Programmable logic control (PLC) and supervisory control and data acquisition (SCADA) system upgrade for plant operational monitoring and control;
- Electrical services including power supply transformer upgrading, a switch room and cabling, pits and conduits for the new infrastructure. A PV system to minimise power costs;
- New buildings, site services and site pipework and pits.

The proposed Scope of Works is as follows for Moss Vale STP;

The concept developed for the plant augmentation includes the following proposed facilities:

Stage 1 to 24,700 EP;

- New inlet works incorporating mechanical fine screening and a grit removal system upstream;
- Provision of a storm detention pond with a capacity of 6.5 ML;
- Provision of a storm detention pond return PS for the existing 17 ML pond;
- Increase the capacity of the existing IDEA reactors to 6,700 EP each by upgrading the aeration system;
- New IDEA reactor for the secondary treatment with either a box configuration or a lagoon type 11,300 EP;

- New alum dosing systems for the increased load (correction for pH will not be necessary since calcium nitrate in the sewerage system was implemented for odour and septicity control);
- Upgrade existing catch/balance ponds;
- New catch/balance tank 2.2 ML;
- Filtration system;
- Upgraded UV disinfection system;
- Chlorination/de-chlorination to meet future NorBE requirements;
- Two new sludge lagoons or an aerobic digester;
- Mechanical dewatering machines, volute dehydrator or similar, sited where the existing sludge dewatering area is;
- A telemetry system upgrade, PLC, SCADA system upgrades;
- Electrical services including power supply transformer upgrading, a PV system to minimise power costs;
- New buildings, site services and site pipework and pits.

Stage 2 to 36,000 EP

- New IDEA reactor for the secondary treatment with either a box configuration or a lagoon type 11,300 EP;
- New catch/balance tank 2.2 ML;
- Expansion of filtration system;
- Expansion of UV system;
- Provide a 3rd sludge lagoon (if an aerobic digester was not built in Stage 1);
- Expansion of the mechanical dewatering system;
- Expansion of the electrical systems and site services for the new structures.

Discharge Volumes – Effluent from Existing EPA Release Points

Dry weather

The 2016 and predicted future dry weather discharge volumes of treated effluent from the STP's are shown in Table 2.

Table 2: Discharge Volumes from Bowral and Moss Vale STPs

	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 Pt 1	3.562	3.796	3.942	4.059	4.197	4.339	4.486
Moss Vale STP (EP)	11,600	15,666	19,733	23,800	27,866	31,933	36,000
ADWF (ML/d) EPA Pt 1	2.784	3.760	4.736	5.712	6.688	7.664	8.640

Wet weather

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.

Discharge Quality – Effluent from Existing EPA Release Points to meet NorBE

Dry Weather

The NorBE baseline has been assessed on the actual loads discharged to the Wingecarribee River and Whites Creek calculated from the fortnightly testing undertaken at Bowral and monthly testing at Moss Vale STPs.

As shown in **Table 3**, the effluent quality from the STPs is currently lower than the NSW EPA Licence limits and indicates that the plants are being operated well, especially in dry weather.

Population is predicted to increase by 40% from the current load to the design horizon in 2046 at Bowral and by 320% at Moss Vale (this includes Moss Vale growth, MVEC and Berrima). Therefore, to achieve a nil increase in loads to the receiving waters (NorBE), a reduction factor of 40% and 320% has been applied for the effluent pollutant concentrations to be released.

Previous assessments and the current investigations have found that due to the climate in the Southern Highlands reuse will be limited and have little impact on the receiving water discharges. This assumes that other measures for reducing effluent discharge to the waterways, such as effluent reuse, are minimal.

The predicted 50 percentile effluent quality limits were estimated and are presented in Table **3**3.

Table 3: Comparison of EPA Licence, Current and Future Pollutant Levels

Bowral STP						
	Current EPA Licence 50 %ile level (mg/L)	**Current EPA Licence 90 %ile level (mg/L)**	**Current Effluent 50%ile level (mg/L)**	**Current Effluent 90 %ile level (mg/L)**	**Predicted Future Limits to meet NorBE (mg/L)**	
Total suspended solids	10	15	4	8	3	
Ammonia Nitrogen		2	0.6	1.3	0.5	
TN	7.5	10	5.6	6.8	4.0	
TP	0.3	0.5	0.13	0.25	0.09	
BOD	5	10	2.0	4	1.4	

Moss Vale STP						
	Current EPA Licence 50 %ile level (mg/L)	**Current EPA Licence 90 %ile level (mg/L)**	**Current Effluent 50 %ile level (mg/L)**	**Current Effluent 90 %ile level (mg/L)**	**NorBE Target (Stage 1 - 2032) (mg/L)**	**NorBE Target (Stage 2- 2046) (mg/L)**
Total suspended solids	10	15	4	7	2.81	1.04
Ammonia Nitrogen		2	0.7	1.6	0.52	0.19
TN	7.0	10.0	3.79	6.96	2.72	1.01
TP	0.5	1.0	0.2	0.52	0.18	0.07
BOD	7.0	10	<1	1	0.30	0.11

Wet weather

Each plant provides primary, secondary and tertiary treatment and storm flow facilities. These provide full treatment for flows to 3xADWF. Partial treatment would be achieved for flows 3-7xADWF. Primary treatment for flows > 7xADWF when the storm detention volume has been exceeded. The Storm detention volume at each plant is as follows;

- Bowral STP
    - Existing Storm Detention Pond (SDP) – 17 ML
    - Augmented – Existing Storm Detention Pond (SDP) 11 ML and new SDP 3 ML – 3.7 days ADWF (2021) and 3 days ADWF (2046) or 1 day storage of storm flows (10-7xADWF)
- Moss Vale STP
    - Existing SDP - 17.3 ML
    - Augmented – Existing SDP 17.3 ML and new SDP 6.5 ML – 6 days ADWF (2021) and 2.75 days ADWF (2046) or 1.3 days reducing to 1 day's storage of storm flows (10-7xADWF)

Treatment Infrastructure Proposed to Meet NorBE

The current STPs are modern standard activated sludge based plants. The current STPs have been proven to provide a very good level of treatment. As shown in Table 3, the effluent quality from the STPs is currently meeting the NSW EPA limits with some exceedances mainly due to wet weather and capacity deficiencies. The augmented plants will address these current issues and improve treatment performance in the future to achieve NorBE requirements.

The upgrade of the two STPs has been based on the continued use of the PWA developed intermittently decanted extended aeration (IDEA) process. Conformance to the expected more stringent future effluent quality requirements is to be achieved by adding/upgrading of tertiary treatment facilities. The IDEA process with additional tertiary treatment facilities has the following advantages over the alternative treatment types such as MBRs;

Makes use of existing treatment units

- Bowral STP - a new MBR to replace the existing STP would cost around $32M as against $20M for the upgraded IDEA STP

- Moss Vale STP - a new MBR to replace the existing STP would cost around $59M for as against $37M for the upgraded IDEA STP

Equivalent nutrient removal – The MBR process uses a MLE biological process followed by membrane filtration. This results in a low SS effluent, however nutrient removal will be similar to an IDEA.

Robust design – IDEA have a long sludge age process, 20-25 days

Better able to handle wet weather inflows – MBR are limited to around 2-2.5 xADWF. All additional inflows will need to be diverted to a SDP and then treated once inflows have returned to normal. Cumulative storm and wet weather periods will lead to an increased rate of discharge.

Table 4: Likely Treatment Requirements for Receiving Waters

Treatment Process Requirements	Bowral STP to meet NorBE	Moss Vale STP to meet NorBE (Stage 1)	Moss Vale STP to meet NorBE (Stage 2)
Primary Treatment	✓	✓	✓
Secondary Treatment			
Extended Aeration	✓	✓	✓
Chemical P removal	✓	✓	✓
Tertiary Treatment			
Filtration – Conventional Cloth	**✓ (additional new)**	**✓ (new)**	**✓ (polymer and flocculation facilities added for improved P removal)**
Breakpoint Chlorination (enhanced ammonia removal)	**✓ (new)**	**✓ (new)**	**✓ (new)**
UV disinfection	✓	✓	✓
Filtration - Membrane Ultra-filtration – as first stage for RO			**✓ (potential future addition)**
Reverse Osmosis (removal of oxidised nitrogen)			**✓ (potential future addition)**

EPA Items – 9 - 16 – Impact Assessment – predict impacts and environmental outcomes

It is considered that a specialist water quality assessment would be required to address these requirements to the EPA's satisfaction. The water quality assessment would be informed by the STP design information such as the contribution of the STP to pollutant loads in the waterways and background studies of the catchment (likely to be available from WaterNSW and / or Council). These assessments will require additional time, which will delay the STP augmentations further.

Item 9 – to be addressed by the water quality assessment.

Item 10 – to be addressed by the water quality assessment.

Items 11 to 13 – these items are generally concerned with the initial mixing zone of the discharge. These items would need to be addressed by the water quality assessment and design information. If sufficient information with regards to the ecological sensitivity of the downstream environment is not available, input from an (external) ecologist in relation to impacts on aquatic ecology may be required.

Item 14 – to be addressed as part of the water quality assessment.

Item 15 – PWA could undertake an assessment of impacts on groundwater and groundwater dependent ecosystems for the construction and operation of the STP infrastructure within the STP site, assuming that geotechnical investigations identify the presence of groundwater on the sites. However, if discharges from the STP also have the potential to impact on groundwater quality (i.e. through recharge) a specialist water quality assessment would be required to address any such impacts.

Item 16 – to be addressed as part of concept design activities.

EPA Items – 17 - 19 – Management and Mitigation

Item 17 –PWA can address through a review of the information provided by the concept design and water quality assessment. It is noted that design information currently at hand indicates that "previous assessments and the current investigations have found that due to the climate in the southern highlands reuse will be limited and have little impact on receiving water discharges". These previous assessments and current investigations would be reviewed to justify discharge as the preferred option for disposal of treated effluent.

Item 18 –PWA can address, assuming that any required stormwater infrastructure/management during operation of the upgraded STPs would be considered in the concept design.

Item 19 –PWA can address through a review of the information provided by the previous assessments, concept design and any relevant information from the water quality assessment.

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Penrith NSW 2750
Ph: 1300 722 468
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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.

NorBE Assessment Requirements

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.

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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

PO Box 398, Parramatta NSW 2124
Level 14, 169 Macquarie Street
Parramatta NSW 2150
www.waternsw.com.au
ABN 21 147 934 787

22 October 2018

Contact: *Miles Ellis*
Telephone: *9865 2502*
Our ref: *D2018/114721*

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

Dear Ms Parmeter

Subject: Upgrade of Moss Vale Sewage Treatment Plant

WaterNSW appreciates the notification that NSW Public Works Advisory has been engaged by Wingecarribee Shire Council (WSC) to prepare a Review of Environmental Factors (REF) for the upgrade of Moss Vale Sewage Treatment Plant (STP), seeking WaterNSW's comments on the proposal for inclusion in the REF 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 quality assessment for the considered Wingecarribee STP 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
  - 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.
  - The proposed raw sewage detention pond and emergency storage pond should have sufficient capacity to prevent any overflow of raw sewage.
  - Provision for power supply back-up in the event of a power failure at a 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 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
  - 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
  - potential for run-off from any biosolids processing, storage or application areas to enter Whites Creek.
- An assessment of the proposed access road, with specific details of any crossing of Whites Creek from Gibbons Road.
- Conceptual Construction Environmental Management plan (CEMP) incorporating a Conceptual Soil & Water Management Plan (SWMP) for the construction phase of the project.

WaterNSW is happy to engage further with NSW Public Works Advisory as the preparation of the environmental impact assessment for this upgrade proceeds.

If you wish to discuss the matter further, please contact Miles Ellis on 9865 2502.

Yours sincerely

MALCOLM HUGHES
Manager Catchment Protection

PO Box 398, Parramatta NSW 2124
Level 14, 169 Macquarie Street
Parramatta NSW 2150
www.waternsw.com.au
ABN 21 147 934 787

19 September 2018

Contact: *Malcolm Hughes*
Telephone: *9865 2520*
Our ref: D2018/102620

Mr Barry Paull
Deputy General Manager
Wingecarribee Shire Council
PO Box 141
MOSS VALE NSW 2577

Dear Mr Paull

Subject: Upgrade of Sewage Treatment Plants

I refer to the meeting held at Council on the 31 July 2018 in relation to the proposed upgrade of Moss Vale, Mittagong and Bowral sewage treatment plants (STPs). The meeting was attended by staff from Council, EPA and WaterNSW. The briefing by Council was very informative and appreciated. WaterNSW is pleased Council has made a significant commitment to the upgrade of these STPs.

WaterNSW – including it's predecessor - the Sydney Catchment Authority – provided substantial funds to Council over many years to assist in improving Council's sewerage system with the aim of protecting and enhancing the quality of water in local waterways. This was part of a program – concluded in 2013 - to improve treatment of sewage across the entire Sydney drinking water catchment. The program resulted in significant reductions in nutrient loads from STPs throughout the catchment and reduced the threat to public health from pathogens.

WaterNSW understands Council needs to undertake further upgrades to its STPs in response to continuing growth in its towns and villages and to meet requirements from regulators. WaterNSW considers that 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.

The above is consistent with the following aims of State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 (the SEPP):

- *to provide for healthy water catchments that will deliver high quality water while permitting development that is compatible with that goal, and*
- *to support the maintenance or achievement of the water quality objectives for the Sydney drinking water catchment.*

WaterNSW understands Council will assess the upgrades pursuant to Part 5 of the *Environmental Planning and Assessment Act, 1979* and has engaged Public Works to prepare environmental assessment documents.

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.*

WaterNSW in its letter to Council dated 16 October 2015 (our reference D2015/106347) contains specific advice on undertaking a neutral or beneficial effect on water assessment for these upgrades. We would welcome a discussion on this advice including consideration of extended dry periods.

As advised during the meeting WaterNSW is happy to continue to engage with Council and the EPA (and Public Works), as these important upgrades proceed.

If you wish to discuss further, please contact me on 9865 2520.

Yours sincerely

MALCOLM HUGHES
Manager Catchment Protection

cc: Mr Peter Bloem
Environment Protection Authority
Level 3, 84 Crown St
WOLLONGONG NSW 2500

Natural Resources Access Regulator

Phone: 1800 663 362
Email: nrar.servicedesk@industry.nsw.gov.au

Public Works Advisory
PO Box N408
Grosvenor Place NSW 1220

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

Dear Sir/Madam

14 April 2020

Review of Planning Proposals

Thank you for giving the Natural Resources Access Regulator (NRAR) the opportunity to comment on the following planning proposals:

- Moss Vale Sewage Treatment Plant Upgrade - Review of Environmental Factors - Notification Letter (Our reference: V15/3876-3#20)

NRAR has received a high volume of inquiries/proposals and acknowledges no formal response to this/these referral has been provided to date.

Works on waterfront land are to be conducted in accordance with NRAR's Guidelines for Controlled Activities on Waterfront Land. Further information, including the Guidelines and exemptions can be found at -

https://www.industry.nsw.gov.au/water/licensing-trade/approvals/controlled-activities

Any extraction of groundwater or surface water must be licensed under the Water Management Act 2000. Further information on water licensing and exemptions can be found at -

https://www.industry.nsw.gov.au/water/licensing-trade/licences

This letter does not represent the endorsement of the referred matter and NRAR has not completed a formal review. If Council requires a formal response to a referral matter listed above, please contact NRAR as soon as possible. This matter will be closed out after 21 days from the date of this letter.

Should you have any further queries in relation to this letter please do not hesitate to contact nrar.servicedesk@industry.nsw.gov.au.

Yours sincerely

Alison Collaros
Licensing and Approvals Manager (East)

Natural Resources Access Regulator
Department of Planning, Industry and Environment

Department of Primary Industries

Our Ref: C18/645

26 November 2018

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

Dear Ms Parmeter

Subject: Moss Vale Sewage Scheme Upgrade – Review of Environmental Factors

Thank you for your letter dated 19 October 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 Whites 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 Whites 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

Dredging and reclamation. 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.

Removal or movement of Large Woody Debris (snags) or boulders. 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

Office of Environment & Heritage

NSW GOVERNMENT

Date: 30 October 2018
Your reference: Moss Vale STP
Our reference: DOC18/823974
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: Moss Vale Sewage Treatment Plant Upgrade
Review of Environmental Factors

Thank you for referring the abovementioned proposal for proposed upgrade works to the Moss Vale sewage treatment plant (STP) at Kennedy Close, Moss Vale. 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.

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, and threatened Paddys River Box (*Eucalyptus macarthurii*) individuals within the vicinity of the subject site. The Whites Creek 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 Whites 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. 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.

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 Whites Creek Flood Risk Study & Management Plan (FRSMP). This FRSMP is currently under review, and we suggest you liaise with Sha Prodhan, Council's Floodplain & Stormwater Engineer in this regard.

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
Senior Conservation Planning Officer, Planning (Illawarra)
South East Branch
Conservation & Regional Delivery

Attachment A: OEH suggested assessment requirements for Moss Vale STP upgrade works REF
Attachment B: Relevant guidance material

ATTACHMENT A: OEH SUGGESTED ASSESSMENT REQUIREMENTS FOR MOSS VALE SEWAGE TREATMENT PLANT UPGRADE 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 Whites Creek 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 apply:

- The proposed SIS must be set out in accordance with the requirements as described 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/
Threatened Species Assessment Guidelines: the Assessment of Significance (DECC 2007)	http://www.environment.nsw.gov.au/research-and-publications/publications-search/threatened-species-assessment-guidelines
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

Appendix D – AHIMS Search Results

AHIMS Web Services (AWS)
Search Result

Your Ref/PO Number : Moss Vale STP

Client Service ID : 760581

Public Works Advisory

Date: 06 March 2023

66 Harrington Street
Sydney New South Wales 2000

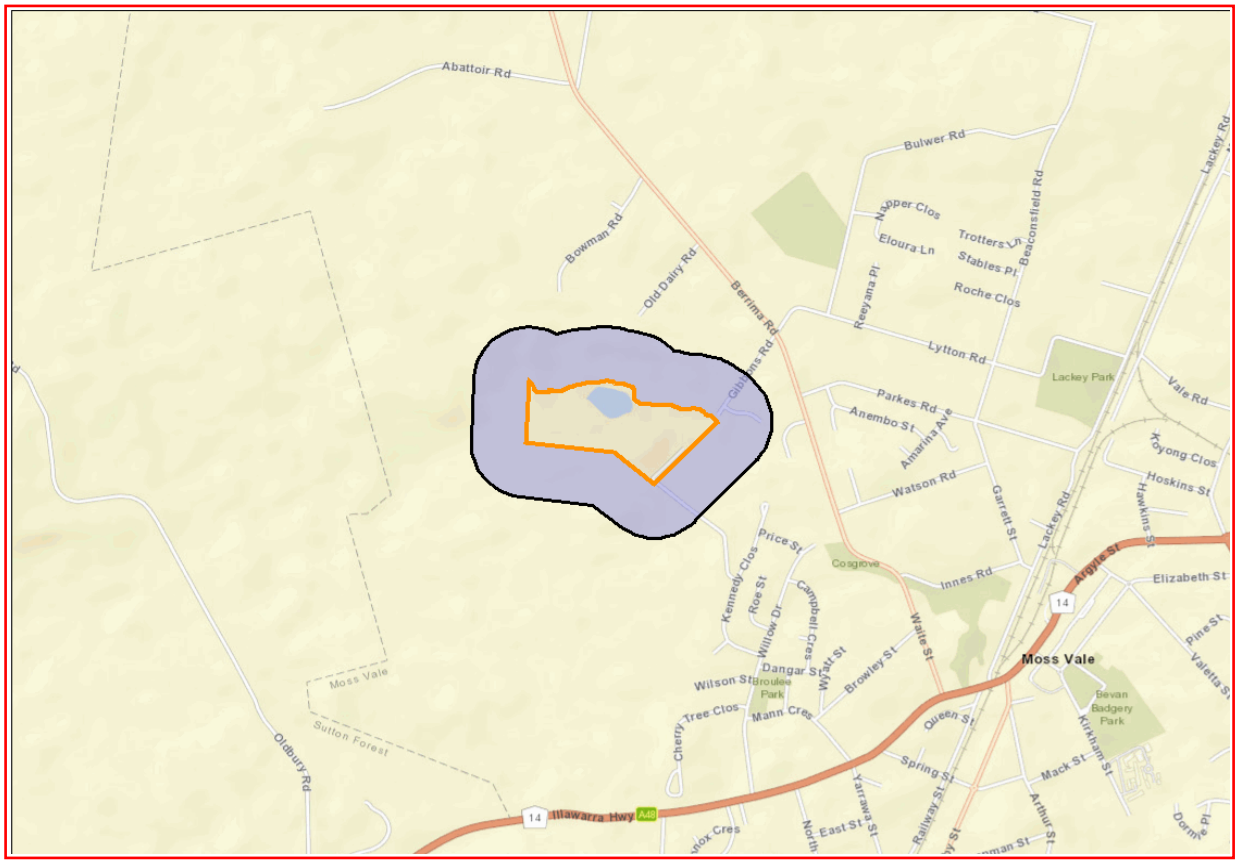
Attention: Kristen Parmeter

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

Dear Sir or Madam:

AHIMS Web Service search for the following area at Lot : 2, DP:DP187926, Section : - with a Buffer of 200 meters, conducted by Kristen Parmeter on 06 March 2023.

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 Heritage NSW 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 (https://www.legislation.nsw.gov.au/gazette) website. Gazettal notices published prior to 2001 can be obtained from Heritage NSW 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 Heritage NSW 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.

Level 6, 10 Valentine Ave, Parramatta 2150
Locked Bag 5020 Parramatta NSW 2124
Tel: (02) 9585 6345

ABN 34 945 244 274
Email: ahims@environment.nsw.gov.au
Web: www.heritage.nsw.gov.au

Appendix E – Flora and Fauna Search Results

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: -34.49 West: 150.31 East: 150.41 South: -34.59] returned a total of 635 records of 24 species.

Report generated on 20/03/2023 6:45 PM

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		6	
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	1	
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		8	
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	E	23	
Animalia	Aves	Cacatuidae	0265	*^Calyptorhynchus lathami*		Glossy Black-Cockatoo	V,P,2	V	11	
Animalia	Aves	Artamidae	8519	*Artamus cyanopterus cyanopterus*		Dusky Woodswallow	V,P		7	
Animalia	Aves	Petroicidae	0380	*Petroica boodang*		Scarlet Robin	V,P		5	
Animalia	Aves	Petroicidae	0382	*Petroica phoenicea*		Flame Robin	V,P		2	
Animalia	Mammalia	Phascolarctidae	1162	*Phascolarctos cinereus*		Koala	E1,P	E	8	
Animalia	Mammalia	Petauridae	1137	*Petaurus norfolcensis*		Squirrel Glider	V,P		1	
Animalia	Mammalia	Pteropodidae	1280	*Pteropus poliocephalus*		Grey-headed Flying-fox	V,P	V	27	
Animalia	Mammalia	Vespertilionidae	1357	*Myotis macropus*		Southern Myotis	V,P		3	
Animalia	Mammalia	Miniopteridae	3330	*Miniopterus orianae oceanensis*		Large Bent-winged Bat	V,P		3	
Plantae	Flora	Fabaceae (Faboideae)	2957	*Phyllota humifusa*		Dwarf Phyllota	V	V	1	
Plantae	Flora	Fabaceae (Mimosoideae)	3728	*Acacia bynoeana*		Bynoe's Wattle	E1	V	1	
Plantae	Flora	Myrtaceae	4038	*Eucalyptus aggregata*		Black Gum	V	V	1	
Plantae	Flora	Myrtaceae	4038	*Eucalyptus aggregata*		Eucalyptus aggregata population in the Wingecaribee local government area	E2,V	V	1	
Plantae	Flora	Myrtaceae	4119	*Eucalyptus macarthurii*		Paddys River Box, Camden Woollybutt	E1	E	513	
Plantae	Flora	Proteaceae	7677	*Persoonia glaucescens*		Mittagong Geebung	E1,P	V	1	
Plantae	Flora	Proteaceae	8997	*Persoonia mollis subsp. revoluta*			V,P		1	

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. Please see the caveat for interpretation of information provided here.

Report created: 20-Mar-2023

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements

Summary

Matters of National Environment 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 (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	5
Listed Threatened Species:	66
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 https://www.dcceew.gov.au/parks-heritage/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 Lands:	15
Commonwealth Heritage Places:	None
Listed Marine Species:	21
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	2
Regional Forest Agreements:	1
Nationally Important Wetlands:	None
EPBC Act Referrals:	8
Key Ecological Features (Marine):	None
Biologically Important Areas:	None
Bioregional Assessments:	1
Geological and Bioregional Assessments:	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.
Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.

Community Name	Threatened Category	Presence Text	Buffer Status
Natural Temperate Grassland of the South Eastern Highlands	Critically Endangered	Community likely to occur within area	In feature area
Robertson Rainforest in the Sydney Basin Bioregion	Critically Endangered	Community likely to occur within area	In buffer area only
Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion	Critically Endangered	Community likely to occur within area	In feature area
Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion	Endangered	Community likely to occur within area	In feature area
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Community likely to occur within area	In feature area

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text	Buffer Status
BIRD			
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area	In feature area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Callocephalon fimbriatum Gang-gang Cockatoo [768]	Endangered	Species or species habitat known to occur within area	In feature area
Calyptorhynchus lathami lathami South-eastern Glossy Black-Cockatoo [67036]	Vulnerable	Species or species habitat known to occur within area	In feature area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area	In feature area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area	In buffer area only
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area	In feature area
Polytelis swainsonii Superb Parrot [738]	Vulnerable	Species or species habitat may occur within area	In feature area
Pycnoptilus floccosus Pilotbird [525]	Vulnerable	Species or species habitat known to occur within area	In feature area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area	In feature area
FISH			
Macquaria australasica Macquarie Perch [66632]	Endangered	Species or species habitat known to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
[Prototroctes maraena](#) Australian Grayling [26179]	Vulnerable	Species or species habitat may occur within area	In buffer area only
FROG			
[Heleioporus australiacus](#) Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat likely to occur within area	In buffer area only
[Litoria littlejohni](#) Littlejohn's Tree Frog, Heath Frog [64733]	Endangered	Species or species habitat may occur within area	In buffer area only
[Litoria watsoni](#) Watson's Tree Frog [91509]	Endangered	Species or species habitat likely to occur within area	In feature area
[Mixophyes balbus](#) Stuttering Frog, Southern Barred Frog (in Victoria) [1942]	Vulnerable	Species or species habitat may occur within area	In buffer area only
INSECT			
[Keyacris scurra](#) Key's Matchstick Grasshopper [89739]	Endangered	Species or species habitat likely to occur within area	In buffer area only
MAMMAL			
[Chalinolobus dwyeri](#) Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area	In feature 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	In feature area
[Isoodon obesulus obesulus](#) Southern Brown Bandicoot (eastern), Southern Brown Bandicoot (south-eastern) [68050]	Endangered	Species or species habitat likely to occur within area	In feature area
[Notamacropus parma](#) Parma Wallaby [89289]	Vulnerable	Species or species habitat may occur within area	In buffer area only
[Petauroides volans](#) Greater Glider (southern and central) [254]	Endangered	Species or species habitat known to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
[Petaurus australis australis](#)			
Yellow-bellied Glider (south-eastern) [87600]	Vulnerable	Species or species habitat likely to occur within area	In feature area
[Petrogale penicillata](#)			
Brush-tailed Rock-wallaby [225]	Vulnerable	Species or species habitat may occur within area	In buffer area only
[Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)](#)			
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Endangered	Species or species habitat known to occur within area	In feature area
[Potorous tridactylus trisulcatus](#)			
Long-nosed Potoroo (southern mainland) [86367]	Vulnerable	Species or species habitat may occur within area	In buffer area only
[Pseudomys novaehollandiae](#)			
New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat may occur within area	In feature area
[Pteropus poliocephalus](#)			
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area	In feature area
PLANT			
[Acacia bynoeana](#)			
Bynoe's Wattle, Tiny Wattle [8575]	Vulnerable	Species or species habitat may occur within area	In buffer area only
[Boronia deanei](#)			
Deane's Boronia [8397]	Vulnerable	Species or species habitat likely to occur within area	In feature area
[Caladenia tessellata](#)			
Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat may occur within area	In feature area
[Calochilus pulchellus](#)			
Pretty Beard Orchid, Pretty Beard-orchid [84677]	Endangered	Species or species habitat may occur within area	In buffer area only
[Commersonia prostrata](#)			
Dwarf Kerrawang [87152]	Endangered	Species or species habitat likely to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Cynanchum elegans White-flowered Wax Plant [12533]	Endangered	Species or species habitat may occur within area	In buffer area only
Eucalyptus aggregata Black Gum [20890]	Vulnerable	Species or species habitat known to occur within area	In feature area
Eucalyptus macarthurii Camden Woollybutt, Paddys River Box [7827]	Endangered	Species or species habitat known to occur within area	In feature area
Genoplesium baueri Yellow Gnat-orchid, Bauer's Midge Orchid, Brittle Midge Orchid [7528]	Endangered	Species or species habitat may occur within area	In feature area
Gentiana wingecarribiensis Wingecarribee Gentian [18033]	Endangered	Species or species habitat may occur within area	In buffer area only
Grevillea molyneuxii [22052]	Endangered	Species or species habitat likely to occur within area	In buffer area only
Grevillea raybrownii [65665]	Vulnerable	Species or species habitat known to occur within area	In buffer area only
Hakea dohertyi Kowmung Hakea [66701]	Endangered	Species or species habitat may occur within area	In buffer area only
Helichrysum calvertianum [5702]	Vulnerable	Species or species habitat known to occur within area	In buffer area only
Kunzea cambagei [11420]	Vulnerable	Species or species habitat known to occur within area	In buffer area only

Scientific Name	Threatened Category	Presence Text	Buffer Status
Leucochrysum albicans subsp. tricolor Hoary Sunray, Grassland Paper-daisy [89104]	Endangered	Species or species habitat may occur within area	In buffer area only
Persicaria elatior Knotweed, Tall Knotweed [5831]	Vulnerable	Species or species habitat may occur within area	In feature area
Persoonia glaucescens Mittagong Geebung [12770]	Vulnerable	Species or species habitat known to occur within area	In buffer area only
Persoonia hirsuta Hairy Geebung, Hairy Persoonia [19006]	Endangered	Species or species habitat may occur within area	In buffer area only
Persoonia mollis subsp. revoluta [56094]	Vulnerable	Species or species habitat known to occur within area	In feature area
Phyllota humifusa Dwarf Phyllota [10133]	Vulnerable	Species or species habitat known to occur within area	In buffer area only
Pomaderris brunnea Rufous Pomaderris, Brown Pomaderris [16845]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Pomaderris cotoneaster Cotoneaster Pomaderris [2043]	Endangered	Species or species habitat likely to occur within area	In feature area
Pomaderris sericea Bent Pomaderris [9597]	Vulnerable	Species or species habitat likely to occur within area	In buffer area only
Prasophyllum affine Jervis Bay Leek Orchid, Culburra Leek-orchid, Kinghorn Point Leek-orchid [2210]	Endangered	Species or species habitat may occur within area	In buffer area only
Prasophyllum fuscum Tawny Leek-orchid, Slaty Leek-orchid [19455]	Vulnerable	Species or species habitat may occur within area	In buffer area only

Scientific Name	Threatened Category	Presence Text	Buffer Status
Pterostylis pulchella Pretty Greenhood [6448]	Vulnerable	Species or species habitat likely to occur within area	In buffer area only
Rhizanthella slateri Eastern Underground Orchid [11768]	Endangered	Species or species habitat may occur within area	In buffer area only
Rhodamnia rubescens Scrub Turpentine, Brown Malletwood [15763]	Critically Endangered	Species or species habitat may occur within area	In buffer area only
Thelymitra kangaloonica Kangaloon Sun Orchid [81861]	Critically Endangered	Species or species habitat likely to occur within area	In feature area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Xerochrysum palustre Swamp Everlasting, Swamp Paper Daisy [76215]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Zieria murphyi Velvet Zieria [4634]	Vulnerable	Species or species habitat likely to occur within area	In feature area
REPTILE			
Hoplocephalus bungaroides Broad-headed Snake [1182]	Vulnerable	Species or species habitat likely to occur within area	In feature area

Listed Migratory Species			[Resource Information]
Scientific Name	Threatened Category	Presence Text	Buffer Status
Migratory Marine Birds			
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area	In feature area
Migratory Terrestrial Species			
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
[Hirundapus caudacutus](#) White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area	In feature area
[Monarcha melanopsis](#) Black-faced Monarch [609]		Species or species habitat known to occur within area	In feature area
[Motacilla flava](#) Yellow Wagtail [644]		Species or species habitat may occur within area	In feature area
[Myiagra cyanoleuca](#) Satin Flycatcher [612]		Breeding known to occur within area	In feature area
[Rhipidura rufifrons](#) Rufous Fantail [592]		Species or species habitat known to occur within area	In feature area
Migratory Wetlands Species			
[Actitis hypoleucos](#) Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
[Calidris acuminata](#) Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area	In feature area
[Calidris ferruginea](#) Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
[Calidris melanotos](#) Pectoral Sandpiper [858]		Species or species habitat may occur within area	In feature area
[Gallinago hardwickii](#) Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area	In feature area
[Numenius madagascariensis](#) Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Pandion haliaetus			
Osprey [952]		Species or species habitat likely to occur within area	In buffer area only
Tringa nebularia			
Common Greenshank, Greenshank [832]		Species or species habitat may occur within area	In buffer area only

Other Matters Protected by the EPBC Act

Commonwealth Lands [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.

Commonwealth Land Name	State	Buffer Status
Commonwealth Trading Bank of Australia		
Commonwealth Land - Commonwealth Trading Bank of Australia [12350]	NSW	In buffer area only
Communications, Information Technology and the Arts - Australian Postal Corporation		
Commonwealth Land - Australian Postal Commission [12363]	NSW	In buffer area only
Communications, Information Technology and the Arts - Telstra Corporation Limited		
Commonwealth Land - Australian Telecommunications Commission [11839]	NSW	In buffer area only
Commonwealth Land - Australian Telecommunications Commission [11838]	NSW	In buffer area only
Commonwealth Land - Australian Telecommunications Commission [12360]	NSW	In buffer area only
Commonwealth Land - Australian Telecommunications Commission [12358]	NSW	In buffer area only
Commonwealth Land - Australian Telecommunications Commission [12354]	NSW	In buffer area only
Commonwealth Land - Australian Telecommunications Commission [12353]	NSW	In buffer area only
Commonwealth Land - Australian Telecommunications Commission [12359]	NSW	In buffer area only
Commonwealth Land - Australian Telecommunications Commission [15415]	NSW	In buffer area only
Commonwealth Land - Australian Telecommunications Commission [12355]	NSW	In buffer area only
Commonwealth Land - Australian Telecommunications Commission [12361]	NSW	In buffer area only

Commonwealth Land Name	State	Buffer Status
Commonwealth Land - Australian Telecommunications Commission [12357]	NSW	In buffer area only
Commonwealth Land - Australian Telecommunications Commission [12356]	NSW	In buffer area only
Commonwealth Land - Telstra Corporation Limited [12362]	NSW	In buffer area only

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text	Buffer Status
Bird			
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area	In feature area
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area	In feature area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area	In feature area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area	In feature area
Chalcites osculans as Chrysococcyx osculans Black-eared Cuckoo [83425]		Species or species habitat likely to occur within area overfly marine area	In buffer area only

Scientific Name	Threatened Category	Presence Text	Buffer Status
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area overfly marine area	In feature area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area	In feature area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area overfly marine area	In feature area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area overfly marine area	In buffer area only
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area overfly marine area	In feature area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area overfly marine area	In feature area
Myiagra cyanoleuca Satin Flycatcher [612]		Breeding known to occur within area overfly marine area	In feature area
Neophema chrysostoma Blue-winged Parrot [726]		Species or species habitat may occur within area overfly marine area	In feature area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Pandion haliaetus			
Osprey [952]		Species or species habitat likely to occur within area	In buffer area only
Rhipidura rufifrons			
Rufous Fantail [592]		Species or species habitat known to occur within area overfly marine area	In feature area
Rostratula australis as Rostratula benghalensis (sensu lato)			
Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area overfly marine area	In feature area
Tringa nebularia			
Common Greenshank, Greenshank [832]		Species or species habitat may occur within area overfly marine area	In buffer area only

Extra Information

State and Territory Reserves			[Resource Information]
Protected Area Name	Reserve Type	State	Buffer Status
Cecil Hoskins	Nature Reserve	NSW	In buffer area only
Morton	National Park	NSW	In buffer area only

Regional Forest Agreements		[Resource Information]
Note that all areas with completed RFAs have been included.		
RFA Name	State	Buffer Status
Southern RFA	New South Wales	In buffer area only

EPBC Act Referrals				[Resource Information]
Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Controlled action				
Hume Coal Project, NSW	2015/7526	Controlled Action	Completed	In buffer area only
Not controlled action				
Highland Source Project	2010/5697	Not Controlled Action	Completed	In buffer area only
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed	In feature area

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Not controlled action				
INDIGO Central Submarine Telecommunications Cable	2017/8127	Not Controlled Action	Completed	In feature area
Retford Road Development, Bowral NSW	2020/8724	Not Controlled Action	Completed	In buffer area only
Weed Management Program within Wingecarribee Swamp	2004/1762	Not Controlled Action	Completed	In buffer area only
Not controlled action (particular manner)				
INDIGO Marine Cable Route Survey (INDIGO)	2017/7996	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Southern Highlands Botanic Gardens Bowral NSW	2012/6273	Not Controlled Action (Particular Manner)	Post-Approval	In buffer area only

Bioregional Assessments			
SubRegion	BioRegion	Website	Buffer Status
Sydney	Sydney Basin	BA website	In feature area

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and 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

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a 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 detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

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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Appendix F – Discharge Impact Assessment and Oestrogen Assessment

Manly Hydraulics Laboratory



Discharge Impact Assessment for the Moss Vale Sewerage Scheme

Report MHL2748-3
10/10/2022

Prepared for:

WINGECARRIBEE SHIRE COUNCIL

Cover Photograph: EPA sampling point on Whites Creek

Discharge Impact Assessment for the Moss Vale Sewerage Scheme

Report MHL2748-3
10/10/2022

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Report No. MHL2748-3

First published as draft in November 2020

Manly Hydraulics Laboratory is Quality System Certified to AS/NZS ISO 9001:2008.

Executive Summary

Wingecarribee Shire is located west of Wollongong in NSW's Southern Highlands. It covers an area of around 2,700 km^2 and contains the towns of Mittagong, Bowral, and Moss Vale. The design capacity at these three sewage treatment plants (STPs) which service these towns are 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 Whites Creek 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 upgrade of the Moss Vale 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

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NorBE annual load requirements. For some scenarios, the proposed STP effluent concentrations of 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 many contaminants and for many scenarios, the tipping point concentrations were less than the concentrations of contaminants proposed by the different levels of treatment. 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.

Moss Vale EP = 12,498

Table E–1.1. Moss Vale (EP = 12,498): 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	7.0	2.6	4.7	4,350	4,090
TN	3.90	6.95	2.46	4.01	4,000	3,790
TP	0.240	0.496	0.128	0.283	260	220

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Table E–1.2. Moss Vale (EP = 12,498): NorBE concentration results and annual loads for each scenario

	Concentrations (mg/L)			Annual load (kg/year)			
	IDEA	MLE	FSB	Existing	IDEA	MLE	FSB
TSS	×	×	×	4,350	8,380	8,270	8,480
TN	×	marginal	✓	4,000	10,570	7,480	4,750
TP	✓	✓	✓	260	370	200	210

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. Moss Vale (EP = 12,498): 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)			2.0		0.10	
	50%	90%	50%	90%	50%	90%
DS-1						
Existing	13	73	3.5	5.5	0.26	1.23
IDEA	13	63	5.5	7.9	0.25	1.04
MLE	13	66	4.2	5.9	0.19	0.99
FSB	13	67	3.0	4.7	0.18	0.96
DS-2						
Existing	9	69	3.4	5.6	0.25	1.13
IDEA	9	62	5.8	8.6	0.24	1.00
MLE	9	64	4.3	6.2	0.17	0.95
FSB	9	62	2.9	4.9	0.17	0.91

Cells shaded green indicate an improvement in water quality compared with the existing conditions.

Moss Vale plus EC EP = 18,000

Table E–1.4. Moss Vale (EP = 18,000): 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	7.0	1.6	3.1	4,350	3,810
TN	3.90	6.95	1.56	2.68	4,000	3,540
TP	0.240	0.496	0.086	0.206	260	220

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Table E–1.5. Moss Vale (EP = 18,000): NorBE concentration results and annual loads for each scenario

	Concentrations (mg/L)			Annual load (kg/year)			
	IDEA	MLE	FSB	Existing	IDEA	MLE	FSB
TSS	×	×	×	4,350	11,900	11,800	11,800
TN	×	marginal	✓	4,000	15,130	10,700	6,700
TP	✓	✓	✓	260	530	290	290

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–1.6. Moss Vale (EP = 18,000): 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)			2.0		0.10	
	50%	90%	50%	90%	50%	90%
DS-1						
Existing	13	73	3.5	5.5	0.26	1.23
IDEA	13	65	5.5	8.0	0.25	1.03
MLE	13	66	4.2	5.9	0.19	0.99
FSB	13	67	3.0	4.7	0.18	0.96
DS-2						
Existing	9	69	3.4	5.6	0.25	1.13
IDEA	10	60	5.7	8.5	0.24	0.92
MLE	9	64	4.3	6.2	0.17	0.95
FSB	13	67	3.0	4.7	0.18	0.96

Cells shaded green indicate an improvement in water quality compared with the existing conditions.

Moss Vale plus EC EP = 27,000

Table E–1.7. Moss Vale (EP = 27,000): 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	7.0	1.1	2.1	4,350	3,820
TN	3.90	6.95	1.03	1.74	4,000	3,500
TP	0.240	0.496	0.059	0.137	260	230

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Table E–1.8. Moss Vale (EP = 27,000): NorBE concentration results and annual loads for each scenario

	Concentrations (mg/L)			Annual load (kg/year)			
	IDEA	MLE	FSB	Existing	IDEA	MLE	FSB
TSS	×	×	×	4,350	18,490	18,010	18,100
TN	×	×	✓	4,000	23,100	16,230	10,180
TP	✓	✓	✓	260	830	450	450

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–1.9. Moss Vale (EP = 27,000): 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)			2.0		0.10	
	50%	90%	50%	90%	50%	90%
DS-1						
Existing	13	73	3.5	5.5	0.26	1.23
IDEA	10	40	6.1	8.5	0.25	0.77
MLE	10	45	4.6	6.3	0.16	0.66
FSB	10	42	2.9	4.5	0.16	0.66
DS-2						
Existing	9	69	3.4	5.6	0.25	1.13
IDEA	8	42	6.2	8.8	0.24	0.76
MLE	9	42	4.5	6.4	0.15	0.63
FSB	8	41	2.9	4.6	0.15	0.65

Cells shaded green indicate an improvement in water quality compared with the existing conditions.

Moss Vale plus EC EP = 36,000

Table E–1.10. Moss Vale (EP = 36,000): 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	7.0	0.8	1.6	4,350	3,880
TN	3.90	6.95	0.78	1.33	4,000	3,600
TP	0.240	0.496	0.043	0.102	260	230

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Table E–1.11. Moss Vale (EP=36,000): NorBE concentration results and annual loads for each scenario

	Concentrations (mg/L)			Annual load (kg/year)			
	IDEA	MLE	FSB	Existing	IDEA	MLE	FSB
TSS	×	×	×	4,350	23,700	24,500	24,400
TN	×	×	✓	4,000	30,200	21,790	13,660
TP	✓	✓	✓	260	1,050	620	610

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–1.12. Moss Vale (EP = 36,000): 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)			2.0		0.10	
	50%	**90%**	**50%**	**90%**	**50%**	**90%**
DS-1						
Existing	13	73	3.5	5.5	0.26	1.23
IDEA	10	37	6.2	8.9	0.25	0.70
MLE	10	38	4.6	6.5	0.16	0.60
FSB	10	39	3.0	4.7	0.15	0.56
DS-2						
Existing	9	69	3.4	5.6	0.25	1.13
IDEA	8	35	6.3	9.1	0.24	0.70
MLE	8	38	4.6	6.5	0.15	0.58
FSB	8	38	3.0	4.7	0.15	0.53

Cells shaded green indicate an improvement in water quality compared with the existing conditions.

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1. Introduction

This report details the results from (a) data statistical analyses and (b) numerical modelling, of the concentrations of contaminants discharged from the Moss Vale Sewage Treatment Plant (STP) which enter Whites Creek, thence the Wollondilly River and Lake Burragorang. the Wingecarribee River. The primary aim of the work presented in this report is to estimate future conditions that may occur from a number of options for sewage treatment. This will help demonstrate that, based on suitable design parameters, discharges from the STP 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 2,700 km^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 for an increase in 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 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 Moss Vale 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.

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1.2. Structure of this report

Below is an outline of the work presented in this report.

Executive summary. A broad summary of the results presented in this report.

Section 1: Introduction (this section). Background information on the project, the Moss Vale STP and the monitoring data used in this study.

Section 2: 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 3: 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 4: 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 5: Summary and conclusions. Summary of the results presented and an overall interpretation of the results from modelled scenarios.

Section 6: References.

Appendix A. Description of the analytes used in this study.

Appendix B. Supplementary data analyses. Provides additional statistical analyses of that presented in Appendix B: Monitoring Analysis.

Appendix C: Modelling details. This supplements the work presented in Appendix C: Modelling Details, providing additional details to the modelling work undertaken.

Appendix D: MHL – Southern Highlands Biological Monitoring Report (February 2022).

1.3. Moss Vale STP Licence Conditions

The Moss Vale STP is located in the Wingecarribee River catchment near the township of Moss Vale. The Moss Vale STP includes the following treatment processes: activated sludge, including biological nitrogen removal, phosphorus removal and UV disinfection. The licenced maximum discharge from monitoring Point 1 is 8.4 ML/day.

Treated effluent discharges directly to Whites Creek, adjacent to the STP. Whites Creek flows into Medway Rivulet, Wollondilly River and Lake Burragorong.

Under wet weather conditions, treated effluent is discharged to Whites Creek, Point 2 (the Emergency Stormflow Discharge Point) (Figure 1.1).

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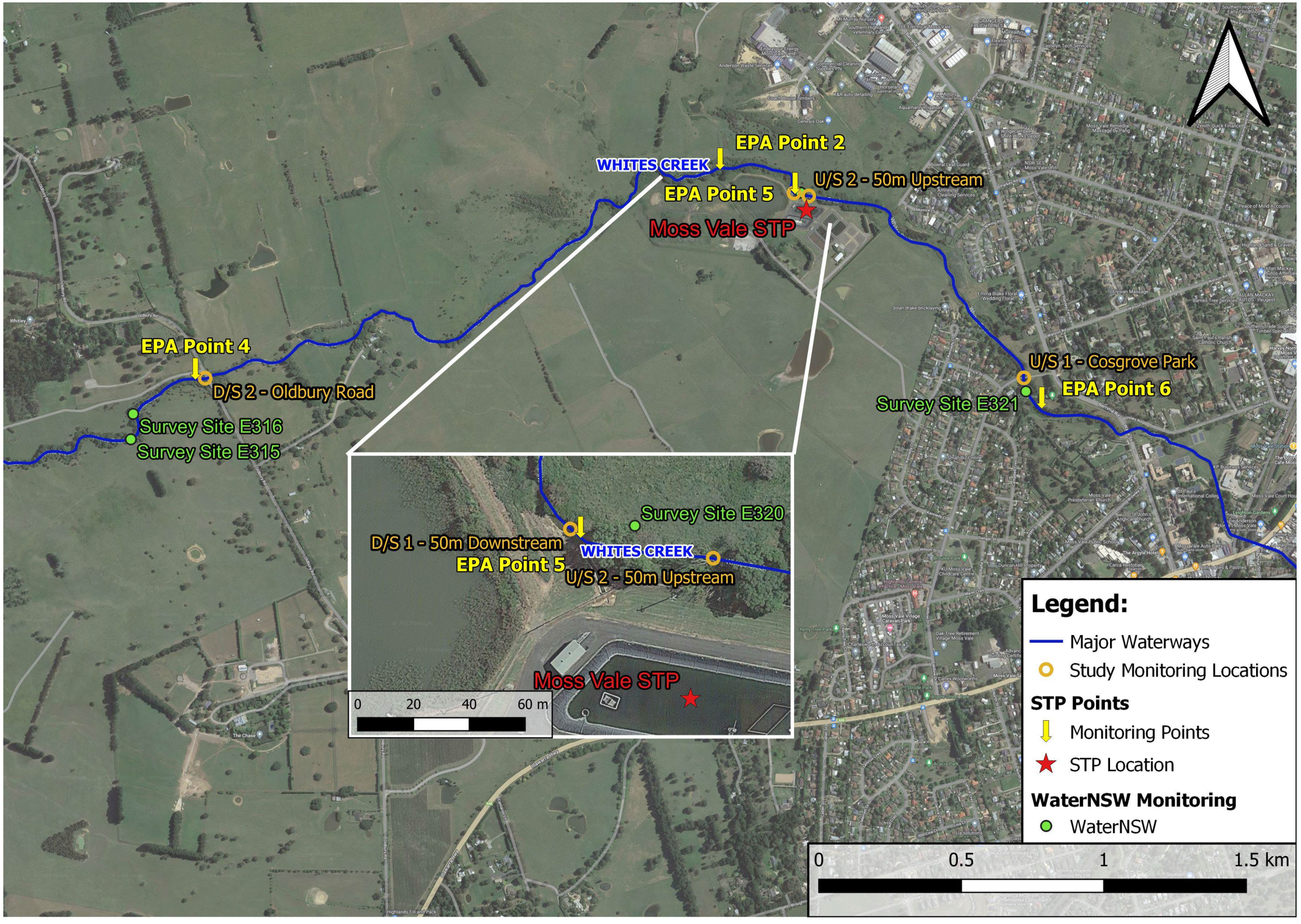

Figure 1.1. Moss Vale STP and receiving waters.

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The concentration and annual load limits for the Moss Vale effluent are presented in Table 1.1. The current license arrangement allows for 8.4 ML/day discharge from the STP. Dry weather discharge occurs at Point 1 and at the Emergency Stormflow Discharge Point (Point 2) under wet weather conditions. Routine monitoring for effluent quantity and quality is required under the Environmental Protection Licence number 1731 (EPL, 2018).

Table 1.1. Concentration and Load Limits for Moss Vale 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	7	n/a	10	n/a	8,274
Faecal Coliforms	cfu/100mL	n/a	200	n/a	n/a	
Total Nitrogen	mg/L	7	n/a	10	n/a	6,619
pH	pH	n/a	n/a	n/a	6.5-8.5	
Total Phosphorus	mg/L	0.5	n/a	1	n/a	414
Total suspended solids	mg/L	10	n/a	15	n/a	12,411
Oil and grease	mg/L	n/a	n/a	n/a	n/a	1,655

NOTE: 'n/a' indicates that there is no associated limit. These cells are also shaded.

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
2122520	Whites Creek (at Oldbury Road) (Q, EC, turbidity, T, pH, DO)	-34.54592	150.33737	2014-2020
STP licences	Site Description and Variables for Licencing	Latitude (°S)	Longitude (°E)	Dates Analysed
Moss Vale STP EPA Point 1	Main monitoring location (Q, BOD, FC, NH3, TN, TP, pH, TSS)	-34.541389	150.356111	2013-2019

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Moss Vale STP EPA Point 2	Wet weather discharge	-34.541111	150.353889	2013-2019
Moss Vale STP EPA Point 3	Volume monitoring (Q)	-34.543056	150.356667	2013-2019
Moss Vale STP EPA Point 4	Whites Creek (at Oldbury Road) (Q, EC, turbidity, T, pH, DO, TN, TP)	-34.546111	150.337500	2013-2019
Moss Vale STP EPA Point 5	Whites Creek immediately downstream from discharge (TN, TP)	-34.541111	150.355833	2013-2019
Moss Vale STP Point 6	Cosgrove Park, 800m upstream Whites Creek (TN, TP)	-34.546111	150.363333	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. A draft 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. 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 Whites Creek 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 about 2,000 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 2.8).

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 was conducted in autumn and spring in 2020 and 2021 in accordance with AUSRIVAS protocols for New South Wales (Turak & Waddell, 2004) and Sydney Water's in-house test methods and was used as a primary indicator for biodiversity and ecological health of the riverine systems. This report is available in Appendix D: MHL – Southern Highlands Biological Monitoring Report (February 2022).

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2. Existing Conditions

Water quality conditions in Whites Creek 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 river monitoring locations upstream of the discharge point (Points 4, 5 and 6) and at Oldbury Road (approximately 2 km downstream of the discharge point). Results from the 3-month, short term monitoring program are presented in Section 2.5.

2.1. Current Land Uses

The primary land use zones surrounding Whites Creek and Medway Rivulet include downstream of the STP include residential, dryland agriculture and natural environments. A map of the land use zones from 2016 is presented in Figure 2.1. There is also the Medway Dam downstream of its confluence with Whites Creek which is used as drinking water supply for Berrima, and parts of Bowral and Mittagong townships. Council holds a 900ML license to take water from the dam for treatment at the Medway Water Treatment Plant (WTP). Historic algal blooms have caused issues at the WTP which have led to long-term ceasing of operations. It has been postulated that some of the nutrient loading which contributes to the Dam's algal blooms comes from the upstream STP at Moss Vale.

There are 13 diversion pumps and 7 storages within the Medway Catchment, however many of these are upstream of the STP. The current licenses allow for the diversion of ~1000 ML per annum. The basic water rights which apply to the Wingecarribee River also apply on Whites Creek and Medway Rivulet.

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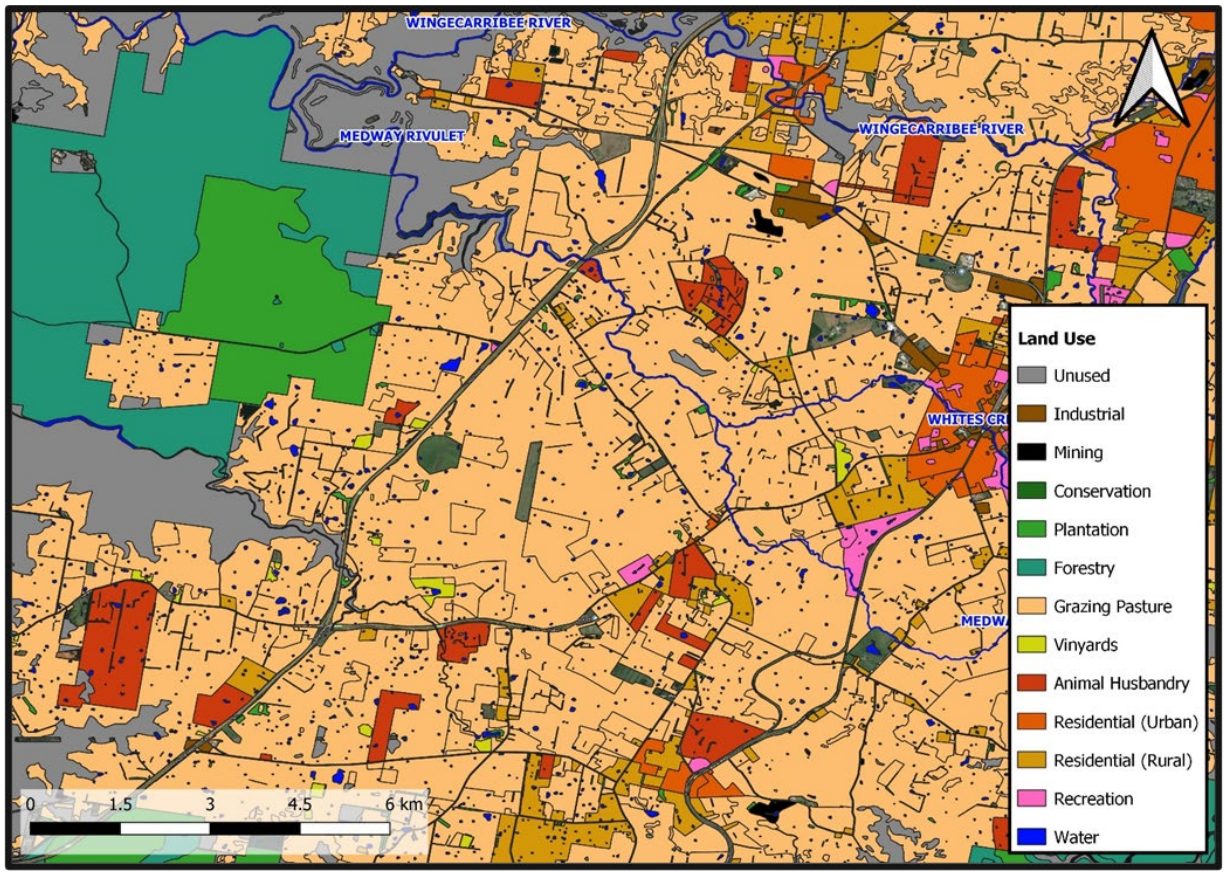

Figure 2.1 – Land Use Zoning of the Medway Rivulet Catchment (including Whites Creek).

2.2. Environmental Values

As waters from the Medway Rivulet eventually make their way to Lake Burragorang and are used in Sydney's drinking water supply, the environmental values assigned to this waterway can be 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 laid out 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.

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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 licence limits. Detailed analysis of STP data can be found in Appendix B, including an assessment of the concentrations under wet weather conditions.

Table 2.1. Moss Vale STP Effluent Constituents (2013-19). Figures in red brackets are the licence limits.

Variable	Units	Number	50th Percentile	80th Percentile	90th Percentile	100th Percentile
BOD	mg/L	164	1.0 (7)	1.0	1.0 (10)	3.0
TSS	mg/L	164	4.0 (10)	6.0	7.0 (15)	19.0
Conductivity		133	58.3	62.6	64.7	69.5
Ammonia	mg/L	164	0.60	1.28	1.62 (2)	3.70
Nitrite	mg/L	164	0.119	0.147	0.169	0.740
Nitrate	mg/L	164	2.25	4.30	6.01	15.10
Oxidised nitrogen	mg/L	164	2.383	4.420	6.155	15.200
Total nitrogen	mg/L	164	4.20 (7)	5.63	7.67 (10)	18.90
Total phosphorus	mg/L	164	0.220 (0.5)	0.397	0.495 (1)	1.720
pH		164	7.2	7.4	7.5	5.1-7.7 (6.5-8.5)
Faecal coliforms	cfu / 100mL	164	13	57 (200)	192	3800
Oil and grease	mg/L	148	2.5	2.5	2.5	6.0
Alkalinity	mg/L, CaCO3	163	86.3	103.8	115.0	138.0

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 Moss Vale 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. A statistically significant increasing trend was identified for suspended solids (for the 2013-2019 period) and for faecal coliforms (for the 2017-2019 period). BOD, nitrite, faecal coliforms and alkalinity showed a reversal in the slope of the linear trend line for the two time periods examined. This may suggest short period fluctuations in those variables. Assuming the increasing linear trends continue with the same slope, the relevant

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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 Moss Vale STP data.

Variable	2013-2019		t-calc	2017-2019	
	slope	significance	t-crit = +/-1.97	slope	significance
BOD	↓	SIG	-12.06	↑	NSD
TSS	↑	SIG	2.72	↑	NSD
Conductivity	↓	NSD	-1.12	↓	SIG
Ammonia	↓	NSD	-0.58	↓	NSD
Nitrite	↑	NSD	1.19	↓	NSD
Nitrate	↓	SIG	-2.56	↓	NSD
Oxidised nitrogen	↓	SIG	-2.50	↓	NSD
Total nitrogen	↓	SIG	-3.87	↓	SIG
Total phosphorus	↑	NSD	1.51	↑	NSD
pH	↓	NSD	-0.42	↓	SIG
Oil and grease	Insufficient data above LoR for reliable statistics				
Faecal coliforms	↓	NSD	-1.93	↑	SIG
Alkalinity	↑	NSD	0.48	↓	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 1 and 2. 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 (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.

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Table 2.3. Estimated concentrations under dry and wet weather conditions

Variable	Units	Dry weather component				Wet weather component			
		Med.	MAD	Mean	Stdev.	Med.	MAD	Mean	Stdev.
BOD	mg/L	1.00	0.53	1.44	0.57	3.00	0.63	2.86	0.77
TSS	mg/L	4.00	1.46	4.45	1.84	7.50	2.35	8.59	2.92
Conductivity	µS/cm	58.30	12.37	56.91	7.26	33.80	6.28	34.85	7.57
Ammonia	mg/L	0.600	0.533	0.791	0.677	0.700	0.278	0.864	0.417
Nitrite	mg/L	0.114	0.045	0.114	0.078	0.078	0.023	0.083	0.031
Nitrate	mg/L	2.105	1.624	2.782	2.059	4.100	1.181	4.016	1.477
Oxidised nitrogen	mg/L	2.238	1.634	2.896	2.065	4.181	1.177	4.100	1.474
Total nitrogen	mg/L	4.000	1.446	4.475	1.879	6.270	1.164	6.241	1.416
Total phosphorus	mg/L	0.219	0.132	0.260	0.163	0.471	0.135	0.540	0.178
pH		7.20	0.13	7.25	0.17	7.200	0.217	7.268	0.268
Faecal coliforms (log10)	(log10) cfu / 100mL	1.15	0.71	1.11	0.88	4.663	0.380	4.509	0.468
Oil and grease	mg/L	2.50	1.11	3.32	1.19	2.50	2.02	2.02	2.18

MAD is the mean absolute deviation.

Using information from Table 2.3, estimates can be made of the average pooled concentration of contaminants discharged to Whites Creek 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: $Q_{DRY} = (1 - x)\, Q_{TOTAl}$ and $Q_{WET} = x\, Q_{TOTAL}$

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.

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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	1.44	2.86	1.51	1.58	1.72	1.87	2.15
TSS	mg/L	4.45	8.59	4.66	4.86	5.28	5.69	6.52
Conductivity	µS/cm	56.91	34.85	55.81	54.70	52.50	50.29	45.88
Ammonia	mg/L	0.791	0.864	0.79	0.80	0.81	0.81	0.83
Nitrite	mg/L	0.114	0.083	0.11	0.11	0.11	0.10	0.10
Nitrate	mg/L	2.782	4.016	2.84	2.91	3.03	3.15	3.40
Oxidised nitrogen	mg/L	2.896	4.100	2.96	3.02	3.14	3.26	3.50
Total nitrogen	mg/L	4.475	6.241	4.56	4.65	4.83	5.00	5.36
Total phosphorus	mg/L	0.260	0.540	0.27	0.29	0.32	0.34	0.40
pH		7.25	7.268	7.25	7.25	7.25	7.26	7.26
Faecal coliforms (log10)	(log10) cfu / 100mL	1.11	4.509	1.28	1.45	1.79	2.13	2.81

2.4. River Water Quality

To assess the existing conditions in Whites Creek, 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 Whites Creek, data from one upstream location (for total nitrogen and total phosphorus only) and two downstream locations are available. Both downstream locations measure total nitrogen and total phosphorus. The far downstream location (Point 4, near Oldbury Road) also monitoring for pH, conductivity, turbidity, temperature and dissolved oxygen). Only total nitrogen and total phosphorus are examined in this section. Further details (at Oldbury Road) are presented in Section B.2.

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2.4.1. Upstream and Downstream Concentrations

Upstream monitoring is required as part of the EPA licence conditions at Point 6 in Whites Creek (near Cosgrove Park, Moss Vale). Downstream monitoring is undertaken at Point 5 (just downstream of the STP discharge into Whites Creek) and at Point 6 (at Oldbury Road, about 2 km downstream from the STP discharge point. Only analyses for total nitrogen and total phosphorus are undertaken.

Basic statistics are given in Table 2.5. The highest concentrations occur in the STP, then at the location in Whites Creek immediately downstream from the discharge point. Total phosphorus concentrations at Point 4 (downstream at Oldbury Road) are close to those at Point 6 (upstream at Cosgrove Park). However, concentrations of total nitrogen at Point 4 (downstream at Oldbury Road) lie between those at Point 5 and Point 6. This may suggest a source(s) of nitrogen (but not phosphorus) entering Whites Creek between Point 5 and Point 6.

Table 2.5. Basic statistics for total nitrogen and total phosphorus.

Total nitrogen (mg/L)	Number	Min.	Max.	Median	M.A.D.	Mean	StDev
Point 6 (upstream)	72	0.310	3.200	0.610	0.296	0.745	0.478
STP	72	2.090	10.500	3.965	1.404	4.506	1.856
Point 5 (near downstream)	72	1.410	8.350	3.755	1.367	4.039	1.739
Point 4 (far downstream)	72	0.310	7.860	1.750	1.154	2.245	1.555
Total phosphorus (mg/L)	**Number**	**Min.**	**Max.**	**Median**	**M.A.D.**	**Mean**	**StDev**
Point 6 (upstream)	72	0.015	0.770	0.061	0.045	0.082	0.095
STP	72	0.045	1.000	0.205	0.142	0.262	0.178
Point 5 (near downstream)	72	0.037	1.570	0.179	0.124	0.228	0.221
Point 4 (far downstream)	72	0.019	0.260	0.068	0.029	0.070	0.041

M.A.D. is the mean absolute deviation.

Results from an ANOVA (Table 2.6) confirm that the highest concentrations occur at the STP and that there is no statistically significant difference between the data collected from Point 5 and those collected at the STP. Concentrations at these two locations are significantly greater than the concentrations from Points 4 and 6. There is no significant difference between Point 4 and Point 6 for total phosphorus, while for total nitrogen, the former location has significantly greater concentrations than at Point 6.

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Table 2.6. ANOVA summary: Point 1 (STP), Point 4, Point 5 and Point 6

Variable	ANOVA	F-calc	F-critical	Kruskal-Wallis
Total nitrogen	Point 6 < Point 4 < Point 5 = STP	94.22	2.64	SIG
Total phosphorus	Point 4 = Point 6 < Point 5 = STP	30.85	2.64	SIG

NSD = the means are not statistically different at the 5% level of significance.
SIG = the means are statistically different at the 5% level of significance.
All calculations were undertaken using a 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 on either side of the '=' sign. The '<' or '>' sign indicates the mean of the data whose location label is on the left, is significantly less than (or greater than) that of the data whose location label is to the right.

Trends at each of the four locations are shown in Table 2.7. Two times periods were used: 2013-2019 and 2017-2019. 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. Freund, 1972; Walpole, 1974).

There is a significant decreasing trend in total nitrogen at the STP. The trend patterns over the two time periods are similar, with the exception of Point 6, which shows a reversal in the slope of the trend line in the two time periods.

Table 2.7. Trends for the Point 1 (STP), Point 4, Point 5 and Point 6.

	2013-2019		t-calc	2017-2019	
	slope	significance	t-crit= +/-1.99	slope	significance
Total nitrogen (mg/L)					
Point 6 (upstream)	↓	NSD	-1.03	↑	NSD
STP	↓	SIG	-2.66	↓	SIG
Point 5 (near downstream)	↓	NSD	-0.93	↓	NSD
Point 4 (far downstream)	↓	NSD	-1.41	↓	SIG
Total phosphorus (mg/L)					
Point 6 (upstream)	↓	NSD	-0.31	↑	SIG
STP	↑	NSD	0.49	↑	NSD
Point 5 (near downstream)	↑	NSD	1.33	↑	NSD
Point 4 (far downstream)	↑	NSD	1.76	↑	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.
TN = total nitrogen, TP = total phosphorus.

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2.4.2. Existing Impacts on River Water Quality

Due to the lack of water quality data in Whites Creek, existing impacts of the STP discharges to Whites Creek are limited to total nitrogen and total phosphorus. The current impact of the three STPs on the receiving waterways was estimated based on the historic data 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 a detailed analysis of the STP and waterway data presented in Section B.2, Appendix B.

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

- The largest concentrations of total nitrogen and total phosphorus occur in the effluent. The next largest concentrations occur at the location immediately downstream of the STP. Concentrations at the STP and Point 5 are significantly greater than those at the other two locations.
- This suggests that impacts from the STP discharge can be detected immediately downstream of the discharge point (as might be expected). Total phosphorus concentrations at Point 6 (2 km downstream) are not statistically different from the upstream concentrations. However, total nitrogen concentrations at Point 6 still appear elevated, compared with the upstream concentrations. This may suggest a source(s) of nitrogen entering Whites Creek between the STP discharge point and Point 6.
- Trends in total nitrogen at, and downstream of, the STP are decreasing i.e. concentrations are decreasing over time. However, for half of these results, the slope of the trend line is not statistically, significantly different from a slope of zero.
- Trends in total phosphorus of the STP are increasing, although the slopes of these trend lines are not statistically, significantly different from a slope of zero.

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. Moss Vale 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 2.8. Note, that 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 2.8. Summary of the concentrations of contaminants in the Moss Vale STP

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	14.500	3.750	5.000	0.250	5.000	0.000
Hydroxide Alkalinity as CaCO3	mg/L						
Carbonate Alkalinity as CaCO3	mg/L						
Bicarbonate Alkalinity as CaCO3	mg/L	88.000	31.250	82.000	2.375	79.000	2.000
Total Alkalinity as CaCO3	mg/L	88.000	31.250	82.000	2.375	79.000	2.000
Sulfate as SO4 - Turbidimetric	mg/L	135.000	26.625	145.000	1.000	72.500	6.250
Chloride	mg/L	67.000	0.500	68.500	1.125	54.000	1.625
Fluoride	mg/L	0.700	0.038	0.500	0.025	0.400	0.000
Calcium	mg/L	30.000	0.500	31.500	1.500	33.000	0.375
Magnesium	mg/L	27.000	0.375	20.500	0.500	11.500	0.500
Sodium	mg/L	72.500	1.125	73.000	0.500	42.500	0.875
Potassium	mg/L	22.500	0.500	30.000	0.375	11.000	0.250
Total Anions	meq/L	7.100	0.681	6.630	0.108	4.645	0.131
Total Cations	meq/L	7.420	0.105	7.155	0.110	4.750	0.094
dissolved Aluminium	mg/L	0.135	0.034	0.075	0.009	0.100	0.046
dissolved Arsenic	mg/L						
dissolved Cadmium	mg/L						
dissolved Chromium	mg/L						
dissolved Copper	mg/L						
dissolved Lead	mg/L						
dissolved Manganese	mg/L	0.020	0.001	0.028	0.001	0.028	0.005
dissolved Nickel	mg/L						
dissolved Zinc	mg/L	0.026	0.000	0.035	0.002	0.014	0.001
dissolved Iron	mg/L						
dissolved Mercury	mg/L						
total Aluminium	mg/L	0.830	0.105	1.095	0.101	1.065	0.129
total Arsenic	mg/L						
total Cadmium	mg/L						
total Chromium	mg/L						
total Copper	mg/L			0.002	0.000	0.002	0.000
total Lead	mg/L						
total Manganese	mg/L	0.032	0.001	0.033	0.001	0.031	0.005
total Nickel	mg/L	0.003	0.000	0.003	0.000	0.002	0.000
total Zinc	mg/L	0.026	0.001	0.047	0.002	0.019	0.001
total Iron	mg/L						
total Mercury	mg/L						
Ammonia as N	mg/L	0.330	0.045	0.315	0.023	0.270	0.030
Nitrite as N	mg/L	0.095	0.010	0.190	0.006	0.100	0.000
Nitrate as N	mg/L	2.095	0.086	3.885	0.325	5.370	0.165
Nitrite + Nitrate as N	mg/L	2.195	0.086	4.075	0.331	5.470	0.165
Total Kjeldahl Nitrogen as N	mg/L	1.350	0.238	1.400	0.113	1.500	0.213

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Bowral STP	Units	18 Dec 2019 (dry)		16 Jan 2020 (dry)		20 Feb 2020 (wet)	
		median	MAD	median	MAD	median	MAD
Total Nitrogen as N	mg/L	3.500	0.188	5.500	0.438	7.100	0.375
Total Phosphorus as P	mg/L	0.285	0.043	0.205	0.031	0.335	0.090
Dissolved Reactive Phosphorus as P	mg/L	0.060	0.020	0.010	0.003	0.010	0.000
Chlorophyll a	mg/m³	39.000	48.500	2.000	0.000	1.000	0.375
Faecal Coliforms	cfu/100mL	140.0	94.3	61.0	51.0	1300.0	237.5
Enterococci	cfu/100mL	15.0	17.3	39.0	32.3	165.0	52.0

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: Moss Vale STP – total phosphorus

Transform: reciprocal

Normal: p-value = 0.979

Homogeneity of variance: p-value = 0.864

Source of Variation	SS	df	MS	F	P-value	F crit	% contribution
Days	19.3333	2	9.6666	18.48	0.001	4.2565	67.9%
Times (within Days)	4.7065	9	0.5229	0.94	0.529	2.7964	-1.1%
Residuals	6.7059	12	0.5588				33.2%
Total	30.7457	23					

Cells coloured pink indicate a significant difference in that term, green cells indicate no difference.

Days	Day 2	Day 1	Day 3	power
Average	-3.87	-2.57	-1.68	0.972

Times	Time 4	Time 3	Time 1	Time 2	power
Average	-2.84	-2.81	-2.71	-2.47	0.054

Cells that are coloured black indicate no significant difference among averages.

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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 were usually considerably different from the two dry day sampling.
- Contributions to the variance from the 'times within days' were generally 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 the above two sources of variation.

2.5.2. Whites Creek

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. Locations on Whites Creek 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 2,000 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) concentrations in the STP and downstream are generally lower than at the upstream locations, possibly indicating an upstream source of those contaminants.
- Nutrients (Figure 2.3) generally show elevated concentrations at the STP location, indicating that the STP is a major source of nutrients to Whites Creek.

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- 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 aluminium, which shows elevated concentrations at the STP and at the near downstream location. This implicates the STP as a likely source of aluminium.
- Concentrations of anions (Figure 2.7) and cations (Figure 2.8) are generally elevated at the STP and the near downstream locations, again suggesting the influence of the STP discharges on their concentrations.
- In general, the concentrations at the far downstream location (DS-2) are close to that of 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.

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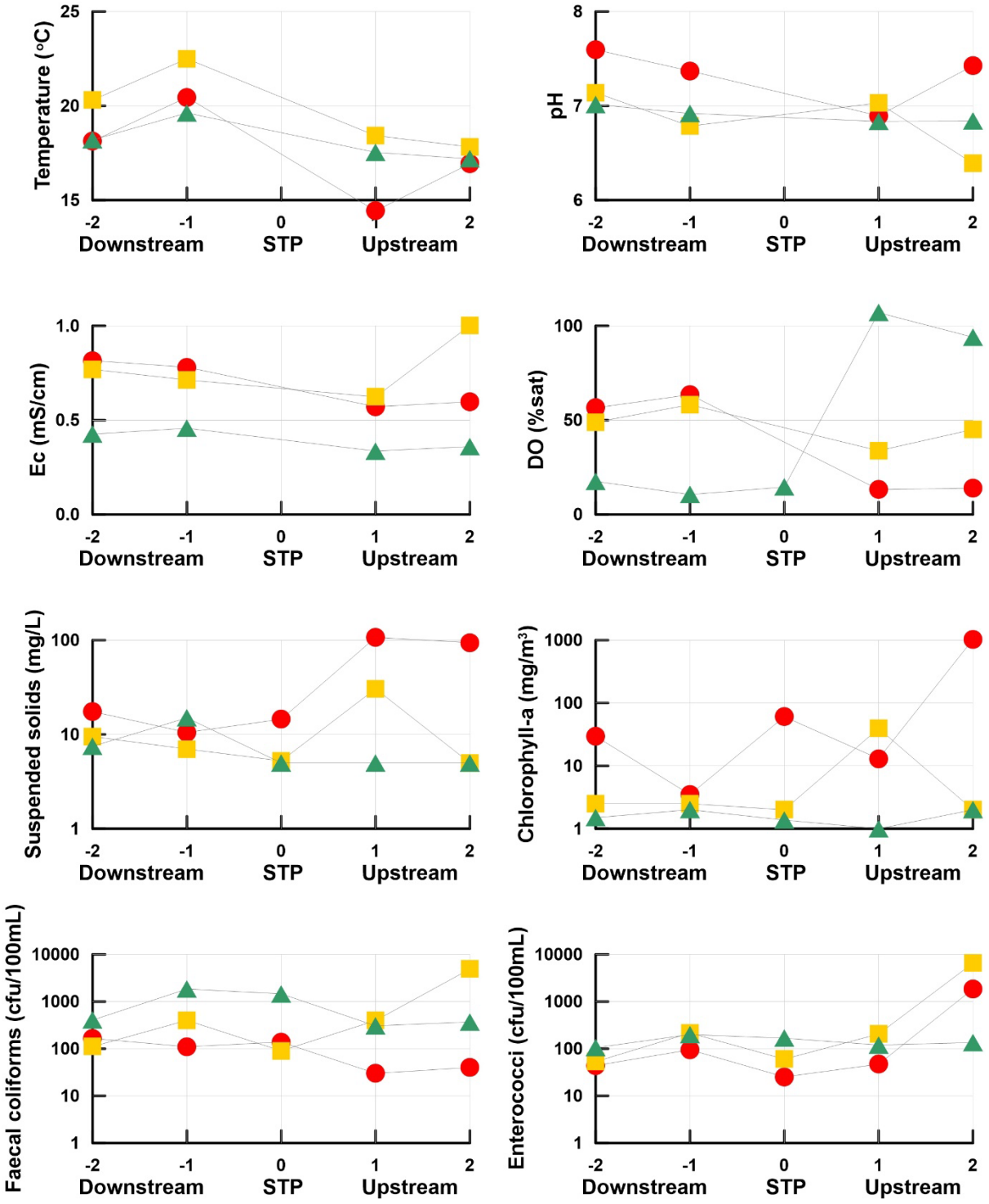

Figure 2.2. Spatial distribution of physico-chemical variables in Whites Creek on the three sampling days.

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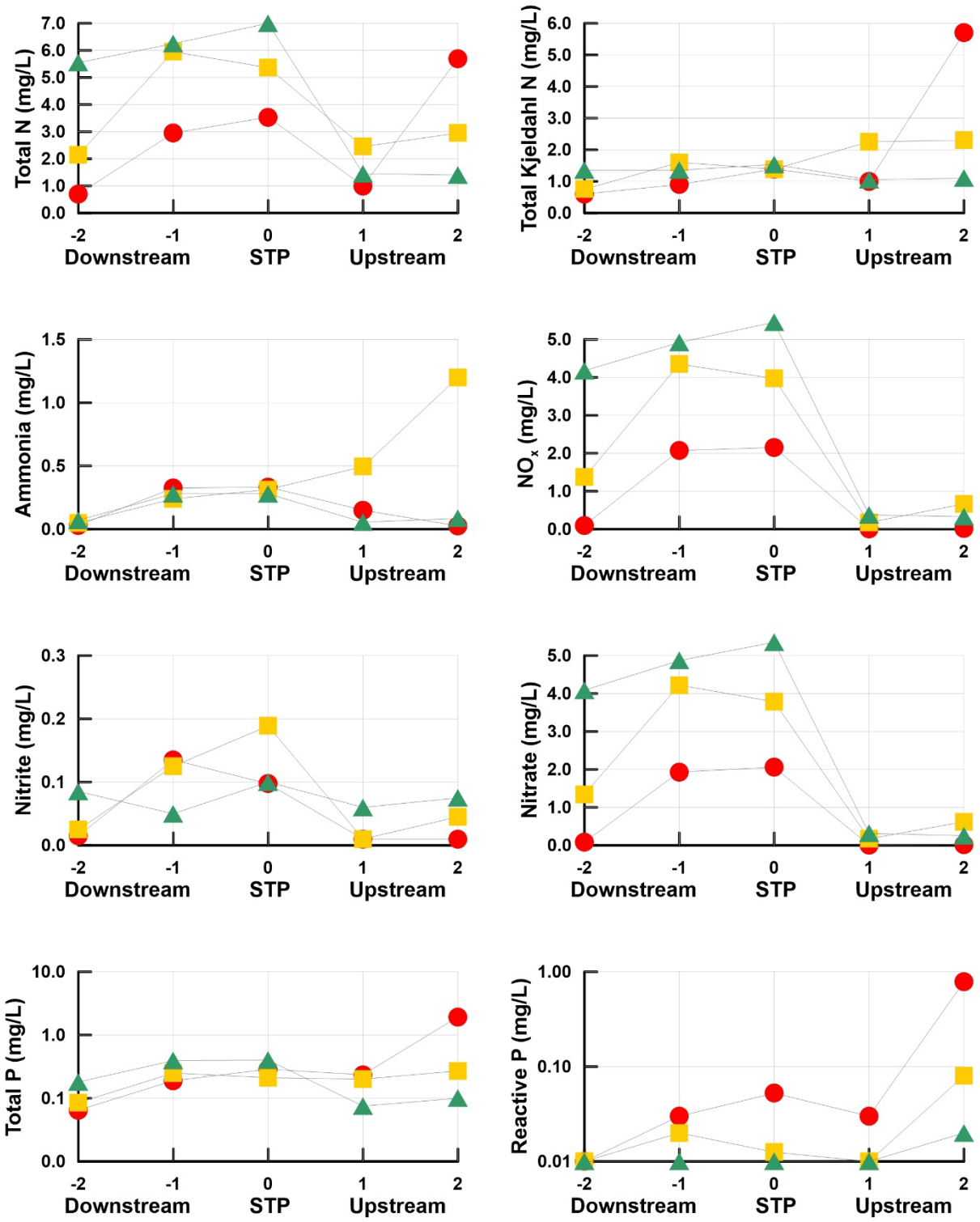

Figure 2.3. Spatial distribution of nutrients in Whites Creek on the three sampling days.

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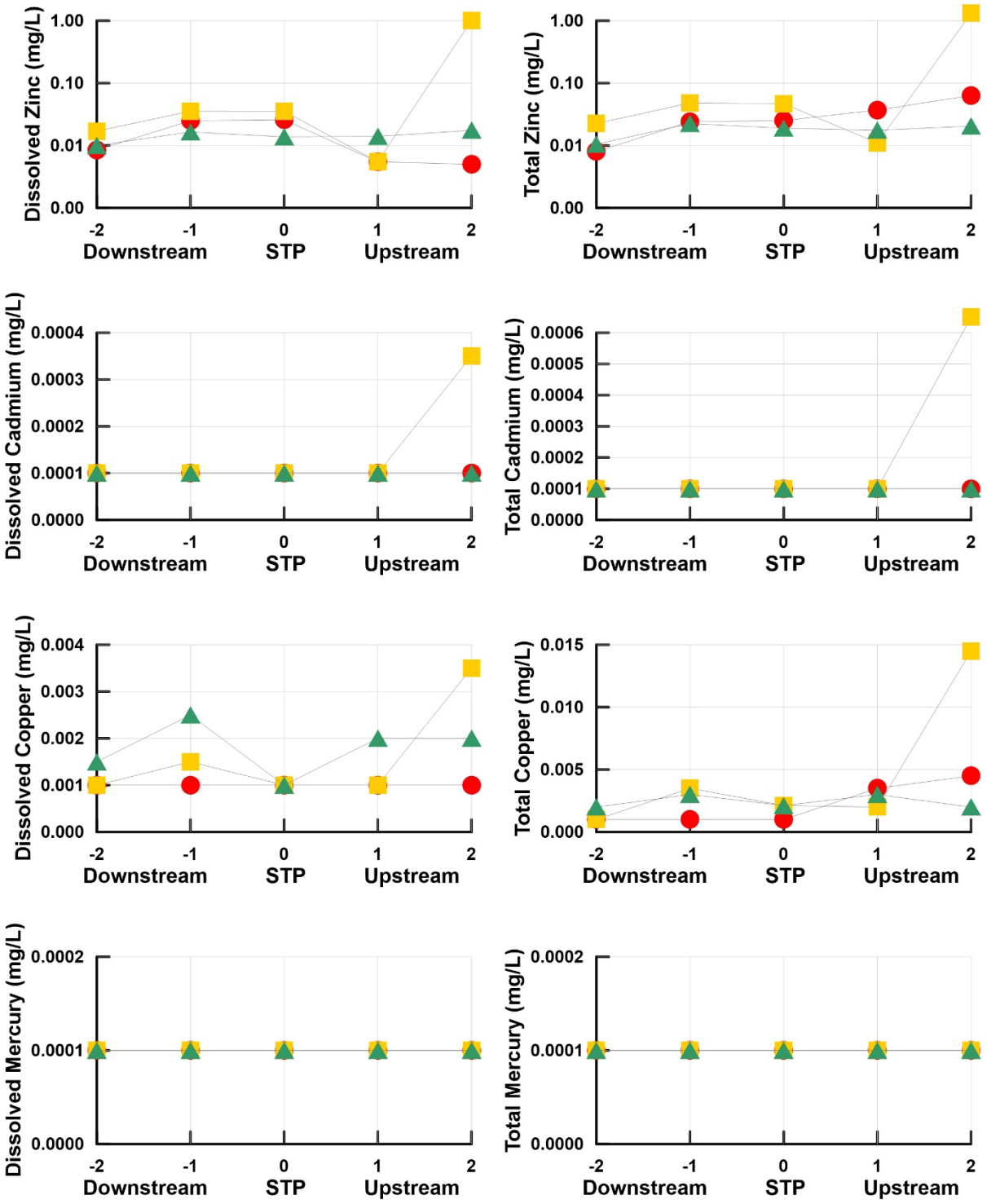

Figure 2.4. Spatial distribution of metals (a) in Whites Creek on the three sampling days.

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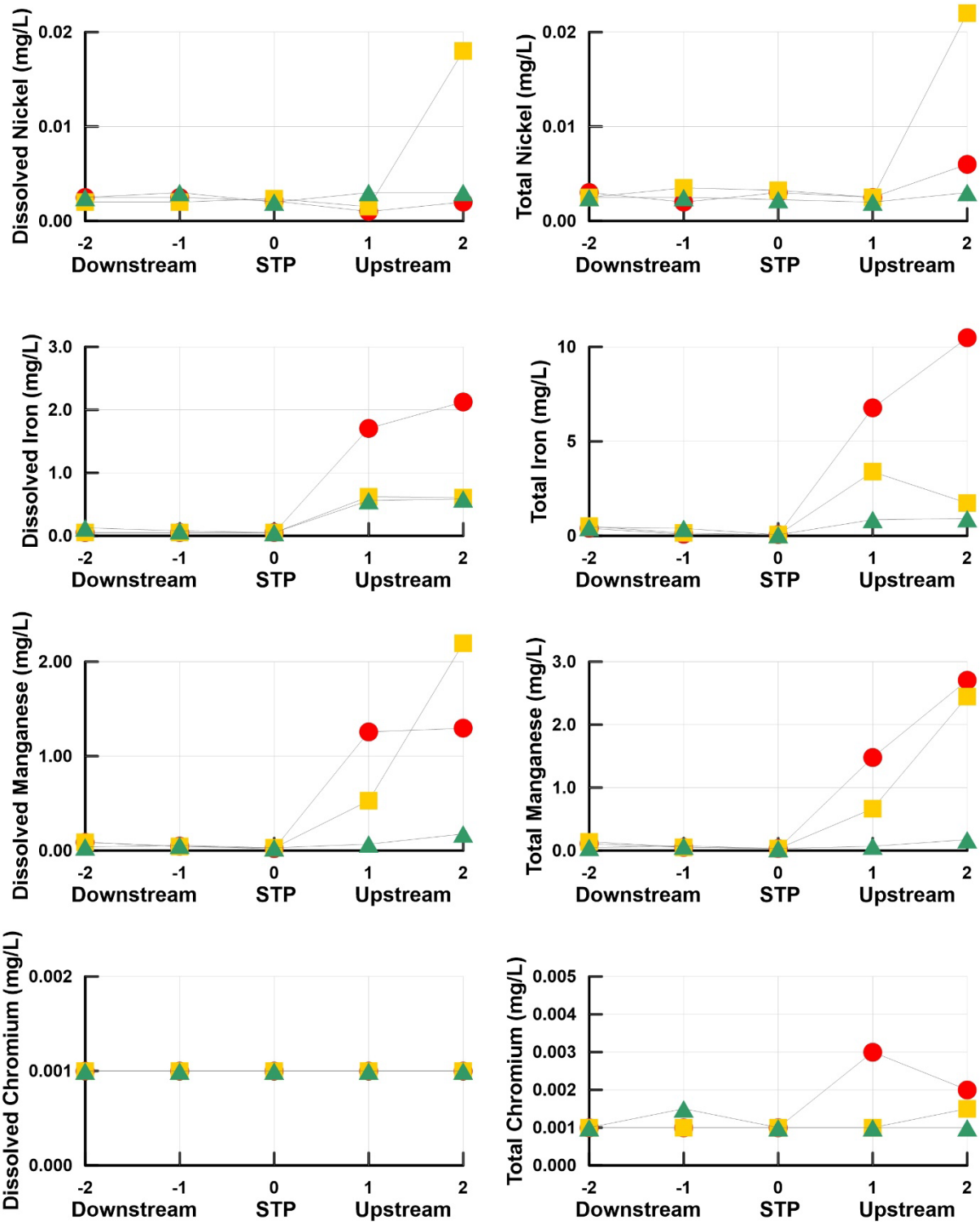

Figure 2.5. Spatial distribution of metals (b) in Whites Creek on the three sampling days.

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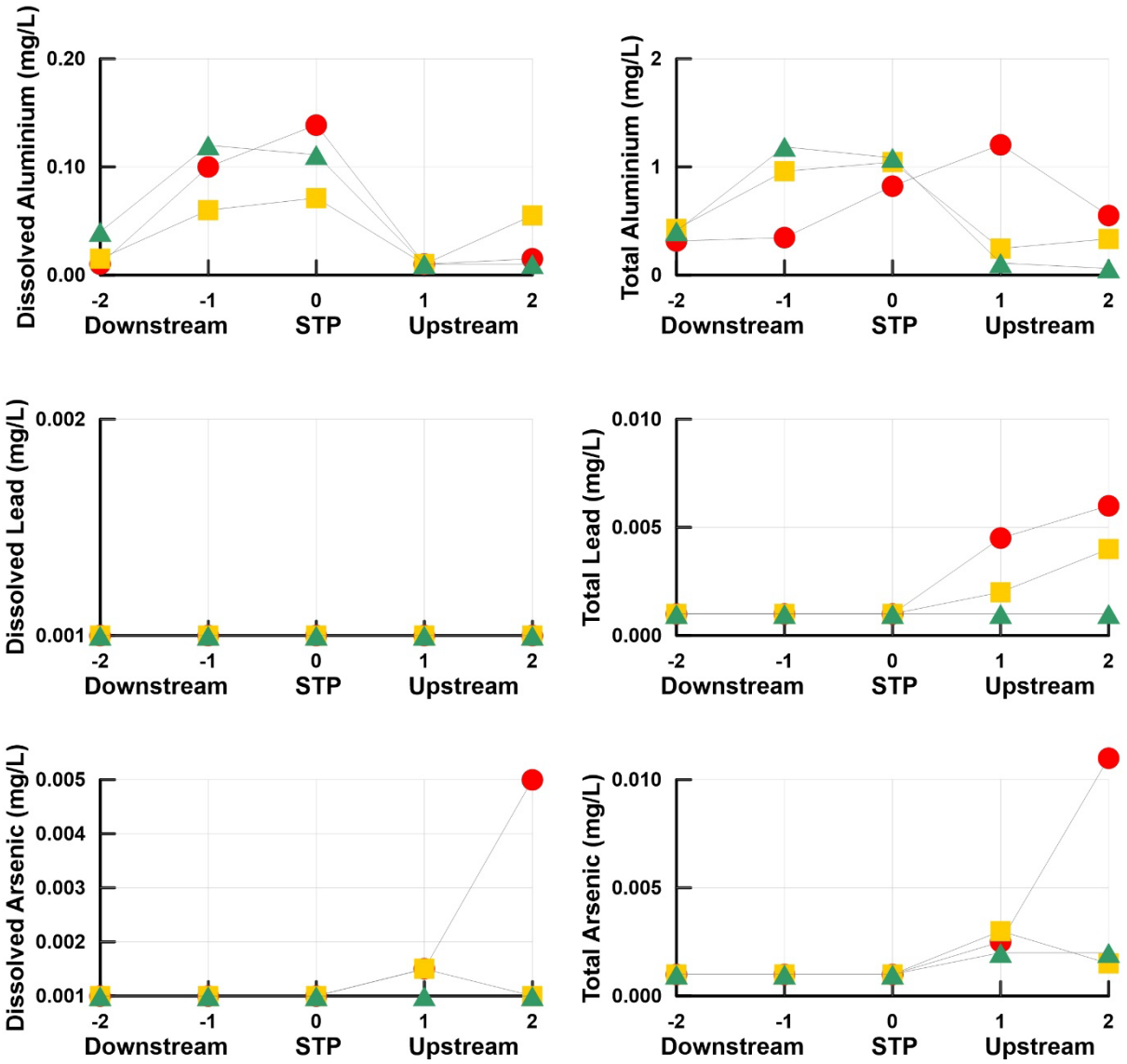

Figure 2.6. Spatial distribution of metals (c) in Whites Creek on the three sampling days.

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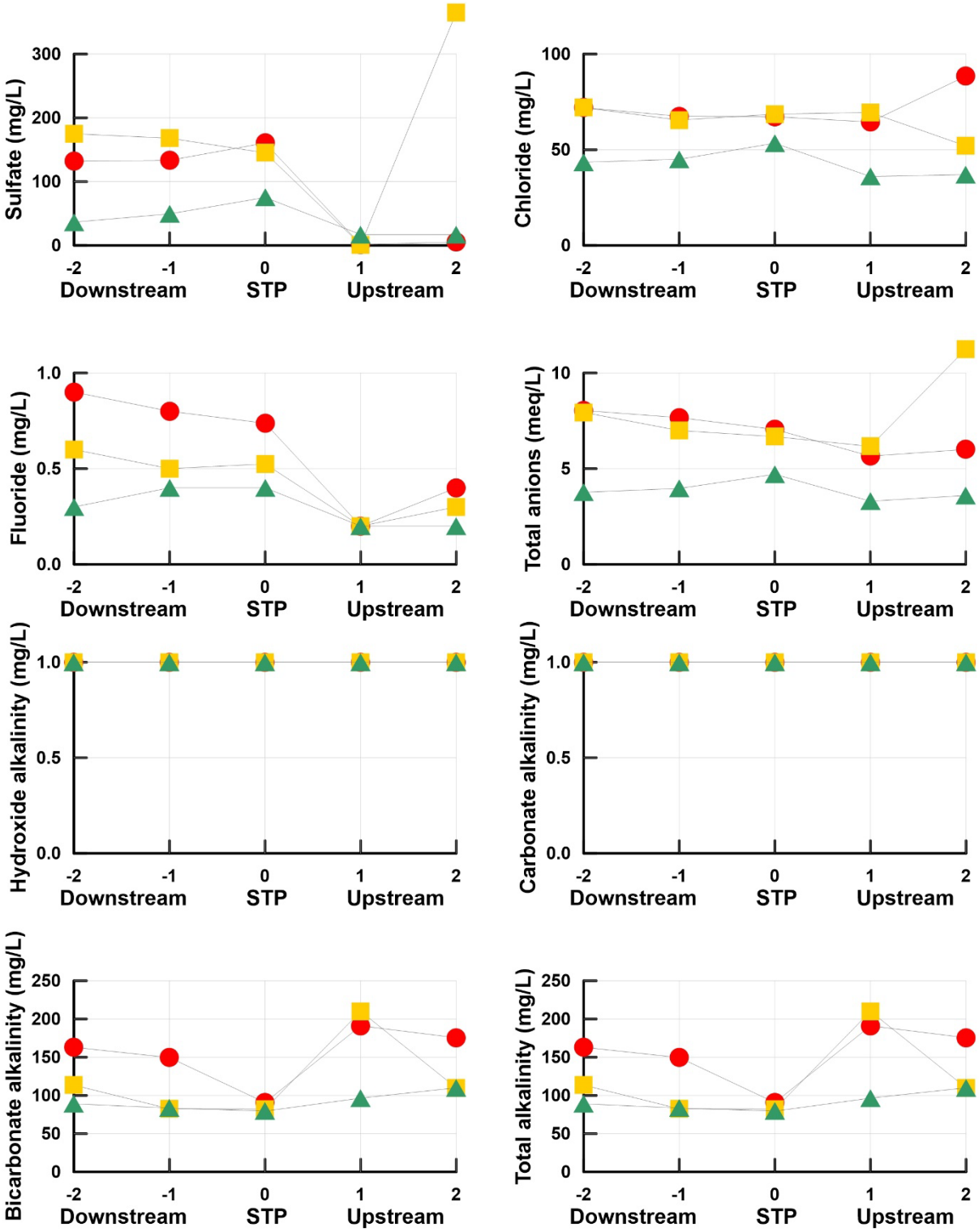

Figure 2.7. Spatial distribution of anions in Whites Creek on the three sampling days.

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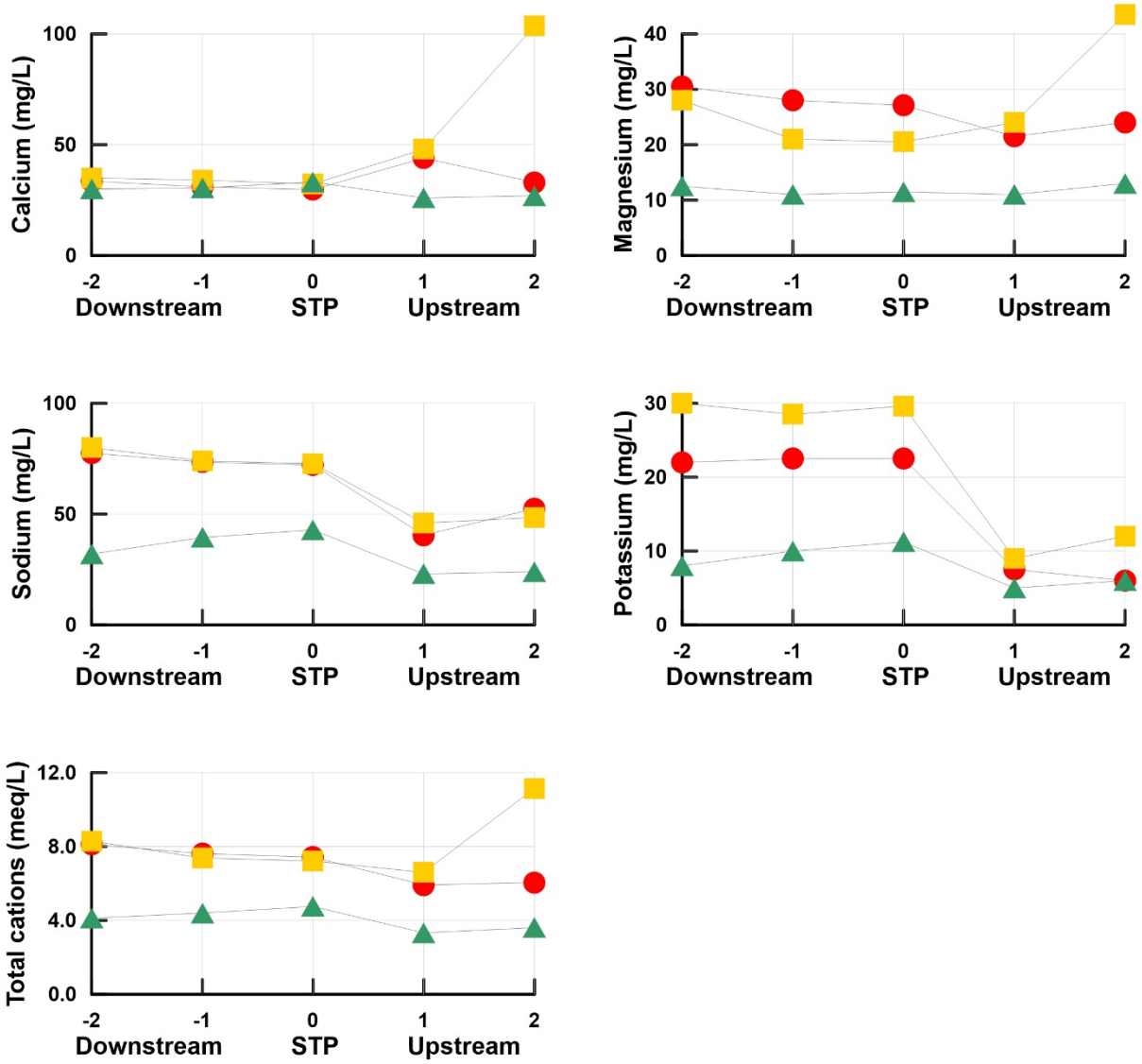

Figure 2.8. Spatial distribution of cations in Whites Creek on the three sampling days.

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Analysis of variance (ANOVA) is used to examine the influence of the STP discharges on Whites Creek. 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 suspended solids).

ANOVA example: Moss Vale STP – suspended solids

Transform: log

Normal: p-value = 0.389

Homogeneity of variance: p-value = 0.145

Source of Variation	SS	df	MS	F	P-value	F crit	% contribution
Days	14.061	2	7.030	7.15	0.0090	3.8853	52.1%
Sites	3.558	3	1.186	1.21	0.3497	3.4903	2.3%
Interaction	5.904	6	0.984	2.91	0.0545	2.9961	22.3%
Residuals	4.057	12	0.338				23.3%
Total	27.580	23					

Cells coloured pink indicate a significant difference in that term, green cells indicate no difference.

Days	Day 3	Day 2	Day 1	power
Average	1.70	2.20	3.51	0.585

Sites	STP	DS-2 (far)	US-1 (far)	US-2 (near)	power
Average	1.96	2.31	2.58	3.02	0.208

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 most 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 lower under wet weather conditions than under dry weather conditions.
- Concentrations of some metals (manganese and iron) are less in the STP than in the river. This may suggest an upstream source of metals.
- Nutrient concentrations from the STP discharges exceeded those observed in the creek.
- 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.

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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. Creek loads were estimated by multiplying the median concentration at the two upstream locations (two replicates at each location) by the total river flow. Load calculation results are presented in Table 2.9. Based on these load calculations, the following points are noted:

- Suspended solids: The Moss Vale STP contribution was moderate (15-30%), at the lower end under dry weather conditions and about 30% under wet weather conditions.
- Ions: In dry weather, the Moss Vale STP contributed about 50% of the total load of ions in Whites Creek. In wet weather, this percentage fell to about 40%.
- Total metals: For most metals, the Moss Vale contribution was between 0-40% and broadly similar under dry and wet weather. The exception was aluminium, where the STP contribution was about 70-80%.
- Nutrients: In dry weather, the Moss Vale STP contributed about 50-60% of the total load of nutrients in Whites Creek. In wet weather, this percentage was slightly higher, rising to about 70%.

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Table 2.9. Estimated loads (kg/day) of contaminants in the Moss Vale STP and Whites Creek

	Whites Creek flow (ML/day)			STP flow (ML/day)			% of STP load to combined STP and river flows		
	0.01	0.30	5.00	1.34	1.72	4.00			
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	123.1	31.0	45.0	19.4	8.6	20.0	14%	23%	31%
Total Alkalinity as CaCO3	243.7	321.0	936.0	117.6	141.1	315.9	33%	36%	25%
Sulfate as SO4	2.0	361.0	153.0	180.4	249.5	289.9	99%	41%	66%
Chloride	88.4	121.0	328.5	89.5	117.9	215.9	50%	49%	40%
Fluoride	0.3	0.5	1.8	0.9	0.9	1.6	74%	63%	47%
Calcium	59.6	151.0	238.5	40.1	54.2	132.0	40%	26%	36%
Magnesium	31.4	67.0	108.0	36.1	35.3	46.0	53%	35%	30%
Sodium	61.6	94.0	216.0	96.9	125.6	170.0	61%	57%	44%
Potassium	11.8	21.0	49.5	30.1	51.6	44.0	72%	71%	47%
total Aluminium	0.439	0.610	0.810	1.109	1.884	4.259	72%	76%	84%
total Arsenic	0.004	0.005	0.018	0.000	0.000	0.000	0%	0%	0%
total Cadmium	0.000	0.001	0.001	0.000	0.000	0.000	0%	0%	0%
total Chromium	0.002	0.002	0.009	0.000	0.000	0.000	0%	0%	0%
total Copper	0.006	0.016	0.023	0.001	0.003	0.008	19%	18%	26%
total Lead	0.005	0.006	0.009	0.000	0.000	0.000	0%	0%	0%
total Manganese	2.613	3.108	1.071	0.043	0.057	0.124	2%	2%	10%
total Nickel	0.005	0.025	0.023	0.004	0.005	0.008	43%	17%	26%
total Zinc	0.066	1.302	0.185	0.034	0.080	0.076	34%	6%	29%
total Iron	5.279	5.020	7.785	0.067	0.086	0.200	1%	2%	3%
total Mercury	0.000	0.000	0.001	0.000	0.000	0.000	0%	0%	0%
Total Nitrogen	3.537	5.400	12.600	4.676	9.466	28.393	57%	64%	69%
Total Phosphorus	0.354	0.460	0.765	0.381	0.353	1.340	52%	43%	64%

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3. Modelled Downstream Conditions

The 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 a 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 4 provides the results of the NorBE assessment. An additional three scenarios associated with Moss Vale also included the possible development known as the Moss Vale Economic Corridor (MVEC).

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 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 12,498 which is projected to be reached in 2046. The Moss Vale Enterprise Corridor (MVEC) is a Wingecarribee Shire Council strategy, broadly designed to take advantage of the nearby road and rail infrastructure and proximity to Sydney to help generate industrial development in the

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region. Three additional scenarios are undertaken in this report each associated with MVEC and its potential for the increased population. The EPs associated with the MVEC are 18,000, 27,000 and 36,000.

The existing EP was were obtained from the concept design report, by 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. Flows in Whites Creek and the regional 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 Moss Vale 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. It is noted that the concentrations provided for the scenarios (Table 3.1) are conservative and the actual performance is likely to be considerably better than these values.

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Table 3.1. Scenarios to be modelled. The practical quantitation limit (PQL) and ANZECC default trigger values are also included.

	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	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 of 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. Moss Vale STP 50%ile and 90%ile value, licence limits (loads and concentrations) and equivalent populations for the Moss Vale sewage treatment system.

	Moss Vale 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						8,557	12,498
TSS (mg/L)	4.0	7.0	10	15	12,411		
TN (mg/L)	3.90	6.95	7	10	6,619		
TP (mg/L)	0.240	0.496	0.5	1.0	414		

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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 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; 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.

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3.4. Results

3.4.1. Moss Vale EP = 12,498

Concentrations of the contaminants (obtained using Equation 3-1) 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 that 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.

- There is little difference in the concentrations at the two downstream locations. This is a direct result of the very low dilutions achieved in Whites Creek.
- The STP concentration for TSS does not change for the different scenarios (the slight differences observed 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 generally less than (but not statistically significantly different from) those at DS-1.
- For TN and TP, downstream nutrient concentrations are greatest for IDEA, thence MLE and the lowest concentrations are from FSB. Upstream concentrations of TN and TP are well in excess of the ANZECC guidelines (a factor of 2 or more) and the simulated concentrations are likewise in excess of the ANZECC guidelines.

Table 3.3. Moss Vale (EP = 12,498): 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	10	104	2.0	5.3	0.20	1.74
DS-1						
Existing	13	73	3.5	5.5	0.26	1.23
IDEA	13	62	5.5	8.0	0.25	1.05
MLE	12	62	4.2	6.0	0.18	1.01
FSB	13	65	2.9	4.6	0.18	0.97
DS-2						
Existing	9	69	3.4	5.6	0.25	1.13
IDEA	9	60	5.7	8.9	0.24	1.02
MLE	9	57	4.3	6.2	0.17	0.95
FSB	9	61	2.9	4.7	0.17	0.92

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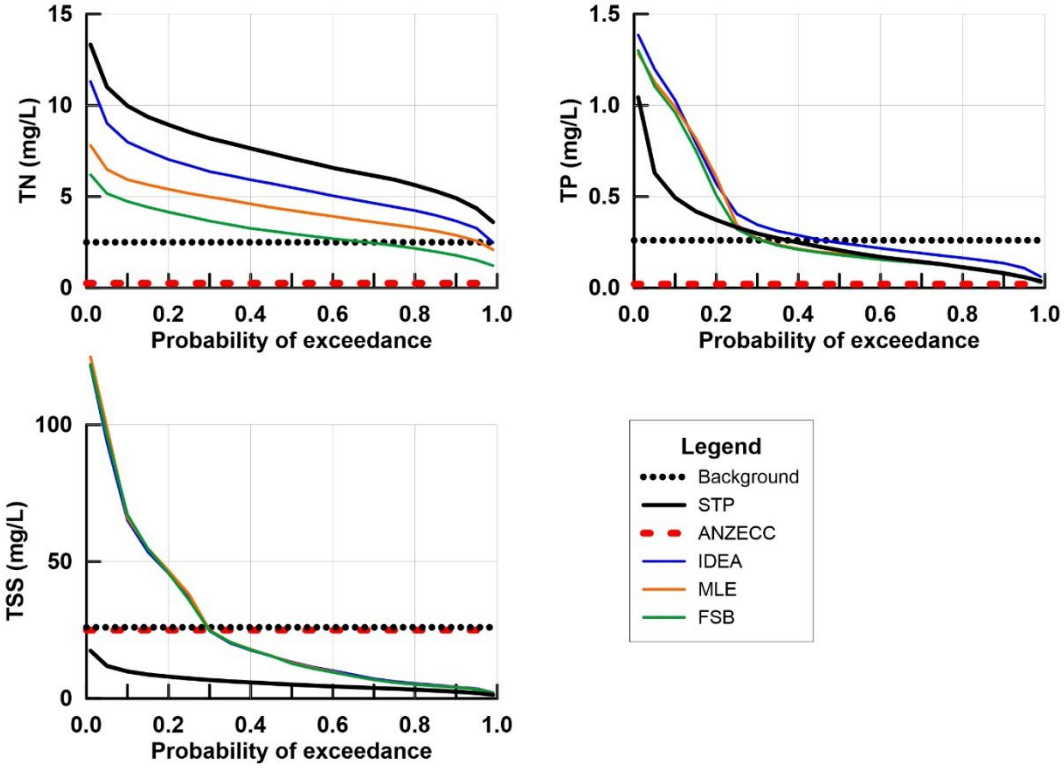

Figure 3.1. Moss Vale exceedance plots (EP = 12,498) for concentrations simulated from the three scenarios and under existing conditions at DS-1.

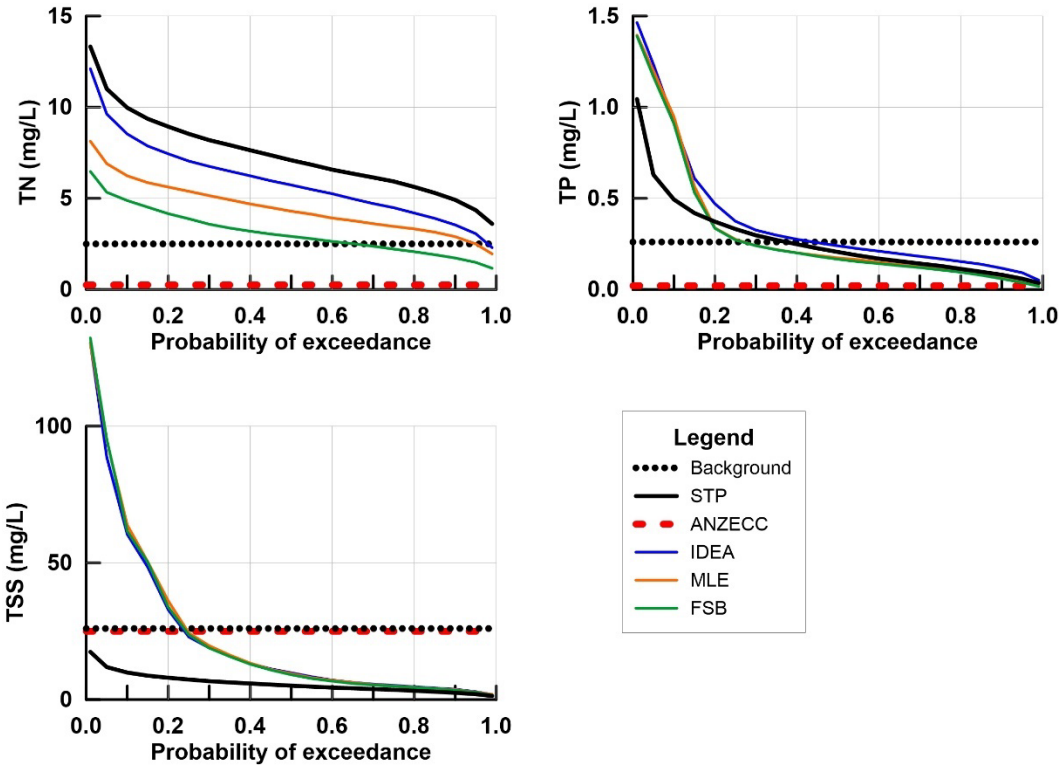

Figure 3.2. Moss Vale exceedance plots (EP = 12,498) for concentrations simulated from the three scenarios and under existing conditions at DS-2.

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3.4.2. Moss Vale plus MVEC (EP = 18,000)

Concentrations of the contaminants (obtained using Equation 3-1) for each scenario are presented in Figure 3.3 for the downstream location, DS-1, and in Figure 3.4 for the downstream location, DS-2. A summary of these results (for the 50% and 90%ile values) is given in Table 3.4. Based on repeated runs of the Monte Carlo simulations the accuracy of the 50%ile values is about 5%, while that 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.

- Statistically, there is not significant difference in the concentrations between the two downstream locations. This is a direct result of low dilutions in Whites Creek.
- Patterns at DS-1 and DS-2 are similar. Concentrations at DS-2 are generally less than (but not statistically significantly different from) those at DS-1.
- The STP concentration for TSS does not change for the different scenarios (the slight differences observed are due to the random inputs into the Monte Carlo simulations).
- Downstream nutrient concentrations are greatest for IDEA, thence MLE and the lowest concentrations are from FSB. Upstream concentrations of TN and TP are well in excess of the ANZECC guidelines (a factor of 2 or more) and the simulated concentrations are likewise in excess of the ANZECC guidelines.

Table 3.4. Moss Vale plus MVEC (EP = 18,000): 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	10	104	2.0	5.3	0.20	1.74
DS-1						
Existing	13	73	3.5	5.5	0.26	1.23
IDEA	12	58	5.8	8.5	0.25	0.92
MLE	12	59	4.4	6.1	0.17	0.84
FSB	12	54	3.0	4.7	0.18	0.96
DS-2						
Existing	9	69	3.4	5.6	0.25	1.13
IDEA	10	54	5.8	8.6	0.24	0.87
MLE	9	55	4.5	6.3	0.16	0.85
FSB	9	52	3.0	4.7	0.16	0.79

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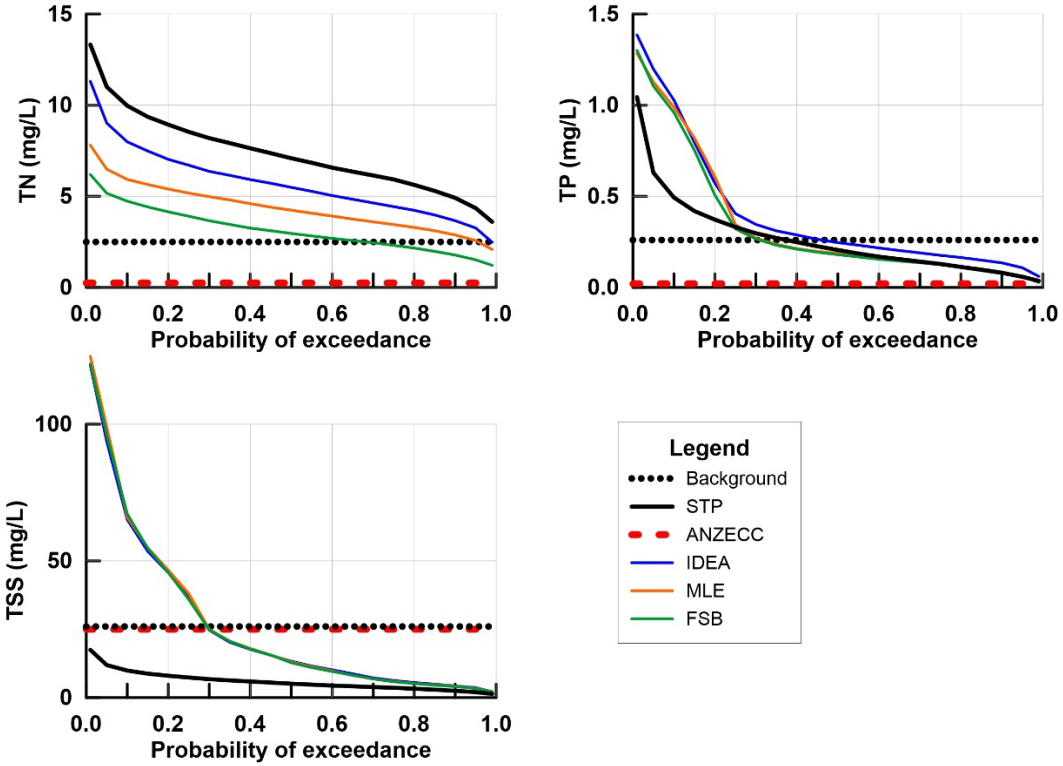

Figure 3.3. Moss Vale plus MVEC exceedance plots (EP = 18,000) for concentrations simulated from the three scenarios and under existing conditions at DS-1.

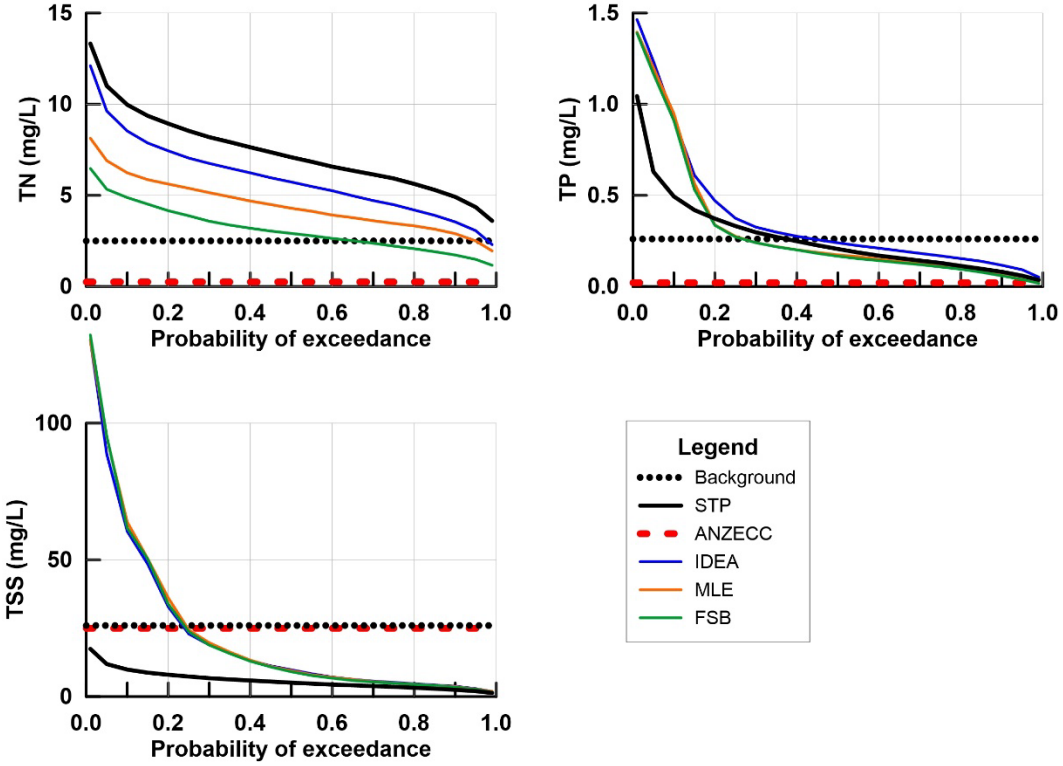

Figure 3.4. Moss Vale plus MVEC exceedance plots (EP = 18,000) for concentrations simulated from the three scenarios and under existing conditions at DS-2.

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3.4.3. Moss Vale plus MVEC (EP=27,000)

Concentrations of the contaminants (obtained using Equation 3-1) for each scenario are presented in Figure 3.5 for the downstream location, DS-1, and in Figure 3.6 for the downstream location, DS-2. A summary of these results (for the 50% and 90%ile values) is given in Table 3.5. Based on repeated runs of the Monte Carlo simulations the accuracy of the 50%ile values is about 5%, while that 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.

- Statistically, there is not significant difference in the concentrations between the two downstream locations. This is a direct result of low dilutions in Whites Creek.
- Patterns at DS-1 and DS-2 are similar. Concentrations at DS-2 are generally less than (but not statistically significantly different from) those at DS-1.
- The STP concentration for TSS does not change for the different scenarios (the slight differences observed are due to the random inputs into the Monte Carlo simulations).
- Downstream nutrient concentrations are greatest for IDEA, thence MLE and the lowest concentrations are from FSB. Upstream concentrations of TN and TP are well in excess of the ANZECC guidelines (a factor of 2 or more) and the simulated concentrations are likewise in excess of the ANZECC guidelines.

Table 3.5. Moss Vale plus MVEC (EP = 27,000): 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	10	104	2.0	5.3	0.20	1.74
DS-1						
Existing	13	73	3.5	5.5	0.26	1.23
IDEA	10	42	6.1	8.6	0.26	0.77
MLE	10	44	4.6	6.2	0.17	0.68
FSB	11	47	3.1	4.7	0.17	0.68
DS-2						
Existing	9	69	3.4	5.6	0.25	1.13
IDEA	9	43	6.1	8.9	0.24	0.81
MLE	8	44	4.7	6.4	0.16	0.67
FSB	8	42	3.0	4.8	0.16	0.65

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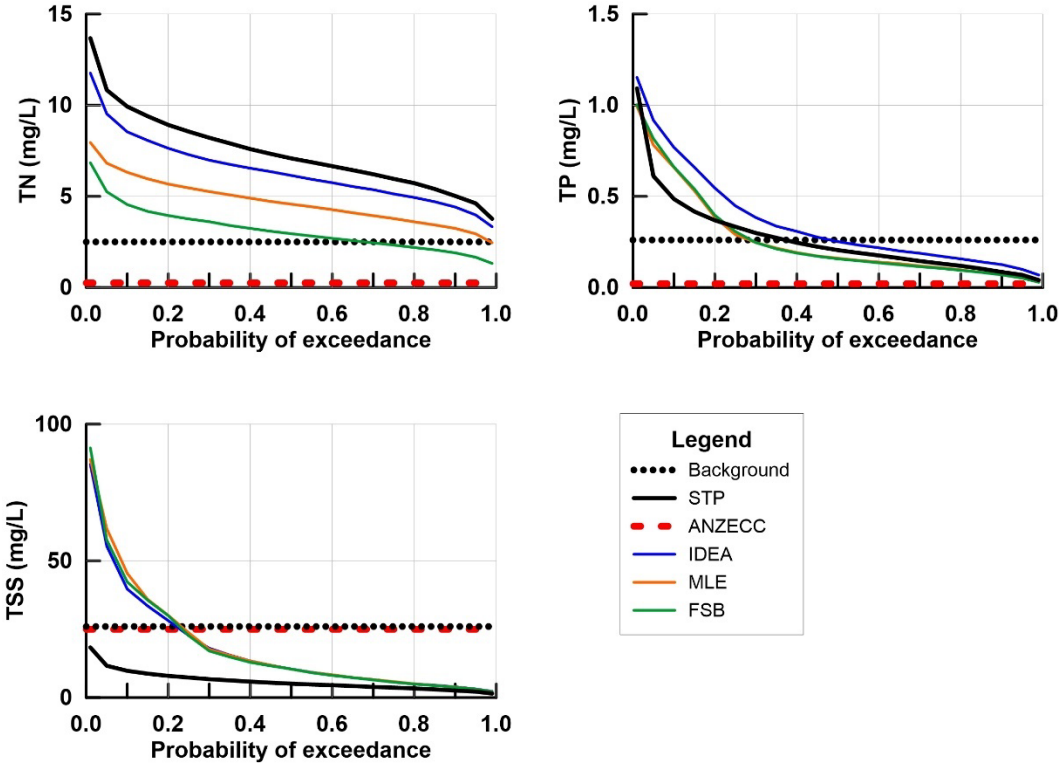

Figure 3.5. Moss Vale plus MVEC exceedance plots (EP = 27,000) for concentrations simulated from the three scenarios and under existing conditions at DS-1.

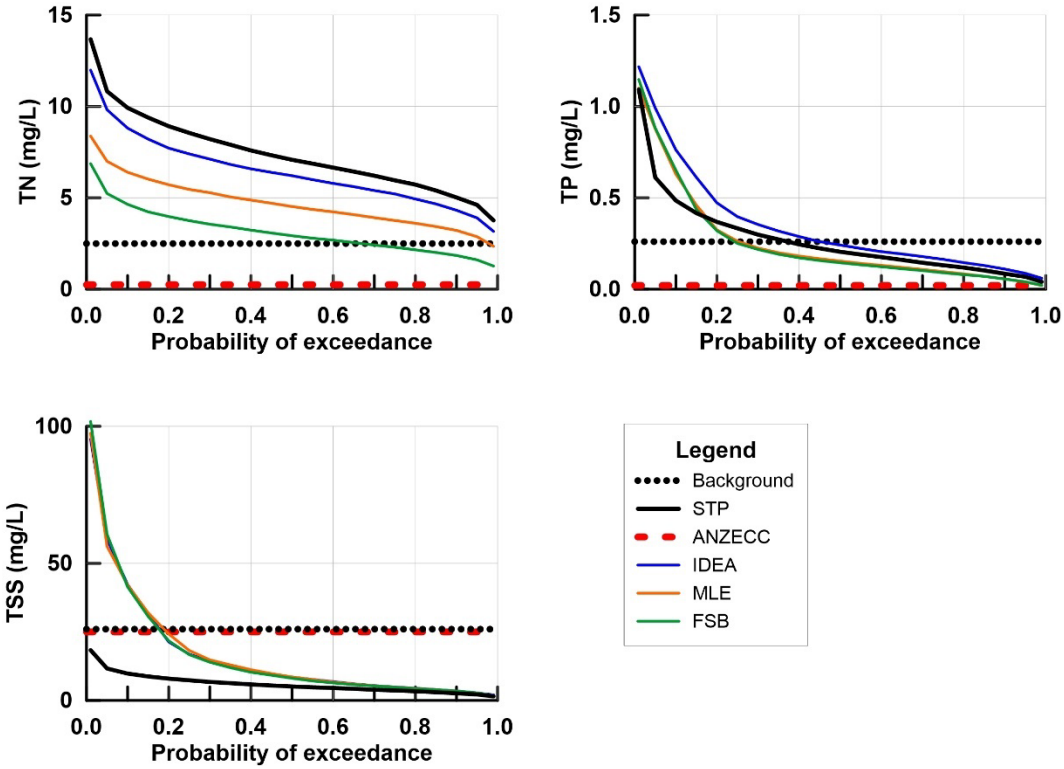

Figure 3.6. Moss Vale plus MVEC exceedance plots (EP = 27,000) for concentrations simulated from the three scenarios and under existing conditions at DS-2.

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3.4.4. Moss Vale plus MVEC (EP=36,000)

Concentrations of the contaminants (obtained using Equation 3-1) for each scenario are presented in Figure 3.7 for the downstream location, DS-1, and in Figure 3.8 for the downstream location, DS-2. A summary of these results (for the 50% and 90%ile values) is given in Table 3.6. Based on repeated runs of the Monte Carlo simulations the accuracy of the 50%ile values is about 5%, while that 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.

- Statistically, there is not significant difference in the concentrations between the two downstream locations. This is a direct result of low dilutions in Whites Creek.
- Patterns at DS-1 and DS-2 are similar. Concentrations at DS-2 are generally less than (but not statistically significantly different from) those at DS-1.
- The STP concentration for TSS does not change for the different scenarios (the slight differences observed are due to the random inputs into the Monte Carlo simulations).
- Downstream nutrient concentrations are greatest for IDEA, thence MLE and the lowest concentrations are from FSB. Upstream concentrations of TN and TP are well in excess of the ANZECC guidelines (a factor of 2 or more) and the simulated concentrations are likewise in excess of the ANZECC guidelines.

Table 3.6. Moss Vale plus MVEC (EP = 36,000): 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	10	104	2.0	5.3	0.20	1.74
DS-1						
Existing	13	73	3.5	5.5	0.26	1.23
IDEA	10	38	6.2	8.9	0.25	0.72
MLE	9	38	4.7	6.5	0.15	0.61
FSB	10	36	3.0	4.7	0.15	0.59
DS-2						
Existing	9	69	3.4	5.6	0.25	1.13
IDEA	8	37	6.4	9.2	0.24	0.70
MLE	8	39	4.7	6.5	0.15	0.60
FSB	8	36	3.0	4.8	0.14	0.54

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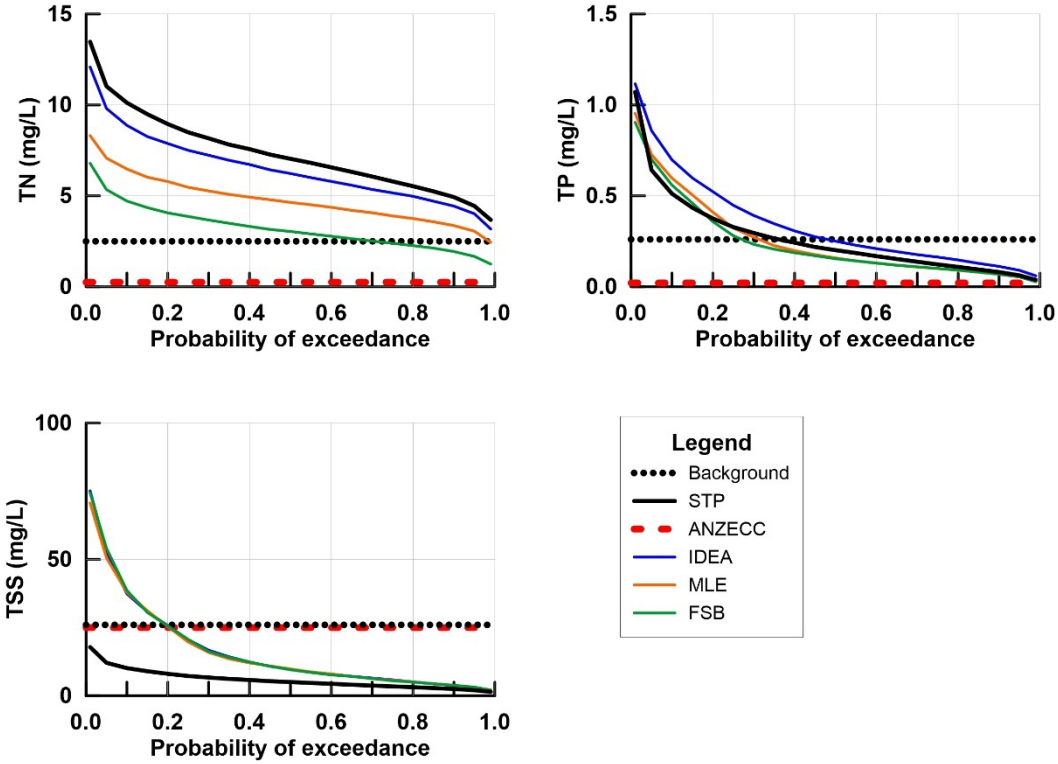

Figure 3.7. Moss Vale plus MVEC exceedance plots (EP = 36,000) for concentrations simulated from the three scenarios and under existing conditions at DS-1.

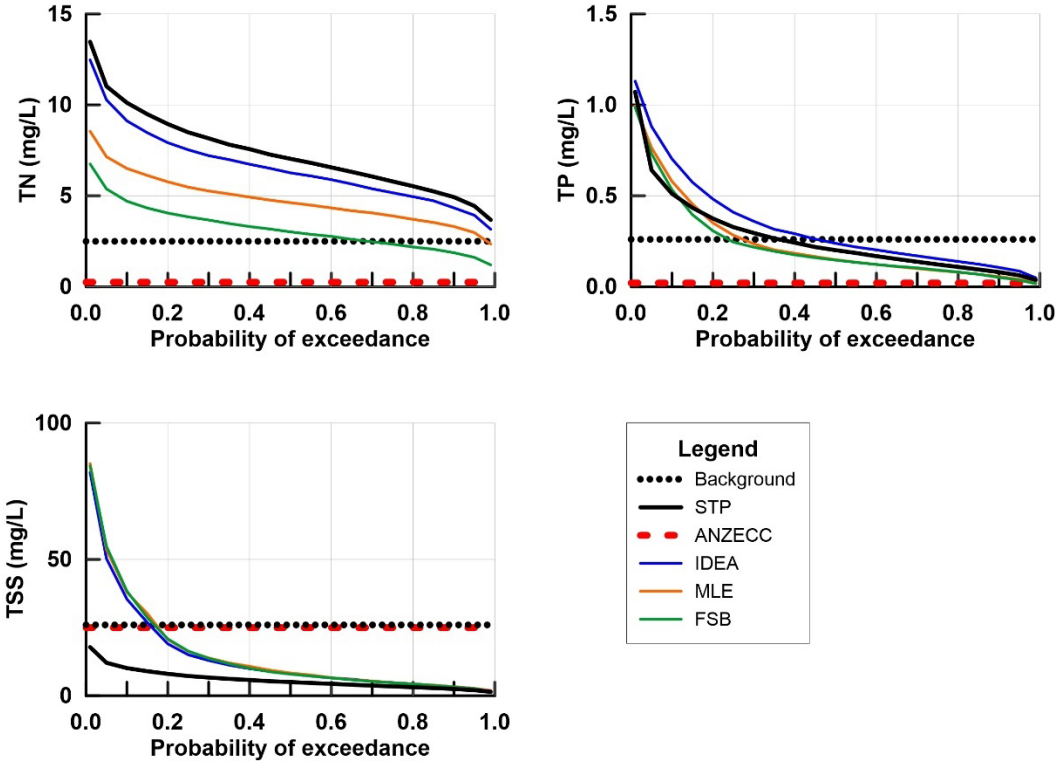

Figure 3.8. Moss Vale plus MVEC exceedance plots (EP = 36,000) for concentrations simulated from the three scenarios and under existing conditions at DS-2.

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4. Neutral or Beneficial Effects Assessment

The 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 the 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. Moss Vale EP = 12,498

4.2.1. 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 undertaken using the iterative process of changing the concentrations in the effluent, running the Monte Carlo simulations and

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comparing the results with the NorBE requirements.

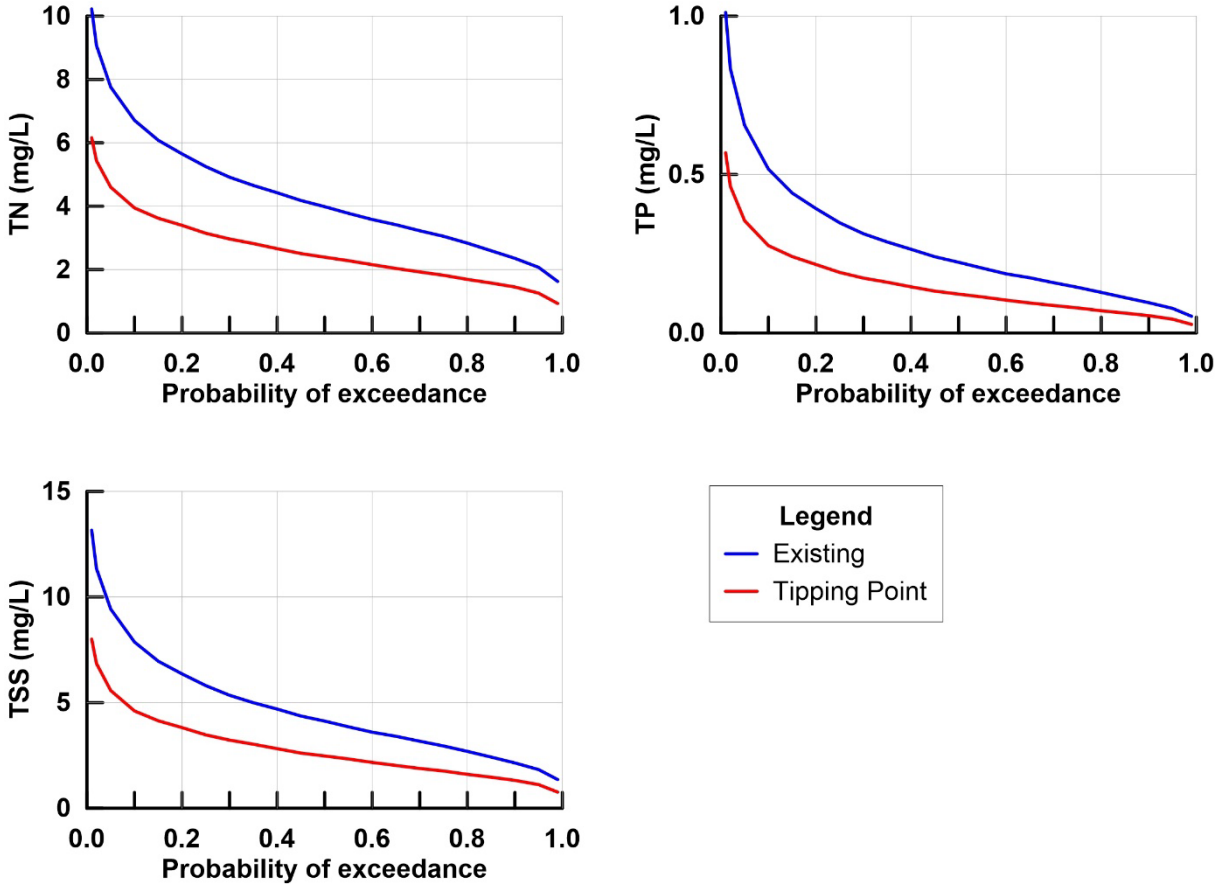

Figure 4.1. Moss Vale exceedance plots (EP = 12,498) for the 'tipping point' concentrations and concentrations under the existing conditions.

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Exceedance plots comparing the 'tipping point' concentrations with the existing concentrations for Moss Vale 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 Moss Vale EP=12,498 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. Moss Vale (EP = 12,498): 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	4,350	4,090	4.0	7.0	2.6	4.7
TN	4,000	3,790	3.90	6.95	2.46	4.01
TP	260	220	0.240	0.496	0.128	0.283

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4.2.2. Scenario Results

Exceedance plots comparing simulations of the IDEA scenario with the existing concentrations for Moss Vale (EP = 12,498) 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).

Existing concentrations between the 50% and 98%iles (i.e. probability of exceedance of 0.50 and 0.02, respectively) are less than the modelled concentrations under the IDEA simulations. NorBE requirements for TSS, TN and TP are not met.

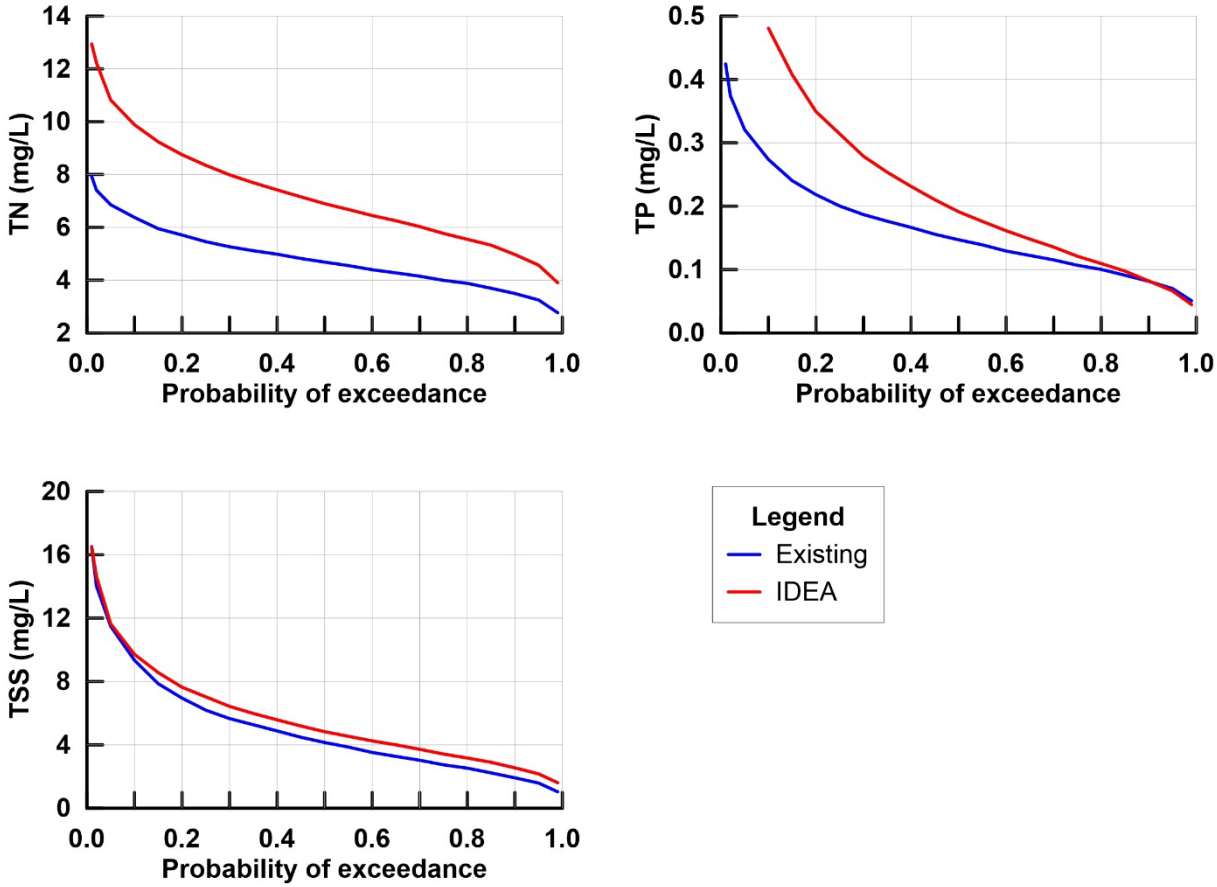

Figure 4.2. Moss Vale exceedance plots (EP = 12,498) for the concentrations simulated from the IDEA scenario and under the existing conditions.

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Exceedance plots comparing simulations of the MLE scenario with the existing concentrations for Moss Vale (EP=12,498) 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 and TSS concentrations do not meet the NorBE concentration requirement.

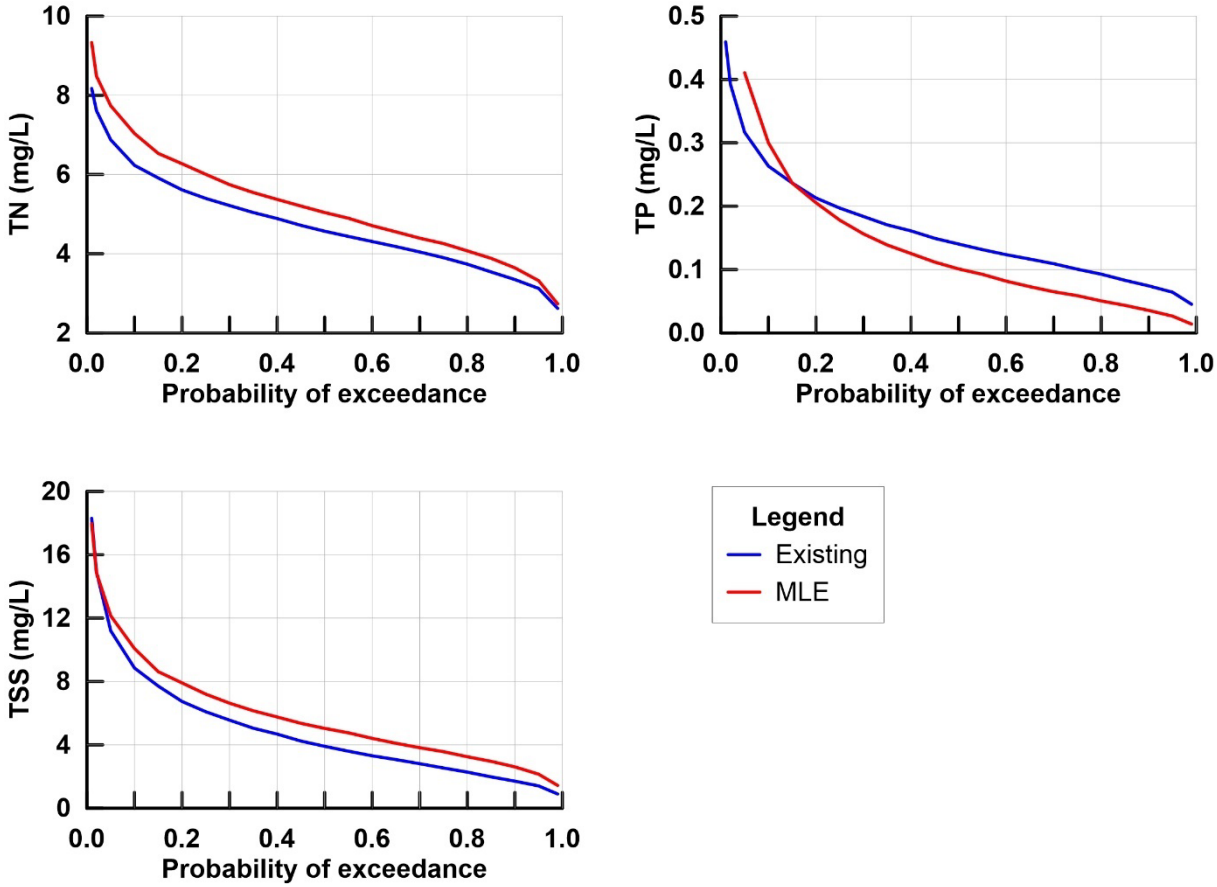

Figure 4.3. Moss Vale exceedance plots (EP = 12,498) for the concentrations simulated from the MLE scenario and under the existing conditions.

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Exceedance plots comparing simulations of the FSB scenario with the existing concentrations for Moss Vale (EP=12,498) 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 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). NorBE concentration requirements for TSS are not met.

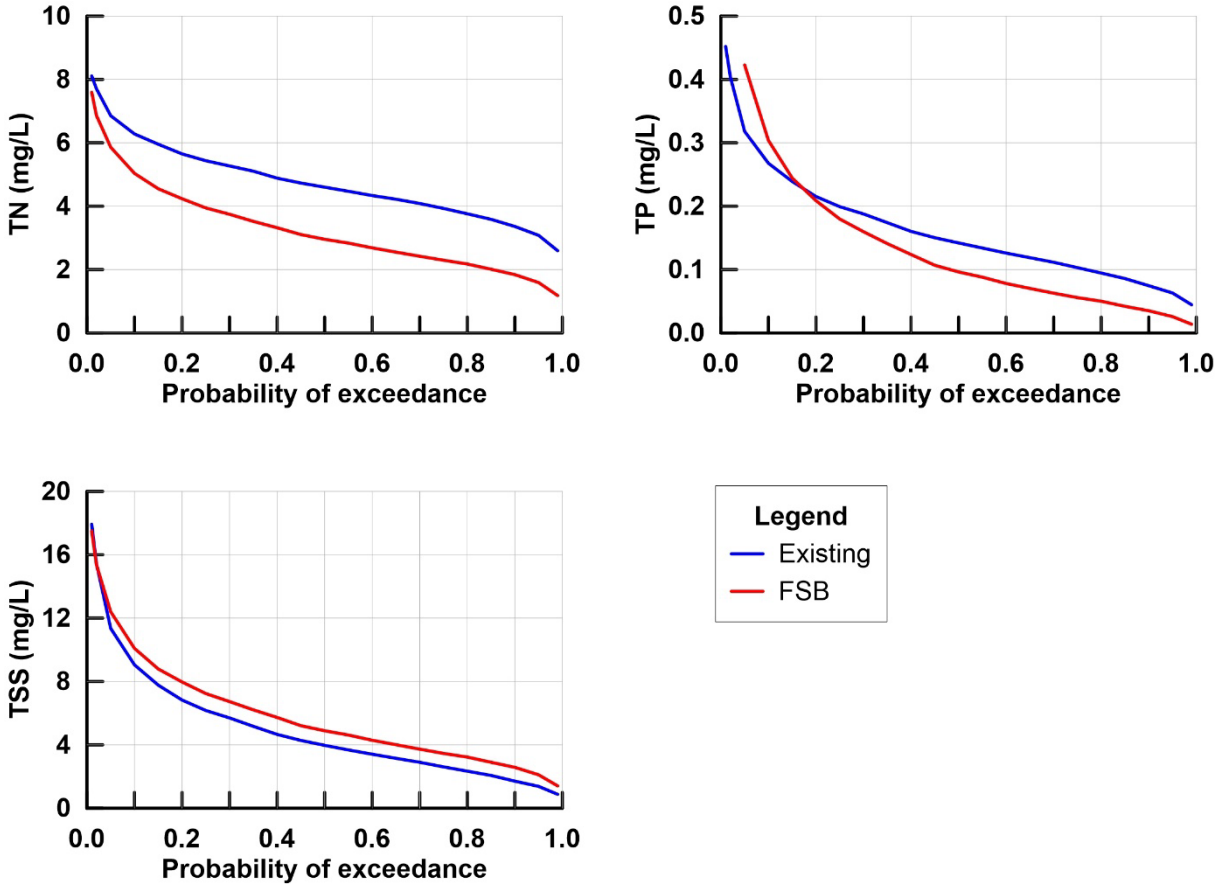

Figure 4.4. Moss Vale exceedance plots (EP = 12,498) for the concentrations simulated from the FSB scenario and under the existing conditions.

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Exceedance plots for Moss Vale (EP=12,498) are presented in Figure 4.5 for each scenario (and for existing conditions) 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 does not meet the NorBE concentration requirement for that scenario. Table cells labelled 'marginal' indicate scenarios that are close to meeting the NorBE concentration requirement.

- TN concentrations are considerably less than the existing conditions for FSB, while MLE concentrations are slightly above the existing conditions.
- TP concentrations are generally less than the existing concentrations for all scenarios.
- TSS concentrations are close to, but slightly above those for the existing conditions.

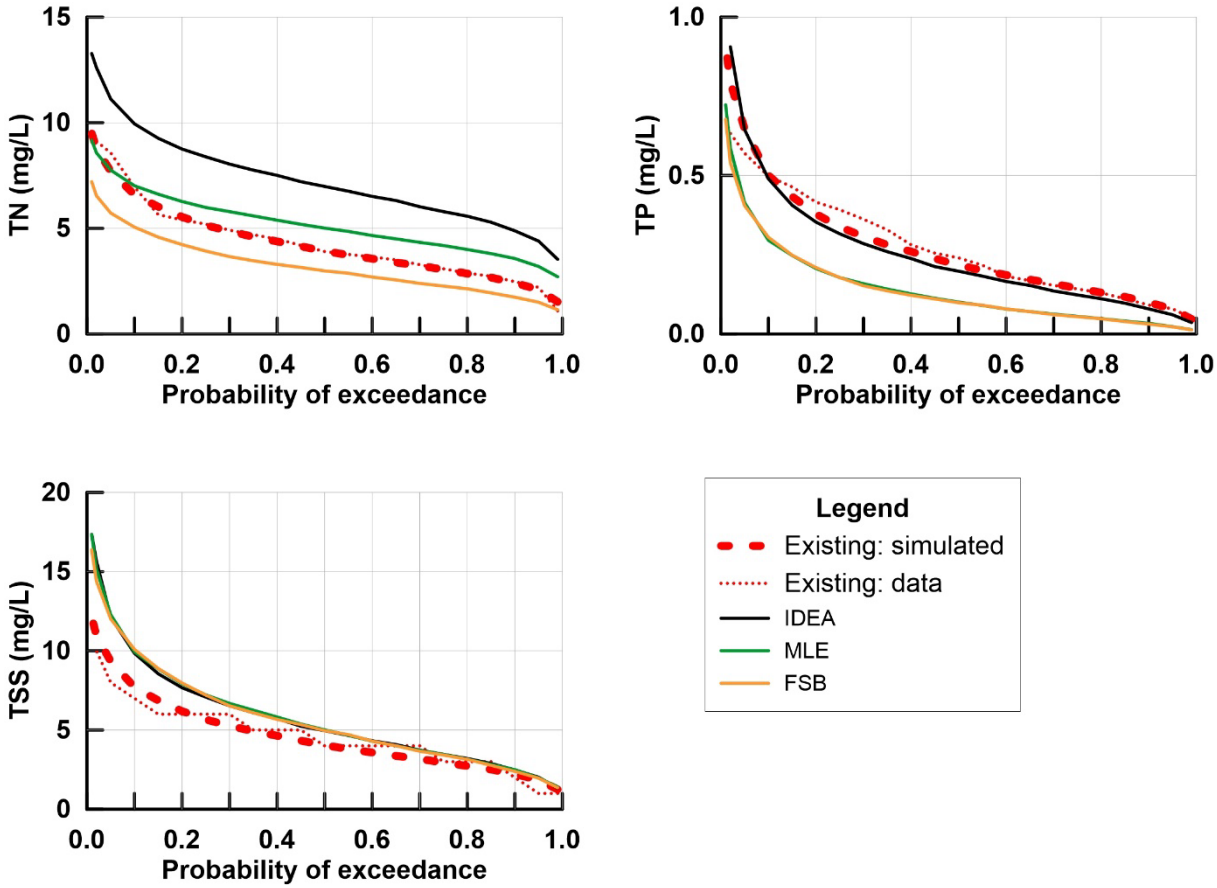

Figure 4.5. Moss Vale exceedance plots (EP = 12,498) for concentrations simulated from the three scenarios and under existing conditions (both the data and simulations are presented).

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Table 4.2. Moss vale (EP = 12,498): NorBE concentrations

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

Cells shaded pink indicates 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 exceed the existing conditions. However, it is noted that the design concentrations are conservative and the actual loads will be less than those presented here. The MLE and FSB loads for TP meet the NorBE annual load requirement and the FSB loads for TN are within 20% of the NorBE annual load requirement.

Table 4.3. Bowral (EP = 18,692): NorBE annual loads

Annual load (kg/year)	Existing	Scenario treatment type		
		IDEA	MLE	FSB
TSS	4,350	8,380	8,270	8,480
TN	4,000	10,570	7,480	4,750
TP	260	370	200	210

Cells shaded pink indicates 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.

4.3. Moss Vale plus MVEC (EP = 18,000)

4.3.1. 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 undertaken using the iterative process of changing the concentrations in the effluent, running the Monte Carlo simulations and comparing the results with the NorBE requirements.

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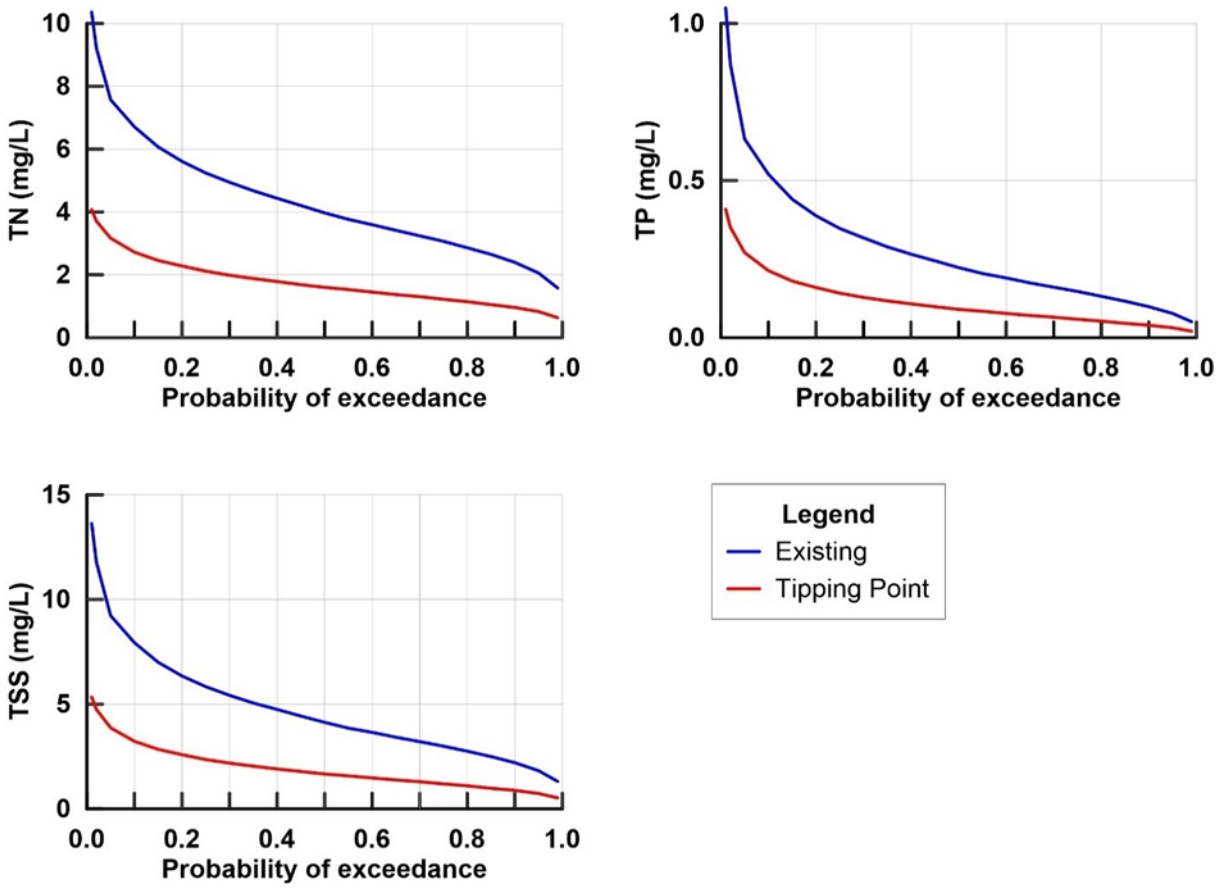

Figure 4.6. Moss Vale exceedance plots (EP = 18,000) for the 'tipping point' concentrations and concentrations under the existing conditions.

Exceedance plots comparing the 'tipping point' concentrations with the existing concentrations for Moss Vale 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 Moss Vale EP=18,000 are shown in Table 4.4. 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 4.4. Moss Vale plus MVEC (EP = 18,000): 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	4,350	3,810	4.0	7.0	1.6	3.1
TN	4,000	3,540	3.90	6.95	1.56	2.68
TP	260	220	0.240	0.496	0.086	0.206

Scenarios

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Exceedance plots comparing simulations of the IDEA scenario with the existing concentrations for Moss Vale (EP=18,000) are shown in Figure 4.7. 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).

Existing concentrations between the 50% and 98%iles (i.e. probability of exceedance of 0.50 and 0.02, respectively) are less than the modelled concentrations under the IDEA simulations. NorBE requirements for TSS and TN are not met.

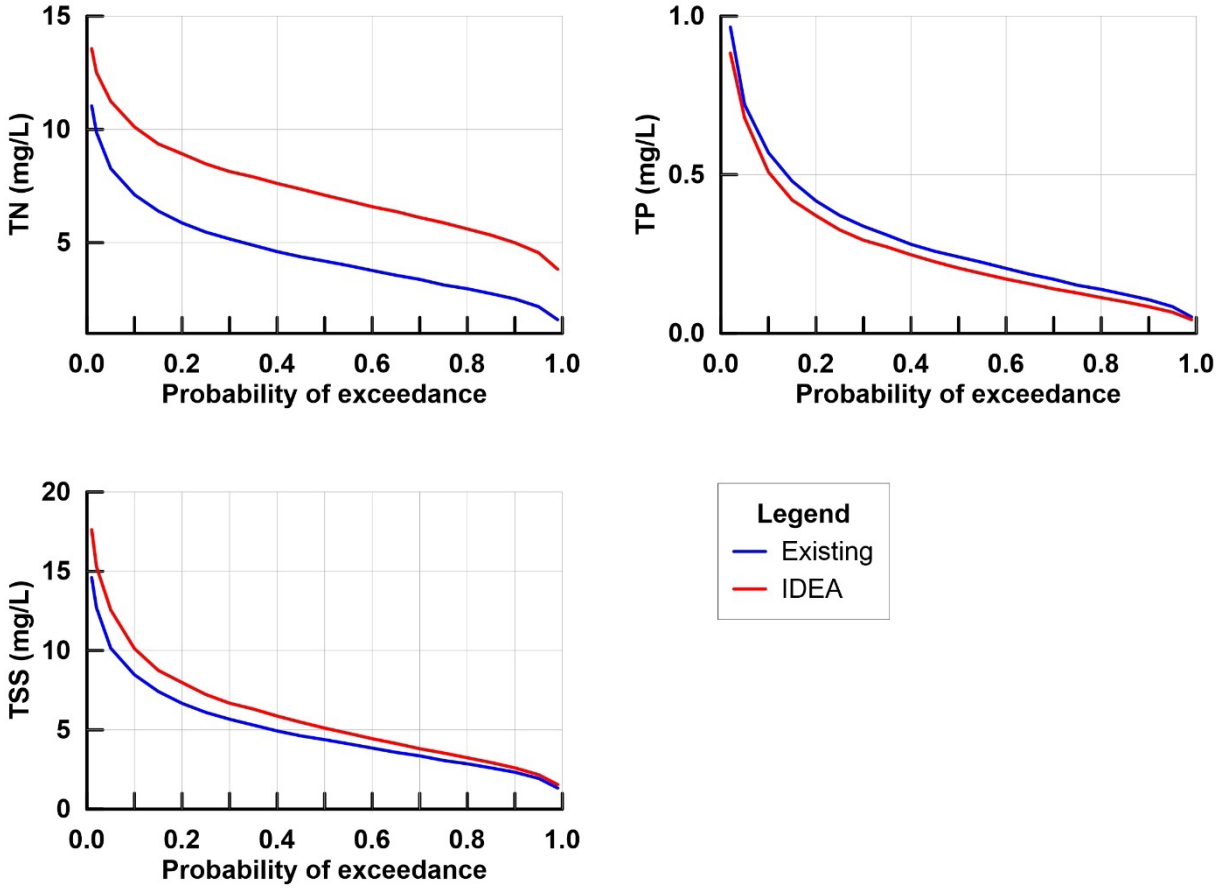

Figure 4.7. Moss Vale exceedance plots (EP = 18,000) for the concentrations simulated from the IDEA scenario and under the existing conditions.

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Exceedance plots comparing simulations of the MLE scenario with the existing concentrations for Moss Vale (EP=18,000) are shown in Figure 4.8. 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. TN and TSS concentrations do not meet the NorBE concentration requirement.

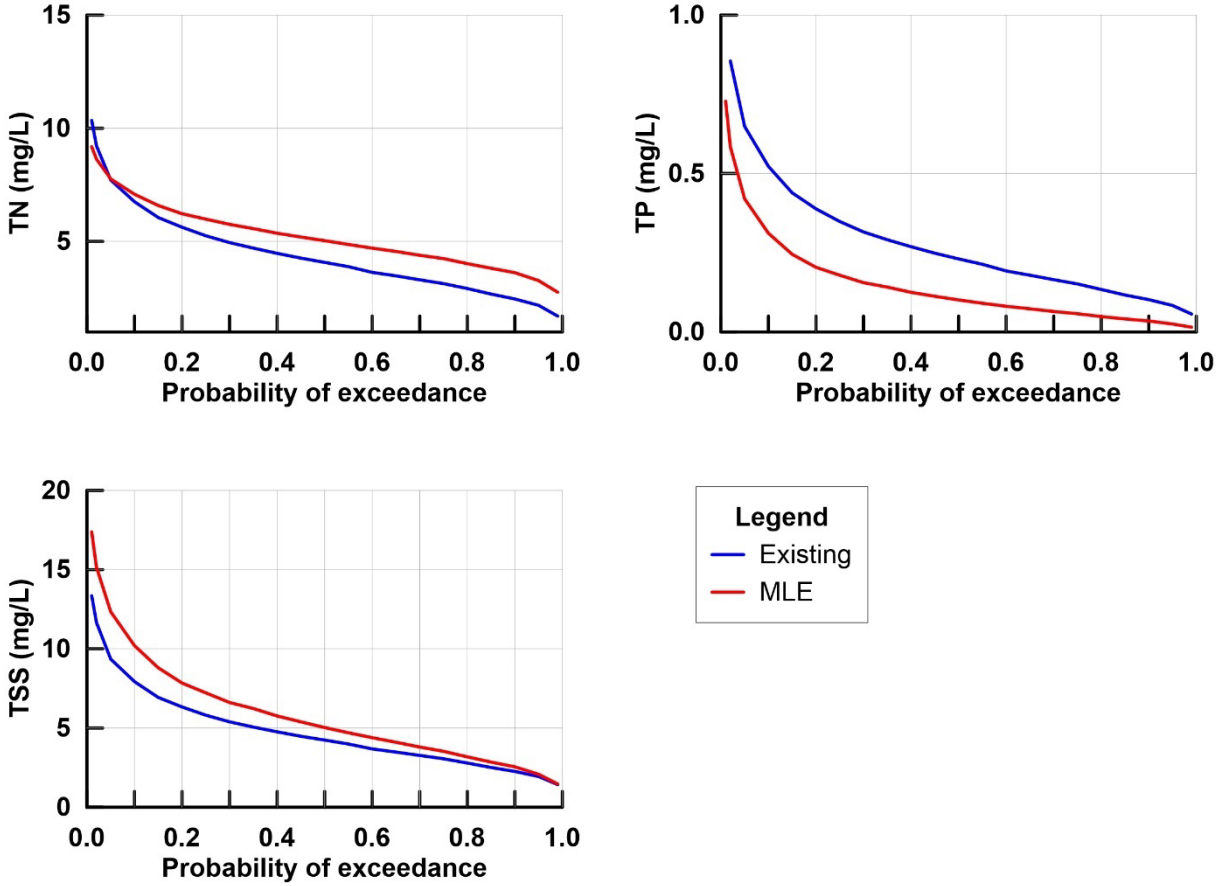
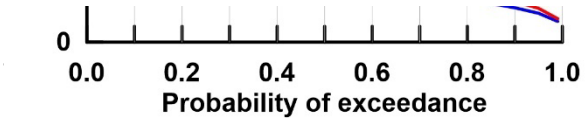


Figure 4.8. Moss Vale exceedance plots (EP = 18,000) for the concentrations simulated from the MLE scenario and under the existing conditions.



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 TN and TP are met. NorBE concentration requirements for TSS are not met.

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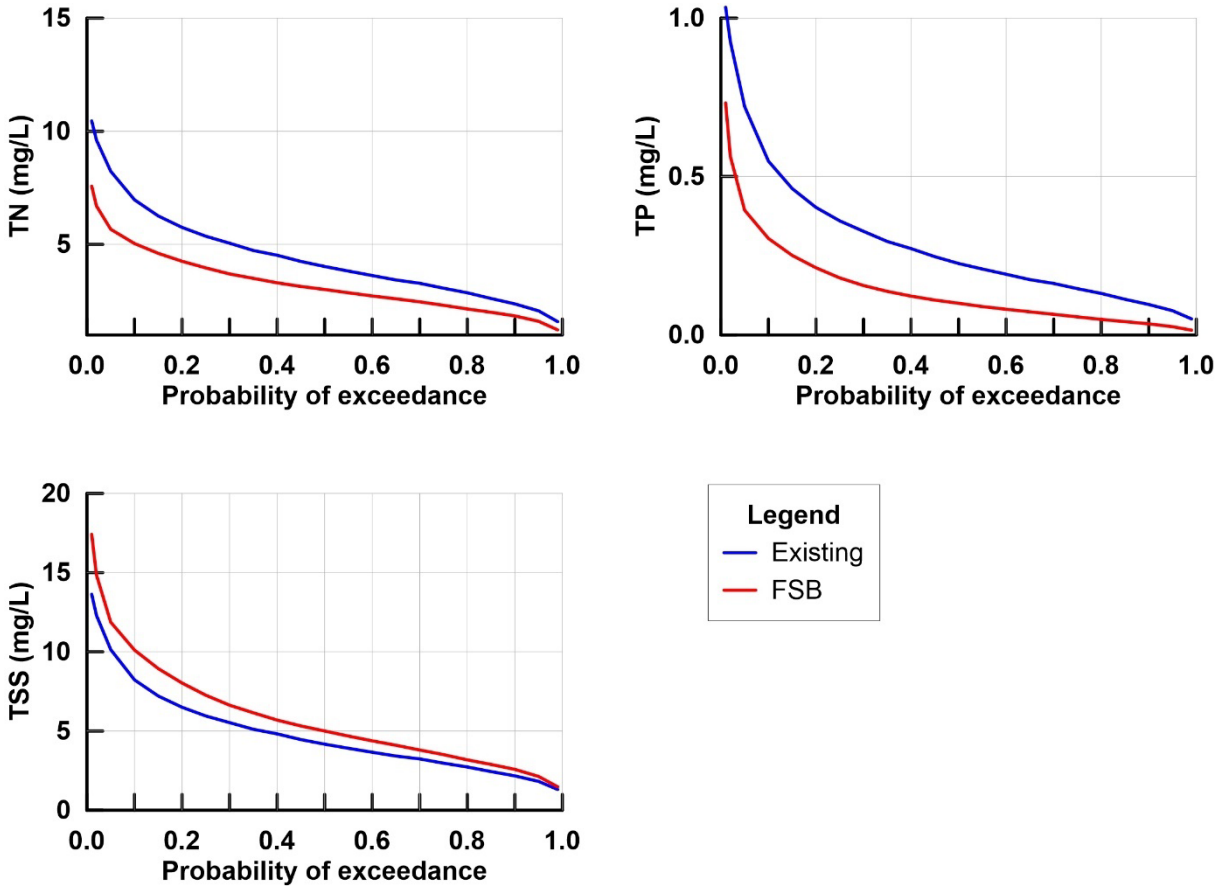

Figure 4.9. Moss Vale exceedance plots (EP = 18,000) for the concentrations simulated from the FSB scenario and under the existing conditions.

Exceedance plots for Moss Vale (EP = 18,000) are presented in Figure 4.10 for each scenario (and for existing conditions) with key results summarised in Table 4.5. Ticks in the table indicate that the contaminant meets the NorBE concentration requirement for that scenario. Crosses indicate that the contaminant does not meet the NorBE concentration requirement for that scenario. Table cells labelled ‘marginal’ indicate scenarios that are close to meeting the NorBE concentration requirement.

- TN concentrations are considerably less than the existing conditions for FSB, while MLE concentrations are slightly above the existing conditions.
- TP concentrations are generally less than the existing concentrations for all scenarios.
- TSS concentrations are close to, but slightly above those for the existing conditions.

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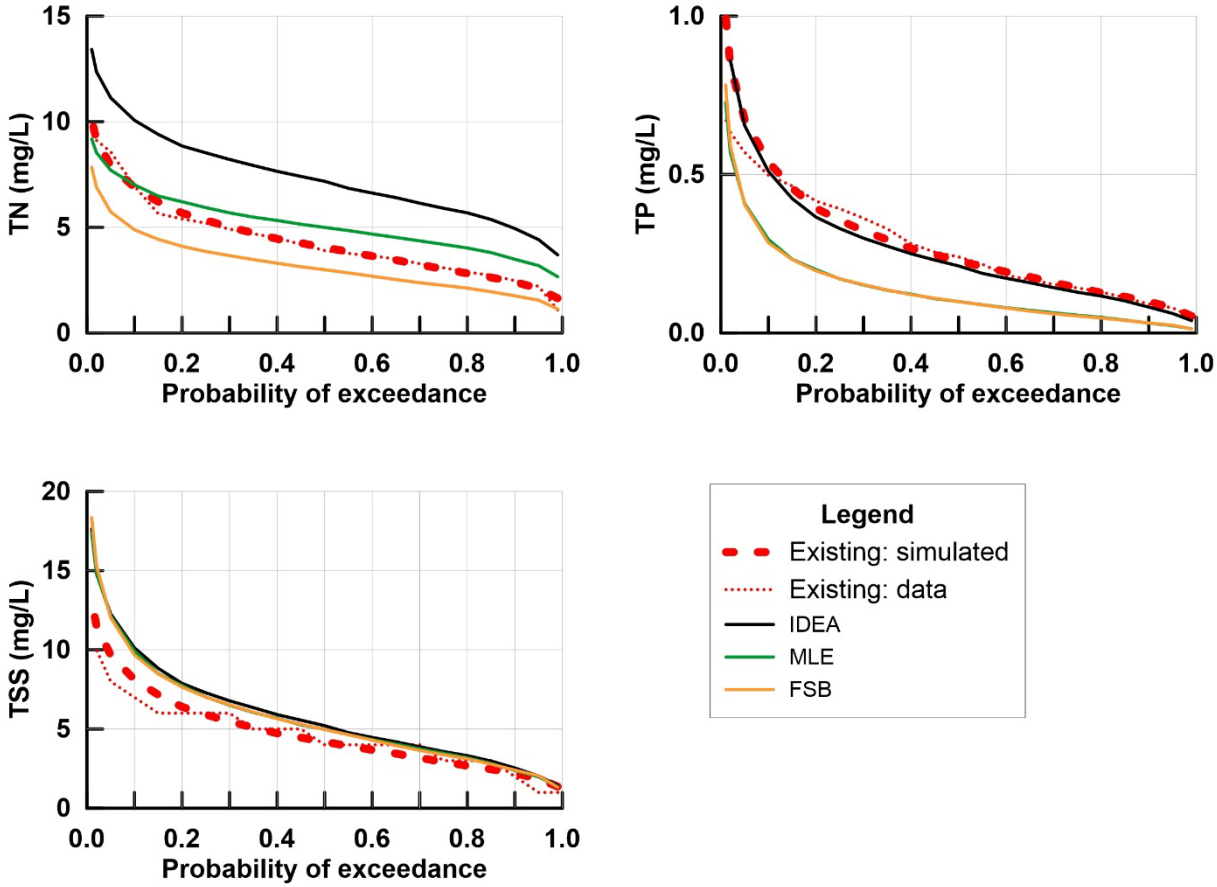

Figure 4.10. Moss Vale exceedance plots (EP = 18,000) for concentrations simulated from the three scenarios and under existing conditions

Table 4.5. Moss Vale (EP = 18,000): NorBE concentrations

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

Annual loads were estimated by averaging the annual loads for each of the 5 years that comprise the simulation period and multiplied by 1.1. Results are presented in Table 4.6. The scaled annual loads for TSS exceed the existing conditions. However, it is noted that the design concentrations are conservative and the actual loads will be less than those presented here. The MLE and FSB loads for TP are close to the existing load values. All other scenarios exceed the NorBE annual load requirements.

Table 4.6. Moss Vale (EP=18,000): NorBE annual loads

Annual load		Scenario treatment type		
(kg/year)	Existing	IDEA	MLE	FSB
TSS	4,350	11,900	11,800	11,800
TN	4,000	15,130	10,700	6,700
TP	260	530	290	290

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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.

4.4. Moss Vale EP=27,000

4.4.1. 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 undertaken using the iterative process of changing the concentrations in the effluent, running the Monte Carlo simulations and comparing the results with the NorBE requirements.

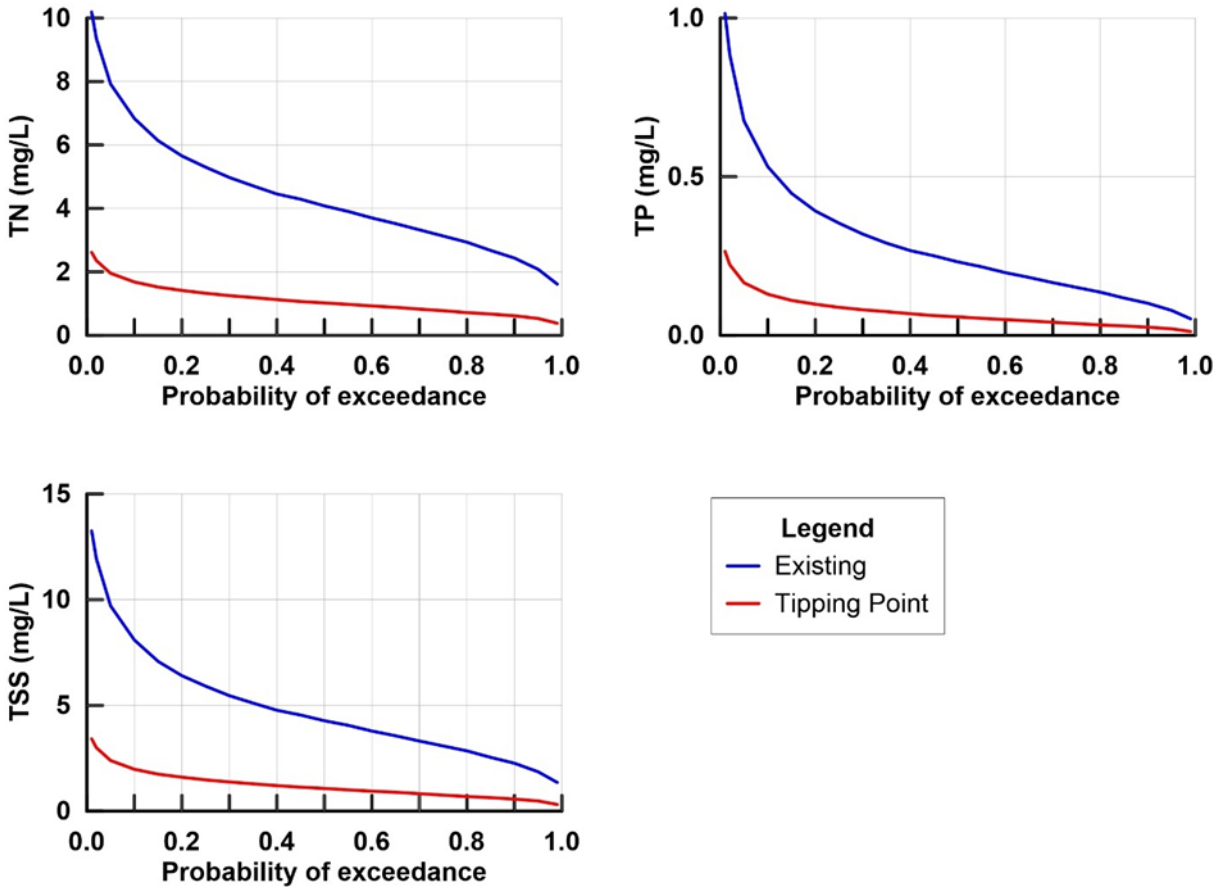

Figure 4.11. Moss Vale exceedance plots (EP=27,000) for the 'tipping point' concentrations and concentrations under the existing conditions.

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The annual loads together with the tipping point concentrations for the Moss Vale EP = 27,000 are shown in Table 4.7. 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 4.7. Moss Vale (EP = 27,000): 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	4,350	3,820	4.0	7.0	1.1	2.1
TN	4,000	3,500	3.90	6.95	1.03	1.74
TP	260	230	0.240	0.496	0.059	0.137

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4.4.2. Scenario Results

Exceedance plots comparing simulations of the IDEA scenario with the existing concentrations for Moss Vale (EP=27,000) are shown in Figure 4.12. 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).

Existing concentrations between the 50% and 98%iles (i.e. probability of exceedance of 0.50 and 0.02, respectively) are less than the modelled concentrations under the IDEA simulations. NorBE requirements for TSS and TN are not met, while those for TP are just met.

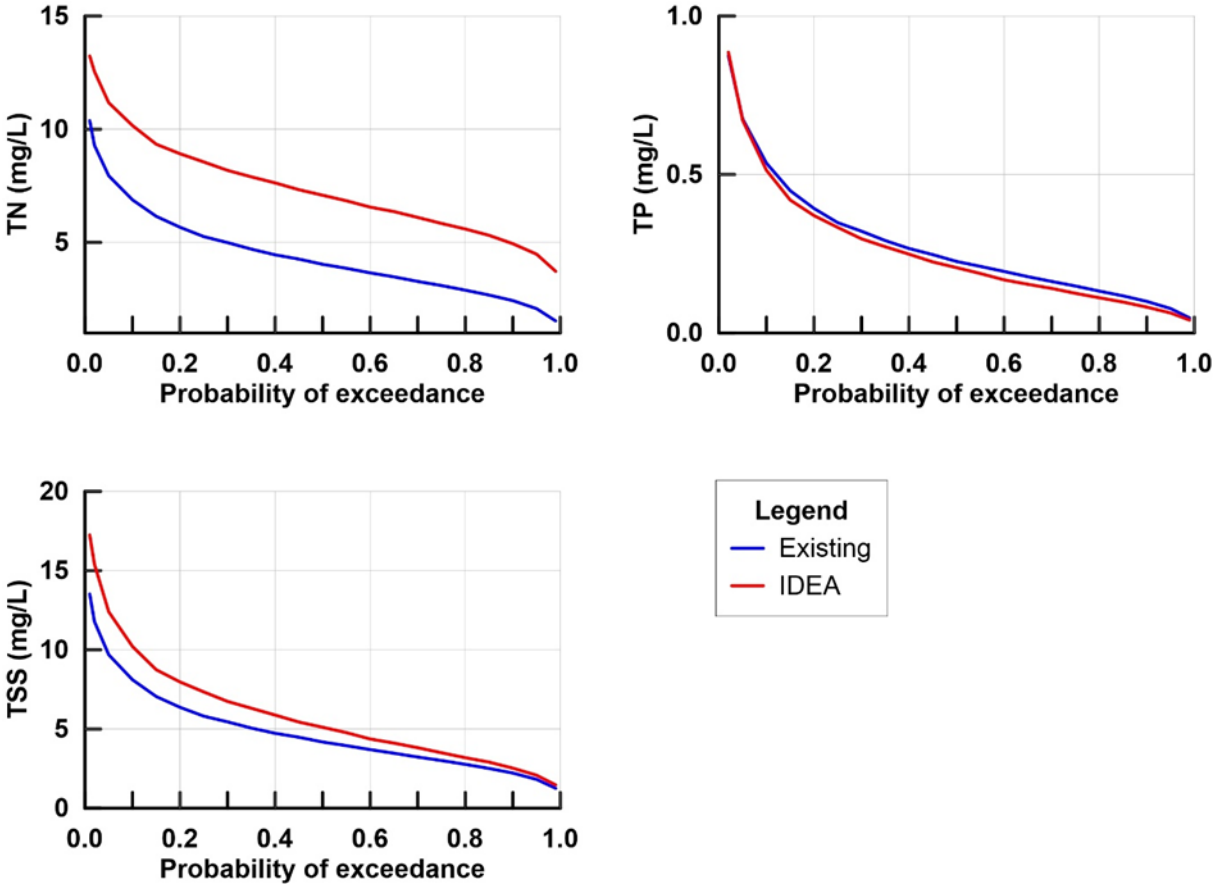

Figure 4.12. Moss Vale exceedance plots (EP = 27,000) for the concentrations simulated from the IDEA scenario and under the existing conditions.

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Exceedance plots comparing simulations of the MLE scenario with the existing concentrations for Moss Vale (EP = 27,000) are shown in Figure 4.13. 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. TN and TSS concentrations do not meet the NorBE concentration requirement.

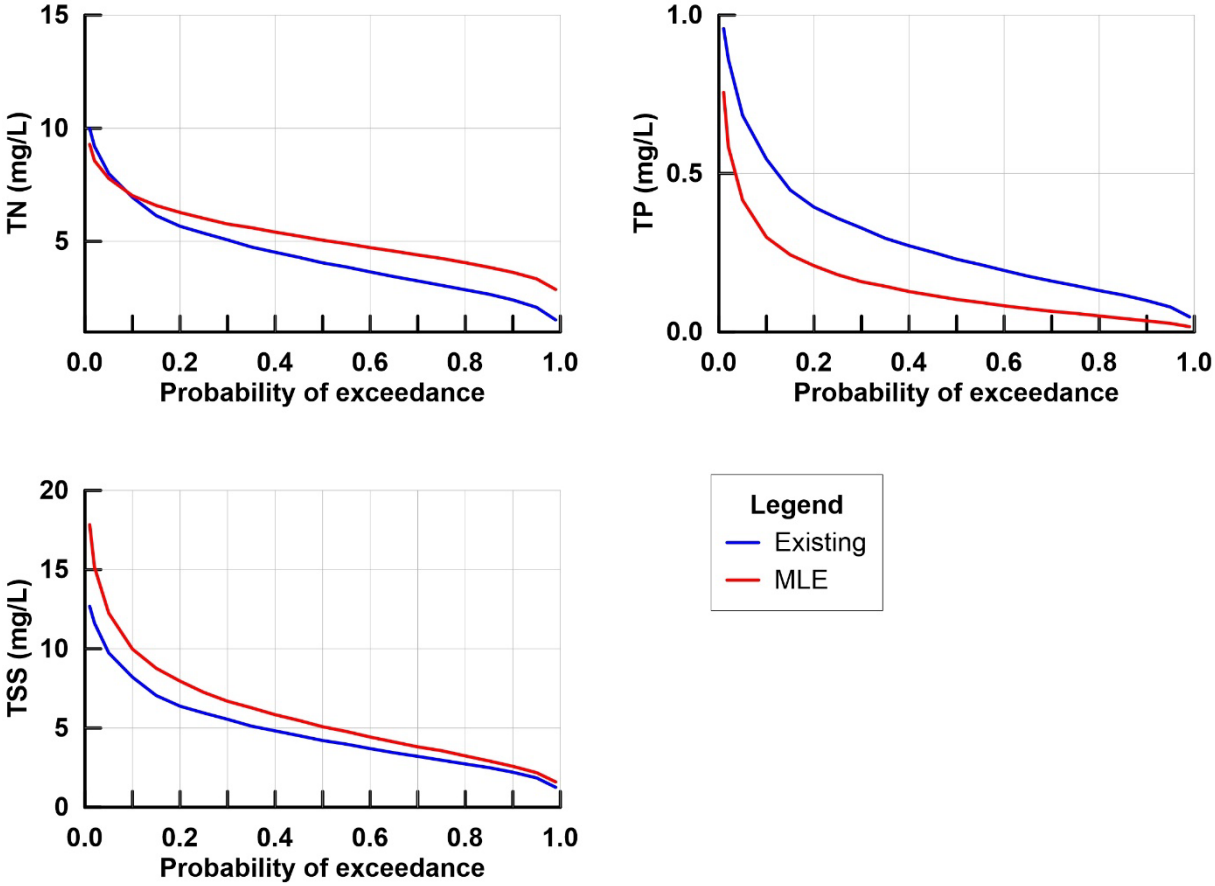

Figure 4.13. Moss Vale exceedance plots (EP=27,000) for the concentrations simulated from the MLE scenario and under the existing conditions.

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Exceedance plots comparing simulations of the FSB scenario with the existing concentrations for Moss Vale (EP=27,000) are shown in Figure 4.14. 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 TN and TP are met. NorBE concentration requirements for TSS are not met.

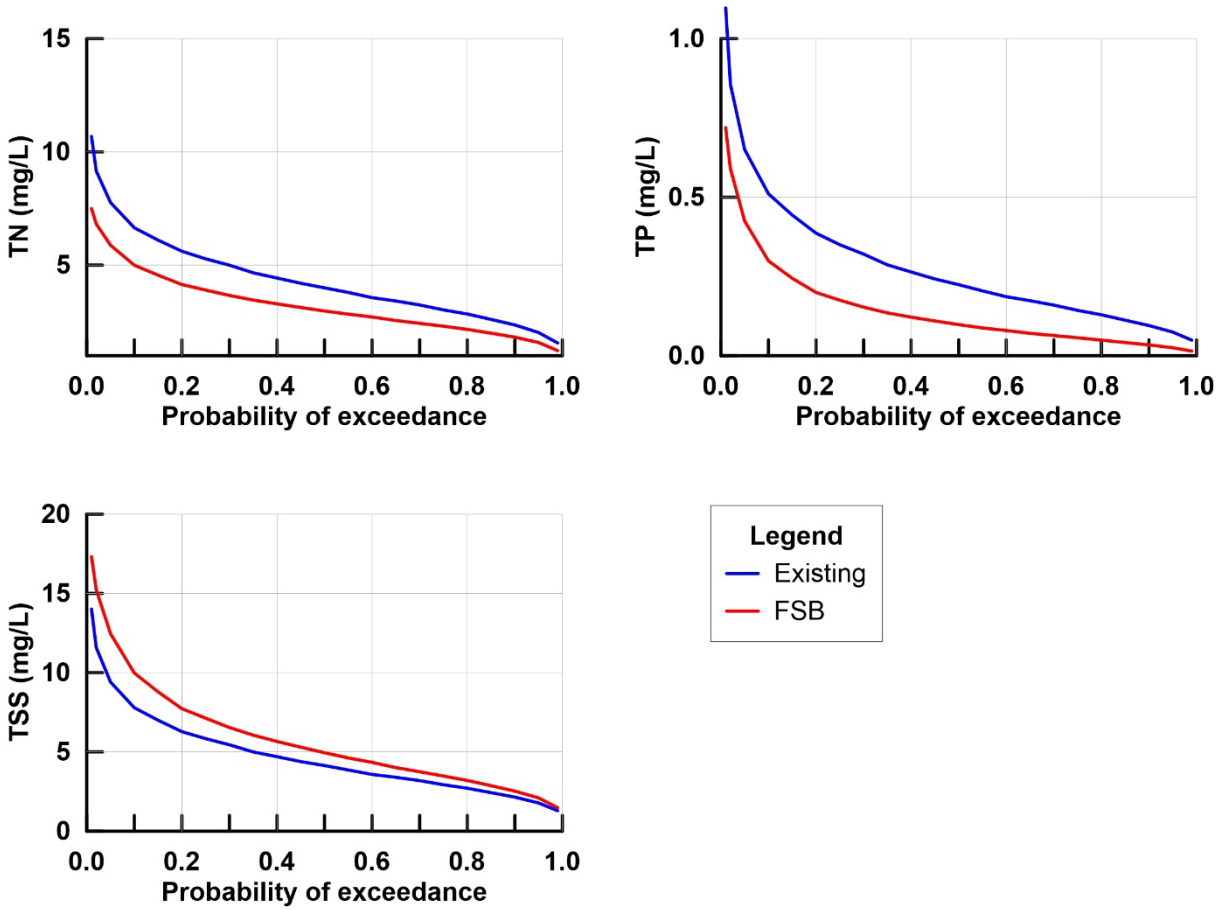

Figure 4.14. Moss Vale exceedance plots (EP=27,000) for the concentrations simulated from the FSB scenario and under the existing conditions.

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Exceedance plots for Moss Vale (EP=27,000) are presented in Figure 4.15 for each scenario (and for existing conditions) with key results summarised in Figure 4.15. Ticks in the table indicate that the contaminant meets the NorBE concentration requirement for that scenario. Crosses indicate that the contaminant does not meet the NorBE concentration requirement for that scenario. Table cells labelled 'marginal' indicate scenarios that are close to meeting the NorBE concentration requirement.

- TN concentrations are considerably less than the existing conditions for FSB, while MLE concentrations are slightly above the existing conditions.
- TP concentrations are generally less than the existing concentrations for all scenarios.
- TSS concentrations are close to, but slightly above those for the existing conditions.

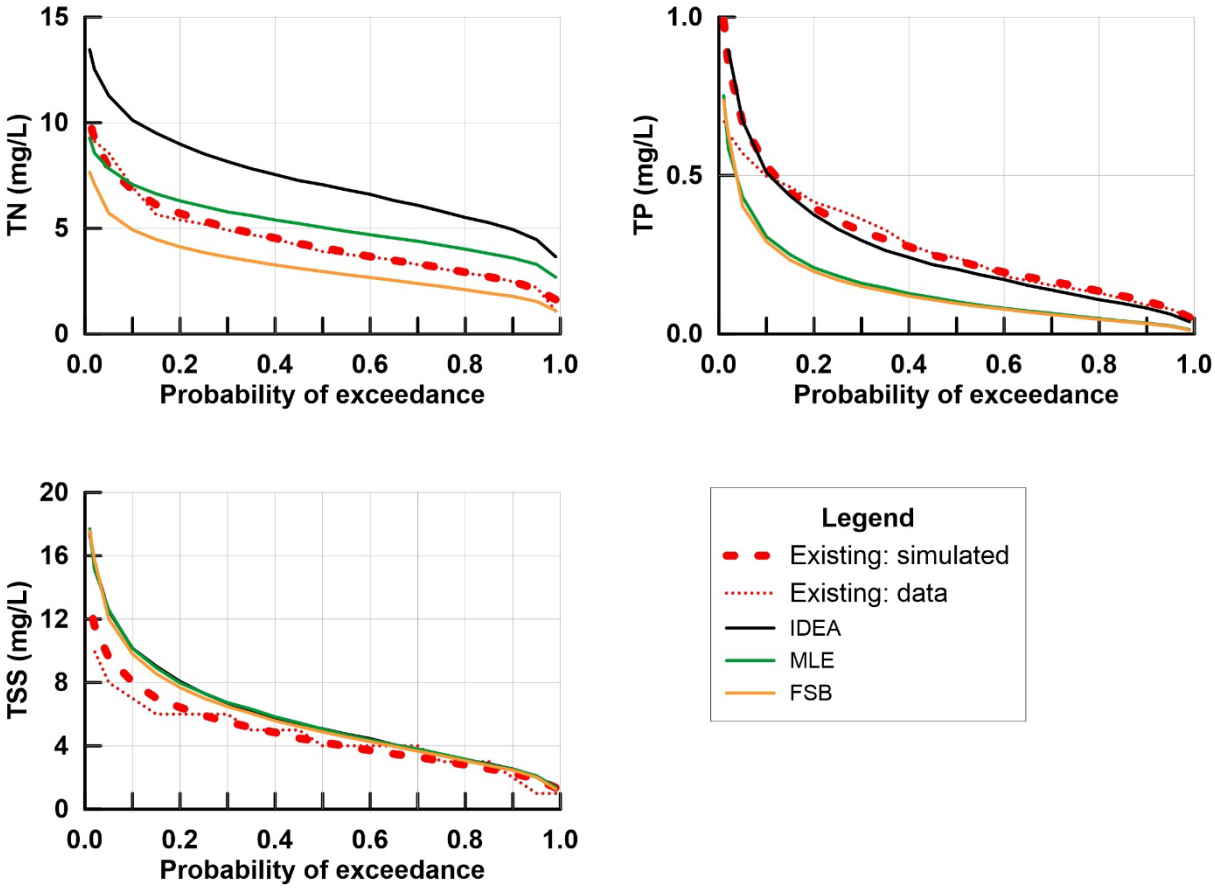

Figure 4.15. Moss Vale exceedance plots (EP=27,000) for concentrations simulated from the three scenarios and under existing conditions (both the data and simulations are presented).

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Table 4.8. Moss vale (EP = 27,000): NorBE concentrations

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

Cells shaded pink indicates 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 that comprise the simulation period and multiplied by 1.1. Results are presented in Table 4.9. The scaled annual loads for TSS exceed the existing conditions. However, it is noted that the design concentrations are conservative and the actual loads will be less than those presented here. The NorBE annual load requirements are not met.

Table 4.9. Bowral (EP = 27,000): NorBE annual loads

Annual load (kg/year)	Existing	Scenario treatment type		
		IDEA	MLE	FSB
TSS	4,350	18,490	18,010	18,100
TN	4,000	23,100	16,230	10,180
TP	260	830	450	450

Cells shaded pink indicates 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.

4.5. Moss Vale EP = 36,000

4.5.1. 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.

Exceedance plots comparing the ‘tipping point’ concentrations with the existing concentrations for Moss Vale are shown in Figure 4.16. The ‘tipping point’ concentrations are substantially less than the existing concentrations to ensure that the NorBE load requirement is simultaneously met.

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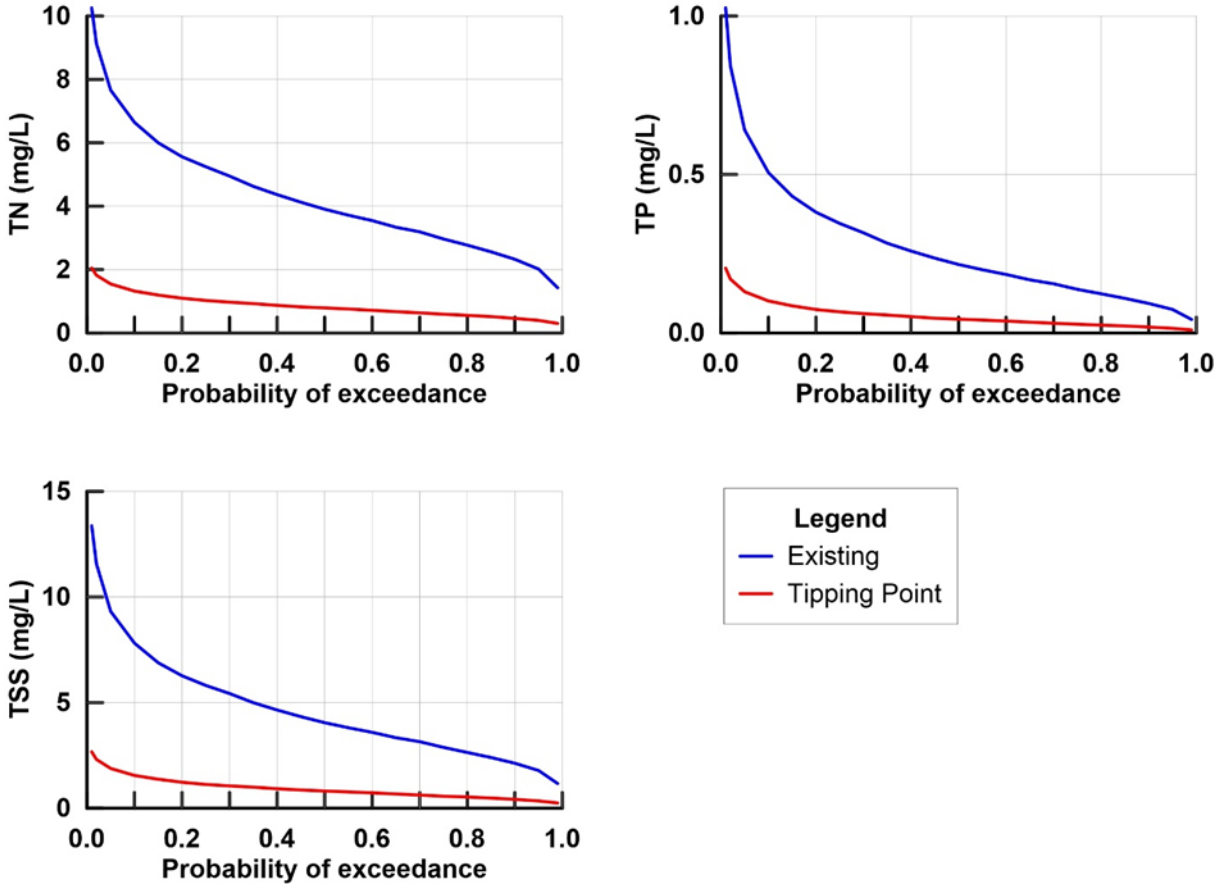

Figure 4.16. Moss Vale exceedance plots (EP = 36,000) for the 'tipping point' concentrations and concentrations under the existing conditions.

The annual loads together with the tipping point concentrations for the Moss Vale EP = 36,000 are shown in Figure 4.17. 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 4.10. Moss Vale (EP = 36,000): 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	4,350	3,880	4.0	7.0	0.8	1.6
TN	4,000	3,600	3.90	6.95	0.78	1.33
TP	260	230	0.240	0.496	0.043	0.102

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4.5.2. Scenario Results

Exceedance plots comparing simulations of the IDEA scenario with the existing concentrations for Moss Vale (EP = 36,000) are shown in Figure 4.17. 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 concentration requirements. TN and TSS concentrations do not meet the NorBE concentration requirement.

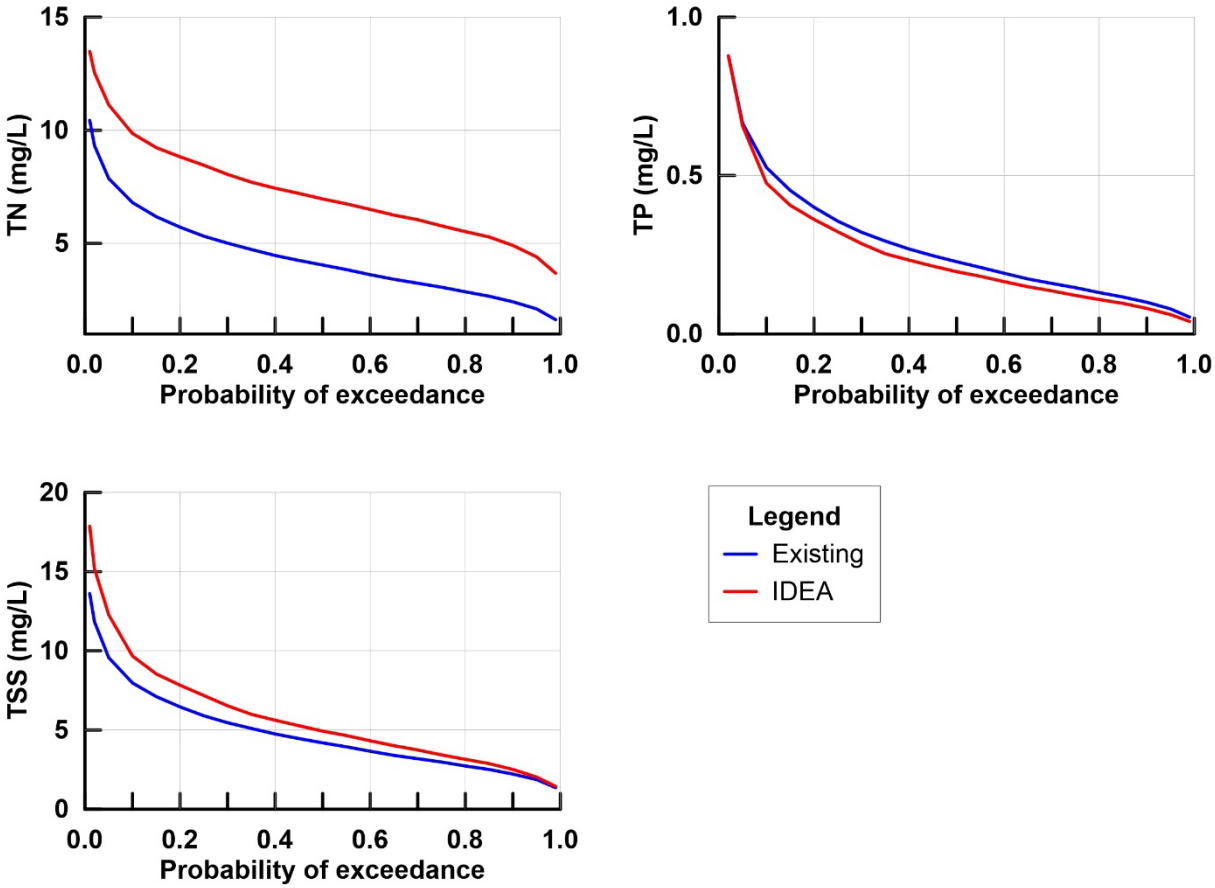

Figure 4.17. Moss Vale exceedance plots (EP = 36,000) for the concentrations simulated from the IDEA scenario and under the existing conditions.

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Exceedance plots comparing simulations of the MLE scenario with the existing concentrations for Moss Vale (EP = 36,000) are shown in Figure 4.18. 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 concentration requirements. TN and TSS concentrations do not meet the NorBE concentration requirement.

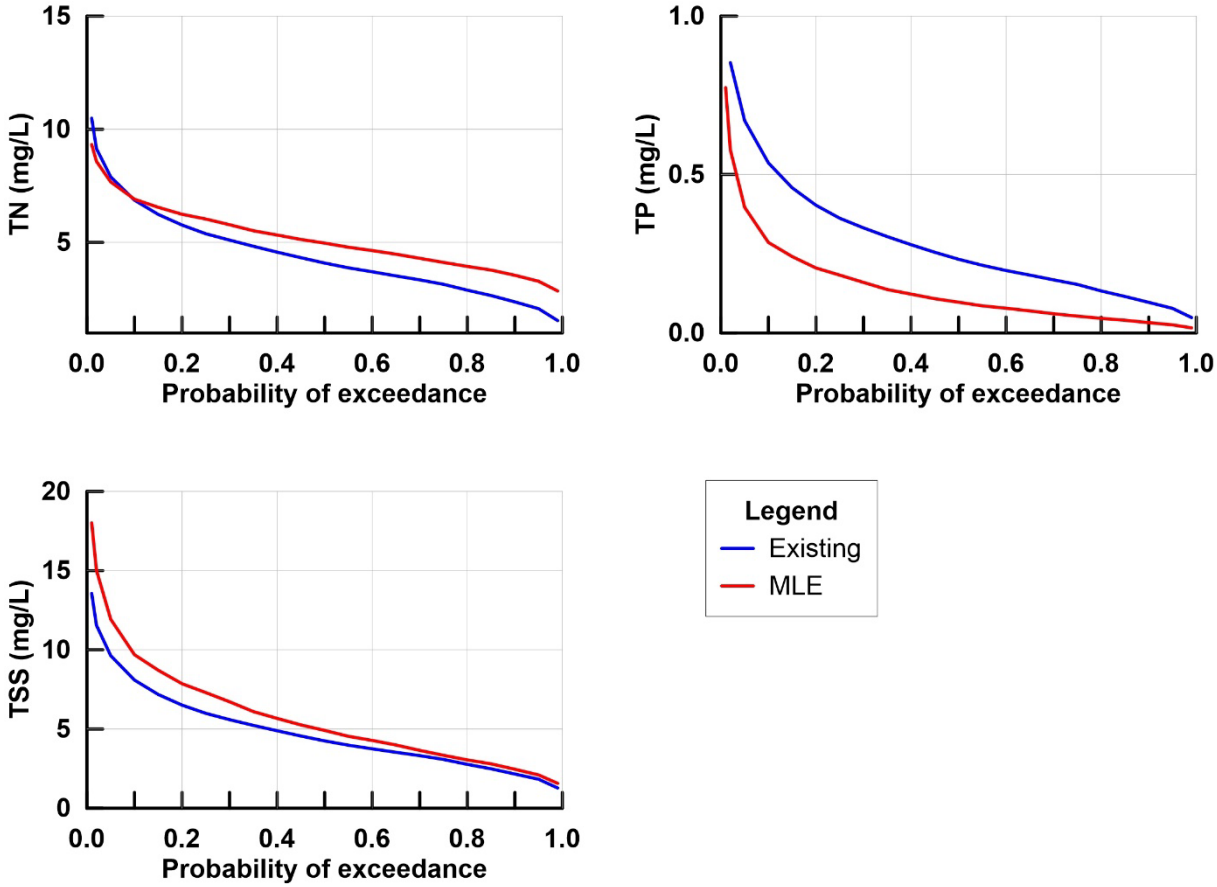

Figure 4.18. Moss Vale exceedance plots (EP = 36,000) for the concentrations simulated from the MLE scenario and under the existing conditions.

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Exceedance plots comparing simulations of the FSB scenario with the existing concentrations for Moss Vale (EP = 36,000) are shown in Figure 4.19. 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 FSB concentrations for TN and TP satisfy NorBE concentration requirements. TSS concentrations do not meet the NorBE concentration requirement.

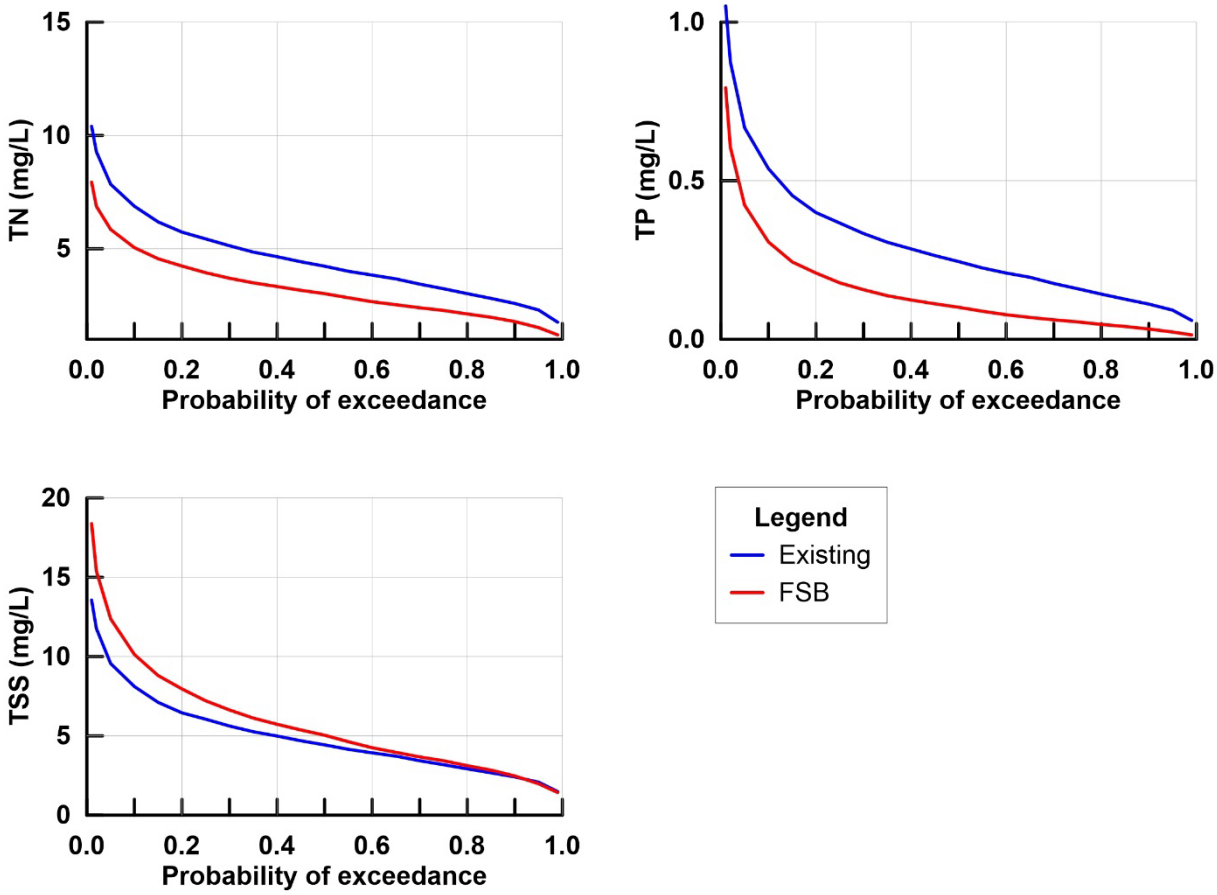

Figure 4.19. Moss Vale exceedance plots (EP = 36,000) for the concentrations simulated from the FSB scenario and under the existing conditions.

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Exceedance plots for Moss Vale (EP=36,000) are presented in Figure 4.20 for each scenario (and for existing conditions) with key results summarised in Figure 4.20. Ticks in the table indicate that the contaminant meets the NorBE concentration requirement for that scenario. Crosses indicate that the contaminant does not meet the NorBE concentration requirement for that scenario. Table cells labelled 'marginal' indicate scenarios that are close to meeting the NorBE concentration requirement.

- TN concentrations are considerably less than the existing conditions for FSB, while MLE concentrations are slightly above the existing conditions.
- TP concentrations are less than the existing concentrations for the MLE and FSB scenarios. TP concentrations for the IDEA scenario lie very close to the existing conditions.
- TSS concentrations are close to, but slightly above those for the existing conditions.

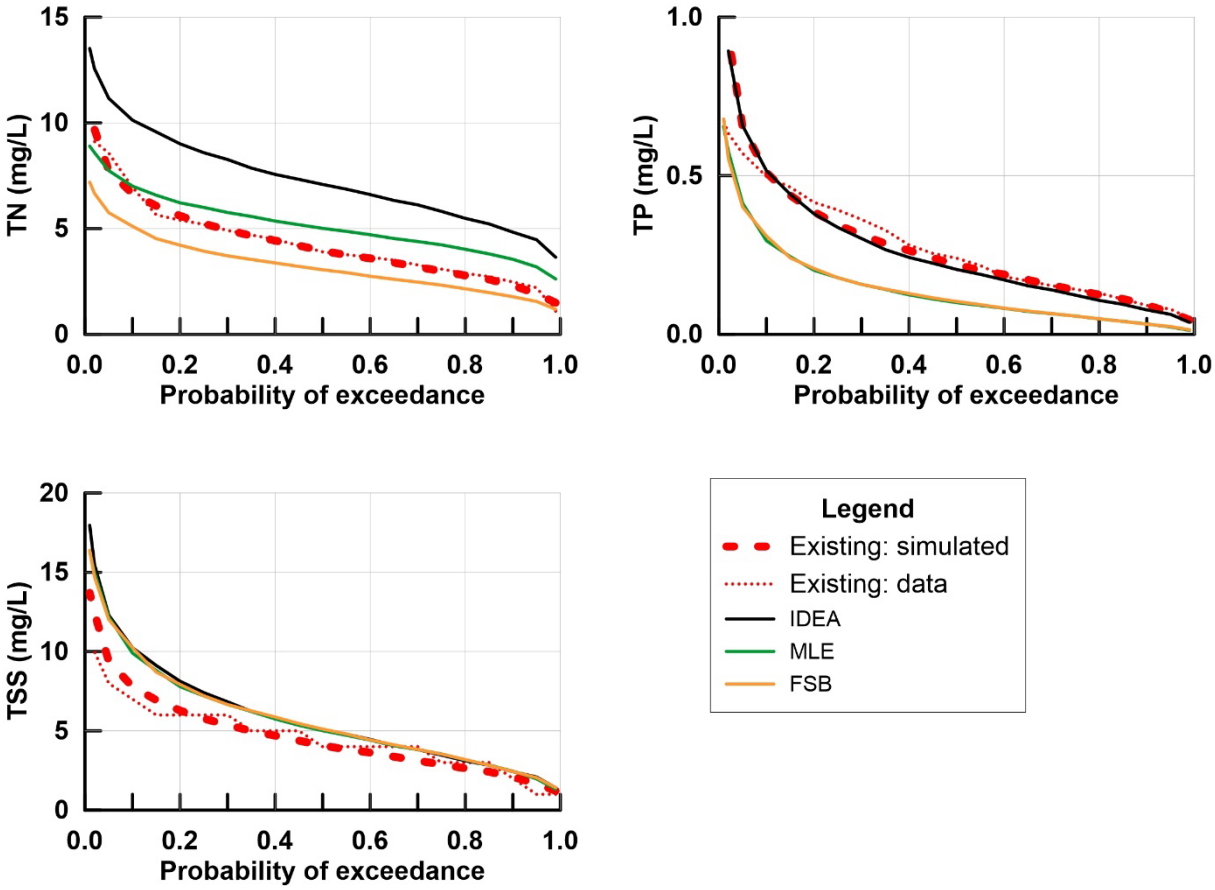

Figure 4.20. Moss Vale exceedance plots (EP = 36,000) for concentrations simulated from the three scenarios and under existing conditions

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Table 4.11. Moss vale (EP = 36,000): NorBE concentrations

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

Cells shaded pink indicates 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 that comprise the simulation period and multiplied by 1.1. Results are presented in Table 4.12. The scaled annual loads for TSS exceed the existing conditions. However, it is noted that the design concentrations are conservative and the actual loads will be less than those presented here. The NorBE annual load requirements are not met.

Table 4.12. Bowral (EP=27,000): NorBE annual loads

Annual load (kg/year)	Existing	Scenario treatment type		
		IDEA	MLE	FSB
TSS	4,350	23,700	24,500	24,400
TN	4,000	30,200	21,790	13,660
TP	260	1,050	620	610

Cells shaded pink indicates 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.

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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 of 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 future conditions.

Quantify and assess the existing condition of the receiving waterways

Temporal trend analysis was undertaken using long term data sets. Only limited long term water quality data were available. Results from temporal trends between 2013 and 2019 indicate decreasing concentrations in the effluent and river for total nitrogen, while increasing trends were observed for total phosphorus. However, it is noted that the slopes of the trend lines were, generally, not statistically different from a slope of zero.

Concentrations of most contaminants sampled during wet weather exceed those sampled during dry weather.

Upstream concentrations of total nitrogen and total phosphorus 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 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 4 times (approximately 2 hours apart) on each sampling day. River samples were collected from two locations upstream from the discharge location and two locations downstream from the discharge location.

A range of data analysis techniques was used to interpret the results (including trend analysis

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and ANOVA). Approximately 10% of samples were duplicated to assess the laboratory procedures. Results indicated (virtually) that 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 aluminium from the STP appear to be elevated compared with the upstream concentrations. Some metals indicated elevated concentrations at locations upstream of the STP discharge location, suggesting an upstream source of metals (possibly from mining activities). Concentrations of bacteria in the receiving waters were highly variable, largely depending on the sampling day. This may suggest upstream sources of bacteria, although the variable results make this assertion difficult to verify.

The Southern Highlands Biological Monitoring Report (2022) concluded that:

- All upstream and downstream sites display some level of impact from urban and/or agricultural pollution.
- While STP discharges would no doubt contribute to pollution to some degree, differences observed between test sites could not be attributed specifically to STP discharges and are most likely also impacted due to urban/ agricultural runoff from the surrounding townships and natural variation.

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 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.

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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. However, it is noted that the design criteria are conservative and the actual performance will be substantially better.

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).

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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

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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.

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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.

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- 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.

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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

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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.

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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 50 mg-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.

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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.

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Appendix B Monitoring Analysis

B.1. Moss Vale STP

Routine monitoring for effluent quantity and quality is required under the Environmental Protection Licence number 1731 (EPL, 2018). Monitoring is summarised below:

- Effluent flow is measured at the STP (Point 1).
- Fortnightly effluent quality sampling at Point 1.

Daily effluent flow at Moss Vale STP, daily flow in Whites Creek (at Oldbury Road) and daily rainfall at Moss Vale between 2013 and 2019 are presented in Figure B.1. High effluent flow generally occurs with high rainfall and a corresponding high river flow, as expected.

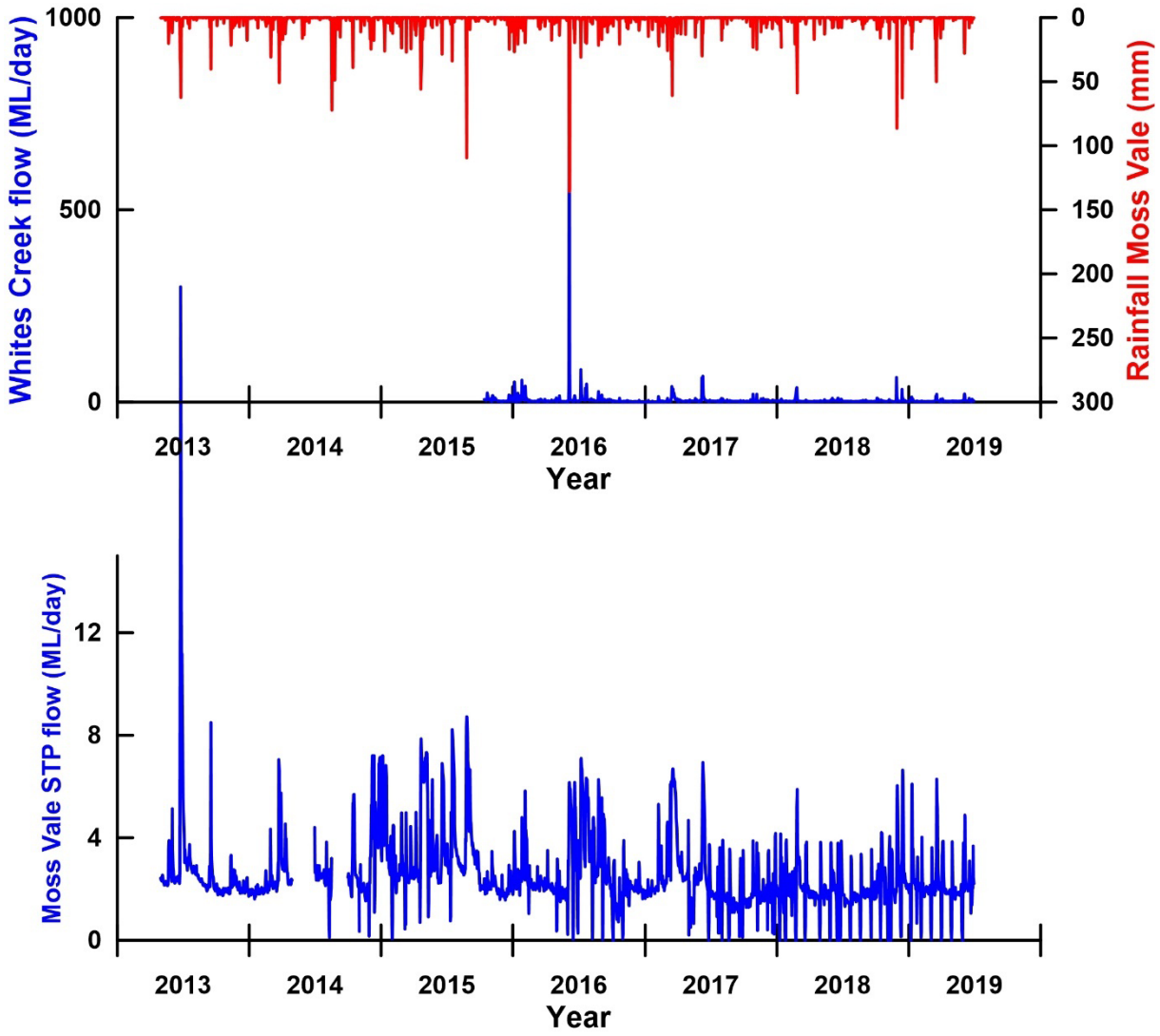

Figure B.1. Effluent flow at Moss Vale STP, flow in White Creek (at Oldbury Road) and rainfall at Moss Vale.

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B.1.1. Dry weather discharges

Time series plots for the physico-chemical and faecal coliform indicators are shown in Figure B.2 and those for nutrients shown in Figure B.3. 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.

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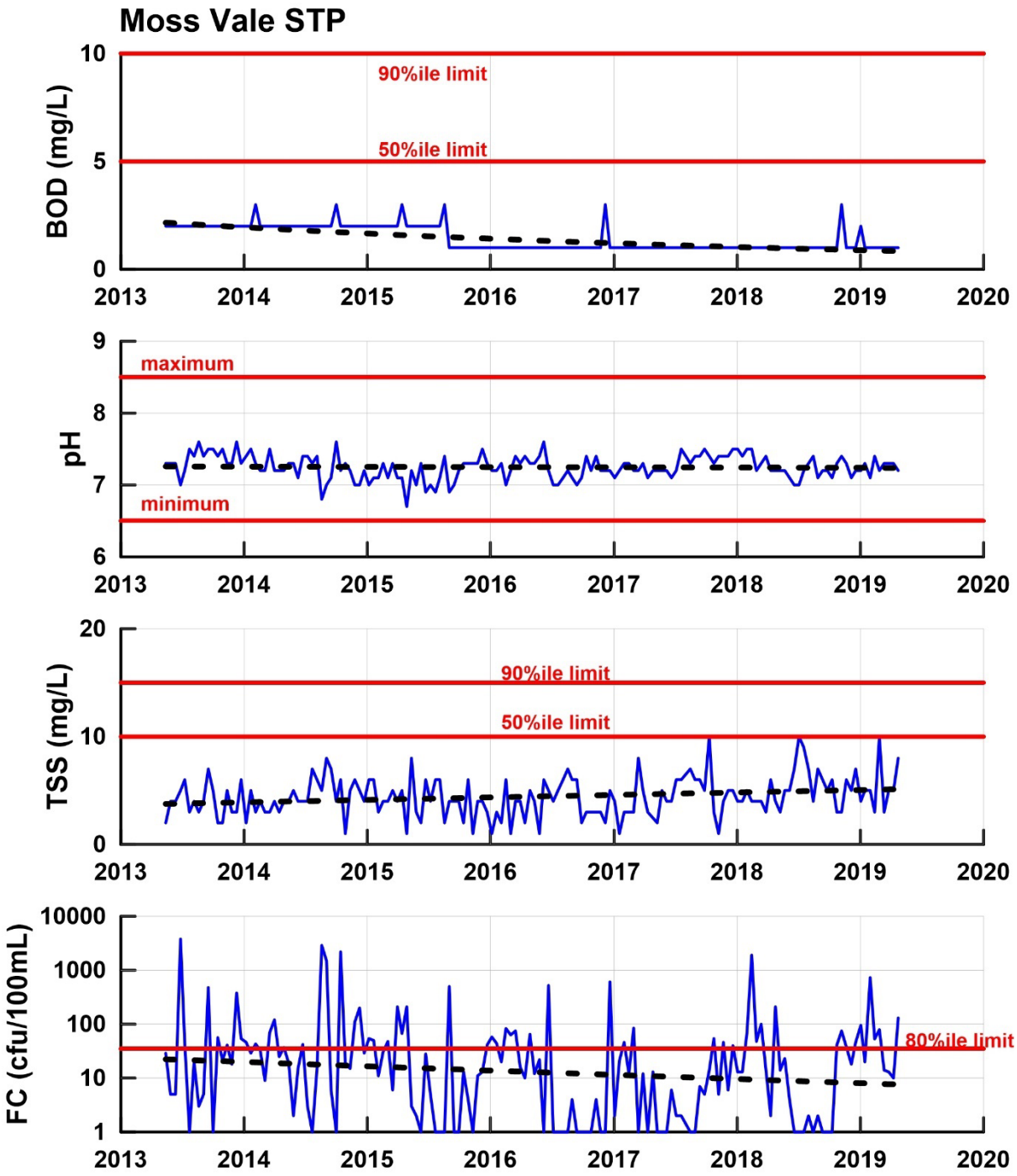

Figure B.2. Physico-chemical and faecal coliform indicators of effluent quality for Moss Vale STP (Point 1)

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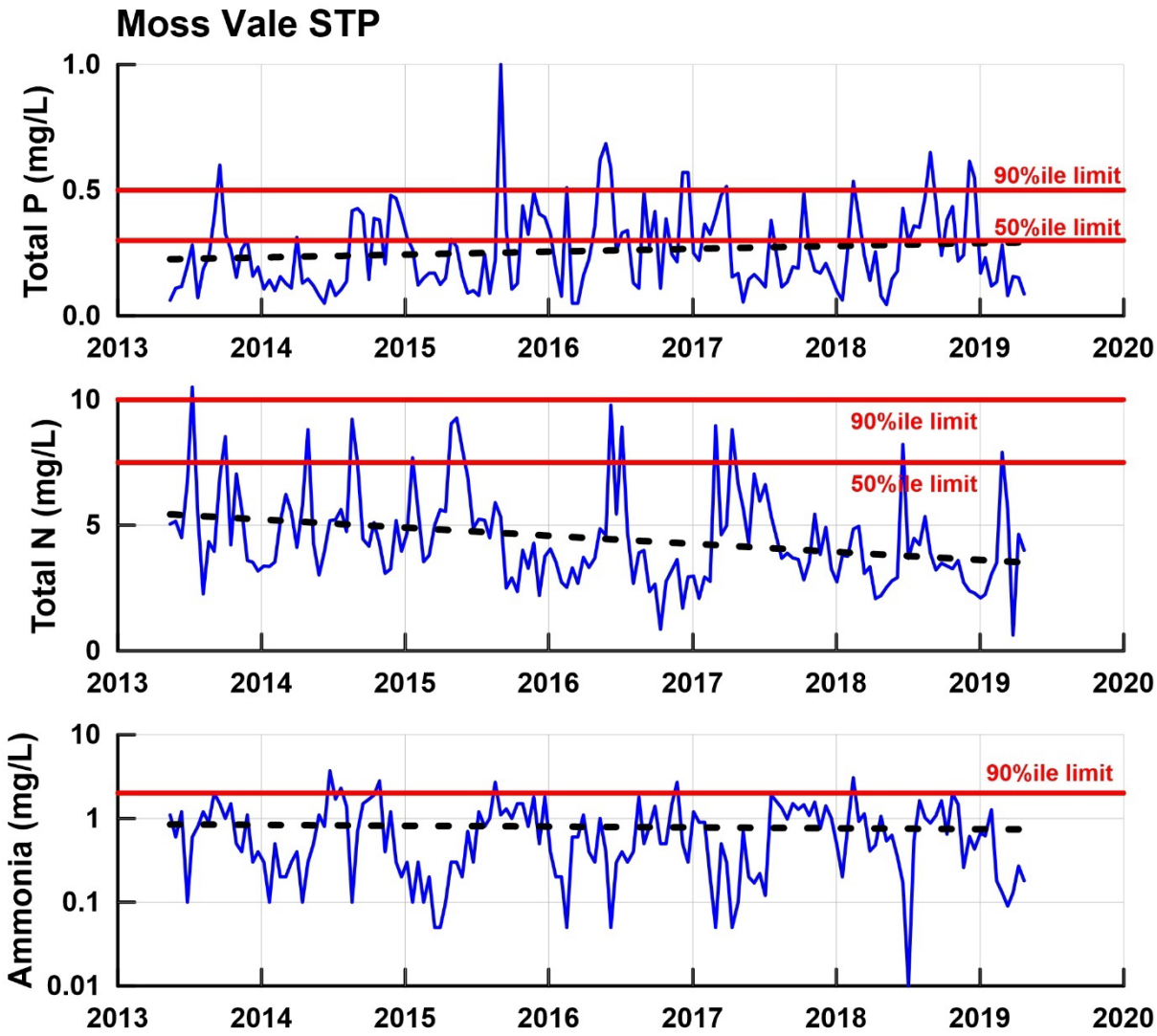

Figure B.3. Nutrient indicators of effluent quality for Moss Vale STP (Point 1).

Basic statistics of the variables measured in the effluent are determined (Table B.1). 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.

$$MAD = \frac{1}{n}\sum_{i=1}^{n}|x_i - \overline{x}|$$

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Table B.1. Basic statistics in the Moss Vale STP data – monitoring Point 1.

Variable	Units	Number	Min.	Max.	Mean	StDev	Median	M.A.D.
BOD	mg/L	164	1.00	3.00	1.11	0.41	1.00	0.11
TSS	mg/L	164	1.00	19.00	4.64	2.48	4.00	1.65
Conductivity	µS/cm	133	27.20	69.50	57.00	7.30	58.30	15.28
Ammonia	mg/L	164	0.01	3.70	0.78	0.66	0.60	0.50
Nitrite	mg/L	164	0.001	0.740	0.116	0.076	0.119	0.044
Nitrate	mg/L	164	0.050	15.100	2.913	2.240	2.245	1.612
Oxidised nitrogen	mg/L	164	0.120	15.200	3.032	2.244	2.383	1.626
Total nitrogen	mg/L	164	0.63	18.90	4.64	2.20	4.20	1.51
Total phosphorus	mg/L	164	0.045	1.720	0.272	0.207	0.220	0.141
pH		164	5.11	7.70	7.23	0.26	7.25	0.16
Faecal coliforms (log10)	(log10) cfu / 100mL	164	0.000	3.580	1.108	0.897	1.114	0.731
Oil and grease	mg/L	148	2.50	6.00	2.52	0.29	2.50	0.02
Alkalinity	mg/L, CaCO3	163	4.00	138.00	86.81	22.40	86.30	16.84

M.A.D. is the mean absolute deviation.

B.1.2. Wet Weather Discharges

Basic statistics for wet weather discharges are presented in Table B.2. In general, contaminant concentrations obtained during wet weather exceed those obtained during dry weather conditions.

Table B.2. Basic statistics in the Moss Vale STP data – monitoring Point 2.

Variable	Units	Number	Min.	Max.	Median	M.A.D.	Mean	StDev
BOD	mg/L	22	2.00	4.00	3.00	0.63	2.86	0.77
TSS	mg/L	22	5.00	15.00	7.50	2.35	8.59	2.92
Conductivity	µS/cm	22	24.10	50.20	33.80	6.28	34.85	7.57
Ammonia	mg/L	22	0.500	2.400	0.700	0.278	0.864	0.417
Nitrite	mg/L	22	0.039	0.160	0.078	0.023	0.083	0.031
Nitrate	mg/L	22	1.010	6.480	4.100	1.181	4.016	1.477
Oxidised nitrogen	mg/L	22	1.049	6.596	4.181	1.177	4.100	1.474
Total nitrogen	mg/L	22	4.190	8.800	6.270	1.164	6.241	1.416
Total phosphorus	mg/L	22	0.350	1.010	0.471	0.135	0.540	0.178
pH		22	6.800	7.700	7.200	0.217	7.268	0.268
Faecal coliforms (log10)	(log10) cfu / 100mL	22	3.447	5.230	4.663	0.380	4.509	0.468
Oil and grease	mg/L	21	0.00	5.00	2.50	2.02	2.02	2.18

M.A.D. is the mean absolute deviation.

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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.

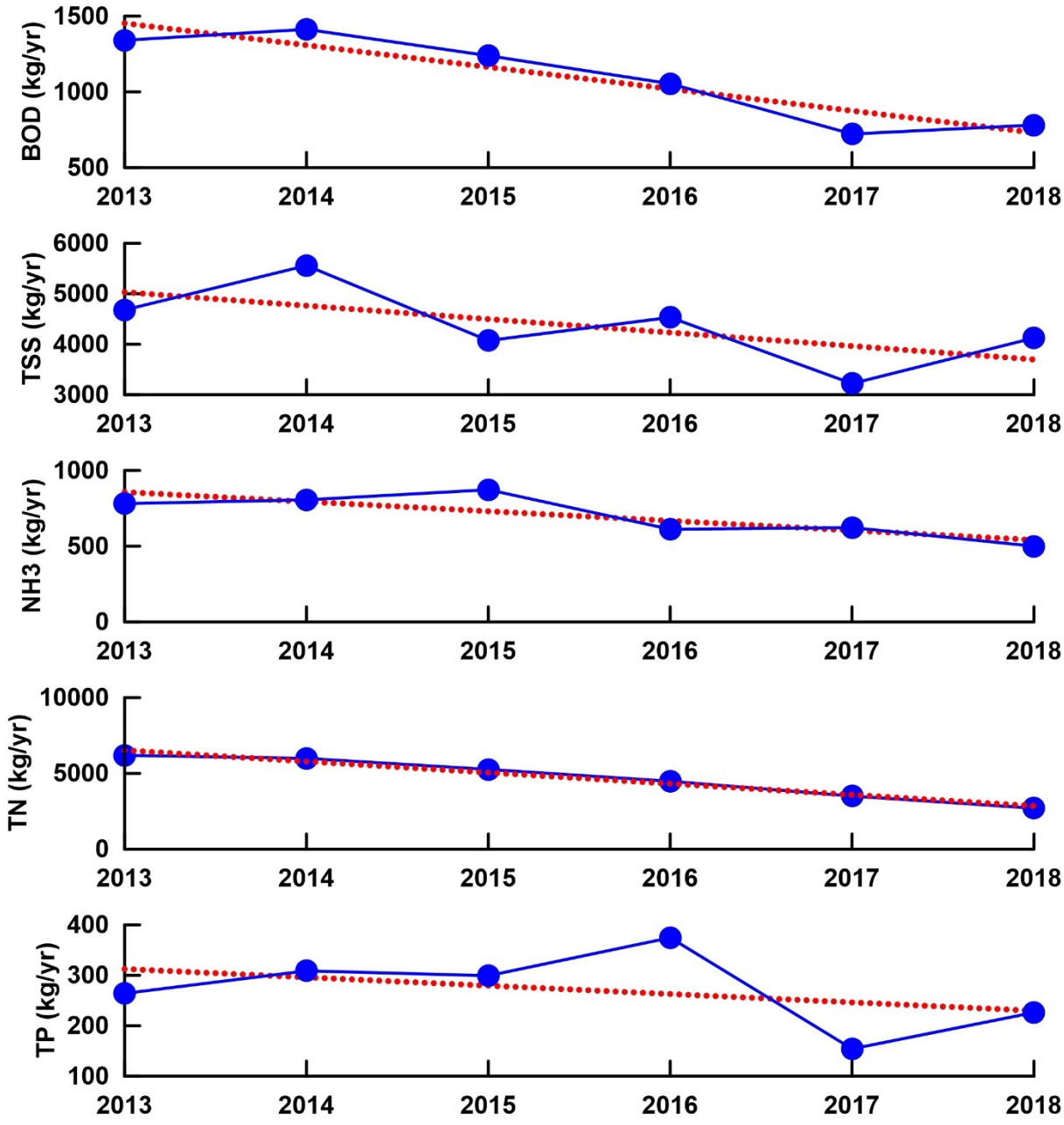

Figure B.4. Annual loads for selected contaminants in the Bowral effluent.

Results of the annual loads are plotted in Figure B.4. 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. This

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demonstrates a continual improvement over time and a reduction in the potential impact on river water quality.

B.2. Whites Creek

This section focuses on water quality data obtained from the long-term monitoring location at Oldbury Road, downstream of the STP discharge point. No equivalent upstream data are available. Data collected as part of the STP licence conditions are presented in Section 2.4.1 (upstream).

Oldbury Road lies about 5 km downstream the Moss Vale STP discharge into Whites Creek. Only a few water quality variables are measured at this location and these are presented as time series plots in Figure B.5 (physico-chemical). Superimposed on these plots are temporal trends and ANZECC default water quality guidelines. These data are measured by instruments that are 'permanently' deployed in the river.

Concentrations of turbidity and pH generally lie below (or within) the ANZECC guideline(s). However, dissolved oxygen and conductivity generally lie outside their respective ANZECC guideline values. Both variables exhibit unusual characteristics compared with similar instruments located in other water bodies. This may suggest that the sensors are not in their manufacturer's specifications. These results should be treated with caution.

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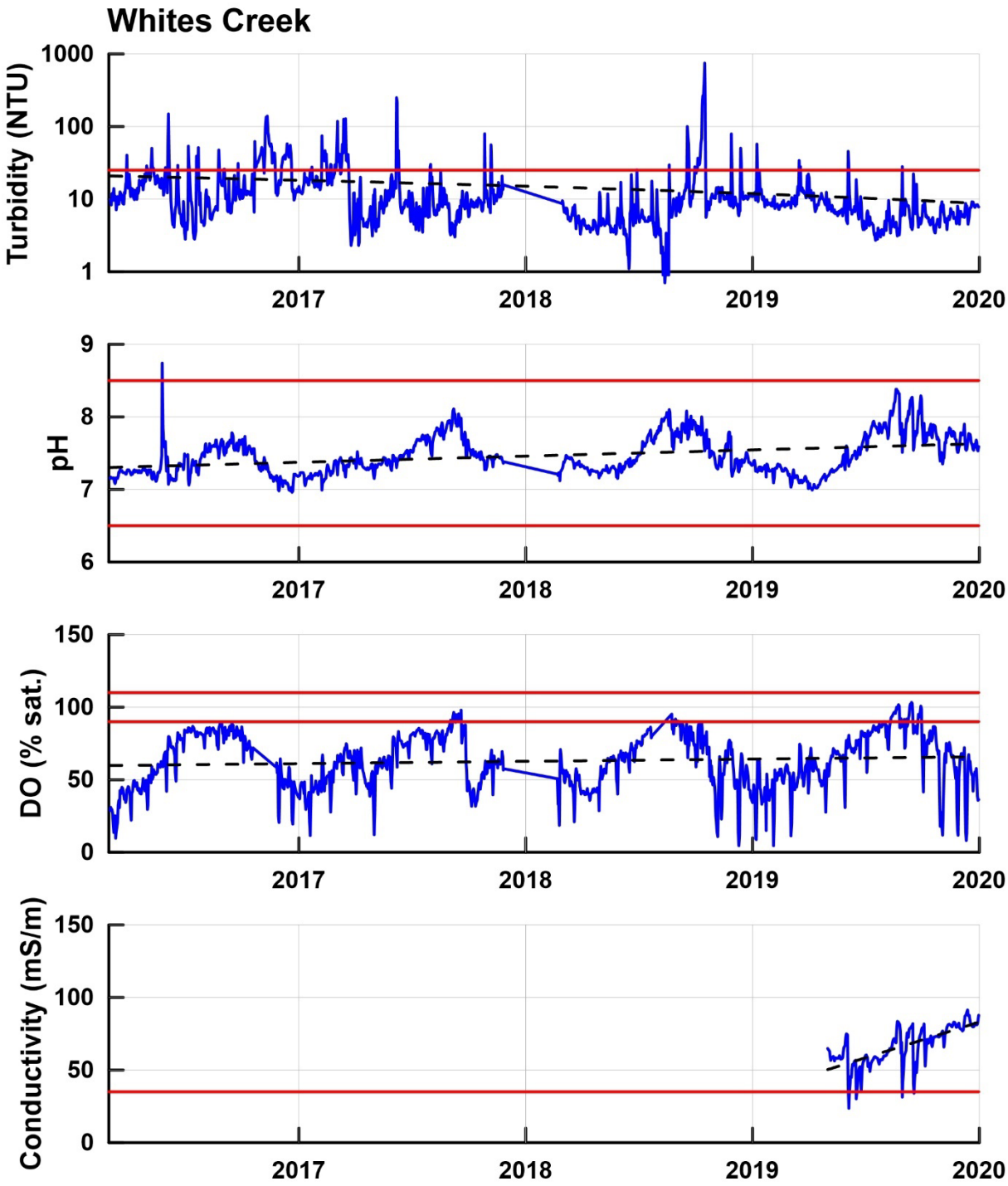

Figure B.5. Physico-chemical indicators of water quality for Whites Creek (at Oldbury Road).

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Summary statistics using for the variables measured at Oldbury Road are presented in Table B.3. Temporal trend lines for the periods 2016-2019 are provided in Table B.4. Note, only a few variables are measured at the Oldbury Road location, all measured by in-situ instruments.

Table B.3. Summary statistics of water quality at Oldbury Road.

Variable	Units	Number	Min.	Max.	Median	M.A.D.	Mean	StDev
Turbidity	NTU	1307	0.70	747.40	8.70	9.02	14.76	30.90
pH		1314	6.96	8.74	7.41	0.22	7.47	0.27
DO	mg/L	1247	0.39	12.02	6.54	2.10	6.64	2.45
Cond	µS/cm	244	236.30	914.50	676.30	110.66	665.70	131.26

Table B.4. Temporal trends at Oldbury Road. Shaded cells indicate a statistically significant slope of the trend line.

	Period	Transform	slope	Significance	p-value
Turbidity (log)	Mar 2016 – Dec 2019	log	↓	SIG	0.0000
pH	Mar 2016 – Dec 2019	none	↑	SIG	0.0000
DO	DO was clearly non-linear despite many transforms attempted				
Cond (log)	May – Dec 2019	log	↑	SIG	0.0000

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 Oldbury Road.

- Only a few variables were available.
- Time frames for each variable were relatively short, generally only a few years. Results should be treated with caution.
- 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.
- Examination of the DO data indicated that, irrespective of any ‘reasonable’ transform used, a linear trend is not appropriate.

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B.3. Background Concentrations in Whites Creek

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. 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 Table B.5. 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.

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Table B.5. Estimated background concentrations – Whites Creek.

	units	Dry weather		Wet weather		Guideline		Source
		median	MAD	median	MAD			
Suspended Solids	mg/L	30.50	39.88	5.00	25.25	40		ANZECC (maximum)
Total Alkalinity as CaCO3	mg/L	186.00	38.00	104.00	25.00	20		ANZECC (minimum)
Sulfate as SO4	mg/L	1.50	94.13	17.00	4.00	400		ANZECC (recreation)
Chloride	mg/L	67.50	9.88	36.50	16.75	250		ADWG (aesthetic)
Fluoride	mg/L	0.25	0.06	0.20	0.05	1.50		ADWG (health)
Calcium	mg/L	45.50	19.38	26.50	2.00	1000		ANZECC (livestock)
Magnesium	mg/L	24.00	6.88	12.00	3.75	15		ANZECC (aquaculture)
Sodium	mg/L	47.00	5.88	24.00	7.50	115		ANZECC (irrigation)
Potassium	mg/L	9.00	1.88	5.50	0.50			no guideline
Total Anions	meq/L	6.17	1.81	3.47	0.89			no guideline
Total Cations	meq/L	6.32	1.75	3.49	0.75			no guideline
dissolved Aluminium	mg/L	0.010	0.011	0.010	0.003	0.027	0.055	ANZECC (99% and 95% species protection)
dissolved Arsenic	mg/L	0.002	0.001	0.001	0.001	0.001	0.024	ANZECC (99% and 95% species protection)
dissolved Cadmium	mg/L	0.00010	0.00006	0.00010	0.00000	0.00006	0.00020	ANZECC (99% and 95% species protection)
dissolved Chromium	mg/L	0.001	0.000	0.001	0.000	0.008	0.027	ANZECC (99% and 95% species protection)
dissolved Copper	mg/L	0.0010	0.0008	0.0020	0.0003	0.0010	0.0014	ANZECC (99% and 95% species protection)
dissolved Lead	mg/L	0.0010	0.0000	0.0010	0.0000	0.0010	0.0034	ANZECC (99% and 95% species protection)
dissolved Manganese	mg/L	1.295	0.696	0.122	0.328	1.200	1.900	ANZECC (99% and 95% species protection)
dissolved Nickel	mg/L	0.002	0.005	0.003	0.000	0.008	0.011	ANZECC (99% and 95% species protection)
dissolved Zinc	mg/L	0.0055	0.2525	0.0160	0.0043	0.0024	0.0080	ANZECC (99% and 95% species protection)
dissolved Iron	mg/L	0.915	0.520	0.575	0.443			no guideline
dissolved Mercury	mg/L	0.00010	0.00000	0.00010	0.00000	0.00006	0.00060	ANZECC (99% and 95% species protection)
total Aluminium	mg/L	0.335	0.348	0.090	0.185	0.027	0.055	ANZECC (99% and 95% species protection)
total Arsenic	mg/L	0.003	0.002	0.002	0.002	0.001	0.024	ANZECC (99% and 95% species protection)
total Cadmium	mg/L	0.00010	0.00014	0.00010	0.00000	0.00006	0.00020	ANZECC (99% and 95% species protection)
total Chromium	mg/L	0.002	0.001	0.001	0.000	0.008	0.027	ANZECC (99% and 95% species protection)
total Copper	mg/L	0.0045	0.0043	0.0025	0.0013	0.0010	0.0014	ANZECC (99% and 95% species protection)

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	units	Dry weather		Wet weather		Guideline		Source
		median	MAD	median	MAD			
total Lead	mg/L	0.0040	0.0019	0.0010	0.0015	0.0010	0.0034	ANZECC (99% and 95% species protection)
total Manganese	mg/L	1.995	0.817	0.119	0.873	1.200	1.900	ANZECC (99% and 95% species protection)
total Nickel	mg/L	0.004	0.005	0.003	0.002	0.008	0.011	ANZECC (99% and 95% species protection)
total Zinc	mg/L	0.0500	0.3388	0.0205	0.0213	0.0024	0.0080	ANZECC (99% and 95% species protection)
total Iron	mg/L	4.03	2.71	0.87	2.21			no guideline
total Mercury	mg/L	0.00010	0.00000	0.00010	0.00000	0.00006	0.00060	ANZECC (99% and 95% species protection)
Ammonia as N	mg/L	0.325	0.373	0.070	0.020	0.013		ANZECC (maximum)
Nitrite as N	mg/L	0.010	0.018	0.065	0.018	30		ANZECC (livestock)
Nitrate as N	mg/L	0.040	0.215	0.290	0.083	400		ANZECC (livestock)
Nitrite + Nitrate as N	mg/L	0.040	0.236	0.355	0.095	0.015		ANZECC (maximum)
Total Nitrogen as N	mg/L	2.700	1.075	1.400	1.125	0.250		ANZECC (maximum)
Total Phosphorus as P	mg/L	0.270	0.265	0.085	0.475	0.020		ANZECC (maximum)
Dissolved Reactive Phosphorus as P	mg/L	0.065	0.049	0.015	0.343	0.015		ANZECC (maximum)
Chlorophyll a	mg/L	27.00	61.00	1.50	417.50			no guideline
Faecal Coliforms	cfu/100mL	207	1312	330	93	150	600	ANZECC (50%ile and 80%ile)
Enterococci	cfu/100mL	770	2047	120	303	35	60-100	ANZECC (50%ile and maximum)
Conductivity	mg/L	0.611	0.144	0.348	0.071	0.030	0.350	ANZECC (range)
pH		6.96	0.25	6.84	0.15	6.50	7.50	ANZECC (range)
DO	% sat	24.30	12.31	38.70	12.75	90	110	ANZECC (range)
Turbidity	NTU	22.65	14.71	2.05	20.68	2	25	ANZECC (range)

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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 $$\boldsymbol{C(x) = BG + \frac{WW - BG}{D(x)}}$$

Where:

$C(x)$ is the concentration at a distance 'x' downstream from the discharge,

BG is the background 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.

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- 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 C.1. 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.

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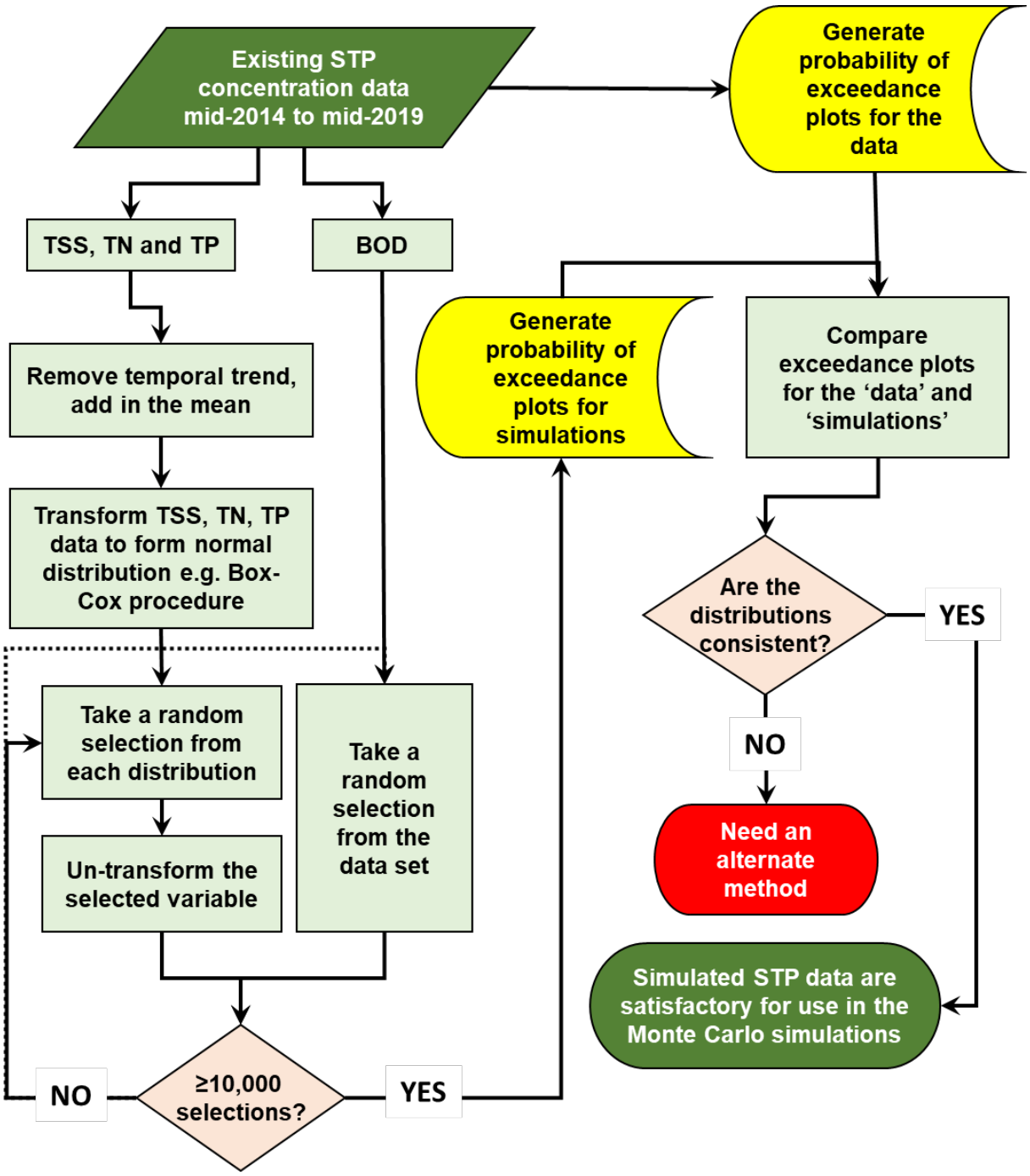

Figure C.1. Flowchart for comparing STP data and simulations.

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.

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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 Figure C.2). 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).

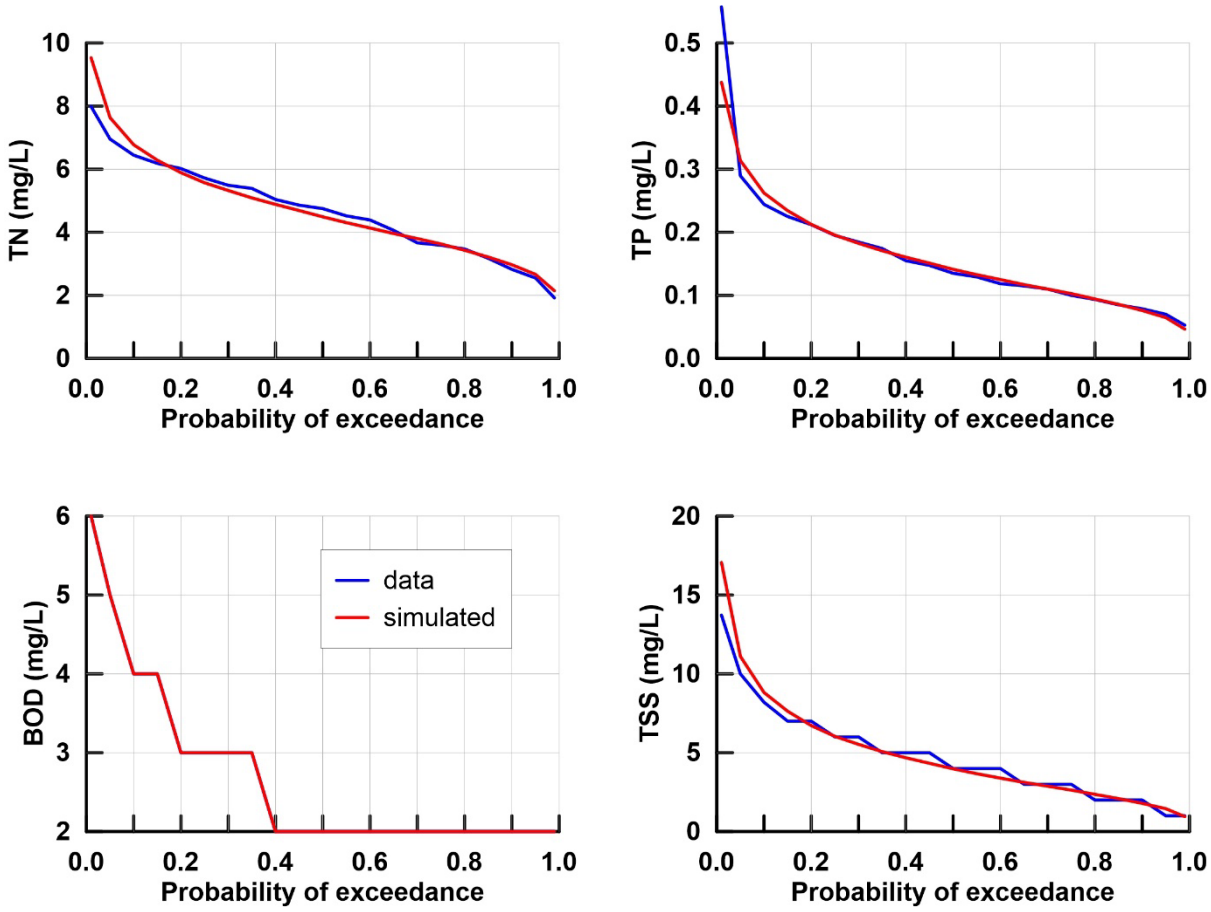

Figure C.2. Comparison of STP data with STP simulations at Bowral STP.

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.

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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 Figure C.3.

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

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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.

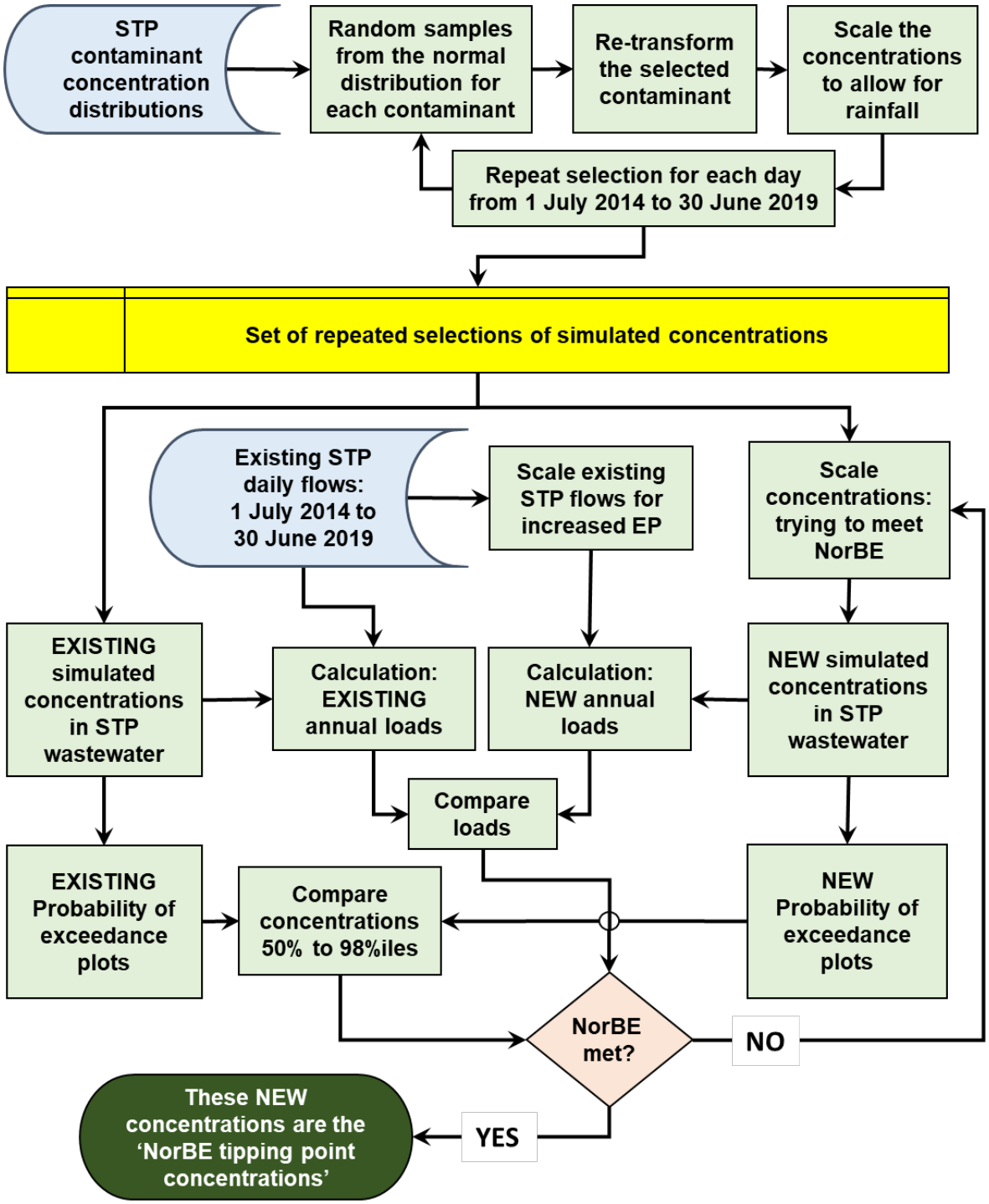

Figure C.3. Procedure for selecting the concentrations of contaminants in the STP such that NorBE is just met – the ‘tipping point’.

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C.3.2. Scenarios

The procedure for examining the scenarios is outlined in Figure C.4. 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.

$$\textbf{Equation C-2} \quad \boldsymbol{\sigma = \frac{90\%ile - \mu}{1.282}}$$

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.

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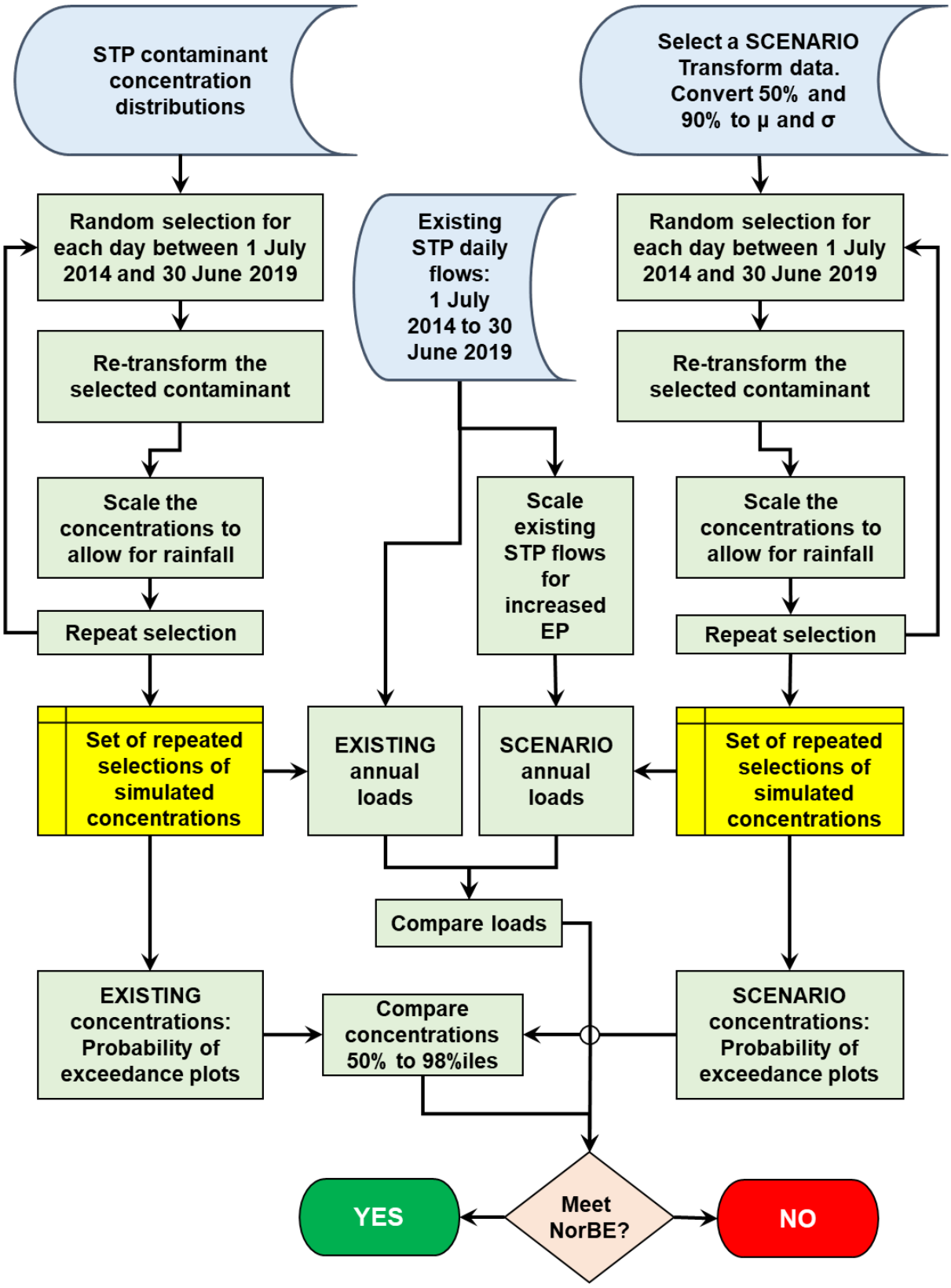

Figure C.4. Procedure for determining whether a scenario will meet NorBE

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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 $$\boldsymbol{D(x) = \frac{WW - BG}{C(x) - BG}}$$

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).

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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 Figure C.5. 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.

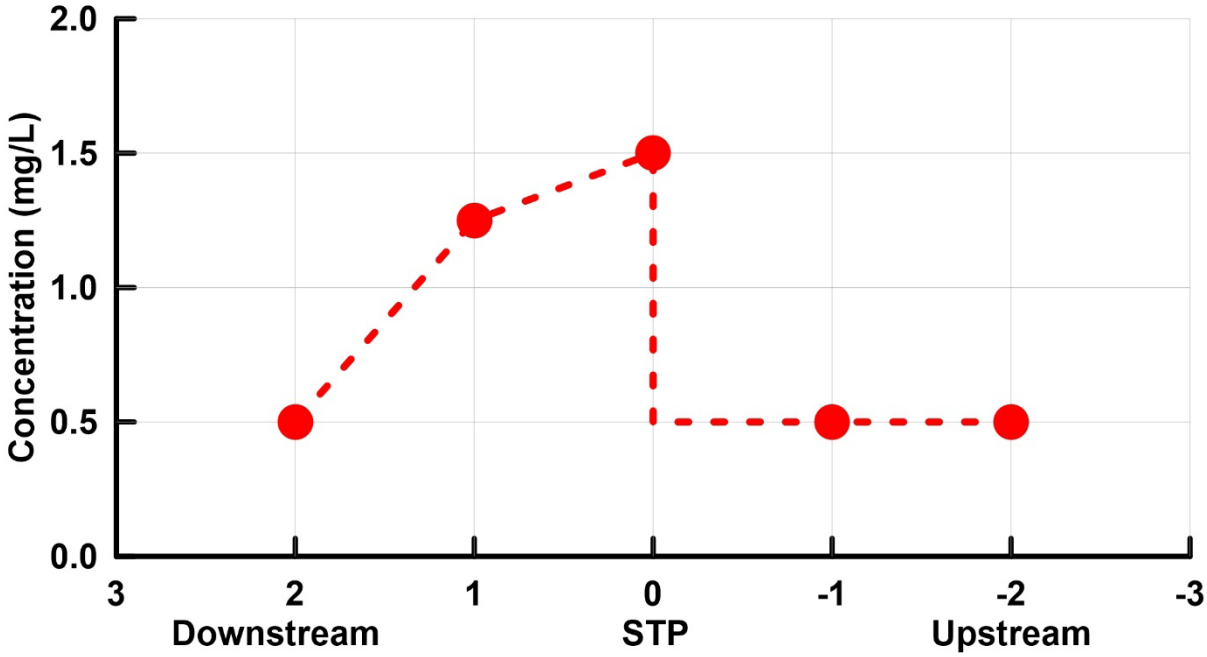

Figure C.5. Spatial gradient of contaminants where the STP appears to be the primary source

*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 Figure C.6. Speciation of these substances was not used. Not all substances displayed the pattern in all river systems. Those substances that did not follow this pattern were not used in the analyses.

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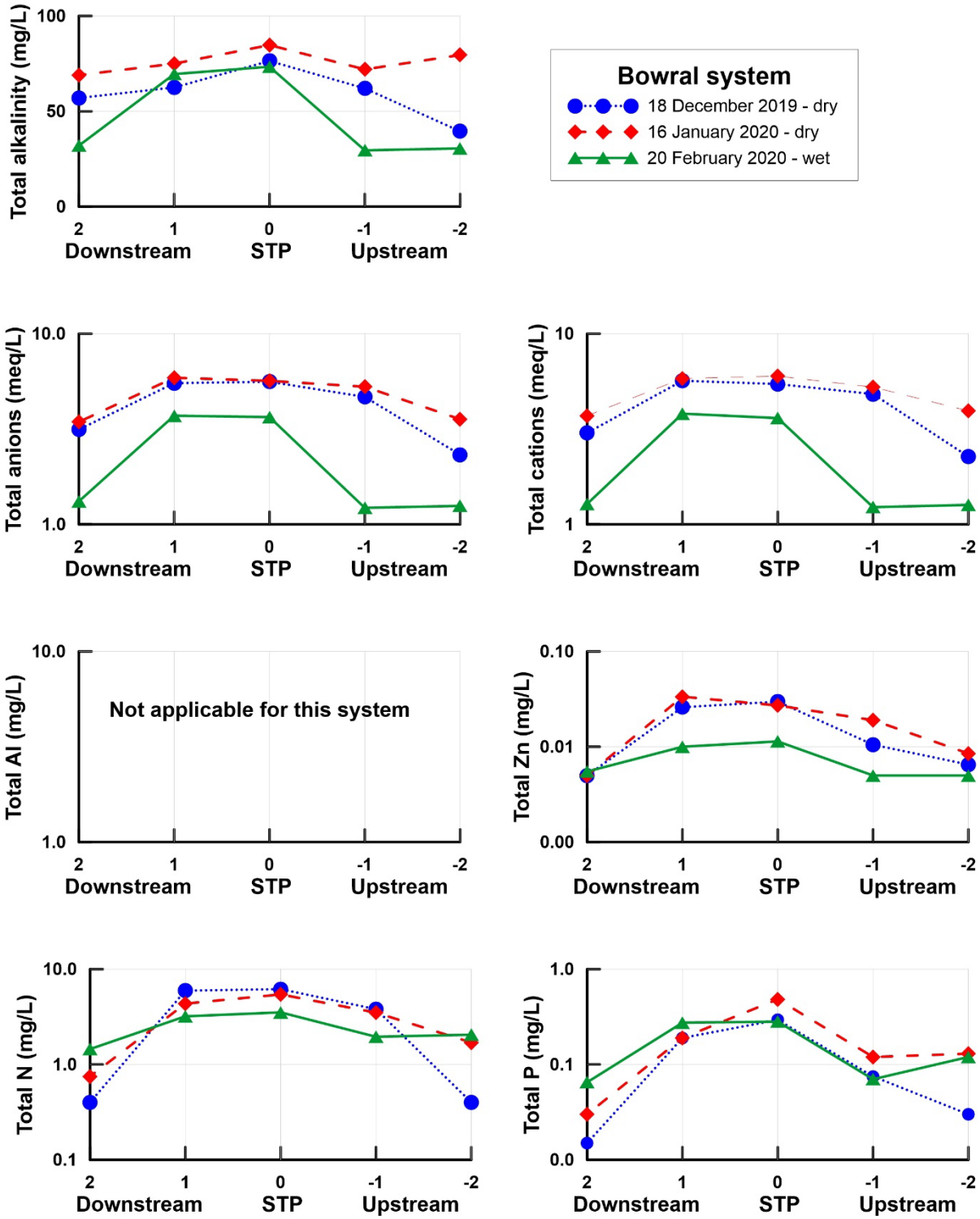

Figure C.6. Spatial gradient of the selected contaminants from the Bowral system (Wingecarribee River)

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Sampling carried out on the three days (above) provide the input data used in Equation C-3. The estimated dilutions are shown in Table C.1. Dilutions at DS-1 are relatively low, but substantially higher under wet weather conditions.

Table C.1. 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 Figure C.7.

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

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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.

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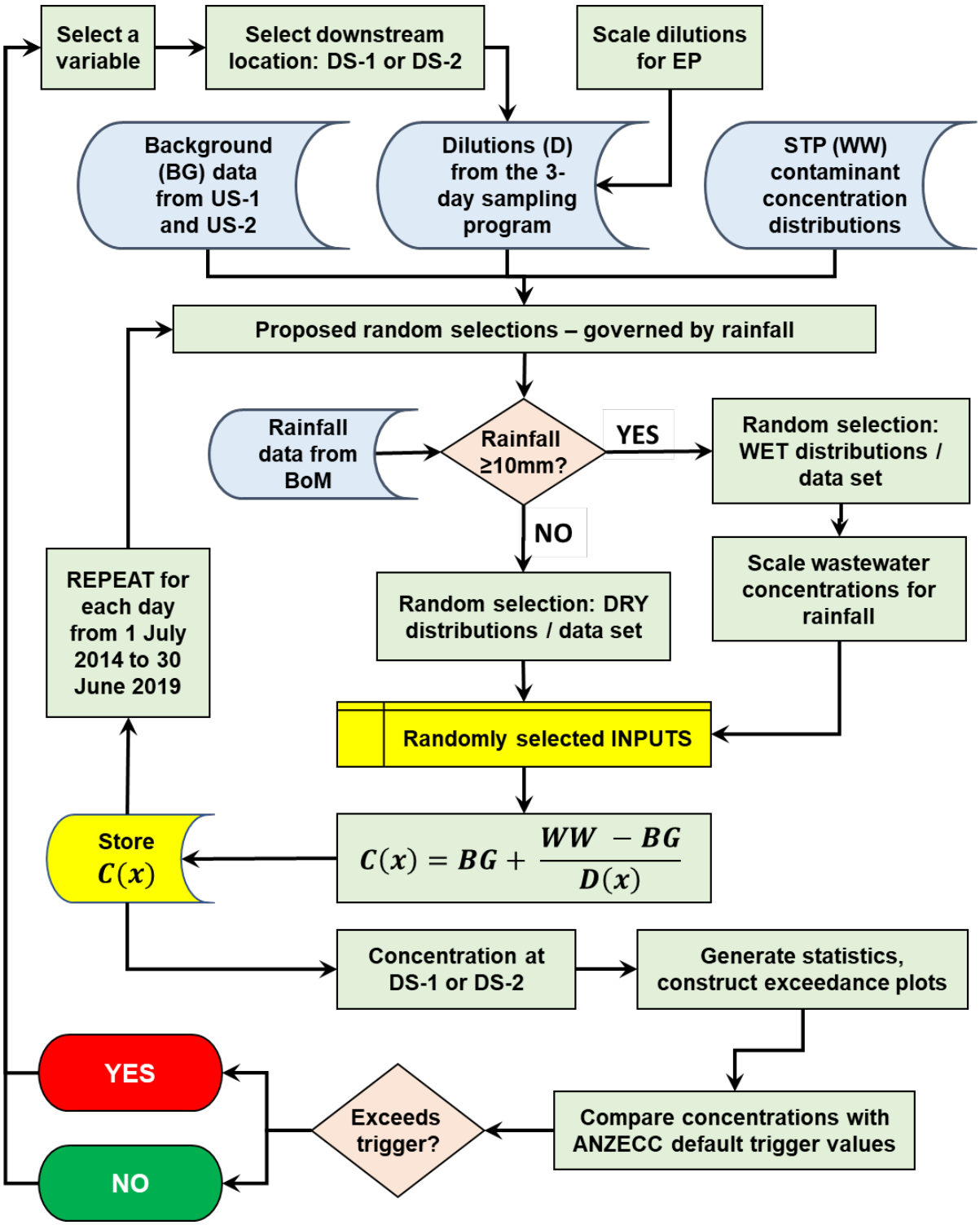

Figure C.7. Procedure for estimating downstream dilutions and comparing results with ANZECC guidelines / default trigger values

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Appendix D MHL – Southern Highlands Biological Monitoring Report (February 2022)

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MHL – Southern Highlands Biological Monitoring Report

February 2022



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Report version: February 2022

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Cover image: Wingecarribee River, Burradoo

Executive Summary

The objective of this study is to indicate aquatic ecosystem health both upstream and downstream of Wingecarribee Shire Council STPs via employing the use of multiple biotic indices.

Eight sites were sampled in total. Six sites were located upstream and downstream of Mittagong, Bowral, and Moss Vale STPs, with two reference sites located at Wildes Meadow Rd and Drapers Rd.

Macroinvertebrate sampling was conducted in autumn and spring in 2020 and 2021. Macroinvertebrate sampling was completed in accordance with AUSRIVAS protocols for New South Wales (Turak et al. 2004) and Sydney Water's in-house test methods. For each sampling site, two edge habitats were sampled. 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 level and Acarina at order level. Macroinvertebrate communities were analysed using several biotic indices, including taxa richness, EPT taxa, SIGNAL2, SIGNAL SF, and AUSRIVAS.

All test sites recorded similar SIGNAL2 scores and had an overall similar placement on the bi-plot. The reference sites displayed slightly higher SIGNAL2 scores on average and had similar bi-plot placement. The SIGNAL SF scores for the reference sites fall on the line indicating natural water quality, delineated by a mean score of 6.5. All test sites were within the category just below this line, indicating possible mild organic pollution.

On all sampling occasions Bowral STP downstream, Mittagong STP downstream, Moss Vale STP upstream, and Moss Vale STP downstream were categorized into Band C (AUSRIVAS OE50), while reference site on Kellys Ck fell within Band C on one occasion. For the remainder of the sampling period, both reference sites were within the Band B category. The reference site on Sheepwash Ck consistently recorded an upper-level Band B. Bowral STP upstream, which moved in and out of Band C and B over the two years, could be considered as in similar condition to the reference site on Kellys Ck. Mittagong STP upstream shows most similarity to reference sites, consistently being placed into the Band B category.

All upstream and downstream sites displayed some level of impact from urban and/or agricultural pollution. Out of all the sites, Moss Vale STP upstream and downstream appear to have the lowest aquatic ecosystem health. Bowral STP upstream appears to have slightly better aquatic ecosystem health than the downstream site, most likely due to environmental conditions and site characteristics. Mittagong STP upstream appears to have the best aquatic ecosystem health of all the test sites and was the most similar to reference sites. Mittagong STP downstream had lower ecosystem health than the upstream site, this is highly likely due to increased runoff from the Mittagong township entering Gibbergunyah Ck between the two sites and a concrete wall disrupting natural hydrology and causing pooling and sedimentation at Mittagong STP downstream. While STP discharges would contribute to pollution to some degree, differences observed between test sites could not be attributed specifically to STP discharges and are most likely also affected by urban/ agricultural runoff from the surrounding townships and natural variation.

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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 wastewater 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	An 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 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 wastewater 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.

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)
STP	Sewerage treatment plant

4. Introduction

Sydney Water has developed this report in response to engagement by Manly Hydraulics Laboratory. Under this program, Sydney Water performed seasonal macroinvertebrate collections at eight sites within the Wingecarribee Shire Council, three located upstream of sewerage treatment plants (STPs), three located downstream of STPs, and two reference sites.

Regular water quality monitoring of biological indicators within urban streams and rivers and their response to impacts is an essential tool for environmental managers and government bodies and assists in decision making. Anthropogenic impacts such as stormwater run-off, industrial and commercial developments, and STP effluent can have a significant impact on aquatic ecosystem health. Biological indices using macroinvertebrates have become an effective tool to give an indication of the ecological health of waterways.

This report details the outcomes of the biological monitoring program performed within the period of Autumn 2020 – Spring 2021. The objectives of this study are to provide an indication of aquatic ecosystem health both upstream and downstream of Wingecarribee Shire Council STPs via employing the use of multiple biotic indices.

5. Study Area

5.1 Catchment

The Wingecarribee Council LGA is located 75 km southwest of Sydney and covers an area of 2700 km^2. Land use in the shire consists of agricultural and urban land use, three of the largest urban centers are the townships Bowral, Mittagong, and Moss Vale. The Wingecarribee Shire is a part of the Sydney Drinking Water catchment and has over 7200km of waterways (Wingecarribee Shire Council, 2016).

5.2 Sampling sites

Eight sites sampled for macroinvertebrates are shown in Table 1 and Figure 1. Sites were sampled seasonally for macroinvertebrates from Autumn 2020 to Spring 2021.



Figure 1 **Map of macroinvertebrate and water quality sampling sites**

Table 1 Macroinvertebrate sampling sites

Site code	Site name	Latitude / Longitude
BOW_DS	Wingecarribee River d/s Bowral STP	-34.499491, 150.386290
BOW_US	Wingecarribee River u/s Bowral STP	-34.504193, 150.393663
MIT_DS	Gibbergunyah Ck d/s Mittagong STP	-34.443435, 150.437605
MIT_US	Gibbergunyah Ck u/s Mittagong STP	-34.444378, 150.432285
MOS_DS	Whites Ck d/s Moss Vale STP	-34.546150, 150.337410
MOS_US	Whites Ck u/s Moss Vale STP	-34.546137, 150.363347
MMP203	Kellys Ck @ Wildes Meadow Rd	-34.599387, 150.487984
MMP87	Sheepwash Ck @ Drapers Rd	-34.417225, 150.471002

5.2.1 BOW_DS: Wingecarribee River d/s Bowral STP

The site BOW_DS is located on the Wingecarribee River downstream of Bowral STP. An image of the site is shown in Figure 2. The Wingecarribee River is a major watercourse in the region. The river was consistently very turbid across sampling seasons. The riparian zone had endured significant land clearing from surrounding agricultural properties and bank erosion appeared to be an issue. In some sections, emergent macrophytes had established themselves in dense patches along the bank. Upstream of the site is the main road into the towns of Burradoo and Bowral which crosses the river, along with a railway track which also crosses the river. The surrounding catchment is dominated by urban and agricultural land use.



Figure 2 Picture of BOW_DS looking upstream.

5.2.2 BOW_US: Wingecarribee River u/s Bowral STP

BOW_US is located along the Wingecarribee River upstream of Bowral STP near Sullivan Rd (Figure 3). Like the downstream site, BOW_US was consistently turbid during sampling occasions and is affected by similar influences, primarily the surrounding land use is dominated by agricultural and urban land use. There is clear evidence of clearing in the riparian zone and a collapsed concrete bridge disrupts the natural hydrology of the river. Emergent macrophytes dominate some sections of the riverbank.



Figure 3 **Picture of BOW_US looking downstream.**

5.2.3 MIT_DS: Gibbergunyah Ck d/s Mittagong STP

The site MIT_DS is located on Gibbergunyah Ck downstream of Ironmines Ck, in which the Mittagong STP discharges (Figure 4). The location of the sampling site is a generally slow-flowing pool that is created by a concrete wall. This wall disrupts the natural hydrology of the creek and can lead to increased sediment build up. The riparian vegetation in this area is in generally good condition, there appears to be some vegetation management occurring and some exotic species are present. The wider catchment of the site contains drainage from the Mittagong township and nearby construction works. The water quality was generally good based on visual observations, although in Spring 2021 it was very turbid and there was a noticeable odour present.



Figure 4 Picture of MIT_DS looking downstream.

5.2.4 MIT_US: Gibbergunyah Ck u/s Mittagong STP

MIT_US is located along Gibbergunyah Ck near Owen St (Figure 5). It is upstream of Ironmines Ck in which the Mittagong STP discharges. It is a small natural creek with an approximate width of two metres. It was occasionally turbid during sampling events. The riparian zone is generally in good condition, some spaces have been cleared and there are some exotic plants present, but it is predominantly native vegetation. The creek has two stormwater drains within the reach. The surrounding land use is primarily urban and on one bank there is a major construction zone in proximity (approximately > 100m).



Figure 5 **Picture of MIT_US looking upstream.**

5.2.5 MOS_DS: Whites Ck d/s Moss Vale STP

The site MOS_DS is located downstream of Moss Vale STP at Oldbury Rd (Figure 6). Water clarity varied over sampling periods with turbidity sometimes being an issue. The riparian zone was severely impacted with land clearing occurring throughout the reach and right up to the creek banks in some areas. The site was downstream of a road bridge which had impacted the natural substrate and hydrology. The surrounding land use was primarily agricultural farmland.



Figure 6 Picture of MOS_DS looking upstream.

5.2.6 MOS_US: Whites Ck u/s Moss Vale STP

MOS_US is located upstream of Moss Vale STP along Whites Ck at Cosgrove Park (Figure 7). It is a narrow urban creek approximately two metres in width. The stream itself has a few point sources in stormwater drainage and some debris within the stream, although natural hydrology did not appear to be impacted. The riparian zone has some moderate impacts with development and clearing evident, although there has been a clear revegetation effort. The surrounding land use is primarily residential and recreational.



Figure 7 Picture of MOS_US looking downstream.

5.2.7 MMP203: Kellys Ck @ Wildes Meadow Rd

MMP203 is located where Kellys Ck meets Wildes Meadow Rd (Figure 8). It is a narrow creek approximately two metres wide in most places. It runs through agricultural paddocks and a homestead. On one side of the road, the private landowner had undertaken extensive restoration works. The creek was consistently turbid during sampling and bank erosion appears to be an issue upstream with livestock destabilizing the bank. The riparian zone upstream is almost completely cleared and there are exotic plants along the bank edge, while downstream restorative works have created a healthy riparian zone. The road disrupts the natural hydrology and substrate alterations with installed rock piles.



Figure 8 **Picture of MMP203 looking downstream.**

5.2.8 MMP87: Sheepwash Ck @ Drapers Rd

MMP87 is located along Sheepwash Ck at Drapers Rd (Figure 9). The creek is located on the fringe of Nattai National Park and is surrounded by natural bushland. There is minor land clearing for tracks and a homestead nearby, but outside of the riparian zone appears in natural good condition. The road crossing disrupts the natural hydrology of the river, and the water was turbid on some sampling occasions. The road as an impervious surface could cause high runoff in high rainfall events. Sheepwash Ck most likely receives some urban run-off from the town of Colo Vale which is situated in the upper reaches.



Figure 9 **Picture of MMP87 looking upstream.**

6. Methods

All field sampling and laboratory methods adhered to internal methods and ISO/IEC 17025 requirements. NATA accreditation details are summarised in Table 2.

Table 2 Sydney Water laboratories' NATA accreditation numbers

Field of Testing	Number	Accredited	Standard
Biological Testing	610	1966	ISO/IEC 17025

6.1 Sampling methods

6.1.1 Macroinvertebrate sampling and identifications

Macroinvertebrate sampling was conducted on 5th – 7th May 2020 (Autumn 2020), 16th – 18th November 2020 (Spring 2020), 12th – 14th May 2021 (Autumn 2021), and 16th – 18th November 2021 (Spring 2021). 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 (Figure 10). 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 the 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 level and Acarina at order level.



Figure 10 Sample jars and a picked specimen, Notonectidae *Enithares* (Back-swimmer).

6.2 Data analysis methods

6.2.1 Macroinvertebrate Analyses

Macroinvertebrate data was analysed through five different indices: Taxa Richness, EPT Taxa Richness, SIGNAL2, SIGNAL-SF, and AUSRIVAS.

Taxa Richness and EPT

Taxa richness is the overall variety (total taxa) of macroinvertebrates in a 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. While taxa richness can be a useful tool in assessing the general health of a water body, it should be applied with caution as taxa numbers can be affected by attributes other than stream health.

Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness shows the abundance of highly sensitive Ephemeroptera (mayfly) Plecoptera (stonefly), and Trichoptera (caddisfly) orders. It is presented as a percentage of the total taxa richness, a high EPT% richness indicates increased health of an aquatic ecosystem. Some caution must be applied when using and interpreting EPT% as some EPT taxa are relatively tolerant to changes in stream health, and some may not be present due to natural factors.

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 SIGNAL2 score combined with the total taxa is plotted on a bi-plot with different quadrants based on potential pollution type. The bi-plot should be used purely as an indicator of likely impacts and caution should be taken when interpreting results. SIGNAL2 calculations followed the method outlined in Chessman (2003).

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 scores were calculated from count data, transformed to square roots from all samples. Square root count data of each family was then multiplied by the sensitivity grade number for that family, the products were then summed and divided by the total square root transformed number of individuals in all graded families. Water quality status (or stream health) is inferred from the calculated SIGNAL_SF scores (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

AUSRIVAS

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.

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 using different "Bands" to assist in interpretation (Table 4).

Table 4 AUSRIVAS OE50 Bands interpretation.

OE50 Band	Band Interpretation
X	More ecologically diverse than reference sites
A	Reference condition
B	Significantly impaired
C	Severely impaired
D	Extremely impaired

7. 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 the 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 buildings. This results in increased stormwater 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 November 2021 and sampling dates are presented in Figure 11. 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 four-day period. March 2020 to May 2020 had relatively low rainfall levels, while moderate rainfall events (around 20 – 30mm), were recorded in late October to early November for both 2020, and 2021.

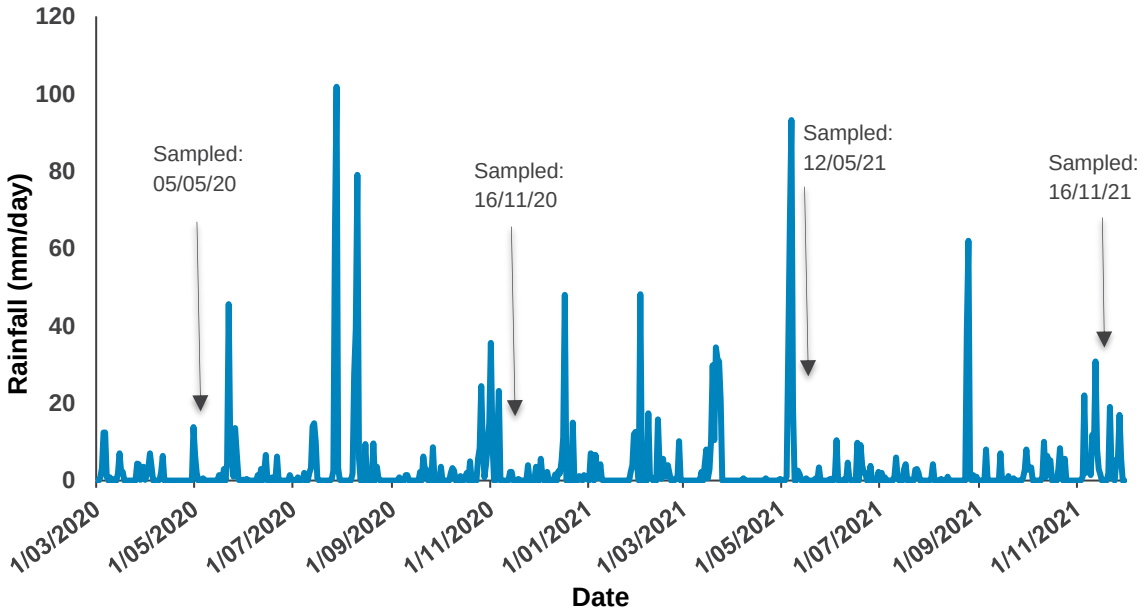

Figure 11 **Daily rainfall data 1st March 2020 – 30th November 2021 and sampling dates for each season.**

8. Macroinvertebrate results and interpretation

8.1 Results – Bowral STP

8.1.1 Taxa Richness & EPT Taxa

Taxa richness results presented as the mean number of macroinvertebrate families per site across four sampling seasons are graphed below in Figure 12.

Taxa richness was similar between BOW_US and BOW_DS, 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, 11.5, and 17, this was only slightly higher than BOW_DS which displayed averages of 11.5, 13.5, 8.5, and 14. Both sites display the same seasonal trend, recording higher taxa richness in spring and lower taxa richness in autumn.

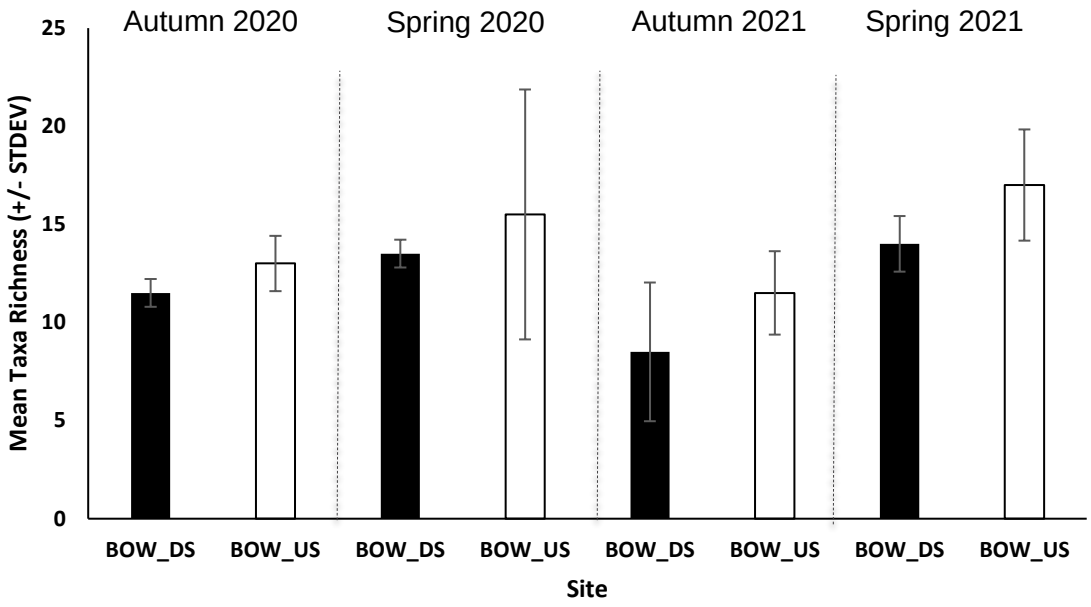

Figure 12 **Mean ± STDEV taxa richness at BOW_DS and BOW_US between Autumn 2020 – Spring 2021.**

The mean EPT% for both sites are presented in Figure 13. The lowest mean EPT% displayed among both sites and seasons was 7.2% at BOW_DS in Spring 2021 while the highest was 23.6% recorded at BOW_US in Spring 2020. As with taxa richness, BOW_US consistently displayed a higher mean EPT% across each season, larger differences between sites were observed in spring. Differences in mean EPT% between BOW_US and BOW_DS ranged from 2.2% in Autumn 2020 to 12.6% in Spring 2020.

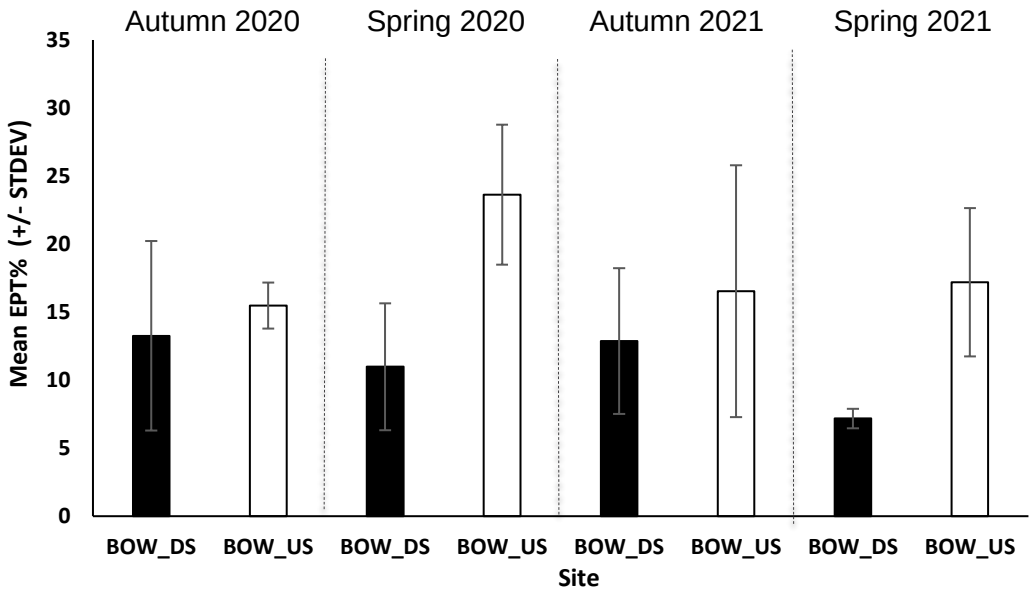

Figure 13 **Mean ± STDEV EPT% collected at BOW_DS and BOW_US between Autumn 2020 – Spring 2021.**

8.1.2 SIGNAL2

Mean SIGNAL2 scores are presented in Figure 14 with associated bi-plot placement in Figure 15. Both BOW_US and BOW_DS were within the range of 2.7 and 3.6 across all seasons with no real trends present. Bi-plot placement for both sites across seasons is indicative of sites experiencing agricultural and/or urban pollution. During spring sampling both sites shift slightly towards a range indicating high nutrient levels.

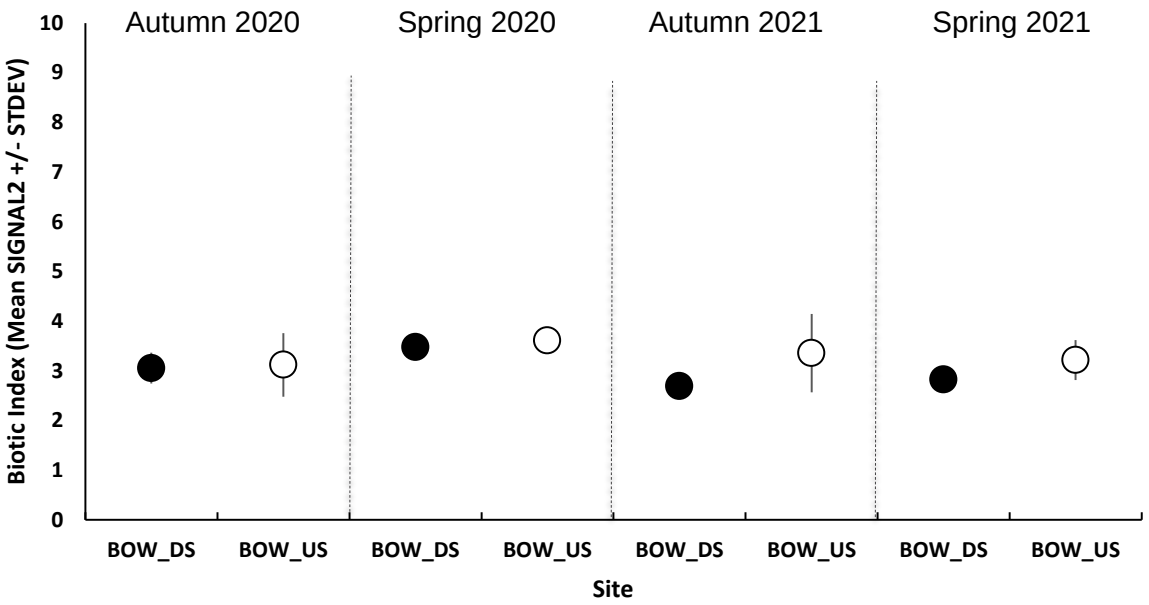

Figure 14 Mean ± STDEV SIGNAL2 scores at BOW_DS and BOW_US between Autumn 2020 - Spring 2021.

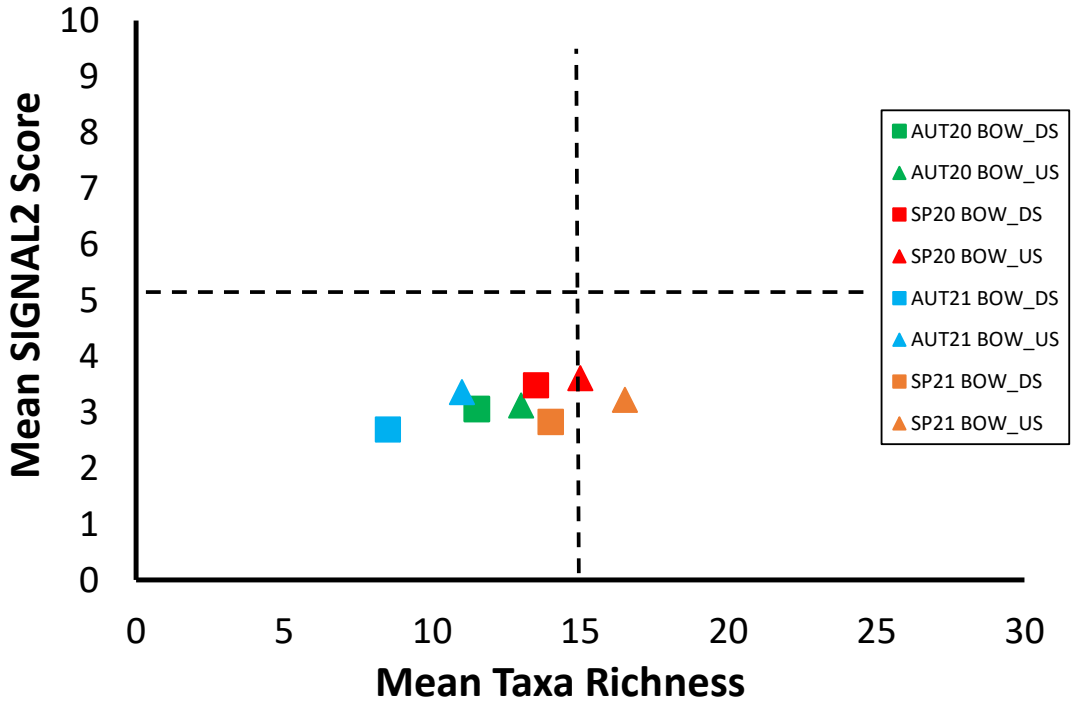

Figure 15 Mean SIGNAL2 bi-plot for BOW_DS and BOW_US between Autumn 2020 – Spring 2021.

8.1.3 SIGNAL SF

SIGNAL-SF results for BOW_US and BOW_DS across all sampling seasons are shown in Figure 16. Mean SIGNAL-SF scores were between 4.8 and 5.8 for both sites across all seasons with no strong trends observed. All SIGNAL-SF scores are below the “natural water quality” level of 6.5 indicating possible mild organic pollution at all sites (Table 3).

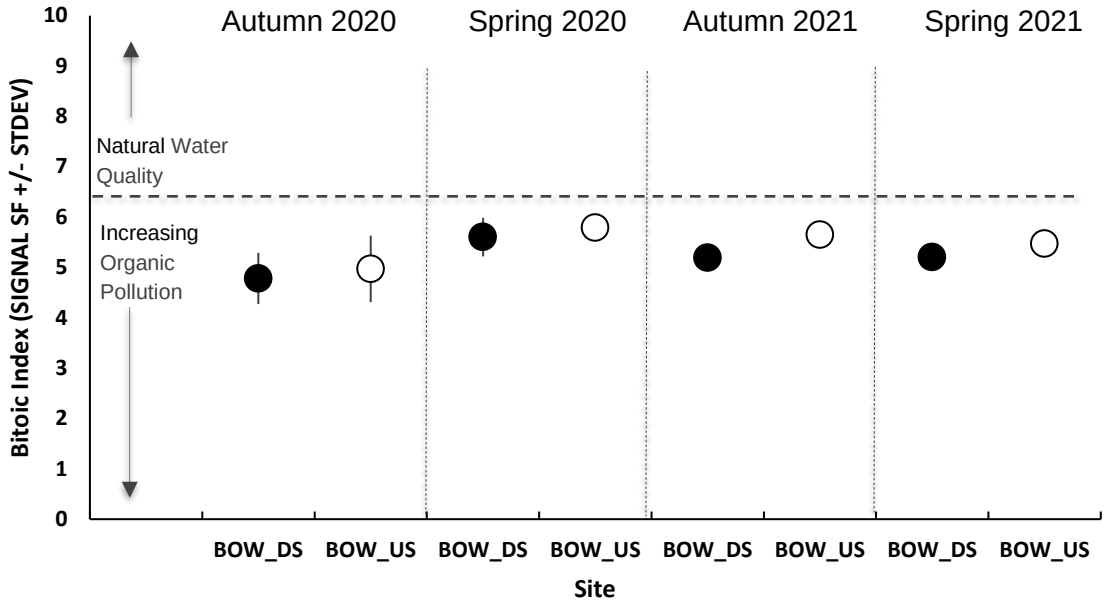

Figure 16 **Mean ± STDEV Signal-SF scores for BOW_DS and BOW_US between Autumn 2020 – Spring 2021.**

8.1.4 AUSRIVAS

The AUSRIVAS OE0 SIGNAL scores ranged between 0.53 and 0.67 for BOW_DS, while BOW_US OE0 SIGNAL scores ranged between 0.66 and 0.80 (Figure 17). Across the four sampling seasons, a consistent trend was present with BOW_US displaying slightly higher OE0 SIGNAL scores, although scores for both sites mostly were within the 0.6-0.7 range.

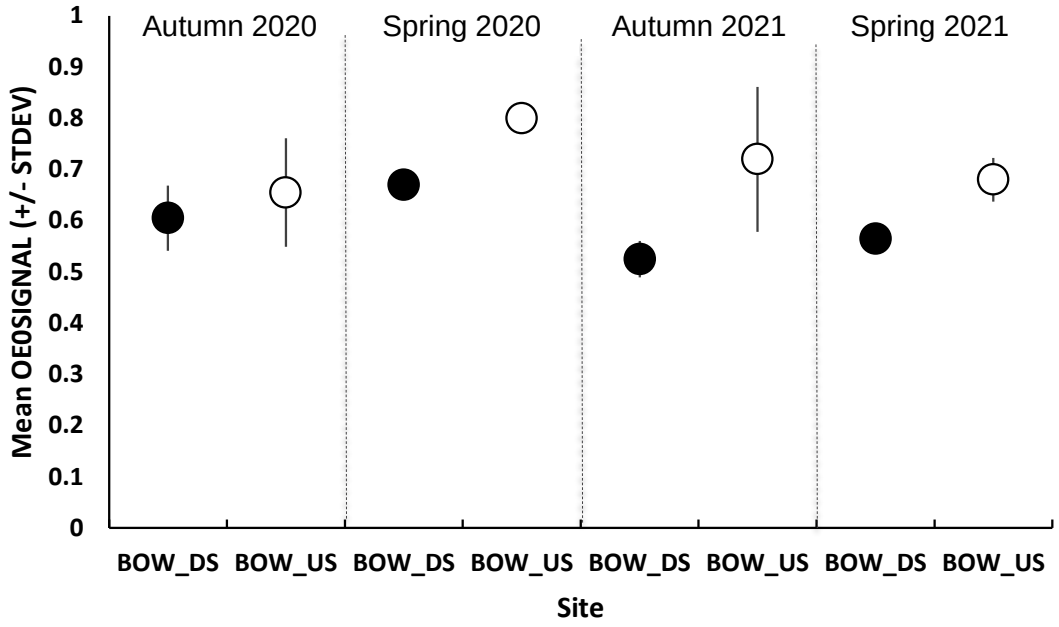

Figure 17 **Mean ± STDEV OE0 Signal scores at BOW_DS and BOW_US sites between Autumn 2020 - Spring 2021.**

AUSRIVAS mean OE50 scores are presented in Figure 18. The mean OE50 scores for BOW_DS fell within Band C on all sampling occasions. Scores for BOW_US were in Band C for both autumn sampling occasions and Band B in both spring sampling occasions. OE50 scores displayed a trend of slightly higher scores at BOW_US across the four seasons. OE50 scores for BOW_DS range from 0.22 to 0.38, while BOW_US ranged from 0.3 to 0.57.

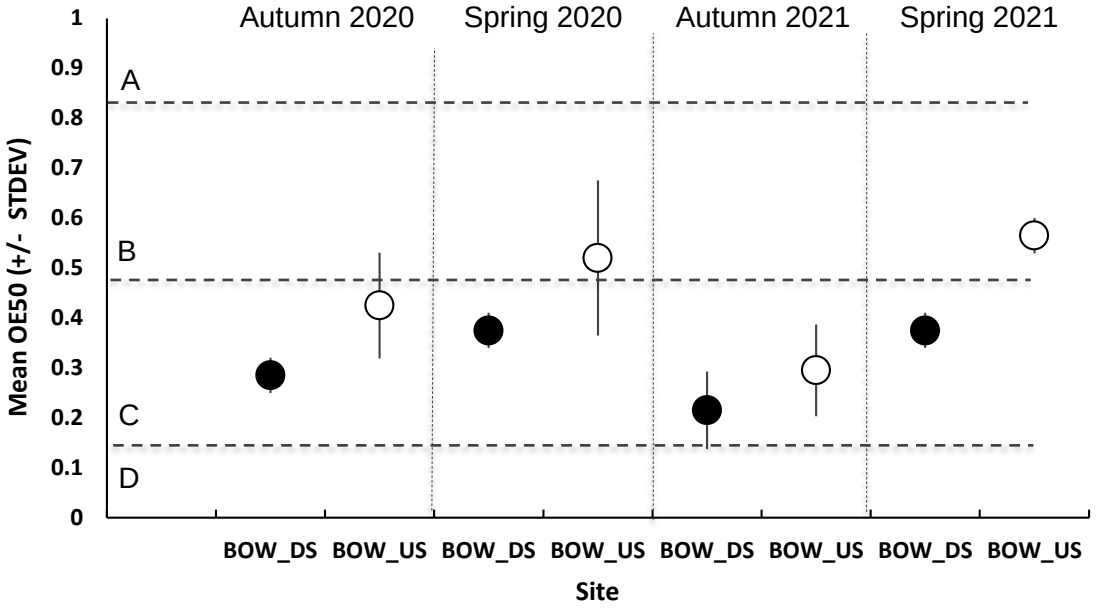

Figure 18 **Mean ± STDEV AUSRIVAS OE50 scores at BOW_DS and BOW_US between Autumn 2020 – Spring 2021.**

8.2 Results – Mittagong STP

8.2.1 Taxa Richness & EPT Taxa

Mean taxa richness for MIT_US and MIT_DS are presented in Figure 19 for all sampling seasons.

Taxa richness was similar between MIT_US and MIT_DS, the overlapping ranges indicated no significant difference in the number of macroinvertebrate families between the sites. MIT_US displayed slightly higher taxa diversity each season with averages of 17.5, 15.5, 18, and 17, while MIT_DS displayed means of 14.5, 14.5, 15.5, and 12 for each respective season. There is no clear seasonal trend between sites.

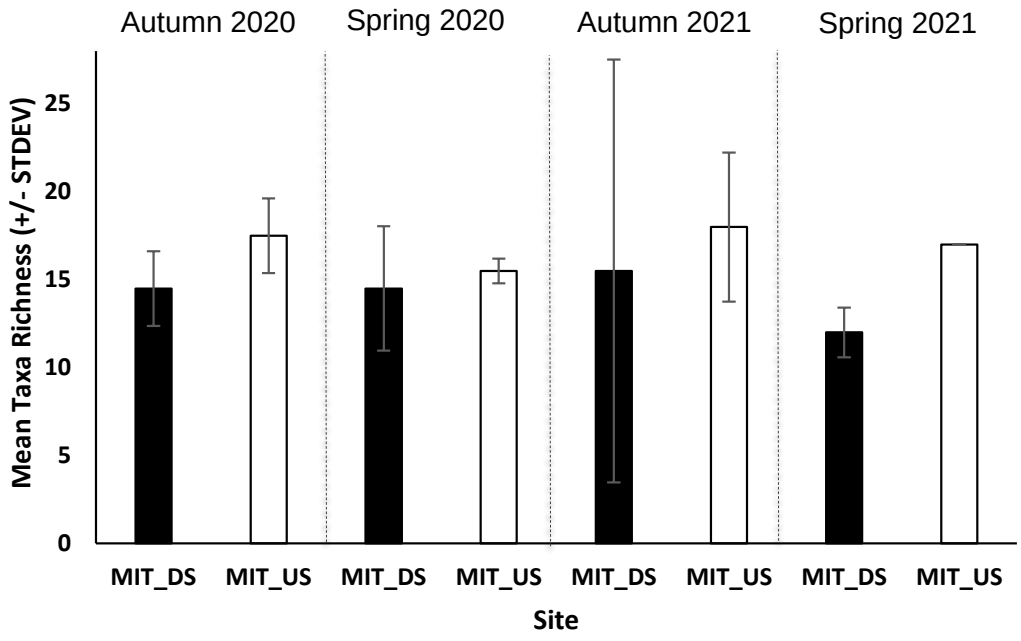

Figure 19 **Mean ± STDEV taxa richness for MIT_US and MIT_DS between Autumn 2020 – Spring 2021.**

The mean EPT% for both sites are presented in Figure 20. The lowest mean EPT% displayed among both sites and seasons was 4.6% at MIT_DS in Spring 2021 while the highest was 30% at MIT_US recorded in Autumn 2021. MIT_US consistently displayed a higher mean EPT% across each season, the largest difference between sites was 14.6% occurring in autumn 2021.

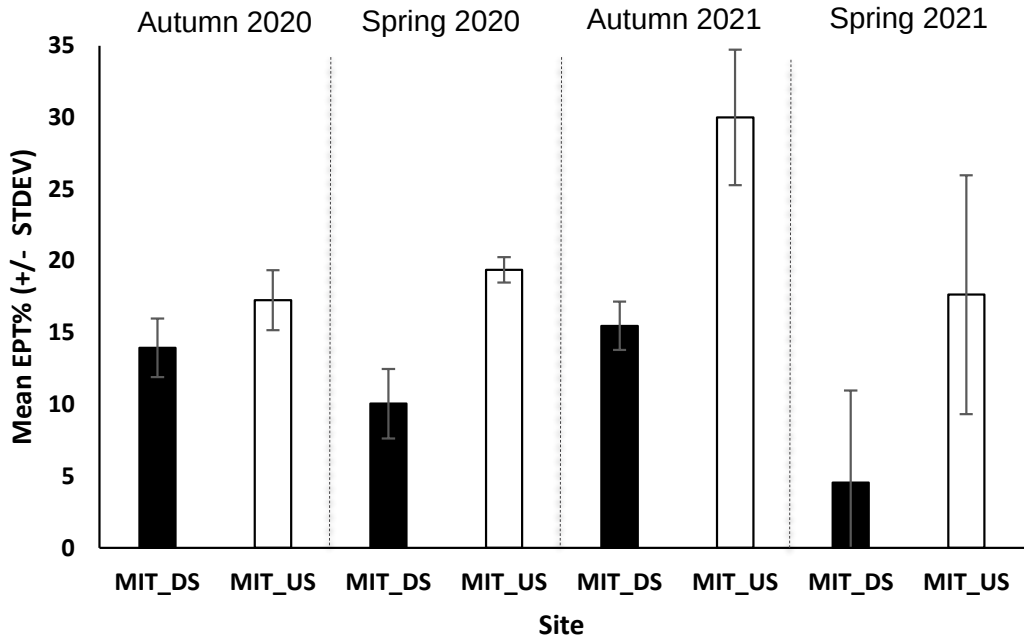

Figure 20 **Mean ± STDEV EPT% for MIT_US and MIT_DS between Autumn 2020 – Spring 2021.**

8.2.2 SIGNAL2

Mean SIGNAL2 scores are presented in Figure 21 with associated bi-plot placement in Figure 22. Both MIT_US and MIT_DS were within the range of 3.1 and 4.1 across all seasons with no real trends present. Bi-plot placement for MIT_DS across all seasons is indicative of a site experiencing agricultural and/or urban pollution. MIT_US is slightly shifted towards a placement indicative of higher nutrients or salinity for all seasons.

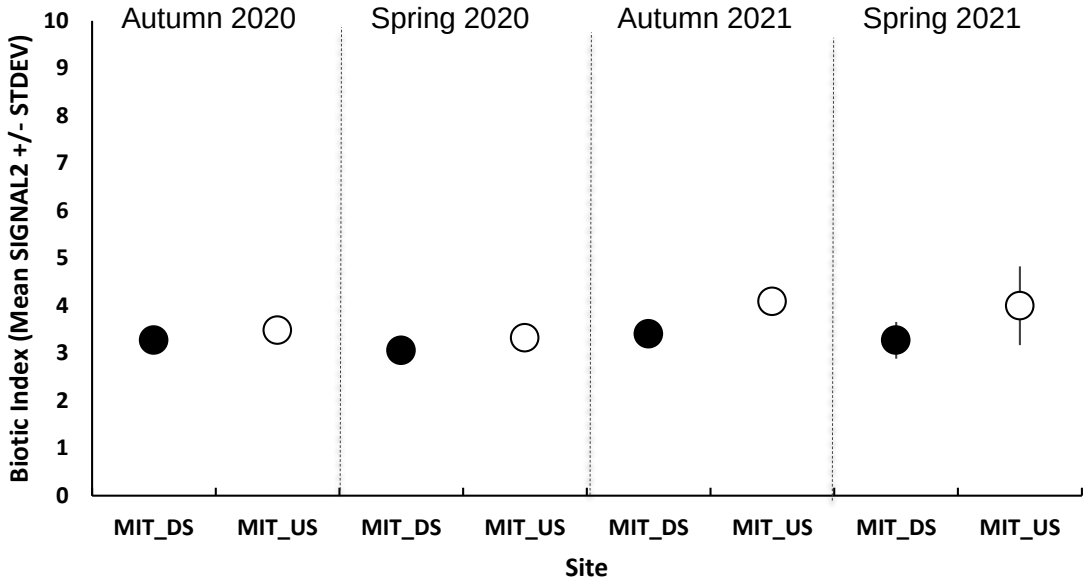

Figure 21 **Mean ± STDEV SIGNAL2 scores for MIT_US and MIT_DS between Autumn 2020 – Spring 2021.**

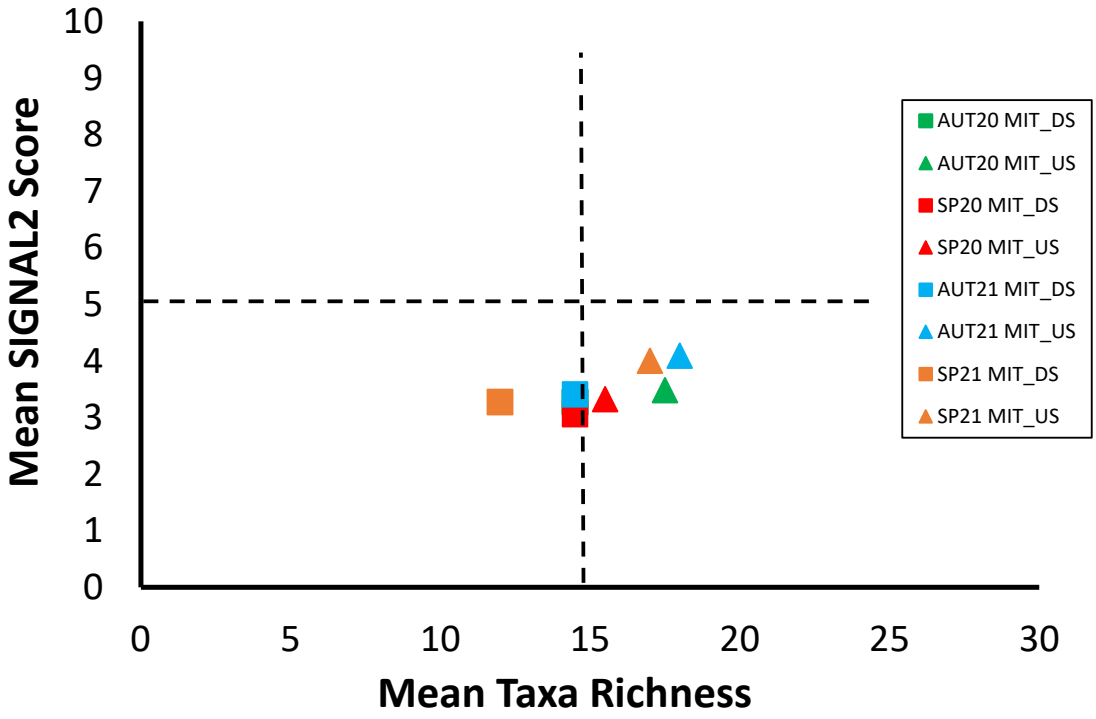

Figure 22 **Mean Signal2 biplot for MIT_US and MIT_DS between Autumn 2020 – Spring 2021. (AUT MIT_DS is positioned behind SP20 MIT_DS and AUT21 MIT_DS).**

8.2.3 SIGNAL SF

SIGNAL-SF results for MIT_US and MIT_DS across all sampling seasons are shown in Figure 23. Mean SIGNAL-SF scores were between 4.6 and 6.0 for both sites across all seasons, MIT_US consistently recorded slightly higher scores across seasons. All SIGNAL-SF scores are below the “natural water quality” level of 6.5 indicating possible mild organic pollution at all sites (Table 3).

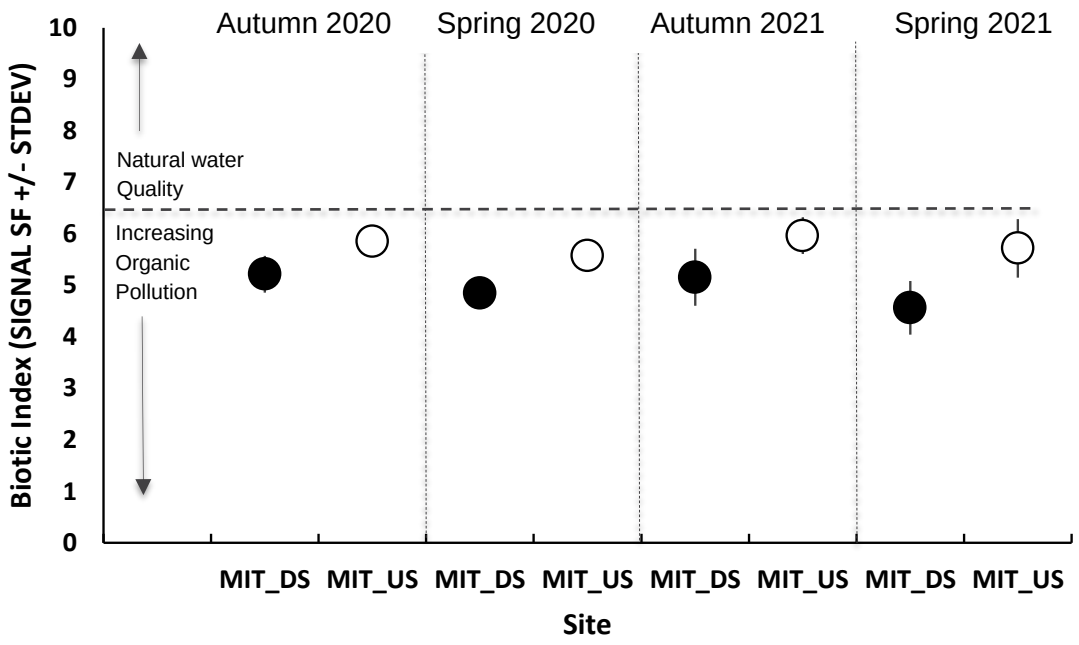

Figure 23 **Mean ± STDEV SIGNAL SF for MIT_US and MIT_DS between Autumn 2020 – Spring 2021.**

8.2.4 AUSRIVAS

The AUSRIVAS OE0 SIGNAL scores ranged between 0.64 and 0.69 for MIT_DS, while MIT_US ranged between 0.74 and 0.91 (Figure 24). Across the four sampling seasons, a consistent trend was present with MIT_US displaying slightly higher OE0 SIGNAL scores, with greater differences between sites in 2021.

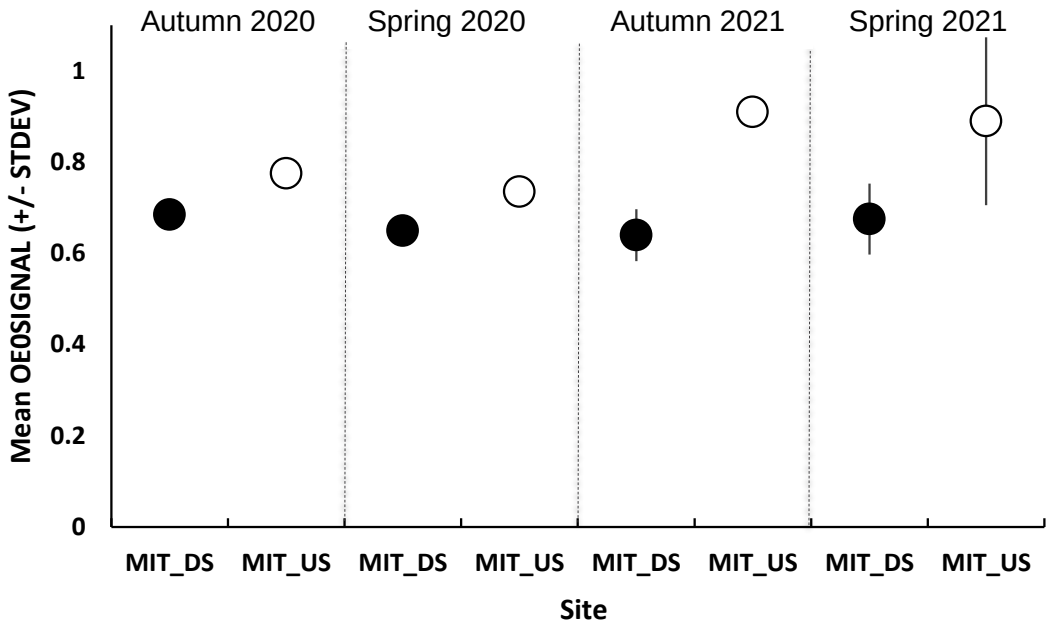

Figure 24 **Mean ± STDEV OE0 SIGNAL for MIT_US and MIT_DS between Autumn 2020 – Spring 2021.**

AUSRIVAS mean OE50 scores for MIT_US and MIT_DS are presented in Figure 25. The OE50 scores for MIT_DS were within Band C for all sampling occasions. Scores for MIT_US were within Band B for all sampling occasions. OE50 scores displayed a trend of higher scores at the upstream site across the four seasons. OE50 scores for MIT_DS range from 0.27 to 0.46, while MIT_US ranged from 0.58 to 0.68.

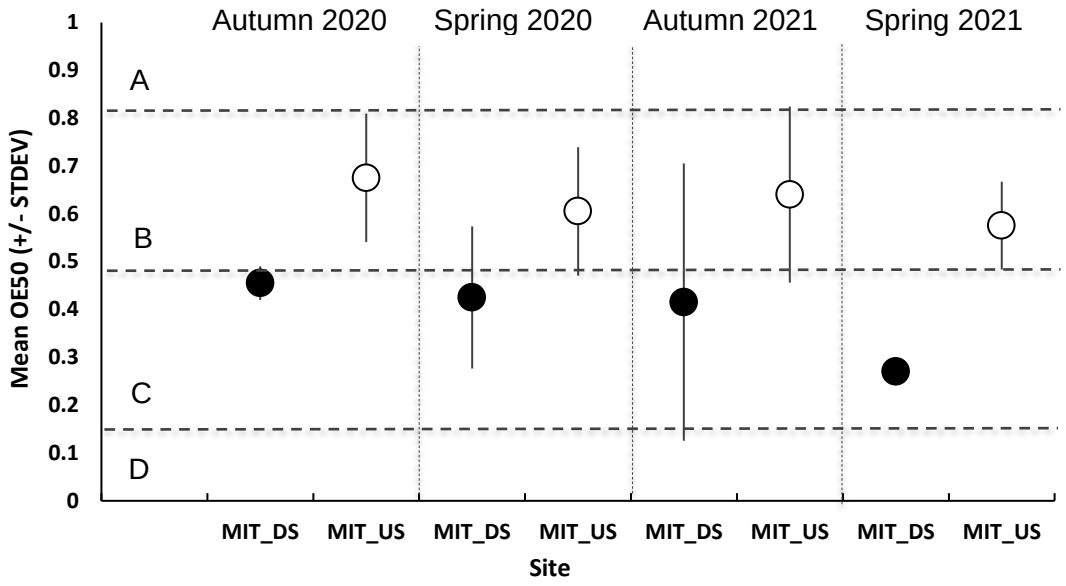

Figure 25 **Mean ± STDEV OE50 for MIT_US and MIT_DS between Autumn 2020 – Spring 2021.**

8.3 Results – Moss Vale STP

8.3.1 Taxa Richness & EPT Taxa

Mean taxa richness for MOS_US and MOS_DS are presented in Figure 26 for all sampling seasons.

Taxa richness was similar between MOS_US and MOS_DS, the overlapping ranges indicated no significant difference in the number of macroinvertebrate families between the sites. There was no clear seasonal trend between sites, in both autumn sampling occasions, MOS_US displays slightly higher mean taxa richness, while in both spring sampling occasions MOS_DS displays higher mean taxa richness, although differences are small. The highest mean taxa richness was recorded at MOS_DS in Spring 2021 with a mean of 17.5, while the lowest was recorded at MOS_US in Spring 2020 with a mean of 9.

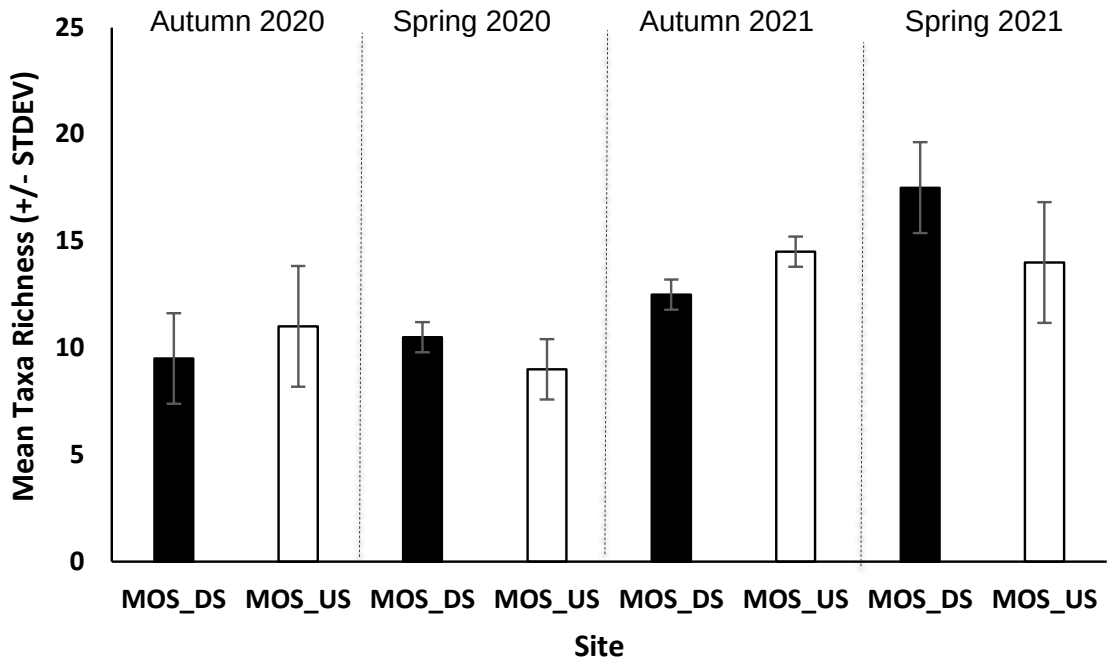

Figure 26 **Mean ± STDEV taxa richness for MOS_US and MOS_DS between Autumn 2020 – Spring 2021.**

The mean EPT% for MOS_US and MOS_DS are presented in Figure 27. MOS_DS had higher levels of EPT taxa compared to MOS_US. While EPT taxa were recorded at MOS_DS on each sampling occasion, EPT taxa were only recorded at MOS_US in Autumn 2021. The lowest mean EPT% recorded at MOS_DS was 4.5% recorded in both sampling occasions in 2020, while the highest EPT% of 19.9% was recorded in Autumn 2021.

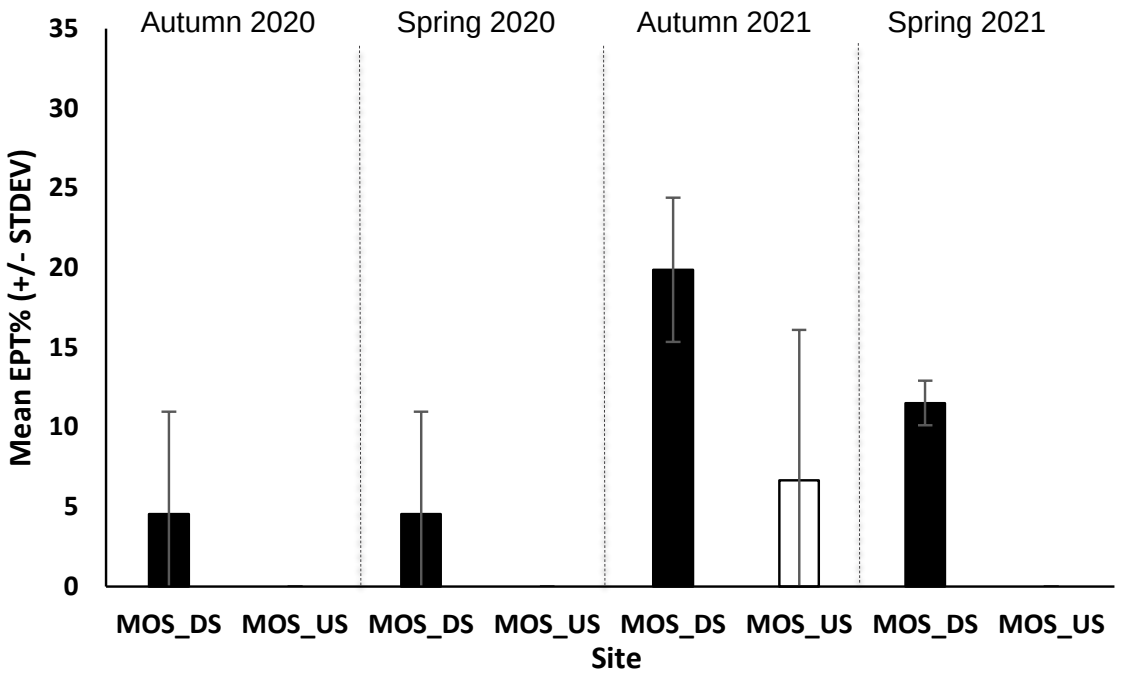

Figure 27 **Mean ± STDEV EPT% for MOS_US and MOS_DS between Autumn 2020 – Spring 2021.**

8.3.2 SIGNAL2

Mean SIGNAL2 scores for MOS_US and MOS_DS are presented in Figure 28 with associated bi-plot placement in Figure 29. Mean scores MOS_US and MOS_DS were within the range of 2.7 and 3.4 across all seasons with no obvious trends present. Bi-plot placement for both sites across all seasons is indicative of a site experiencing agricultural and/or urban pollution, except for MOS_DS in Spring 2021 which is shifted towards a placement indicative of higher nutrients or salinity.

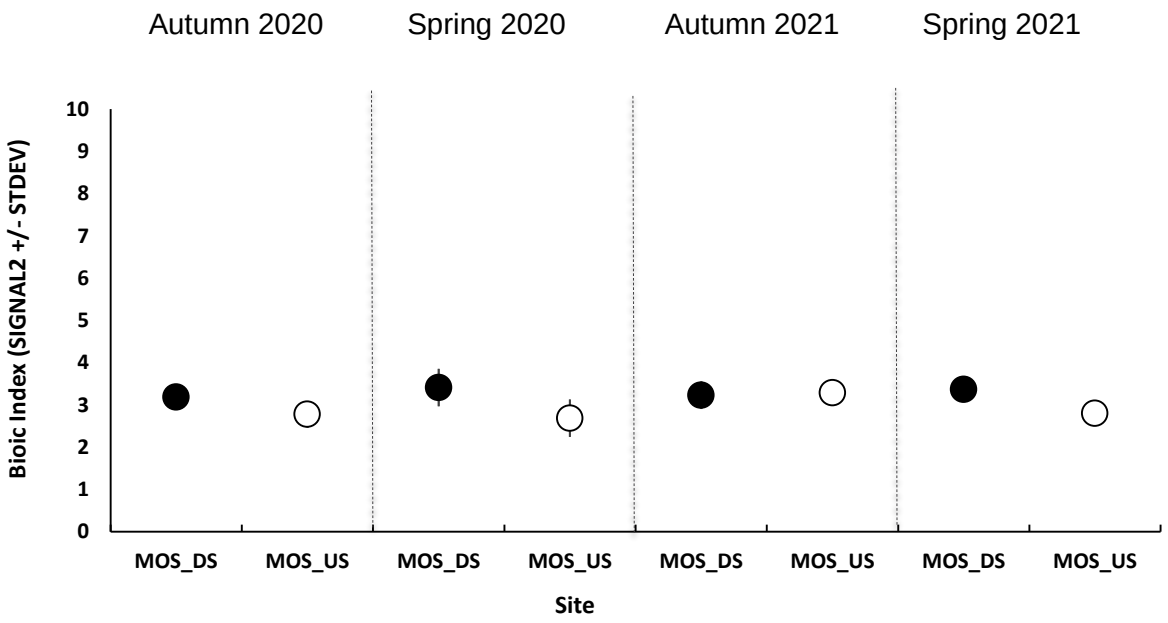

Figure 28 **Mean ± STDEV SIGNAL2 for MOS_US and MOS_DS between Autumn 2020 – Spring 2021.**

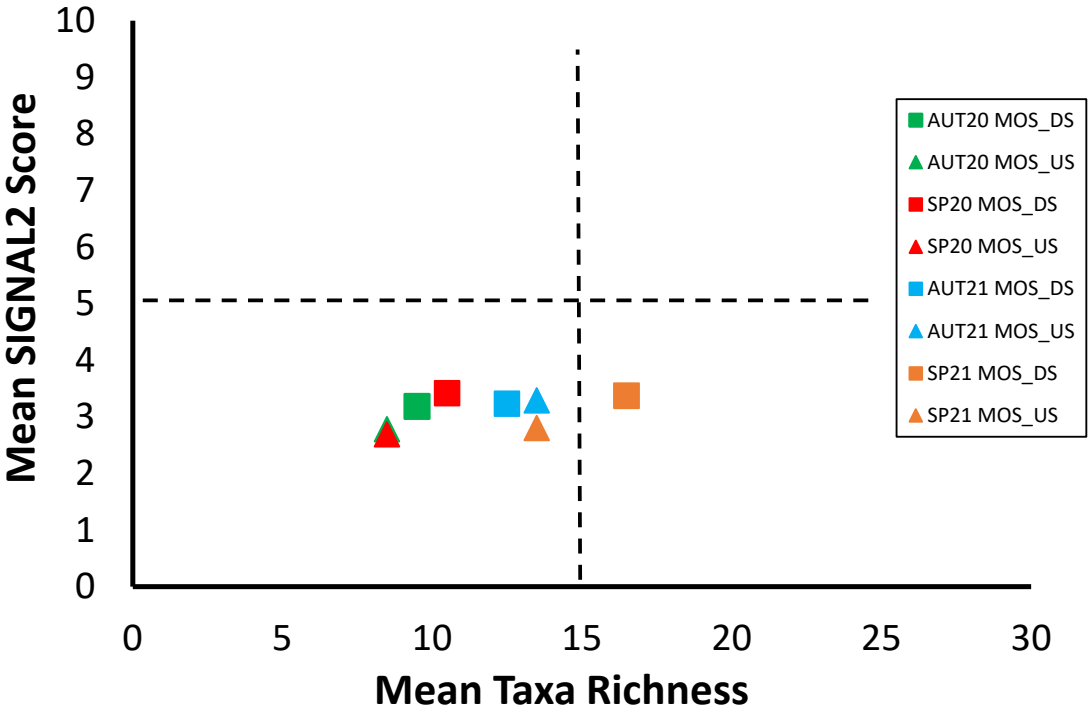

Figure 29 **Mean SIGNAL2 biplot for MOS_US and MOS_DS between Autumn 2020 – Spring 2021.**

8.3.3 SIGNAL SF

SIGNAL-SF results for MOS_US and MOS_DS across all sampling seasons are shown in Figure 30. Mean SIGNAL-SF scores were between 3.8 and 5.5 for both sites across all seasons, MIT_DS consistently recorded slightly higher scores across seasons. All SIGNAL-SF scores are below the “natural water quality” level of 6.5 indicating possible mild organic pollution at all sites (Table 3).

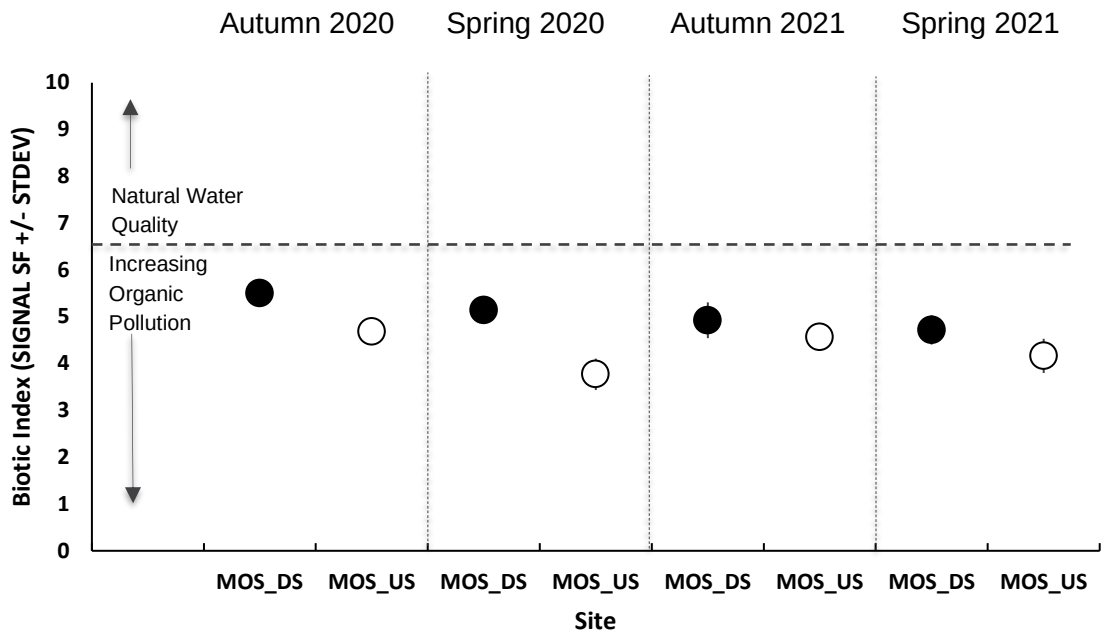

Figure 30 **Mean ± STDEV SIGNAL SF for MOS_US and MOS_DS between Autumn 2020 – Spring 2021.**

8.3.4 AUSRIVAS

The AUSRIVAS mean OE0 SIGNAL scores for MOS_DS ranged between 0.68 and 0.73, while MOS_US scores ranged between 0.56 and 0.66 (Figure 31). Across the four sampling seasons, a consistent trend was present with MOS_DS displaying slightly higher OE0 SIGNAL scores, although scores for both sites were mostly within the 0.5 - 0.7 range.

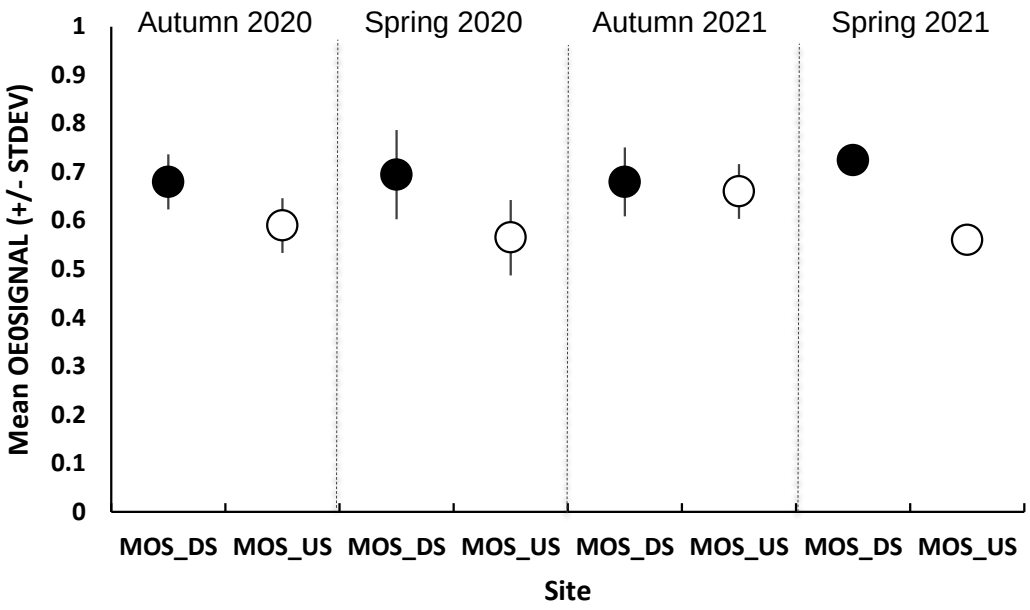

Figure 31 **Mean ± STDEV OE0 SIGNAL for MOS_US and MOS_DS between Autumn 2020 – Spring 2021.**

AUSRIVAS OE50 scores are presented in Figure 32. The OE50 scores for both MOS_DS and MOS_US fell within Band C for all sampling occasions. OE50 scores displayed a trend of slightly higher scores at MOS_DS across the four seasons. OE50 scores for MOS_DS range from 0.27 to 0.39, while MOS_US ranged from 0.17 to 0.3.

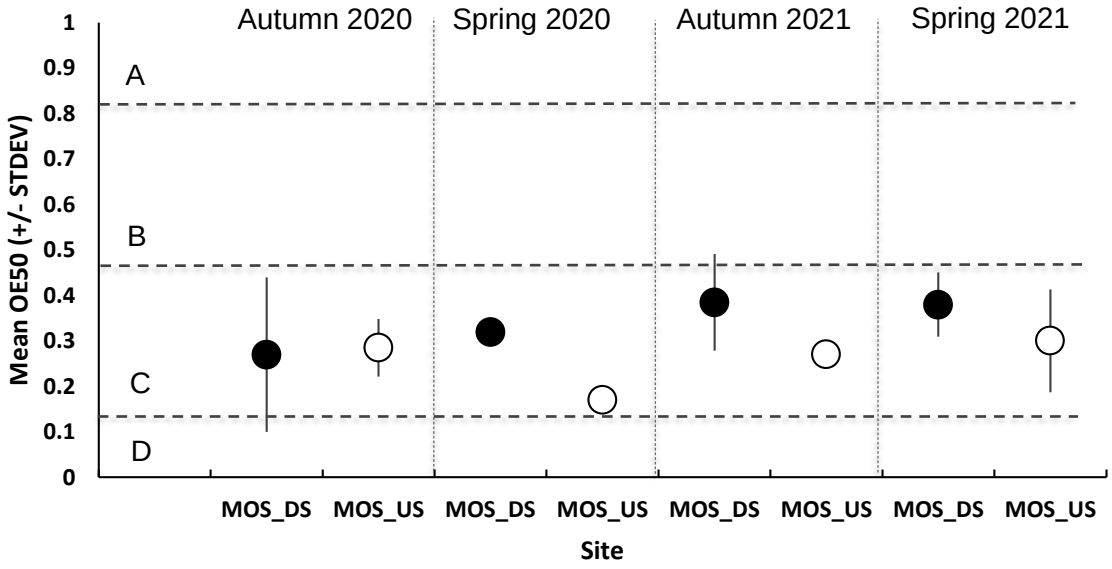

Figure 32 **Mean ± STDEV OE50 for MOS_US and MOS_DS between Autumn 2020 – Spring 2021.**

8.4 Results – Reference Sites

8.4.1 Taxa Richness & EPT Taxa

Mean taxa richness for MMP203 and MMP87 are presented in Figure 33 for all sampling seasons.

The highest mean taxa richness recorded at MMP203 was recorded in Autumn 2021 with a value of 15, while the lowest value was 9.5 occurring in Autumn 2020. The highest mean taxa richness recorded at MMP87 was 16.5, recorded in Spring 2021, while the lowest was 14.5 recorded in Autumn 2020. No obvious seasonal trends are observed for either reference site.

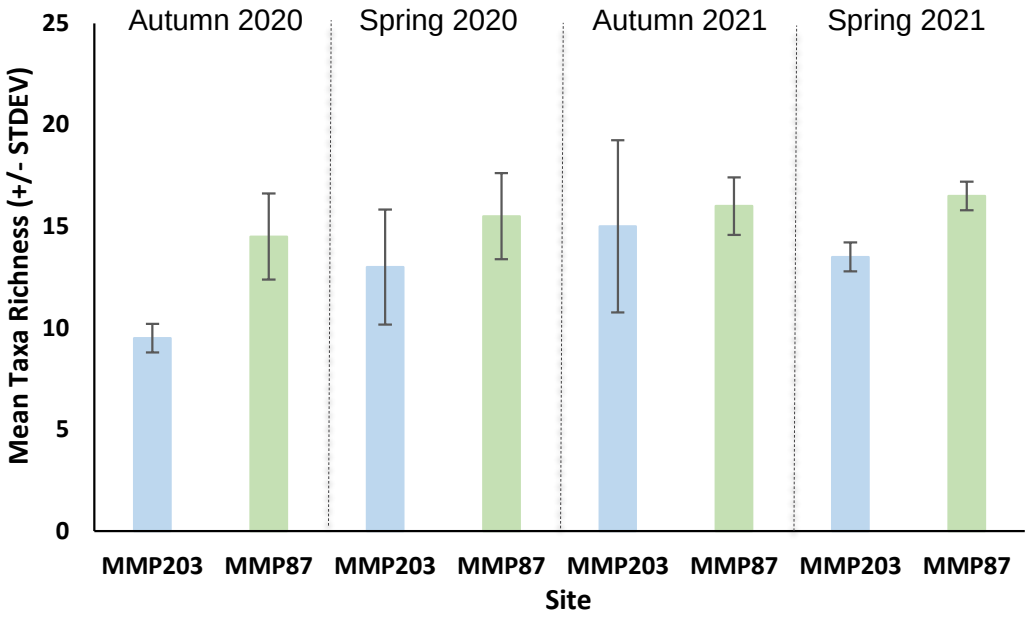

Figure 33 **Mean ± STDEV taxa richness for MMP203 and MMP87 between Autumn 2020 – Spring 2021.**

The mean EPT% for MMP203 and MMP87 are presented in Figure 34. Higher mean EPT% were recorded at MMP203 in autumn sampling compared to spring. The highest mean EPT% at MMP203 was 26.4%, recorded in Autumn 2021. The lowest EPT% recorded was 11% in spring 2021.

MMP87 displayed consistent levels of mean EPT% over the two years. The highest recorded EPT% for MMP87 occurred in Spring 2020 with 22.5%, while the lowest percentage was 13.9% in Autumn 2020.

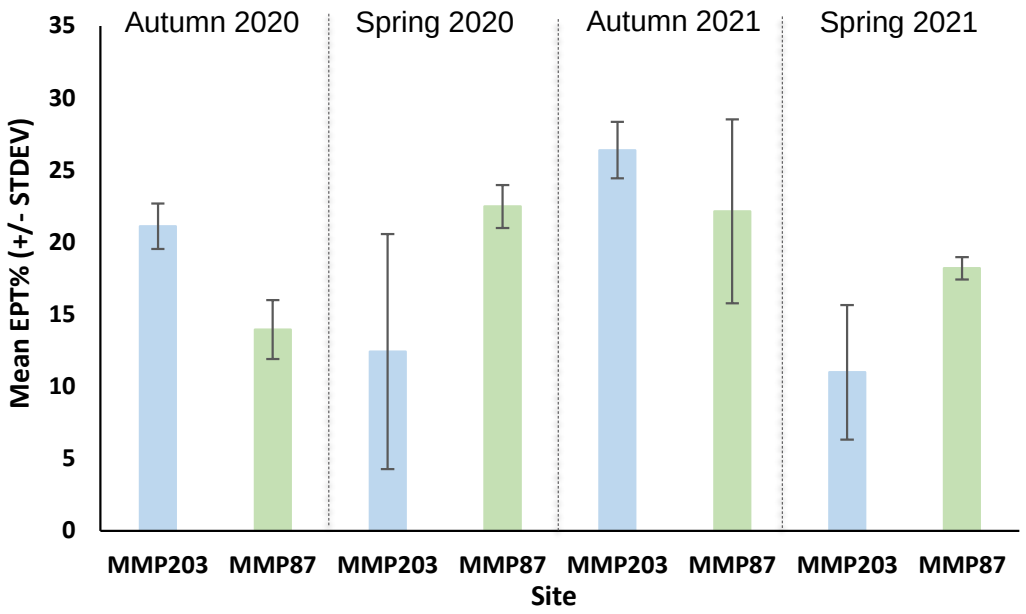

Figure 34 **Mean ± STDEV EPT% for MMP203 and MMP87 between Autumn 2020 – Spring 2021.**

8.4.2 SIGNAL2

Mean SIGNAL2 scores for MMP203 and MMP87 are presented in Figure 35 with associated bi-plot placement in Figure 36.

Mean SIGNAL2 scores for MMP203 were within the range of 3.5 and 4.1 across all seasons with no real trends present. Bi-plot placement for MMP203 across most seasons is indicative of a site experiencing agricultural and/or urban pollution, Autumn 2021 is slightly shifted towards a placement indicative of higher nutrients or salinity.

Mean SIGNAL2 scores for MMP87 were within the range of 3.7 and 4.4 across all seasons with no real trends present. Bi-plot placement for MMP87 across most seasons is indicative of higher nutrients or salinity, Autumn 2020 is slightly shifted towards a placement indicative of a site experiencing agricultural and/or urban pollution.

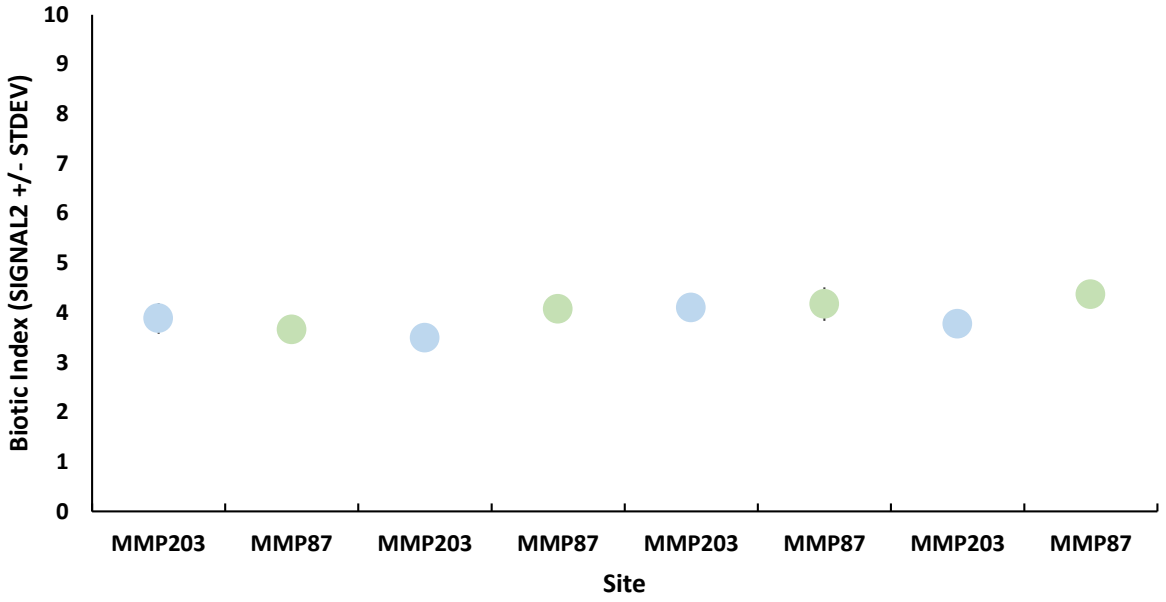

Figure 35 Mean ± STDEV SIGNAL2 for MMP203 and MMP87 between Autumn 2020 – Spring 2021.

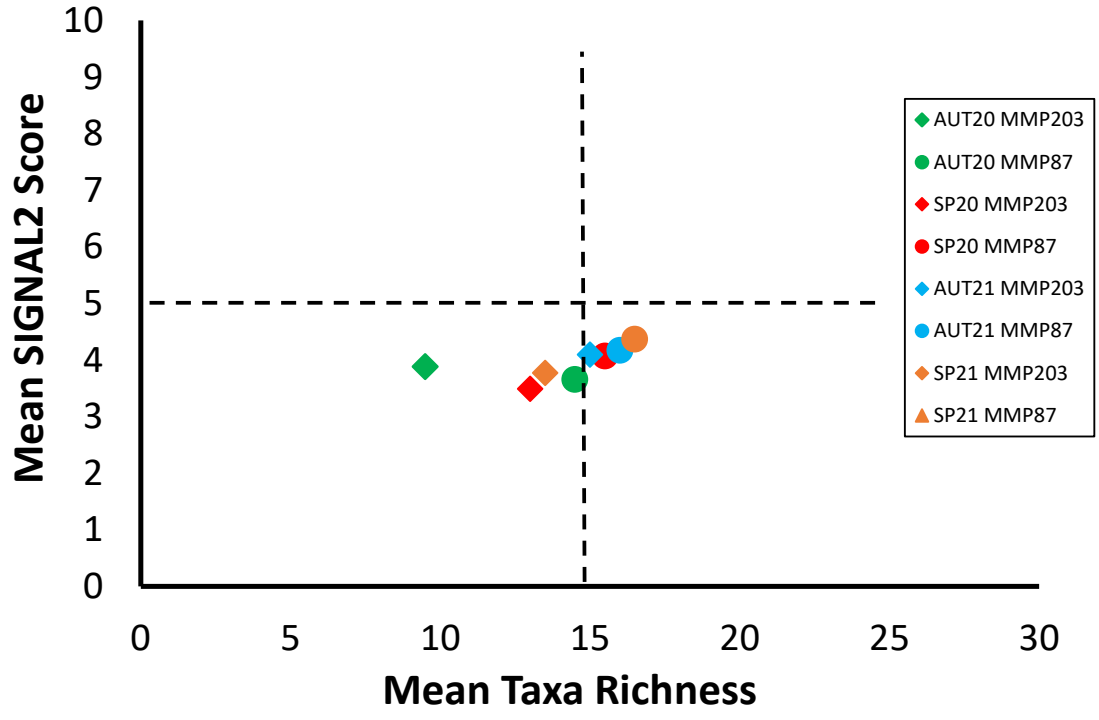

Figure 36 Mean SIGNAL2 biplot for MMP203 and MMP87 between Autumn 2020 – Spring 2021.

8.4.3 SIGNAL SF

SIGNAL-SF results for both MMP203 and MMP87 across all sampling seasons are shown in Figure 37. Mean SIGNAL-SF scores for MMP203 were between 5.9 and 6.3 across all seasons. All SIGNAL-SF scores for MMP203 are below the “natural water quality” level of 6.5 indicating possible mild organic pollution at all sites (Table 3).

Mean SIGNAL-SF scores for MMP87 were between 6.2 and 6.8 across all seasons. SIGNAL-SF scores recorded on both sampling occasions in 2020 for MMP87 are below the “natural water quality” level of 6.5 indicating possible mild organic pollution at all sites. While SIGNAL-SF scores recorded on both sampling occasions in 2021 are indicative of natural water quality (Table 3).

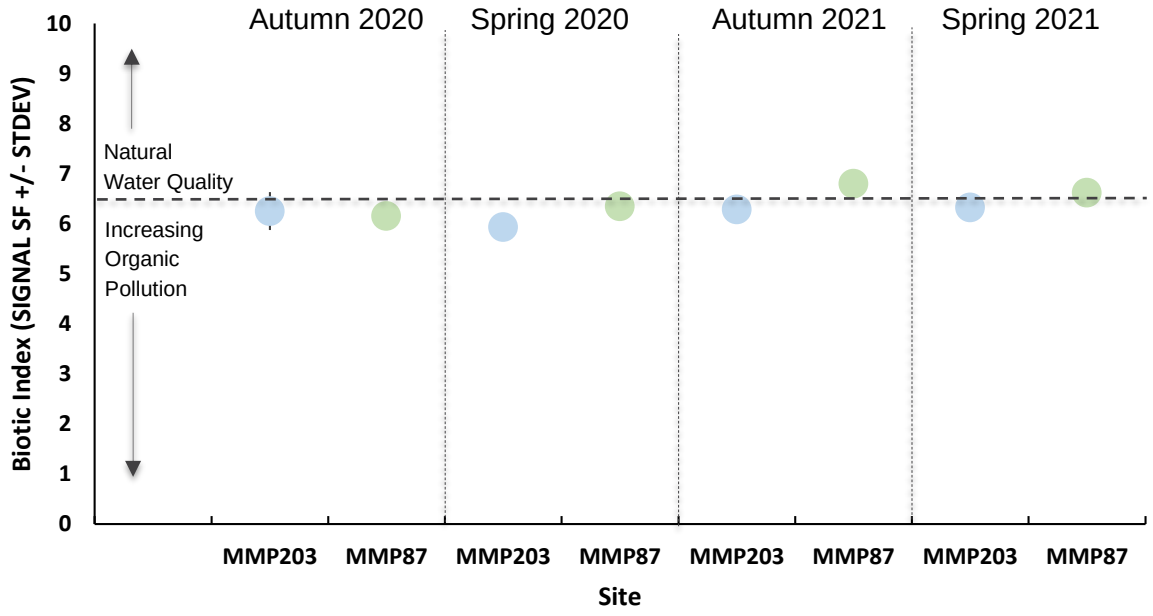

Figure 37 Mean ± STDEV SIGNAL SF for MMP203 and MMP87 between Autumn 2020 – Spring 2021.

8.4.4 AUSRIVAS

The AUSRIVAS OE0 SIGNAL scores for MMP203 and MMP87 are presented in Figure 38. OE0 SIGNAL scores for MMP203 ranged between 0.77 and 0.9. Across the four sampling seasons, there were no clear trends present. Scores were within the range of 0.7 - 0.9.

OE0 SIGNAL scores for MMP87 ranged between 0.81 and 0.98. Across the four sampling seasons scores gradually increased over time. Scores were within a range of 0.8 - 1.

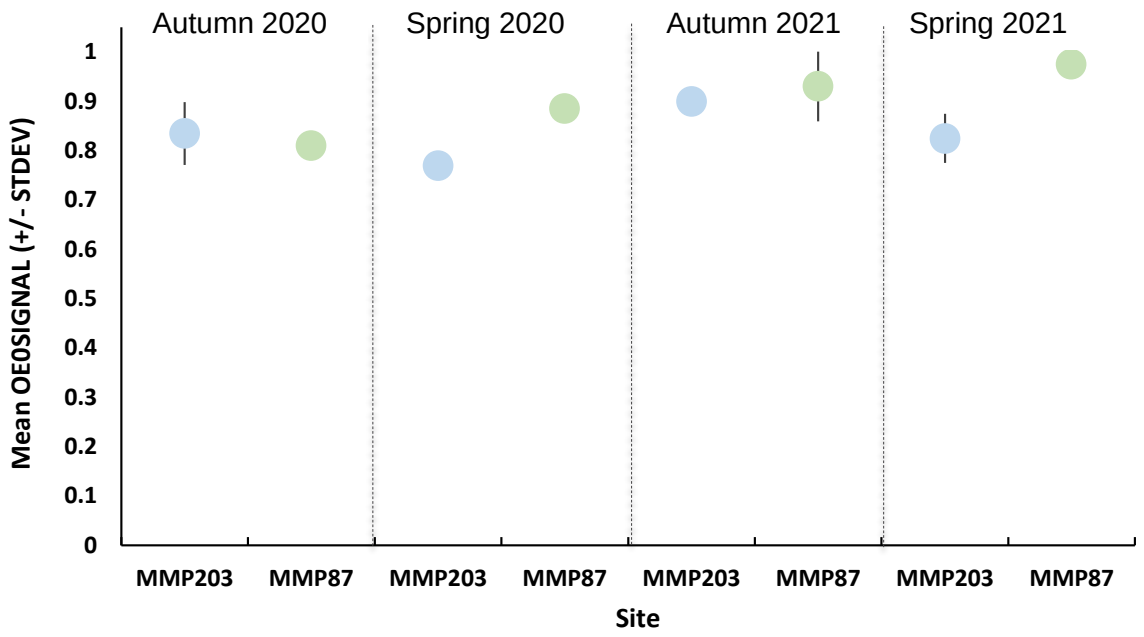

Figure 38 **Mean ± STDEV OE0 SIGNAL for MMP203 and MMP87 between Autumn 2020 – Spring 2021.**

AUSRIVAS OE50 scores for MMP203 and MMP87 are presented in Figure 39. The OE50 scores for both MMP203 fell within Band C for Autumn 2020 and then Band B for the remaining sampling occasions. OE50 scores for the MMP203 range from 0.41 to 0.72. The OE50 scores for both MMP87 were within Band B for all sampling occasions. OE50 scores for MMP87 range from 0.68 to 0.74.

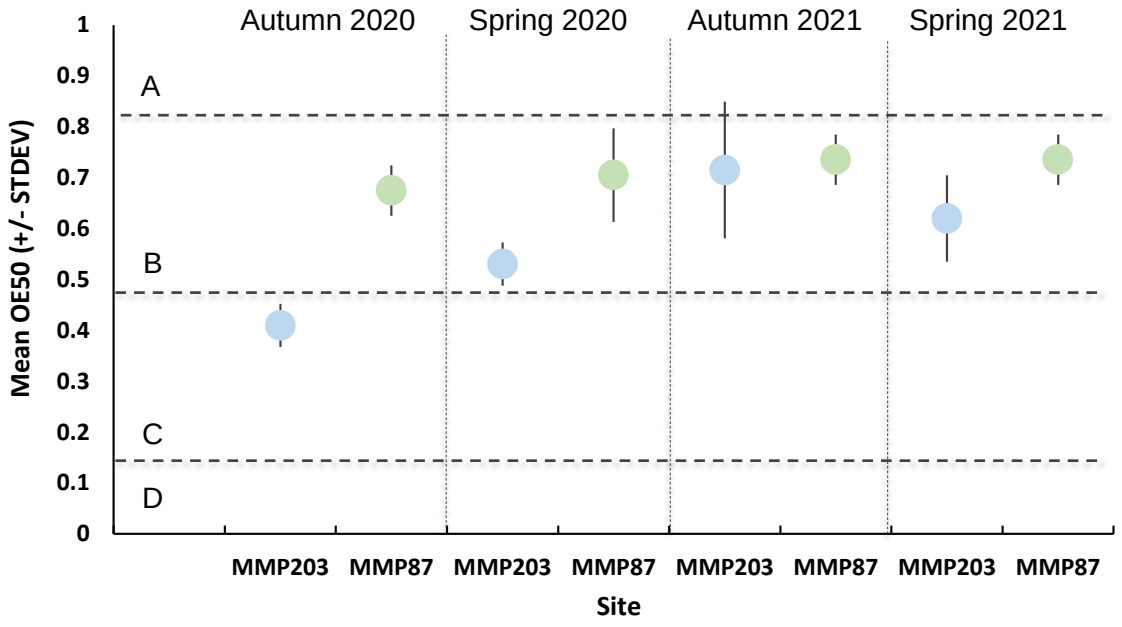

Figure 39 **Mean ± STDEV OE50 for MMP203 and MMP87 between Autumn 2020 – Spring 2021.**

9. Discussion

Biotic indices suggest varying levels of impact between the different creeks. Most of the sites situated upstream and downstream of STP discharges displayed results indicative of urban and/or agricultural pollution. The reference sites used, while displaying signs of some mild pollution, generally yielded results indicating a healthier waterway and stream ecosystem.

Bowral STP Sites

BOW_US had higher taxa richness and a higher EPT% than the BOW_DS, although these differences were not huge and could be down to environmental and/or habitat factors. The SIGNAL2 results indicated both sites were in similar condition, with urban and agricultural pollution being the major sources of water quality decline. SIGNAL SF scores for both sites were indicative of mild organic pollution at both sites which is consistent with urban and agricultural pollution. AUSRIVAS OE50 indicated the upstream was in slightly better condition. There were some seasonal factors influencing results as BOW_US consistently moved into Band B each spring. All these results indicate that both sites are under the same pressures and BOW_DS appears to be slightly more impacted than BOW_US. Both sites displayed low OE50 values in Autumn 2021, which may be due to the high rainfall event that occurred just before sampling (Figure 3).

The difference between BOW_US and BOW_DS could be due to natural variation and site-specific features. BOW_US has a slightly denser surrounding of riparian vegetation along with an increased amount of emergent macrophytes 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 that 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 runoff entering urban waterways (Walsh et al, 2005).

Mittagong STP Sites

MIT_US appears to have better aquatic ecosystem health than MIT_DS. Taxa Richness and EPT% were similar in both sites with MIT_DS displaying slightly higher levels, it is difficult to assign specifically to water quality and could be caused by a range of natural factors. There was an increase in EPT% difference between the sites in 2021. MIT_US shows a spike in EPT% in Autumn 2021, it's not clear what caused this spike and could just be natural variation. MIT_DS appears to maintain a consistent EPT% until a drop in Spring 2021, when sampling on this occasion MIT_DS was clearly in worse condition than the previous sampling with odour and poor water clarity being observed. It's possible it was experiencing a pulse in pollution which could have caused a change in EPT%. SIGNAL2 scores for both sites indicate a site is affected by urban and/or agricultural pollution, MIT_US placement in bi-plot could indicate high levels of nutrients, increased nutrients can be a consequence of urban run-off, and given the surrounding land use, it is likely this is the cause. SIGNAL SF

scores for both sites fall within the same range and indicate mild organic pollution at both sites. AUSRIVAS OE50 consistently places MIT_US in Band B, indicative of a significantly impaired system, while MIT_DS is consistently placed within Band C, indicative of a severely impaired system.

The results indicate both sites suffer from urban and/or agricultural pollution and are to some degree impacted. It would appear MIT_DS had lower aquatic ecosystem health, but it is hard to say how much lower as only AUSRIVAS OE50 shows a particularly strong difference between sites. MIT_DS is likely receiving a greater load of runoff and pollution than MIT_US. MIT_DS receives water not only from MIT_US drainage but also through two tributaries that enter Gibbergunyah Ck downstream of MIT_US. Chinaman's Ck runs directly through the main town of Mittagong and discharges into Gibbergunyah Ck, this would likely provide an increased runoff load from a large urban centre. Ironmines Ck also drains from the main township and contains the Mittagong STP discharge. With these two tributaries draining into MIT_DS and the concrete wall at MIT_DS disrupting flow and causing pooling, it could create an accumulation of pollutants at this location which would adversely affect the aquatic life. Suspended sediment can also have a major impact on aquatic macroinvertebrates, the concrete wall at MIT_DS was observed to be causing sediment accumulation, and during high flow, events could cause an increase in suspended sediment. The change in natural hydrology can also alter flow patterns which can change the macroinvertebrate communities.

Moss Vale STP Sites

There appears to be little difference between MOS_US and MOS_DS sites. Taxa richness between the two sites displayed similar levels across all seasons. The biggest difference present between the two sites was in EPT taxa. MOS_US only recorded EPT taxa on one occasion, Autumn 2021, while MOS_DS consistently recorded EPT taxa at low levels. Leptoceridae, Baetidae, Caenidae, and Hydroptiliae were all the families of EPT taxa found at these sites, all are relatively tolerant taxa. This difference could be due to a natural variation between sites. SIGNAL2 scores and bi-plot placement for both sites indicated urban and/or agricultural pollution which is consistent with the surrounding land use for both sites. SIGNAL SF scores were indicative of possible mild organic pollution for both sites, while AUSRIVAS OE50 placed both sites within Band C which indicates a severe impact.

These results indicate both sites are under stress from pollutants. MOS_US is based in a more rural setting and would receive urban runoff from the surrounding area, indeed a stormwater pipe that discharges into the creek was observed. MOS_DS is situated right near a road and surrounded by primarily agricultural land with land clearing and bank erosion appearing to be issues. The road would also be a source of high runoff being an impervious surface that leads directly to the creek. This along with the Moss Vale STP discharge upstream would all contribute to a polluted waterway.

Comparison to Reference Sites

Both reference sites appear to be in slightly better aquatic ecological health than the other sites. They performed slightly better in most biotic indices compared to the test sites. The

biggest differences observed were mostly in the AUSRIVAS OE50 metric. BOW_DS, MIT_DS, MOS_US, and MOS_DS were all categorized as Band C on all sampling occasions, while MMP203 fell within Band C on one occasion, the rest of the time both reference sites were within the Band B category. Upper-level Band B values were consistently recorded at MMP87. BOW_US which moved between Bands C and B over the two years could probably be compared to being in a similar aquatic ecological health to MMP203. MIT_US is most similar to reference sites consistently falling in the Band B category.

There is little difference between reference sites and test sites in the other biotic indices. All test sites recorded similar SIGNAL2 scores and had an overall similar placement on the bi-plot, the reference sites displayed slightly higher SIGNAL2 scores on average and had similar bi-plot placement. Both reference sites SIGNAL SF scores fall right on the line indicating natural water quality, delineated by a mean score of 6.5. All the test sites were within the category just below this line indicating possible mild organic pollution, this suggests that while under some pollution impacts both reference sites are not quite as impacted as test sites. Taxa Richness and EPT% of most test sites displayed levels slightly below reference sites, although the differences in these taxa metrics are not so significant to signify impact to water quality and could be due to natural variation and environmental differences between sites.

One possible reason for the observed differences between reference sites and test sites could be the proximity to major towns. Kellys Ck runs through agricultural and farmland, and passes underneath a road, very much like some of the test sites. However, a major difference is it appears to originate from a farm dam and does not take in wide drainage from a major town centre the same way the Wingecarribee River, Gibbergunyah Ck, and Whites Ck do. The same could be said of Sheepwash Ck, which might get some drainage from Colo Vale, but has a good intact riparian zone and native bushland to help buffer the runoff and is not the main passage of drainage out of the town.

Conclusion

All upstream and downstream sites display some level of impact from urban and/or agricultural pollution. Out of all sites, MOS_US and MOS_DS along Whites Ck appear have the lowest aquatic ecosystem health. BOW_US appears to be in slightly better aquatic ecosystem health than BOW_DS most likely due to environmental conditions and site characteristics. MIT_US appears to have the best aquatic ecosystem health of all the test sites and was the most similar to the reference sites. MIT_DS had lower aquatic ecosystem health compared to MIT_US, but this is highly likely due to increased runoff from the Mittagong township entering Gibbergunyah Ck between these two sites and a concrete wall disrupting natural hydrology and causing pooling and sedimentation at MIT_DS. While STP discharges would no doubt contribute to pollution to some degree, differences observed between test sites could not be attributed specifically to STP discharges and are most likely also impacted due to urban/ agricultural runoff from the surrounding townships and natural variation.

10. Key findings summary

- All community indices and biological indices indicate that all sites are at least moderately impacted by urban and agricultural pollution.
- Of all test sites only BOW_US and MIT_US displayed AUSRIVAS OE50 values placing them in Band B (BOW_US on 2 occasions and MIT_US on all occasions). All other test sites were within Band C, indicating a severely impacted system.
- SIGNAL SF scores for all test sites indicated possible mild organic pollution.
- SIGNAL2 bi-plot indicated all sites are under similar levels of agricultural/urban impact with sites distributed in the same quadrat.
- Reference sites appear to be less impacted than the test sites. Proximity and run-off from major townships are the most likely key factors.
- MIT_US was most similar to reference sites.
- 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.

11 References

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Appendix 1 – Macroinvertebrate Raw Data

| Order | Family | MMP203 Autumn 20 m 1 | MMP203 Autumn 20 m 2 | MOS_D Autumn 20 m 1 | MOS_D Autumn 20 m 2 | MOS_U Autumn 20 m 1 | MOS_U Autumn 20 m 2 | BOW_D Autumn 20 m 1 | BOW_D Autumn 20 m 2 | BOW_U Autumn 20 m 1 | BOW_U Autumn 20 m 2 | MIT_DS Autumn 20 m 1 | MIT_DS Autumn 20 m 2 | MIT_US Autumn 20 m 1 | MIT_US Autumn 20 m 2 | MMP87 Autumn 20 m 1 | MMP87 Autumn 20 m 2 | MMP87 Spring 20 m 1 | MMP87 Spring 20 m 2 | MOS_D Spring 20 m 1 | MOS_D Spring 20 m 2 | MOS_U Spring 20 m 1 | MOS_U Spring 20 m 2 | BOW_D Spring 20 m 1 | BOW_D Spring 20 m 2 | BOW_U Spring 20 m 1 | BOW_U Spring 20 m 2 | MMP203 Spring 20 m 1 | MMP203 Spring 20 m 2 | MIT_DS Spring 20 m 1 | MIT_DS Spring 20 m 2 | MIT_US Spring 20 m 1 | MIT_US Spring 20 m 2 | MOS_D Autumn 21 m 1 | MOS_D Autumn 21 m 2 | MOS_U Autumn 21 m 1 | MOS_U Autumn 21 m 2 | BOW_D Autumn 21 m 1 | BOW_D Autumn 21 m 2 | BOW_U Autumn 21 m 1 | BOW_U Autumn 21 m 2 | MIT_DS Autumn 21 m 1 | MIT_DS Autumn 21 m 2 | MIT_US Autumn 21 m 1 | MIT_US Autumn 21 m 2 | MMP203 Autumn 21 m 1 | MMP203 Autumn 21 m 2 | MMP87 Autumn 21 m 1 | MMP87 Autumn 21 m 2 | MOS_D Spring 21 m 1 | MOS_D Spring 21 m 2 | MOS_U Spring 21 m 1 | MOS_U Spring 21 m 2 | BOW_D Spring 21 m 1 | BOW_D Spring 21 m 2 | BOW_U Spring 21 m 1 | BOW_U Spring 21 m 2 | MIT_DS Spring 21 m 1 | MIT_DS Spring 21 m 2 | MIT_US Spring 21 m 1 | MIT_US Spring 21 m 2 | MMP203 Spring 21 m 1 | MMP203 Spring 21 m 2 | MMP87 Spring 21 m 1 | MMP87 Spring 21 m 2 |
|---|---|---

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 G – Detailed Design Report

Sensitivity: General

Moss Vale Sewage Treatment Plant Upgrade

Detailed Design Report

Wingecarribee Council

JUNE 2023

ABN 16 602 201 552



Report Details

Report Title	**Moss Vale** Sewage Treatment Plant Upgrade: **Detailed Design** Report
Project No.	5949
Status	Final
File Location	P:\Wingecarribee Shire Council\5949 Moss Vale STP Updated Detailed Design\2. Tasks\Detailed Design Report\Moss Vale STP Detailed Design Report_Final.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	Michael Collins	Michael Collins	20/05/2020
2	Final	Michael Collins Adrian Ridgley Jason Sandford Daniel Ballinger Brett Thompson	Michael Collins	Michael Collins	3/06/2023

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Executive Summary

Wingecarribee Shire Council (WSC) is planning to upgrade the Moss Vale Sewage Treatment Plant (STP). WSC have engaged Hunter H2O to undertake the detailed design of the Moss Vale STP upgrade and amplification. Hunter H2O have engaged ASpect Process Services (ASpect) to undertake the process design components of the detailed design.

Project Context

Wingecarribee Shire Council (WSC) owns and operates the Moss Vale Sewage Treatment Plant (STP), located in the Southern Highlands of NSW. The STP was last upgraded in 1996 to a nominal design capacity of 9,000 equivalent persons (EP). The urban population of Moss Vale in 2016 was approximately 7,900 EP, with an estimated total STP load (including non-residential loads) as high as 10,200 EP. Therefore the current load on Moss Vale STP is predicted to exceed the design load. This is supported by operational data that suggests that plant is currently overloaded, particular in terms of bioreactor aeration.

Another capacity upgrade driver is the proposed Moss Vale Enterprise Corridor (MVEC). This could result in a significant increase in future loads, predicted to be up to an additional 19,000 EP.

Design Basis Summary

Key design parameters adopted for the detailed designs are summarised below;

Parameter	Unit	Commissioning 2022	Design	Ultimate 2046
Hydraulic Contribution	L/EP/day	230	230	230
Equivalent Persons (EP)		11,053	20,000	35,000
Peak Dry Weather Flow (PDWF): Average Dry Weather Flow (ADWF)		2.0	2.0	2.0
Design Full Treatment Flow (DFTF):ADWF		5.4	3.0	3.0
Design Storm Treatment Flow (DSTF):ADWF		10.9	6.0	6.0
Peak Wet Weather Flow (PWWF):ADWF		23.5	13.0	13.0
Design PWWF L/s	L/s	59.800	59.800	104.650
Inlet Chemical Oxygen Demand (COD)	mg/L		573.9	
Suspended Solids (SS)	mg/L		282.6	
Inlet Total Nitrogen (TN)	mg/L		56.5	
Inlet Total Phosphorus (TP)	mg/L		9.6	
Inlet Alkalinity (Alk) as $CaCO_3$	mg/L		300.0	

Scope of Upgrade Works

WSC wish to amplify and upgrade the Moss Vale STP to meet the following objectives:

- Increase the capacity to at least 20,000 EP at Stage 1.
- Provide contingency for expansion to 34,000 EP, being the projected ultimate population (including MVEC)
- 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;

- A new inlet works sized for 10 ADWF at Ultimate (17 ADWF at Stage 1) including:
  - Sewage flow monitoring

  - Two mechanical band screens (duty/duty), incorporating screen 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. These will all be replaced by larger pumps at Ultimate (duty/assist/standby).
  - Two bypass (solids contact) pumps in duty/assist configuration, each sized for 1.5 ADWF. These will be replaced by larger pumps at ultimate.
- The existing catch/balance ponds are converted to storm ponds, accepting overflow sewage and overflow secondary effluent, consisting of:
  - A new storm splitter box allowing the ponds to store overflow sewage or secondary effluent separately or combined, or to allow the ponds to be bypassed to the effluent pond.
  - New self-priming storm return pumps (duty/assist) each sized for 1.5 ADWF.
  - New rising mains to the screened sewage channel or filter feed control system.
- 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) at Stage 1. This increases to 2.0 ADWF (FSB or MLE mode) each at ultimate. Each of the bioreactors includes the following:
  - Three (3) MLR pumps in duty/assist/assist configuration
- A new bioreactor aeration supply system including:
  - Three blowers in duty/assist/standby configuration at Stage 1, with an additional blower (duty/assist/assist/standby) at ultimate. The Stage 1 blowers are sized to meet ultimate demand, which is slightly higher per blower than Stage 1.
- Two new secondary clarifiers each sized for up to 3 ADWF (FSB mode) or 3.75 ADWF (MLE mode). Provision for a further two clarifiers at ultimate, each sized for 1.5 ADWF.
- Two RAS pumps in duty/standby configuration.
- A new scum pump station sized for ultimate, with a single scum pump (duty only) accepting scum from the two clarifiers (four at ultimate) and delivering it to the aerobic digester or bioreactors (via the lift pump station).
- A new filter feed control system consisting of:
  - A balance tank sized for ultimate.
  - A filter feed control valve and flow element controlling the gravity flow to the filters.
- 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 (a further three at Ultimate).
  - 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 space for a further three banks at Ultimate).
- An upgraded reclaimed effluent (RE) system including:
  - Relocation of the RE lift pump (duty only) to downstream of the new UV system.
  - A new 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). This system will be replaced with a larger system at Ultimate.
  - 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 storm ponds. 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, sized for Ultimate.

    - 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. This is replaced by a larger pump at Ultimate.
- An aerobic digester consisting of one existing IDEA bioreactor (both used in parallel at Ultimate). Each digester (one at Stage 1 and two at Ultimate) consist of the following:
    - New TWAS and scum feed pipes to join the existing feed manifold at one end of the digester.
    - New submerged baffle walls dividing the digester into three cells.
    - Replacement removable aeration diffusers and control valves. The control valves switch aeration between the first cell and the last two cells (in parallel), as well as modulating to control DO.
    - The existing IDEA decanter that can be used for alternative digester thickening if the WAS thickener is out of service.
    - Retention of existing instrumentation plus an additional DO element.
    - 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 last digester cell 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 and a third at Ultimate if required. This includes:
    - A new dewatering feed tank, sized for ultimate, complete with mixer/aerator
    - A polymer make-up, storage, dosing and dilution system. Two dosing pumps in duty/duty configuration (duty/standby initially), with provision for a third at Ultimate.
    - Two dewatering feed pumps in duty/duty configuration (duty/standby initially), with the provision for a third at Ultimate.
    - A polymer dosing point to each feed line.
    - Two screw press dewatering units in duty/duty configuration (duty only initially), with provision for a third at Ultimate. Dewatering can be accommodated with the use of only one unit (two at Ultimate) by extending the dewatering period each week.
    - A duty only, horizontal, biosolids cross-conveyor, designed for Ultimate.
    - A slewing, inclined biosolids conveyor delivering biosolids to a truck trailer (default), designed for Ultimate.
    - 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, sized for Ultimate.
    - Two new foul water pumps (duty/standby). These are replaced by larger pumps at Ultimate.
- An alkalinity storage and dosing system.
- A new alum storage and dosing facility.
- A new chlorine storage and dosing facility.
- A new carbon storage and dosing system (sized for sucrose solution).
- Site provision for future recycled water treatment system.
- Site provision for future tertiary clarifiers for trimming effluent TP if needed at Ultimate.
- Site provision for a moving bed biological reactor for trimming TN if needed at Ultimate.

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	7	10
Ammonia Nitrogen (NHx-N) mg/L	-	2
Total Nitrogen (TN) mg/L	7	10
Total Phosphorus (TP) mg/L	0.5	1.0
Suspended Solids (SS) mg/L	10	15

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.

Cost Estimate

A summary of capital, annual Operating and Maintenance (O&M) and Net Present Value (NPV) is presented below:

Parameter	Value
Capital Cost	$42,382,000
Capital Cost (Including Contingency)	$50,858,000
Average Annual Operating Cost	$1,550,000
Net Present Value	$68,580,000

It is worth noting however that disruptions caused by the COVID-19 pandemic and current global conflicts is impacting project delivery costs, most notably increased supply costs. This is due to increases in shipping costs and availability of vital materials (steel, plastic piping systems etc.). Given this uncertainty, it may be prudent to increase project contingencies / allowances to ensure sufficient budget is available to cater for cost fluctuations.

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 delivery in a number of phases;

1. Phase 1 – Site establishment
2. Phase 2 – Construct new treatment infrastructure
3. Phase 3 – Pre Commission new infrastructure
4. Phase 4 – Cutover to new treatment processes
5. Phase 5 – Decommission redundant assets
6. Phase 6 – Augment retained infrastructure
7. Phase 7 – Finalise earthworks, roads, drainage, landscaping etc.
8. Phase 8 – Demobilisation

It is vital that detailed staging and interface plans are developed and implemented during the construction phase, with sufficient input from SMRC to ensure effective treatment can be maintained at both sites.

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1 Introduction and Background

Wingecarribee Shire Council (WSC) is planning to upgrade the Moss Vale Sewage Treatment Plant (STP). WSC engaged Hunter H_2O to undertake the detailed design summarised in this report. Hunter H_2O have engaged ASpect Process Services (ASpect) to undertake process design components of the detailed design.

1.1 Project Context

WSC owns and operates the Moss Vale STP, located in the Southern Highlands of NSW. The STP was last upgraded in 1996 to a nominal design capacity of 9,000 Equivalent Persons (EP). The urban population of Moss Vale in 2016 was approximately 7,900 EP, with an estimated total STP load (including non-residential loads) as high as 10,200 EP. Therefore the current load is predicted to exceed the design load. This is supported by operational data that suggests that plant is currently overloaded, particular in terms of bioreactor aeration.

Another capacity upgrade driver is the proposed Moss Vale Enterprise Corridor (MVEC). This could result in a significant increase in future loads, predicted to be up to an additional 19,000 EP.

WSC wish to amplify and upgrade the Moss Vale STP to meet the following objectives:

- Increase the capacity to at least 20,000 EP at Stage 1.
- Provide expansion contingency to 34,000 EP – the projected ultimate population (including MVEC)
- To improve performance over time to meet Neutral or Beneficial Effect (NorBE) as published by the Sydney Catchment Authority.

1.1.1 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 screening and grit removal capacity.
- Build a third 6000 EP to 7000 EP IDEA bioreactor complete with anoxic selector.
- Construct an additional catch/balance pond to serve the new IDEA bioreactor.
- Provide additional alum storage.
- Upgrade the UV system.
- Construct additional drying beds or consider mechanical dewatering.

1.1.2 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:

- Increase the sludge age of the existing IDEA bioreactors and re-rate them to 7,200 EP total.
- Build a third 3,500 EP IDEA bioreactor.
- Consider omitting the third catch/balance pond.
- Provide an alum flocculation system between the IDEAs and catch/balance ponds.
- Include a suitable sludge extraction system in the catch/balance ponds.
- Install alkalinity storage and dosing (caustic) to counteract the impact of increased alum dosing.
- Install disc filters, including upstream flocculation for phosphorus trimming.
- Consider replacing the UV system with a break point chlorination and de-chlorination system for enhanced total nitrogen (TN) removal for future NorBE requirements.

1.1.3 2020 Concept Design Report

In 2020, PWA prepared a Concept Design Report (CDR). PWA undertook a more detailed options investigation into the best way to upgrade and amplify the various Moss Vale 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:

- Construct a new 11,300 EP IDEA bioreactor.
- Upgrade one of the existing IDEA bioreactors to provide a capacity of 6,700 EP (total of 18,000 EP).
- Once the capacity is exceeded, upgrade the second existing bioreactor and another new bioreactor to provide a total capacity of 36,000 EP.
- Do not construct additional catch/balance ponds.
- Construct a new disc filtration system including a filter feed pump station and polymer dosing system.
- Upgrade the UV disinfection system.
- Include future break point chlorination for TN removal (NorBE), plus de-chlorination.
- Build the future large IDEA early and use it as an aerobic digester. Replace this with a purpose built aerobic digester once the second large IDEA is required.
- Provide permanent mechanical dewatering facilities near the second large IDEA (aerobic digester). Move this dewatering facility to be near the future aerobic digester once it is constructed.
- Provide a new reclaimed effluent system.

1.2 Scope of Work

In late 2020, WSC called for quotations for the Detailed Design of the Moss Vale STP upgrade. This was intended to be in keeping with the CDR by PWA. The scope of work for the Detailed Design was (broadly):

PHASE 1

- 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.
- Facilitation of a Design Development Workshop.
- Production of a Final Concept Design Report as a preliminary version of the Detailed Design Report (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).

PHASE 2

- 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%).
  - DDR including Safety in Design.

PHASE 3

- Tender documentation.
- Technical Specification
- Assistance with completion of the Review of Environmental Factors (REF)
- Tender schedules.

PHASE 4

- 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 - 3, with subsequent phases to be undertaken on a rates basis as required.

1.3 Revised Option

In 2019, WSC awarded Hunter H2O the detailed design of Bowral STP. This scope of work also included a review of the CDR by PWA. The preferred concept for Bowral STP was similar in treatment style to that proposed for Moss Vale STP. The Design Development Report for Bowral STP was prepared by Hunter H_2O during March to June 2020. This report discussed three secondary treatment options. These were:

- PWA Option & H2O Option – These were similar to the preferred option for Bowral STP outlined in the CDR. They both retained IDEA bioreactor technology, but utilised more advanced bioreactors for nitrogen removal rather than utilising chlorination/dichlorination. Aerobic digestion and mechanical dewatering were also provided. The differences between these two options was not so much in style, but how to best utilise the existing IDEA (retain as an IDEA or use as the aerobic digester).
- 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 for Bowral STP 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.
- It carried 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 provided equal or better wet weather treatment capacity and performance.

Some modifications were made during further design development. 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 advantages of the FSB option are equally (if not more) evident for Moss Vale STP. The future NorBE requirements for Moss Vale STP could be even more stringent than for Bowral STP. This is because the growth in Moss Vale is likely to be significantly greater, such that the need for highly advanced denitrification bioreactors becomes even more paramount. Furthermore, there are considerable operational advantages in delivering consistent process styles and (where possible) process unit sizes at the two plants.

For these reasons, the FSB option was selected for Moss Vale STP. Where possible, the design sizing of Stage 1 at Moss Vale STP is identical to Bowral STP, allowing common spares and bulk purchases.

The FSB option is described in detail in Section 4. A process flow diagram can be found in Appendix B.

2 Existing STP Site Description

The existing Moss Vale STP consists of the following process units and systems:

- An inlet works including mechanical step screening and grit removal.
- Two 4,500 EP (nominal) intermittently decanted extended aeration (IDEA) bioreactors. Each including:
  - Twin feed points, one at each end.
  - A centre decanter with a double sided weir.
  - Diffused aeration and associated blowers.
  - Waste activated sludge (WAS) pumping.
  - No anoxic zones or mixed liquor recycle (MLR) pumps.
- Two decant effluent catch/balance ponds. Alum is dosed into the IDEA decant, creating solids that settle in these ponds. Each can be bypassed for cleaning.
- An alum storage and dosing system for phosphorus precipitation. Alum is also dosed directly to the IDEAs (i.e. as well as the decanted effluent)
- A channel style ultraviolet (UV) disinfection unit sized for faecal coliform inactivation.
- Two sludge lagoons for sludge stabilisation.
- Sludge drying beds 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 effluent/storm pond. This cannot be completely emptied, but provides some storage and return via the catch/balance ponds.



Figure 2-1 Aerial Photograph of Moss Vale STP

3 Design Basis

This section outlines the loadings and performance used as the basis of the detailed design.

3.1 Loadings

A first principles approach was adopted to review loadings adopted by Public Works Advisory (PWA) in their Concept Design Report (CDR). This review is 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.

Estimates of the population, flow records, sewage concentration data and an understanding of the catchment have been used to determine appropriate design loads. Current loads were converted to EP, standard sewage mass contributions (g/EP/d) and hydraulic contributions (L/EP/d), then extrapolated into the future.

3.1.1 Equivalent Persons and Growth

3.1.1.1 Moss Vale Census Data

Moss Vale STP services the township of Moss Vale. There are two 2016 Census areas that cover the urban area of Moss Vale, including;

- Moss Vale Urban Centre and Locality (UCL) – This covers most of the Moss Vale sewerage catchment with the exception of some sparsely populated outlying areas such as parts of SPS-MV15 and SPS-MV12. It also covers some small areas outside the sewerage catchment. Therefore, it should provide a close approximation for the population in the sewered area of Moss Vale.
- Moss Vale State Suburb (SSC) – This covers a significantly greater area than the sewered boundary of Moss Vale, especially to the south and west.

There is no 2016 Census area that exactly reflects the sewered area serviced by Moss Vale STP. The most accurate area is that covered by Moss Vale UCL. This is a close approximation and should provide a realistic estimate for the actual sewered population.

Census data was reviewed for the previous two Census years (2006 and 2011). The Moss Vale UCL area did not change significantly over these years.

Key Census statistics are summarised in Table 3-1.

Table 3-1 Census Data for the Moss Vale Census Area

	2006 Moss Vale UCL	2011 Moss Vale UCL	2016 Moss Vale UCL
People(1)	6,723	7,305	7,865
All Private Dwellings	2,895	3,207	3,465
Occupied Dwellings	89.5%	89.1%	86.1%
Occupied Dwellings	2,590	2,858	2,984
Occupied Occupancy Rate	2.5	2.4	2.4
Overall Occupancy Rate	2.3	2.3	2.3
Average Bedrooms per Dwelling		3.2	3.2
Overall Total Bedrooms		10,262	11,088

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 Moss Vale appears to be growing quite rapidly. The population has grown on average 1.7% per annum over the past 10 years.
- 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 (2.4) is less than the NSW and Australian average (both 2.6). This suggests an older demographic.
- The average bedrooms per household (3.2) is greater than the NSW (3.0) and Australian (3.1) averages. This is despite the low occupancy rate. The total existing bedrooms is close to the 11,000 EP.
- The 2016 Census permanent population is very similar to that predicted in the CDR (7,711), which was based on predicted growth from the 2011 Census.

3.1.1.2 Growth

Simplified growth rates are assumed to be as follows:

- Residential = 1.7% per annum based on census data.
- Non-Residential = 0.25% per annum based on the IWCM.
- MVEC = 1.1 ML/d at connection plus 0.2 ML/d increase per year for 15 years as per the IWCMI.

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 3.1%) until 2031, then slows to lower, steady growth rate (0.7%) from 2031 to 2046. This is similar to the drop-off in growth rate forecast for Bowral STP at the same time.

3.1.1.3 IWCM EP

The CDR adopted the design EP figures of the IWCM. This report had adopted the 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. It was based on predicted and measured flow. The estimates relied heavily on the Infoworks model for the Moss Vale sewerage scheme. This provided a sum of the 'trade flow' in the Moss Vale 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. This was found to be 269 L/EP/d. 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 Moss Vale STP from the IWCMI

Parameter	Moss Vale Values
Estimated 2014 ADWF (kL/d)	2100
Flow from Non Residential Sources (kL/d) - Infoworks	86
Flow from Residential Sources (kL/d)	2014
Hydraulic Contribution (L/EP/d)	269
2014 Non Residential EP	590
2014 Residential EP	7486
2014 Total EP	8076
2014 Total Equivalent Tenements (ET)	3365

There appears to be an error in the calculation. Dividing the non-residential flow (86 kL/d) by the hydraulic contribution (269 L/EP/d) gives a non-residential EP of just 320. Given the opaque method for the derivation of this non-residential EP it is difficult to reconcile these figures. If the Non-Domestic Flow figure in the table is the source of the error, and the non-residential EP is the correct figure, then the figures reconcile better using a hydraulic contribution of 255 L/EP/d. This then provides the following figures:

- 2014 residential EP = 7,645 (reconciles well with interpolated Census data).
- 2014 Non Residential EP = 590
- 2014 Total EP = 8,235

The estimation of non-residential EP is never straightforward. The figures derived in the IWCMI and CDR are based solely on flows. 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. It should be noted, for example, that the IWCMI adopted a hydraulic contribution of 269 L/EP/d to derive the non-residential EP figure. However, the CDR adopted a figure of 240 L/EP/d.

This method also seems to preclude visitor population that stay in private residences (including Air BNB) or use public amenities.

The non-residential EP thus derived is just under 8% of the residential population. This is a fairly low proportion when compared to most catchments. For example, Bowral projections assumed 19%.

The non-residential EP is assumed to grow 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 (1.7%). The residential growth predicted in Table 4.8 of the IWCMI shows a variable residential growth rate over time. The residential growth is around the 1.7% figure up to 2036 (with a spike up to 3.1% between 2021 and 2026). This then falls to 0.7% after 2036. The spike may be due to the proposed Chelsea Gardens sub-division (1500 EP) mentioned in the CDR. The projections reconcile if the Chelsea Gardens growth is spread over 15 years.

3.1.1.4 Corrected EP

In 2019, WSC updated their predictions on non-residential EP. It appears that there was an error in the IWCMI predictions. The estimate for the 2018/2019 period was a non-residential EP of 22%. This aligns very well with the predictions and cross calculations later in this report.

A new set of historical population projections has been derived based on the following assumptions;

- Residential EP of 7865 in 2016 as per the 2016 Census.
- A constant residential growth rate of 1.7% as per the 2006 to 2016 census figures.
- A non-residential load of 22% of the total load based on updated WSC calculations.
- A constant non-residential growth rate of 0.25% as per the IWCMI.

Based on these assumptions, the historical and near future EP figures are as follows.

Table 3-3 Corrected Historical EP Projections

Year	Residential EP (Growth of **1.7%**)	Non-Residential EP (Growth of **0.25%**)	Non-Residential % of Total EP	Total EP
2014	7600	2304	23%	9904
2015	7731	2310	23%	10041
2016	**7865**	2316	23%	10181
2017	7999	2322	22%	10320
2018	8135	2328	22%	10462
2019	8273	2333	**22%**	10606
2020	8414	2339	22%	10753
2021	8557	2345	22%	10902
2022	8702	2351	21%	11053

The corrected total EP in 2014 is 22% greater than that predicted in the IWCMI.

The predicted current (2020) EP is 19% more than the design capacity of the current plant (9000 EP). There is anecdotal evidence (insufficient aeration capacity) that the plant is currently overloaded. This lends further support to these revised loading predictions.

The CDR (Table 2-1) adopted a loading of 8557 EP in 2016, rising to 9744 in 2021. The corrected predictions in Table 3-3 suggest that these are optimistic. The result is that the capacity of the CDR stages could be exceeded well ahead of schedule. For example, if the actual loading is 20% more than previously thought, then stages would exceed capacity 14 years earlier than predicted in the CDR.

3.1.1.5 MVEC EP

The Moss Vale Enterprise Corridor (MVEC) is the major influence on growth in flows and loads to Moss Vale STP. In fact, it represents the vast majority of the projected growth in the catchment. According to the CDR:

"The MVEC is a significant area of land between Moss Vale and New Berrima set aside for an employment generating development under the Wingecarribee Local Environmental Plan 2010. The MVEC is currently zoned for General Industrial with some Heavy Industrial zoned land to the south of New Berrima (Boral Cement Plant) and the eastern perimeter fronting McCourt Road, Moss Vale."

Flows and loads for MVEC were itemised separately in the IWCM and IWCMI. The IWCMI assumed that MVEC would come on line in 2016 at 1.1 ML/d, then grow by 0.2 ML/d every year for the next 15 years. This has not occurred. The EP projections are then assumed to be proportional to flow, with a contribution of around 220 L/EP matching the growth of 0.2 ML/d per year.

The figures for MVEC appear rather speculative, with connection and growth forecasts based on potential rather than approved industrial developments. Since these loads will be industrial, they are unlikely to match domestic sewage characteristics and equating them to EP with a hydraulic contribution is unlikely to reflect actual loads.

According to the IWCMI, loads on Moss Vale STP without MVEC are forecast to reach 12,224 EP by 2046. Extrapolating the corrected EP methodology outlined in Section 3.1.1.4, the predicted 2046 load (without MVEC or Berrima) would be 15,538 EP. The IWCMI projects an MVEC load of over 19,000 EP by 2031. The forecast MVEC load swamps the domestic and non-domestic growth. Given the lack of certainly in MVEC growth, wastewater flow generation and characteristics, it is difficult to plan the staging of Moss Vale STP with any certainty. Staging should therefore be flexible, with the ability to customise the staging and modules to suit MVEC as it actually occurs.

3.1.2 EP Staging

As expressed in the previous sections, the lack of certainly in MVEC commencement date, growth rate and ultimate development makes Moss Vale STP difficult to stage. One set of simplified population growth forecasts, with and without MVEC, is provided in Table 3-4. These forecasts are based on the following:

- A residential EP datum based on the 2016 Census.
- A growth rate of 1.7% based on the steady growth between the 2006 and 2016 Census periods.
- A non-residential datum based on 22% of the total load in 2019.
- A non-residential growth rate of 0.25% based on the IWCMI.
- An MVEC connection date just after commissioning in 2022 / 2023
- An initial MVEC flow of 1.2 ML/d at 220 L/EP/d as per the IWCMI.
- An MVEC growth of 0.2 ML/d per annum at 220 L/EP/d as per the IWCMI.
- MVEC growth ceasing after 15 years as per the IWCMI.
- No transfer of Berrima STP loads.

Table 3-4 Simplified Growth Projections (EP) for Moss Vale STP

Year	Residential	Non-Residential	Total Without MVEC	MVEC	Total With MVEC
2020	8414	2339	10753		10753
2025	9154	2369	11522	8182	19704
2030	9958	2398	12357	12727	25084

Year	Residential	Non-Residential	Total Without MVEC	MVEC	Total With MVEC
2035	10834	2429	13263	17273	30535
2040	11787	2459	14246	19091	33337
2045	12823	2490	15313	19091	34404
2050	13951	2521	16472	19091	35563

One staging approach would be to adopt the staging in the CDR. This was based on an ultimate population of 36,000 EP, delivering half of that (18,000 EP) at Stage 1. Based on the simplified growth assumptions above, this would result in the following events.

- Stage 1 (18,000 EP) would be oversized for 2046 (ultimate) development (around 15,500 EP) if MVEC did not go ahead.
- It would provide sufficient capacity for baseline EP plus initial MVEC loads plus one or two years of MVEC growth. The design life of Stage 1 could be as small as two (2) years meaning that design for Stage 2 would need to commence immediately after commissioning. It would be impossible to characterise the MVEC industrial wastewater characteristics, so Stage 2 may prove difficult to customise.
- The next stage, Stage 2 at 27,000 EP would provide growth to 2032. This is a more sensible staging life, suggesting Stage 1 and 2 should be constructed together. However, if MVEC did not eventuate then the plant would be 1.8 times the ultimate capacity, potentially wasting significant capital.
- The final stage, Stage 3 at 36,000 EP would be slightly oversized for ultimate loads (around 35,000 EP).

Another option would be to ignore MVEC and design for known growth. This would involve constructing one stage at 15,500 EP. Another stage (or a different plant) would then need to be designed and constructed before MVEC could be connected. It is recognised that this would be an impediment to regional jobs growth and is likely unacceptable.

A third staging option could revolve around constructing (near) identical process units to Bowral STP. The capacity of these units would be slightly down-rated to suit the Moss Vale sewage characteristics. The first stage could consist of two modules (i.e. identical to Bowral STP). Individual bioreactors and clarifiers would then be added to suit MVEC growth and wastewater characteristics. This would involve the following events.

- Stage 1 (approximately 20,000 EP) would be oversized for ultimate development (around 15,500 EP) if MVEC does not go ahead. If MVEC does not eventuate then the plant would be 1.3 times the ultimate capacity, wasting less capital than building Stage 1 and 2 above.
- It would provide sufficient capacity for baseline EP, plus initial MVEC loads, plus three to four years of MVEC growth. The design life of Stage 1 would be four (4) years meaning that design would need to commence for Stage 2 after two (2) years if the full potential of MVEC eventuated. This would be sufficient time to adequately determine the growth and wastewater characteristics of the future stage(s).
- Stage 2 could be customised to suit actual MVEC wastewater characteristics. For example, if MVEC wastewater was heavily pre-treated, it may have high flows and low concentrations. This may just require an additional clarifier but no bioreactor. If the wastewater was high strength, but low flow then an additional bioreactor may be all that is required.
- The worst case for Stage 3 (35,000 EP) could be satisfied with three bioreactors and four clarifiers (one less bioreactor than the 9,000 EP modules in the CDR).

In short, if MVEC is unlikely to go ahead, or if it is delayed for (say) a decade, then it may be sensible to construct a Stage 1 with 15,500 EP capacity. If MVEC is likely to go ahead any time in the next decade, then it makes more sense to construct a Stage 1 with around 20,000 EP. A Stage 1 Capacity of 18,000 EP provides very little Stage 1 design life and does not allow Stage 2 to be customised to actual MVEC wastewater characteristics. The exception would be if the starting load and growth rate of MVEC is much less than the figures adopted in the IWCMI.

Other advantages of providing a Stage 1 capacity of around 20,000 EP (the same modules as Bowral STP);

- It provides even greater operator familiarity between plants.
- Many of the equipment items (dewatering units, blowers, Ultraviolet (UV) units, clarifier scrapers, etc) could be common between plants, providing greater redundancy and spares or reducing the number of spares in store.

- Construction costs could be reduced if a single contract is let. Savings may be possible due to the bulk purchase of identical equipment items, some re-use of concrete formwork, similar power supply and cabinetry requirements, etc.

Based on discussions with WSC, the 20,000 EP approach has been adopted.

3.1.3 EP Mass Contributions

WSC provided one set of data based on sewage sampling and analysis. This was for the following period:

- January 2017 – This set consisted of four result per day from the 24th January to the 26th January 2017. Each sample appears to be a composite taken over identical time periods each day. The time periods vary within each day suggesting that there was an attempt to make them flow paced (for example, more frequent and shorter duration sampling during the morning peak). These days lead up to the Australia Day public holiday (which fell on a Thursday). WSC do not believe that this should make the results non-representative as Moss Vale is not particularly impacted by holiday visitors.

The CDR reports the calculated results for a second 72 hour sewage data set for some time in 2009. This data was not available at the time of writing this report.

WSC also provided sewage results for the period from 24th September 2018 to 4th October 2018. Unfortunately, this data set did not contain any COD results. The SS results were also extremely low but variable. One result was typical (280 mg/L), one was very high (670 mg/L) and the remaining five were very low (60 to 86 mg/L). These results appear to be erroneous and this data set was ignored.

The results within each day were averaged. The flows for these days were as measured by the Inflow element at Moss Vale STP on those days (imported from supplied operational spreadsheets). These were used to convert the measured average concentrations to mass loads (kg/d) for each day. The average of the daily loads was then used to determine the typical mass load for the period.

The estimates in Table 3-3 for EP were then used to determine the mass contributions of each component as presented in Table 3-5.

Table 3-5 Measured Sewage Contributions

	January 2017
Equivalent Persons (EP)	10320
Hydraulic Contribution L/EP/d	191
Suspended Solids (SS) g/EP/d	71.3
Chemical Oxygen Demand (COD) g/EP/d	133.9
Biochemical Oxygen Demand (BOD) g/EP/d	46.1
Total Nitrogen (TN) g/EP/d	12.4
Total Phosphorus (TP) g/EP/d	1.9

The results for January 2017 look internally consistent. The exception is BOD, which appears very low (e.g. a COD:BOD ratio of 2.9 compared to typical figures of 2.2 to 2.4). WSC suggest that this could be due to BOD inhibitors being discharged from a research laboratory (Australian Bio-Resources) located in the catchment. As BOD is not used for design, this is of no consequence and can be ignored.

With the exception of BOD, the contributions are very similar to typical design contributions and those adopted at Bowral STP. They are all fractionally high, but this could be due to a few extra, local visitor numbers or experimental error due to the small sample base.

Table 3-6 Measured Contributions versus Design Contributions

Contribution	CDR Design Contributions	Measured Contributions (2017 only)	Bowral Adopted Design Contributions	Moss Vale Adopted Design Contributions
Hydraulic Contribution L/EP/d	240	191	220	230
Suspended Solids (SS) g/EP/d	60	71	60	65
Chemical Oxygen Demand (COD) g/EP/d(1)	132	134	132	132
Biochemical Oxygen Demand (BOD) g/EP/d(2)	60	46	60	60
Total Nitrogen (TN) g/EP/d	15	12.4	13.0	13.0
Total Phosphorus (TP) g/EP/d	2.5	1.9	2.2	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;

- The SS appears greater than that assumed in the CDR and assumed at Bowral STP. This is consistent with a higher, measured, non-volatile suspended solids component. The SS contribution has therefore been raised from that in the CDR and Bowral STP.
- The TP contribution in the CDR appears 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 has been adopted. This is still conservative when compared to the measured value.
- There appears no justification for increasing the TN contribution to 15 g/EP/d as proposed in the CDR. This is well above typical values for Australian sewage (12 to 14 g/EP/d).
- The TN performance predictions from process modelling are extremely sensitive to the COD:TN ratio of the sewage. Some safety margin has been added to the measured TN contribution. A TN contribution of 13 g/EP/d has been adopted to add conservatism to aeration design, carbon dosing and performance predictions.
- The adopted contributions are the same as those adopted for Bowral STP, with the exception of flow (230 L/EP/d see below - compared to 220 L/EP/d) and SS (65 g/EP/d compared to 60 g/EP/d). This will have a conservative impact on the EP rating of Moss Vale STP when compared to Bowral STP.

3.1.4 Hydraulic Contribution

WSC provided daily flow data stretching back as far as 2014. The data was in multiple spreadsheets and there were periods where data was missing. The ADWF has not been constant over the period. The data was collected using both Inflow and Outflow flow elements. The operators report that the Outflow flow element suffers from calibration problems, so the Inflow flow element was used where possible.

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. The average of the remaining days was (as is usually the case) 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 (1.7% for residential and 0.25% for non-residential) resulting in the values of Table 3-7

It is worth noting that the ADWF figures in Table 3-7 are the numbers as measured and recorded. WSC have confirmed that these flows do not contain recycle flows so they should be accurate (within the inherent errors of the flow elements).

Table 3-7 ADWF and Hydraulic Contributions over Time

Time Period	Measured ADWF (kL/d)	Estimated EP	Hydraulic Contribution (L/EP/d)
May 2014 to April 2015[1][2]	2605	10041	259
May 2015 to April 2016	2573	10181	224
May 2016 to April 2017[3]	2627	10320	271
May 2017 to April 2018[2]	1789	10462	171
July 2018 to June 2019	2171	10606	182
July 2019 to June 2020	2297	10753	212
Average			220

Note (1): The 2014/2015 figures did not include rainfall, and some periods of no flow were recorded (edited out).

Note (2): The Inflow flow element was not available for this period, so the Outflow flow readings were adopted.

Note (3): The flow element was not working for periods during 2016/2017

It is apparent that 2017/2018 and 2018/2019 had considerably less flow than the other years. This may be a result of drought 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, and influenced by long term rainfall patterns.

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 average of the hydraulic contributions over this period was 220 L/EP/d. The analysis above suggests that the CDR design figure of 240 L/EP/d may be conservative. As shown in Section 3.1.5.1, there is considerable conservatism built into the flow peaking factors. It would therefore be unnecessarily costly to build significant conservatism into the hydraulic contribution as well. As with Bowral STP, a small safety factor of 10 L/EP/d has been applied to the average of the measured values. This increases the design contribution to 230 L/EP/d compared to the Bowral STP design figure of 220 L/EP/d.

The slight changes between the Bowral STP and Moss Vale STP EP contributions will result in the same facilities having different EP ratings.

3.1.5 Flow Peaking Factors

3.1.5.1 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 two influent flow data sets that contained flows for each five minute period. The data sets were:

- From 8:26 am on 27/01/2020 to 8:26 am on 30/01/2020.
- From 5:21 am on 09/03/2020 to 8:21 am on 12/03/2020.

Each data set contained two complete days from midnight to midnight (total of four). The graphs for the four complete days are shown in Figure 3-1.

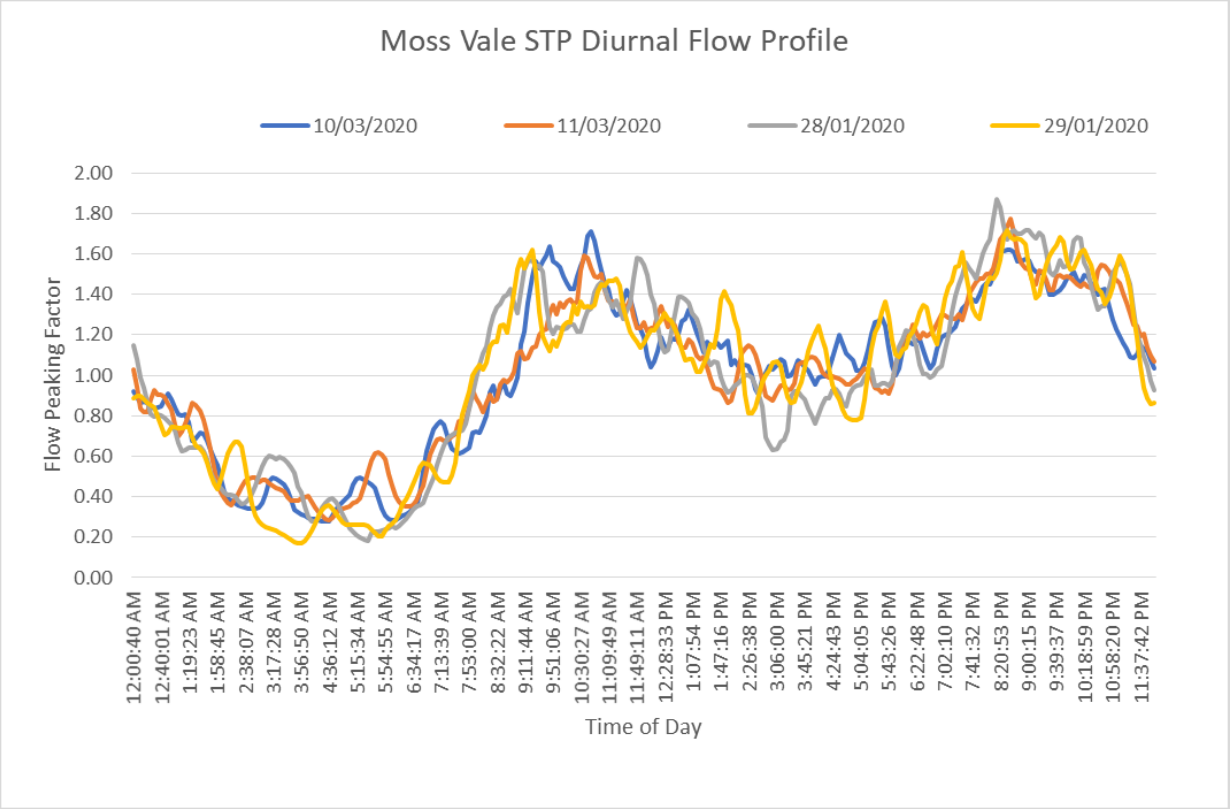


Figure 3-1 – Moss Vale STP Diurnal Flow Profile

These days show both the variability and consistency of trends. The raw data was converted to flow peaking factor by dividing a rolling average (30 minutes) by the daily average for each day. The influence of fixed speed sewage pumping in the catchment 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 1.75 ADWF. Interestingly, the evening peak appears slightly larger than the morning peak.

From this analysis a PDWF of 1.75 ADWF appears appropriate as the PDWF peaking factor. However, the design adopts a peaking factor of 2 ADWF as this is the typical minimum for design purposes. It also provides additional DFTF conservatism to accommodate wetter years (see Section 3.1.5.2).

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 as it helps guide turndown requirements.

3.1.5.2 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 Moss Vale STP, this is 3.0 times ADWF. The CDR adopted a DFTF of 3.0 ADWF and has been adopted for the design.

It should be noted that the actual PDWF appears to be around 1.75 ADWF. The DFTF could be 1.5 times this (2.6 ADWF). However, the regulator is unlikely to accept a DFTF below 3.0 ADWF. A DFTF of 3.0 ADWF at 230 L/EP/d is equivalent to a DFTF of 2.6 ADWF at 262 L/EP/d. Therefore, this sizing criteria should be more than adequate to cover all but the wettest year in Table 3-7. The hydraulic design is conservative.

3.1.5.3 Design Storm Treatment Flow

The Design Storm Treatment Flow (DSTF) is the maximum flow that can receive partial treatment. In the case of Moss Vale STP, this will be the maximum flow that can pass through the secondary clarifiers (in a solids

contact mode). 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 allows 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. It also simplifies treatment plant hydraulics.

The DSTF has virtually no impact on the sizing of continuous flow bioreactors that incorporate pre-clarifier solids contact for partial treatment. The solids contact system leads to only a marginal increase in clarifier diameter. The mixed liquor and effluent pipes have been appropriately increased in size.

3.1.5.4 Peak Wet Weather Flow

The Peak Wet Weather Flow (PWWF) is the highest sustained (i.e. within a day) that can arrive at the STP. It is typically used as the design basis for the inlet works. The CDR selected a PWWF of 10 times ADWF. This is a reasonably typical design figure.

The highest daily flow recorded since July 2014 was 25.138 ML/d on 26th August 2015. This was an Inflow flow element reading. This represented 9.8 ADWF when compared to the ADWF for the same year (which was a high flow year with a flow loading of 304 L/EP/d). This flow represents just over 11 ADWF when compared to the measured 2019/2020 ADWF. The peak sustained flow during that day may have been greater.

WSC suggested a PWWF of 13 ADWF for Bowral STP. As some components (i.e. inlet works) are being design for ultimate flows, adopting the same conservative figure for Moss Vale may result in significantly oversized infrastructure. Given that the Moss Vale catchment will need to expand (and therefore include a large proportion of new reticulation infrastructure) it seems prudent to adopt a lower PWWF of 10 ADWF as suggested in the CDR.

3.1.5.5 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 any gravity mains. The PIF dictates the sizing of bypass conduits and weirs and can impact on the hydraulic design of the inlet works.

The Moss Vale sewerage scheme contains a large gravity network plus a series of pumping stations. The fringes of Moss Vale are serviced by SPSs and rising mains. The centre of Moss Vale (and the majority of the sewered properties) are serviced by gravity mains. The sum total of all the SPS pumps in the system is 279 L/s (IWCMI). All pumps operating concurrently all day results in a flow of 24 ML/d (10.5 times current ADWF). Adding gravity flow to this could result in a PIF above 10 ADWF. However given that the inlet works has been sized for ultimate flows (I.e. Stage 4) exceeding 10 ADWF, only becomes an issue if all MVEV growth eventuates and the industrial connections have hydraulic contributions similar to or exceeding domestic values.

The PIF was not provided in the CDR. It appears that PWA assumed that the PIF was equal to the PWWF of 10 ADWF. Given that WSC wish for all inflows to be mechanically screened, the most appropriate PIF figure is 10 ADWF

3.1.6 Design Flow Summary

A summary of the design flows for each loading scenario can be found in Table 3-8.

It should be noted that the EP rating of the ultimate facilities assume that the MVEC wastewater is identical to domestic sewage. This is unlikely to be the case. The eventual capacity will depend on what constitutes an MVEC EP. However, the flexible staging option proposed will cater for whatever that may be.

The commissioning load is likely to be more than 50% of the first stage design load. This load should be more than adequate for commissioning and ongoing operations provided there is sufficient turndown. The only effluent parameter that should be adversely impacted by under-loading would be TN. This can be mitigated by operating at a higher sludge age, a lower DO set point and perhaps a small increase in carbon dosing.

Table 3-8 Design Flows for Moss Vale STP

	Commissioning 2022	Design	Ultimate 2046
Hydraulic Contribution L/EP/d	230	230	230
EP(1)	11053	20000	35000
PIF:ADWF	23.5	13.0	10.0
PWWF:ADWF	23.5	13.0	10.0
DSTF:ADWF	10.9	6.0	6.0
DFTF:ADWF	5.4	3.0	3.0
PDWF:ADWF	2.0	2.0	2.0
ADWF:ADWF	1.0	1.0	1.0
MDWF:ADWF	0.3	0.3	0.3
PIF ML/d	59.800	59.800	80.050
PWWF ML/d	59.800	59.800	80.050
DSTF ML/d	27.600	27.600	48.300
DFTF ML/d	13.800	13.800	24.150
PDWF ML/d	5.084	9.200	16.100
ADWF ML/d	2.542	4.600	8.050
MDWF ML/d	0.763	1.380	2.415

3.1.7 Sewage Characteristics

3.1.7.1 Sewage Concentrations

The sewage concentrations can be determined by combining the design hydraulic and mass contributions. These concentrations are summarised in Table 3-9.

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 sewage data set (72 hour sampling run) was as follows:

- January 2017 316 mg/L

This 2017 figure is moderately high for sewage. The CDR estimated a figure of 300 mg/L. The CDR figure has been adopted as a conservative approach.

Table 3-9 Sewage Concentrations for Moss Vale STP

Sewage Characteristic	Moss Vale STP
Chemical Oxygen Demand (COD) mg/L	573.9
Suspended Solids (SS) mg/L	282.6
Total Nitrogen (TN) mg/L	56.5
Total Phosphorus (TP) mg/L	9.6
Alkalinity (Alk) mg/L	300.0

3.1.7.2 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 can't.

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. Based on this small data set, the following ratios were calculated:

- NH_x-N:TN = 0.742 compared to a default of 0.667
- VSS:SS = 0.916 compared to a default of 0.900
- SCOD:COD = 0.262 compared to a default of 0.224.

The limited measured values are not significantly different to defaults values and therefore the defaults have been adopted.

Table 3-10 Sewage Fractions for Moss Vale 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}	0.900
Non-Biodegradable Volatile SS: Volatile SS	NBVSS:VSS	f_{vu}	0.318
Particulate COD: Volatile SS	PCOD:VSS	f_{cv}	1.750
Particulate Biodegradable COD: Biodegradable Volatile SS	PBCOD:BVSS	f_{cvb}	1.904
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}	0.253
Soluble Non-Biodegradable TKN: TKN	SNTKN:TKN	f_{nus}	0.020

Sewage Characteristic	Abbreviation	Also Known As	Ratio
Ammonia Nitrogen: TKN	NH_x-N:TKN	f_{na}	0.667
Soluble Biodegradable Organic Nitrogen: TKN	SBOrg-N:TKN	f_{nbs}	0.043

A tabulated and graphical summary of all sewage characteristics and fractions for the Base EP case can be found in Appendix A.

3.1.8 Other Wastewater Loads

There is no septage disposal or other tankered waste disposal at Moss Vale STP. WSC have stated that there are no plans to tanker such wastes to Moss Vale STP in the future. Therefore there are no loads other than sewage assumed in the design.

3.2 Performance

3.2.1 Effluent Quality Performance

3.2.1.1 Current EPA Licence Limits

The current NSW Environment Protection Authority (EPA) licence for Moss Vale STP are summarised in Table 3-11. 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 3-11 Current EPA Licence Limits

Effluent Quality Parameter	50%ile Limit	90%ile Limit
Biochemical Oxygen Demand (BOD) mg/L	7	10
Ammonia Nitrogen (NH_x-N) mg/L	-	2
Total Nitrogen (TN) mg/L	7	10
Total Phosphorus (TP) mg/L	0.5	1.0
Suspended Solids (SS) mg/L	10	15

The following points are notable.

- None of these limits are particularly onerous for an activated STP with 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 (0.1 mg/L as a 50%ile).
- The equivalent NH_x-N 50%ile target would be around 0.5 mg/L.
- These limits do not require filters.

3.2.1.2 Recent Performance

WSC provided data files that contained recent effluent quality data. These were:

- Moss Vale Process Data Sheet 2019-20 – Data from July 2019 to June 2000. Samples were taken roughly four times per week and analysed on site using test kits. This contains results for PO_x-P (labelled as TP), NH_x-N, Nitrate Nitrogen (NO_3-N), Alkalinity and pH.
- Moss Vale Annual Return 2019-20 – Data from May 2019 to April 2020. Samples were taken at fortnightly intervals and analysed by external laboratories for BOD, SS, TN, TP and Oil and Grease (O&G).

The statistics of this data is summarised in Table 3-12.

Table 3-12 Recent Effluent Quality Performance

Effluent Quality Parameter	50%ile	90%ile
Biochemical Oxygen Demand (BOD) mg/L	< 2	3
Ammonia Nitrogen (NH_x-N) mg/L	0.8	1.9
Ammonia Nitrogen (NH_x-N) mg/L(1)	0.8	2.4
Total Nitrogen (TN) mg/L	5.0	8.6
Total Phosphorus (TP) mg/L	0.2	0.6
Suspended Solids (SS) mg/L	4.5	17.0
Oil and Grease (O&G) mg/L	0	0
Faecal Coliforms (F-Coli) CFU/100 mL	31.5	206.0
Orthophosphate (PO_x-P) (1)	0.2	0.6
Nitrate Nitrogen (NO_3-N) (1)	1.9	3.6
Alkalinity(1)	120	170

Note (1): These were based on internal monitoring which is not used to test licence compliance.

The following points are worth noting.

- The internal and external NH_x-N results suggest a relatively high 90%ile. This is likely due to a lack of aeration capacity and the inherent sub-optimal nitrification performance of IDEA style bioreactors.
- The internal and external 50%ile NH_x-N results are also very high. Once again, this is likely due to a lack of aeration capacity. The NO_3-N results are subsequently very low. If the nitrification shortfall was resolved then the denitrification performance would likely be adversely effected. It would be more difficult to sustain the current TN performance once the nitrification shortfall is rectified. In short, the effluent TN performance may be artificially low.
- The 90%ile SS performance is relatively high. However, the SS performance is typically good.
- The internal POx-P results match the external TP results. As discussed in Section 3.2.1.3.1, the external TP results appear to be inexplicably low.

3.2.1.3 Possible Future NorBE Targets

WSC is currently in negotiation with the EPA over the licence limits for the future Moss Vale STP. The future licence limits are not yet known.

The CDR contains a possible set of future 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, concentration targets may decrease. The possible NorBE criteria for Moss Vale STP were outlined in the Brief and the CDR (Table 2-6). These have been repeated here, adjusted for changes in EP projections and with other relevant milestones added.

Table 3-13 Possible NorBE Effluent Goals

Effluent Quality Parameter	2007 (Benchmark)	Commissioning	Ultimate (no MVEC)	First Stage	Ultimate (with MVEC)
Load (EP)	8,906	11,053	15,538	20,000	35,000
BOD mg/L	2.2	1.8	1.3	1.0	0.6
SS mg/L	4.1	3.3	2.4	1.8	1.0
TN mg/L	7.4	6.0	4.2	3.3	1.9
TP mg/L	0.18	0.15	0.10	0.08	0.05

The BOD limits are irrelevant as the detection limit for the BOD test is 2 mg/L.

The SS limits require filtration. The supplier suggests the performance limit of disk filters is 3 mg/L, though 2 mg/L may be attained on occasions. Therefore they are unlikely to be suitable for Moss Vale STP in the medium term (by the end of the life of the proposed first stage). It seems false economy to install anything short of deep bed filters. These should achieve 2 mg/L, or as low as 1 mg/L if combined with flocculation.

The limits with the greatest impact on design and risk are TP and TN. These are covered in detail below.

3.2.1.3.1 Future TP Limits

There are two mechanisms for chemical TP removal:

- Precipitation of orthophosphate (PO_x-P) through chemical dosing (e.g. alum). As the target PO_x-P decreases, the molar rate of the required 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 tertiary clarifiers (clariflocculators). This mechanism focuses on reducing effluent solids (that inherently contain phosphorus) to reduce the overall effluent phosphorus concentration.

Phosphorus content in system 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) 0.2 mg/L, the following SS limits must be achieved to meet the current TP limits:

- A 50%ile TP limit of 0.5 mg/L requires a 50%ile SS of 6 mg/L.
- A 90%ile TP limit of 1.0 mg/L requires a 90%ile SS of 16 mg/L.

This is similar to the current Moss Vale STP performance (see Table 3-12). 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 may be incomplete digestion of the precipitated TP in the samples at the laboratory. It would be risky to conclude that there is any room for tightening the TP targets without providing additional treatment in the form of additional dosing points and better SS removal (e.g. 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 limits as low as 0.04 mg/L TP once the STP reached the ultimate design load of 36,000 EP. The figures in Table 3-13 correct this to 0.05 mg/L at 2046. This is unlikely to be achievable using filtration alone. Clariflocculation and filtration may be required in the future. At 20,000 EP, the figure is 0.08 TP. This may be achievable using deep bed filtration and adequate chemical dosing and flocculation. It appears risky to install disk filters and these are unlikely to have an adequate performance life and could rapidly become sunken assets. For this reason, deep bed tertiary filtration with flocculation is suggested as the minimal post treatment step for Moss Vale STP. Site provision should be retained for clariflocculation before the filters if ever required in the future.

In summary, the 50%ile TP targets 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 approach).
- < 0.05 mg/L – The above plus clariflocculation prior to filtration.

3.2.1.3.2 Future TN Limits

The TN limits impact on the biological reactor 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).
- Continuous flow oxidation ditch or carousel.
- Membrane biological reactor (MBR).

Recent Moss Vale STP performance is a TN of 5.0/8.6 (50%ile/90%ile). However, this is at the cost of high ammonia. Nitrification should be complete (0.1/0.5 mg/L) in a well-designed and well sized activated sludge bioreactor to ensure operational stability. This would likely drive up the effluent TN. In short, the current TN performance suggests a plant under stress (ammonia) and TN may increase once that stress in relieved.

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 processes. 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 onerous to 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 forecasts (see Table 3-13) suggest that an MLE process may be sufficient at commissioning. In fact, an MLE plus carbon dosing may be sufficient (with some risk) if MVEC loads never eventuate. However, if MVEC loads do eventuate, even at a fraction of the forecast ultimate EP, then an MLE will be inadequate, and a FSB bioreactor will be required.

The Brief and CDR forecast the possibility of NorBE limits as low as 1.7 mg/L TN once the STP reaches the ultimate design load of 36,000 EP. The figures in Table 3-13 correct this to 1.9 mg/L at 2046. This may be beyond the capability of even a FSB bioreactor (heavily dependent on unbiodegradable nitrogen fractions of the incoming sewage). This could be offset by increased off-site recycled water (not part of the current design). The treatment units and cost required to meet off site recycled water would depend on the recycled water application. Restricted public access would likely require the upgrade or addition of the following process units:

- A higher UV dose by adding to the discharge UV units or adding higher dose units to the recycled water side-stream, and
- Chlorination (including a chlorine contact tank) on the recycled water side-stream.
- Some degree of buffer storage on site and/or at the recycled water destination.
- A pressure pumping system.
- Recycled water reticulation mains.

These are all relatively common processes for recycled water systems. They are becoming more common as water shortages demand more holistic catchment solutions. This may be the long term strategy for Moss Vale STP if the 50%ile TN target falls below 3 mg/L.

Other alternatives that may be required in the long term involve post denitrification bioreactors. These include technologies involving suspended, fixed film or integrated (both) bioreactors, coupled with carbon dosing. These technologies are uncommon in Australia and have proven to be operationally complex. Fortunately, this step should not be needed in the short or even medium term. Nevertheless, retaining site provision for future installations would be prudent.

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. If TN targets continue to tighten, then this can be coupled with recycled water (to reduce the discharge flow and raise the TN limit) or post denitrification bioreactors. Site provision should be retained for both.

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 – IDEA, MLE or MBR bioreactors.
- 5 to 7 mg/L – The above plus carbon dosing.
- 3 to 5 mg/L – FSB bioreactors with carbon dosing (design approach).
- < 3.0 mg/L – The above plus post denitrification bioreactors with a second point of carbon dosing.

3.2.2 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 Moss Vale 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 the appropriate treatment and management practices required. 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 designed STP processes, and relatively low cost add-on processes are summarised in Table 3-14. It should be noted that the LRVs for filtration assume that flocculation (alum dosing to filters) is employed. Claiming LRVs for these processes also requires elements and alarms in addition to those proposed.

Table 3-14 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 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 3-15.

Table 3-15 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) would 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. This would permit municipal irrigation without any additional treatment processes at the STP.

If the recycled water is to be applied to pastures grazed by livestock then additional helminth control (25 day retention pond) may also be required. This may not be necessary if it can be proven that livestock helminths cannot enter the sewerage network.

3.2.3 Biosolids Performance

3.2.3.1 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 Moss Vale STP through sludge lagoons. The CDR suggested a change to aerobic digestion and has been adopted as part of the design as it removes the major cause of 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 needs to be met, for completeness theoretically compliance against each criteria has been assessed.

3.2.3.2 Biosolids Dewatering

The biosolids dewatering concept in the CDR consists of utilising screw press technology for dewatering. This is the same technology that WSC have selected for Bowral STP.

The criteria adopted in the CDR is for dewatering 5 days per week, 12 hours per day (60 hours per week). There is no commentary on this criteria. There appears to be shortfalls with this approach, namely:

- Any problems with dewatering generally occur during start-up and shut-down. Having five start-ups and five shut-downs per week increases risks.

- Unsupervised operation is acceptable with screw press technology, so extending the period from 7 to 12 hours per day is a good way of decreasing the dewatering facility size. However, it means that start-up or shut-down must occur during an unmanned period. This activity occurs five times per week.
- There is no stated allowance for public holiday periods.

WSC are 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 at Moss Vale STP (as per the Bowral STP).

- Start 10 am Mondays
- Stop 2 pm Fridays
- Normal operating period = 100 hours per week (4 days and 4 hours)
- Longest operating pause = 68 hours per week (2 days and 20 hours)

The long operating pause time can be used to catch up on dewatering if ever required. It will also allow for maintenance to be undertaken.

Other criteria are:

- A biosolids solids content of 18% or better (as per the CDR).
- A solids recovery of > 90%
- A polymer use of < 10 kg/DST (dry solids tonne)

3.2.4 Reactor Temperatures

The reactor temperature range, particularly the winter temperature, is critical to process design. The temperature of the Moss Vale STP bioreactors has not historically been measured.

WSC conducted bioreactor temperature testing at Moss Vale STP as the process design was progressing. This consisted of temperature readings every hour from the 13th May 2020 until the 8th 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 ^{o}C.
- Minimum 7 day average = 11.2 ^{o}C.
- Minimum 14 day average = 11.8 ^{o}C.
- Minimum 21 day average = 11.6 ^{o}C.

By way of comparison, Cooma STP has a minimum temperature of around 11 ^{o}C and Orange STP around 12 ^{o}C. These cities are subjected to periodic snowfalls. Western Sydney STPs typically have a minimum temperature of 13 ^{o}C, Sydney coastal plants 15 ^{o}C and South Coast plants 14 ^{o}C.A minimum temperature of 12 ^{o}C has been adopted. This provides greater nitrification conservatism that that proposed in the CDR. If the temperature falls to 12 ^{o}C, 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 ^{o}C allows a hydraulic 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.

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 ^{o}C assumption appears valid. It should be noted that some scientific papers suggests that the default nitrification kinetics in the literature may include some conservatism. Therefore the selection of 12 ^{o}C as the basis for sludge age calculations may already include conservatism. Selecting a temperature of 11 ^{o}C would increase the bioreactor size markedly would likely be overly conservative.

The annual average and maximum summer temperature have been estimated based on experience as follows;

- Minimum Sustained Temperature (>2 weeks) = 12 ^{o}C.
- Annual average Temperature = 20 ^{o}C.
- Maximum Summer Temperature = 28 ^{o}C.

3.2.5 Odours

The following high odour generation process units will be decommissioned.

- Sludge lagoons.
- Sludge drying beds.

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. The new STP at Moss Vale will generate less odours than the current STP.

The Draft REF suggests that 'odour modelling / monitoring is to be undertaken during the detailed design or post construction phase to verify achievement of 2 Odour Units (OU) at the boundary of the nearest residence. To this effect provision has been made for a future odour control system treating foul air from the inlet works as per the Bowral STP detailed design. The site layout has also been configured to maximise the distance of plant infrastructure from sensitive receptors as far as practicable.

3.2.6 Noise

The technology solutions incorporated into the design 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, buildings, the plant layout and screening.

It should be noted that the STP licence makes no reference to noise generated from site.

3.3 Manning, Response and Redundancy

The Moss Vale STP operator is 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 is set in the control system (at least three levels) with the most critical alarms resulting in remote notifications (e.g. text messages). Remote control is also 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) does not need to have an 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. Critical equipment items (those that must operate within 4 hours to sustain performance) include installed standby.

3.4 Sustainability

The new STP will be 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.

Energy

- 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.

3.5 Capacity Staging

As previously discussed, there are likely construction and operational gains to constructing identically sized bioreactor and clarifier modules as those designed for the 21,000 EP Bowral STP. However, the rating is different at Moss Vale STP due to the larger hydraulic contribution and greater load of inert solids.

Continuous flow bioreactors allow a greater granularity in staging. This is because there can be a different number of bioreactors and clarifiers. This decoupling also allows staging to be better tailored to actual loads. This is especially valuable for Moss Vale STP due to the unknown characteristics of the future MVEC wastewater. For example, if the MVEC wastewater proves to be weak (higher hydraulic contribution than mass contribution) then more clarifiers can be constructed. More bioreactors can be constructed if the wastewater is strong or high in inert solids.

Table 3-16 estimates the capacity of Moss Vale STP with various numbers of bioreactors and clarifiers. This was based on the Bowral STP detailed process model with sewage characteristics adjusted to match those adopted for Moss Vale STP. The limiting condition is MLE mode (DSTF of 7.5 ADWF). Slightly more capacity is available in FSB mode (DSTF of 6.0 ADWF).

Table 3-16 Predicted Capacity of Various Bioreactor and Clarifier Combinations

	2 Clarifiers	3 Clarifiers	4 Clarifiers
2 Bioreactors	20,000 EP	24,000 EP	26,000 EP
3 Bioreactors	25,000 EP	30,000 EP	34,000 EP
4 Bioreactors	30,000 EP	37,000 EP	42,000 EP

As discussed in detail in Section 1.1, a sensible first stage would be two bioreactors and two clarifiers, providing a capacity of roughly 20,000 EP. This would allow for the connection of MVEC at any time in the next decade, plus three to four years of projected MVEC growth. This time could be spent analysing MVEC flows and wastewater characteristics in detail, projecting MVEC growth, designing the next stage and constructing it.

The ultimate capacity in the CDR is 36,000 EP. This aligns with three clarifiers and four bioreactors. However, this is a rather arbitrary number. Analysis in this report suggests that approximately 35,000 EP (2046) could be more realistic. Therefore the more likely ultimate STP would be three bioreactors and four clarifiers, operating in FSB mode. This would save significant capital as bioreactors are far more costly to construct than clarifiers.

For this reason, the design assumes an ultimate stage of three bioreactor and four clarifiers. Splitters and connections have been designed accordingly so that future units can be easily constructed and connected. Allowance has been made for additional filtration, aerobic digestion and dewatering capacity to 34,000 EP.

Staging also considers future performance improvements that may be necessary. These include:

- Carbon dosing to the bioreactors (may be necessary at the initial stage).
- Off-site recycled water treatment and delivery.
- Tertiary clarifiers for improved TP performance.
- Post denitrification bioreactors for TN performance.

The off-site recycled water system, tertiary clarifiers and post denitrification bioreactors have not been sized, however the layout considers there installation. The design allows new assets to be delivered with minimal impact on the operating plant (i.e. minimises non-compliance risks).

4 Process Configuration and Modelling

The FSB concept taken to detailed design consists of the following.

- A new inlet works consisting of:
  - Sewage flow monitoring.
  - Two mechanical band screens (duty/duty) each sized for 10 ADWF at Ultimate (17 ADWF at Stage 1).
  - A bypass channel fitted with a manual screen sized for 10 ADWF at Ultimate.
  - Appropriate screen washing and dewatering.
  - Screened sewage flow monitoring.
  - An overflow to the storm ponds (existing catch/balance ponds) for flows above 7.5 ADWF at Stage 1 and 6.0 ADWF at Ultimate.
  - A single vortex style grit chamber sized for 6.0 ADWF at Ultimate.
  - 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 sized for Ultimate.
  - 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. These will all be replaced by larger pumps at Ultimate (duty/assist/standby).
  - Two bypass (solids contact) pumps in duty/assist configuration, each sized for 1.5 ADWF. These will be replaced by larger pumps at ultimate.
- The existing catch/balance ponds are converted to storm ponds, accepting overflow sewage and overflow secondary effluent, consisting of:
  - A new storm splitter box allowing the ponds to store overflow sewage or secondary effluent separately or combined, or to allow the ponds to be bypassed to the effluent pond.
  - Isolation of the existing overflow from pond A to pond B.
  - Isolation of the existing floating weir connection to the decommissioned UV system.
  - Retention of the existing overflow weirs and pipes to the existing effluent pond.
  - New storm return pumps (one per pond) each sized for 1.5 ADWF.
  - New rising mains to the screened sewage channel or filter feed control system.
- 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 (Stage 1) with provision for a third bioreactor (Ultimate).
  - A Mixed Liquor (ML) splitter accepting ML from the two bioreactors (three at Ultimate) and splitting it to the two clarifiers (Stage 1) with provision for four clarifiers at Ultimate. 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 (four at Ultimate). It mixes with the ML, providing solids contact, before gravitating to each clarifier.
  - A return activated sludge (RAS) splitter accepting flows from the two RAS pump stations (four at ultimate) and splitting it to the two bioreactors (three at ultimate). This mixes with the feed before gravitating to each bioreactor.
  - An emergency overflow (alarmed) of 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) at Stage 1. This increases to 2.0 ADWF (FSB or MLE mode) each at ultimate. 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.
  - A 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.
- A 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 at Stage 1, with an additional blower (duty/assist/assist/standby) at ultimate. The Stage 1 blowers are sized to meet ultimate demand, which is slightly higher per blower than Stage 1.
  - Acoustic enclosures for each blower.
  - A new blower building with further acoustic insulation and ventilated cooling.
- Two new secondary clarifiers each sized for up to 3 ADWF (FSB mode) or 3.75 ADWF (MLE mode). Provision for a further two clarifiers at ultimate, each sized for 1.5 ADWF. Each clarifier consists of:
  - ML feed pipes.
  - An energy dissipating inlet (EDI).
  - A 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 below the effluent weirs to deflect any momentum currents away from the weirs.
  - An effluent pipe to the filter feed control system (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 sized for ultimate, with a single scum pump (duty only) accepting scum from the two clarifiers (four at ultimate) and delivering it to the aerobic digester or bioreactors (via the lift pump station).
- A new filter feed control system consisting of:
  - Secondary effluent pipes from each clarifier.
  - A balance tank sized for ultimate.
  - A filter feed control valve and flow element controlling the gravity flow to the filters.
  - An overflow from the filter feed control system to the storm ponds.
  - An optional return pipe from the storm ponds.
- Tertiary filters consisting of:
  - A new gravity main from the filter feed control system.
  - A new feed splitter including a filter bypass weir and pre flocculation tanks. The filter bypass can be directed to the storm ponds or the UV facility.
  - An alum dosing point to the flocculation tank.
  - Four deep bed, dual media filter cells (a further three at Ultimate).
  - An air scour system including duty/standby blowers.
  - A clean backwash tank and duty/standby pumps.
  - A dirty backwash tank and duty/standby pumps.
  - An overflow from the dirty backwash tank to the storm ponds.
  - 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 valve 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 an additional bank at Ultimate).
  - A modulating effluent penstock for level control.
  - A manual UV channel bypass.
- An upgraded reclaimed effluent (RE) system consisting of:
  - New RE lift pump (duty only) to downstream of the new UV system.
  - A new 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). This system will be replaced with a larger system at Ultimate.
  - A chlorine dosing point to the RE tank feed line.
- 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. The WAS pump is replaced by a larger pump at Ultimate.
  - A picket fence style gravity thickener with centre drive and scraper, sized for Ultimate.
  - 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. This is replaced by a larger pump at Ultimate.
  - Provision for two future digester loading control valves, to switch loading between the two digesters.
- An aerobic digester consisting of one existing IDEA bioreactor (both used in parallel at Ultimate). Each digester (one at Stage 1 and two at Ultimate) consist of the following.
  - 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.
  - New submerged baffle walls dividing the digester into three cells.
  - Replacement removable aeration diffusers and control valves. The control valves switch aeration between the first cell and the last two cells (in parallel), as well as modulating to control DO.
  - 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 storm ponds via existing pipework. From there is can be returned to the head of works via the storm return pumps.
  - Retention of existing instrumentation plus an additional DO element.
  - 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 last digester cell 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 and a third at Ultimate if required. This consists of:
  - A new dewatering feed tank, sized for ultimate, complete with mixer/aerator
  - A polymer make-up, storage, dosing and dilution system. Two dosing pumps in duty/duty configuration (duty/standby initially), with provision for a third at Ultimate.
  - Two dewatering feed pumps in duty/duty configuration (duty/standby initially), with the provision for a third at Ultimate.
  - A polymer dosing point to each feed line.
  - Two screw press dewatering units in duty/duty configuration (duty only initially), with provision for a third at Ultimate. Dewatering can be accommodated with the use of only one unit (two at Ultimate) by extending the dewatering period each week.
  - A filtrate collection system delivering filtrate to the FWPS.
  - A duty only, horizontal, biosolids cross-conveyor, designed for Ultimate.
  - A slewing, inclined biosolids conveyor delivering biosolids to a truck trailer (default), designed for Ultimate.
  - 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 sludge lagoons as emergency liquid sludge storage.
- A foul water pump station (FWPS) consisting of:

    - A new pump station wet well, sized for Ultimate.
    - Two new foul water pumps (duty/standby). These are replaced by larger pumps at Ultimate.
    - 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 storm ponds.
- An alkalinity storage and dosing system consisting of:
    - Two new alkalinity storage tanks (a third at Ultimate), cross connected and used for alkalinity storage (based on 25% sodium hydroxide).
    - Two new alkalinity dosing pumps (duty/duty) with a third at Ultimate, one dosing to the primary aerobic zone of each bioreactor.
    - New unloading and bunded storage areas.
- A new alum storage and dosing facility consisting of:
    - Two new alum storage tanks (a third at Ultimate).
    - Two new (duty/standby) alum dosing pumps to dose to the bioreactor feed splitter (via the influent rising main), sized for Ultimate.
    - Two new (duty/standby) alum dosing pumps dosing to the ML splitter box (via the common ML gravity main) or the filter feed, sized for Ultimate.
    - New unloading and bunded storage areas (combined with alkalinity dosing)
- A new chlorine storage and dosing facility consisting of:
    - A duty only storage tank, manually filled from intermediate bulk containers (IBC).
    - A new chlorine dosing pump (duty only), dosing to the feed to the existing RE storage tank.
- A new carbon storage and dosing system (sized for sucrose solution) consisting of:
    - One new carbon storage tank.
    - Two new (duty/duty) carbon dosing pumps (a third at Ultimate) to dose to each bioreactor primary anoxic zone (MLE) or secondary anoxic zone (FSB).
    - A hot water cleaning system with duty only booster pump and residential hot water service.
    - New unloading and bunded storage areas.
- Site provision for future recycled water treatment system.
- Site provision for future tertiary clarifiers for trimming effluent TP if needed at Ultimate.
- Site provision for a moving bed biological reactor for trimming TN if needed at Ultimate.

A process flow diagram of the proposed Moss Vale STP can be found in Appendix B.

4.1 Process Model

A whole plant process model was developed by ASpect to mimic the proposed processes at Moss Vale 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 B.
- The sewage characterisation is as developed in Section 3.1.7 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 is provided in Appendix B. This corresponds to Stage 1 loading (20,000 EP) at Moss Vale STP under worst case winter temperature conditions, including carbon dosing.

4.2 Modelling Scenarios

Three loading scenarios were modelled for Moss Vale STP:

1. Current – The loading at commissioning in 2022 (11,053 EP) with one dewatering train.
2. Stage 1 – The future, Stage 1, design loading (20,000 EP) with two dewatering trains.
3. Ultimate – The future, Ultimate, design loading (34,000 EP) with two dewatering trains.

Three seasonal scenarios were also modelled.

1. Winter (12 ^{o}C)
2. Typical (20 ^{o}C)
3. Summer (28 ^{o}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. Carbon is dosed to the second anoxic zone, resulting in a TN well below 4 mg/L 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. Carbon is added to the primary anoxic zone to obtain an effluent TN of 4 mg/L for most of the year and 6 mg/L in winter.

It is assumed that the MLE scenario will not achieve the necessary TN effluent quality if the loading increases to Ultimate. Therefore the Ultimate MLE scenario was excluded from the design scenarios, limiting the Ultimate DFTF to 3 ADWF and the ultimate DSTF to 6 ADWF. This allows many of the civil facilities to be sized for Ultimate without creating turndown limitations at Stage 1.

Therefore there were a total of fifteen (15) 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, FSB, Winter scenario. Exceptions are noted in Section 5. Some pumps were sized for Stage 1 to provide the necessary turndown. These are earmarked for replacement with larger pumps at Ultimate.

A process flow and mass balance diagram for Moss Vale STP under Future, MLE and FSB, Winter conditions can be found in Appendix B. Process and Instrumentation Diagrams are included 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 Screening

5.1.1 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 biosolids quality
  - 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 ponds.

5.1.2 Equipment and Instruments

The screening system consists of the following mechanical equipment and instruments.

- One (1) sewage flow element on the sewage gravity 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/duty).
- 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 water solenoid valve.
- One (1) screenings sluice water 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 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.

5.1.3 Description

Sewage from the Moss Vale catchment is delivered to Moss Vale STP through a single gravity main. Sewage pump stations in the Moss Vale sewerage system deliver to the gravity main. Therefore flow can be highly variable over short periods. The process units (lift pump station, bioreactors, clarifiers and filter feed control system) tend to attenuate these variable flows, smoothing them as they pass through the plant.

A number of options for delivering the inlet works staging were considered. These were:

- Construct the inlet works sized for Stage 1 and then replace it completely at Stage 2. This is costly and a waste of resources, undermining WSC's sustainability goals.
- Construct the civil structures for Ultimate, but provide smaller screens at Stage 1. This is not ideal as the civil structures should ideally be sized to suit the equipment exactly. It could create dead zones where solids could accumulate, increasing odour risk. Furthermore, the screens may need to be replaced before they reach the end of their practical life, once again compromising sustainability.
- Construct an additional parallel screen train (three instead of two) but only fit out two mechanically. This would once again create dead zones, risky odour and increasing manual labour. It would also rely on the same sized screen being available once Stage 2 was constructed.
- Construct the civil structures and deliver the screens necessary for ultimate development. While slightly more costly at Stage 1, the overall life cost would be considerably less.

Therefore, the decision was made to size the inlet works and screens for Ultimate loading. The design criteria adopted was to provide screening up to 10 ADWF at Ultimate. This provides capacity up to 17 ADWF at Stage 1.

A single gravity main flow element is used to monitor sewage flow into the inlet works. Level over the bypass weir is also converted to a flow rate and subtracted from the incoming flow to provide an indication of grit feed flow during wet weather events. A rolling average is applied to the grit feed flow in order to smooth short term flow variability. This rolling average is used to control return of the storm pumps. The relatively inaccurate grit feed flow 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.

There are two band screens in duty/standby 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.

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 is 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. 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 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 cycle.

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 penstock and a sewage overflow weir. The penstock 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. A separate high level switch alarms overflows. Screened sewage overflows a weir within the feed channel and gravitates to the storm ponds via a storm splitter. The level over the weir provides an estimate of this overflow flow while it is occurring (as outlined above)

The height of the overflow weir upstream of the penstock 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 penstock, causing additional flow over the bypass weir. The design intent is for 6 ADWF in FSB configuration or 7.5 ADWF in MLE configuration. The Ultimate design is for 6 ADWF only as the MLE mode is unlikely to deliver the NorBE TN performance necessary at Ultimate loads. Adjustable weir plates on the bypass weir accommodate this flexibility.

5.1.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The maximum screen feed flow is the sewage PWWF (an allowance is also provide for odour control system flows in the future).
- The overflow manual screen is designed for PWWF.
- Each band screen is designed for PWWF.
- 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 is 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 screen RE flows.

See Table 5-1 for details.

5.1.5 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.

5.1.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-1. Worst case sizing is for the Ultimate loading scenario and does not vary with other scenarios.

Table 5-1 Screening System Process Sizing

	Units	Process Design Assumptions	Process Design Sizing Stage 1	Process Design Sizing Ultimate
Number of Duty Screens		2		
Max Odour Control RE (future)	L/s	0.2		
Odour Control RE Operation (future)	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		
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		1		
Max Flow per Screen Unit	L/s		905	905
Max Screen Bypass Flow	L/s		905	905
Max Screen RE	L/s		11.0	11.0
Screen RE Operation	h/d		2.0	2.0
Screen RE Use	L/d		79200	79200
Avg Screen Volume Captured	L/d		167	284
Avg Screen Mass Captured	wet kg/d		92	156
Screw Press Capacity Each	L/h		118	118
Screw Press Capacity Each	wet kg/h		65	65
Screen Bin Volume Each	L		1171	1991

5.1.7 Control Philosophy

There is a sewage gravity main flow element. The sewage flow calculation is suspended if the element fails. The integrated volume since midnight and for the previous day are also calculated and displayed.

The grit feed flow is monitored continuously using the difference between incoming and bypass flows. The channel level and grit feed flow is 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). 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 is calculated in the SCADA based on the level over the weir. Overflow 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 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 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 in an oscillating lead / lag arrangement. Once a screen sequence is triggered, the following occurs.

- The sluice water solenoid valve opens, the lead screen spray water solenoid valve opens, the lead screen starts and the run timer starts.
- When the lead run timer expires, the lead screen stops, the lag spray water solenoid valve opens ,the lag screen starts and the lead spray water run on timer starts.
- When the spray water run on timer expires the solenoid closes
- When the lag run timer expires, the lag screen stops and the lag spray water time starts.
- When the lag spray water run on timer expires all solenoids closes.

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.
- Throughput mode – The washpactor operators in a washing function only.

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 at clearing drain blockages. If this sequence does not result in the level falling, then the washpactor fails.

5.2 Grit Removal

5.2.1 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.

5.2.2 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 washer 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) fixed speed, reversible grit washer inclined screw (duty only).
- One (1) grit washer screw torque switch.

The grit feed flow element can also be used for control of the grit system.

5.2.3 Description

Screened sewage flows from the screening system to the grit tank via a concrete channel. Returns from the storm ponds 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 number of options for delivering the grit tank staging were considered. These were:

- Construct the inlet works sized for Stage 1 and then replace it completely at Stage 2. This is costly and a waste of resources, undermining WSC's sustainability goals.
- Construct an additional parallel grit removal train (two instead of one) but only fit out one mechanically. However, this would require the Stage 1 grit tank to be undersized, or the Stage 2 tanks to be oversized. It is also complex to split flows evenly between two grit tanks while maintaining velocities and reducing headloss.
- Construct the civil structures and deliver the grit tank necessary for ultimate development. The difference in cost is negligible. However, oversizing grit tanks can compromise performance under low flow conditions.

The last option is the only one that is viable. Fortunately, the grit tank only receives DSTF, with flows between PWWF and DSTF shed to the storm ponds. Furthermore, the DSTF at ultimate is only 6 ADWF (FSB only), whereas the DSTF at Stage 1 could be 7.5 ADWF (MLE). Therefore, the grit tank would only be oversized by 36%. While turndown at commissioning may still be an issue, this is more likely to result in greater putrescible solids capture, which can then be removed in the grit washer. Therefore, the decision was made to size the inlet works and grit system for Ultimate loading. The design criteria adopted was to provide grit removal up to 6 ADWF at Ultimate.

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 on line, but organic separation will suffer. This is not a major issue because grit washing is later undertaken in the grit washer. 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 grit washer. 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 a combined screenings / grit trailer

The grit washer and trailer 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.

5.2.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The grit system is designed for:
  - Sewage Ultimate DSTF, 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 5-2 for details.

5.2.5 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. 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 vacuum tanker. Therefore, it is possible to bypass the grit removal system for short periods to rectify faults or maintain the equipment. A standby grit tank or standby equipment is therefore not warranted. The grit pump includes a standby in store. The grit chamber is the same size as the unit at Bowral STP to minimise the number of spares that must be kept by WSC.

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.

Grit turndown is assisted by the lower DSTF at Ultimate. Nevertheless, oversizing may result in sub-optimal organic solids separation during commissioning flows. This should be alleviated by the washing effectiveness of the grit washer, which should separate the organics and return them to the process for treatment.

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 Ultimate loading scenario.

Table 5-2 Grit Removal System Process Sizing

	Units	Process Design Assumptions	Process Design Sizing Stage 1	Process Design Sizing Ultimate
Number of Duty Grit Tanks		1		

	Units	Process Design Assumptions	Process Design Sizing Stage 1	Process Design Sizing Ultimate
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 Washers		1		
Grit Storage Required	d	7		
Number of Grit Bins		1		
Maximum Flow per Grit Tank	L/s		410	554
Maximum Grit Bypass Flow	L/s		410	554
Max Grit RE	L/s		6.5	6.5
Grit RE Operation	h/d		1.0	1.0
Grit RE Use	L/d		23400	23400
Avg Grit Volume Captured	L/d		173	293
Average Grit Mass Captured	wet kg/d		276	469
Grit Washer Capacity Each	L/h		122	122
Grit Washer Capacity Each	kg/h		196	196
Grit Bin Volume Each	L		1208	2053

5.2.7 Control Philosophy

The grit paddle operates continuously. An alarm is generated if the grit paddle fails, but the grit extraction 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 a 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 grit 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 cycles, then the screw fails and latches.

There is a closed proximity switch on the grit washer access hatch. 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.

5.3 Storm Detention and Return System

5.3.1 Purpose

The purpose of the storm detention system is:

- To accept screened sewage flows in excess of the DSTF.
- To accept secondary effluent flows in excess of the DFTF.
- To accept emergency decant supernatant from the aerobic digester if the thickener is out of service.
- To accept a variety of contamination stormwater and emergency overflows.
- To accept all flows as required occasionally for plant maintenance or power failure.
- To store screened sewage and secondary effluent under wet weather or emergency conditions.
- To keep screened sewage and secondary effluent separated if desirable.
- 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.

5.3.2 Equipment and Instruments

- Two (2) storm detention level elements, one for each pond.
- Six (6) storm pond level switches, three for each pond.
- Two (2) variable speed storm return pumps (one for each pond)

- Two (2) storm pond selection valve closed switches, one for each pond.
- One (1) storm return flow element.

5.3.3 Description

There are two storm ponds. These are the pre-existing catch balance ponds. These can be used to accept screened sewage from the inlet works in excess of DSTF, or secondary effluent from the filter feed control system in excess of DFTF, or both.

A variety of other stormwater or emergency flows are also directed to the storm ponds. These are:

- Stormwater from the chemical unloading bund.
- Stormwater from each of the chemical storage and dosing bunds.
- Overflows (secondary effluent) from the filter feed splitter.
- Overflows from the foul water pump station (FWPS).
- Overflows from the dirty water backwash tank.
- Supernatant from the aerobic digester (via existing pits EF2 and EF1 and associated conduits).

The destination of the emergency supernatant is controlled via manual valves EF1 via the pre-existing pipework (decant effluent). It can be directed to either or both storm ponds. All the other streams above combine with the filter feed control system overflow. The combined stream is called the emergency overflow.

Manual stop boards and valves can be used to either combine or separate the screened sewage or emergency overflows and store them in the storm ponds. The possibilities are numerous, and include:

- Direct the screened sewage overflow to storm pond 1 and the emergency overflow to storm pond 2, or vice versa.
- Split both overflow evenly between the storm ponds, storing a mixture.
- Direct both overflows to one storm pond, to empty and clean the other.
- Direct the screened sewage to one or both storm ponds and direct the emergency overflow to the effluent pond, bypassing the storm ponds.
- Direct both screened sewage and emergency overflows directly to the effluent pond, bypassing both storm ponds (e.g. for cleaning).

This splitter provides a high degree of flexibility to suit the circumstance and operator preference.

Screened sewage in excess of DSTF overflows a weir in the screened sewage channel of the inlet works and gravitates to the storm splitter. 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 control system, etc).

There are two storm ponds in parallel (existing Catch Pond 1 and Catch Pond 2). The intent is for most of the settleable sewage solids to settle in the storm ponds prior to overflow to the existing “Storm Balance Pond” if required. The long retention time and slow rise rate should provide excellent primary treatment before discharge to the Storm Balance Pond, which should then provide additional physical and biological treatment. This treatment, in addition to stormflow dilution of the sewage, should result in a reasonable bypass quality.

The converted catch ponds provide over a day’s storage at average flow, allowing such repairs or maintenance to be undertaken. This will fall to less than a day at Ultimate loading. The ponds are currently configured such that Pond 1 overflows to Pond 2 and Pond 2 overflows to the “Storm Balance Pond” (an old maturation pond from the original trickling filter plant). A dedicated spillway within the Storm Balance Pond directs excess directly to Whites Creek. Each overflow point is alarmed. The level and weir length is used to approximate the flows if the high level switch is activated.

A DN300 DICL pipe connected to the Pond 2 overflow pipe allows a portion of the Storm Balance Pond volume to be returned to the process (controlled via a manual valve). As the pipe is above the BWL of the Storm Balance pond it is not possible to fully empty the Storm Balance Pond (the top approximately 700mm of water can be returned). Regardless, with a surface area in the order of 1.4 Ha this significantly increases storm storage capacity (~ 10ML of potential storage if the system is kept at the minimum water level). There is no plan to alter the current Storm Balance Pond configuration.

Stored storm flows are returned to the inlet works (usual) or the filter feed control system (if the stored overflow is high quality secondary effluent) 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 a new storm pumps within each catch pond. The return does not start until the operator activates it.

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 (or the filters directly if so desired). 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 storm is emptied.

Speed mode is used as a backup if the grit feed or return flow elements are failed.

The operator selects which of the ponds to draw from using SCADA. Each pump is sized to be the same flow rate as the pumps in the lift pump station. The intent is to deliver the return pumps to suit Stage 1 sizing, then replace them with larger pumps at Stage 2. The return pipework is sized for Stage 2.

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 0).

5.3.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The volume of the storm ponds was calculated from the construction drawings (DWGs 49 to 57).
- The return pumps are sized identically to the lift pump station pumps (just over 1.5 ADWF each).
- The 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.
- The storm balance pond provides additional 10 ML of storages. This provides more than 3 x ADWF at Stage 1 flows, consistent with the design approach at Bowral STP.

See Table 5-3 for details.

5.3.5 Turndown and Redundancy

There are two return pumps. These operate as duty only in each pond. The pumps are able to be interchanged between ponds as required. Failure of two pumps will prevent returns, but this has no immediate consequence.

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 elements 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.

5.3.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-3. The worst case sizing for storage and return is the Ultimate FSB option as this is when sewage flows are greatest and DFTF is least. The sizing does not vary with season.

Note that process sizing does not include the available volume within the Storm Balance Pond. The maximum volume provided by the Storm Balance Pond effectively triples the potential storm storage volume.

Table 5-3 Storm Detention Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Ultimate FSB)
Storm Pond Active Volume Total	ML	5.771		
Sewage ADWF	ML/d	4.600		
Storm Return Pumps		2		
Reduced Return Flow	h	7.0		
Average Reduced Return Flow	ADWF	0.2		
Total Storm Detention Storage	ML		5.8	5.8
Sewage DSTF:ADWF	ADWF		6.00	6.00
Sewage PWWF:ADWF	ADWF		17.00	10.00
Storage at PWWF	h		1.8	1.8
Storage at PWWF - DSTF	h		2.7	4.4
Storage at ADWF	d		1.3	0.7
Max Return Rate	ADWF		1.66	1.60
Equivalent Return Flow	ADWF		1.62	1.55
Return Pump Size	L/s		**88.6**	144.5
Storm Return Pumps Tot	L/s		177.2	**289.0**
Time to Drain Storm Ponds	d		0.8	0.5

The return times can be reduced under the Stage 1 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.

The intent is to deliver the return pumps to suit Stage 1 sizing, then replace them with larger pumps at Stage 2. The return pipework is sized for Stage 2.

5.3.7 Control 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 5.2.7). The overflow weir at the filter feed control system is also alarmed by a level element and high level switch in the filter feed control tank (see Section 5.15.7).

The return pumping system is typically set to Unavailable. Therefore, the return pumps do not operate as the storm ponds fill. The level in each storm pond is monitored with a level element. The real time level, average level today and average level yesterday, for each pond are calculated, displayed and recorded.

There is a high level switch in each storm pond (two catchponds and storm balance pond). These alarm overflows. If overflow of either pond 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 from each pond and total are calculated, displayed and recorded. The integrated bypass discharge duration today and yesterday are also calculated displayed and recorded.

There is a low level switch in each storm pond. 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 each storm pond. These act as a dry cut out, failing and latching both respective pumps if this switch is activated.

Two storm return pumps operate in duty only configuration in the respective pond. The operator can select which pump is operational.

There is a flow element in the storm return main. This is used for monitoring and can also be used for control of the storm return pumps (Flow mode only). The real time flow, integrated volume today and integrated volume yesterday are calculated, displayed and recorded. There is a no flow set point. An alarm will be generated and the duty pump will be failed if the flow 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 default is that the return pumps are Unavailable. The return system will operate only if the operator sets it as Available, and will empty the respective pond. 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 respective pond is emptied

There are two possible control modes for the return pumps:

- Flow Mode – The operator sets a target pump inflow. The target return flow is calculated by subtracting the rolling average grit feed flow from the target inflow. Therefore, the return flow target changes in real time, decreasing as the grit feed flow increases and increasing as the grit feed 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 pond 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. If the sewage flow element is available, then the return flow will stop and the pumps will be made Unavailable if the grit feed flow exceeds a high inhibit flow, or the pond is emptied, whichever occurs first.

5.4 Lift Pump Station

5.4.1 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.

5.4.2 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) feed splitter high level switch.
- One (1) RAS 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.

5.4.3 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 – Fixed 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 feed splitter (alarm only). This warns 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 RAS splitter and ML splitter. If either of these is activated, then this will fail and latch all feed and bypass pumps to prevent overflow of the splitters. This should only occur during wet weather and with one bioreactor (RAS splitter) or clarifier (ML splitter) 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.

The lift pump station wet well and pipework are design for Ultimate flows with a DFTF of 3ADWF and a DSTF of 6ADWF. The lift pumps are sized for Stage 1 flows with a DFTF of 4.5ADWF (three pumps under MLE mode) and a DSTF of 7.5 ADWF (five pumps under MLE mode). The intent is to maintain the same number of pumps at Stage 2, but replace them with larger pumps.

5.4.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The maximum influent flow is
  - The sewage DFTF, plus
  - The maximum screen RE flow, plus
  - The maximum grit RE flow.
- At Stage 1, 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.
- At Stage 2 (Ultimate) there is no MLE mode so the DFTF is restricted.
- 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 under Ultimate flows. This storage time is to allow for smooth level and flow control over a wide range of flows.

See Table 5-4 for details.

5.4.5 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 (Stage 1). At Stage 2 (Ultimate) the influent pumps operate as duty/assist/standby only. 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 the storm ponds 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.

Turndown would be compromised if the lift pumps were sized for Ultimate flows. This is why the pumps are sized for Stage 1 flows and replaced at Stage 2 with larger pumps.

5.4.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-4. Worst case sizing is for the pump station and feed pipe sizing is the Ultimate FSB scenario. The worst case sizing for the pumps is the Stage 1 FSB scenario. The sizing does not vary with season.

Table 5-4 Lift Pump Station Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
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			
Sewage ADWF	ML/d		4.600	4.600	7.820
Sewage DFTF:ADWF	ADWF		3.00	4.50	3.00
Max Lift PS Flow at DFTF	ML/d		15.312	22.212	24.972
Max Lift PS Flow at DFTF	L/s		177.2	257.1	**289.0**

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Sewage DSTF:ADWF	ADWF		6.00	7.50	6.00
Max Lift PS Flow at DSTF	ML/d		29.112	36.012	48.432
Max Lift PS Flow at DSTF	L/s		336.9	416.8	**560.6**
Duty Influent Pumps			2	3	2
Duty Bypass Pumps			2	2	2
Lift Pump Capacity Each	L/s		88.6	**85.7**	144.5
Lift Pump Capacity Each	:ADWF		1.66	1.61	1.60
Lift PS Volume Each	m^3		253	313	**420**

The slight difference in pump sizing between the Stage 1 FSB AND MLE 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.

The lift pump station volume and pipe sizes are based on the Ultimate FSB scenario. The pump sizes are based on the Stage 1 FSB scenario. These are replaced by larger pumps at Stage 2.

5.4.7 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 splitter or 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 modulate 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 are 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.

5.5 Bioreactor Splitter

5.5.1 Purpose

The purpose of the bioreactors 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 for the easy connection of a third bioreactor at Stage 2.
- To allow a bioreactor to be manually isolated if necessary for maintenance.

5.5.2 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 5.4).

5.5.3 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. Foul water from the foul water pump station (FWPS) is also delivered to the feed chamber, where it mixes with the dosed influent.

At Stage 1, 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. Provision is made to connect a third bioreactor at Stage 2, providing an even three way split of bioreactor feed.

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. At Stage 1, 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. Provision is made to connect a third bioreactor at Stage 2, providing an even three way split of RAS.

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 at Stage 1. This is a worse case than splitting three ways at Stage 2. 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 weirs, causing the level to rise in the feed chamber. An emergency overflow weir and pipe 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 high level switches.

5.5.4 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 at Stage 1), 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 Stage 1 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 the level could rise and fail and latch the lift pump station.
- The maximum capacity of the bypass flow is the worst case difference between DSTF and DFTF.

See Table 5-5 for details.

5.5.5 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 storm ponds until maintenance is complete. There should be no need for such maintenance.

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 Future MLE scenario. The sizing does not vary with season.

Table 5-5 Bioreactor Splitter Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Maximum Screen RE	ML/d	0.950		
Maximum Grit RE	ML/d	0.562		
Maximum Reactor Spray	ML/d	0.086		
Sewage ADWF	ML/d		4.600	7.820
Sewage DFTF:ADWF	ADWF		4.50	3.00
Sewage DSTF:ADWF	ADWF		7.50	6.00
Maximum FWPS	ML/d		2.340	**3.117**
Bioreactors			2	3
Bioreactor with 1 O/S			1	2
Feed at DFTF	ML/d		24.552	28.089
DFTF Feed Flow Each	ML/d		12.276	9.363
DFTF Feed Flow Each	L/s		142.1	108.4
DFTF Feed with 1 O/S	ML/d		13.446	11.441
DFTF Feed with 1 O/S	L/s		**155.6**	132.4
Maximum RAS Flow	ML/d		16.389	32.778
Max RAS Flow Each	ML/d		8.195	10.926
Max RAS Flow Each	L/s		94.8	126.5
Max RAS Flow with 1 O/S	ML/d		8.976	13.351
Max RAS Flow with 1 O/S	L/s		103.9	**154.5**
Max Feed & RAS Each	ML/d		20.471	20.289
Max Feed & RAS Each	L/s		236.9	234.8
Max Feed & RAS with 1 O/S	ML/d		22.422	24.792
Max Feed & RAS with 1 O/S	L/s		259.5	**286.9**

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Max ML Each	ML/d		20.514	20.332
Max ML Each	L/s		237.4	235.3
Max ML Each with 1 O/S	ML/d		22.509	24.922
Max ML Each with 1 O/S	L/s		**260.5**	288.4
Max Bypass Flow	ML/d		13.800	**23.460**
Max Diluted ML Flow	ML/d		54.828	84.457
Max Diluted ML Flow	L/s		634.6	**977.5**

5.5.7 Control Philosophy

The control philosophy for calculating the bioreactor feed flow is covered in Section 5.4.7.

5.6 Bioreactors

5.6.1 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, removing 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.

5.6.2 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 (one additional at Stage 2).
- Two (2) low flow switches, one for each solenoid (one additional at Stage 2).

5.6.3 Description

A decision was made to adopt identical bioreactor configurations for both Bowral STP and Moss Vale STP. The slight changes in contributions and sewage characteristics for the Moss Vale catchment results in the bioreactors being de-rated from 21,000 EP total, to 20,000 EP total. Otherwise the bioreactors and associated equipment are identical to Bowral STP, reducing spares and improving operational consistency between the two plants.

At Stage 1, there are two bioreactors in duty/duty configuration. A third bioreactor is required at Stage 2 to treat Ultimate loads. 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. If conditions are favourable, then it should be possible to effectively treat sewage under ultimate loading with one of the three bioreactors out of service.

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.

As the flow increases, the NorBE concentration targets reduce. It is envisaged that the Stage 2 plant will need to meet TN targets that are beyond the capability of an MLE bioreactor. Therefore, it is assumed that the bioreactors will be operated in FSB mode only after Stage 2. The MLE mode will still be available, but the DFTF will be restricted to 3 ADWF. There is no hydraulic allowance to fully treat 4.5 ADWF at Ultimate.

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.
- The carbon dose is directed to the secondary anoxic zone.

This can be achieved operationally in a matter of minutes and can be reversed at any time.

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 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 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 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.

5.6.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The sludge yield (see Table 5-6) 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 5.28.4. The precipitants formed are assumed to be aluminium phosphate ($AlPO_4$) and aluminium hydroxide ($Al(OH)_3$).
- The maximum feed flow for Stage 1 is:
  - The sewage DFTF (3.0 ADWF for FSB and 4.5 ADWF for MLE), plus
  - The maximum screenings RE flow, plus
  - The maximum grit RE flow, plus
  - The maximum FWPS flow, plus
- The maximum feed flow for Stage 2 is limited to 3.0 ADWF regardless of operating configuration.
- 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 and dimensions are identical to Bowral STP. 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 5.11).
- 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 5-6 and Table 5-7 for details.

5.6.5 Turndown and Redundancy

At Stage 1, 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. At Stage 2, this will be 2 ADWF, which is still 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 the storm ponds as dry weather balancing tanks.

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.

5.6.6 Process Sizing

Details of the biomass yield assumptions and resulting biomass yield can be found in Table 5-6. This feeds into the process rating (EP) of the bioreactors. Worst case sizing is for the Ultimate, Winter, FSB option.

Table 5-6 Loading and Biomass Yield

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Temperature	^{o}C	12			
Sludge Age(1)	d		24	19	24
Feed Non Volatile SS (NVSS)	kg/d		196	196	332
Feed NBVSS	kg/d		406	406	691
BCOD(2) Consumed	kg/d		2031	2032	3452
Active NHOs(3)	kg/d		182	225	311
NHO Endogenous Residue	kg/d		167	163	285
Nitrogen Nitrified	kg/d		187	184	314
Nitrifier Active Mass	kg/d		11	11	18
Nitrifier Endogenous Residue	kg/d		2	1	3
PO_x-P Precipitated	kg/d		37	37	64
Chemical Precipitants	kg/d		241	240	411
Total Yield	kg/d		1205	1244	2051
VSS:SS Ratio			64%	65%	64%
Total SS Inventory	kg		28914	23632	49214

Note (1) – This is the actual sludge age (includes biomass in the clarifiers and effluent SS). The hydraulic sludge age is one day less.

Note (2) – Biodegradable Chemical Oxygen Demand

Note (3) – Active Normal Heterotrophic Organisms

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 to be identical to those at Bowral STP. Details of the process sizing assumptions and resulting process sizing can be found in Table 5-7. Worst case sizing is for the Ultimate, Winter, FSB scenario.

Table 5-7 Bioreactor Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Temperature	°C	12			
Effluent SS	mg/L	5.0			
Biomass Volume Total	ML		7.691	7.691	11.726
Max Bioreactor Spray	L/s		1.0	1.0	1.5
Bioreactor Spray Operation	h/d		12.0	12.0	12.0
Solids Retention Time	d		24	19	24
Unaerated Mass Fraction			51.6%	43.2%	52.4%
Nitrification Safety Factor			1.3	1.3	1.3
SS Yield	kg/d		1205	1244	2051
Total Inventory	kg		28914	23632	49214
Bioreactor MLSS	mg/L		3759	3073	4197

The reduction in MLSS in the Stage 1 MLE scenario means that the DFTF can be increased from 3.0 ADWF to 4.5 ADWF without increasing the size of the clarifiers.

The highest MLSS is for the Ultimate FSB scenario. This is because the load increases from 20,000 EP to 34,000 EP (an increase of 70%) but the number of bioreactors only increases from 2 to 3 (50%). However, this MLSS is not unusually high for bioreactors and can be accommodated by adding two clarifiers at Stage 2 instead of one.

The bioreactor geometry was designed specifically to suit the Bowral STP needs and then adopted as is for Moss Vale STP. The full details of the bioreactor geometry can be found in Table 5-8. 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 5-8 Bioreactor Geometry

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Ultimate FSB)
Inside Length Each	m	40.3		
Inside Width Each	m	20.3		
Structural Wall Width	m	0.4		
Baffle Wall Width	m	0.3		
Bioreactor Liquid Depth	m	4.6		

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Ultimate FSB)
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	5.0		
Equivalent Clarifier Blanket	m	0.5		
Bioreactors			2	3
Bioreactor Liquid SA Each	m^2		795	795
Bioreactor Volume Each	ML		3.655	3.655
Bioreactor Volume Total	ML		7.311	10.966
Clarifier SA Each	m^2		380	380
Clarifier SA Total	m^2		760	1521
Clarifier Biomass Volume	ML		0.380	0.760
Total Biomass Volume	ML		7.691	11.726
Selector Fraction			2.0%	2.0%
Primary Anoxic Fraction			38.3%	38.3%
Primary Aerobic Fraction			42.3%	42.3%
Secondary Anoxic Fraction			8.8%	8.8%
Secondary Aerobic Fraction			4.3%	4.3%
De-Aeration Fraction			4.3%	4.3%
MLE Unaerated Mass Fraction			43.2%	44.1%
FSB Unaerated Mass Fraction			51.6%	52.4%

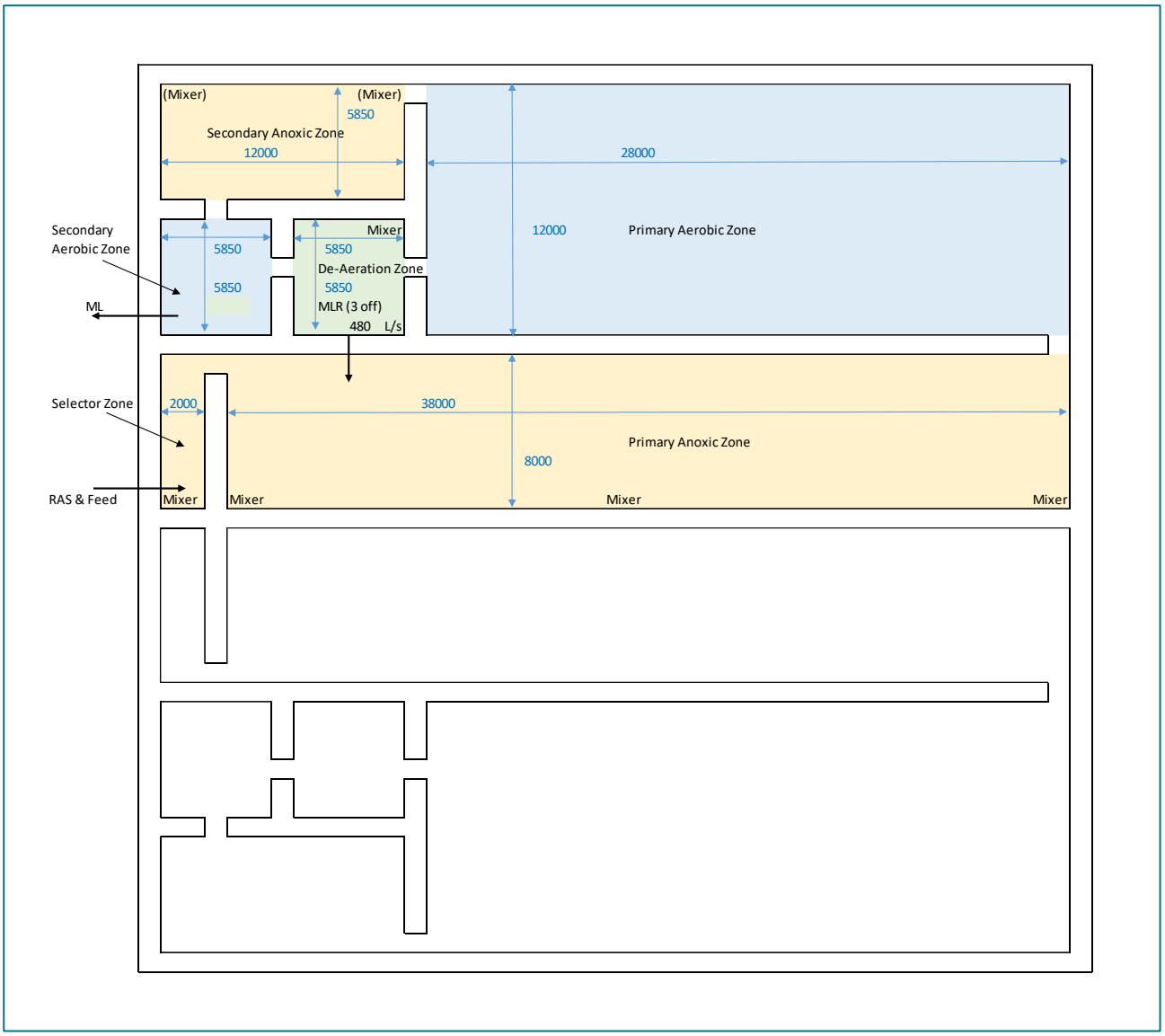


Figure 5-1 Bioreactor Sketch

The clarifiers were sized to suit the flow and MLSS conditions at Bowral STP. Modelling was then used to determine the Stage 1 capacity of Moss Vale STP with two bioreactors and two clarifiers. It was found to be 20,000 EP for Moss Vale STP (compared to 21,000 EP for Bowral STP).

Adding another bioreactor and two additional clarifiers was found to increase the capacity to 34,000 EP (see Table 3-16), which was then adopted as the Ultimate loading. This was deemed to be better than adopting four bioreactors and three clarifiers (36,000 EP) as clarifiers are less costly to construct and maintain than bioreactors. The cost penalty of increasing the Ultimate capacity by 2,000 EP did not appear to be value for money given the lack of certainty in what the ultimate load would be.

5.6.7 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.

5.7 Clarifier Splitter

5.7.1 Purpose

The purpose of the clarifier splitter is:

- To accept ML from the two bioreactors.
- To provide for the simple connection of a third bioreactor at Stage 2.
- To evenly split the ML between the two clarifiers.
- To provide for the simple connection to two more clarifiers at Stage 2.
- To evenly split reactor bypass flows between the clarifiers.
- To allow a clarifier to be manually isolated if necessary for maintenance.

5.7.2 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 5.4.

5.7.3 Description

The bioreactor system has been designed for Stage 1 loads, but readily upgradable to Ultimate loads. The stages are as follows.

- Stage 1 (20,000 EP) = Two (2) bioreactors and Two (2) clarifiers
- Stage 2 (34,000 EP) = One (1) additional bioreactor and two (2) additional clarifiers.

Stage 2 can be split into smaller sub-stages to match growth and any changes in sewage characteristics associated with MVEC. For example, if MVEC sewage has a high degree of trade waste pre-treatment, then it may be accommodated (at least in the early years) by more clarifiers only, delivered one at a time. The important design consideration for Stage 1 is to provide simple, modular amplifications all the way to the projected Ultimate load of 34,000 EP (three bioreactors and four clarifiers).

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 returned to the bioreactor via the RAS for treatment.

Feed to any clarifier can be isolated manually using stop boards at the ML and bypass splitter weirs.

The clarifier feed pipes are hydraulically designed to accommodate worst case conditions with all clarifiers in service. At Stage 1, this is half the DSTF (7.5 ADWF under MLE mode) plus the maximum foul water flow and slightly more than half the maximum RAS flow. At Ultimate, this is a quarter of the DSTF (6 ADWF) plus the maximum (amplified) foul water flow and slightly more than a quarter of 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(s) 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.

5.7.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The maximum influent flow at Stage 1 is:
  - The sewage DFTF (4.5 ADWF for MLE and 3.0 ADWF for FSB), plus
  - The maximum screen RE flow, plus
  - The maximum grit RE flow.

- The maximum influent flow at Stage 1 should be capped to 2.25 ADWF if one clarifier is out of service and isolated.
- The maximum sewage DTFT is capped at 3.0 ADWF at Ultimate.
- 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 foul water pumps are assumed to be replaced with larger pumps at Stage 2 to satisfy ultimate conditions.
- 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 is slightly greater.
- 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 at Stage 1 and 2.25 ADWF at Ultimate if one clarifier is out of service.

See Table 5-9 for details.

5.7.5 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.

5.7.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-9. Worst case sizing is for the combined mains is the Ultimate FSB scenario. The worst case sizing for the individual mains is the Stage 1 MLE Scenario. The sizing does not vary with season.

Table 5-9 Clarifier Splitter Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB
Maximum Screen RE	ML/d	0.950			
Maximum Grit RE	ML/d	0.562			
Maximum Reactor Spray	ML/d	0.086			
Sewage ADWF	ML/d		4.600	4.600	7.820
Sewage DSTF	ADWF		6.00	7.50	6.00
Maximum FWPS Flow	ML/d		2.340	2.340	3.117
Maximum RAS Flow	ML/d		16.389	16.389	**32.778**
Clarifiers			2	2	4
Clarifiers with 1 O/S			1	1	3
Maximum ML Flow	ML/d		47.928	54.828	84.457
Maximum ML Flow	L/s		554.7	634.6	**977.5**

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB
Maximum ML Flow Each	ML/d		23.964	27.414	21.114
Maximum ML Flow Each	L/s		277.4	317.3	244.4
Max ML Each with 1 O/S	ML/d		26.264	29.409	28.706
Max ML Each with 1 O/S	L/s		304.0	**340.4**	332.2
Maximum SE Flow	ML/d		31.539	38.439	51.679
Maximum SE Flow	L/s		365.0	444.9	**598.1**
Maximum SE Flow Each	ML/d		15.769	19.219	12.920
Maximum SE Flow Each	L/s		182.5	222.4	149.5
Max SE Each with 1 O/S	ML/d		16.983	20.433	15.355
Max SE Each with 1 O/S	L/s		196.6	**236.5**	177.7

It can be seen that the sizing of combined mains (ML and secondary effluent) are based on the Ultimate flows. However, the flows in the individual mains reduce at Ultimate, so their sizing is dictated by the Stage 1 MLE scenario.

5.7.7 Control Philosophy

There are no automated controls for the clarifier splitter.

5.8 Secondary Clarifiers

5.8.1 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.

5.8.2 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 additional at Stage 2).
- Two (2) high torque switches, one for each scraper mechanism (two additional at Stage 2).
- Two (2) proximity switches (plough), one on each scraper mechanism (two additional at Stage 2).
- Two (2) proximity switches (rotation detection), one on each scraper mechanism (2 additional at Stage 2).

5.8.3 Description

There are two secondary clarifiers at Stage one in duty/duty configuration. Two more are added at Stage 2, providing a total of four (duty/duty/duty/duty). 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 control system 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 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.

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.

5.8.4 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 Stage 1 DFTF conditions is:
  - The sewage DFTF (3.0 ADWF for FSB mode and 4.5 ADWF for MLE mode), plus
  - The maximum screen RE flow, plus
  - The maximum grit RE flow, plus
  - The maximum FWPS flow,
  - The maximum bioreactor RE flow.
- The maximum sewage DFTF at Ultimate is 3 ADWF.
- 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 5.6.6.
- The clarifier diameter (see Section 5.6.6) was as determined for Bowral STP.
- The worst case MLSS dilution under DSTF conditions is calculated by mass and flow balance.

See Table 5-10 for details.

5.8.5 Turndown and Redundancy

The clarifiers are provided in duty/duty configuration at Stage 1, and duty/duty/duty/duty at Stage 2. Under Stage 1 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 Stage 1 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. At Ultimate, the DFTF is reduced to 2.25 ADWF with one clarifier out of service. The operator simply reduces the DFTF cap at the lift pump station. Even under worst case conditions (Stage 1, 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 storm ponds 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.

5.8.6 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 under Winter conditions.

Table 5-10 Secondary Clarifier Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
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			

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Maximum Odour Control RE	ML/d	0.000			
Maximum Screen RE	ML/d	0.950			
Maximum Grit RE	ML/d	0.562			
Clarifier Inside Diameter Each	m	**22.0**			
Clarifier Side Wall Depth	m	**4.0**			
Clarifiers			**2**	2	4
Clarifier SA Total	m^2		760	760	1521
Sewage ADWF	ML/d		4.600	4.600	7.820
Maximum FWPS	ML/d		2.340	2.340	3.117
Maximum Bioreactor Spray	ML/d		0.086	0.086	0.130
Flux Constant Vo	m/h		6.64	6.64	6.64
Flux Constant n	kg/m^3		0.49	0.49	0.49
Sewage DFTF	ADWF		3.00	4.50	3.00
Bioreactor MLSS	mg/L		3759	3073	4197
DFTF Sludge Settling Rate	m/h		1.1	1.5	0.8
DFTF Solids Flux	$kg/m^2/h$		6.8	6.7	6.7
Clarifier Overflow at DFTF	ML/d		17.739	24.639	**28.219**
Clarifier Overflow at DFTF	m/h		0.97	1.35	0.77
Clarification Capacity at DFTF			93%	92%	91%
Sewage DSTF	ADWF		6.00	7.50	6.00
Solids Contact Flow	ML/d		13.800	13.800	23.460
DSTF Clarifier Feed MLSS	mg/L		2649	2278	2990
DSTF Sludge Settling Rate	m/h		1.8	2.2	1.5
Clarifier Overflow at DSTF	ML/d		31.539	38.439	51.679
Clarifier Overflow at DSTF	m/h		1.7	2.1	1.4
Clarification Capacity at DSTF			95%	97%	92%
Clarifier Overflow at DSTF	ML/d		31.539	38.439	51.679

It is apparent that the limiting condition is Stage 1 DSTF under the MLE configuration. The clarifier is sized to be identical to Bowral STP, which was sized to the nearest 0.5 m diameter. The capacity ratings (EP) for Stage 1 and Ultimate were modelled to the nearest 1000 EP, which resulted in a small amount of spare capacity under all scenarios.

There is greater spare capacity under DFTF conditions because the flux limit is slightly greater.

5.8.7 Control Philosophy

Each clarifier mechanism has a single, fixed speed, peripheral drive. The drive speed can be mechanically 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 pumps and bypass pumps when activated.

5.9 Return Activated Sludge System

5.9.1 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.

5.9.2 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 (four additional at Stage 2)
- Two (2) RAS flow elements, one for each clarifier (two additional at Stage 2).

5.9.3 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.

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 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 be unable balance mass. 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.

5.9.4 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 5.6.6.
- The clarifier diameter (see Section 5.6.6) was adjusted to just meet worst case design conditions for Bowral STP. An identical size has been adopted for Moss Vale STP.
- The RAS pump size is proportional to clarifier size (critical underflow method). Therefore the RAS pump capacities are also identical to Bowral STP.

See Table 5-11 for details.

5.9.5 Turndown and Redundancy

There are two sets of RAS pumps at Stage 1 and four at Stage 2. 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 another 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.

5.9.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-11. Worst case sizing is based on critical underflow which is independent of the scenario. The ideal operating conditions change with scenario (Winter is worst case).

Table 5-11 Return Activated Sludge Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Stage 1 FSB)
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			
RAS Pump Turndown	of Max	40%			
Bioreactor Feed at ADWF	ML/d		5.609	5.692	9.331
Critical RAS Thickness	mg/L		8158	8158	8158
Critical Underflow	m/h		0.90	0.90	0.90
Required RAS Capacity	m^3/h		683	683	1366
Duty RAS Pumps			**2**	2	4
RAS Pumps at ADWF			2	2	4
RAS Pumps Each	L/s		**94.8**	94.8	94.8
Ideal RAS Recycle Rate			0.85	0.60	1.06
Minimum RAS Flow Total	L/s		75.9	75.9	151.8
ADWF RAS Flow	ML/d		6.556	6.556	13.111
RAS Rate at ADWF			1.17	1.15	1.41
Bioreactor MLSS	mg/L		3759	3073	4197
DFTF RAS Flow	ML/d		15.162	14.888	29.898
DFTF RAS Flow	L/s		175.5	172.3	346.0
RAS Capacity at DFTF	mL/g		93%	91%	91%

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.

5.9.7 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 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.

5.10 Scum System

5.10.1 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.

5.10.2 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.

5.10.3 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 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 (all four at Stage 2). 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 greater than the clarifiers. 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 5.14).

The scum pump station volume is based on Ultimate scum flows (4 clarifiers). There is no need to replace the scum pump at Stage 2.

5.10.4 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 (secondary effluent).

See Table 5-12 for details.

5.10.5 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.

5.10.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-12. The scum pump station volume is based on the Ultimate scenario.

Table 5-12 Scum System Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
Scum Box Volume Each	L	50		
Scum Boxes per Clarifier		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%		
Clarifiers			2	4
Scum Drain Total	L/s		50.0	**100.0**
Scum Volume Total	ML/d		0.010	0.019
Max Scum Flow	L/s		1	**1**
Scum Pump Operation	h/d		2.7	5.3
Scum Tank Volume Each	m^3		2.0	**4.0**

5.10.7 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.

5.11 MLR Pumping System

5.11.1 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.

5.11.2 Equipment and Instruments

The MLR pumping system consists of the following mechanical equipment and instruments.

- Six (6) variable speed MLR pumps (three additional at Stage 2), three per bioreactor.
- Two (2) primary anoxic zone oxygen reduction potential (ORP) elements (one additional at Stage 2), one per bioreactor.

5.11.3 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.

Modelling suggests that the MLR pumping capacity per bioreactor should ideally increase slightly at Ultimate. Therefore, the design assumes that all MLR pumps are replaced with larger pumps at Stage 2. The benefit (or otherwise) of this should become operationally evident before Stage 2 is constructed.

5.11.4 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 3.3 mg/L under Typical and Summer conditions where possible.
- 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 under 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.
- It was found that, in MLE mode, the plant is capable of achieving a TN of 3.3 mg/L in Typical and Summer conditions under Current (commissioning) flows, provided carbon was dosed. As flows increased, the MLR pump capacity becomes limiting. The Typical and Summer performance of the MLE scenario falls to just under 4.0 mg/L at the end of Stage 1 and Ultimate due to MLR pumping capacity limitation.
- It is envisaged that FSB mode would be adopted if the TN target falls below 4.0 mg/L. The MLR pump capacity then becomes limiting only in summer, but the effluent TN falls to 2.5 mg/L.
- Given the complexity of denitrification performance predictions, these figures should be seen as a guide only.
- Denitrification during Typical temperature conditions is sufficient to meet 50%ile NorBE TN target (3.3 mg/L) for Stage 1 provided FSB is adopted before the Stage 1 capacity is reached. The modelled TN for Ultimate was 2.5 mg/L, falling short of the 1.9 mg/L required.
- All these TN predictions assume steady state, completely mixed, nitrification kinetics. Since the bioreactors contain baffle walls and compartments, they are more plug flow. This should reduce the effluent NH_x-N and TN by up to 0.5 mg/L under typical conditions. This may come close to meeting Ultimate NorBE TN targets.

See Table 5-13 for details.

5.11.5 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.

5.11.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-13. The MLR pumps are assumed to be replaced with larger pumps at Stage 2, but this should be confirmed operationally. Their replacement may be able to be deferred until the flows approach Ultimate.

Table 5-13 MLR Pumping Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
MLR Turndown	of Max	50%			
MLR Pumps Each	L/s		160.0	160.0	180.0
MLR Pumps			**6**	6	9
Min MLR Pumps			2	2	3
Feed & Spray	ML/d		5.609	5.692	9.331
Max MLR Total	L/s		960.0	960.0	1620.0
Min MLR Total	L/s		**160.0**	160.0	270.0
Maximum MLR Rate	:1		14.8	14.6	15.0
Typical MLR Rate(1)	:1		11.0	14.6	11.5
Minimum MLR Rate	:1		2.5	2.4	2.5

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 for Stage 1 should be able to be met provided carbon dosing occurs.

The same cannot be said for Ultimate. The performance predictions and conservatism built into nitrification performance suggests that the performance could get close to the Ultimate TN target of 1.9 mg/L, but with little confidence. It may be that post bioreactor denitrification bioreactors are found to be required in the long term. Site area provision has been made for this. The predictions in Table 5-14 are for typical temperature conditions and represent NorBE (annual 50%ile) conditions.

Table 5-14 Denitrification Predictions

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Temperature	°C	20			
Overall COD:N Ratio		7.92			
NO_x-N:O Ratio		2.86			

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Active Mass	kgVASS		3472	3459	5954
Selector Fraction			2.0%	2.0%	2.0%
Primary Anoxic COD Dose	mg/L		0	39	0
SBCOD Entering Selector	kgCOD/d		501	722	851
Selector Denitrification Potential	kgN/d		55	54	92
DO-N Entering Selector	kgN/d		1	1	2
NO_x-N Entering Selector	kgN/d		5	8	7
NO_x-N Removed in Selector	kgN/d		5	8	7
Primary Anoxic Fraction			38.3%	38.3%	38.3%
SBCOD Entering 1st Anoxic	kgCOD/d		501	709	851
1st Anoxic Denit Potential	kgN/d		191	217	323
DO-N Entering 1st Anoxic	kgN/d		33	48	58
NO_x-N Entering 1st Anoxic	kgN/d		158	168	265
NO_x-N Removed in 1st Anoxic	kgN/d		158	168	265
Optimum MLR Recycle Rate			11.0	14.6	11.5
NO_x-N Entering 1st Aerobic	kgN/d		0	0	0
NO_x-N Created in 1st Aerobic	kgN/d		189	193	320
NO_x-N Entering De-Aeration	kgN/d		158	168	265
NO_x-N Not Recycled in MLR	kgN/d		31	25	55
DO in 1st Aerobic	mg/L		2.0	2.0	2.0
Secondary Anoxic Fraction			8.8%	8.8%	8.8%
Secondary Anoxic COD Dose	mg/L		26	0	30
SBCOD Entering 2nd Anoxic	kgCOD/d		146	0	282
2nd Anoxic Denit Potential	kgN/d		39	0	71
DO-N Entering 2nd Anoxic	kgN/d		9	0	16
NO_x-N Entering 2nd Anoxic	kgN/d		31	0	55

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
NO_x-N Removed in 2nd Anoxic	kgN/d		31	0	55
NO_x-N Entering 2nd Aerobic	kgN/d		0	0	0
NO_x-N Created in 2nd Aerobic	kgN/d		8	0	14
NO_x-N Leaving 2nd Aerobic	kgN/d		8	0	14
DO in 2nd Aerobic	mg/L		4.0	0.0	4.0
De-Aeration Fraction			4.3%	4.3%	4.3%
De-Aeration Denit Potential	kgN/d		10	10	17
DO-N Entering De-Aeration	kgN/d		43	58	75
DO Removed in De-Aeration	kgN/d		10	10	17
DO Leaving De-Aeration	kgN/d		33	48	58
DO in De-Aeration	mg/L		1.5	1.6	1.5
NO_x-N in De-Aeration	mg/L		2.5	2.0	2.5
Clarifier Fraction			4.9%	4.9%	6.5%
RAS Recycle Rate			1.2	1.2	1.4
RAS Denitrification Potential	kgN/d		12	12	28
DO-N Entering RAS	kgN/d		9	5	18
NO_x-N Entering RAS	kgN/d		4	13	8
NO_x-N Removed in RAS	kgN/d		3	8	8
NO_x-N Leaving RAS	kgN/d		1	6	0
DO in RAS	mg/L		0.0	0.0	0.0
NO_x-N in RAS	mg/L		0.2	0.9	0.0
Nitrification Capacity	kgN/d		197	193	334
NO_x-N in Feed	kgN/d		3	2	7
NO_x-N Denitrified	kgN/d		196	184	335
NO_x-N in Effluent and WAS	kgN/d		4	12	6

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
NO_x-N Denitrified			98%	94%	98%
TN in Effluent	mg/L		2.6	3.9	2.6
NO_x-N in Effluent	mg/L		0.7	2.0	0.6

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 below 4.0 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 performance of the MLE option with no carbon dosing was shown to be within a TN range of around 4.0 to 11.0 mg/L (summer to winter), with a typical annual average of less than 7 mg/L. The actual winter performance is likely to be better than this as the NH_x-N concentration is likely to be 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.

5.11.7 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.

5.12 Aeration System

5.12.1 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 the 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.

5.12.2 Equipment and Instruments

The aeration system consists of the following mechanical equipment and instruments.

- Three (3) variable speed blowers in duty/assist/standby configuration (one additional at Stage 2).
- Three (3) low pressure switches, one for each blower suction (one additional at Stage 2).
- Three (3) high pressure switches, one for each blower discharge (one additional at Stage 2).
- Three (3) temperature elements, one for each blower discharge (one additional at Stage 2).
- Three (3) low flow switches, one for each blower discharge (one additional at Stage 2).
- 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 (one additional at Stage 2).
- Two (2) fixed speed exhaust fans on the blower building.
- One (1) temperature element in the blower building.
- One (1) temperature switch in the blower switch room.
- Six (6) air control valves, three for each bioreactor (three additional at Stage 2).
- Six (6) position elements, one for each air control valve (three additional at Stage 2).
- Six (6) DO elements, three for each bioreactor (three additional at Stage 2).

5.12.3 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 the MLR suction, reduces denitrification effectiveness. Operating at a slightly low DO at the start of the primary aerobic zone 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). A fourth blower is added at Stage 2 (duty/assist/assist/standby). The load increase (20,000 EP to 34,000 EP) is greater than the bioreactor and blower increase (2 to 3). Therefore, the worst case condition for each blower and the aeration system in each bioreactor is Ultimate. However, sizing them for Ultimate would make the blowers and diffusers slightly larger than those for Bowral STP, negating one of the aims of having consistent equipment. Furthermore, if Stage 2 is delayed for many years (e.g. if MVEC take up is delayed), then it may not be possible to find a fourth identical blower or set of diffusers, meaning that the entire aeration system may need to be replaced at Stage 2 anyway.

The logical upgrade strategy for the aeration system is therefore:

- Size each blower and each bioreactor aeration system for Stage 1 loads (10,000 EP per blower and bioreactor).

- Utilise identical equipment to Bowral STP, which will be slightly oversized for Moss Vale STP (10,500 EP per blower and bioreactor).
- Deliver a third 10,500 EP duty blower and third 10,500 EP bioreactor aeration system at Stage 2, assuming that the equipment is still available. If not, then consider replacing the entire system with slightly larger units (see below).
- When the Stage 2 load increases to three by 10,500 EP (31,500 EP) replace the entire aeration system with three by 11,333 EP modules (34,000 EP), but only if found to be necessary.

The diffuser grids are removable. The peak aeration demand for can be delivered with one grid out of service for repair or maintenance. 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 at Stage 1). 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 modulate 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 switch, a temperature element (with a high temperature set point) and a low flow. 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.

5.12.4 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 spray) 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 5-15 for details.

5.12.5 Turndown and Redundancy

The blowers are provided in duty/assist/standby configuration at Stage 1 and duty/assist/assist/standby configuration at Stage 2. The peak demand for the worst case scenario (Ultimate FSB Summer) can be provided if one blower is failed. The average demand can probably be supplied with two blowers failed, but ammonia breakthrough could occur during peak loading periods at Stage 1. This could be accommodated by reducing the DFTF at the lift pump station and utilising the storm ponds as a sewage balance tank.

The system is designed to treat the worst case Ultimate 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, especially at Stage 1. Once again, ammonia breakthrough may occur, but can be offset by using the storm ponds as a sewage balance tank.

There are multiple, removable diffuser grids in each bioreactor. The peak aeration demand can be delivered with one grid out of service for repair or maintenance.

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 at Stage 1 and 13% at Stage 2. Average demand for Current loading is around 40% of the peak demand under Stage 1 loading. Therefore, aeration should be continuous under all conditions without the DO becoming excessive.

5.12.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-15. Worst case sizing is for the Ultimate 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 5-15 Aeration Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB Summer)	Process Design Sizing (Stage 1 MLE Summer)	Process Design Sizing (Ultimate FSB Summer)
Load Peaking Factor	:1	2			
Temperature	^{o}C	28			
Bioreactor MLSS	mg/L		3565	2841	3983

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB Summer)	Process Design Sizing (Stage 1 MLE Summer)	Process Design Sizing (Ultimate FSB Summer)
Oxygen in Effluent and WAS	mg/L		4.0	2.0	4.0
NO_x-N in Effluent and WAS	mg/L		0.7	2.1	0.6
Oxygen in Feed and Spray	kgN/d		1.3	0.7	2.0
Carbonaceous O_2 Demand	kgO/d		1715	1611	2946
Nitrification O_2 Demand	kgO/d		914	912	1552
Denitrification O_2 Payback	kgO/d		580	550	990
Oxygen in Effluent and WAS	kgN/d		7.8	4.0	13.0
Average AOR	kgO/d		2068	1981	3539
Aeration Peaking Factor	:1		1.45	1.46	1.44
Bioreactor Peak AOR	kgO/d		2992	2897	5113
Bioreactor Peak OAR	kgO/h		125	121	213
Bioreactors			**2**	2	3
Bioreactor Peak AOR Each	kgO/h		**62.3**	60.4	71.0
Bioreactor Blowers			**2**	2	3
Blower Peak AOR Each	kgO/h		**62.3**	60.4	71.0
Aeration Alpha Factor (including fouling allowance)			0.55	0.55	0.55
Aeration Beta Factor			0.95	0.95	0.95
Average DO Target	Mg/L		1.5	1.5	1.5
Bioreactor Maximum SOTR	kgO/h		316	306	360
Bioreactor Minimum SOTR	kgO/h		76	73	87
Aerobic Zone 1 Aeration Requirement	% of Total		81	91	91
Anoxic Zone 2 Aeration Requirement	% of Total		13	0	0
Aerobic Zone 2 Aeration Requirement	% of Total		6	9	9

SOTR determined based on ASCE “Measurement of Oxygen Transfer in Clean Water)

The worst case blower size is for Ultimate. However, given the uncertainly of the organic loading from MVEC it is impossible to predict when or even if this loading will be realised. A third blower the size of the Stage 1 blowers should get close to satisfying Ultimate load. It is more than likely that their economic life would be

exceeded before their capacity. Therefore, the blowers are sized for Stage 1 to keep them the same size as those for Bowral STP.

5.12.7 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 and elements 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 as measured by a temperature element 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 element 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.

5.13 Bioreactor Mixing

5.13.1 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.

5.13.2 Equipment and Instruments

The bioreactor mixing system consists of the following mechanical equipment and instruments.

- Two (2) fixed speed, reversible selector mixers, one per bioreactor (one additional at Stage 2).
- Six (6) fixed speed, reversible primary anoxic mixers, three per bioreactor (three additional at Stage 2).
- Four (4) fixed speed, reversible secondary anoxic mixers, two per bioreactor (two additional at Stage 2).
- Two (2) fixed speed, reversible de-aeration mixers, one per bioreactor (one additional at Stage 2).

The aeration equipment detailed in Section 5.12.2 is also used for mixing of the aerobic zones.

5.13.3 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 must be switched off manually once the level risks dry operation.

5.13.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The mixing energy required is based on ‘rule of thumb’ defaults.

The aerated mixing criteria was checked using alternative methods based on air flow criteria. This is detailed further in Section 5.13.6.

See Table 5-16 for details.

5.13.5 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 installed standby mixers, 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.

5.13.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-16. There is no difference between scenarios other than the number of operating mixers.

Table 5-16 Bioreactor Mixing Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
Mixing Power	W/m^3	15		
Selector Each	m^3	74		
Primary Anoxic Each	m^3	1398		
Secondary Anoxic Each	m^3	323		
De-Aeration Each	m^3	157		
Bioreactors			2	3
Selector Mixers Total			**2**	3
Selector Mixers Each	kW		**1.1**	1.1
Primary Anoxic Mixers Total			**6**	9
Primary Anoxic Mixers Each	kW		**7.0**	7.0
Secondary Anoxic Mixers Tot			**4**	6
Secondary Anoxic Mixers Each	kW		**2.4**	2.4
De-Aeration Mixers Total			**2**	3
De-Aeration Mixers Each	kW		**2.4**	2.4

A check of aerated mixing performance of the aerobic zones based on air flow was undertaken. The criteria was that air flow should exceed 2.5 m^3/h/m^2 of reactor surface area. Required air flow rates indicate that the mixing requirement will be exceeded. Mixing should not be limiting, and the blowers should be sized to meet the maximum AOR demand.

5.13.7 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.

5.14 WAS Thickening System

5.14.1 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.

5.14.2 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.

Two digester feed control valves, each with open and closed switches, will be added at Stage 2.

5.14.3 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. Typically, WAS would be drawn from the RAS splitter during this time.
- 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 (Stage 1 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 the 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 his 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 sized for Stage 2 (third bioreactor). 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 exactly doubled (small differences result in 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 must 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 cooling 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.

The WAS and TWAS pumps are sized for Stage 1. They should both be replaced with larger pumps at Stage 2.

5.14.4 Design Assumptions

The following assumptions have been adopted for the process design.

- WAS is assumed to be wasted as ML (worst case).
- The WAS 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 WAS pump is replaced with a larger WAS pump at Stage 2.
- 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 Hunter H2O 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.
- The TWAS pump is replaced with a larger pump at Stage 2.

See Table 5-17 for details.

5.14.5 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 by one in store. 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. See above.

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.

5.14.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-17 and Table 5-18. The limiting condition is MLE mode as this has a lower design sludge age. The pumps are sized to

accommodate Stage 1 volumes and are replaced with larger pumps at Stage 2. The thickener and pipework are sized to accommodate Stage 2 (Ultimate).

Table 5-17 WAS Pumping Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Bioreactor Volume Each	ML	3.655			
Duty WAS Pumps		1			
Design WAS Operation Each	h/d	12			
Bioreactors			**2**	**2**	3
Design Hydraulic SRT	d		23	18	23
WAS Pumps Each	L/s		7.1	7.1	10.6
Maximum WAS Flow	L/s		**7.1**	**7.1**	10.6

Table 5-18 WAS Thickening Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Digester Operating SRT	d	40			
Minimum Digester SRT	d	25			
Thickener Recovery		99%			
Duty TWAS Pumps		**1**			
Thickeners		**1**			
Thickener Diameter Each	m	**10.0**			
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			
Digester Volume	m^3		3013	3013	6026
Target TWAS Volume	ML/d		0.066	0.066	0.131
Scum	ML/d		0.010	0.010	0.019

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
WAS Load	kg/d		1178	1217	2006
TWAS Load	kg/d		1166	1205	1986
Target TWAS Thickness	mg/L		17747	18335	15109
Typical Supernatant Flow	ML/d		0.248	0.330	0.347
Supernatant SS	mg/L		47.6	36.8	57.9
Max TWAS Flow	ML/d		0.111	0.111	**0.222**
TWAS Pumps Each	L/s		**1.3**	1.3	2.6
Thickener SA	m^2		78.5	78.5	78.5
Max Thickener Loading Rate	m/d		7.8	7.8	11.6
Typical Flux	$kg/m^2/d$		15.0	15.5	25.5
Maximum Supernatant Flow	ML/d		0.609	0.609	**0.914**
Maximum Overflow Rate	m/d		7.8	7.8	11.6
Worst Case Capacity	m3		52%	54%	89%

5.14.7 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.

5.15 Filter Feed Control System

5.15.1 Purpose

The purpose of the filter feed control 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.

5.15.2 Equipment and Instruments

The following equipment forms the filter feed control system.

- One (1) filter feed control system level element.
- One (1) filter feed control system level switch.
- One (1) filter feed control valve (duty only).
- One (1) filter feed control valve position element.
- One (1) filter feed flow element.
- One (1) level switch in the filter bypass chamber.
- One (1) level switch in the UV receival pit.

5.15.3 Description

Secondary effluent flows under gravity from the clarifiers to the filter feed control system (FFCS). Emergency storage return flows can also be pumped directly to the filter feed control system as an option.

Flows in excess of DFTF cause the level in the FFCS to rise and overflow to the storm ponds (existing catch/balance ponds). The filter feed control system therefore acts as the hydraulic control for bypasses to the storm ponds and (if they fill) to the existing effluent pond and discharge.

There is a single filter feed control valve (duty only). The filter feed control valve delivers secondary effluent up to the DFTF (set by operator) to the filters. The filter feed flow is monitored. The filter feed control valve is typically open, but will partially close and modulate to cap the filter feed flow to DFTF.

Alum is dosed into the filter feed flocculation chamber to 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.
- Position Mode – Valve position varies with level.
- Backup Mode – Valve adopts a fixed, backup position.

The filter feed flow is monitored and used for the control of the filter feed control valve 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 storm ponds 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 valve to close and latch so as to prevent overtopping of the UV receival pit or UV channel. This should only occur if the UV modulating penstock fails.

5.15.4 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 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 size of the filter feed pipework has been selected such that the control valve needs to be nearly fully open to pass full design flow. This provides a level of inherent protection against severely overloading the tertiary system.
- The active volume of the filter feed control tank 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.
- A future feed (Stage 2) to additional filters and associated flocculation tanks is provided and currently capped.

See Table 5-19 for details.

5.15.5 Turndown and Redundancy

There is a single filter feed control valve (duty only). The failure of the valve could result a diversion to the storm ponds, especially if the flow is high. If the valve fails closed, then the filter feed control system will overflow to the storm ponds. If the filter feed control valve fails wide open (more likely) then the filter feed splitter will overflow to the storm ponds. The valve can be manually adjusted to a known position to ensure that DFTF is sustained. A manual valve is also supplied to allow the control valve to be removed for servicing and replaced with a pipe section. The manual valve position can then limit the flow to DFTF. In short, the modulation of the control valve is there for operational simplicity, accuracy and to optimise filter performance. A manual valve is simply a slightly less effective backup.

The failure of the filter feed flow element results in the valve adopting position control. Filter feed 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 the valve adopting a fixed position. Treatment of all dry weather flows will continue, but filtration performance could suffer due to more rapid changes in filter feed rate.

The valve turndown is virtually limitless.

5.15.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-19. Worst case sizing is for the Ultimate scenario. The entire filter feed system (tank, valve, pipes and splitter) is sized for Ultimate flows.

Table 5-19 Filter Feed Control System Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
Maximum Screen RE	ML/d	0.950		
Maximum Grit RE	ML/d	0.562		
Sewage DFTF	ADWF	3.0		
Filter Feed Valves		**1**		
FFCS Storage at Max Outflow	mins	5		
FFCS Active Volume		100%		
Number of FFCS Tanks	#	**1**		
Sewage ADWF	ML/d		4.600	7.820
Maximum FWPS	ML/d		2.340	3.117
Maximum Bioreactor Spray	ML/d		0.086	0.130
Maximum Filter Feed Flow	ML/d		17.739	28.219
Maximum Filter Feed Flow	L/s		205.3	**326.6**
Filter Feed Valves Each	L/s		205.3	**326.6**
FFCS Volume Each	m^3		77.0	**122.5**

5.15.7 Control Philosophy

There is a no flow set point for the filter feed. An alarm will be generated if the flow through the filter feed flow element is below the no flow set point after the filter feed control valve has been not closed for more than the no flow delay period.

The position of the valve is limited to a Maximum Position set point, regardless of the control mode.

The filter feed control station is fitted with a level element and a high high level switch. The high high level switch indicates that an overflow to the storm ponds is occurring.

The level element is used for level monitoring as well as valve control when in Flow or Position control modes. Failure of this level element results in the valve adopting a fixed backup position. 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 control valve (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 the filter control valve will close, fail and latch.

There are three possible control modes for the filter feed control valve:

- Flow Mode – The level in the filter feed control station is converted to a flow target for the filter feed control valve. The flow target varies with the filter feed control station level, increasing as the level rises and decreasing as the level falls. The filter feed control valve position 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 Position mode.

- Position Mode – The level in the filter feed control station is converted to position targets for the filter feed control valve. The position target varies with the lift pump station level, opening as the level rises and closing as the level falls. 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 control valve adopts a backup position.

5.16 Emergency Storage and Return System

This is covered under Section 5.3.

5.17 Filter Feed Splitter

5.17.1 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 storm splitter or directly to the UV system.
- To prevent dosed alum from bypassing the filters.

5.17.2 Equipment and Instruments

The filter feed system consists of the following mechanical equipment and instruments.

- Two (2) variable speed mixers in the flocculation zone (two additional at Stage 2)

5.17.3 Description

Filter feed is delivered to the filter feed splitter by the filter feed control system. The filter feed is capped to DFTF (operator adjustable) by the filter feed 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 Stage 1 DFTF with three cells in service or Ultimate DFTF with five 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 storm ponds (via the storm splitter). 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 storm ponds 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 (five at Stage 2). 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 storm ponds or filter bypass. The flow remains evenly split between all filters whose valves are open.

Two additional filter cells and associated flocculation tanks are provided at Ultimate. This is fed from a dedicated main from the FFFS. There is slightly less hydraulic loading on each filter at Ultimate.

5.17.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The maximum filter feed control system flow is:
  - The sewage DFTF (3 ADWF only), 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 at Stage 1 is this the maximum filter feed pump control system flow divided by three (one cell on backwash).
- The maximum flow to each filter at Stage 2 is this the maximum filter feed control station flow divided by five (one cell on backwash).
- The maximum filter bypass flow (to the storm ponds or UV units) is the capacity of the filter feed control system.
- 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 5-20.

5.17.5 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 also still occur, but mixing would be driven by flow alone and could be inadequate under low flow periods.

There are no analogue elements in the filter feed splitter.

There is no turndown limitation.

5.17.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-20. Sizing is based on Stage 1 to make the filters identical to those at Bowral STP. The filters are slightly oversized at Ultimate.

Table 5-20 Filter Feed Splitter Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
Minimum Flocculation Time	mins	5.0		
Active Flocculation Volume		100%		
Flocculation Tanks		**1**		
Flocculation Tank Mixers		**2**		
Mixing Power	W/m^3	15		
Maximum Filter Feed Flow	ML/d		17.739	**28.219**
Filter Cells			**4**	6
Minimum Cells on Line			3	5

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
Average Filter Feed Flow	ML/d		5.287	8.834
Maximum Feed Per Cell	ML/d		5.913	5.644
Maximum Feed Per Cell	L/s		**68.4**	65.3
Maximum Filter Bypass	ML/d		17.739	28.219
Maximum Filter Bypass	L/s		205.3	**326.6**
Flocculation Tank Volume	m^3		62	**98**
Flocculation Mixer Each	kW		**0.5**	0.7

5.17.7 Control Philosophy

There is no automated control of the mixers. The operator merely selects them as on or off and sets their speed. An alarm is generated if either mixer fails.

5.18 Tertiary Filtration

5.18.1 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.

5.18.2 Equipment and Instruments

The tertiary filtration system consists of the following mechanical equipment and instruments.

- Four (4) filter feed valves (duty/duty/duty/duty), (two additional at Stage 2), one per filter.
- Four (4) open proximity switches (two additional at Stage 2), one per feed valve.
- Four (4) closed proximity switches, (two additional at Stage 2), one per feed valve.
- Four (4) filter effluent valves (duty/duty/duty/duty), (two additional at Stage 2), one per filter.
- Four (4) position elements, (two additional at Stage 2), one per effluent valve.
- Four (4) filter ripening valves (duty/duty/duty/duty), (two additional at Stage 2), one per filter.
- Four (4) position elements, (two additional at Stage 2), one per ripening valve.
- Four (4) filter dirty backwash valves (duty/duty/duty/duty), (two additional at Stage 2), one per filter.
- Four (4) open proximity switches, (two additional at Stage 2), one per dirty backwash valve.
- Four (4) closed proximity switches, (two additional at Stage 2), one per dirty backwash valve.
- Four (4) filter clean backwash valves (duty/duty/duty/duty), (two additional at Stage 2), one per filter.
- Four (4) open proximity switches, (two additional at Stage 2), one per clean backwash valve.
- Four (4) closed proximity switches, (two additional at Stage 2), one per clean backwash valve.
- Four (4) filter air scour valves (duty/duty/duty/duty), (two additional at Stage 2), one per filter.
- Four (4) open proximity switches, (two additional at Stage 2), one per air scour valve.
- Four (4) closed proximity switches, (two additional at Stage 2), one per air scour valve.
- Four (4) filter air bleed valves (duty/duty/duty/duty), (two additional at Stage 2), one per filter.
- Four (4) open proximity switches, (two additional at Stage 2), one per air bleed valve.

- Four (4) closed proximity switches, (two additional at Stage 2), one per air bleed valve.
- Four (4) filter level elements, (two additional at Stage 2), one per filter.
- Four (4) filter differential pressure elements, (two additional at Stage 2), 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) temperature elements, 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.

5.18.3 Description

Secondary effluent from the filter feed control system gravitates 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, sand and coal. Each layer is of a uniform grain size and density. The coal layer provided 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) at Stage 1, with two additional filters at Stage 2 (total of six). The Stage 2 filters are part of a separate structure comprising the two cells and dedicated flocculation tanks. Flow distribution is achieved by actuated flow valves on the feed lines from the FFFS. The ratio between flows changes depending on available filter cells within each filter structure. Flow is split evenly between the operating cells within a structure with the use of filter feed bellmouths. Any cell can be taken out of service simply by manually closing its feed valve. A filter cell should ideally be backwashed before being left out of service.

Each cell has 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. Stage 2 filter cells utilise the dirty backwash and clean backwash tanks constructed as part of Stage 1.

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 storm ponds, 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). The dirty backwash pumps are replaced with larger pumps at Stage 2 to empty the dirty backwash tank faster. This provides for up to twelve backwashes per day.

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 breakthrough 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.

The filter cells are sized identically to Bowral STP. The worst case loading per cell is at Stage 1 (four filter cells). There is slightly more spare filtration capacity at Stage 2 (six filter cells). The sizing of the clean backwash tank, clean backwash pumps, our scour blowers and dirty backwash tank are based on filter cell size. Therefore, these do not change at Stage 2. These remain the same size as those at Bowral STP. The common tertiary effluent main and dirty backwash main to the FWPS are sized for Ultimate. The dirty backwash pumps are sized for Stage 1 and replaced with larger pumps at Stage 2.

5.18.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The design for Stage 1 assumes four cells, with no more than one out of service for backwashing at any one time.
- The design for Ultimate assumes six cells, with no more than one out of service for backwashing at any one time.
- The filters must accept DFTF from the filter feed control system (3 ADWF plus plant recycles) with only one cell on backwash or out of service.
- The filters must accept PDWF from the filter feed control system (2 ADWF plus plant recycles) with up to two cells on backwash or out of service.
- The maximum loading rate with all cells in service must be less than 10 m/h.
- The maximum loading rate with one cell out of service must be less than 13 m/h.
- The filters were slightly oversized for Bowral STP so that the same filters and associated equipment could 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 at Stage 1 and 6 per day at Stage 2). 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. These are replaced with larger pumps at Stage 2.
- Separate filter structure and associated flocculation tanks for Stage 2, with flow distribution controlled by actuated valves on FFFS outlet. Flow distribution within filter structures achieved passively via inlet weirs.
- Stage 2 filters utilise Stage 1 clean and dirty backwash tanks.

See Table 5-21 for details.

5.18.5 Turndown and Redundancy

At Stage 1, 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 storm ponds 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, load or staging. There is no need for significant turndown.

5.18.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-21. The sizing does not change significantly with staging, though Stage 1 is limiting on the filter cells. The limiting size for the dirty backwash pumps and main is Ultimate. The main is sized for ultimate, with Stage 1 dirty backwash pumps replaced with larger pumps at Stage 2.

Table 5-21 Filter Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
Filter Cell SA Each	m^2	**20**		
Typical Backwash Rate	m/h	50		
Typical Backwash Duration	min	6		
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		**25%**		
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%		

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
Typical B/W Frequency	h per cell	24		
Worst Case B/W Frequency	h per cell	12		
Dirty Backwash Pumps		**1**		
Backwash Tank Mixers		1		
Solids Recovery		95%		
Maximum Feed SS	mg/L	20.0		
Coal Depth	m	1.5		
Maximum Filter Feed Flow	ML/d		17.739	**28.219**
Filter Cells			**4**	6
Minimum Cells on Line			3	5
Maximum Filter Feed Flow	m^3/h		739	1176
Max SLR During B/W	m/h		12.3	11.8
Max SLR Without B/W	m/h		9.2	9.8
Filter Capacity			95%	98%
Typical Filter Feed SS	mg/L		11.3	11.3
TE SS	mg/L		0.6	0.6
TE TP	mg/L		0.09	0.09
Clean B/W Pumps Each	L/s		**285**	285
Min Backwash Flow	L/s		**85**	85
Min Backwash Rate	m/h		15	15
Air Scour Blowers Each	m^3/h		**1200**	1200
Max Clean B/W Volume	m^3		218	218
Typical Clean B/W Volume	m^3		118	118
Clean B/W Tank Each	m^3		**295**	295
Worst Case B/W Stored			1.1	1.1
Typical Dirty B/W Volume	m^3		118	118
Dirty B/W Tank Each	m^3		**236**	236
Worst Case B/W Stored			1.1	1.1
Dirty Backwash Pumps Each	L/s		**10.9**	16.4

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
Dirty Backwash	:Feed		8%	7%
Backwash SS	mg/L		120	134
Typical Solids Loading	kg/d		59.8	99.9
Typical Storage	kg/m^3		0.5	0.6
Worst Case Storage	kg/m^3		1.6	1.7

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 effluent solids concentration 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. This was afforded by slightly oversizing the Bowral STP filters so they would meet Moss Vale STP flows. This allowed at Moss Vale STP can be identically sized to those at Bowral STP despite the higher per capita hydraulic contribution and more stringent performance requirements at Moss Vale STP.

5.18.7 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 backwash tank mixer operates in conjunction with the duty backwash pump.

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.

5.19 UV Disinfection

5.19.1 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.

5.19.2 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 (an additional one at Stage 2).
- Three (3) UV intensity (UVI) elements, (an additional one at Stage 2), one per UV bank (subject to supplier configuration).
- Three (3) UV wiper park proximity switches, (an additional one at Stage 2), one for each UV unit (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.

5.19.3 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 storm ponds 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).

At Stage 1, 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. An additional bank is added at Stage 2. The UV channel is designed to accommodate this extra bank. These are sized to treat 3 ADWF plus recycles. At Stage 1, 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 and 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 buffering in the filter feed control system should maintain near continuous flow through the UV unit, except when a 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. 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 elements 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 achieve 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.

There is a high level switch in the UV receival pit. This closes the filter feed control valve 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 control valve is told to close. 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.

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.

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 a 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.

5.19.4 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 control system, being:
  - Sewage DFTF (3ADWF), plus
  - Maximum screen RE flow, plus
  - Maximum grit RE flow, plus
  - Maximum FWPS capacity, plus
  - Maximum bioreactor RE flow.

See Table 5-22 for details.

5.19.5 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. A further bank will be required at Stage 2 to treat ultimate flows.

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 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.

5.19.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-22. Worst case sizing for the UV channel and conduits is Ultimate. The worst case sizing for each UV bank is Stage 1.

Table 5-22 UV System Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
Design UVT		60%		
UV Banks			**3**	5
Maximum UV Feed Flow	ML/d		17.739	28.219
Maximum UV Feed Flow	L/s		205.3	**326.6**
UV Banks Each	L/s		**68.4**	65.3

5.19.7 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.

5.20 Reclaimed Effluent System

5.20.1 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 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 (including storm storages)
- The supply RE for grounds watering.
- To maintain the RE in an appropriate pressure range.
- To discharge excess final effluent to the discharge point.
- To monitor and record the flow of RE and final effluent.

5.20.2 Equipment and Instruments

The reclaimed effluent (RE) system consists of the following mechanical equipment and instruments. The RE pumping system is based on a typical pressure system with three pump and is subject to supplier configuration.

- 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) 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.

5.20.3 Description

There are a number of uses for non-potable water around the STP site. These are:

- 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 storm ponds 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.

Recycled effluent is chlorinated and stored in an RE tank. 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 an RE tank with the use of an 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 (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 designed for Ultimate as there is little difference in pump size. The pumps are pressure controlled. This system discharges to a pressurised ring main around the site. The pressure is monitored and alarmed.

During most of the day, the disinfected effluent flow should exceed the RE demand.

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 main. 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.

5.20.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The RE pumps are sized to accommodate:
  - 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.

See Table 5-23 for details.

5.20.5 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 (if used by the supplier) is critical to RE control. It is rare for such an element to fail.

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.

5.20.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-23. Sizing is largely independent of scenarios as it is based on equipment and cleaning requirements, which should be identical under all scenarios. The exception is the additional spray for the third bioreactor at Stage 2. Therefore, sizing is based on Ultimate.

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 5-23 Reclaimed Effluent Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
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**		
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

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
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	1.5
Reactor Spray Operation	h/d		12.0	12.0
Reactor Spray Use	m^3/d		43	65
Dewatering RE Max Flow	L/s		5.5	5.5
Dewatering Operation	h/d		3.7	7.3
Dewatering RE Use	m^3/d		73	145
Watering RE Use	m^3/d		4	4
Total RE Use	m^3/d		222	316
Total RE Max Flow	L/s		25.0	**25.5**
RE Pumps Each	L/s		12.5	**12.8**
Total RE Operation	h/d		2.5	3.4
Time to Fill RE Tank	mins		67	67
Overnight RE Use	m^3/h		17	18
Overnight RE Use	ADWF		0.09	0.05
RE Storage at Max Demand	h		0.3	0.3
RE Storage at Average Demand	h		3.0	2.1
Storage at Overnight Demand	h		1.7	1.6

5.20.7 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.

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.

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.

Backup Mode

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 an 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. This 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.

5.21 Aerobic Digester

5.21.1 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 thicken the digested waste activated sludge (DWAS) if required to reduce dewatering time.
- To provide a consistent DWAS thickness to help optimise dewatering.

5.21.2 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).

5.21.3 Description

One of the pre-existing IDEA bioreactors has been re-used as an aerobic digester, including some of the equipment. The second pre-existing bioreactor will be required to be converted to a second aerobic digester at Stage 2. Until then, it will remain disused.

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 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.

At Stage 2, the digester feed (TWAS plus scum) will be switched between the two digesters with the use of actuated feed valves. Timer control will be used to ensure an even loading between the two digesters. The feed timing can be linked to the phase timing of the digester. For example, the feed can be timed to start when the first zone of the digester is aerating. At Stage 1, feed is near continuous to the single digester.

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 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 is divided into three zones with the use of retrofitted, submerged baffle walls. This provides the following advantages:

- This creates plug flow conditions, improving stabilisation performance for the same volume and sludge age.
- It allows aeration to be switched between zones, halving the size of the Stage 1 blowers.

The first of the three zones will have roughly half the oxygen demand of the digester. Therefore, aeration switches between zone 1 and zone 2&3 (in parallel). The duty blower operates continuously.

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:

- Zone 1 Aerate – The contents of zone 1 are mixed through diffused 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. Zones 2&3 remain unaerated and may settle somewhat.

- Zone 1 Settle – Aeration switches to zones 2&3. The zone 1 contents stop mixing and begin to settle. 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 Zone 1 Settle only, when zone 3 of 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 the digester gets too thick (high sludge age) then it can get difficult to transfer oxygen and it can become anaerobic. This is undesirable as it can lead to significant odours and poor digestion performance. The design limit for Moss Vale STP is 1.0% in the digester and DWAS, but 1.2% could be tolerable. If the digester is too thin (the sludge age is too short) then the biosolids may not achieve the required stabilisation grade. A thin DWAS also increases the dewatering time each week.

5.21.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The digester dimensions are as per the construction drawings (DWG 12A and 15A).
- 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 5-24 and Table 5-25 for details.

5.21.5 Turndown and Redundancy

There is only one digester at Stage 1. 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.

5.21.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-24 and Table 5-25. Worst case sizing is for the Stage 1, Winter, MLE scenario.

Table 5-24 Digester Geometry

	Units	Process Design Assumptions	Process Design Sizing
Old IDEA Floor Width	m		
Old IDEA Floor Length	m	11.100	
Old IDEA Angled Side Width	m	49.530	
Old IDEA Coping Level (CPL)	m	6.000	
Old IDEA Bottom Water Level (BWL)	m	2.8	
Old IDEA Top Water Level (TWL)	m	4.0	
Old IDEA Batter Slope	:1	3.400	
Old IDEA SA at TWL	m^2		1272
Old IDEA BWL Volume	m^3		2304
Old IDEA TWL Volume	m^3		3013

The process sizing varies between scenarios. The worst case for digester thickness is the Stage 1, 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 Ultimate scenario is not limiting as the increase in digester volume is greater than the increase in sewage and sludge loads.

Table 5-25 Digester Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Ultimate FSB)
Digester Operating SRT	d	40			
Swg NBVSS Mass Loss Rate	d^{-1}	0.06			
Digesters			**1**	1	2
Dewatering Operating	h/w		47.1	47.1	94.2
Max Catch-up Period	h/w		120.9	120.9	73.8
Average Digester Feed Flow	ML/d		0.075	0.075	0.151
Average Digester Feed Load	kg/d		1167	1205	1986
Digester Feed Thickness			1.55%	1.60%	1.32%

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Ultimate FSB)
Typical Fill Depth	m		0.30	0.30	0.18
NHO BVSS Before Digestion	kg/d		141	175	241
NHO BVSS After Digestion	kg/d		16	20	28
Auto BVSS Before Digestion	kg/d		8	9	14
Auto BVSS After Digestion	kg/d		4	4	6
Swg NBVSS Before Digestion	kg/d		394	394	669
Swg NBVSS After Digestion	kg/d		116	116	197
DWAS Thickness			1.01%	1.02%	0.86%
VSS in	kg/d		743	783	1266
VSS out	kg/d		336	346	573
VSS Reduction			54%	55%	54%
BVSS:VSS Out			6%	7%	6%
SOUR	gO/kgSS/h		1.06	1.15	1.06

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 0.6%. 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.

5.21.7 Control Philosophy

The operator enters the digester cycle set points as follows:

- Cycles per Day
- Cycle 1 Start Time (hh:mm)
- Zone 1 Aerate Phase Time (min)

The SCADA calculates the cycle time and the Zone 1 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 digester in each phase is as follows:

- Aerate – The blowers and aeration system operate under automated control (see Section 5.22.7)
- Settle – There is no automated control.

The operation of the DWAS pumping system (see Section 5.22.7) is also linked to the cycle timetable.

5.22 Digester Aeration System

5.22.1 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.

5.22.2 Equipment and Instruments

The aeration system consists of the following mechanical equipment and instruments.

- Two (2) variable speed blowers in duty/standby configuration (one additional at Stage 2).
- Two (2) low pressure switches, one for each blower suction (one additional at Stage 2).
- Two (2) high pressure switches, one for each blower discharge (one additional at Stage 2).
- Two (2) temperature elements, one for each blower discharge (one additional at Stage 2).
- Two (2) low flow switches, one for each blower discharge (one additional at Stage 2).
- One (1) pressure element on the digester air main (one additional at Stage 2).
- One (1) temperature element on the digester air main (one additional at Stage 2).
- One (1) flow element for the digester air main (one additional at Stage 2).
- Two (2) fixed speed exhaust fans on the blower building.
- One (1) temperature element in the blower building.
- Two (2) air control valves for the digester (two additional at Stage 2).
- Two (2) position elements, one for each air control valve (two additional at Stage 2).
- Two (2) DO elements for the digester (two additional at Stage 2).
- One (1) digester temperature and pH element (one additional at Stage 2).
- One (1) ACL level switch in the digester (one additional at Stage 2).

Two control valves and associated open and closed switches will need to be added at Stage 2 to provide duty allocation of the standby blower.

5.22.3 Description

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 and filtrate. 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.

The existing diffused aeration system will be replaced as part of the Stage 1 upgrade. The existing aeration blowers and diffusers are past their practical life. The replacement diffused aeration system will consist of duty/standby blowers and removable course bubble diffusers.

The digester is separated into three zones with retrofitted baffle walls. The first zone will have roughly half the overall oxygen demand. Therefore the number of diffusers in the first zone is equal to the number of diffusers in the second and third zone combined.

The air is switched between the first zone and the other two zones (in parallel) with the use of air control valves. This allows the duty blower to operate continuously, halving the blower size and extending the blower life. These valves open and close based on the digester cycle and phase map. The open air control valve modulates to sustain a DO set point in the associated zone.

There is a DO element in zone 1 and zone 2 of the digester. These are used for monitoring, alarming and control. A pH and temperature element is 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, backup control consists of adopting a backup blower speed and air control valve position.

At the start of the Aerate phase of the associated zone, the control valve fully opens resulting in the blower speed increasing. This occurs for a mix period to ensure adequate mixing and re-suspension of settled solids. Aeration control then reverts to DO control, with the associated valve modulating.

The duty blower stops and is inhibited if:

- The decanter is not in the WRL position, or
- The ACL level switch is activated.

This is aimed at preventing biomass overtopping the overflow weir during aeration

A second digester is provided at Stage 2. An identical aeration system will be provided at that time, including diffusers, air control valves, elements and a third blower. There will be a dedicated duty blower for each digester so that they can operate at different levels. Two additional control valves will allow the utilisation of a common standby blower. The aeration demand per digester is slightly less at Stage 2, but the Stage 1 blower size should not cause turndown issues. If the blowers have exceeded their practical life by the time Stage 2 is constructed, then they could be replaced by smaller blowers.

5.22.4 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.

See Table 5-26 for details.

5.22.5 Turndown and Redundancy

There are a number of aeration diffusers banks in each zone. The worst case oxygen demand should be met with one bank out of service.

There are duty/standby blowers. The failure of a single blower has no impact on aeration. Failure of both blowers can be accommodated by bypassing the digester and utilising a pre-existing sludge lagoon.

Backup control is provided if DO or other instruments fail.

The blower turndown should be sufficient for Commissioning loads. The blower can also be operated intermittently. This should provide sufficient turndown for any likely condition.

5.22.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-26. Worst case sizing is for the Stage 1, Summer, MLE scenario.

Table 5-26 Digester Aeration Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Oxygen in S/N and DWAS	mg/L	1.0			
Aeration Time per Zone	h/d	12			
Blower Operation	h/d	24			
Sludge Age	d	40			
Number of Cycles per Day		6			
Temperature	^{o}C		28.0	28.0	28.0
Digester Volume	m^3		3013	3013	6026
Denitrification Potential	kgN/d		29.5	34.2	50.6
NO_x-N in Supernatant and DWAS	mg/L		80.7	37.3	80.1
Oxygen in Digester Feed	kgN/d		0.1	0.1	0.2
Carbonaceous Demand	kgO/d		517.8	537.8	882.5
Nitrification Demand	kgO/d		133.6	139.6	228.0
Denitrification Payback	kgO/d		66.4	79.7	108.5
Oxygen in DWAS	kgN/d		0.0	0.0	0.1
Average AOR	kgO/d		584.7	597.5	1001.6
Peak AOR	kgO/h		24.4	24.9	41.7
Number of Blowers			1	**1**	2
Peak AOR per Blower	kgO/h		24.4	**24.9**	20.9
Aeration Alpha Factor (including fouling allowance)			0.3	0.3	0.3
Aeration Beta Factor			0.95	0.95	0.95

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Average DO Target	Mg/L		1.5	1.5	1.5
Digester Maximum SOTR	kgO/h		111	113	95

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 5-26.

5.22.7 Control Philosophy

Two 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 duty will change automatically once the duty time has expired.

There are two DO elements. The real time DO and a rolling average DO for each is monitored and displayed. The average DO for each DO element when its zone is in the Aerate phase is also calculated and displayed for today and yesterday. Each of the two 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 (if the zone is in the Aerate phase) for more than a DO alarm delay time.

There are two aeration control valves. Each control valve uses one DO element for control. If a DO element fails, then the valve using it for control will retain its current position. Each valve, when open, modulates to try to maintain the rolling average DO at the DO target.

There is a control valve for zone 1 and another control valve for zones 2 & 3. These open and close based on the digester cycle and phase map. During the Zone 1 Aerate phase, the control valve for zone 1 will be open and the control valve for Zone 2 & 3 will be closed. During the Zone 2 Settle phase, the control valve for zone 1 will be closed and the control vale for zones 2&3 will be open. At least one valve should be open at all times. The duty blower will be inhibited if both valves are fully closed.

The following occurs when the phase change from Zone 1 Aerate to Zone 1 Settle:

- The mix timer starts.
- The DO alarms are inhibited.
- The zone 2 & 3 valve fully opens and the Zone 1 valve fully closes.
- Once the mix duration time expires, the zone 2 &3 valve begins to modulate and the DO alarms for zone 2 is enabled.

The following occurs when the phase change from Zone 1 Settle to Zone 1 Aerate:

- The mix timer starts.
- The DO alarms are inhibited.
- The zone 1 valve fully opens and the Zone 2 & 3 valve fully closes.
- Once the mix duration time expires, the zone 1 valve begins to modulate and the DO alarms for zone 1 are enabled.

There are a number of switches and elements 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).
- Both control valves closed (inhibit the duty blower).

There are two blower room exhaust fans in duty/duty configuration. If the temperature is sustained above a high temperature as measured by a temperature element 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 element in the switchroom. This generates an alarm but there is no automated response.

The pressure and temperature in the digester air main are monitored continuously. These values are converted to normalised air flow in the SCADA. This normalised air flow is integrated to provide a normalised air volume for the current day (since midnight) and the previous day (midnight to midnight).

There are two possible control modes for the duty blower. These are:

- Pressure Mode – The blower speed modulates to try to sustain the pressure target in the digester pressure main.
- Constant Speed Mode – The blower speed matches the backup speed set point.

Pressure Mode relies on the pressure element in the digester air main. The failure of the pressure element results in the control switching to Constant Speed mode. The operator can also select Constant Speed mode.

The pH and Temperature are all monitored in real time. The average pH and temperature for today and yesterday is calculated, displayed and recorded.

The duty blower is inhibited from operating if:

- The WRL position switch is not activated, or
- The ACL level switch is activated.

The duty blower can operate once these conditions no longer exist.

5.23 DWAS Pumping and Storage System

5.23.1 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 Zone 2 & 3 Aerate phases in the aerobic digester.
- To transfer DWAS to the sludge lagoons under emergency conditions.

5.23.2 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 additional at Stage 2).
- 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.

5.23.3 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 zones 2 & 3 of the digester are in the Aerate phase and provide buffer storage to allow dewatering to continue while they are in the Settle and phase. The dewatering feed tank capacity has been sized to accommodate up to two hours of maximum Stage 1 dewatering feed flow. Two hours should cover the longest realistic zone 2 & 3 Settle phase time.

There will be two digesters at Stage 2. It is assumed that these will be aerated out of phase with each other. Therefore, one of the digesters will always have a mixed zone 2 & 3 to draw DWAS from. Therefore, the storage volume is no longer required, other than to buffer short term failure or inhibition of the DWAS pumps. The worst case condition for sizing the dewatering feed tank volume is therefore Stage 1. The required volume at Stage 2 will be less, even if a third dewatering train is added later. The buffer time will still be 80 minutes at maximum dewatering throughput, which should provide adequate contingency.

The dewatering feed tank can also be filled with undigested TWAS. This allows the digester to be taken out of service. There is no automated system for filling the dewatering feed tank with the TWAS pumps (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. 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.

5.23.4 Design Assumptions

The following assumptions have been adopted for the process design.

- The digester TWL volume is as outlined in Table 5-24.
- 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 tank includes sufficient capacity for the longest likely zone 2 & 3 Settle phase time.
- The size of the jet aerator is based on rule of thumb mixing criteria. This will be confirmed by suppliers.

See Table 5-27 for details.

5.23.5 Turndown and Redundancy

There is a single duty DWAS pump. Dewatering can continue for many hours 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.

5.23.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-27. The Current and Stage MLE scenarios (Winter) are provided to show the difference between one and two dewatering trains. The Stage 1 FSB scenarios are almost identical, but with slightly less solids in the dewatering feed (longer bioreactor sludge age).

Table 5-27 DWAS Pumping and Storage System Sizing

	Units	Process Design Assumptions	Process Design Sizing (Current MLE)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Typical Digester SRT	d	40			
Max Dewatering Operation	h/w	100			
DWAS Buffer Storage	h	2.0			
DWAS Buffer Tanks		**1**			
Effective Volume		100%			
DWAS Pump Each	L/s	**15**			
DWAS Buffer Tank Jet Pumps		**1**			
DWAS Mixing Power	W/m^3	40			
Digester Volume Total	m^3		3013	3013	6026
Number of DWAS Pumps			1	**1**	2
Max Dewatering Feed	m^3/h		6.5	13.0	13.0
Average Dewater Feed Solids	kg/d		426	768	1293
Typical Dewatering Operation	h/w		94.2	47.1	94.2
Typical Dewatering Load	kg/h		32	114	96
Average Digester Thickness			0.57%	1.02%	0.86%
Typical Feed Solids[(1)]			0.49%	0.88%	0.74%

	Units	Process Design Assumptions	Process Design Sizing (Current MLE)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Minimum Digester SRT	d		37.7	18.8	37.7
DWAS Buffer Tanks Each	m^3		13	**26**	26
Jet Pump Motor Each	kW		0.5	**1.0**	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 Stage 1 and Stage 2 scenarios). However, only one train will initially be provided. This is reflected in the Current scenario. Provision is made for installing a third dewatering train at Stage 2 if deemed required. The design will accommodate this, but it has not been modelled.

5.23.7 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 5.24.7) 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 5.24.7). 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. The DWAS pump is inhibited from operating unless zones 2 & 3 of 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.

There are two termination triggers for the DWAS pump. These are:

- Volume trigger – The DWAS pump becomes Unavailable once the weekly DWAS volume has been achieved.
- Duration trigger – The DWAS pump becomes Unavailable once the weekly DWAS duration has been achieved.

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 zones 2 & 3 of the digester are 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 zones 2 & 3 of the digester are 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 zones 2 & 3 of 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 zones 2 & 3 of the digester are 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.

5.24 Sludge Dewatering

5.24.1 Purpose

The purpose of sludge dewatering is:

- To dewater biosolids to reduce transport and disposal costs.
- To convey biosolids to a prime mover trailer.
- 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.

5.24.2 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 (Stage 1 scenarios) caters for a second train to be added later if needed. There is also a provision for a third train if ever required in the future, but this has not been modelled.

- Two (2) variable speed dewatering feed pumps (duty/standby), (provision for third).
- Two (2) temperatures switches, one for each dewatering feed pump, (provision for third).
- Two (2) fixed speed cooling fans, one for each dewatering feed pump drive, (provision for third).
- Two (2) pressure switches, one for each dewatering feed pump, (provision for third).
- One (1) flow switch for the dewatering feed pump pressure relief
- One (1) dewatering feed flow element (one additional at Stage 2 and provision for third).
- Two (2) variable speed polymer dosing pumps (duty/standby), (provision for third).
- Two (2) temperature switches, one for each polymer dosing pump stator, (provision for third).
- Two (2) fixed speed cooling fans, one for each polymer dosing pump drive, (provision for third).
- Two (2) flow switches, one for each polymer dosing pump, (provision for third).
- One (1) flow switch for the polymer dosing pump pressure relief.
- Two (2) polymer dilution water solenoid valves, (provision for third).
- Two (2) flow switches, one for each polymer dilution water supply, (provision for third).
- One (1) variable speed, reversible dewatering screw press (one additional at Stage 2, provision for third).

- One (1) torque switch for the dewatering screw press (one additional at Stage 2, provision for third).
- One (1) torque element for the dewatering screw press (one additional at Stage 2, provision for third).
- One (1) pressure element for the dewatering screw press (one additional at Stage 2, provision for third).
- One (1) solenoid valve of the screw press wash water (one additional at Stage 2, provision for third).
- One (1) flow switch on the screw press wash water (one additional at Stage 2, provision for third).
- 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 (one additional at Stage 2, provision for third).
- One (1) dewatering screw press pressure cone solenoid valve (one additional at Stage 2, provision for third).
- 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 5.25.2).

The dewatering feed tank level element and switches are also used (see Section 5.23.2).

5.24.3 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 Stage 1 design as a future option. The second dewatering train will be required at Stage 2, with provision for a third at Stage 2 and beyond if needed. The intent will be to run 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. The filtrate and FWPS pump and conduits may need to be augmented if three trains are operated in parallel in the future. Similarly, the conveyors may also require augmentation. This description is based on the single dewatering train (Current scenario). The duty/standby feed pumps and polymer dosing pumps become duty/duty when dual thickeners are operated.

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 for many days 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 (and possibly third), 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.

5.24.4 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 5.25 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 is based on supplier advice and experience.
- The biosolids bulk density is based on experience.

See Table 5-28 for details.

5.24.5 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 pre-existing sludge lagoon 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 storing 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.

5.24.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-28. The worst case for flows is Stage 2 (two dewatering trains), Winter, MLE. The worst case for operating period is Current (one dewatering train), Winter, MLE or Ultimate (two dewatering trains), Winter FSB. The operating period does not change with load, only the number of digesters. The conveyors, RE supply and filtrate systems are based on the two dewatering train scenarios so that a second train can be added in the future. If a third train is added and operated in parallel, then the capacity of some systems and units may need to be assessed and augmented. These include:

- The filtrate system
- The foul water system
- The biosolids conveyors

The cost of upgrade should be minor, may not ever be required, and even if required, should be a long time in the future. The alternative would be to design systems and purchase equipment that may never be fully utilised. In short, the dewatering building, layout and electrical provisions assume three dewatering trains, but the Stage 2 equipment and minor conduits assume only two trains operating in parallel.

Table 5-28 Sludge Dewatering Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Current MLE)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
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**			
Duty Cross Conveyors		**1**			
Duty Slewing Conveyors		**1**			
Dewatering Trains			**1**	2	2

	Units	Process Design Assumptions	Process Design Sizing (Current MLE)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Typical Dewatering Flow(1)	m^3/h		5.6	11.2	11.2
Dewatering Feed Pumps			**1**	2	2
Duty Dewatering Units			**1**	2	2
Average Carrier Water Use	m^3/d		2.5	5.0	5.0
Dewatering Spray Water Total	L/s		12	12	24
Average Spray Water Use	m^3/d		61	61	121
Dewatering RE	L/s		2.8	5.5	5.5
Average Dry Biosolids	kg/d		405	719	1211
Average Biosolids Wet Mass	Wet T/d		2.3	4.0	6.7
Average Biosolids Volume	m^3/d		2.6	4.7	7.9
Typical Dewatering Operation	h/w		94	47	94
Max Dewatering Load	kg/h		31.7	114.2	96.1
DWAS Thickness			0.57%	1.02%	0.86%
VSS:TSS Ratio			45%	45%	44%
Dewatering Feed Pumps Each	L/s		**1.8**	1.8	1.8
Dewatering Feed Pumps Each	m^3/h		**6.5**	6.5	6.5
Dewatering Capacity Each	m^3/h		**6.5**	6.5	6.5
Dewatering Capacity Each	kg/h		31.7	**57.1**	48.1
Max Conveyor Flux	Wet T/h		0.17	**0.60**	0.51
Max Conveyor Flow	m^3/h		0.20	**0.71**	0.60
Biosolids Weekly Storage	Wet T		15.8	28.4	47.8
Biosolids Weekly Storage	m^3		18.5	33.4	56.2
Average Filtrate Flow	ML/d		0.146	0.144	0.289
Maximum Filtrate Flow	L/s		4.6	**9.1**	9.1
Filtrate SS	mg/L		146	267	224

Note (1) – The maximum carrier water flow is subtracted from the hydraulic capacity to obtain the dewatering feed pump flow.

5.24.7 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 or third 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 adjusted 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 following 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 operator 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 counter 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 pump results in it being allocated as standby. The SCADA will automatically change the duty 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.

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 be inhibited 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 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 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 inhibit 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.
- 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 a 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.

5.25 Polymer Make-Up Storage and Dosing

5.25.1 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.

5.25.2 Equipment and Instruments

The polymer make-up, storage and dosing system consists of the following mechanical equipment and instruments. These are based on an 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 5.24.2.

5.25.3 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 Moss Vale 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 5.24.3 for dosing details. A low level in the polymer dosing tank inhibits the dewatering feed pumps, which will eventually lead to dewatering shut-down.

5.25.4 Design Assumptions

The following assumptions have been adopted for the process design.

- 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 5-29 for details.

5.25.5 Turndown and Redundancy

The polymer make up system equipment is all duty only. The failure of the polymer feeder screw, polymer mixers, or polymer dosing tank level element 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.

Polymer dosing pumps are provided in duty / standby and have sufficient turndown for all scenarios. Additional turndown can be achieved by altering the polymer solution strength.

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.

5.25.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-29. 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 (Stage 1) scenarios. More frequent batching would be required under Ultimate scenarios. This may require the replacement of the system at Stage 2.

Table 5-29 Polymer Make-Up Storage and Dosing Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Current MLE)	Process Design Sizing (Stage 1 MLE)
Maximum Polymer Dose	kg/DST	10.0		
Average Polymer Dose	kg/DST	5.0		
Poly Make-Up Concentration	w/w	0.5%		
Poly Dosing 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		3.0	5.4
Min Dewatering Operation	h/w		94.2	47.1
Dewatering Feed	DST/h		0.03	0.11
Max Dry Polymer Dose	dry kg/h		0.3	**1.1**
Average Dry Polymer Use	dry kg/d		2.1	3.9
Max Polymer Use	L/h		63	229
Min Batching Frequency	h		13.1	3.7
Typical Batching Frequency	h		26.2	7.3
Polymer Dosing Pump Each	L/h		63	**114**
Minimum Dilution	w/w		0.03%	0.06%
Typical Dilution	w/w		0.02%	0.03%

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.

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 5.24.7.

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.

5.26 Biosolids Storage Area

5.26.1 Purpose

The purpose of the biosolids storage area;

- 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.

5.26.2 Equipment and Instruments

There is no equipment or instruments associated with the storage area.

5.26.3 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 storage area.

The slewing conveyor can be pivoted to discharge into the edge of the storage area, however biosolids need to be manually transported throughout the storage area. Manual loading into a truck trailer will then be required.

5.26.4 Design Assumptions

There is no process sizing associated with the associated biosolids storage area

5.26.5 Turndown and Redundancy

The biosolids hardstand is not typically required.

5.26.6 Process Sizing

There is no process sizing associated with the storage area.

5.26.7 Control Philosophy

There is no automated control of the biosolids storage area.

5.27 Foul Water Pump Station

5.27.1 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 storm ponds.

5.27.2 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.

5.27.3 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.
- Supernatant from the WAS thickener.
- Filtrate and washdown from the dewatering facility.

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 storm ponds. 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.

The volume of the FWPS and the rising main to the bioreactor feed splitter are sized for Ultimate conditions. As explained in Section 5.24, this is based on two dewatering trains operating in parallel. If a third dewatering train is ever added and operated in parallel, then the rising main may need to be assessed. The FWPS pumps are sized for Stage 1 (with two dewatering trains) and will need to be replaced with larger pumps at Stage 2.

This is intentional to limit the maximum FWPS flow until the additional bioreactors and clarifiers. The alternative would be to unnecessarily oversize the secondary treatment facilities.

5.27.4 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 (two dewatering trains), plus
  - The maximum polymer dilution water flow (two dewatering trains), plus
  - The maximum screw press wash water flow (two dewatering trains).
- Other flows are assumed to be negligible.
- The dirty backwash pumps and WAS pump are assumed to be replaced by larger pumps at Stage 2, resulting in a need to also increase the size of the FWPS pumps.
- The storage capacity in the FWPS is based on control and failure objectives only. There is no attempt at flow attenuation.
- The storage capacity in the FWPS should also be sufficient to prevent the maximum starts per hour of the Ultimate duty foul water pump being exceeded.

See Table 5-30 for details.

5.27.5 Turndown and Redundancy

Foul water pumps are provided in duty/standby configuration. The loss of one pump has no impact on operation. Failure of both pumps will lead to a high level inhibition of 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.

5.27.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-30. The worst case for the pumps is the Stage 1 MLE scenario, where there are two parallel dewatering trains. The worst case for the pump station volume and rising main is the Ultimate FSB scenario, also assuming two dewatering trains.

Table 5-30 Foul Water Pump Station Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
FWPS Pumps		**1**			
Number of FWPS Tanks		**1**			
Active Volume		80%			
Storage and Peak Inflow	mins	5.0			

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Maximum Filter Backwash	ML/d		0.944	0.944	1.416
Maximum Supernatant	ML/d		0.609	0.609	0.914
Maximum Dewatering Filtrate	ML/d		0.787	0.787	0.787
Average Foul Water	ML/d		0.864	0.946	1.344
FWPS Capacity	L/s		27.1	27.1	**36.1**
FWPS Pumps Each	L/s		27.1	**27.1**	36.1
FWPS Volume Each	m^3		10.2	10.2	**13.5**

5.27.7 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 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 is 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 5.24.7).
- The dirty backwash pumps are inhibited (see Section 5.18.7).

5.28 Alum Storage and Dosing

5.28.1 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.

5.28.2 Equipment and Instruments

The alum storage and dosing system consists of the following mechanical equipment and instruments.

- Two (2) alum storage tank pressure elements (one additional at Stage 2), doubling as level elements, one for each tank.
- Four (4) alum storage tank level switches, (two additional at Stage 2), 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.

5.28.3 Description

Traditional 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 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:

- To the bioreactors (influent rising main), with precipitants enmeshed in the activated sludge flocs and removed with the WAS.
- 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.
- 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 if 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 inlet lift pump station, 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 sized to contain more than the volume of one storage tank in case of tank or pipe rupture. The bunded area each contains a sump with 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 inlet lift pump station. Large spills should be removed by tanker.

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 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, adjacent to the dosing skid and within the bund. 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.

5.28.4 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 5-31 for details.

5.28.5 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.

5.28.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-31. Worst case sizing for the dosing pumps is based the Ultimate, Summer, FSB scenario. There is no need to replace the pumps at Stage 2. The worst case for storage is the Stage 1, Summer, FSB option. An additional storage tank is required at Stage 2 to maintain the desired storage duration.

Table 5-31 Alum Storage and Dosing Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
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 Tank Volume Each	m^3	**30**			
Usable Volume		80%			
Maximum Filter Feed Flow	ML/d		17.739	17.739	28.219
Effluent SP Without Dosing	mg/L		7.3	7.2	7.4
Max Primary Alum Each	L/h		111.3	111.4	**189.4**
Primary Al Mass Dose	kg/d		66.1	66.2	112.4
Primary Precipitants	kg/d		245	245	417
Primary Solution Use	kg/d		1726	1717	2938
Primary Solution Use	L/d		1328	1321	2260
Max Secondary Alum Each	L/h		29.3	29.3	**46.6**
Secondary Al Mass Dose	kg/d		10.4	10.4	17.3
Secondary Precipitants	kg/d		33	33	56
Secondary Solution Use	kg/d		272	272	455
Secondary Solution Use	L/d		209	209	350
Total Average Alum Usage	L/d		1537	1530	2610
Alum Storage Tanks			**2**	2	3
Storage at Average	d		31.1	31.0	27.4

5.28.7 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 to park 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 each 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 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 each 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 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 one alum 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), 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 secondary 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 dosing pump speed then varies with the combined influent pump speed. This is an approximation for filter feed flow only as attenuation occurs through the bioreactors. The operating description of each mode is covered hereunder.

Dosing Point 3 Flow Paced Mode

The dosing pump is interlocked with the filter feed flow. The dosing pump starts when the filter feed flow is above an operator adjustable minimum setpoint. The filter feed pump starts and stops when the flow falls below the minimum setpoint. 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 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.

5.29 Alkalinity Chemical Storage and Dosing

5.29.1 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.

5.29.2 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).
- One (1) level switch, in the alkalinity bund
- Two (2) variable speed alkalinity dosing pumps (duty/duty), (one additional at Stage 2), one for each bioreactor.
- Two (2) no flow switches, (one additional at Stage 2), one on each dosing pump.
- One (1) dosing pressure relief flow switch.
- Two (2) level switches, (one additional at Stage 2), one for each sodium hydroxide dosing double containment pipe.
- Two (2) combined pH and temperature elements, (one additional at Stage 2), one for each bioreactor.

5.29.3 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 influence 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:

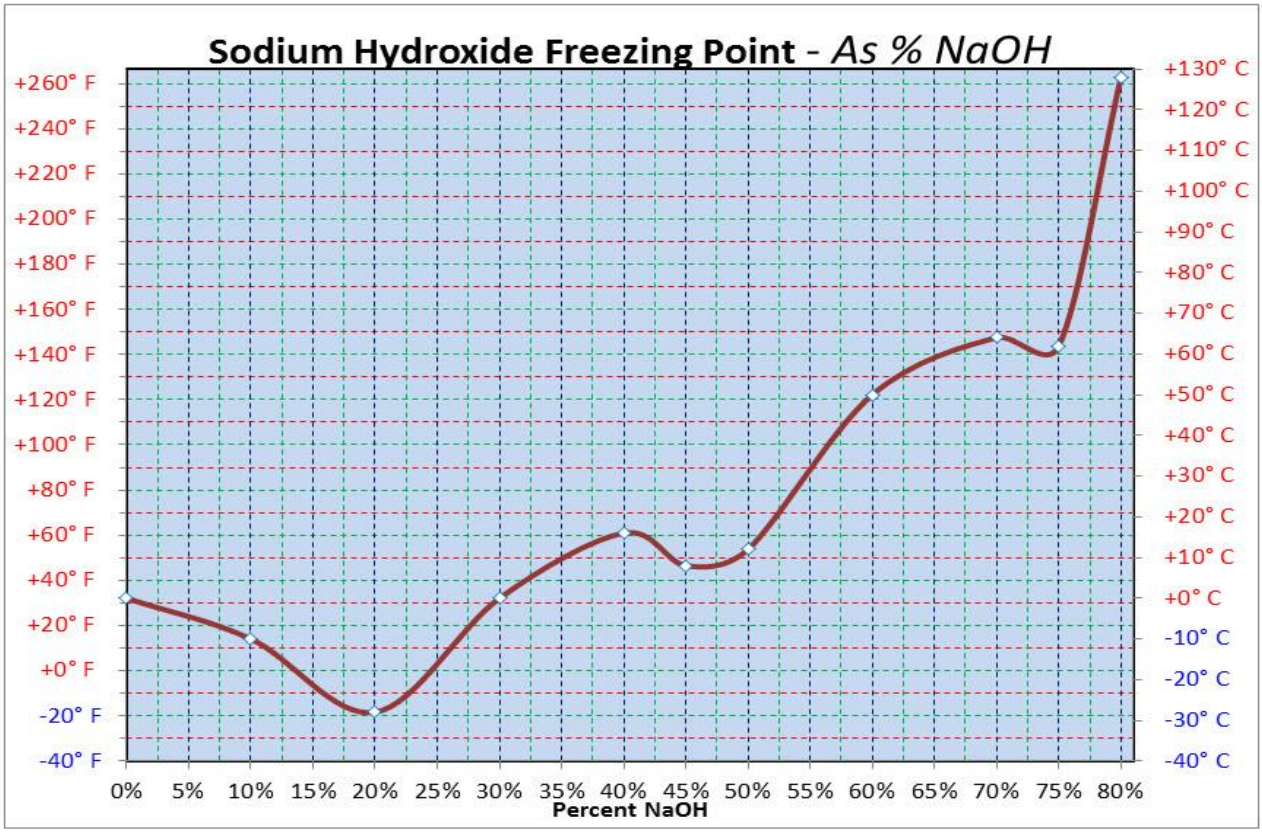
- Quicklime (CaO).
- Hydrated or Slaked Lime ($Ca(OH)_2$).
- Sodium hydroxide or caustic soda (NaOH).
- Sodium carbonate or soda ash (Na_2CO_3).
- Calcium carbonate ($CaCO_3$).

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 ^{o}C. The lowest freezing point is at 20% solution (approaching -30 ^{o}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.

Figure 5-2 Freezing Point of Sodium Hydroxide (Caustic Soda) Solution



Source: https://www.doeingalls.com/liquid-sodium-hydroxide-reaches-freezing-point/

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. 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 inlet lift pump station, from where it can be pumped back for treatment through the STP.

The storage tanks and dosing pumps are located within a bunded area that contains a sump with a level switch and drain line with a manual valve. The valve can be opened to allow rainwater, washdown water or minor spills to drain to the inlet lift pump station. Large spills should be removed by tanker.

Two dosing pumps in duty/duty configuration are provided, one dedicated to each bioreactor. A third pump and associated instrumentation is required to service the third bioreactor at Stage 2. 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.

5.29.4 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.
- An additional dosing pump is provided at Stage 2.

See Table 5-32 for details.

5.29.5 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 of 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. A standby dosing pump is also provided in store.

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 primarily 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.

5.29.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-32. Worst case sizing is based on the Stage 1, Summer, MLE scenario.

Table 5-32 Alkalinity Chemical Storage and Dosing Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
Stored NaOH Content	w/w	25%			
Specific Gravity		1.27			
TE Alkalinity	mg/L	80			
Peaking Factor	:1	2			
Dosing Period	h/d	24			
Tank Volume Each	m^3	30			
Usable Volume		80%			
Alkalinity Content	w/w		31%	31%	31%
Typical Reactor Flow	ML/d		5.609	5.692	9.331
Alkalinity Dosed	mg/L		43.6	47.7	44.2
Dosing Pumps			**2**	2	3
Peak Pump Rate each	L/h		25.8	28.6	**29.0**
Alkalinity Mass Dose	kg/d		245	271	413
Solution Mass Use	kg/d		761	818	1283
Solution Volume Use	L/d		602	646	1014
Number of Alkalinity Tanks			**2**	2	2
Storage at Average	d		77.6	70.0	47.3

5.29.7 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.

There is a high level switch in the sump of the sodium hydroxide dosing bund. An alarm is generated if the either 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 one alkalinity 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 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.

5.30 Carbon Chemical Storage and Dosing

5.30.1 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.

5.30.2 Equipment and Instruments

The carbon chemical storage and dosing system could be deferred depending on the outcomes of negotiations with the regulators. The 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), (one additional at Stage 2).
- Two (2) no flow switches, one on each dosing pump, (one additional at Stage 2).
- Two (2) level switches, one for each dosing line containment pipe, (one additional at Stage 2).
- 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.

5.30.3 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 use carries explosion risk and requires costly storage and dosing facilities. 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 carbon dosing facility at Moss Vale 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 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 inlet lift pump station, 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 inlet lift pump station. Rainwater collection is minimised by having a roof over the bunded area.

Two dosing pumps in duty/duty configuration are provided, one for each bioreactor. A third pump is required at Stage 2 to service the third 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 to 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.

5.30.4 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 5-14).
- The target effluent TN for each scenario as outlined in Section 5.11.
- 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 storage tank has been sized to be identical to the alum and sodium hydroxide storage tanks.

See Table 5-33 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. 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 be 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.

5.30.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-33. Worst case sizing for the storage based on the Ultimate, Winter, FSB scenario. The worst case sizing for the dosing pumps is the Stage 1, 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 5-33 Carbon Storage and Dosing Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1 FSB)	Process Design Sizing (Stage 1 MLE)	Process Design Sizing (Ultimate FSB)
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 Storage Tanks		**1**			
Carbon Tank Volume Each	m^3	**30**			
Usable Volume		80%			
Average Bioreactor Flow	ML/d		5.609	5.692	9.331
Typical COD Dose	mg/L		40.0	50.0	43.4
Typical COD Dose	kg/d		224	285	405
Typical Sucrose Dose	kg/d		200	254	361
Typical Carbon Solution Dose	kg/d		301	381	543
Typical Carbon Solution Dose	L/d		227	288	410
Peak Dose Rate	L/h		37.8	48.0	68.3
Carbon Dosing Pumps			**2**	2	3
Carbon Dosing Pumps Each	L/h		18.9	**24.0**	22.8
Storage at Average	d		106	83	59

5.30.7 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.

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 and booster pump supplying wash water. The hot water service operates based on internal thermostats. The pump and hot water service can be turned on and off in the field. These are not connected to the SCADA.

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.

5.31 Chlorine Chemical Storage and Dosing

5.31.1 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.

5.31.2 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.

5.31.3 Description

Chlorine is dosed to the plant RE only. 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 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.

Potable water can be used to dilute the hypochlorite solution if required (i.e. storage times are resulting in excessive degradation of hypochlorite). This is a manual operation and achieved via the same connection as per the chemical delivery.

5.31.4 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.
- Storage tank sized to allow for transfer of full IBC and allow for dilution
- Dosing pumps sized to allow for 2:1 dilution of hypochlorite with potable water
- The typical RE use is based on individual uses as per the RE system (see Table 5-23).

See Table 5-34 for details.

5.31.5 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.

5.31.6 Process Sizing

Details of the process sizing assumptions and resulting process sizing can be found in Table 5-34. Worst case sizing for the dosing pump is based on the size of the RE lift pump, so does not change with scenarios. The worst case size for the storage is based on the Ultimate scenario.

Table 5-34 Chlorine Chemical Storage and Dosing Process Sizing

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
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	**2.0**		
Chlorine Tank Usable Volume		80%		
Average RE Use	ML/d		0.222	0.316

	Units	Process Design Assumptions	Process Design Sizing (Stage 1)	Process Design Sizing (Ultimate)
Chlorine Solution Mass Use	kg/d		9.3	13.2
Chlorine Solution Volume Use	L/d		7.7	11.0
Chlorine Peak Dose Rate	L/h		1.8	1.8
Chlorine Dosing Pumps			1	1
Max Chlorine Pump Rate each	L/h		**5.4**	5.4
Chlorine Storage at Average (assuming no dilution)	d		104	73

5.31.7 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.

The pump discharge is fitted with a pressure relief valve. The relief line is returned to the storage tank and 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 the pump.

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 pump then operates at this fixed speed whenever the RE lift pump is operating. The Dosing pump starts when the lift pump starts. The dosing pump stops when the 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;

3. Phase 1 – Site establishment
4. Phase 2 – Construct new treatment infrastructure
5. Phase 3 – Pre Commission new infrastructure
6. Phase 4 – Cutover to new treatment processes
7. Phase 5 – Decommission redundant assets
8. Phase 6 – Augment retained infrastructure
9. Phase 7 – Finalise earthworks, roads, drainage, landscaping etc.
10. Phase 8 – 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 fenced area of the existing treatment plant. There is a small area adjacent to the site entry that could be used, however it is anticipated that a majority of the site compound (including laydown area and parking) will be located in the large area currently nominated as a biosolids area to the west of the treatment plant. Both areas are shown in orange in Figure 6-1, however a larger area within the biosolids area can be utilised provided sufficient room is maintained for WSC to manage biosolids.



Figure 6-1 Proposed Site Compound Locations

Temporary power and potable water would be provided from the existing infrastructure within the main treatment plant boundary.

Access to the Moss Vale STP passes through privately owned farm land accessed from residential streets. It is vital that access is maintained to the biosolids area at all times as it is utilised by WSC to manage biosolids across it's treatment plants. Management of the increased vehicle movements utilising this access 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 - Construct New Treatment Infrastructure

A majority of the new treatment infrastructure is located on vacant land to the south of the existing treatment plant. This allows construction activities to be demarcated from existing operations, minimise impacts. There a number of areas that encroach on existing assets and special consideration is required to accommodate operational and construction activities as summarised below;

- New Inlet Works & Lift Pump Station and switchroom – These are located to the immediate west of the existing inlet works. All access (including road) for the existing structure occurs to the west such that it should not be impeded during construction. It may be necessary to protect existing structures during excavation for the new works (especially around the lift pump station). The bypass pipeline from the inlet works crosses the existing structure and this crossing is to be deferred until the new inlet works is decommissioned.
- Dewatering Facility and Switchroom – The dewatering facility is constructed on the north eastern edge of the dewatering handling area. WSC will need to divert any biosolids to a different area with the biosolids area. Construction will need to be implemented to allow biosolids trailers to access the alternate areas of the biosolids area as needed.
- Storm Splitter – The storm splitter is located between IDEA 2 and Catch Pond 2. Construction must be carefully managed to ensure that access to the plant is not impacted during construction. Connection to the catchponds should not occur until the new treatment process is commissioned.
- Digester Blower building – The new aerobic digester building is located to the north of the existing blower building. Construction involves earthworks to create a new pad and blockwork building. This should be possible without impacting on any other structures. The building needs to be constructed during this phase to minimise the time required to convert the IDEA to an aerobic digester.

The following items are completed once the new system is accepting raw sewage;

- Inlet works bypass pipework
- Storm splitter pipework (to the catch ponds and the storm storage pond)
- Conversion of the IDEA to digester.

6.1.3 Phase 3 – Pre Commission Stage 1 Works

Once the new treatment infrastructure has been constructed, pre commissioning can commence. This involves a number of steps to prepare 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 new works will be ready to accept raw sewage.

6.1.4 Phase 4 – Cut Over to New Treatment Process

This phase involves connecting the incoming gravity mains to the new inlet works. This involves intercepting the main within the paddock to the east of the treatment plant at a suitable manhole and directing flow to the new inlet works. The design allows a majority of the pipework can be laid prior to the cutover, such that the final connection pipework is installed to complete the cutover.

These cutover works requires 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)

Once the incoming diversions are complete, the new primary and secondary treatment processes will be online and wholly responsible for achieving effluent quality objectives. 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.

As the new treatment infrastructure is accepting all inflow, UV system discharge must be connected to the existing outlet pipework. It is envisaged that this will occur at the same time as the gravity main cutover such that it available to accept the necessary flow as they are transferred to the treatment process.

6.1.5 Phase 5 – Decommission Redundant Assets

With the new secondary treatment infrastructure online, the existing IDEA tanks and inlet works can be decommissioned. This allows the aerobic digester conversion to be undertaken and the storm bypass pipework from the inlet works to the storm splitter to be completed.

Residual biomass from the reactors will be transferred to the sludge lagoons. The reactors will then be cleaned in preparation for civil and mechanical installation works. The existing inlet works will be cleaned and then capped. The inlet works will ultimately be demolished.

6.1.6 Phase 6 – Augment Retained Infrastructure

With the new treatment process accepting all inflows, it is possible to augment retained assets as required. This includes;

- Conversion of an IDEA tank to an aerobic digester
- Connection of the catch pond inlet pipes to the storm splitter
- Connection of storm splitter bypass to Catch Pond 2 outlet pipework
- Installation of replacement return pumps within the Catch Ponds.

Commissioning of the aerobic digester will be completed once the mechanical / electrical installation works is complete and will follow the same steps as Stage 4. The process is fully operational once activated sludge is wasted from the new process to the digester. Any biosolids produced by the new process prior to availability of the digester will be directed to the existing sludge lagoons by manipulating manual valves within the dewatering feed tank inlet pipework.

It is envisaged that installation of the return pumps is completed in one pond at a time. This allows a pond to remain online to accept bypass flows in the event of an emergency. The other pond can be isolated, drained and cleaned to allow installation.

6.1.7 Phase 7 - 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 6. 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.

6.1.8 Phase 8 - Demobilisation

With works complete, the Contractor will 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 small compound to allow coordination and completion of any 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
- Emergency response plans.

Note that allowance has been made for the following additional structures that can be added as part of subsequent upgrades when needed due to increasing loads;

- Additional bioreactor (site allowance and connection to splitters)
- Two additional clarifiers (site allowance and connection to splitters)
- Additional switch room (site allowance)
- Additional digester (conversion of existing IDEA)
- Two additional filters (site allowance and connection to filter feed splitter)
- Additional alum storage tank (allowance within bund for additional tank, electrical / control connections)
- Sugar dosing (site allowance for bund, electrical / control connections)
- Dewatering (allowance for two additional screw presses, electrical / control connections).

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 Main – As described in Phase 4 above the interfaces associated with the existing incoming main are complex and must be carefully managed. The existing admin building waste is to be rediverted to the incoming gravity network
2. Effluent Discharge Main – The outlet from the new UV disinfection channel connects to the existing effluent discharge main. This connection needs to occur concurrently with the incoming gravity main
3. Catch Pond Inlets – The existing inlets are connected to the storm splitter to accommodate a range of additional feeds. This approach minimises penetrations within the catch ponds
4. Storm Pond Overflow – A new overflow from the storm splitter will connect with the existing Catch Pond 2 overflow pipework. The connection point is adjacent to the plant boundary and should remain relatively clear of existing services
5. Storm Return Pumps – The existing return pumps will be replaced with larger units installed within the existing sump. This work can be completed once flows can be diverted from the ponds for sufficient periods to complete the installation works.
6. Sludge Lagoons – The two 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.
7. Roadways – New roadways will interface with existing access at the front gate and at the biosolids area
8. Storm Water – Storm water from the treatment plant will be directed offsite via new infrastructure. Existing storm water systems will be retained.
9. Potable Water – A new potable water metering point will be provided at the entrance gate and connect to the incoming main
10. Catch Pond Ring Main – The existing catch pond ring main will be replaced with a new main
11. 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.
12. Telemetry – A telemetry SCADA pack Telemetry RTU and Trio data radio has been included in the design to communicate with the WSC Telemetry network. 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 Moss Vale 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 point
3. All new infrastructure is to be above the 1 in 100 year flood level (655.98 – Review of Whites Creek Flood Plain Risk Management Study & Plan, Catchment Simulation Solutions, 2020).

There is minimal available site footprint below the invert level of the incoming gravity mains. This drove the inclusion of at least one lift pump station. 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 lift pump station downstream of the inlet works.

The inlet works was designed such that the Top Water Level (TWL) remains below the current level as shown within the plants hydraulic profile (Drawing 5A) under worse case conditions. Allowance has been made to pass PIF through to the storm splitter such that the structure is hydraulically fail safe.

The treatment processes have been designed to accommodate gravity flows without the need for a second lift pump station (as was required for Bowral STP). This approach reduces both capital and operating costs. The UV system is deigned to pass PFTF via the existing discharge structure when Whites Creek is at the 1 in 100 year flood level. By default, this ensures that all processes associated with the liquid treatment stream area above the 1 in 100 year flood level (all structures have been designed above this level).

The existing catch pond and storm balance ponds have been retained for storm / emergency storage. Flow is distributed between the two catch ponds via a new storm splitter. The existing inlet and overflow pipework has been retained and is capable of passing PIF to the storm balance pond when it is at TWL. A new bypass line from the storm splitter to the storm balance pond has been provided to allow the catch ponds to be bypassed if required.

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 ultimate PIF / 10 x ADWF (916 L/s) to the inlet works.
- The TWL within the inlet works has been capped at the TWL within the existing receival chamber 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.
- An adjustable penstock downstream of the 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.
- 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 length of the bypass weir continues downstream of the penstock to ensure the system is hydraulically fail safe.
- The capacity of the inlet works bypass pipework has been sized for PIF (i.e. inlet lift pump station is also offline).
- The storm splitter allows bypass flows as well as emergency overflow from a number of secondary processes to be directed to either of the existing Catch Ponds or to bypass the Catch Ponds directly to the storm balance pond if required.
- 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.

- Additional splitting chambers and pipes (capped) have been provided for one additional bioreactor and two additional clarifiers.
- The level of structures has been set to provide full hydraulic carriage through the treatment process following the lift pump station
- The earthworks are configured to allows access to the eastern edge of the bioreactor and such that the clarifier launder acts as a handrail.
- 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.
- The outlet pipework from the filter feed splitter is designed to PFTF + Recycles Flows with the control valve 90% open. This provides some level of redundancy should the control valve fail
- Flows that exceed the filter capacity are overflowed to the storm splitter via a dedicated bellmouth
- 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 storm splitter
- 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 storm splitter 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 storm splitter 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 10 x ultimate 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 full flow, 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 level controlling penstocks and into the vortex style grit chamber. The penstock 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 weir and pass through to the storm splitter. The splitter is used to direct flows to one of the existing catch ponds. Once the capacity of Catch Pond 1 is reached, storm flows overtop a weir and continue through top Catch Pond 2. Once the storage capacity within Catch Pond 2 is exceeded, flow bypasses directly to the existing storm balance pond. A weir within the storm balance pond discharges directly to Whites Creek once storage capacity is exceeded. Pump stations within each catch pond return storm flows to the inlet works once inflows subside. A hydraulic connection between the storm balance pond and Catch Pond 2 allows a portion of the pond volume to also be returned (i.e. via the Catch Pond 2 pumps).

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 the filter feed control station. A control valve and is used to cap flows to the flocculation tank below 3 x ADWF plus recycles. Flow in excess of the filter capacity overflows the pump station to the storm splitter. 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 storm splitter 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. 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. Tertiary effluent beyond the demands of the RE system overflows the RE lift pumping station and connects to the existing effluent main (upstream of the UV channel). 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 storm splitter. The storm splitter receives flow from a number of other locations on site (chemical bunds, pump station overflows, digester etc.) and these flows can be segregated from inlet works bypass flows or combined. Storm return pumps can also return flows to the filter feed splitter if required (i.e. secondary treated flows don't have to pass through the entire treatment process again)

Further details are available within the flow balance (Appendix C) and the hydraulic profile (Appendix E).

8 Civil Design

8.1 Site Layout

The site layout (provided in Appendix F and Figure 8-1) has been developed in consideration of the existing Moss Vale 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.

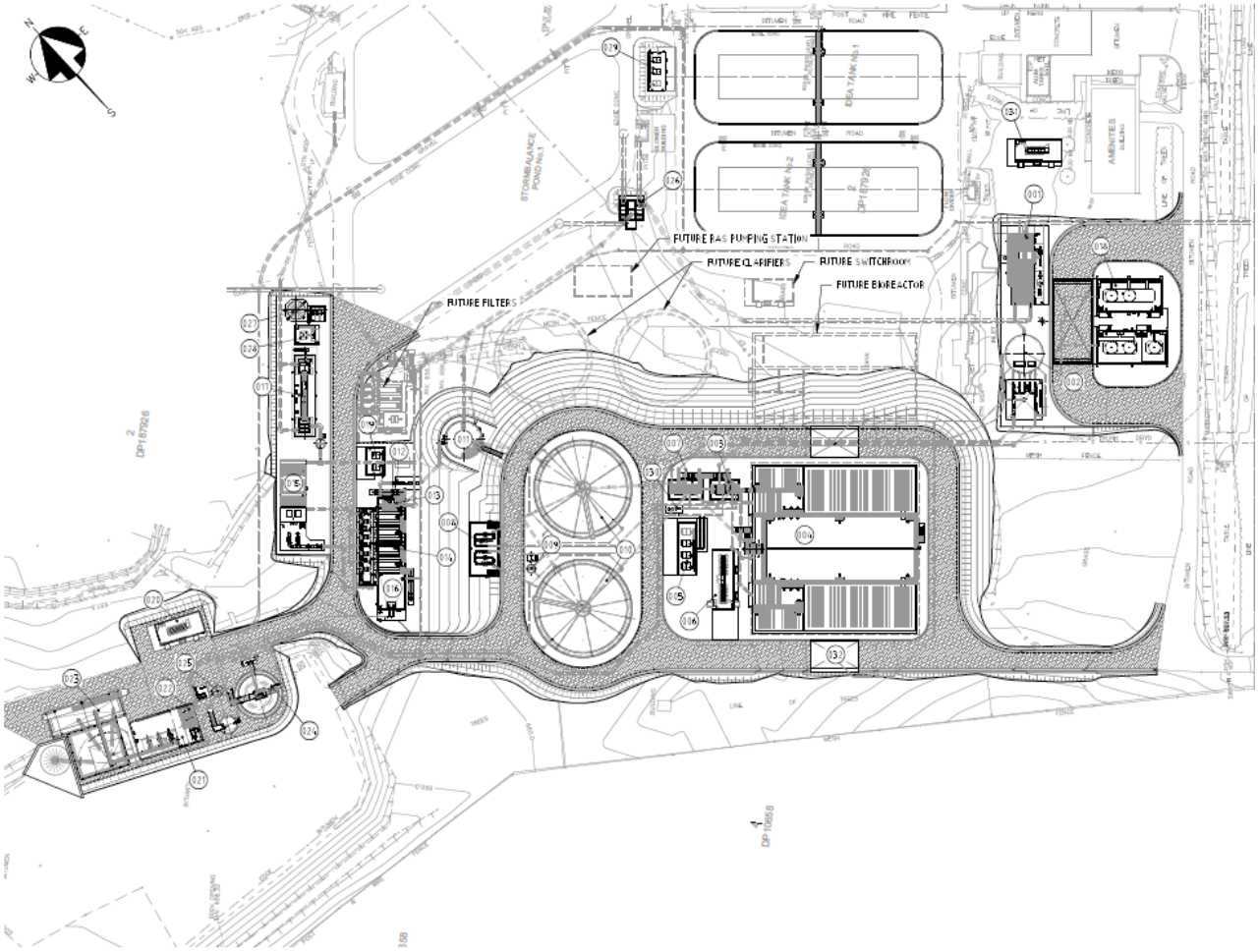


Figure 8-1 Site Arrangement

The chemical facility and influent receival area (inlet works and inlet pumping station) are located between the existing amenities building and incoming access road. This enables chemical delivery and waste disposal vehicles access to the respective areas without having to traverse throughout the other process units of the STP. The ring road surrounding the chemical facility will also be utilised by waste disposal vehicles for disposal of solids from inlet works area. Incoming sewer mains will be diverted to the new inlet works from the East of the site, whilst

The remaining components of the STP are located to the South-West of the existing STP with access road provided from adjacent to the incoming access road, as well as connections to the existing access road at the South-West corner of the existing storm balance tank no.1. The main process units follow the fall of the existing topography to utilise gravity hydraulics throughout the plant. This comprises the bioreactor, clarifier feed splitter, clarifiers, filter feed pumping station, tertiary filters, clean backwash water tank, UV followed by connection to the existing outfall pipework. In addition to this, a blower room is located adjacent to the bioreactor to minimise blower pipework run to the bioreactor.

The sludge dewatering facility is located further to the South-West of the main process units and comprises a thickener, foul water pumping station, dewatering facility and outload area (for solids waste). The access road for the sludge dewatering outload is alongside the south-west boundary of the site.

There are three new switchooms provided for the site. An inlet works switchroom is located adjacent to the existing amenities building and in close proximity to the inlet works. A bioreactor switchroom is located between the bioreactor and clarifiers, and is located in close proximity to the blower room to minimise cable runs to main drives for the site. An additional tertiary treatment and dewatering switchroom is located adjacent to the dewatering facility to supply power local to those facilities.

The road 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. Concrete hardstand are provided adjacent to the bioreactors for individual aeration grids to be placed on the hardstand for cleaning purposes.

8.2 Geotechnical

For the purposes of this project, Wingecarribee Shire Council provided existing geotechnical reports for two previous phases of geotechnical investigation, associated with historical upgrades and proposed designs (dated 1992 and 2020). The extent of available geotechnical information was deemed to have three key areas identified as lacking adequate information to inform detailed design:

- Central portion of the site (within footprint of old decommissioned plant) – although extensive ground coverage was observed in the available geotechnical information in this part of the site, the investigation depths were largely insufficient to cover the proposed foundation depths of new infrastructure, requiring further geotechnical investigation to understand excavation, foundation and groundwater conditions across this range.
- Groundwater – no groundwater monitoring data was available at the site, and limited groundwater observation records available on existing logs, to provide an understanding of the associated implications for design and construction.
- Pavement thickness design – no site pavement thickness design was available, and limited CBR test data was available to inform any design.

In 2021, Hunter H2O engaged D&N Geotechnical on behalf of WSC to conduct further geotechnical investigations and reporting for Moss Vale 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.

The 2021 geotechnical investigation comprised the drilling of thirteen boreholes, environmental sampling, installation of data loggers within two existing 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 2.25m^2) for rafts beneath outriggers was supplied to enable a thickened

pavement design for bearing capacity requirements at designated crane set-down areas, applying factor of safety of 2.0.

- Waste classification assessment due to identified presence of uncontrolled filling within the footprint of proposed construction / earthworks.

The geotechnical report, preliminary waste classification assessment report, preliminary groundwater quality assessment report and groundwater Monitoring report are provided in Appendix G, summarised as follows:

- The regional topography comprises slightly undulating hillsides, with the site located at lower lying terrain associated with the southern bank of Whites Creek.
- The site is underlain by Bringelly Shale of the Tertiary aged Wianamatta Group, typically pertaining to shale, claystone, siltstone and sandstone. Quaternary residual deposits associated with the weathering of this formation make up the surface geology.
- 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/silty CLAY, medium plasticity, brown, fine to medium sand, with rootlets, trace fine to medium, sub-angular gravel	0	0.2 to 0.3
2	Fill – General	Gravel and cobbles, fine to coarse grained, sub-angular basalt fragments (ballast), dark grey; OR Sandy gravelly CLAY/SILT, low and medium plasticity, pale brown, fine to coarse sand	0	0.25 to 2.6
3	Alluvium	Sandy CLAY/Clayey SAND, medium plasticity orange-brown, mottled grey, fine to coarse sand, trace fine roots, typically firm consistency, or loose with some soft organic clay layers towards the base of the unit	0 to 2.6	1.2 to 1.6
4	Colluvium	Silty/sandy CLAY, medium to high plasticity, orange-brown, mottled brown, grey, fine to medium sand, typically firm to stiff consistency	0 to 0.2	1.1 to 2.7
5	Residual Soil	Sandy CLAY/CLAY, medium to high plasticity, orange-brown, mottled yellow-brown, grey, fine to medium sand, trace fine to medium, sub-angular gravel. Typically, stiff to very stiff consistency, hard in parts.	0.3 to 2.7	0.5 to 5.2
6a	Siltstone Bedrock	Extremely to highly weathered, inferred soil strength to low strength.	1.9 to 5.5	0.7 to Unproven
6b		Highly to moderately weathered, low to medium strength	3.1 to 7.3	0.4 to Unproven
6c		Moderately weathered or better, medium strength	4.0 to 5.2	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 BH104 and BH107 at between about 0.3 m to 1.6 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.
- The results of groundwater monitoring and in-situ permeability testing, undertaken over a three-month period following the site investigation, will be provided in June 2021 in a separate report (currently ongoing).
- Foundations:

- Site classification to AS2870-2011: the site is classified as Class P where existing fill extends to depths greater than 0.3 m, and Class H1 within the natural soil profile, with up to 60 mm seasonal movements due to climatic effects. Refer to geotechnical report for commentary on effects of trees and effect of fill placement in regard to site classification.
- Shallow footings, *allowable* bearing pressures:
  - Unit 1 and 2 Topsoil / filling: do not use for foundation support (strip before the works)
  - Unit 3 and 4 Alluvium / colluvium: 50 kPa
  - Unit 5 Residual soil: 100 kPa
  - Unit 6a Extremely weathered rock: 400 kPa
  - Unit 6b, or better: 1,000 kPa (higher values may be feasible after site inspection)
- Settlements of strip and pad footings designed using the allowable values are expected to be less than 1% of the footing dimension.
- Bored pile footings, *ultimate* bearing pressures (to be further reduced by geotechnical strength reduction factor, which can be conservatively adopted as 0.4, to be refined):

Unit ID	Ultimate end bearing (MPa)	Ultimate shaft adhesion (kPa)
Unit 3 and 4 Soils	-	20
Unit 5 Residual soil	0.6	35
Unit 6a Extremely weathered rock	3.0	85
Unit 6b, Highly / moderately weathered rock	5.0	200
Unit 6c, Slightly weathered or better rock	8.0	300

  Refer to geotechnical report for parameters to be used for estimation of settlements, horizontal bearing capacity and uplift, as well as commentary on selection of the geotechnical strength reduction factor.

- Soil aggressivity in accordance with AS2159-2009 Piling:
  - The soil is non-aggressive towards buried steel.
  - The soil is mildly aggressive towards buried concrete under Soil Condition A, but non-aggressive towards buried concrete under Soil Condition B
- Thrust blocks, *allowable* lateral bearing capacities:
  - Units 1 and 2 Topsoil / filling: do not use for foundation support (strip before the works)
  - Controlled cohesive fill: 50 kPa
  - Controlled granular fill ($\varphi' \geq 32^o$): 60 kPa/m x depth (m)
  - Units 3 and 4 Alluvium / colluvium: 40 kPa at 0.5 m depth, increasing to 150 kPa at a depth below FSL of 5 times the bearing width
  - Unit 5 Residual soil: 70 kPa at 0.5 m depth, increasing to 300 kPa at a depth below FSL of 5 times the bearing width
  - Unit 6a Extremely / highly weathered rock: 300 kPa (where at least deeper than 5 times the bearing width, otherwise use residual soil properties)
  - Unit 6b, or better: 500 kPa.
- Retaining wall and shoring / retention design parameters are provided in the geotechnical report (cannot be succinctly summarised).
- Earthquake design parameters to AS1170.4-2007:
  - Seismic Hazard Factor (Z): 0.09
  - Sub-Soil Class: Ce.

- Earthworks:
  - Presence of filling:
    - Based on the findings of the preliminary waste classification assessment, asbestos contaminated material debris were identified and analysed in T2 and T4, with samples collected from 0.8m and 1m below ground surface level respectively. A previous investigation also identified fibre cement and fibre cement pipe in the 2020 investigation. These test locations were all located within the former trickling filter area.

  - Further geo-environmental investigation would be required to delineate areas where existing filling material could instead potentially be classified as general solid waste. This may involve stockpile sampling during construction.
  - Natural soils underlying the existing fill material may potentially be classified as virgin excavated natural material (VENM), requiring validation during construction in accordance with NSW EPA requirements.
  - The filling present is uncontrolled and is not suitable for structural foundations or pavement subgrade.
- Site preparation:
  - Topsoil to be stripped and stockpiled for site restoration.
  - Existing fill materials should be subject to excavation and re-compaction (if suitable) or replaced with engineered fill.
  - Refer to geotechnical report for further site preparation measures including fill placement requirements.
- 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, low to medium strength (or better) 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 D7 or 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 to Unit 5 natural soils, 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 batter slopes provided in the table below can be assumed for preliminary design of unsupported excavations:

Unit ID	Temporary Batters	Permanent Batters
Units 1 – Topsoil / uncontrolled fill	Strip back away from excavation	4(H):1(V)
Controlled filling	1(H):1(V)	2(H):1(V)
Unit 2 – Fill – General (Uncontrolled)	2(H):1(V)	4(H):1(V)
Unit 3 –Alluvium	2(H):1(V)	3(H):1(V)
Unit 4 –Colluvium	2(H):1(V)	3(H):1(V)
Unit 5 – Residual soils	1(H):1(V)	2(H):1(V)
Units 6a and 6b – Extremely weathered rock	1(H):1(V)	1.5(H):1(V)
Unit 6c – Moderately weathered rock	0.25(H):1(V)*	1.5(H):1(V)

Note: * - requires geotechnical inspection on exposure for risk assessment AND batters recommended on the proviso that a 3 m wide bench is provided at the top of rock.

Refer to geotechnical report for further discussion around batter slopes.

- Pavement thickness designs – the following pavement designs are considered acceptable for the expected site subgrade (design CBR 3%) and design traffic loads (2 x 10^4 ESA). The prescribed thicknesses are the minimum acceptable for pavements internal to the site boundary (and therefore potentially subject to vehicle turning):
  - Flexible:
    - Wearing course: minimum 40 mm AC14 overlying single coat seal with C450 binder;
    - Base course: minimum 150 mm DGB20 (CBR >80%, PI <6%) (or approved equivalent material / product)
    - Subbase course: minimum 225 mm DGS20 (CBR >60%, PI <10%) (or approved equivalent material / product).
  - Rigid:
    - Concrete base course: minimum 200 mm with SL92 mesh reinforcement
    - Granular subbase course: minimum 100 mm DGB20 (CBR >80%, PI <6%) (or approved equivalent material / product):
  - Alternative pavement thickness design options are included in the geotechnical report for allowance of a 150 mm select fill layer over the natural subgrade.
- Groundwater monitoring was undertaken following the geotechnical report. The key findings are:
  - The groundwater level measured at B20 in May 2019 was approximately 4.2m below ground level, whereas measured groundwater level in April 2021 was approximately 2.8m below ground level, and approximately 2.45m below ground level in June 2021.
  - The groundwater level measured at B25 in May 2019 was approximately 2.5m below ground level, whereas measured groundwater level in April 2021 was approximately 0.5m below ground level, and approximately 0.45m below ground level in June 2021.
  - Significant depths to groundwater are evident based on seasonal and climatic effects.

8.3 Survey and Services

WSC provided a survey of Moss Vale STP, with additional detail survey and services location carried out by Hunter H2O to pick up interfacing constraints associated with the detailed design, extending 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 were not identified during these site works.

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, whilst hot dipped galvanised platforms / handrails are provided for other areas where the rate of corrosion is typically reduced. This provides WSC 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 from Kennedy Close is to be retained. The access road has a manual gate located approximately 40m off Kennedy Close and then traverses through private property to the STP

site. Traffic management plan and site co-operative use plan (SCUP) will need to be developed prior to construction in consultation with WSC and the operators of the STP.

New access roads are provided within the site to enable 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, switchrooms, 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.

The residual UV treated water that does not get pumped to the RE system or storm pond is discharged to the creek 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 fire fighting requirements, then an onsite storage and / or booster pumpset may be required to meet the fire fighting 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 fire fighting 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 Moss Vale 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 Moss Vale STP is being amplified and upgraded to increase the capacity and improve the plant performance.

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 repurposed or upgraded, with the associated electrical equipment also being 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 tertiary treatment switchroom and Inlet/digesters switchroom. New switchboards and PLC panels will be installed in each switchroom as well as a new remote I/O panels in the filter blower room. The design will include new PLCs, remote I/O, SCADA system, as well as 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 Mossvale STP is supplied by an 11kV overhead high voltage line, running along the northern eastern and south eastern boundaries of the site, to a dedicated Endeavour Energy 400kVA pole mount substation (pole substation 32032), which is located on the STP site, near the western corner of the existing site administration office building.

The existing 400VAC supply runs via UGOH from the transformer then underground to the existing switchroom within the amenities building.

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.

The existing power supply will remain in service during the construction and commissioning stages of the project until all existing loads are decommissioned. A submain from the new main switchboard will be installed to re-supply power to the amenities building switchroom at the completion of the project, and the existing power supply will then be decommissioned.



Figure 9-1 Existing Amenities Building, 400kVA transformer & HV Powerline



Figure 9-2 HV Powerline entering the STP site

The current site is supplied via Endeavour Energy overhead 11kV powerlines from HV Feeder MVE2, running along the northeastern boundary of the site from pole PL953046 shown above.

9.3 Power Supply

A new main switchroom is included in the design as there is insufficient space and capacity in the existing amenities building main switchroom, and its location is not suited for the supply of the new equipment required for the upgrade, hence an upgrade of the power supply is required and will include:

- A new main switchroom SWRM-1001 and main switchboard MCC-1001 located in the bioreactor area.
- A new tertiary treatment switchroom SWRM-2001 and switchboard MCC-2001 located near the sludge outloading facility, as well as a new LV supply cable from MCC-1001.
- A new inlet/digesters switchroom SWRM-3001 and switchboard MCC-3001 located between the digesters and existing amenities building, as well as a new LV supply cable from MCC-1001.
- A new LV supply cable from MCC-3001 to the existing amenities building.
- An upgraded Endeavour Energy power supply in accordance with the ASP3 certified design including:
    - A new 1000kVA pad mount substation installed adjacent to the new main switchroom.
    - Replacement of existing HV power pole 3K1662 (near the existing amenities building) with a new pole and UGOH.
    - A new HV underground cable will run from pole 3K1662 to the new substation via the south-eastern and south-western boundaries of the site, following the site access roadways, and including road crossing under the access road at the site southern corner.
    - Decommissioning of the existing HV power supply and 400kVA transformer at completion of cutover to the new system.

Note, an ASP3 certified design for the new substation, HV supply extension, and decommissioning of the existing supply is in progress and will be supplied to the contractor prior to commencement of the project.

9.4 Maximum Demand

The maximum demand for the upgraded plant has been calculated using the following factors:

- Duty loads are at nameplate capacity and standby loads are not using any power
- An overall diversity factor of 0.85 has been applied.
- Distribution board capacity is determined using a diversified AS3000 calculation
- 120kVA of distribution board load has been determined using an estimated circuit diversity calculation.
- Motorised control valve demand is determined based on a diversity factor of 0.1
- 72kVA of future loads included in the MCC designs are included in the demand calculation
- 41kVA of future load for the future bioreactor (MCC-4001)are included in the demand calculation

Based on the above, the maximum demand for the new plant including future loads is calculated to be 883kVA.

A new 1000kVA pad mount substation is recommended for the site to meet the increased demand, allow for future loads, and provide an additional 10% spare capacity.

The detailed maximum demand calculation is attached as Appendix H.

9.5 Power Quality

The upgrade design includes many variable speed drives (VSDs) .There are 54 included in the design, 15 in MCC-1001, 25 in MCC-2001, and 14 in MCC-3001as required to provide efficient process control. An additional 7 VSDs are estimated to be required for future bioreactors MCC-4001.

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.

Active Harmonic Filters (AHFs) are used to counteract and compensate for this harmonic content, and have been included in the design as follows:

- For MCC-1001 a 300 Amp AHF will counteract the harmonics for the site
- Spare capacity of the AHF unit will be used in each switchboard for power factor correction and phase balancing.

Verification of the AHF size by the VSD vendor is required prior to completion of the detailed design.

The active harmonic filter will be configured and tuned during the commissioning process to operate in a dual mode configuration. The filter will operate to providing harmonic correction to reduce the harmonics to acceptable levels, and using spare AHF capacity to provide 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 all major structures in the new plant, including switchrooms, transformer area, bioreactors, blower facility, UV facility and chemical dosing facility. Details of the direct strike protection requirements will need to be reviewed with WSC prior to design completion.

9.7 Switchrooms

A new main switchroom SWRM-1001 will be constructed in the bioreactors area as part of the upgrade works and will house the main switchboard MCC-1001. Wall mounted L&P DB, process DB, AHF, VSDs, PLC panel and network communication cabinet will be installed in the room. Supply for the site will be connected to the

main incomer from the new pad mount substation, and a space will be allocated adjacent to the switchroom to allow for an emergency backup generator near the external generator connection panel.

A new tertiary treatment switchroom SWRM-2001 will be constructed in the sludge dewatering area as part of the upgrade works and will house switchboard MCC-2001. Wall mounted L&P DB, process DB, AHF, VSDs, PLC panel and network communication cabinet will be installed in the room. Power for the new MCC will be supplied via a submain cable from MCC-1001.

A new inlet/digesters switchroom SWRM-3001 will be constructed in vacant space near the existing amenities building as part of the upgrade works and will house switchboard MCC-3001. Wall mounted L&P DB, process DB, AHF, VSDs, PLC panel and network communication cabinet will be installed in the room. Power for the new MCC will be supplied via a submain cable from MCC-1001.

All switchrooms are sized to house back-to-back switchboards 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.

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

Switchrooms are 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.

A new 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

Three (3) 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 new tertiary treatment switchroom.
- MCC-3001 Inlet/Digesters Switchboard, housed in the new inlet/digesters switchroom.

All 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, inlet/digesters MCC-3001, and future bioreactors MCC-4001.
- 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 double-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.

MCC-3001 is a double-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.
- Submain feeders to the existing amenities building and distribution board.
- 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 each switchroom, 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 Mossvale STP; 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

A risk assessment was undertaken on each motor, with only motors that presented a risk during normal operation undertaking a further AS4024 risk assessment in order to define the emergency stop category.

The risk assessment did not take into account operation with guards removed and assumed that if 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.

Most 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 was 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 two main concerns for discrimination are the clearance between the incomer and the following feeders and largest drives:

- Tertiary treatment, inlet/digesters switchroom submain feeder
- Light & Power distribution board feeders
- Process distribution board feeders
- Bioreactor, filter, and digester blower drives

These larger circuit breakers are modelled in the PowerCAD software to confirm discrimination. Settings and discrimination curves are detailed in the PowerCAD report.

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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.

9.13 PLC Systems

Wingecarribee Shire Council has standardised on the Omron PLC platform and use the Omron PLCs across multiple sites. The Mossvale 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 Mossvale.

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. 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 panel in the blower room.

There are three (3) PLC systems on site, in the main switchroom, tertiary treatment switchroom, and inlet/digesters switchroom. Each of these PLC systems will include NJ/NX Ethernet connected PLC and remote I/O racks as per Table 9-1 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
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
INLET/DIGESTERS SWITCHROOM				
PNL-3001	Inlet/digesters Switchroom	Standalone panel	Main panel – CPU rack	Instrument & control loops
RIO-3001	Tertiary treatment Switchroom	Tier in MCC-3001	Remote I/O	Drive & MCC controls

9.14 Control Network and Communications

The Mossvale STP control system architecture will use an Ethernet network topology. There are 3 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.

9.14.1 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 (e.g., switchrooms) 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.

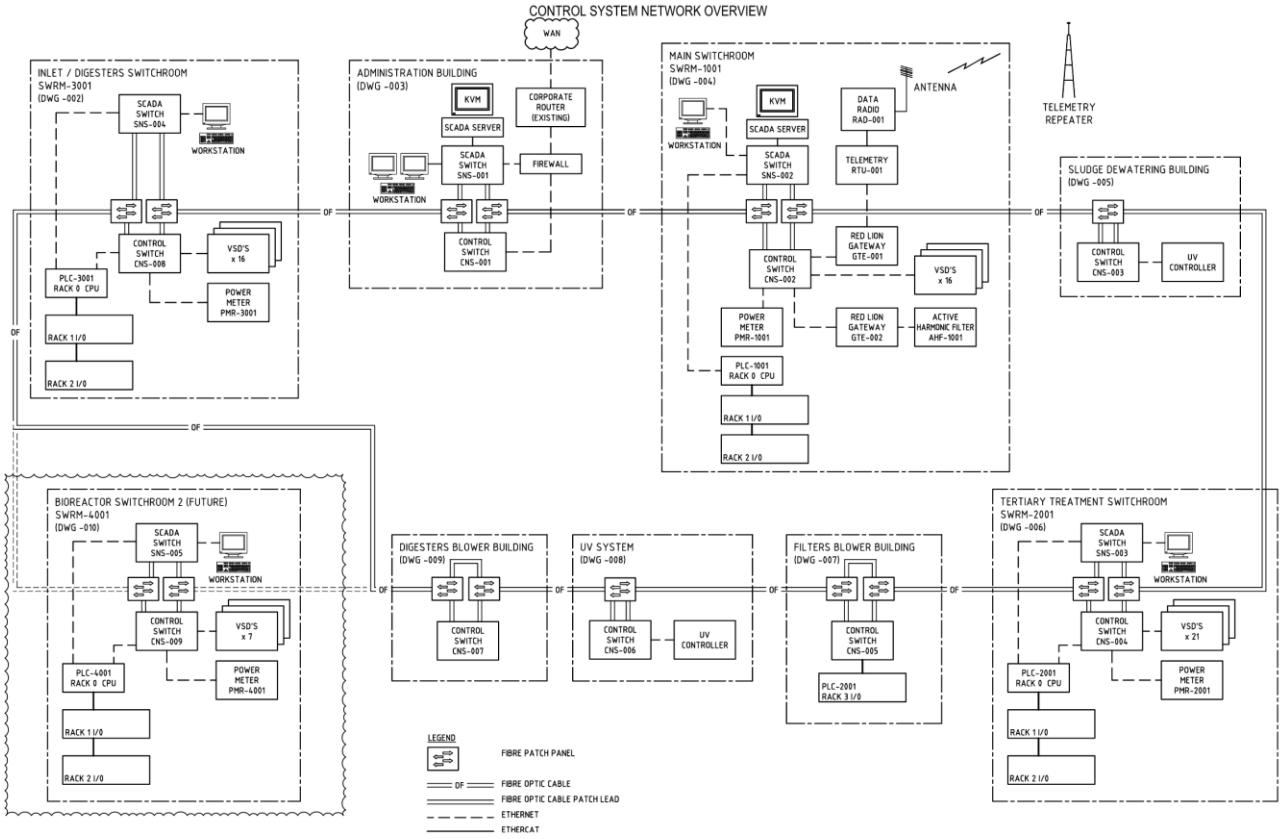

Figure 9-3 Fibre Optic Communications Network Overview

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.

9.14.2 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)

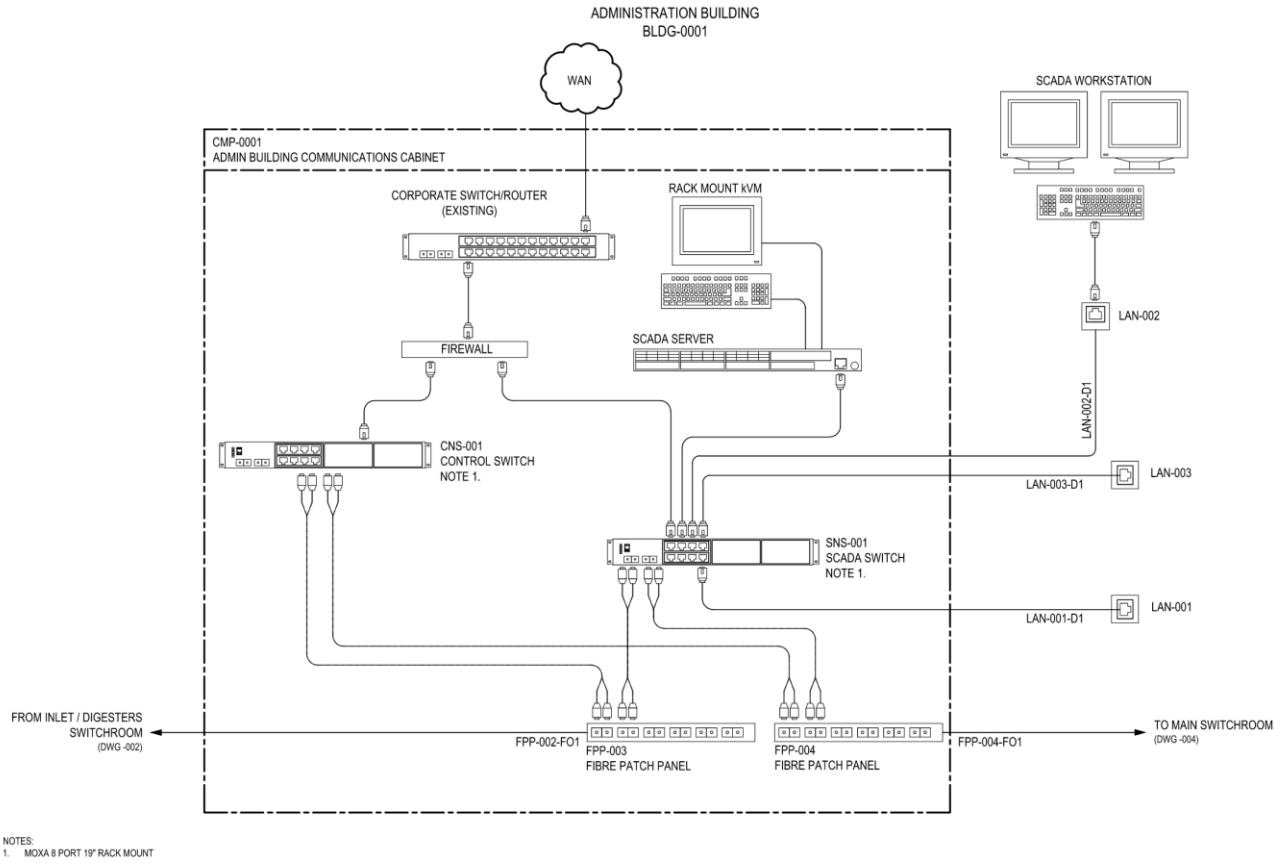

Figure 9-4 Admin Building Communications Network Connections

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
Inlet / Digesters Switchroom	CMP-3001	42RU Floor	2 x 24pt rack mount switches 1 x Rack mount 230V UPS	FPP-001 FPP-002	FPP-016-FO1 FPP-002-FO1

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-003 FPP-004	FPP-002-FO1 FPP-004-FO1
Main Switchroom SWRM-1001	CMP-1001	42RU Floor	2 x 24pt rack mount switches 1 x SCADA Server & KVM 1 x Rack mount 230V UPS 2 x Redlion Gateways	FPP-005 FPP-006	FPP-004-FO1 FPP-006-FO1
Sludge Dewatering Building	CMP-2002	12RU Wall mount IP56	1 x 8 port din rail mount switch	FPP-007 FPP-008	FPP-006-FO1 FPP-008-FO1
Tertiary Treatment Switchroom	CMP-2001	42RU Floor	3 x 24pt rack mount switches 1 x Rack mount 230V UPS	FPP-009 FPP-010	FPP-008-FO1 FPP-010-FO1
Filters Blower Building	RIO-2102	Within RIO Panel	1 x 8 port din rail mount switch	FPP-011 FPP-012	FPP-010-FO1 FPP-012-FO1
UV System	CMP-2002	12RU Wall mount IP56	1 x 8 port din rail mount switch	FPP-013 FPP-014	FPP-012-FO1 FPP-014-FO1
Digesters Blower Building	CMP-3002	12RU Wall mount IP56	1 x 8 port din rail mount switch	FPP-015 FPP-016	FPP-014-FO1 FPP-016-FO1
Bioreactor Switchroom 2 (future allocation only)	CMP-4001	42RU Floor	2 x 24pt rack mount switches 1 x Rack mount 230V UPS	FPP-017 FPP-018	FPP-014-FO1 FPP-016-FO1

9.14.3 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. These will communicate with the plant PLCs via the SCADA Ethernet network.

Three (4) 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.

9.15 Staging and constructability

The construction and cutover for the electrical equipment is to be staged in order to ensure minimal impact on plant operation.

The changeover will require periods of outages in order to transfer power from the existing switchroom to the new switchroom. There are a number of options available for the changeover, and may require the use of a temporary generator to supply power to the new or old plant during the changeover.

The changeover will in general align with the Process requirements and cutovers. An example cutover process is provided as follows:

- During Phase 2, the new switchroom and new main cable between new main switchboard and transformer will be installed (not terminated at transformer end). A temporary cable can be installed from a spare feeder on new main switchboard, to existing incomer switch (not terminated at existing incomer)
- To simplify the Phase 3 transition, it is possible to utilise a temporary generator for the pre-commissioning tasks, or supply power to the existing plant from the new switchboard. To supply power to the existing plant from the new switchboard, the following steps are required.
    - During plant power outage, disconnect existing main cable at transformer, and terminate new main cable at transformer, energising new main switchboard.
    - Disconnect existing main cable at old switchboard and terminate temporary new feeder from new main switchboard, and re-energise existing main switchboard.
    - Restart existing plant for normal operation (now supplied via new main switchroom), and undertake commissioning activities of new plant.
- Following commissioning of new plant, remove temporary feeder cable and all redundant equipment.

The final staging and construction sequencing is to be confirmed by the construction contractor and outlined within their construction management documentation.

10 Safety in Design

The purpose of the Safety in Design Report (refer to Appendix I:) 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:

- 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 and CHAIR 2/3 components of the risk management approach. 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. The studies built on outcomes of the Bowral STP detailed design, including the CHAIR 1 process undertaken for that project.

11 Cost Summary

This section presents cost estimate summaries for the upgrade. The developed costs have been benchmarked against recently completed and under construction brownfield sewage treatment plant upgrades. The referenced projects include;

- Bowral STP, currently in the early stages of construction
- Queanbeyan STP Upgrade (70,000 EP) continuous activated sludge treatment complete with tertiary filtration, aerobic digestion and centrifuge dewatering
- Goulburn STP Upgrade (30,000 EP) MBR complete with UV disinfection, including storm screening and lift pump station
- Cessnock STP Upgrade (42,000 EP) dual continuous reactor with dual secondary clarifiers. The process reused existing inlet works, primary clarifiers and anaerobic digesters
- Longford STP Upgrade (25,000 EP) intermittent granular activated sludge system, complete with inlet works, odour control, sludge handling and tertiary filtration.

It is worth noting however that disruptions caused by the COVID-19 pandemic and current global conflicts is impacting project delivery costs, most notably increased supply costs. This is due to increases in shipping costs and availability of vital materials (steel, plastic piping systems etc.). Given this uncertainty, it may be prudent to increase project contingencies / allowances to ensure sufficient budget is available to cater for cost fluctuations.

11.1 Capital Cost Estimate

A capital cost estimate has been developed from first principles, utilising Hunter H_2O project delivery experience, combined with supplier quotations. Table 11-1 provides a summary of the capital cost estimates

Table 11-1 Capital Cost Estimate

Item	Value
Site Establishment - Non Electrical	$805,000
Inlet works	$193,000
Lift Pumping Station	$1,295,000
Flow Splitter - Bioreactor & Clarifier	$662,000
WAS Pumping Station	$596,000
Bioreactors	$67,000
Clarifiers	$556,000
RAS Pumping Station	$6,702,000
Scum Pumping Station	$2,990,000
Filter Feed Pumping Station	$244,000
Flocculator Tanks, Tertiary Filters & Dirty/Clean Backwash Tank	$63,000
UV Disinfection System	$252,000
Site Based RE	$2,565,000
Sludge Digester	$676,000
Thickener	$100,000
Dewatering Building, Polymer Dosing System & Sludge Out loading Facility	$144,000
Storm Detention Ponds (Incl. Demolish Pasveers)	$1,641,000
Foul Water Pump Station	$306,000
Chemical Dosing System	$146,000

Item	Value
Bioreactor Blowers & Blower Building	$1,004,000
Filter Blowers & Blower Building	$423,000
New Bioreactor Switch Room & Refurbish Existing Switch Room	$362,000
Pipelines	$738,000
Other Civil & Misc.	$1,488,000
Electrical Upgrade	$1,378,000
Completion (Non Electrical)	$6,615,000
TOTAL DIRECT COSTS	**$32,266,000**
Project Management	$3,227,000
Contractor Profit	$3,872,000
WSC Costs	$3,017,000
TOTAL INDIRECT COSTS	**$10,116,000**
TOTAL COSTS	**$42,382,000**
CONTINGENCY	$8,476,000
TOTAL PROJECT COST	**$50,858,000**

11.2 Replacement Cost Summary

Table 11-2 provides a summary of the replacement costs adopted for the upgraded plants over the design horizon.

Table 11-2 Replacement Cost Summary

Item	Replacement Frequency	Replacement Estimate
Inlet Works Mechanical Items	15 years	$700,000
Inlet Lift & Storm Return Pumps	15 years	$270,000
Secondary Treatment Mechanical Items	15 years	$800,000
Bioreactor Diffusers	8 years	$180,000
Filter Equipment	15 years	$325,000
Filter Media	15 years	$110,000
UV Lamps	1200 hours	$800
UV System	15 years	$255,000
Reclaimed Effluent Pumps	15 years	$60,000
Foul Water Pumps	15 years	$30,000
Chemical Dosing Systems	15 years	$130,000
Dewatering System Mechanical Items	15 years	$465,000
Instrumentation	15 years	$310,000
Valves	15 years	$150,000

11.3 NPV Summary

A summary of capital, annual O&M and NPV costs is presented in Table 11-3

Table 11-3 O&M and NPV Cost Estimates

Item	Value
Capital Cost Estimate	$50,858,000
Annual O&M Estimate (2025)	$1,200,000
Annual O&M Estimate (2048)	$1,415,000
Average O&M Estimate (Including Replacements)	$1,550,000
Net Present Value	$68,580,000

11.4 Costing Assumptions

The following points outline basics assumptions adopted in the cost estimate:

- Resources such as Hunter Water Cost Estimate Rates spreadsheet and Rawlinson's 2022 were used to determine rates
- First principles and Hunter H_2O experience utilises to determine quantities
- Electrical and mechanical equipment rates have been adopted from quotations and rates from previous similar projects;
- Other miscellaneous rates have been adopted from past works or from quotations;
- NPV estimate is based on a discount rate of 7% over 25 years;
- Annual maintenance cost allowance of 0.15% for civil items, 1.5% for mechanical and electrical
- Operational costs determined on a pro-rata basis from ultimate connected population estimates
- Biosolids transportation cost of $30 per wet tonne;
- Biosolids disposal cost of $25 per wet tonne;
- Alum cost of $0.5/L
- Caustic cost of $0.6/L
- Sodium Hypochlorite cost of $1.2/L
- Polymer Cost of $6/kg
- Operator allowance for 16 hours per day at $100,000 per annum full time equivalent
- Power costs of $0.20 per kWh
- Contractor profit 10% of direct costs
- Contractor project management 12% of direct costs
- WSC project management 8% of direct costs
- Contingency of 20% of total costs

Further details are available in Appendix J.

Appendix A: Detailed Sewage Characteristics

Appendix B: Process Flow Diagram

Appendix C: Flow and Mass Balance

Appendix D: Process & Instrumentation Diagrams

Appendix E: Hydraulic Information

Appendix F: Site Arrangement

Appendix G: Geotechnical Report

Appendix H: Maximum Demand Calculations

Appendix I: Safety in Design Report

Appendix J: Cost Estimates

Appendix H – Odour Impact Assessment

MOSS VALE SEWAGE TREATMENT PLANT UPGRADE

Odour Impact Assessment

Prepared for:

NSW Public Works Advisory
Level 4, 66 Harrington Street
Sydney NSW 2000

SLR Ref: 610.30766.00000-R01
Version No: -v1.0
May 2022

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) 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
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APPENDICES

Appendix A Selection of Representative Meteorological Data

1 Introduction

Wingecarribee Shire Council (the Council) is proposing to upgrade the Moss Vale Sewage Treatment Plant (STP) to provide capacity for future development within the catchment. In addition, the proposed upgrade aims to improve process and operational performance and provide treatment infrastructure to meet environmental objectives from regulators such as the New South Wales Environment Protection Authority (NSW EPA)and WaterNSW.

To assess potential odour impacts from the proposed operations, the New South Wales Public Works Advisory (PWA) has commissioned SLR Consulting Australia Pty Ltd (SLR Consulting) to prepare an Odour Impact Assessment (OIA) to support the Review of Environmental Factors being prepared for the proposed upgrade.

This OIA has been performed in accordance with the 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'. 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 potential odour emissions from the Moss Vale STP to predict the level of impact 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:

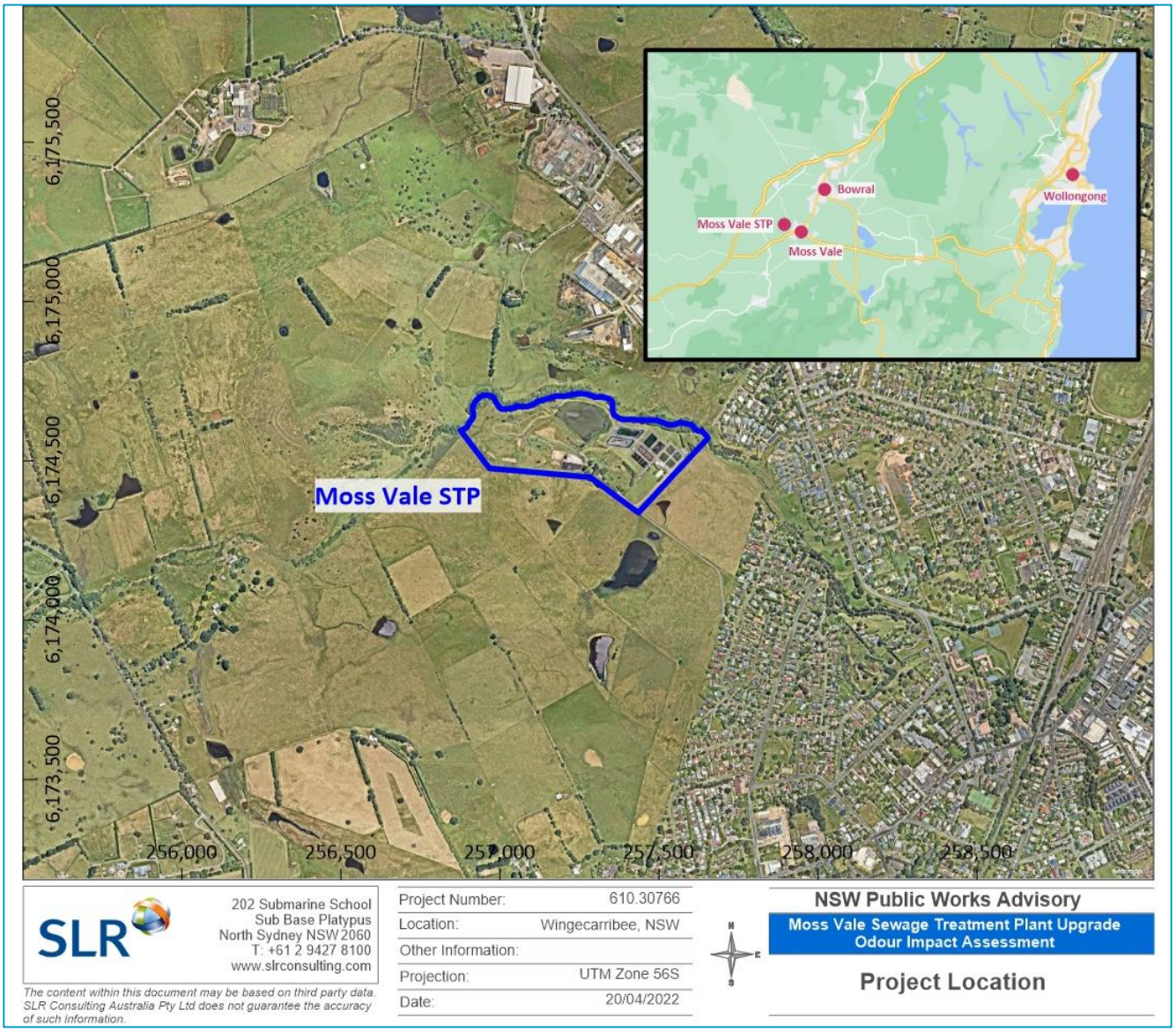
- Description of local topographic features and sensitive receptor locations (**Section 2.4**).
- Description of existing air quality environment (**Section 2.5**).
- Establishment of air quality assessment criteria (**Section 3.4.2**).
- Analysis of climate and dispersion meteorology for the region (**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 Moss Vale STP (**Section 8**).

2 Project Overview

2.1 Project Location

The Moss Vale STP is located in Moss Vale in the Southern Highlands of New South Wales (NSW), in the Wingecarribee Shire Local Government Area (LGA). The Moss Vale STP is located off Kennedy Close (Lot 2 DP 187926) approximately 1.3 kilometres (km) west of Moss Vale train station, approximately 8 km south of Bowral and 50 km southwest of Wollongong. A location plan and an aerial view of the Moss Vale STP are illustrated in **Figure 1.**

Figure 1 Location of the Moss Vale STP



2.2 Project and Site Description

The Moss Vale STP was last upgraded in 1996 to a nominal design capacity of 9,000 equivalent persons (EP). The urban population of Moss Vale in 2016 was approximately 7,900 EP, with an estimated total STP load (including non-residential loads) as high as 10,200 EP. Therefore, the current load on Moss Vale STP is predicted to exceed the design load. This is supported by operational data that suggests that plant is currently overloaded, particularly in terms of bioreactor aeration.

Another capacity upgrade driver is the proposed Moss Vale Enterprise Corridor (MVEC). This could result in a significant increase in future loads, predicted to be up to a possible 19,000 EP (depending on the type of industrial uses that may develop).

2.2.1 Existing Operations

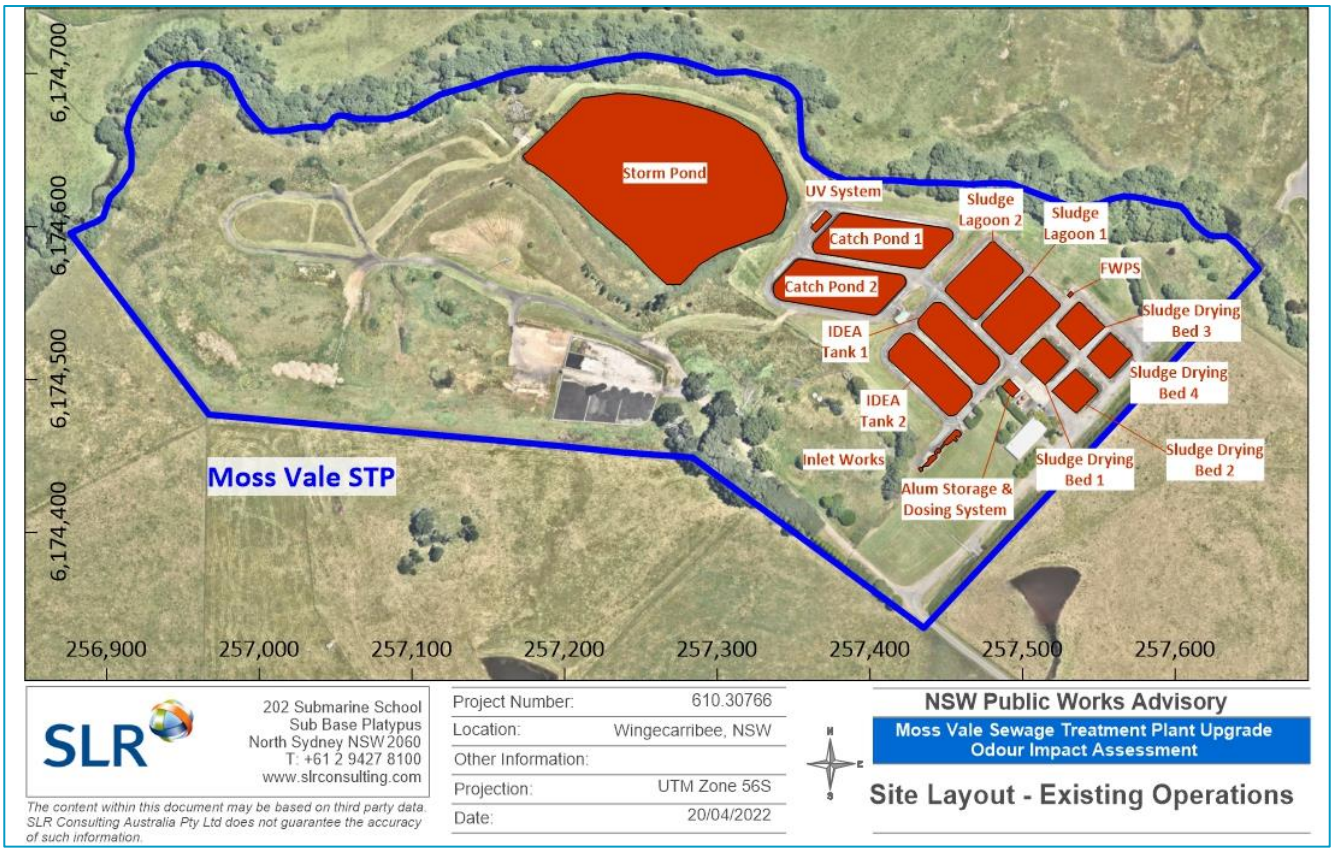
The existing Moss Vale STP consists of the following process units and systems:

- An inlet works including mechanical step screening and grit removal.
- Two 4,500 EP (nominal) intermittently decanted extended aeration (IDEA) bioreactors, each including:
  - Twin feed points, one at each end
  - A centre decanter with a double-sided weir
  - Diffused aeration and associated blowers
  - Waste activated sludge (WAS) pumping
  - No anoxic zones or mixed liquor recycle (MLR) pumps.
- Two decant effluent catch/balance ponds. Alum is dosed into the IDEA decant, creating solids that settle in these ponds. Each can be bypassed for cleaning.
- An alum storage and dosing system for phosphorus precipitation. Alum is also dosed directly to the IDEAs (i.e., as well as the decanted effluent)
- A channel style ultraviolet (UV) disinfection unit sized for faecal coliform inactivation.
- Two sludge lagoons for sludge stabilisation.
- Sludge drying beds for biosolids dewatering.
- A Foul Water Pump Station (FWPS) returning foul water streams from around the plant back to the head of the works for treatment.
- An effluent/storm pond. This cannot be completely emptied but provides some storage and return via the catch/balance ponds.

The layout of the existing Moss Vale STP is provided in **Figure 2**.

According to information provided by the Council, only two odour complaints relating to the operation of the existing Moss Vale STP were received since 2017. This indicates that the existing operations at the STP are generally performing well with regards to odour emissions.

Figure 2 Moss Vale STP Site Layout – Existing Operations



2.2.2 Proposed Operations

The upgrade of the Moss Vale STP is proposed to be staged. The initial upgrade (proposed operations) would involve an increase in capacity to 20,000 EP. The proposed design will provide contingency for expansion to 34,000 EP, being the projected ultimate population (ultimate operations).

The upgraded STP will included the following key infrastructure:

- A new inlet works
- A new lift pump station
- The existing catch/balance ponds are converted to storm ponds, accepting overflow sewage and overflow secondary effluent
- A new bioreactor feed splitter
- Two new bioreactors
- Two new secondary clarifiers
- A new scum pump station sized for ultimate, with a single scum pump (duty only) accepting scum from the two clarifiers (four at ultimate) and delivering it to the aerobic digester or bioreactors (via the lift pump station).
- A new filter feed control system

- Tertiary filters
- A new UV system to replace the existing UV system
- An upgraded reclaimed effluent (RE) system
- A new WAS pumping and thickening system
- An aerobic digester consisting of one existing IDEA bioreactor (both used in parallel at Ultimate). Each digester (one at Proposed and two at Ultimate)
- 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 and a third at Ultimate if required.
- One existing sludge lagoon to be retained and used as emergency liquid sludge storage.
- A foul water pump station (FWPS)

The layouts of the proposed and ultimate operations are provided in **Figure 3** and **Figure 4**.

Figure 3 Moss Vale STP Site Layout – Proposed Operations

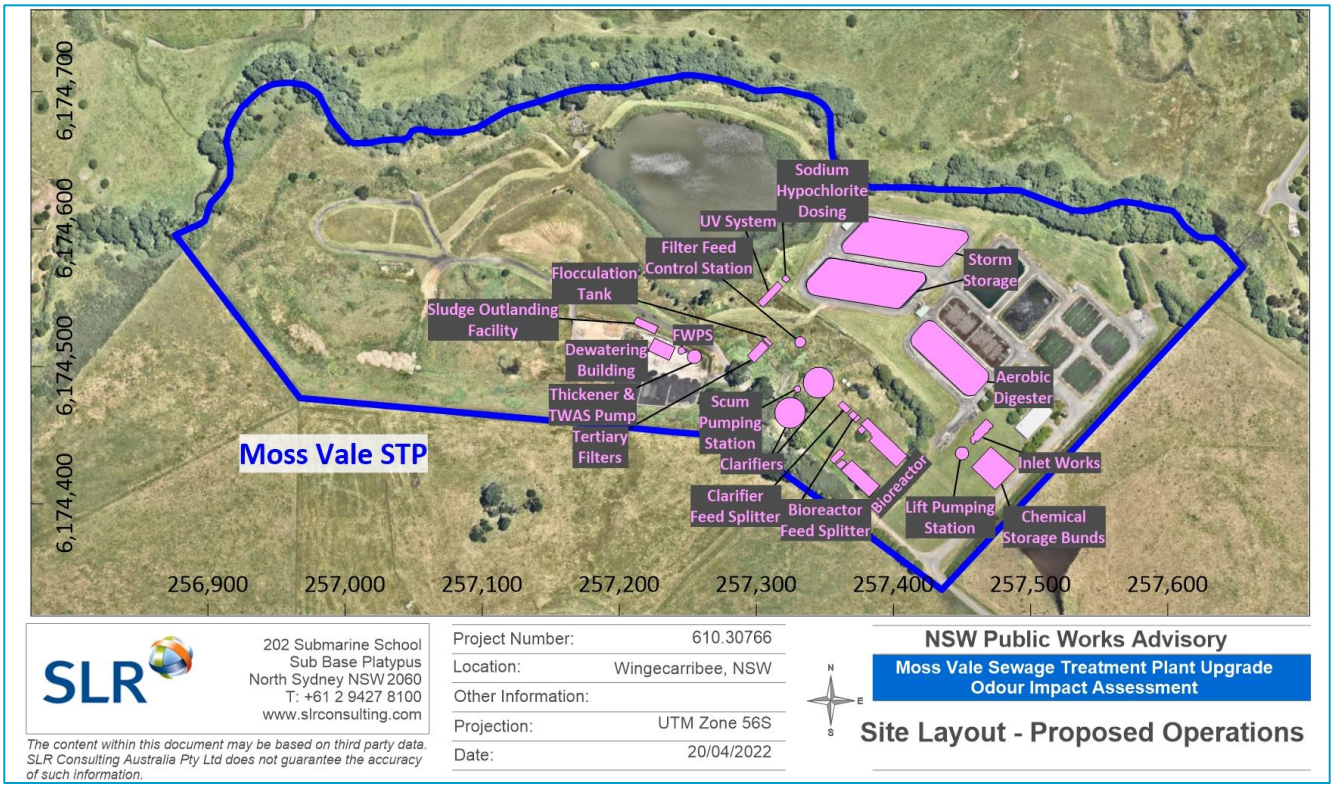
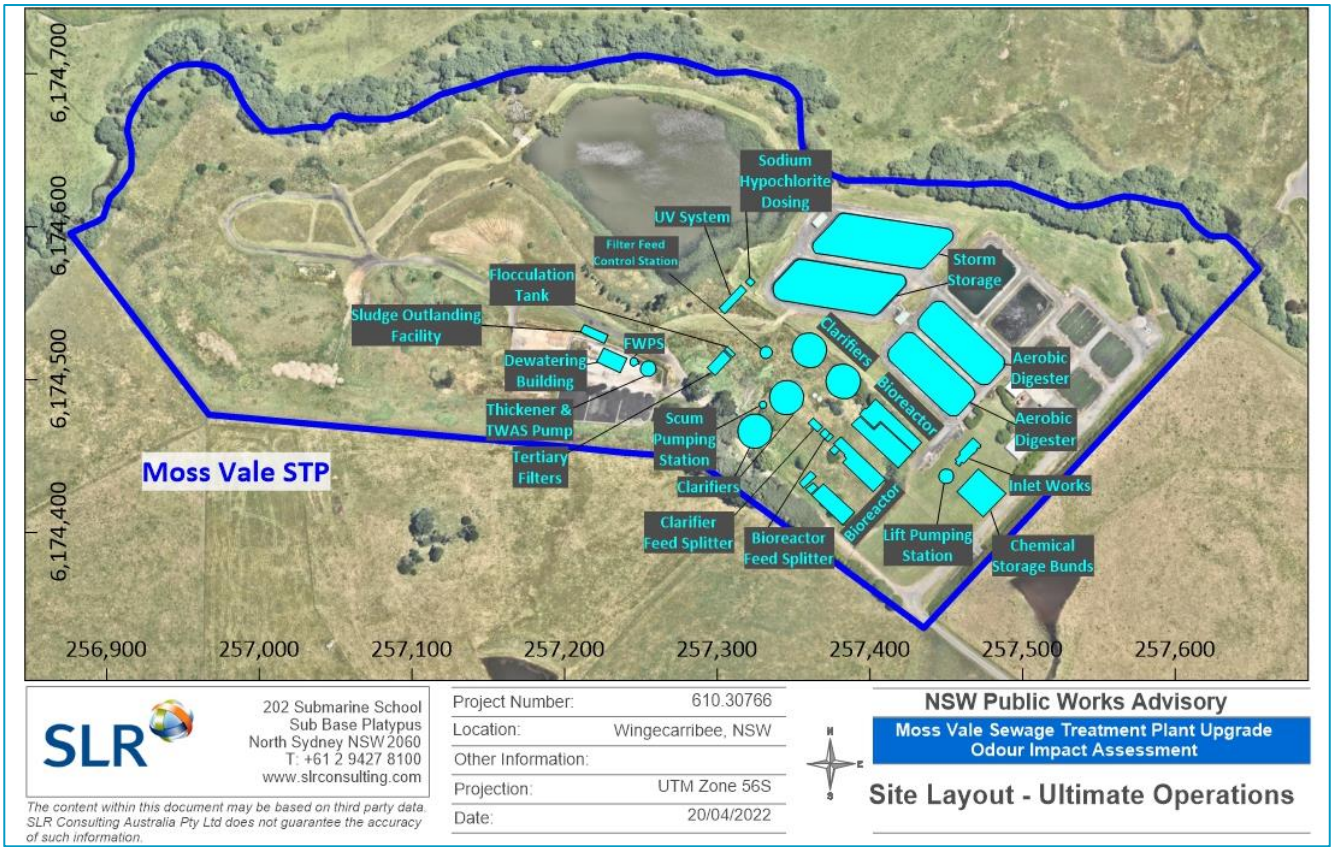


Figure 4 Moss Vale STP Site Layout – Ultimate Operations



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 Moss Vale STP includes lands zoned as Rural Landscape (RU2), Public Recreation (RE1), and Low Density Residential (R2) zoned by the *Wingecarribee Local Environmental Plan 2010* (refer **Figure 5**).

The Moss Vale STP is situated in an area surrounded by rural areas to the north, south and west and higher density residential to the east. A list of existing sensitive receptor points identified in the immediate vicinity of the Moss Vale STP is provided in **Table 1**, along with the respective distances of each of these receptor points to the Moss Vale STP boundary. **Figure 6** illustrates the location of the surrounding receptors in relation to the Moss Vale STP. Predicted concentrations of odour have been assessed at each of these receptors, for the operational scenarios modelled. It is noted that a single receptor in each direction (closest to the Moss Vale STP) has been identified for assessment. Impacts at sensitive receptors located further away in each direction will be less than the modelling results presented in this report.

Figure 5 Surrounding Land Zoning

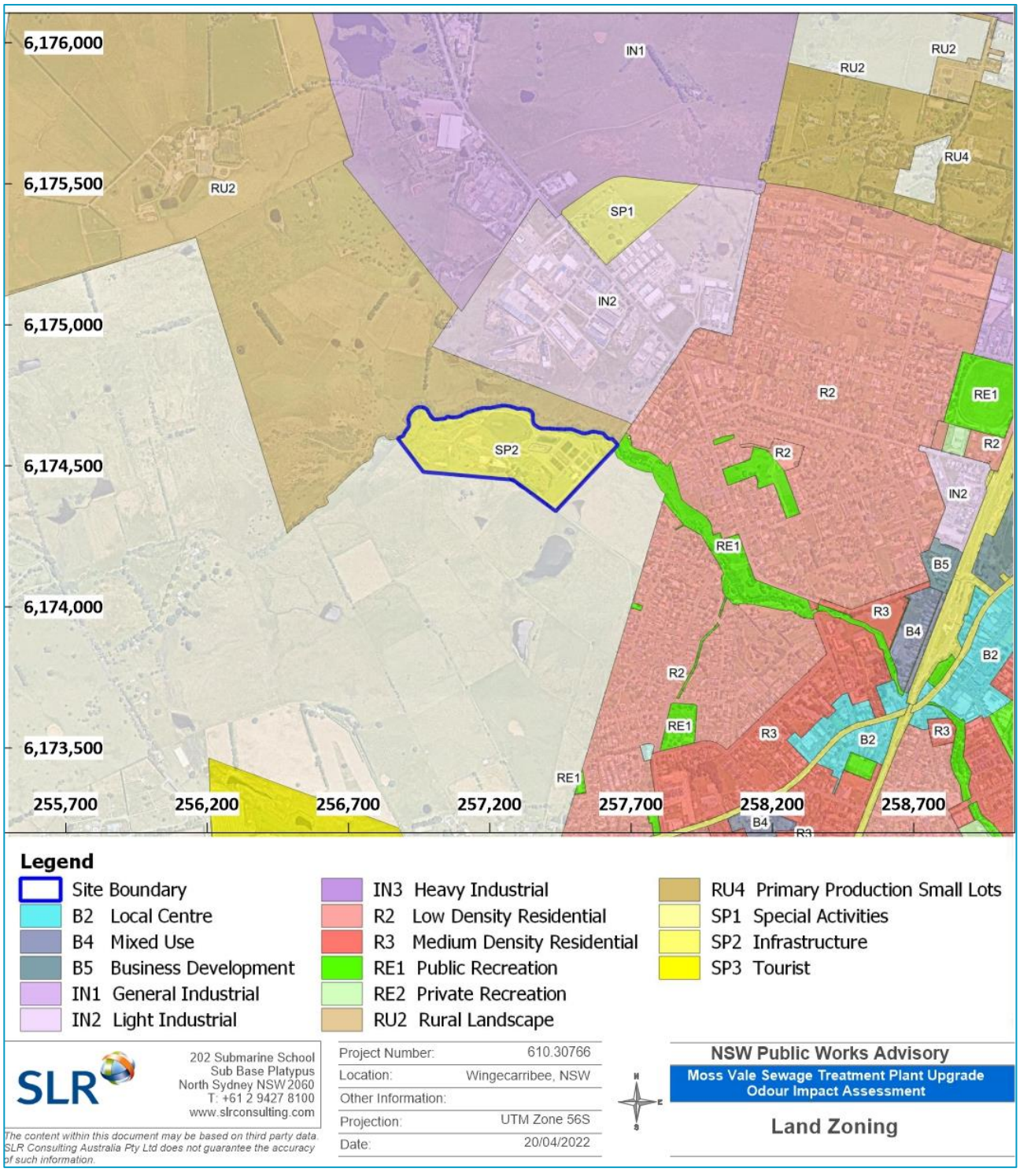
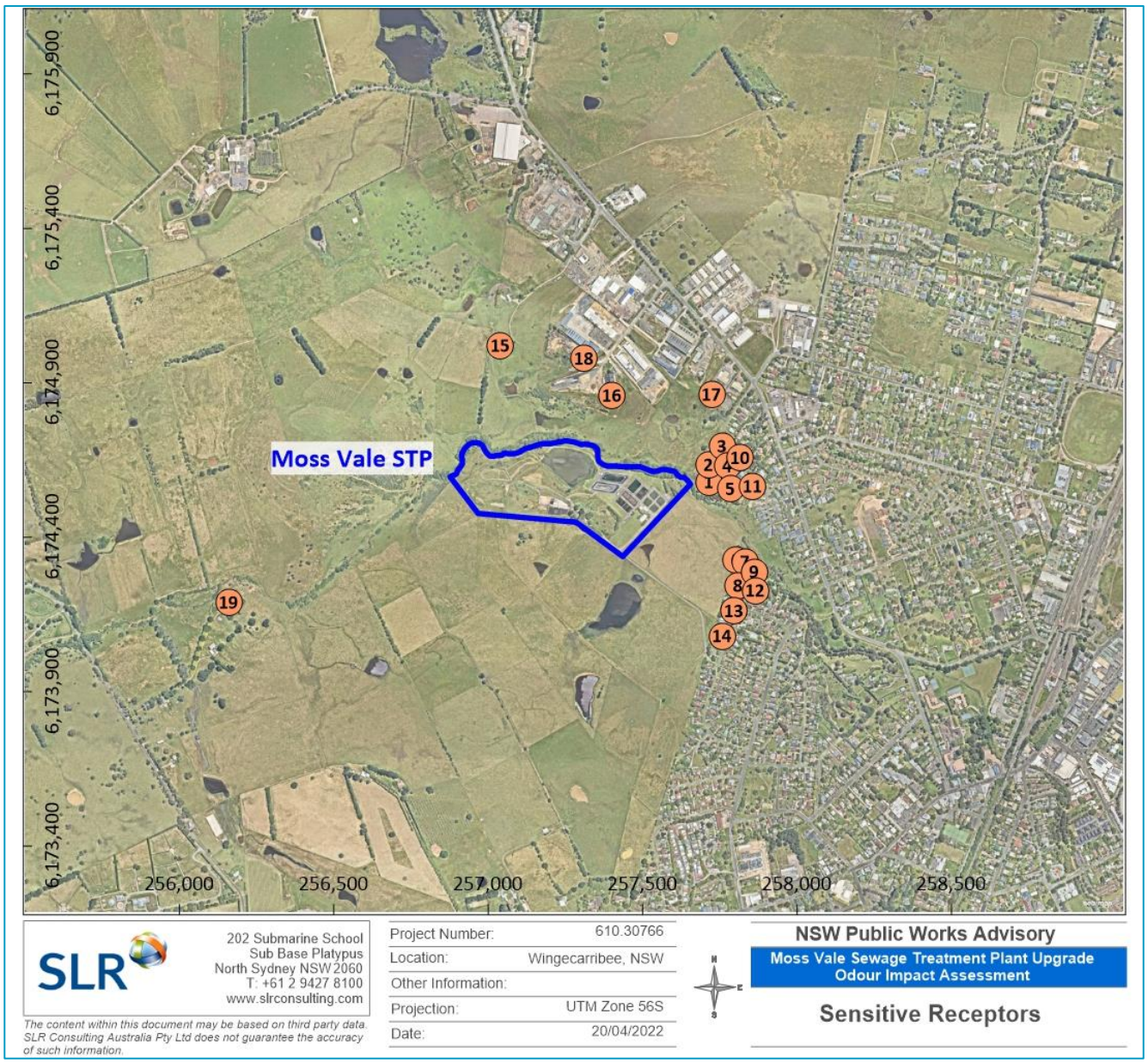


Table 1 Details of Identified Sensitive Receptors

Receptor ID	Location (m, UTM)		Approximate Distance from Nearest Boundary (m)	Elevation (m, AHD)
	Northing	Easting		
1	257,715	6,174,578	60	663
2	257,714	6,174,634	85	665
3	257,758	6,174,695	160	670
4	257,775	6,174,630	135	669
5	257,784	6,174,556	130	666
6	257,807	6,174,310	290	663
7	257,831	6,174,320	300	662
8	257,810	6,174,243	340	665
9	257,862	6,174,288	345	663
10	257,816	6,174,657	180	672
11	257,857	6,174,565	200	672
12	257,865	6,174,228	390	666
13	257,796	6,174,161	385	668
14	257,758	6,174,080	410	671
15	257,040	6,175,020	325	683
16	257,401	6,174,859	175	679
17	257,723	6,174,862	275	679
18	257,311	6,174,979	270	679
19	256,160	6,174,188	825	650

Figure 6 Locations of the Identified Sensitive Receptors

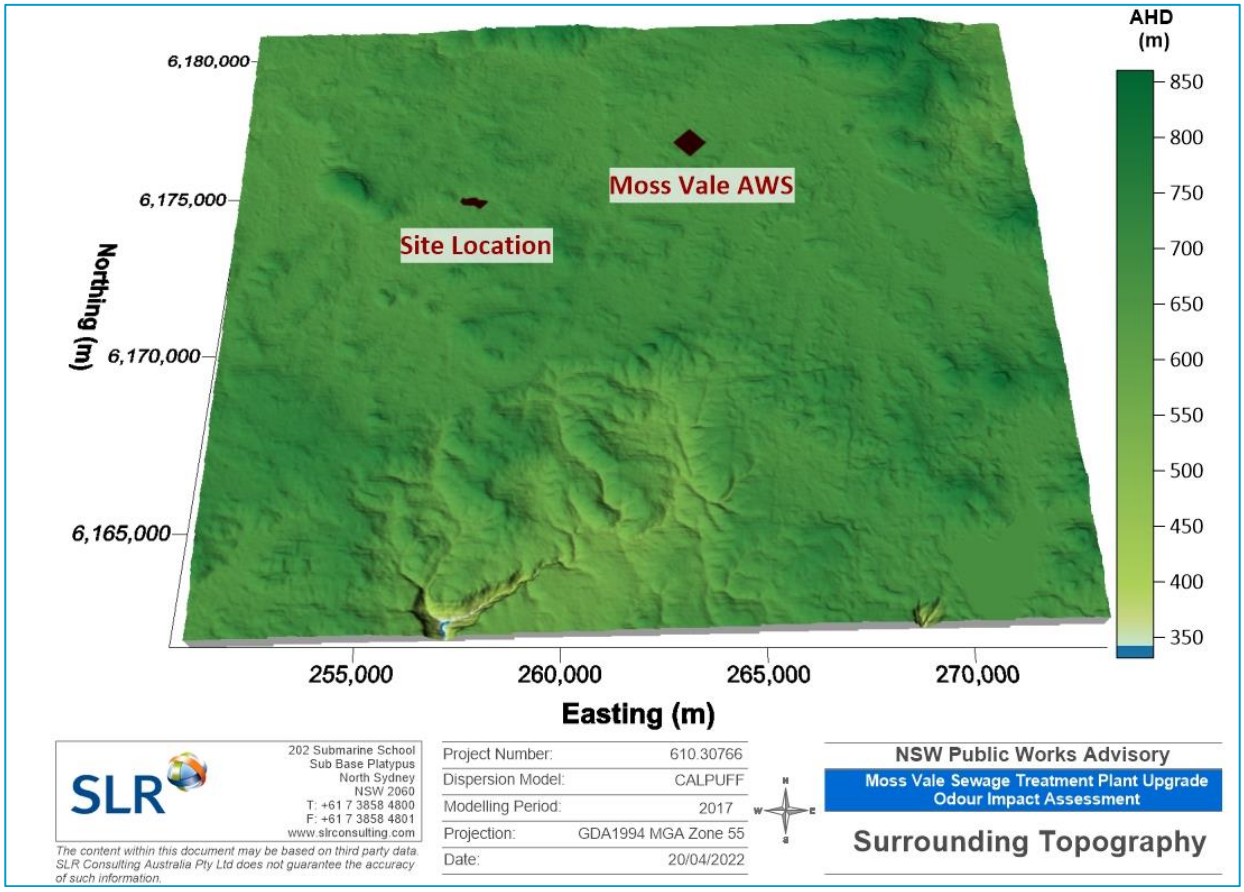


2.4 Surrounding Topography

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 Moss Vale STP is given in **Figure 7**. The ground elevation within the area illustrated in **Figure 7** ranges from approximately 350 m to 850 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 Moss Vale STP. This has been taken into consideration in the selection of the model and modelling grid resolution used for the study.

Figure 7 Local Topography Surrounding the Moss Vale 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 of potentially odour generating facilities within a 2 km radius of the Moss Vale STP (see **Figure 8**). These are:

- Moss Vale Meter Station (Operated by APT Management Services Pty Limited and located at a concrete batch plant operated by Concrite)
- Moss Vale Refuelling Facility
- Moss Vale Resource Recovery Centre
- Southern Regional Livestock Exchange

Odour from three of the four identified odour sources (ie Moss Vale Meter Station, Moss Vale Refuelling Facility and Moss Vale Resource Recovery Centre) are expected to have different characteristics compared to odours from the Moss Vale STP operations. Therefore, it is not appropriate to assume that the odours from these facilities are directly additive. The Technical Notes only requires:

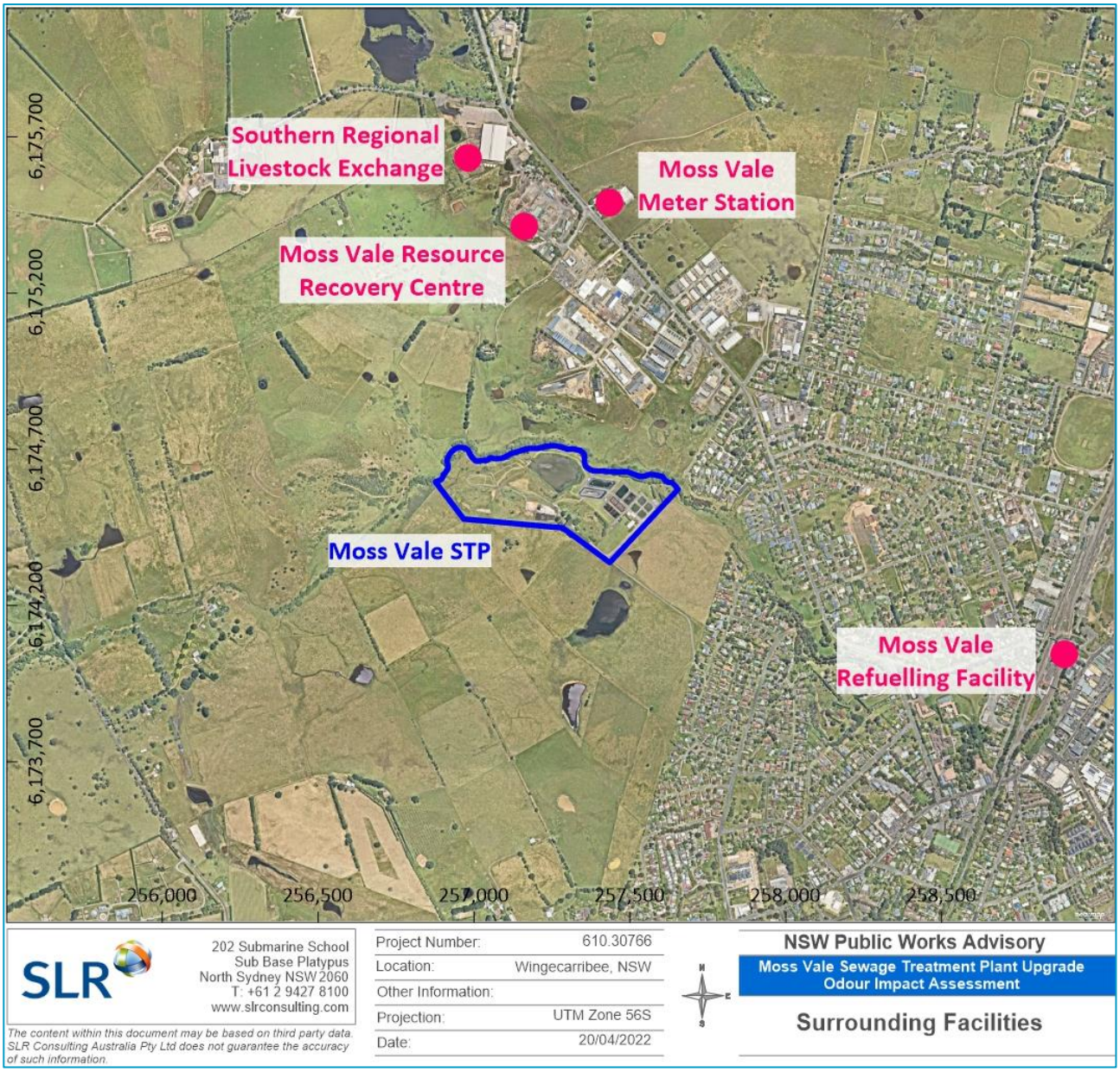
> *"Where it is likely that two or more facilities with **similar odour character** will result in cumulative odour impacts, the combined odours due to emissions resulting from all nearby facilities should also be assessed against the odour assessment criteria."*

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.*

A review of aerial imagery shows that the SRLX operations include a dry cattle stock yard and two facultative ponds which may have odours of similar characteristics to Moss Vale STP. This OIA conservatively assumes that odours from the SRLX sales yard will result in cumulative impacts to the surrounding receptors Therefore, odour-emissions from both the SRLX sales yard and the Moss Vale STP have been assessed within this report.

Figure 8 Surrounding Licenced Facilities



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 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 Moss Vale 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 DoP 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 Moss Vale 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. For this Project, a Peak-to-Mean Ratio (P/M60) of 2.5 for stability classes A, B, C and D and 2.3 for stability classes E and F has been applied and a P/M60 of 2.3 has been applied to all volume sources for all stability classes.

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 6.3 km east of the Moss Vale 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 Moss Vale STP	Elevation (m, AHD)
	Easting	Northing		
Moss Vale AWS	263,346	6,176,578	6.3 km / east	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 9**. Mean maximum temperatures range from 12°C in winter to 26.3°C in summer, while mean minimum temperatures range from 2.5°C in winter to around 14.3°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 10.** The average monthly rainfall is relatively high between late spring and early autumn, generally reducing from mid-autumn to mid spring with the lowest average of 36.4 mm/month recorded during September. On average, all months recorded an average of greater than ten days of rain days per month. The highest average monthly rainfall of 104.6 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 on 5 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 11**. 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 9 Long Term Temperature Data for Moss Vale AWS

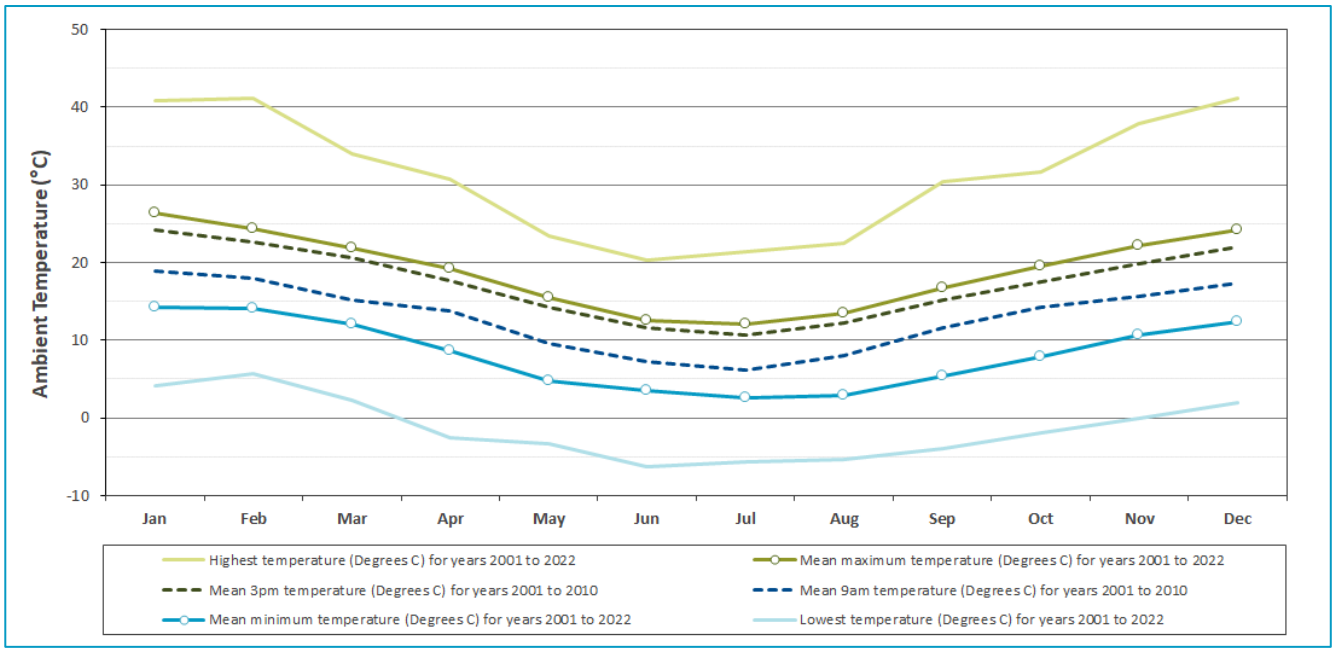


Figure 10 Long Term Monthly Rainfall Data for Moss Vale AWS

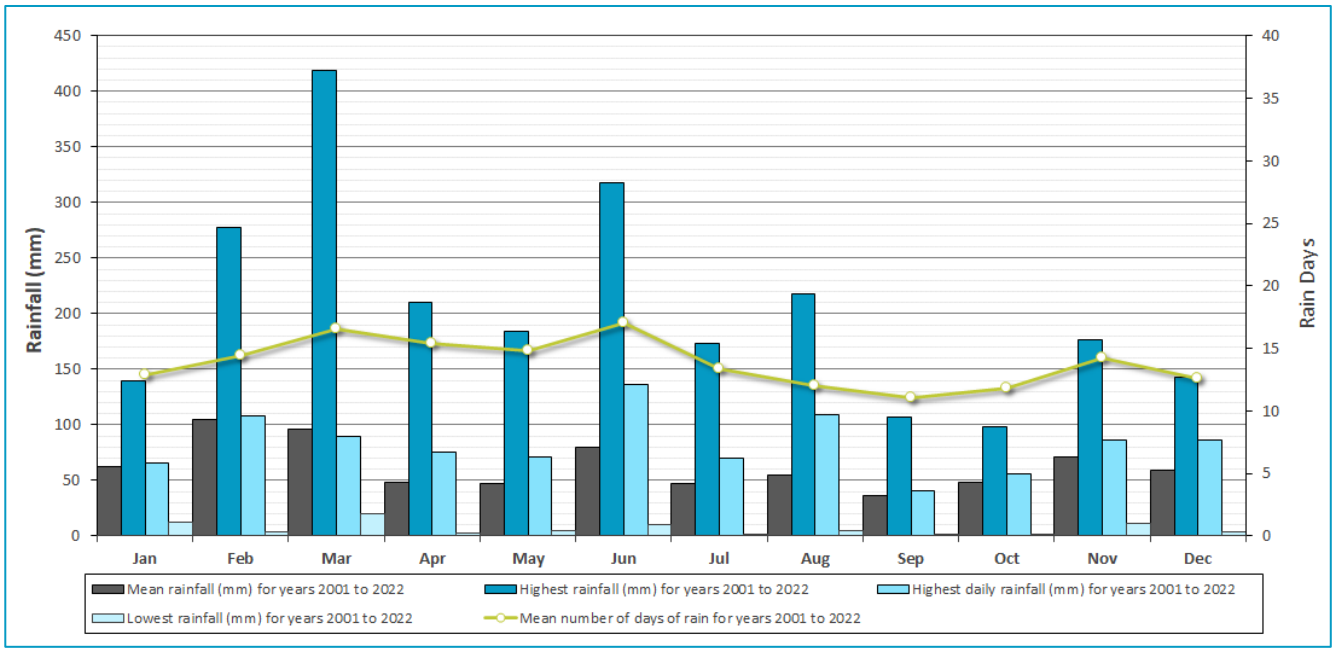
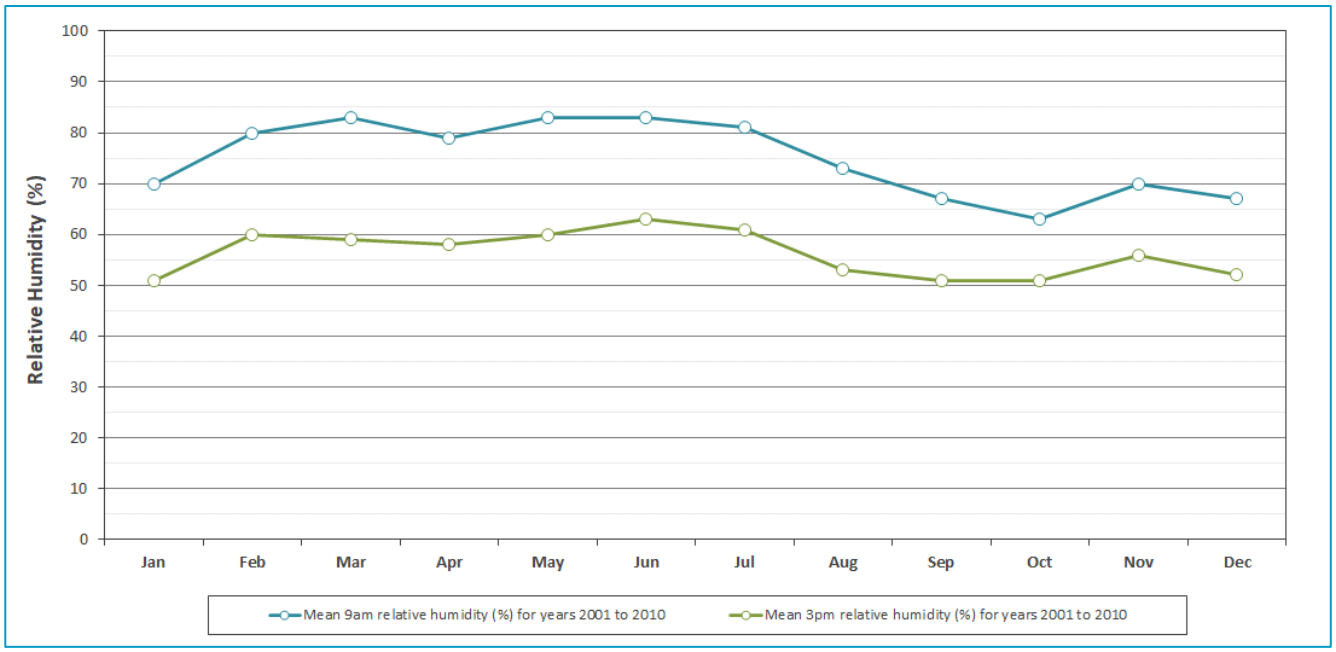


Figure 11 Long Term Humidity Data for Moss Vale AWS



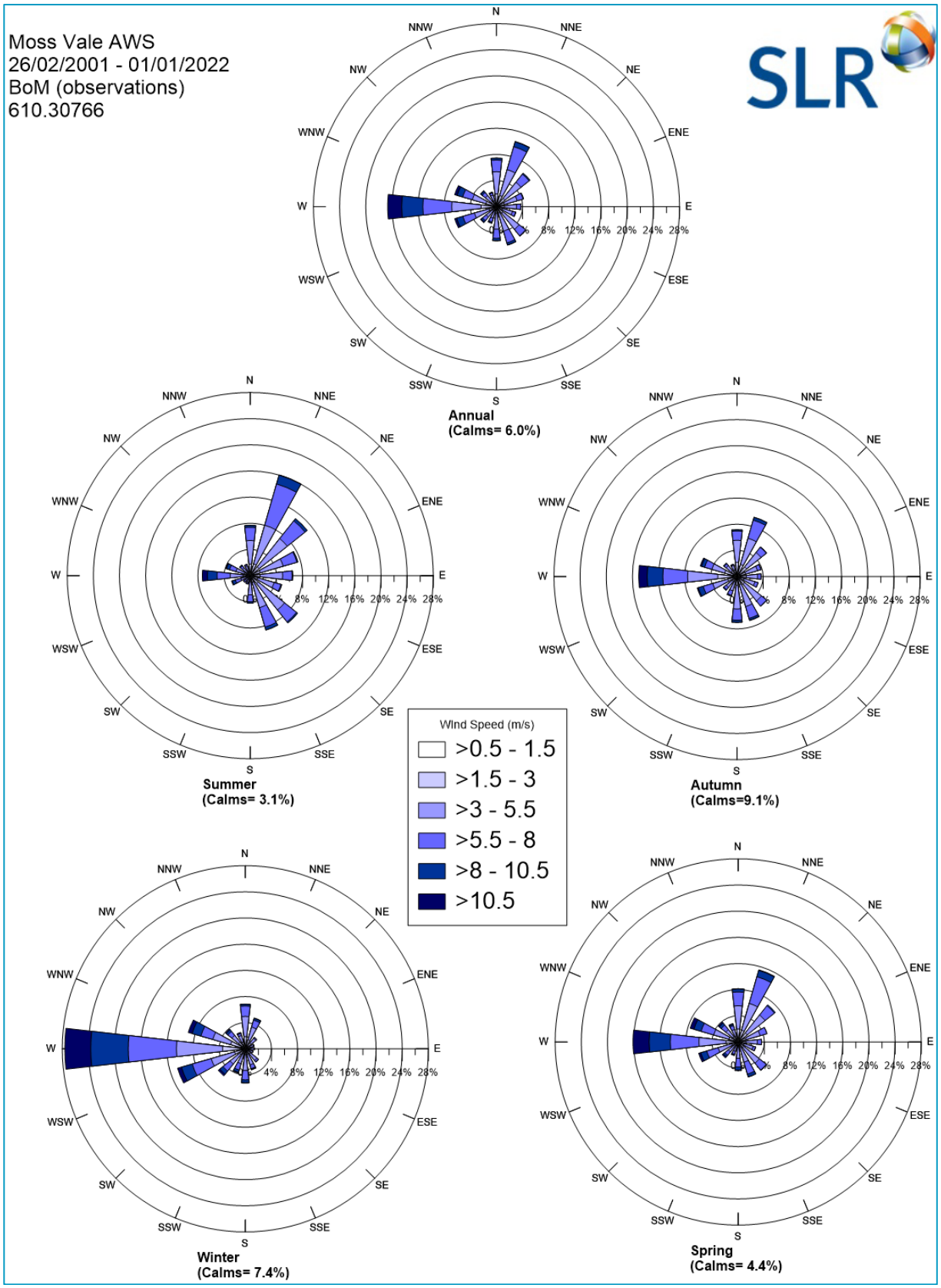
4.4 Wind Speed and Direction

Long term wind data (2001 – 2021) recorded by the Moss Vale AWS are presented as wind roses in **Figure 12**. 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 (m/s)], and the percentage of the time that winds are calm are shown as a note on the wind rose.

Figure 12 shows 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% of the time over the 20-year period reviewed. The seasonal wind roses indicate that typically:

- In summer, winds predominantly blow from the northeast and southeast quadrants with a very low frequency of winds from the northwest and southwest quadrants. On average, calm winds are experienced 3.1% 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 9.1% 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 7.4% of the time during winter.
- In spring, winds predominantly blow from the west and northeast quadrants. On average, calm winds were experienced 4.4% of the time during spring.

Figure 12 Rose of Wind Direction Vs Wind Speed for Moss Vale AWS (2001 -2021)



5 Estimation of Air Emissions

5.1 Potential Odour Sources

The potential odour sources at the existing and proposed Moss Vale STP include:

- **Inlet works** – Inlet works could be a major source of odour. 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 facility includes Sewage flow monitoring and two mechanical band screens (duty/duty), incorporating screen washing and manual bypass screen.
- **IDEA Reactors and Aerobic Digesters** – As part of the proposed upgrades, the existing IDEA reactors will be re-purposed and converted to aerobic digesters, one during Stage 1 and the second as part of the ultimate upgrade.
- **Catch Pond and Storm Storage -** There are two storm storage ponds in parallel (existing Catch Pond 1 and Catch Pond 2). The intent is for most of the settleable sewage solids to settle in the storm ponds prior to overflow to the existing Storm Balance Pond if required. The long retention time and slow rise rate provides effective primary treatment before discharge to the Storm Balance Pond, which then provides additional physical and biological treatment. This treatment, in addition to stormflow dilution of the sewage, results in a reasonable bypass quality. The existing catch pond and Storm Balance Pond have been retained for storm / emergency storage
- **Sludge lagoons and Sludge Drying Beds** – Sludge lagoons and drying beds could be a major source of odour. Currently, the sludge is stabilised for several months, and only mixed in the week before it is emptied. These will be decommissioned as part of the proposed upgrades. Sludge lagoons are proposed to be replaced with aerobic digestion and sludge drying beds with a mechanical dewatering plant.
- **Lift Pump Station** - Screened and degritted sewage flows from the inlet works to the lift pump station. There are three influent pumps and two bypass pumps in the lift pump station. Due to the relatively small surface areas, lift pump stations are not considered to be a significant source of odour.
- **Bioreactor Splitter** - 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. Foul water from the foul water pump station (FWPS) is also delivered to the feed chamber, where it mixes with the dosed influent. In the initial stage of the proposed upgrade, only 25% of the bioreactor splitter would accept raw sewage and rest would be dedicated to mixed liquors. At the ultimate stage, the bioreactor splitter could accept raw sewage at full capacity.
- **Bioreactor** - Two bioreactors are proposed for the proposed Moss Vale STP upgrade. A third bioreactor is required at the ultimate stage to treat ultimate loads.
- **Thickener and Thickened Waste Activated Sludge Pump** – Waste Activated Sludge (WAS) is proposed to be drawn from the bioreactors and pumped to the WAS thickener. Thickened WAS (TWAS) would be drawn from the thickener and pumped to the aerobic digester for stabilisation.
- **Clarifier Feed Splitter -** The bioreactor system has been designed for proposed stage loads, but readily upgradable to ultimate loads. In the proposed stage, there are two bioreactors and two clarifiers and in the ultimate stage, there are one additional bioreactor and two additional clarifiers.
- **Clarifiers** - Two secondary clarifiers are proposed with an additional two units added at the ultimate stage.

- **Dewatering Building** – Digested waste activated sludge (WAS) is proposed to be dewatered through a dewatering train. In the initial stage, a single dewatering train would be required. However, provision for two additional units has been included for the ultimate stage.
- **Sludge Outloading Facility** – Dewatered biosolids from the proposed dewatering building are directed onto a fixed speed cross conveyor. The cross conveyor delivers the biosolids to an inclined conveyor that subsequently lifts the biosolids into a truck trailer

The locations of identified sources of odour emissions are illustrated in **Figure 2** to **Figure 4** above.

5.2 Emission Estimation Methodology

No odour emission sampling has been performed for the existing Moss Vale STP. A literature review of publicly available odour emission testing reports and impact assessments for STPs and livestock saleyards in Australia has therefore been performed to identify potential odour emission rates relevant to the existing and proposed operations at the Moss Vale STP and the SRLX operations. Three relevant references reviewed as part of this study, which were:

- Rosebery Wastewater Treatment Plant (WWTP) – Air Quality Impact Assessment (MWH, 2013); and
- Sydney Water Database
- Ambient Air Quality Impact Assessment – Livestock Facility (ERM, 2016)

The SOERs used in the above assessments for processing units relevant to the Moss Vale STP and the SRLX sales yard were identified and are presented in **Table 4**.

Table 4 Surface Odour Emission Rates Identified from the Literature Review

Moss Vale STP		
Emission Source	SOER (ou.m³/m²/s)	
	Rosebery WWTP	Sydney Water Database (75th Percentile#)
Inlet works	5.50	6.20
IDEA Tank	0.60	0.20
Catch Pond	-	0.18
Sludge Lagoon	-	0.71
Sludge Drying Bed	-	0.44
Bioreactor feed Splitter - Mixed Liquor	-	0.66
Bioreactor - Aerobic	-	0.28
Bioreactor - Anoxic	-	0.28
Clarifier	-	0.13
Dewatering Building	-	-*
Sludge Out-loading Facility	-	0.66
Thickener & TWAS Pump	-	0.18
Aerobic digester	-	0.57
Storm Storage	-	0.04
SRLX Sales Yard		
Emission Source	**SOER (ou.m³/m²/s)**	**Reference**
Cattle Stock Yard Dry	0.064	(ERM, 2016)
Facultative Pond	0.056	(ERM, 2016)

*Given the area and the height of the building are 170 m² and 6.5 m respectively, and considering Sydney Water Database 70th percentile concentration of 527 ou, and 5 air changes per hour, OER for the dewatering building equates 809 ou/s.

The 75th percentile provides a realistic estimate of normal operations from the STP (compared to maximum SOERs) while still maintaining a level of conservatism. The 75th percentile omits data outliers (which are representative of upset condition, not well maintained or old STPs) while still including elevated conditions more likely representative of normal operational odour emissions.

The adopted odour emission rates for this assessment are presented in in **Table 5**. In order to estimate conservative odour emission rates from the Moss Vale 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 Moss Vale STP

Activity	Raw SOER ($ou.m^3/m^2/s$)*	Reference
Inlet works	6.20	Sydney Water Database 75th percentile
IDEA Tank	0.60	Rosebery WWTP
Catch Pond	0.18	Sydney Water Database 75th percentile
Sludge Lagoon	0.71	Sydney Water Database 75th percentile
Sludge Drying Bed	0.44	Sydney Water Database 75th percentile
Lift pump station	6.20	Assumed same as Inlet works
Bioreactor feed Splitter - Raw Sewage	6.20	Assumed same as Inlet works
Bioreactor feed Splitter - Mixed Liquor	0.66	Sydney Water Database 75th percentile
Bioreactor - Aerobic	0.28	Sydney Water Database 75th percentile
Bioreactor - Anoxic	0.28	Sydney Water Database 75th percentile
Clarifier Feed Splitter	0.28	assumed same as bioreactor - aerobic
Clarifier	0.13	Sydney Water Database 75th percentile
Sludge Outloading Facility	0.66	Sydney Water Database 75th percentile
Thickener & TWAS Pump	0.18	Sydney Water Database 75th percentile
Aerobic digester	0.57	Sydney Water Database 75th percentile
Storm Storage	0.04	Sydney Water Database 75th percentile
SRLX Cattle Stock Yard Dry	0.064	(ERM, 2016)
SRLX Facultative Pond	0.056	(ERM, 2016)

* For sources with multiple emission rates available in the literature, the highest reported values have been used for the purpose of this assessment

5.3 Estimated Emissions

The odour emission rate and source parameters used in the modelling for the existing, proposed, and ultimate operations as well as the SRLX sales yard are presented in **Table 6** to **Table 8**.

It has been assumed in the modelling that odours will be emitted from the identified sources at the estimated odour emission rate constantly throughout the year.

Table 6 Odour Emission Rate and Source Parameters – Existing Operations

Source	Area (m^2)	Height (m)	Raw SOER ($ou.m^3/m^2/s$)	Raw OER ($ou.m^3/s$)
Inlet works	90	0.5	6.20	558
IDEA Tank 1	1,150	0.5	0.60	690
IDEA Tank 2	1,150	0.5	0.60	690
Catch Pond 1	2,314	0.5	0.18	417
Catch Pond 2	2,137	0.5	0.18	385
Sludge Lagoon 1	1,323	0.5	0.71	939

Source	Area (m^2)	Height (m)	Raw SOER ($ou.m^3/m^2/s$)	Raw OER ($ou.m^3/s$)
Sludge Lagoon 2	1,323	0.5	0.71	939
Sludge Drying Bed 1	490	0.5	0.44	216
Sludge Drying Bed 2	452	0.5	0.44	199
Sludge Drying Bed 3	500	0.5	0.44	220
Sludge Drying Bed 4	453	0.5	0.44	199
Total STP Odour Emissions				**5,452**

Table 7 Odour Emission Rate and Source Parameters – Proposed Operations

Source	Area (m^2)	Height (m)	Raw SOER ($ou.m^3/m^2/s$)	Raw OER ($ou.m^3/s$)
Inlet Works	140	0.5	6.20	868
Lift pump station	64	0.5	6.20	394
Bioreactor feed Splitter - Raw Seage	9	5.5	6.20	54
Bioreactor feed Splitter - Mixed Liquor	26	5.5	0.66	17
Bioreactor - Aerobic	492	1.5	0.28	140
Bioreactor - Anoxic	428	1.5	0.28	118
Clarifier Feed Splitter	40	3	0.28	11
Clarifier -1	380	1.5	0.13	49
Clarifier -2	380	1.5	0.13	49
Dewatering Building	170	6.5	-	809
Sludge Outloading Facility	78	7	0.66	51
Thickener & TWAS Pump	79	1	0.18	14
Aerobic digester – Existing IDEA Tank 1	1,150	0.5	0.57	656
Storm Storage – Existing Catch Pond 1	2,314	0.5	0.04	93
Storm Storage – Existing Catch Pond 2	2,137	0.5	0.04	85
Total				**3,410**

Table 8 Odour Emission Rate and Source Parameters – Ultimate Operations

Source	Area (m^2)	Height (m)	Raw SOER ($ou.m^3/m^2/s$)	Raw OER ($ou.m^3/s$)
Bioreactor - Anoxic	428	1.5	0.28	428
Clarifier Feed Splitter	40	3	0.28	40
Clarifier -1	380	1.5	0.13	380
Clarifier -2	380	1.5	0.13	380
Dewatering Building	170	6.5		170

Source	Area (m^2)	Height (m)	Raw SOER ($ou.m^3/m^2/s$)	Raw OER ($ou.m^3/s$)
Sludge Outloading Facility	78	7	0.66	78
Thickener & TWAS Pump	79	1	0.18	79
Aerobic digester – Existing IDEA Tank 1	1,150	0.5	0.57	1,150
Storm Storage – Existing Catch Pond 1	2,314	0.5	0.04	2,314
Storm Storage – Existing Catch Pond 2	2,137	0.5	0.04	2,137
Aerobic digester – Existing IDEA Tank 2	1,150	0.5	0.57	1,150
Future Bioreactor - Aerobic	492	1.5	0.28	492
Future Bioreactor - Anoxic	428	1.5	0.28	428
Future Clarifier - 1	380	1.5	0.13	380
Future Clarifier - 2	380	1.5	0.13	380
Total				**4,568**

Table 9 Odour Emission Rate and Source Parameters – SRLX sales yard

Source	Area (m^2)	Height (m)	Raw SOER ($ou.m^3/m^2/s$)	Raw OER ($ou.m^3/s$)
Cattle Stock Yard Dry	3,897	0.5	0.064	249
Facultative Pond 1	603	0.5	0.056	34
Facultative Pond 2	1,110	0.5	0.056	62
Total				**345**

6 Atmospheric Dispersion Modelling Methodology

6.1 Model Selection

Emissions from the Moss Vale STP have been 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 (2017-2021) 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 2017 was representative of the last five years of meteorological conditions experienced at the Moss Vale STP and hence the 2017 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 Moss Vale 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, rainwater 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) has been used to nudge (i.e. influence) the TAPM predictions. **Table 10** details the parameters used in the TAPM meteorological modelling for this assessment.

Table 10 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 35
Year of Analysis	2017
Centre of Analysis	255,184 m E 6,178,250 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 11** details the parameters used in the meteorological modelling to drive the CALMET model.

Table 11 Meteorological Parameters Used for this Study – CALMET (V 6.1)

CALMET Domain	
Meteorological Grid	12 km × 12 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 Moss Vale 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 Moss Vale 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 2017 (extracted at the Moss Vale STP) is presented as wind roses in **Figure 13** and as a wind speed distribution plot in **Figure 14**. These plots show that winds in the study area were predicted to be predominantly of gentle to moderate strength (between 3 m/s and 8 m/s) during 2017. Calm wind conditions were predicted to occur approximately 1.9% 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 quadrant with a very low frequency of winds from the southwest quadrant. On average, calm winds are experienced 0.6% of the time during summer.
- In autumn, there is a significant increase in winds from the southwest quadrant. The highest frequency of winds is from the northeast and south quadrant and the lowest frequency of winds is from the northwest quadrant. On average, calm winds are experienced 2.2% of the time during autumn.
- In winter, winds predominantly blow from the west and southwest quadrant, with the lowest frequency of winds from the east quadrant. On average, calm winds are experienced 3.9% of the time during winter.
- In spring, winds predominantly blow from the north-northeast quadrant with the lowest frequency of winds from the south quadrant. On average, calm winds were experienced 0.8% of the time during spring.

A comparison of the wind roses presented in **Figure 13** with the Moss Vale AWS wind roses presented in **Figure 12** shows a similar distribution of wind directions, however the frequency of westerly winds is significantly higher at Moss Vale STP an higher wind speeds are recorded at this location. Based on the wind roses, the seasons with the greatest potential for odour impacts at the nearest sensitive receptors (located to the northeast of the site) would be autumn and winter.

Figure 13 CALMET-Predicted Seasonal Wind Roses for the Moss Vale STP – 2017

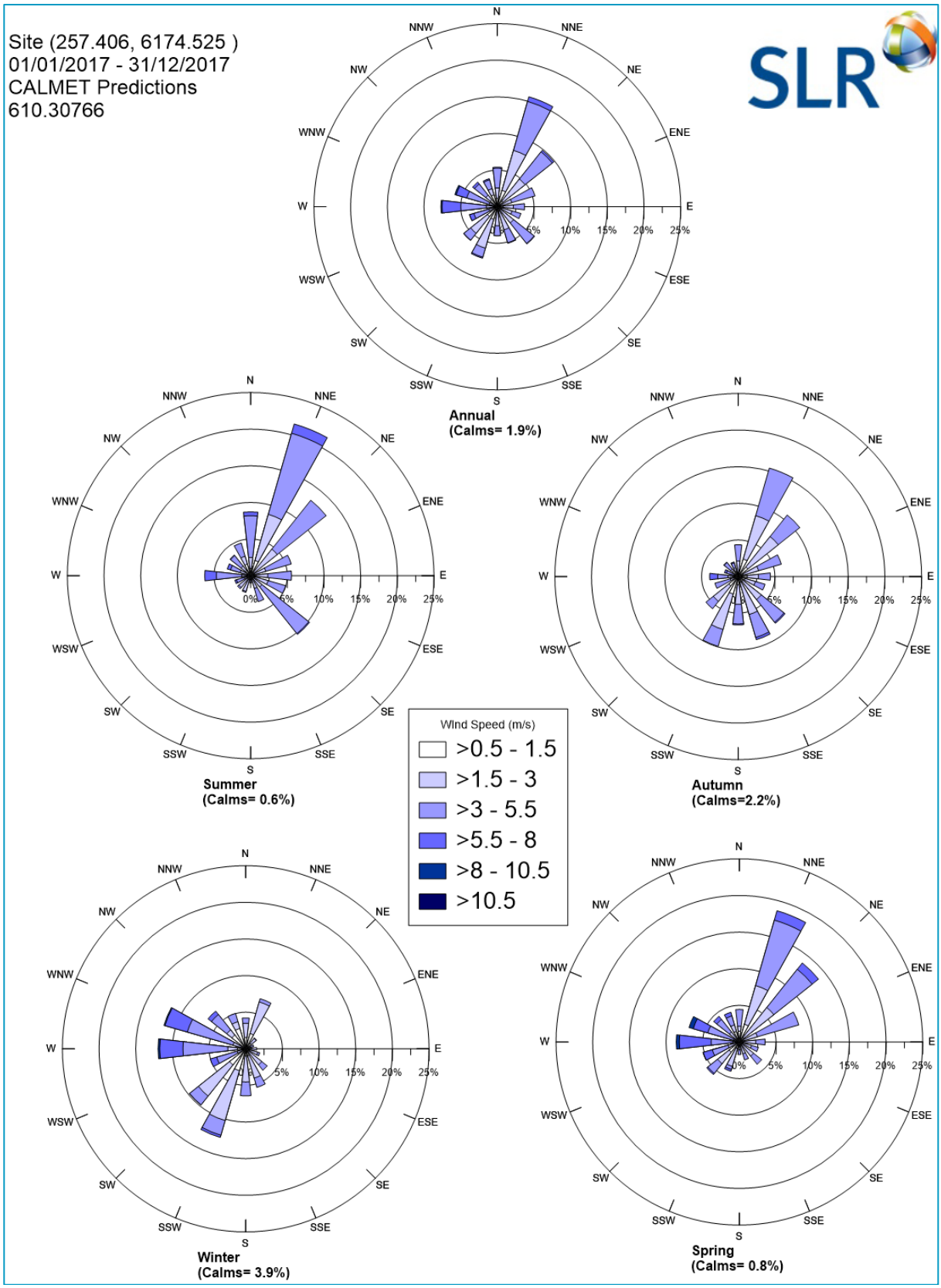
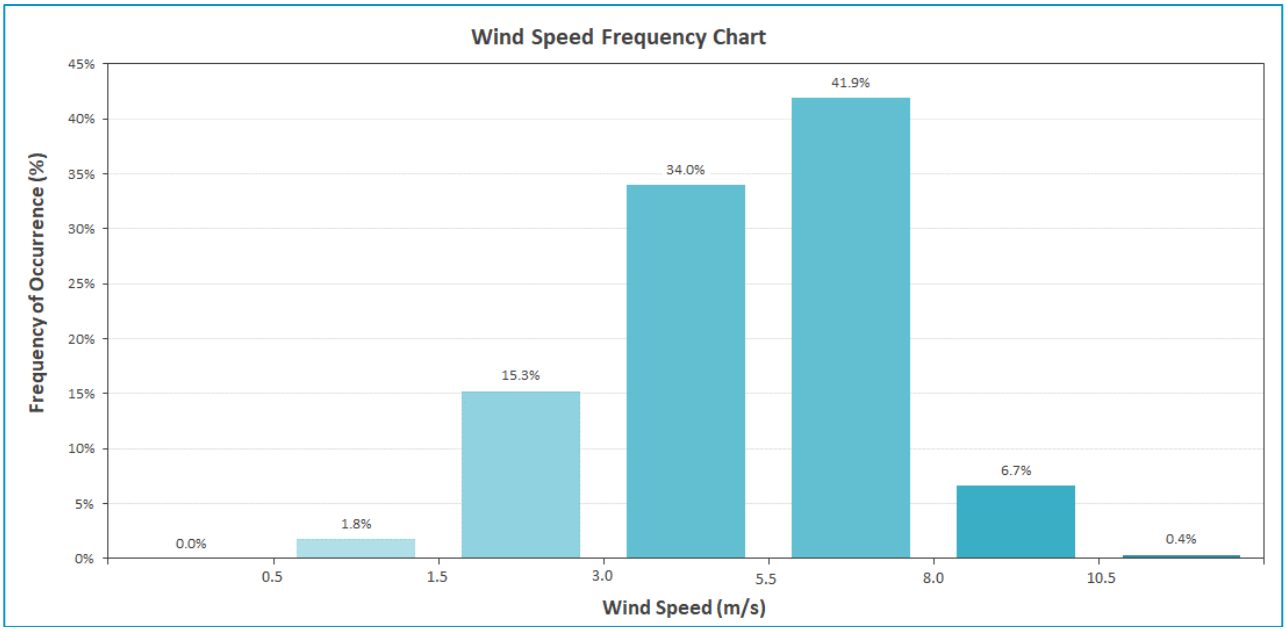


Figure 14 Annual Wind Speed Frequencies at the Moss Vale STP (CALMET Predictions, 2017)



1.1.1 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 12**.

Table 12 Meteorological Conditions Defining PGT Stability Classes

Surface **W**ind **S**peed (m/s)	Daytime **I**nsolation			Night-**T**ime **C**onditions	
	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

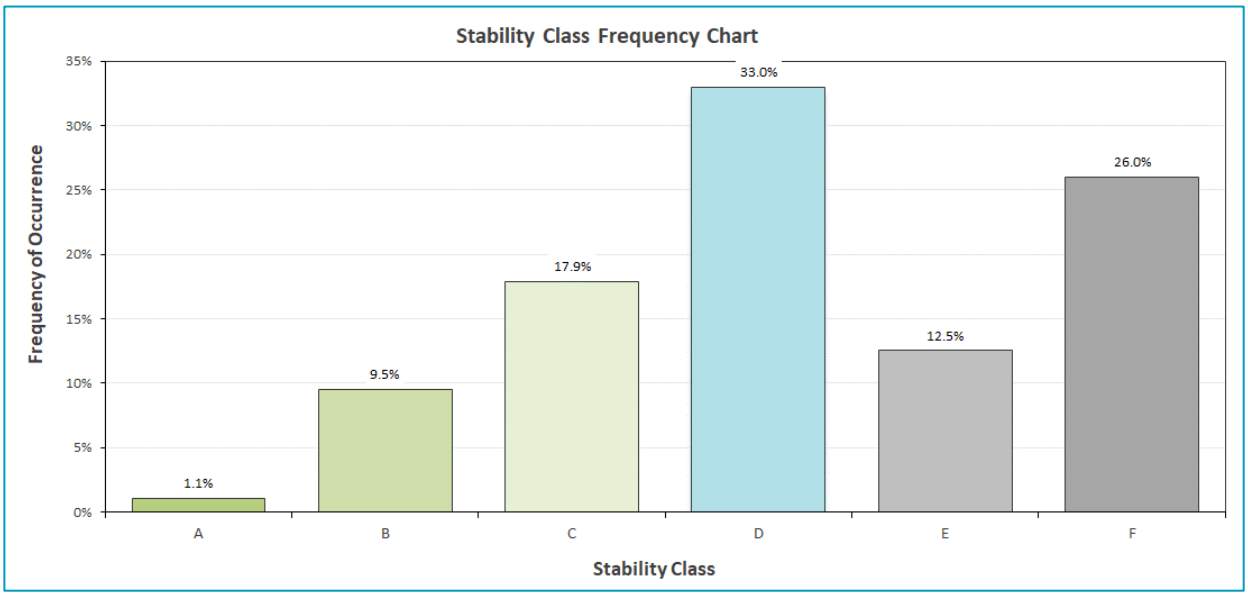
Source: (NOAA, 2018)

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 Moss Vale STP during the modelling period is presented in **Figure 15**. 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 15 Predicted Stability Class Frequencies at the Moss Vale STP (CALMET predictions, 2017)

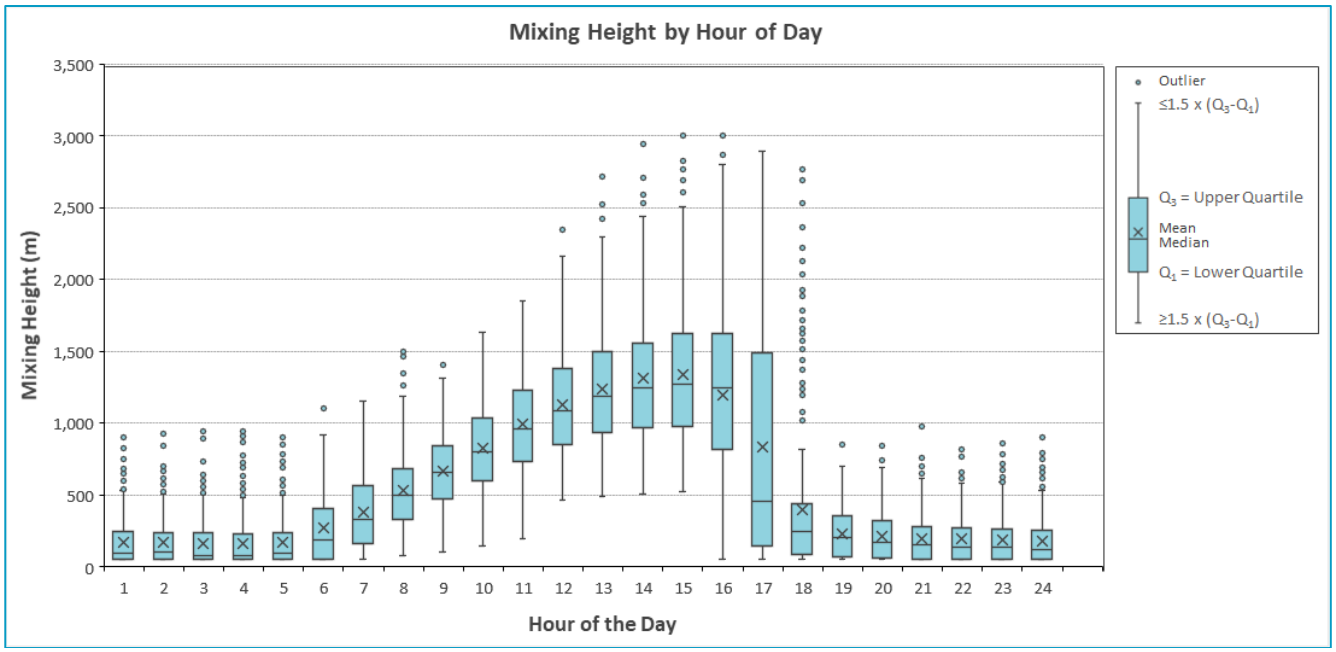


6.3.2 Mixing Heights

Diurnal variations in maximum and average mixing heights predicted by CALMET at the Moss Vale STP during the 2017 modelling period are illustrated in **Figure 16**.

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 16 Predicted Mixing Heights at the Moss Vale STP (CALMET predictions, 2017)



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 a worst-case assessment of potential off-site impacts. Emissions from the activities at the Moss Vale STP were represented by a series of area sources.

7 Odour Impact Assessment

This section identifies an appropriate odour impact assessment criterion for the Moss Vale STP and presents a summary of the odour impacts predicted by the modelling at the sensitive receptors identified in **Section 2.3**.

7.1 Adopted Odour Impact Assessment Criterion

As illustrated in **Figure 17**, the area predicted to be affected by the existing, proposed, and ultimate operations at the Moss Vale STP (ie the area within the 2 ou contour line) is 0.39 km^2, 0.28 km^2, and 0.36 km^2 respectively. It is noted that as a conservative measure, these areas include the area occupied by the Moss Vale STP (approximately 0.16 km^2) as well as areas to the north and northeast of the Moss Vale STP where residential development is constrained due to flooding impacts.

According to the 2016 ABS Census data, the area affected by the existing and future proposed operations is located within the Statistical Area Level 1 (the smallest geographic unit for the release of Census data) SA1:1128715 and SA1:1128716 (refer **Figure 17**). **Table 13** 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, proposed and ultimate operations of the Moss Vale STP.

Table 13 Potential Affected Population

Statistical Area	Population Density (ppl/km^2)	Affected Area (km^2)		
		Existing Operations	Proposed Operations	Ultimate Operations
1128716	10	0.35	0.28	0.35
1128715	307	0.04	<0.01	<0.01

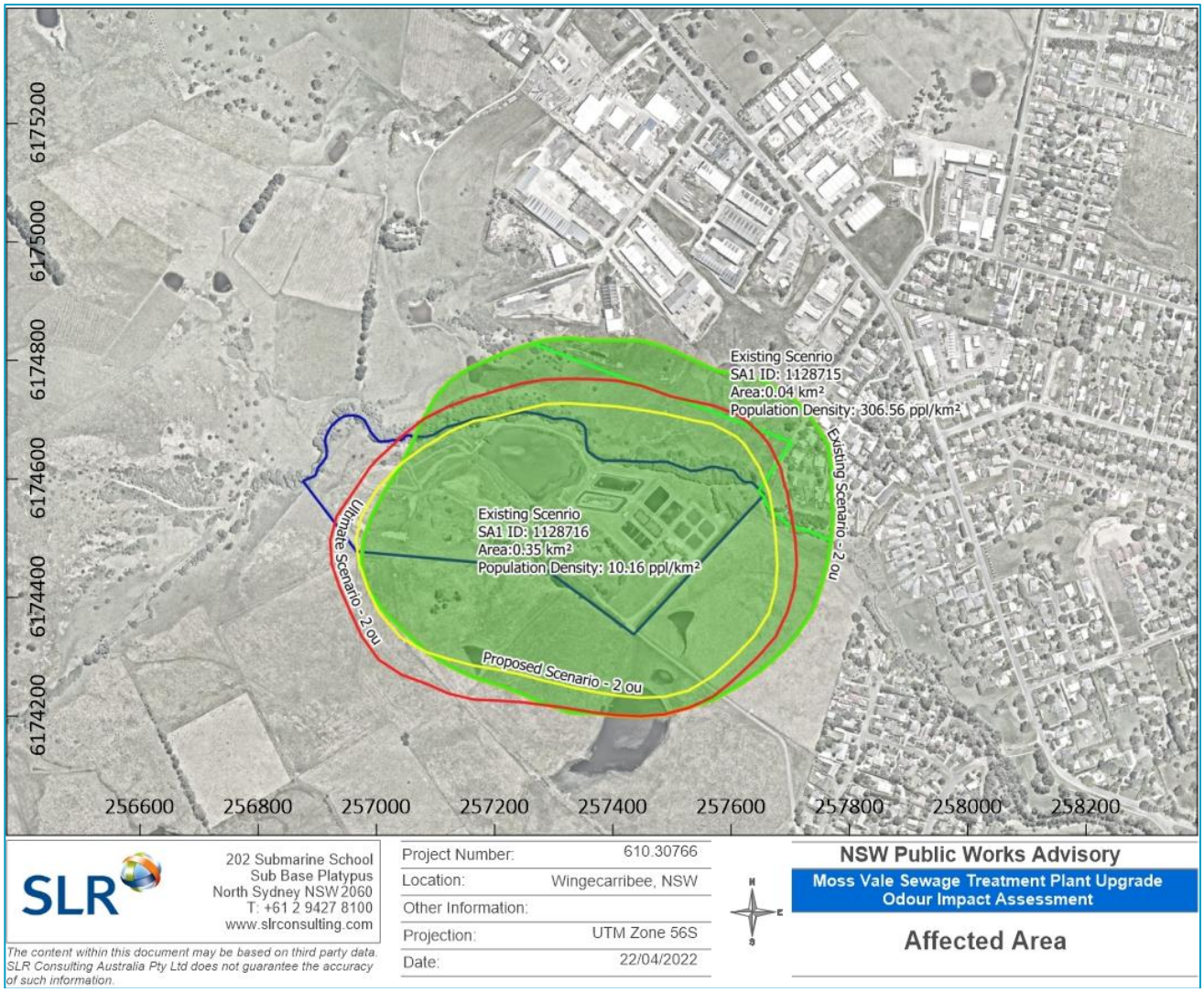
ppl/km^2 = people per square kilometre

Based on the data presented in **Table 13**, it is estimated that a population of approximately 16 people may be affected by the cumulative emissions from existing operations at the Moss Vale STP. It is predicted that the affected population would decrease to 3 people as a result of the proposed upgrades and increase to 4 people when the Moss Vale STP operates at the ultimate capacity.

Therefore, the following odour impact assessment criteria (expressed as the 99th 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 operations; and
- 6.0 ou for the assessment of odour impacts due to proposed and ultimate operations.

Figure 17 Affected Area for Modelled Scenarios



7.2 Dispersion Modelling Results

Dispersion modelling was performed to predict worst-case impacts associated with the existing, proposed, and ultimate operations at the Moss Vale STP as well as the SRLX sales yard. The cumulative 99th percentile nose-response-time odour concentrations predicted for the existing, proposed, and ultimate operations at the Moss Vale STP at the surrounding sensitive receptors are presented in **Table 14**. The results show that the predicted 99th percentile odour concentrations due to the existing operations comply with the adopted criterion of 5 ou at all the identified nearest sensitive receptors. The incremental impact due to the SRLX sales yard operations at the modelled sensitive receptors is predicted to be negligible.

A significant decrease in the 99th percentile 1-hour average odour concentrations (average of 45% and 27% reduction for proposed and ultimate upgrades respectively) has been predicted at all receptors modelled for the proposed and ultimate upgrades of the Moss Vale STP. The results indicate that after the upgrade, the predicted 99th percentile odour concentrations, which range between 0.2 ou and 1.7 ou will be well below the adopted criterion of 6 ou at all of the discrete receptors modelled for the modelled proposed and ultimate scenarios (refer to **Table 14**).

The predicted 1-hour average 99th percentile odour concentrations for the existing, proposed, and ultimate operations are presented as a contour plots in **Figure 18** to **Figure 20**. 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 14 Predicted Odour Concentrations at Discrete Sensitive Receptors

Receptor ID	Predicted 99th Percentile Odour Concentrations at Sensitive Receptor Locations (ou, nose-response time)			
	SRLX Sales Yard	Cumulative		
		Existing Operations	Proposed Operations	Ultimate Operations
R1	< 0.1	3.0	1.3	1.7
R2	< 0.1	2.9	1.2	1.6
R3	< 0.1	1.8	0.8	1.1
R4	< 0.1	1.9	0.9	1.2
R5	< 0.1	1.8	0.9	1.2
R6	< 0.1	1.1	0.7	0.9
R7	< 0.1	1.0	0.6	0.8
R8	< 0.1	0.9	0.6	0.7
R9	< 0.1	0.9	0.5	0.7
R10	< 0.1	1.5	0.7	0.9
R11	< 0.1	1.2	0.6	0.8
R12	< 0.1	0.7	0.5	0.6
R13	< 0.1	0.7	0.4	0.6
R14	< 0.1	0.6	0.4	0.5
R15	< 0.1	0.8	0.5	0.6
R16	< 0.1	1.7	0.8	1.1
R17	< 0.1	1.0	0.5	0.7
R18	< 0.1	0.9	0.5	0.6
R19	< 0.1	0.3	0.2	0.3
Criterion		**5.0**	**6.0**	**6.0**

Figure 18 Predicted Cumulative 99th Percentile (Nose Response Time) Odour Concentrations – Existing Operations

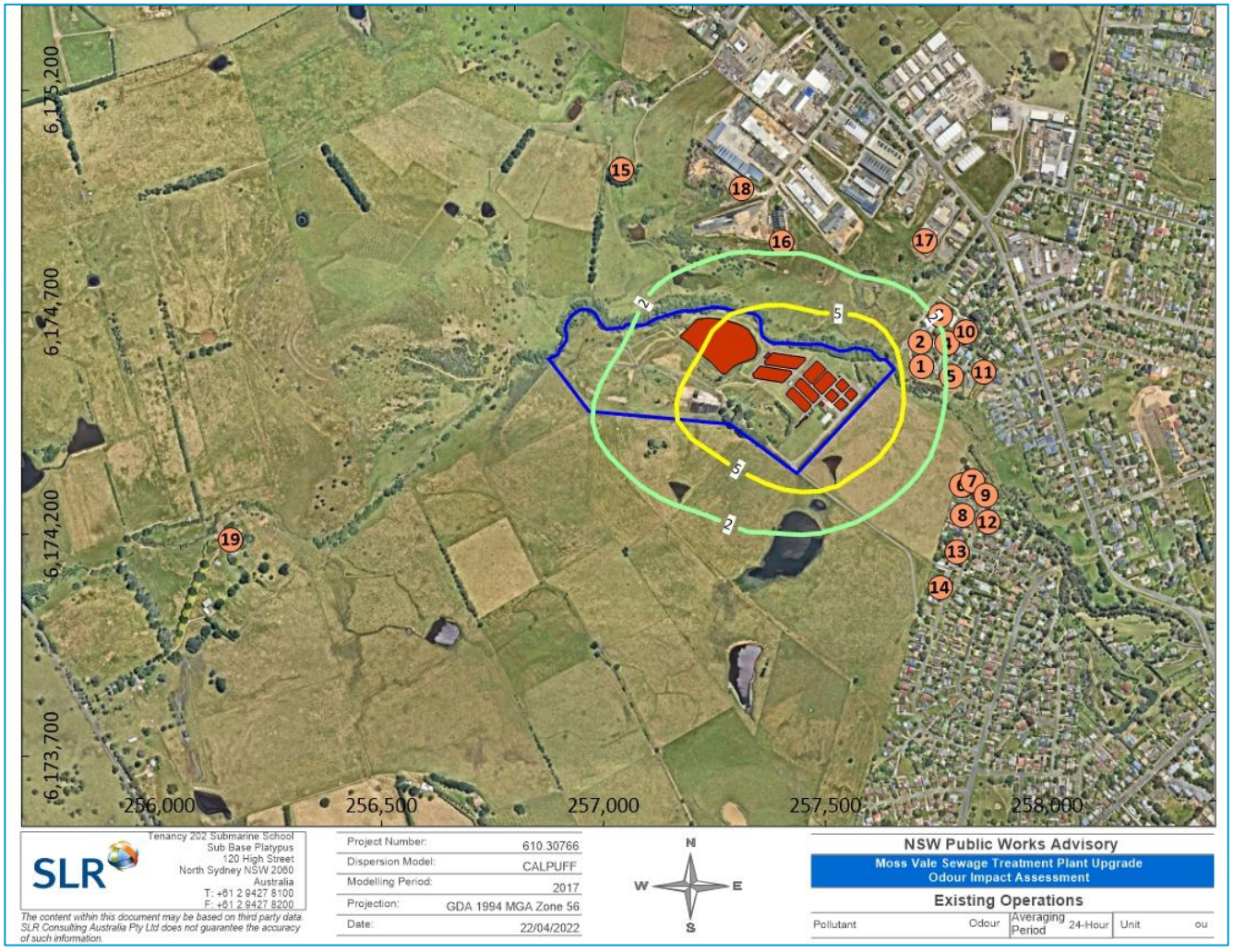


Figure 19 Predicted Cumulative 99th Percentile (Nose Response Time) Odour Concentrations – Proposed Operations

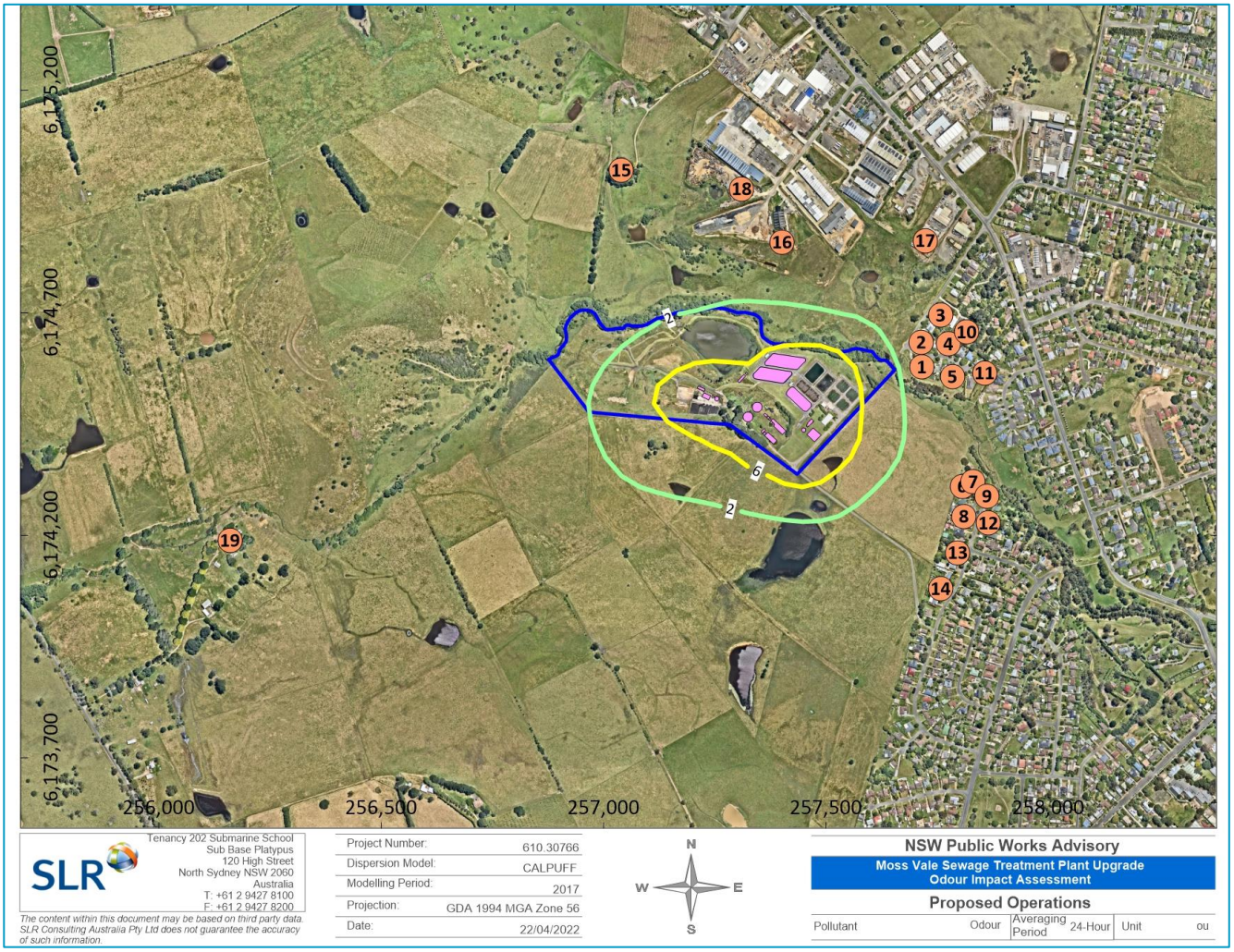


Figure 20 Predicted Cumulative 99th Percentile (Nose Response Time) Odour Concentrations – Ultimate Operations

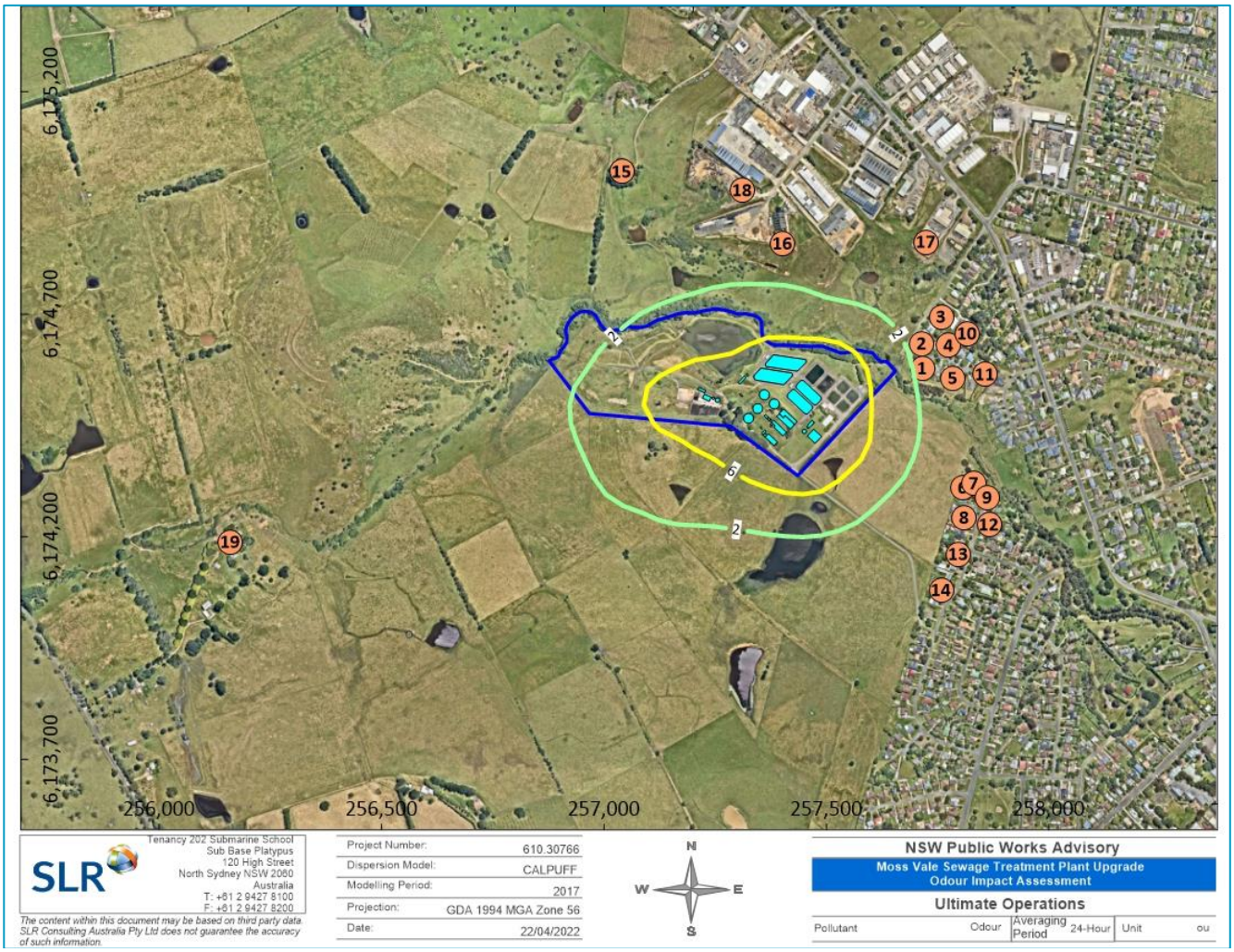


Figure 21 and **Figure 22** present the odour concentrations predicted along the Moss Vale STP SP2 boundary for both proposed and ultimate upgraded operations to assess compliance with the DoP Best Practice Odour Guideline requirement (see **Section 3.3**) of:

> *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 show that neither the proposed nor the ultimate designs meet the odour design criteria recommended by the DoP Odour Guideline, as the predicted 99th percentile odour concentrations at the SP2 boundary range between 0.2 – 20.1 ou with an average of 4.4 ou for proposed operations and 1.2 – 24.4 ou, with an average of 6.8 ou for ultimate operations across all boundary receptors.

Figure 21 Predicted Cumulative 99th Percentile (Nose Response Time) Odour Concentrations at the SP2 Boundary – Proposed Operations

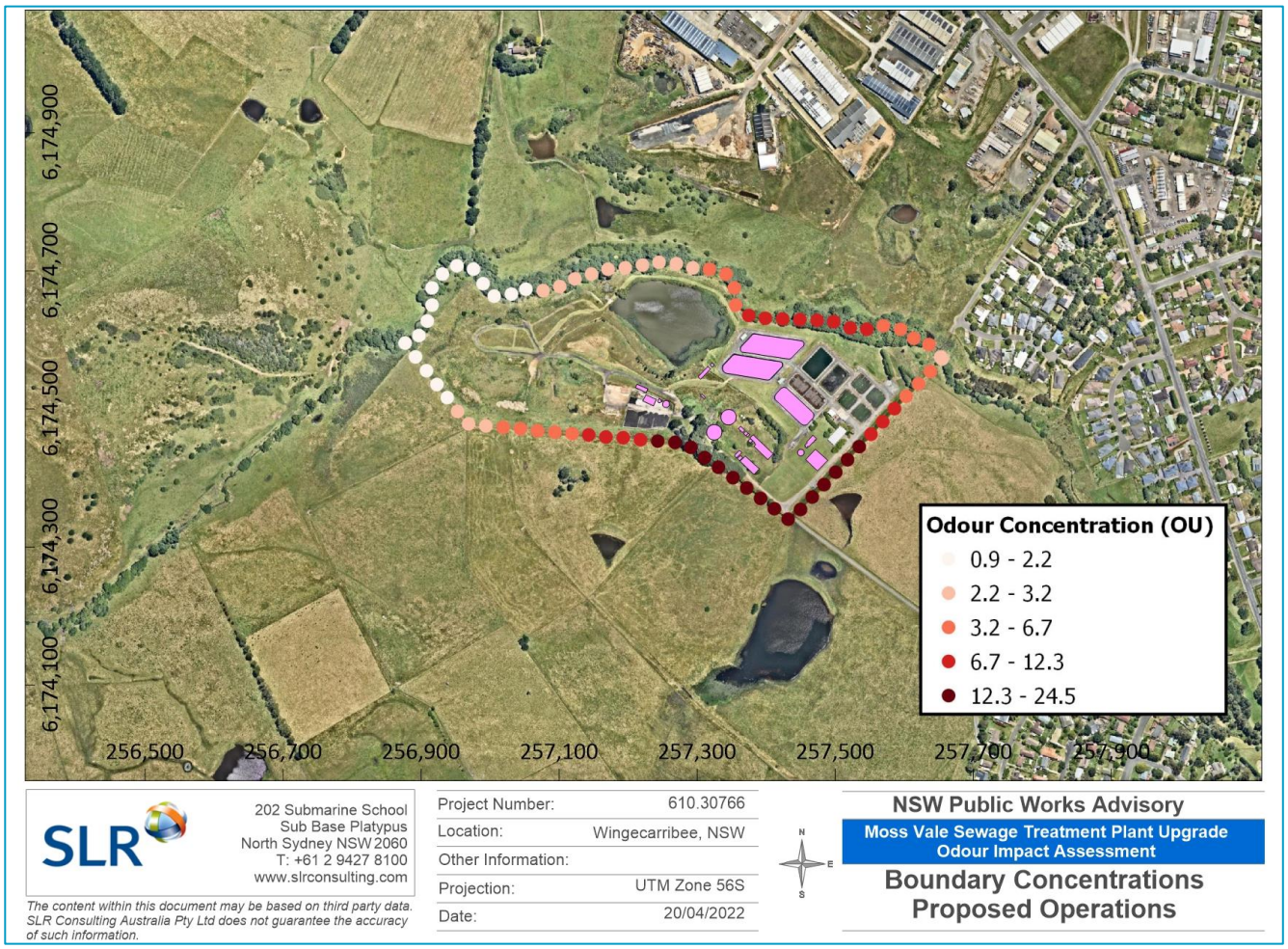
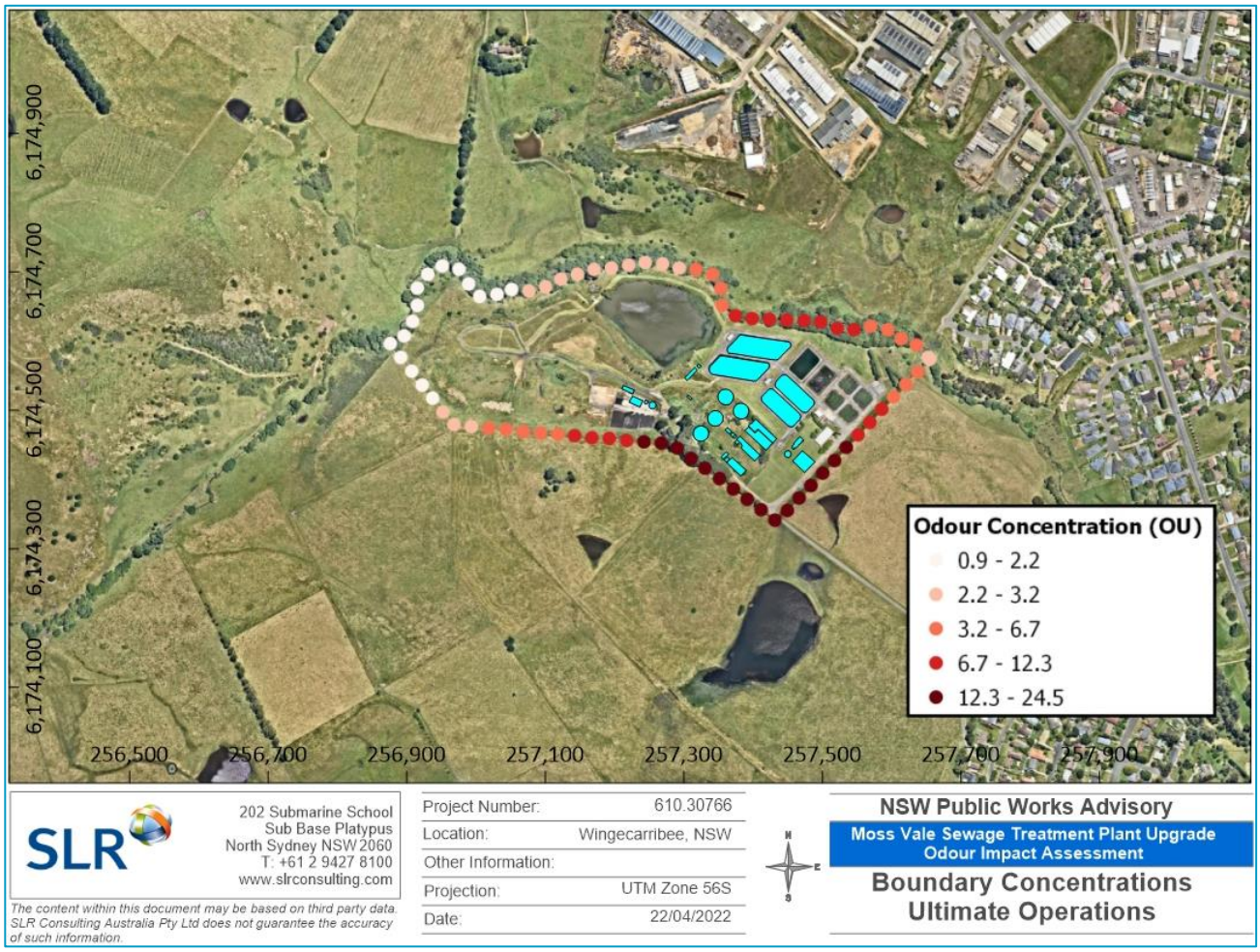


Figure 22 Predicted Cumulative 99th Percentile (Nose Response Time) Odour Concentrations at the SP2 Boundary – Ultimate Operations



8 Mitigation Measures

As outlined in **Section 7**, the predicted 99th percentile odour concentrations due to the proposed and ultimate upgrades are predicted to decrease by an average of 45% and 27% across the receptors respectively and the predicted 99th percentile odour concentrations at all nearby sensitive receptors are predicted to be below the adopted odour impact assessment criterion of 6 ou for both proposed and ultimate concept designs. However, the Moss Vale STP upgrade does not meet the 2 ou odour design criterion (at the boundary of the SP2 lot) recommended by the relevant DoP Odour Guideline. It is noted that the 2 ou odour design criterion is met at all sensitive receptors modelled for the proposed and ultimate operations.

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. Some reductions may be achievable through optimising the site layout within to provide maximum buffer distance between the odour emission sources and the SP2 boundary. However, given the constraints associated with relocation existing structures and the limited space available within the existing site boundary, it is highly unlikely that compliance with the 2 ou design criterion could be achieved by changes to the layout alone.

Further reductions in the odour concentrations at the boundary could potentially be achieved through:

- Installation of pollution control equipment (e.g. biofilters, carbon filtration, etc.); and
- Tree breaks (may redirect wind flows, aid dispersion and remove dust).

Apart from physical controls as outlined above, good management procedures could also 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 Moss Vale 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 complaints registering and investigation.

Complaints monitoring is a very useful tool in assessing whether nuisance is being caused. SLR understands that complaints monitoring is currently being undertaken by the Council and it is recommended that complaints investigations be continued with appraisals and actions undertaken as per current procedures. Where odour complaints are verified, engineering, operational or other odour reduction measures may be implemented.

9 Conclusions

Wingecarribee Shire Council (the Council) is currently planning to upgrade the Moss Vale 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

SLR Consulting was commissioned by the New South Wales Public Works Advisory (PWA) to conduct an OIA for the proposed upgrade of the Moss Vale STP to support a Review of Environmental Factors (REF) which is being prepared for the proposed augmentation.

Emissions of odour from all existing and upgraded on-site activities were estimated using publicly available data. The calculated emissions were modelled using the CALMET/CALPUFF modelling software to investigate the transport of emitted odour from the Moss Vale 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 and upgraded operations at the Moss Vale STP showed that predicted 99th percentile odour concentrations at all nearby sensitive receptors would be below the adopted odour impact criterion of 6 ou (nose response time) as a result of the upgrade. According to the modelling predictions, the proposed upgrades will result in a 45% to 27% decrease (compared to the existing operations) in the 99th percentile odour concentrations at the nearby sensitive receptors for proposed and ultimate operations respectively.
- The proposed and ultimate concept designs do 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. However, the predicted concentration at all sensitive receptors is below 2.0 ou.
- Given the proposed capacity of the STP and site limitations, emissions from all sources may need to be captured and treated before discharge to the atmosphere in order to achieve the 2.0 ou odour design criterion at the boundary of the SP2 lot.

Full compliance with the odour design criterion recommended by the draft DoP Odour Guideline would most likely involve enclosure of significant areas of the STP, which is not considered to be feasible by the design team. However, given that the 99th percentile odour concentration is predicted to be well below the adopted odour impact criterion of 6.0 ou (designed to preserve amenity in communities neighbouring odour-emitting activities) at the worst impacted sensitive receptor (1.3 – 1.7 ou), ongoing odour issues at the surrounding residential dwellings are highly unlikely.

Further to the above, as odour concentrations at the nearby sensitive receptors are predicted to decrease as a result of the upgrade, a decrease in any existing odour issues associated with the current STP operations is expected.

To further reduce the potential for odour emissions, it is recommended that management measures including an Odour Management Plan, good neighbour procedures and a complaints register be adopted in line with the recommendations of the DoP 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 (2017 to 2021 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 2017 to 2021 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. Although it is noted that the most significant difference in observed for the year 2017, since most of the surrounding sensitive receptors are located to the northeast of the Moss Vale STP 2017 (with higher frequency of south-westerly winds) is the worst case year in this case.
- **Figure A2** indicates that 2017 exhibit wind speeds that are closest to the long term average; and
- **Figure A3** shows that temperatures in 2017 and 2018 more closely reflect the long term average.

Given the above considerations, the year 2017 was selected as the representative year of meteorology.

Figure A1 Frequency of Winds at Moss Vale AWS for 2017 – 2021

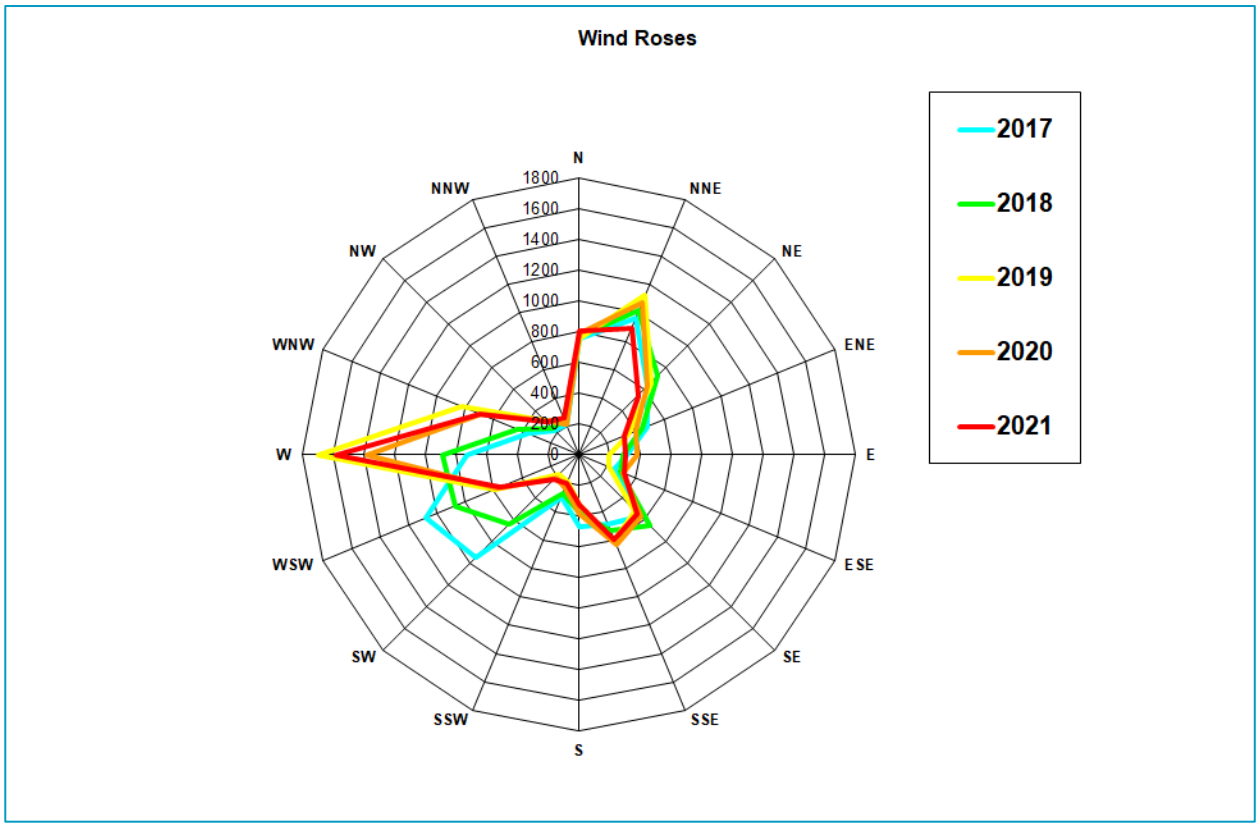


Figure A2 Monthly Average Wind Speed at Moss Vale AWS for 2013 – 2017

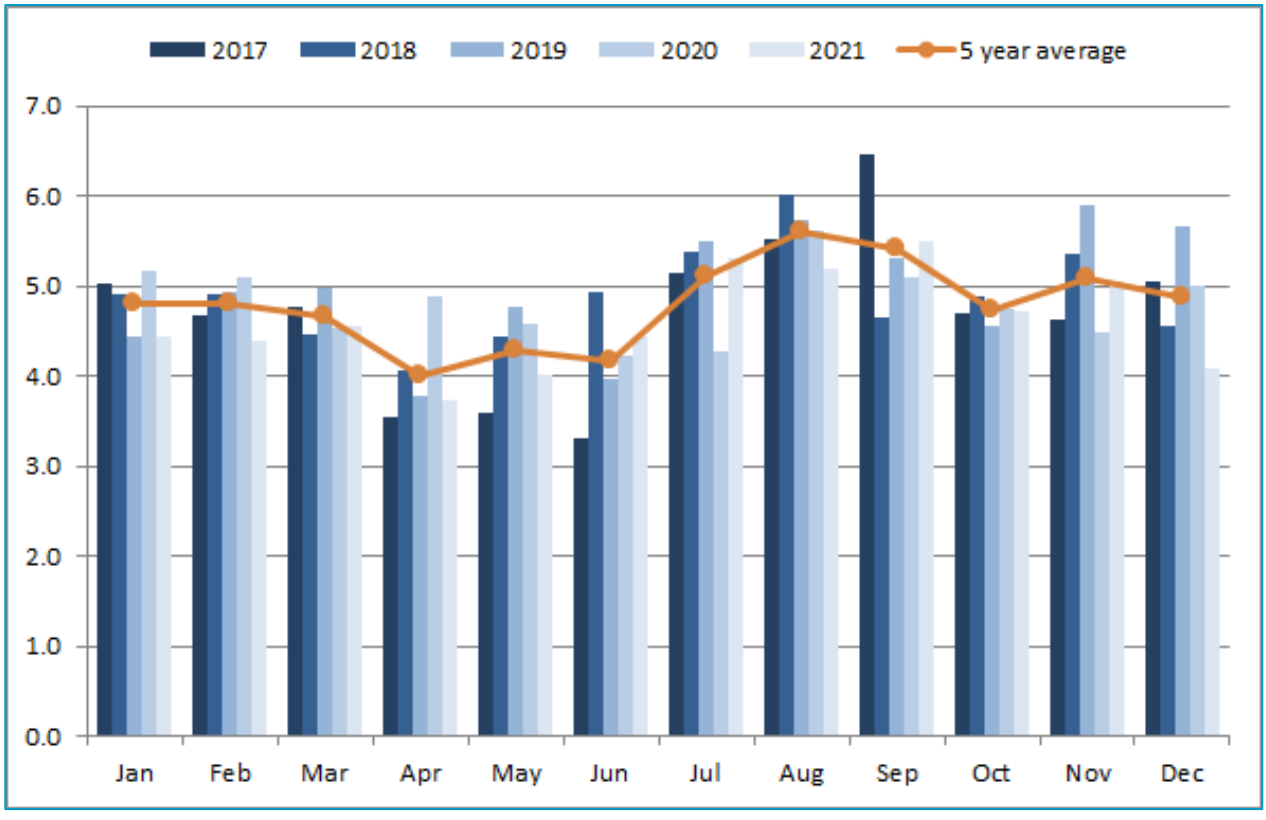
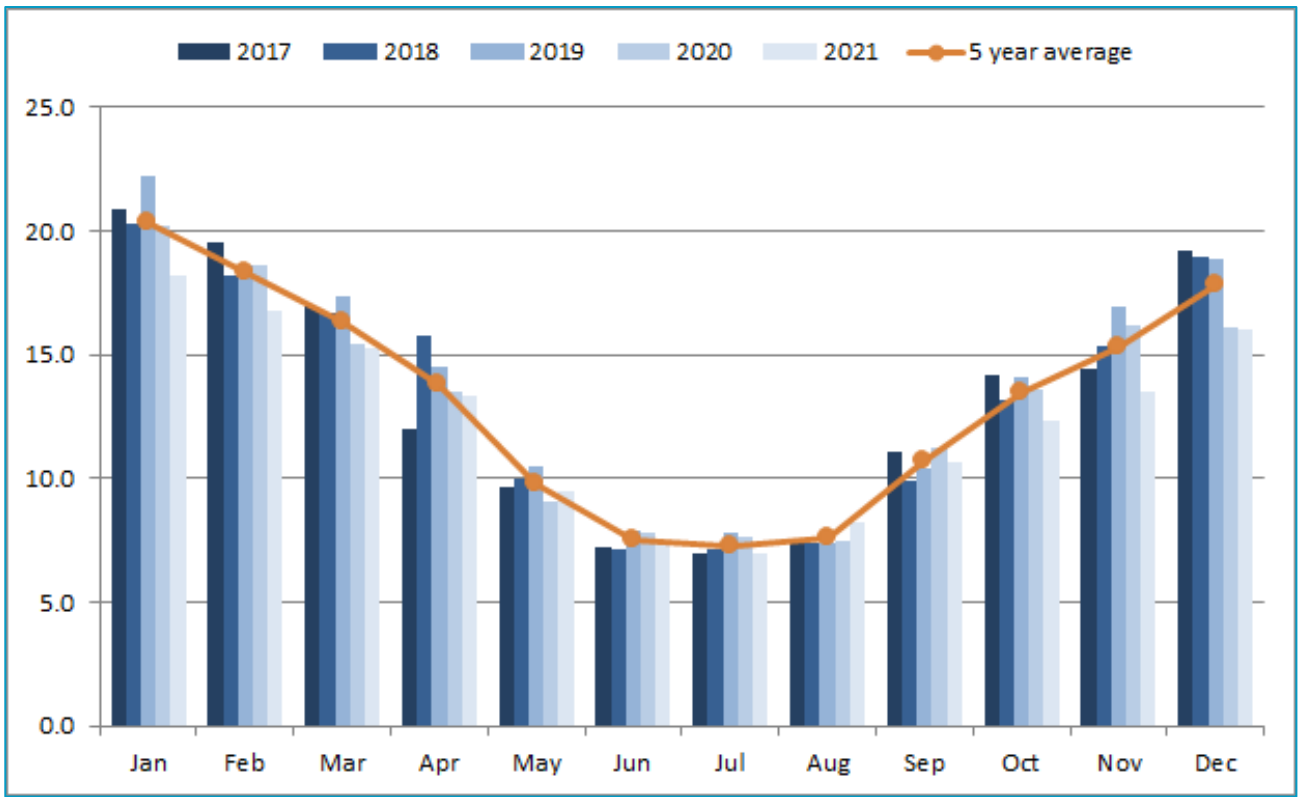


Figure A3 Monthly Average Temperature at Moss Vale AWS for 2017 – 2021



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Appendix I – Geotechnical Reports

Moss Vale Sewage Treatment Plant

Geotechnical Investigation Report

Hunter H_2O Holdings Pty Ltd

20 April 2021 – Revision 1



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Issued by:



Dan Butterworth | Company Director

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Appendix A – Engineering Borehole logs and Core Photographs
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1. Introduction

1.1. Background

This report presents the findings of a geotechnical investigation carried out by D&N Geotechnical Pty Ltd (D&N), at the Moss Vale Sewage Treatment Plant (STP) site.

The investigation was commissioned by the Hunter H_20 Holdings Pty Ltd (Hunter H_2O) on behalf of Wingecarribee Shire Council (WSC) and carried out in accordance with our fee proposal (D&N document reference: C-0760.00 P1, dated 21 January 2021).

The objective of the investigation was to assess the subsurface conditions across the general site footprint to support civil/structural design of planned upgrade works.

Our report includes a summary of the investigation methods adopted, approximate investigation locations, engineering logs and laboratory test certificates. Geotechnical discussion and recommendations are provided for the development, including excavation conditions/support requirements, footings, and subgrade design CBR.

A preliminary site and groundwater contamination assessment was carried out as part of this study. The contamination assessments are presented separately in the Ballpark Environmental Pty Ltd reports BPE21011-R01 and BPE21011-R02 for the site and groundwater contamination assessments, respectively.

An overview of the existing Moss Vale STP site/layout is shown in Plate 1 below (the approximate study area extent(s) are shown by the orange dashed line).



Plate 1 – Existing Moss Vale STP site layout/extents (Source: NSW Six Maps)

1.2. Proposed Site Development

On review of the initial Hunter H_2O Project Brief, we note that that development will generally comprise decommission/demolition of existing facilities and construction of numerous upgrades as summarised below. An extract from the proposed site plan is shown in Plate 2 below.

- New water retaining structures for sewage treatment with maximum anticipated foundation pressures (hydrostatic pressures and mass of concrete base / walls) in the order of 100kPa.
- Pumping stations (in-ground wet wells)
- New buildings including chemical dosing facility, blower building, electrical switch room and solids handling facility with maximum anticipated foundation pressures in the order of 50kPa.
- Internal new pipework, to include predominantly in-ground sewer rising main, between inlet pumping station to bioreactor, between clarifiers to filter feed pumping station, final treatment area to maturation ponds, and numerous minor (<10 m lengths of gravity/rising main.
- New pavement/hardstand areas:
  - Access (ring) roads accommodating heavy vehicle access
  - Chemical delivery areas
  - Solids handling facility outload area
  - Hardstand areas

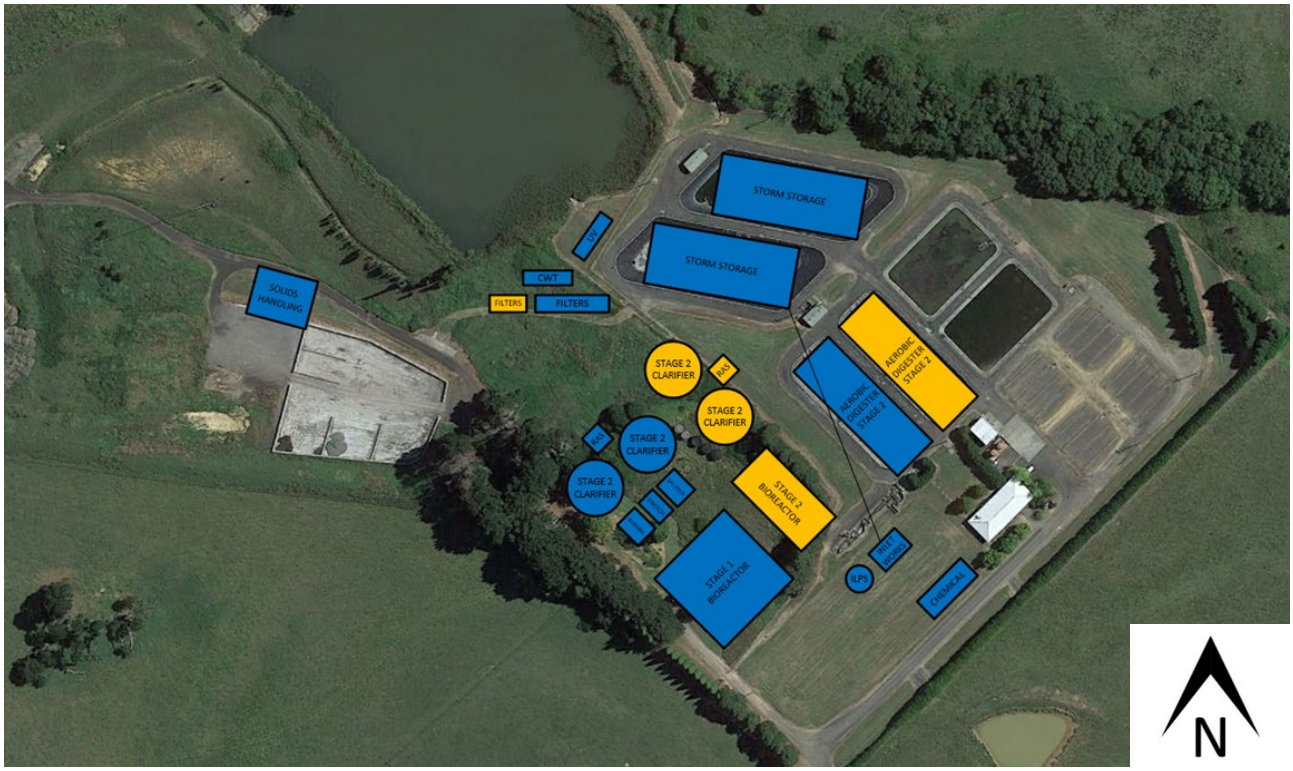


Plate 2 – Proposed new Moss Vale STP upgrades (provided extract from Hunter H_20 project brief – January 2021).

2. Existing Geotechnical Information

The Moss Vale STP site has been the subject of several previous phases of geotechnical investigation, by others.

The following existing geotechnical investigation reports were made available to D&N, companying the initial H2O Project Brief, as summarised below:

- *"Moss Vale Sewerage Augmentation Upgrading of Sewage Treatment Works – Geotechnical Investigation*" prepared by NSW Public Works (Report Reference: 91157, April 1992);
- *"Moss Vale Sewerage, Sewage Treatment Plant Upgrade, Concept Design Geotechnical Investigation"* prepared by NSW Public Works Advisory (Report Reference: ISR18106, February 2020); and

The findings presented in the above referenced previous geotechnical reports were considered in the preparation of this geotechnical investigation report, geotechnical models, and geotechnical design parameters.

3. Method of Investigation

3.1. Planning

D&N prepared a safety management plan prior to commencement of fieldwork. The field supervisor was provided with a final hard copy of the plan, which was utilised on site for subcontractor induction, and retained as a reference for emergency management.

A pre-start meeting was held at the start of each day/when working conditions differed to assess specific hazards and update approaches to site works where the work activity/environment was observed to have changed.

Dial before you Dig, and client provided service plans were reviewed in detail prior to commencing intrusive fieldworks as part of borehole set-out.

3.2. Fieldwork

Fieldwork for the geotechnical investigation was carried out under a single mobilisation to site between 17 and 19 February 2021, and comprised the following main site activities:

- Walkover to note features of geotechnical significance;
- Clearance of underground services by a suitably qualified contractor;
- Advancement of thirteen (13) boreholes across the general site footprint, comprising
  - Five (5) auger boreholes to depths of between 2 m and 6 m
  - Eight (8) cored boreholes to depths of between 6 m and 8.5 m
- 10 Dynamic Cone Penetrometer (DCP) tests (adjacent to boreholes); and
- Collection of soil and rock samples for submission to a NATA registered laboratory.

Boreholes were drilled using a purpose-built track mounted drilling rig, initially advanced using solid flight augers and Tungsten Carbide (TC) drill bit to the nominated target depth or prior refusal within bedrock. Following auger refusal, eight of the boreholes (BH101 to BH104 and BH113) were advanced to depths of between 6 and 8.5 m depth using NMLC diamond rock coring techniques.

On completion, all boreholes were backfilled with drill cuttings and the surface reinstated to match surrounds.

At the pre-existing monitoring wells installed by NSW Public Works Advisory (BH-B20 and BH-B25), dataloggers were installed to monitor groundwater levels. At the time of installation, the following procedure was carried out to provide well recharge data for estimation of soil permeability:

- The wells were purged of existing water using a manual bailer to provide confidence that the water within the wells provided a greater reflection of groundwater conditions rather than potential surface inflow.
- After the removal of more than three times the well volume, a water level datalogger was installed.
- The water level dataloggers were set to collect the water level data as the well was recharged.

Monitoring was ongoing at the time of this report revision.

All fieldwork was carried out under the fulltime direction of a D&N Engineering Geologist, who was responsible for coordination of subcontractors, management of site safety, logging of subsurface conditions to AS 1726 - 2017 and collection of soil samples for subsequent laboratory analysis.

The Engineering Borehole Logs are presented in Appendix A, with DCP test results included on each log in graphical format. DCP data is presented in tabular format in Appendix B.

Figure 1, attached, shows the approximate investigation locations, which were located using hand-held GPS equipment (accurate to ±3 m).

3.3. Laboratory Testing

Selected soil samples were submitted to NATA accredited laboratories for a suite of tests, as defined in Table 1 below.

For detail, reference should be made to laboratory test certificates, included as Appendix C.

Table 1 - Summary of Laboratory Testing

Test Type	No. of Tests
Field moisture content	4
California Bearing Ratio (4-day soak, 4.5 kg surcharge, 100% SMDD)	2
Atterberg Limit Incl. Linear Shrinkage	6
Aggressivity test suite - pH, Sulphate, Chloride and Conductivity	4
Uniaxial Compressive Strength (Rock Core)	2

On completion of drilling, recovered rock cores were boxed in steel core trays and transported to our core storage facility. Following photography, Point Load Index Strength (I_{s50}) tests were performed at regular intervals of approximately 1 m on average, or where specific zones of core were of interest.

3.4. Preliminary Contamination Assessment Sampling

Sampling for the preliminary contamination assessment was carried out concurrently with the geotechnical investigation works. The sampling methodology for contamination sampling is presented in the separate reports as follows:

- Ballpark Environmental Pty Ltd report BPE21011-R01 for soil/in-situ contamination.
- Ballpark Environmental Pty Ltd report BPE21011-R02 for groundwater contamination.

4. Results of Investigation

4.1. Site Description

The site is located approximately 1.2 km to the north west of Moss Vale Town Centre and is accessible via gated entrance and sealed roadway which passes through grazing land, located off Kennedy Close within a residential area.

Regionally the site topography comprises gently undulating hillsides. The site is located with locally lower lying terrain (when compared with the surrounding topography), associated with the southern bank of Whites Creek, which forms the northern site extent, and flows towards to the west.

The site has been formed through modification to the existing Whites Creek alignment and construction of several lagoons of varying geometry, constructed through excavation and cut to fill on the southern and northern creek banks.

The overall site surface across the STP area is generally flat, with a slight reduction in surface elevation of about 1 to 2 m across the general site footprint. Our investigation included assessment of subsurface conditions within a local depression associated with former use as a pond area, which appears to have been partially backfilled.

Existing STP infrastructure on the site includes the facility buildings, in-ground tanks, a large maturation pond (which outlets to Whites Creek), and services to the plant.

Vegetation and site use surrounding the STP site typically comprised of grasses and pasture for agricultural purposes.

4.2. Regional Geology

An extract of the NSW Surface Geology data set (State of NSW) is shown in Plate 1.

Regional geological mapping indicates that the site is underlain by Quaternary Residual Deposits, associated with weathering of the parent geology, described as comprising *"unconsolidated clayey SAND (fine to coarse grained), to weakly consolidated sandy CLAY layers, poor to extensive soil development*".

The underlying solid geology is expected to comprise of Bringelly Shale of the Tertiary aged Wianamatta Group, described as light to dark grey, sideritic claystone to siltstone, dark grey carboniferous claystone, sandstone to siltstone, and quartz lithic, very fine to medium grained sandstone. This unit is shown to represent the surface geology beyond the northern and southern site extents.

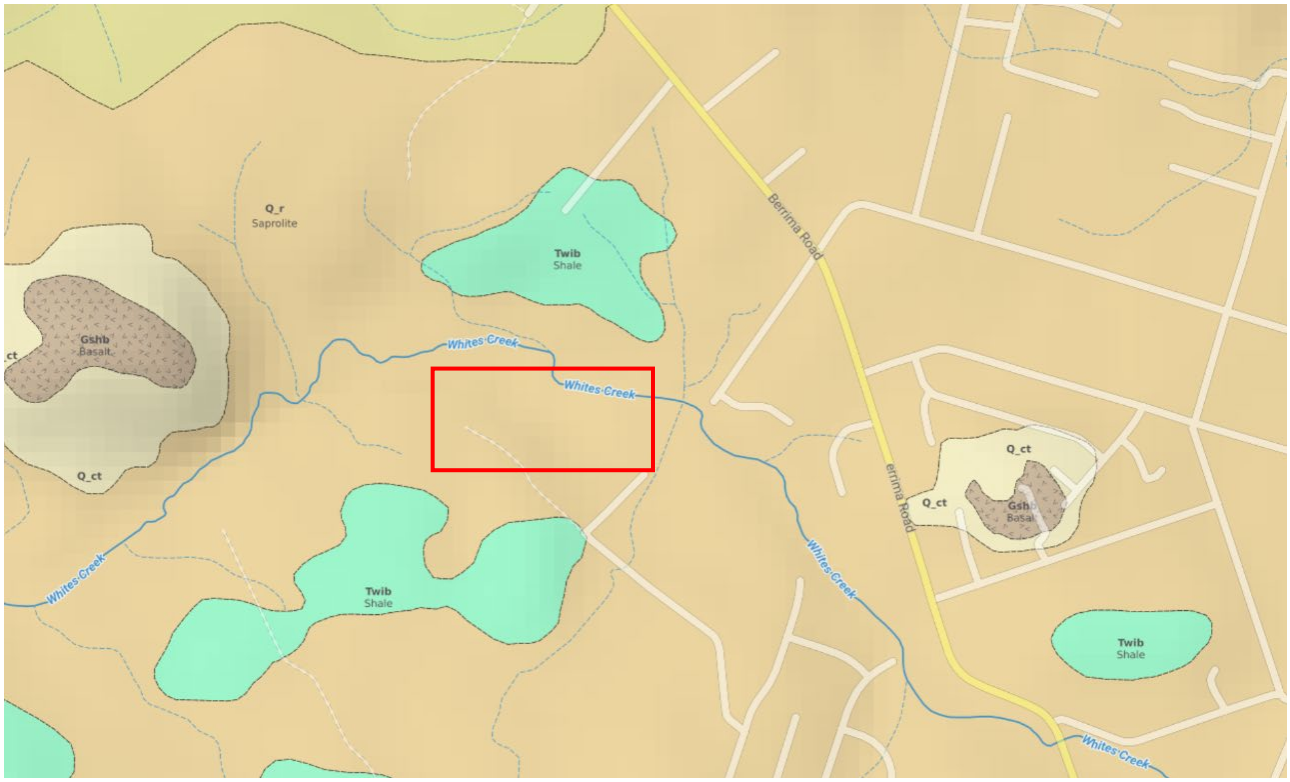


Plate 3 – Extract from NSW Surface Geology. The site is shown in Red.

4.3. Subsurface Conditions

Reference should be made to the Engineering Borehole Logs included as Appendix A for specific detail regarding subsurface conditions at each investigation location.

Dynamic Cone Penetrometer (DCP) test results are included on the engineering logs and presented again in tabular format as Appendix B. Table 2 below provides a summary of the main geotechnical units observed across the Moss Vale STP site.

Table 2 - Summary of the Main Geotechnical Units

Unit[1]		Material Origin	Material Description	Depth Range to Top of Unit (m)[2]	Range of Unit Thickness (m)[2]
1		Topsoil/Fill	Sandy/silty CLAY, medium plasticity, brown, fine to medium sand, with rootlets, trace fine to medium, sub-angular gravel	0	0.2 to 0.3
2		Fill - General	Gravel and cobbles, fine to coarse grained, sub-angular basalt fragments (ballast), dark grey Or Sandy gravelly CLAY/SILT, low and medium plasticity, pale brown, fine to carse sand	0	0.25 to 2.6
3		Alluvium	Sandy CLAY/Clayey SAND, medium plasticity orange-brown, mottled grey, fine to coarse sand, trace fine roots, typically firm consistency, or loose with some soft organic clay layers towards the base of the unit	0 to 2.6	1.2 to 1.6
4		Colluvium	Silty/sandy CLAY, medium to high plasticity, orange-brown, mottled brown, grey, fine to medium sand, typically firm to stiff consistency	0 to 0.2	1.1 to 2.7
5		Residual Soil	Sandy CLAY/CLAY, medium to high plasticity, orange-brown, mottled yellow-brown, grey, fine to medium sand, trace fine to medium, sub-angular gravel. Typically, stiff to very stiff consistency, hard in parts.	0.3 to 2.7	0.5 to 5.2
6	a	Siltstone Bedrock	Extremely to highly weathered, inferred soil strength to low strength.	1.9 to 5.5	0.7 to Unproven
	b		Highly to moderately weathered, low to medium strength	3.1 to 7.3	0.4 to Unproven
	c		Moderately weathered or better, medium strength	4.0 to 5.2	Unproven

Table 2 Notes:
1. Units were not encountered at every borehole location, reference should be made to specific engineering boreholes logs, included as Appendix A
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

4.4. Groundwater

Groundwater inflows were encountered during auger drilling within BH104 to BH107 at between about 0.3 m to 1.6 m depth but not observed during auger drilling within any of the remaining boreholes advanced as part of this investigation.

Subsequent groundwater observations during diamond core drilling within bedrock were not possible as water was added to each borehole to facilitate coring.

Groundwater levels may increase in response to rainfall. It is possible that groundwater may be temporarily perched above the rock level during and after heavy or sustained rain events.

The standing water level at the NSW Public Works Advisory boreholes B20 and B25 was measured on Monday, 12 April 2021 as:

- 2.8 m below ground level at B20 and
- 0.5 m below ground level at B25.

These levels vary significantly from the NSW Public Works Report measurements on 10 May 2019 as:

- 4.2 m below ground level at B20 and
- 2.5 m below ground level at B25.

The difference in water levels between 2019 and 2021 may be ascribed to drier conditions during 2019 in comparison to 2021, and the difference shows that a significant range in groundwater levels is possible in response to rainfall, seasonal and climatic effects.

The locations of these boreholes are shown on Plate 4 below (an extract from the NSW Public Works Advisory Report).

Groundwater level monitoring and the recharge rate of the wells were being monitored electronically at the time of issue of this report revision and will be reported separately in a groundwater assessment memorandum.

A preliminary groundwater quality assessment was carried out and reported in the Ballpark Environmental Pty Ltd report BPE21011-R02.

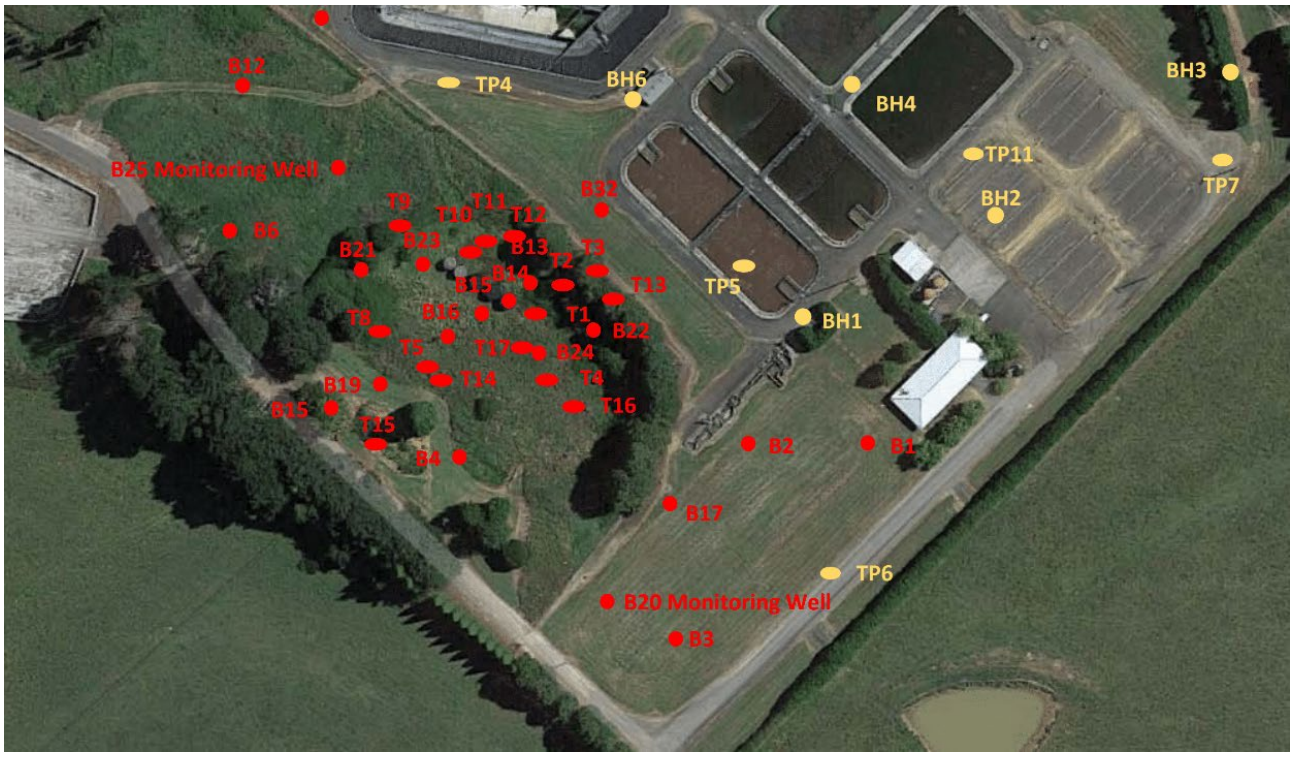


Plate 4 – Extract from NSW Public Works Advisory geotechnical investigation report showing Monitoring Wells B20 and B25

4.5. Laboratory Test Results

Tables 3 to 6 below provide a summary of laboratory test results for the site soils. Reference should be made to the test certificates included as Appendix C, for further detail.

Table 3 - Summary of Atterberg Limits Test Results

ID	Geotechnical Unit	Depth (m)	LS (%)	PI (%)	LL (%)	PL (%)
BH101	5	2.0 - 2.45	11.0	29	51	22
BH103	3	1.0 - 1.45	10.0	19	38	19
BH108	5	1.0 - 1.45	8.5	15	30	15
BH111	4	0.5 - 0.6	13.0	27	47	20
BH111	4	2.0 - 2.45	17.5	49	72	23
BH111	5	3.0 - 3.45	12.0	29	47	18

Table 4 - Summary of CBR Test Results

ID	Geotechnical Unit	Depth (m)	OMC (%)	Field Moisture (%)	CBR Swell (%)	MDD (t/m^3)	CBR (%)
BH101	3	0.2 - 1.0	18.5	21.8	0.0	1.67	9.0
BH113	5	0.3 - 1.0	23.5	24.1	1.0	1.64	3.5

Table 5: Summary of UCS Test Results

BH ID	Depth (m)	Unit	UCS Strength	Strength Classification	Nearest Point Loads
BH101	4.5 - 4.78	6c	13.8	Medium	0.9 to 1.1
BH102	6.22 - 6.45	6c	17.6	Medium	1.13 to 1.36

Table 6 - Summary of Soil Aggressivity Results

ID	Geotechnical Unit	Depth (m)	pH	Chloride (mg/kg)	Sulfate (mg/kg)	Electrical Resistivity (Ω.cm)
BH101	3	1.0 - 1.45	6.4	22	176	8160
BH104	5	1.0 - 1.45	7.8	22	31	20100
BH111	4	2.0 - 2.45	6.8	32	30	18400
BH113	5	4.0 - 4.45	7.3	45	31	18700

5. Discussion and Recommendations

5.1. Earthworks

5.1.1. Presence of Fill

Fill was observed at most borehole locations to depths of typically between 0.3 m and 2.6 m as described in Table 2.

Given the nature of the site, it is expected that other areas of previous filling are likely to be present across the site footprint, associated with previous site development, trenching and disposal of waste materials.

The main fill thickness was encountered within BH04 to BH08 associated with likely partial backfill of a former pond within this part of the site, generally comprising of gravel and cobbles with some building waste such as ceramic/terracotta pipe fragments.

Unless there are records confirming that the existing fill has been compacted in accordance with an engineering specification, where present, this material should be classified as uncontrolled and is not considered suitable as a foundation for structures or pavements due to the potential for differential settlement. Therefore, it is recommended that the existing fill materials be subject to excavation and re-compaction (if suitable) or replaced with engineered fill.

A preliminary site/in-situ contamination assessment was carried out and reported in the Ballpark Environmental Pty Ltd report BPE21011-R01.

5.1.2. Site Preparation and Fill Placement

Where natural soils are exposed and no filling is required, subgrade and foundations for structures and/or pavements should consist of bulk excavation to design level(s) (including to the underside of any fill encountered on the site) followed by a geotechnical assessment of the exposed stratum.

General guidelines for earthworks are as follows:

- Strip all topsoil and unsuitable material such as softened or heaving soils, if present;
- Box out to proposed subgrade/foundation level if this is deeper than the stripped level;
- Where uncontrolled fill is noted following a geotechnical assessment, treatment should be under the direction of the project geotechnical consultant. Methods may include removal and replacement, or where fill is present to an uneconomical depth, engineer designed bridging layers may be incorporated;
    - Where existing deep (> 1.0 m) of uncontrolled fill is noted, a presumptive treatment (bridging layers) may be adopted as follows:
        - Remove, moisture condition (if required) and recompact at least the upper 1.0 m of the subgrade below the underside of the pavement layers.
        - Should the existing uncontrolled fill display handling, moisture or compaction difficulties, replacement with select material or gravel and geofabric bridging courses may be required.
        - Manage risk of differential pavement settlement by providing a pavement reinforcement grid to the underside of the subbase, using for example, Tensar Tri-axial T160 geogrid.
        - Where founding pavements on uncontrolled fill as above, some residual risk of pavement performance will remain and must be accepted, as uncontrolled fill properties can vary. However, the above recommended removal and replacement of 1 m of uncontrolled fill subgrade and provision of a geogrid are aimed to reduce this risk.
- If engineered fill is to be placed to achieve subgrade or foundation level, then compact in maximum 0.3 m loose thickness layers as outlined below;

- Engineered fill at depths greater than 0.5 m below foundation level for structures or top of subgrade for pavements should be compacted to achieve a minimum Dry Density Ratio of 98% Standard Maximum Dry Density (MMDD) and moisture conditioned to Standard Optimum Moisture Content (SOMC) ±2 % at the time of compaction.
- Engineered fill and natural material at depths within 0.5 m of foundation level for structures or top of subgrade for pavements should be compacted to achieve a minimum Dry Density Ratio of 100% SMDD and moisture conditioned to SOMC ±2 % at the time of compaction.
- Once excavations are complete and prepared, assessment by the geotechnical consultant should be undertaken. This may include proof rolling of the entire formation with at least 4 passes of a non-vibratory minimum 12-tonne dead weight smooth drum roller, a loaded water cart, and/or pocket penetrometer, vane shear, and Dynamic Cone Penetrometer testing to confirm design intentions.

The subgrade should be graded to drain effectively to subsoil drains and should be cleared of any softened material prior to pouring of footings or placement of fill materials.

All fill placement and subgrade preparation should be constructed under Level 1 Geotechnical Inspection and Testing as defined in *AS3798-2007 Guidelines on Earthworks for Commercial and Residential Developments.* The extent of subgrade treatment will largely depend on preceding weathering conditions and construction methodology and should be treated as advised by the project geotechnical consultant.

5.1.3. Subgrade Trafficability

Site soils are expected to behave poorly if exposed to heavy construction traffic, particularly when wet. A platform of granular material such as road base or crushed concrete may be needed to support construction plant.

Where heavy plant such as piling rigs or mobile cranes are to traffic to site, specific analysis of working platform requirements may be required to assess working platform equipment. Such assessment could include the use of DCP testing (or similar) to confirm bearing capacity. Working platform design shall be carried out to the UK Building Research Establishment (BRE) Guideline BR470.

To help reduce, but not eliminate trafficability issues associated with wet weather, exposed subgrades should be sealed with a smooth drum roller and graded such that they promote surface drainage and prevent ponding.

5.1.4. Re-use of Site Won Materials

From a geotechnical viewpoint, 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. Re-used material should be screened for such physical contaminants, reworked, and compacted as controlled fill.

The project geotechnical consultant should undertake further observation, sampling and testing to verify the suitability of excavated material to confirm suitability for the respective proposed usage.

Silty soils and high plasticity clays (if encountered) will be sensitive to moisture content and may be difficult to compact. Careful management of soil moisture content will therefore be required.

The Unit 3 to Unit 5 natural soils generally comprises of medium to high plasticity sandy CLAY, subject to suitable blending; this material may be considered for re-use as compacted clay liner material. Moisture conditioning is likely to be required, depending on prevailing weather conditions. In any case additional laboratory testing should be carried out on this geotechnical unit to confirm suitability, to include Atterberg limits, Hydrometer testing, Linear Shrinkage, Dispersion and Permeability tests.

It is not expected that material directly won from the geotechnical units would be suitable for pipe bedding material.

5.2. Subgrade Design CBR

Following stripping of topsoil and existing site fill, the subgrade soils in the vicinity of BH101 to BH03 are expected to typically comprise Unit 3 Alluvium (medium plasticity silty CLAY) or Unit 5 Residual Soil (medium to high plasticity sandy CLAY). Laboratory testing yielded CBR values of between 3.5% and 9%.

Based on Atterberg Limit testing and tactile assessment, the site soils are generally of medium to high plasticity, consistent with the above reported CBR swell values. The presence of high plasticity Residual Soils generally corresponded to the lower bound CBR value (3.5%) that was observed.

However, based on interpretation recorded DCP blow counts, we assess that the in-situ CBR values are typically in the order of CBR 3% on the basis that the field moisture content of the natural site soils is above the Optimum Moisture content (assessed in the laboratory) for the respective materials, which is generally supported by the laboratory reported moisture values within Table 5.

Considering the above, in this case, we recommend adoption of the in-situ CBR values for design purposes which are expected to reflect site conditions more accurately during the lifetime of pavements within areas of clayey subgrades.

Notwithstanding the above, DCP testing at BH103 and BH109 returned DCP blow counts of ≤1 blow per 100 mm, which indicates that some form of subgrade treatment will be required to achieve a design subgrade CBR of 3%. Subgrade treatment will need to be assessed as part of site preparatory earthworks but is expected to include a combination of removal and replacement of moisture affected materials and/or adoption of bridging materials such as rock fill and/or reinforced select materials.

The boxed-out profile will require subsoil drains to be installed along the shoulder on both sides of the pavement, to avoid moisture collection in the boxed-out profile and control seasonal variability. These drains shall be connected to suitable discharge points.

5.3. Excavations

5.3.1. Excavation Conditions

Based on the proposed upgrade works, we expect that the project will comprise:

- General site cut/excavation depths of typically less than 1.5m for footings and levelling;
- High level footings founded typically founded within residual soil or better;
- Pipeline depths for gravity lines are not known but anticipated to be less than 2 m depth;

We anticipate that 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 refusal, as summarised in Table 8 below.

Table 8 - Summary of Auger Refusal Depths

BH ID	Auger Refusal Depth (m)	Inferred Unit on Termination
BH101	3.1	Unit 5b
BH102	4.0	Unit 5c
BH103	4.2	Unit 5a
BH104	5.0	Unit 5c
BH105	Not Encountered	Unit 5b
BH106	Not Encountered	Unit 4

BH ID	Auger Refusal Depth (m)	Inferred Unit on Termination
BH107	Not Encountered	Unit 5a
BH108	Not Encountered	Unit 5a
BH109	Not Encountered	Unit 4
BH110	Not Encountered	Unit 4
BH111	5.9	Unit 5a
BH112	Not Encountered	Unit 5a
BH113	7.0	Unit 5a

We note that BH106, BH109 and BH110 were terminated at a target depth of 2 m. Early auger refusal was encountered during drilling at BH101, BH102 and BH103, with earlier refusal most notably at BH01. 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 highly and moderately weathered, low and medium strength (or better) siltstone. Based on Pettifer & Fookes[1] it is estimated that 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 D7 or D8 dozers equipped with ripping tynes.

In any event, excavation contractors shall be provided with the Engineering Logs and be required to make their own assessment of the suitability and productivity of excavation plant. Natural variation can occur from the observed conditions to be both more or less favourable for excavation. It is possible that shallower rock levels will be encountered between investigation locations. The rock surface (or level of auger refusal, or excavator refusal) may be undulating and variable across the site.

5.3.2. Excavation Support

Unsupported excavations may be practicable where there is sufficient space to allow for the creation of batter slopes. For preliminary design purposes, we recommend the following unsupported batters be adopted for the site. Ultimately, selection of batter slopes is the responsibility of the site operator in consultation with a geotechnical professional at the time of exposure.

Table 9 - Temporary and Permanent Batter Slopes

Unit	Unsupported Temporary Batter Slopes, Less than 1-month exposure	Unsupported Permanent Batter Slopes
Unit 1 - Topsoil/FILL	Strip back away from the excavation	1V:4H
Controlled Filling *Material dependent, guidance provided for re-compacted cohesive soil won from the site*	1V:1H	1V:2H

[1] Pettifer, G. S. and Fookes, P. G. *A revision of the graphical method for assessing the excavatability of rock*. Quarterly Journal of Engineering Geology and Hydrogeology, 1994, volume 27, pp 145-164.

Unit	Unsupported Temporary Batter Slopes, Less than 1-month exposure	Unsupported Permanent Batter Slopes
Unit 2 - Fill – General (Uncontrolled)	1V:2H	1V:4H
Unit 3 - Alluvium	1V:2H	1V:3H
Unit 4 - Colluvium	1V:2H	1V:3H
Unit 5 - Residual Soil	1V:1H	1V:2H
Unit 6a/Unit 6b – Extremely and highly weathered bedrock	1V:1H	1V:1.5H
Unit 6c – Moderately weathered Bedrock	1V:0.25H See Note 4 and 5	1V:1.5H

Notes to Table 9:

1. Protection against erosion is required for permanent batters steeper than or equal to 1V:3H. Erosion and sediment controls are required for temporary batters.
2. The contractor shall be responsible for batter maintenance and monitoring of batter performance. Contact D&N should batters deteriorate during construction, for example because of rain.
3. Maximum overall slope heights may include up to 3 m vertical in Units 1 to 6b and up to 5 m near vertical in Units 6c. For higher slopes, contact D&N for slope stability analysis.
4. Rock batters require geotechnical inspection on exposure for risk assessment to construction workers from defect-controlled failures. Contact D&N on exposure for this inspection.
5. Provide a min. 3 m wide bench at the top of rock.

A temporary shoring box system may be required where existing services or structures will be affected by or prevent the use the proposed temporary batters. Shoring systems shall be provided where personnel are entering excavations greater than 1.2 m vertical depth and the above batter slopes are not provided. All such entries shall be risk assessed prior to access and treated as confined space entry.

Existing services near excavations should be located at least 2 m laterally behind the batter surface, or behind a line projected backwards from the toe of the batter at an angle of 30°, whichever provides the greatest setback to the underground service or structure footing. If this setback is not achievable, the excavation will require shoring.

Permanent batters to water-holding facilities shall be considered in detail by the facility's designer. It is recommended as a minimum that such analysis be carried out using limit-equilibrium techniques, and the analysis must consider the range of water levels, seepage conditions and drawdown conditions that may occur at the facility over the operating conditions.

5.4. Retention and Shoring Methods

Shoring systems shall be designed by a qualified engineer. As a guide, Table 10 below presents typical design parameters that can be adopted for the design temporary shoring systems.

Coefficients are provided for the following cases:

- Case 1 = Active conditions, where deflections would be relatively greater to mobilise active connections.
- Case 2 = At-rest conditions, where deflections are required to be reduced (e.g. adjacent to existing infrastructure).

Table 10 - Material Parameters and Earth Pressure Co-efficients for Level Ground above the retention

Geotechnical Unit	Mohr-Strength Envelope Material Properties		Value of Lateral Earth Pressure Coefficient[1]		Passive Earth Pressure Coefficient, K_p[1]	Bulk Density (kN/m^3)
	Effective Cohesion	Effective Friction Angle	Case 1, K_a	Case 2, K_0		
Unit 1 – Topsoil/FILL	0	26	0.39	0.56	2.6	18
Controlled Filling *Material dependent, guidance provided for re-compacted cohesive soil won from the site*	2	30	0.33	0.5	3.0	20
Unit 2 – General Fill (uncontrolled)	2	26	0.39	0.56	2.6	18
Unit 3 (Alluvium) and Unit 4 (Colluvium)	4	26	0.39	0.56	2.6	18
Unit 5 - Residual Soil	5	30	0.33	0.5	3.0	20
Unit 6a/6b - HW to XW Bedrock	20	34	0.28	0.44	3.5	22
Unit 6c – MW Bedrock	100	40	0.22	0.36	4.5	25

Notes to Table 10:

1. These values are only applicable for a horizontal ground surface behind the shoring system.
2. Failure in rock units may be governed by defects. Rock exposures shall be assessed on site for possible defect-controlled instability.
3. Mohr-coulomb equivalent parameters for the rock units (Units 6a to 6c) may be significantly higher, however, a more detailed study on the rock would be required to characterise these.

The magnitude of adjacent ground movements within the retained fill/soil profile will depend on the ground conditions, design lateral pressure, shoring system adopted, construction sequence and workmanship. If this aspect is critical (e.g., low redundancy water supply lines or settlement sensitive infrastructure), further appraisal should be carried out to assess likely ground movements when designing the shoring system. Such analyses should include modelling of predicted deflections for comparison to the critical values of the infrastructure, and D&N can assist with these models and analysis once the design excavation profiles have been excavated.

Groundwater inflow was observed during auger drilling within BH104 to BH107 at between about 0.3 to 1.6 m depth, generally within Unit 2 Fill (pond backfill materials), which was not observed within the remaining boreholes. However, we recommend that permanent retaining walls and temporary shoring systems be designed to allow for groundwater to a height of 50% of the retained height.

5.5. Foundations

5.5.1. Site Classification to AS2870-2011

While the site classification to AS2870-2011 is based on requirements for residential structures, designers may find the classification useful to assist in design of structures from first principles or design of structures such as single level office facilities, amenities blocks, and the like.

The site classification has been considered and assessed as Class P where existing fill extends to depths greater than 0.3 m, and Class H1 with up to 60 mm seasonal movements due to climatic effects within the natural soil profile, based on:

- Climate Zone 2 (TMI +10 to +40);
- Depth of suction of 1.8 m;
- Cracked depth of 50%;
- Design Suction change Δu = 1.2 pF;
- Design residual soil depth of greater than the depth of suction;
- Shrink-swell index (I_{ss}) of up to 2.2% based on Atterberg Limit testing; and
- No allowance for tree effects.

Trees are to be more than two mature tree heights from the facilities. Otherwise, the designer shall make allowances for trees per AS2870-2011 using the maximum tree effects below, and actual offset of the facilities from the trees.

The maximum tree effect has been estimated as an additional movement of:

- +25 mm for a single tree (total 85 mm, up to Class E); and
- +45 mm for a line or stand of trees (total 105 mm, up to Class E).

The maximum tree effects may be reduced when considering the guidance from AS2870-2011 with respect to distance between trees and the facilities.

Should more than 400 mm of controlled fill be considered, please contact D&N for further advice. Controlled filling will affect the site reactivity, which may be more adverse than the natural site. For example, controlled filling using site-won soils would increase the Site Classification to Class H1 (total movement up to 45 mm. It is feasible to design fill works with lesser movement using non-reactive fill higher in the profile, however such fill would need to be imported to the site.

Footings should generally be provided on the same geotechnical unit, however, if this is not feasible due to variation of units and levels, allowances should be made for the range of support conditions.

5.5.2. Shallow Footings

The below values may be adopted for an allowable bearing capacity of shallow footings, slab stiffenings, and the like:

- Unit 1 Topsoil/Fill and Unit 2 General Fill: Do not use for foundation support (strip before the works)
- Unit 3 and 4 Alluvium/Colluvium 50 kPa
- Unit 5 Residual soil: 100 kPa
- Unit 6a XW Material: 400 kPa
- Unit 6b, or better: 1,000 kPa (higher values may be feasible after site inspection)

The recommended allowable bearing pressures provided above assume that the bearing surfaces are clean and free from spoil and other soft and loose material, and free of water at the time of placement of concrete. A concrete blinding layer should be poured as soon as practical to limit the disturbance to the surface and any likely degradation of the exposed materials.

Settlements of strip and pad footings designed using the allowable values are expected to be less than 1% of the footing dimension.

On excavation, should the ground conditions differ from those outlined above, further advice should be sought from D&N. On-site verification of exposed foundation material is required by a geotechnical engineer once the contractor has exposed foundations.

5.5.3. Piled Footings

Piled footings may be considered where the high-level footing parameters do not allow economical or practical high-level footings to be constructed, or where settlement-sensitive structures or equipment are present. Piled footings may further reduce the potential for differential support between variable distribution of geotechnical units and may be used to avoid the reactivity of the site. It is expected that structures within the former pond area would require adoption of piled footings where it is considered impracticable to remove and replace or recompact existing fill due to material suitability or the presence of shallow groundwater.

Parameters for pile design for those materials encountered in this investigation are provided in Table 11 below.

It is recommended that bored piles be considered, as driven piles would likely not be suitable to the site conditions and/or variable founding levels, including early refusal. However, the potential exists that bored piles may also encounter difficulty due to variable weathering, including high strength zones.

Shallow groundwater and predominantly granular fill materials were observed within the former pond area (BH104 to BH108), but not observed within the remaining boreholes. Open bored piers will not be feasible within the formers pond area due to a high potential form sidewall collapse; therefore, temporary, or permanent casing support will be required for bored pile hole retention. Such casing could be recovered on completion, or alternatively left in-situ provided the pile designer considers the effect of these uses on the shaft adhesion utilised.

For the design of piled footings to comply with AS2159-2009, a limit state design method should be adopted. Recommended design parameters for piles are presented in Table 11.

Table 11 - Recommended Geotechnical Parameters for Bored (non-displacement, concrete) Piles

Unit	Unit Weight (kN/m^3)	Ultimate End Bearing Capacity (MPa) (1)	Ultimate Shaft Adhesion (kPa) (2)	Ultimate Lateral Capacity (MPa) (2)	Elastic Modulus Axial (MPa) (3)
Unit 3 and 4 Soils – Alluvium and Colluvium	18	-	20	0.2	6
Unit 5 - Residual Soil	20	0.6	35	0.5	12
Unit 6a - XW to HW Bedrock	22	3.0	85	0.8	100
Unit 6b - HW to MW Bedrock	24	5.0	200	1.5	200
Unit 6c - MW or better Bedrock	26	8.0	300	2.0	500

Table 11 Notes:

1. Assumes a minimum embedment of at least four pile diameters below ground surface.

2. Assumes a minimum embedment of at least 2 pile diameters into relevant bearing stratum. Ignore shaft adhesion or the contribution from lateral resistance in the upper 2m or first four pile diameters of the profile.
3. Lateral stiffness may be taken as 70% of vertical stiffness.
4. Steel piles will require separate consideration. Contact D&N for further advice.

For uplift loads that are reliant on low-redundancy systems (e.g., single, or isolated anchors that would result in catastrophic failure of a structure if the tension/pull-out failure occurred), the shaft adhesion values in Table 11 should be multiplied by an additional partial reduction factor or 0.7, in addition to the geotechnical strength reduction factor (outlined below). Contact D&N should for the specific uplift/stability mechanism being considered.

For limit state design a geotechnical reduction factor (ϕ_g) is to be applied to the ultimate geotechnical pile capacity assessed using the ultimate shaft resistance and end bearing values shown in Table 11 to derive the design ultimate geotechnical pile capacity.

In accordance with AS2159-2009, ϕ_g is dependent on assignment of an Average Risk Rating (ARR) which considers various geotechnical uncertainties, redundancy of the foundation system, construction supervision, and the quantity and type of pile testing. The assessment of ϕ_g therefore depends on the structural design of the foundation system as well as the design and construction method, and testing (if any) to be employed by the designer and piling contractor.

We have carried out a risk assessment per AS2159-2009 and have assessed an ARR of 3.97 (Moderate to High), and we recommend that a ϕ_g value of 0.45 be adopted. The assessment in included in Appendix D. The reduction factor shall be applied to determine the value of the factored down geotechnical resistance, R*, in accordance with AS2159-2009, as $R^* = \phi_g \times R_u$. R* is then to be compared to the factored up load action for the respective limit states, S*.

To reduce the potential for differential settlement between footings, we recommend that all footings be uniformly founded within the same geotechnical unit. Where this is not practicable, analysis should be undertaken to assess potential effects on the proposed structure.

The use of limit state design also requires that serviceability performance of the foundation system be assessed, including pile group interaction effects. Such assessment should be carried out by experienced geotechnical professional using well-established and soundly based methods. The modulus values given above may be adopted for such assessment, but it should be recognised that the accuracy of settlement prediction is a function of construction methodology as well as the assessed values of material stiffness, both of which can involve considerable uncertainty. Therefore, the accuracy of settlement predictions may be no better than ± 50%. It is assumed that foundation settlement is critical to the performance of the structure, serviceability pile load testing should therefore be considered to confirm the design assumptions and/or assess prediction accuracy.

The recommended design parameters for bored piles assume that the bearing surfaces are clean and free from spoil and other soft and loose material and free of water at the time of placement of concrete. If the bored pile holes cannot be dewatered sufficiently, then tremmie pouring methods should be employed to displace the water from the pile hole. On excavation, should the ground conditions differ from those outlines above then further advice should be sought from D&N. The above values for shaft adhesion assume that the walls of the shaft are suitably roughened and cleaned of smear.

5.5.4. Soil Aggressivity

The results of Soil Aggressivity testing were assessed in accordance with AS2159-2009 Piling – "Design and Installation". The results are summarised in Table 12 below.

Table 12 - Soil Aggressivity Assessment to AS2159-2009

Buried Material	Assessed Aggressivity	
	Soil Condition A	Soil Condition B
Concrete	Mild	Non-aggressive
Steel	Non-aggressive	Non-aggressive
Concrete or steel where in contact with wastewater	Specific assessment required based on wastewater properties	

5.5.5. Thrust Block Design Parameters

Lateral bearing capacities for thrust blocks are provided in Table 13 below for materials observed. The capacities are provided for limited overburden of min. 0.5 m below FSL.

Table 13 - Lateral Bearing Capacities for Thrust Blocks

Unit	Allowable lateral bearing capacity
Topsoil, uncontrolled fill, organic soil, deleterious material	Do not use for thrust block support
Controlled cohesive fill	50 kPa
Controlled granular fill, $\phi' \geq 32°$	60 kPa/m x depth (m)
Unit 3 and 4 Soils	40 kPa at 0.5 m depth, increasing to 150 kPa depth below FSL of 5 times the bearing width
Unit 5 - Residual Soil	70 kPa at 0.5 m depth, increasing to 300 kPa at a depth below FSL of 5 times the bearing width
Unit 6a/6b - XW/HW Bedrock	300 kPa (where at least deeper than 5 times the bearing width, otherwise use residual soil properties)
Unit 6c - MW Bedrock, or better	500 kPa

5.6. Earthquake Design

Based on AS1170.4-2007 the following parameters should be adopted for seismic design:

- Seismic Hazard Factor (Z) 0.09
- Sub-Soil Class C_e

5.7. Acid Sulfate Soil Risk Maps

The dataset for Acid Sulfate Soils (*State of NSW and Department of Planning, Industry and Environment, eSPADE tool*) indicates that the site is not underlain by Acid Sulfate Soils.

The site geology is not commensurate with the development of actual or potential acid sulfate soils.

5.8. Pavement Thickness Design

5.8.1. Introduction

Hunter H_20 requires a pavement thickness design for flexible and for rigid pavements. The design traffic has been specified as one rigid truck (with 2.1 ESA per truck) per day over 25 years. The calculated design traffic is approximately 2 x 10^4 ESA.

Where heavy vehicles can travel as free-flowing traffic, a spray seal surfacing may be adopted. Where heavy vehicles are required to stop, turn, decelerate, etc. (and including in parking areas) an asphalt wearing course should be provided over a spray seal surfacing.

Pavement thickness designs are provided for CBR 3% and carried out in accordance with Austroads *Guide to Pavement Technology Part 2 - Pavement Structural Design* (2017) for lightly traffic roads.

5.8.2. Flexible Pavement

The flexible pavement analysis has been carried out using the graphical approach from AGPT02/2017 with a design tolerance and consideration of minimum pavement course layer thicknesses. The flexible pavement design is shown in Table 14 below.

Table 14 - Flexible Pavement Thickness Design

Layer Description	Pavement constructed on Residual Soil Subgrade		Pavement Constructed with min. 150 mm Selected Layer	
	Free-flowing heavy vehicles	**Otherwise**	**Free-flowing heavy vehicles**	**Otherwise**
Asphalt Course, Dense graded AC14 with C450 Binder	-	40 mm	-	40 mm
Emulsion Prime (Tack Coat) Assuming no trafficking between prime and asphalt paving	-	Required CRS Rapid Set	-	Required CRS Rapid Set
Prime and seal	AMC0/00 Prime, single/single 10 mm seal with C170 binder	-	AMC0/00 Prime, single/single 10 mm seal with C170 binder	-
Granular Course, DGB20	150 mm		150 mm	
Granular Course, DGS20	225 mm		175 mm	
Selected Material Layer CBR ≥ 15%, PI ≤ 25%	-		150 mm	
Subgrade	Existing site soils, CBR 3%		Existing site soils, CBR 3%	

We understand that certain crane lifts will be carried out using the proposed pavement areas. Hunter H_20 have requested an assessment of the flexible granular pavement with respect to the proposed applied bearing pressures.

Crane outrigger pressures have been provided by Hunter H_20 as 270 kPa applied over a bearing area of 2.25 m^2 (1.5 m by 1.5 m).

- For the residual soil unit, typically exposed at BH104 to BH108, BH112 and BH113, the factor of safety against bearing failure for the above pavement thicknesses is greater than 1.6, in accordance with the requirements of the UK BRE470 publication for working platforms. Accordingly, the pavement areas (where prepared and constructed in accordance with this report and the works specifications) may be used for the applied bearing pressure as described above.
    - Where existing fill is present (BH105 to BH108) overlying the residual soil, removal and replacement is recommended to at least 1.0 m below the underside of pavement to provide controlled engineering properties (also see Section 5.1.2). A proof roll should be carried out at the boxed-out level to verify compressibility of uncontrolled fill would not be a concern.
- For the alluvium and colluvium soil units, as encountered at BH102 to BH103, and BH109 to BH111, replacement of the weak soils will be required as part of the pavement subgrade preparation/replacement (also see Section 5.1.2 and Section 5.2). Once these remediations have been provided, the factor of safety against bearing failure for the above pavement thicknesses is greater than 1.6, in accordance with the requirements of the UK BRE470 publication for working platforms. Accordingly, the pavement areas (where prepared and constructed in accordance with this report and the works specifications) may be used for the applied bearing pressure as described above.

5.8.3. Rigid Pavement

The rigid pavement option has been assessed based on the requirements of AGPT02/17 Section 12 - Lightly Trafficked Pavements (for concrete pavements with less than 10^6 HVAG.

The design traffic for rigid pavements are expressed as the cumulative number (N_{DT}) of Heavy Vehicle Axle Groups (HVAG). For this analysis, we have adopted a value of 1.05 ESA/HVAG to arrive at $N_{DT} \approx 1.9 \times 10^4$ HVAG.

The concrete base thickness assessment was based on the following inputs:

- Plain Concrete Pavement with Reinforcement (PCP-R) will be used;
- No integral shoulders will be provided (i.e., wheels can traffic the slab to the edge of the slab);
- The base will be un-dowelled;
- A design reliability of 90% was adopted (Load Safety Factor = 1.2); and
- Concrete for the base course shall comprise min. 32 MPa compressive strength and min. 4.5 MPa flexural strength, both values measured at 28 days.
- Inclusion of a 10 mm tolerance in the design.

The concrete pavement configurations are shown in Table 15 below.

Table 15 - Rigid Pavement Configurations

Layer Description	Pavement constructed on Residual Soil Subgrade	Pavement Constructed with min. 150 mm Selected Layer
Concrete Base Course with SL92 mesh reinforcement	200 mm	195 mm
Granular Subbase Course, DGB20	100 mm	100 mm
Selected Material Layer CBR ≥ 15%, PI ≤ 25%	-	150 mm
Subgrade	Existing site soils, CBR 3%	Existing site soils, CBR 3%

Note to Table 15: Concrete Base thickness includes a 10mm design tolerance.

The concrete pavement will need to be provided with joints to control shrinkage and warping, and to allow for construction joints.

Joints may be created by sawing or wet forming, to 25% of the slab thickness. Joints should be sealed with a backer rod and sealing compound to avoid moisture ingress. The reinforcement mesh shall be extended across joints, and cover shall be maintained to reinforcement where joints are formed. Reinforcement should be placed min. 90 mm below the finished concrete surface level and max. 75 mm above the underside of the slab. For PCP-R, the reinforcement does not contribute to flexural strength in the design but aids in reducing crack apertures.

Joints shall be provided in a rectangular pattern as far as practicable, with joint spacings between 3.0 m and 4.2 m. The aspect ratio for should be between 0.7 and 1.4. Where the geometry does not allow rectangular slabs, or acute angles will be formed, the RMS rigid pavement drawings should be consulted. \

5.8.4. Pavement Construction Specifications

All pavement materials, supply and works shall conform to Aus-Spec 1 series of specifications, or NSW RMS Specifications.

5.8.5. Hardstand Works

We recommend that hardstands be designed for the specific lifting equipment and loads proposed by the operator of the equipment at the time of the construction.

6. Limitations

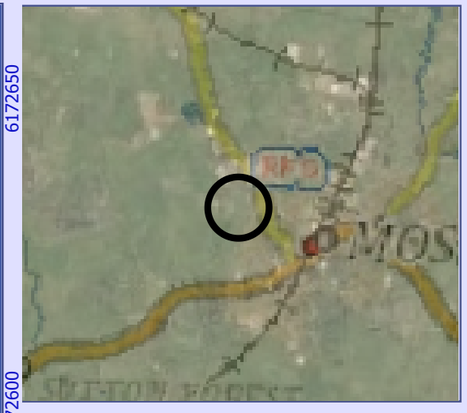
Subsurface conditions can be complex and may vary over relatively short distances – and over time. The inferred geotechnical model and recommendations in this report are based on limited subsurface investigations at discrete locations. The engineering logs describe subsurface conditions only at the investigation locations.

Further investigations may be required to support detailed design if there are scope limitations or changes to the nature of the project.

Figures

C-0760.00 | Moss Vale Sewage Treatment Plant | Geotechnical Investigation





Legend

Borehole Locations

Data Source:

https://data.nsw.gov.au/data/

Cartographic Data and Orientation:

N

1:1000
Datum: GDA2020
Coordinate Unit: Metres

0 40 m

D&N Geotechnical

Company: D&N Geotechnical
Drawn: AW
Approved: LC
Original size: A3
Project: Moss Vale Sewage Treatment Plant Geotechnical Investigation

Date:	Client:	Figure 1
28/02/2021	Hunter H20 Holdings Pty Ltd	

Appendix A - Engineering Borehole Logs and Core Photographs

D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**101**
sheet:	1 of 2
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**19 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**19 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AP**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257285; N: 6174537 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.: Canb01

drill model: Hanjin DB8, Track mounted | drilling fluid: Water | casing diameter : HW

drilling information | **material substance**

method & support	penetration	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa)	DCP (blows/ 100 mm)	structure and additional observations
AD/T; HW casing	1 2 3	Not Observed	B		0.0		CI	**Sandy Silty CLAY**: medium plasticity, brown, fine to coarse sand.	~Wp		100 200 300 400	2 4 6 8 10 12	**TOPSOIL**
							CI	**CLAY**: medium plasticity, orange-brown, with fine to medium sand.	>Wp	F to St			**ALLUVIUM**
			SPT 1, 0, 1 N*=1		1.0		OL	**ORGANIC CLAY**: low to medium plasticity, black and brown, hydrocarbon odour.	>Wp	F			
			SPT 3, 8, 9 N*=17		2.0		CI-CH	**CLAY**: medium to high plasticity, yellow, off-white and orange.	~Wp	VSt			**RESIDUAL SOIL**
			SPT 18, 32, 18/20mm N*=R		3.0			**SILTSTONE**: layered, grey, highly to moderately weathered, inferred very low to low strength.					**BEDROCK**
								Borehole 101 continued as cored hole					
					4.0								
					5.0								
					6.0								
					7.0								

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration: 1 2 3 — no resistance ranging to refusal

water: 10-Oct-12 water level on date shown; water inflow; water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

D&N Geotechnical

Engineering Log - Cored Borehole

Borehole ID.	**101**
sheet:	2 of 2
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**19 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**19 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AP**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257285; N: 6174537 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted | drilling fluid: Water | casing diameter : HW | vane id.:

drilling information | **material substance** | **rock mass defects**

method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
			1.0								
			2.0								
			3.0		start coring at 3.10m						
NMLC	Not Observed		4.0		**SILTSTONE**: layered, grey, dark grey, some iron staining through substance and along joints/defects.	HW MW SW		a=0.04 a=1.10 d=0.42 a=0.93 d=0.49	86%		PT, 10°, IR, RO, CO - CL Clay PT, 10°, IR, RO, CO - CL Clay SM, 10°, PL, SO, CO - CL Clay SM, 10°, PL, SO, CO - CL Clay PT, 10°, IR, SO, CO - CL Clay PT, 10°, IR, SO, CO - CL Clay SM, 10°, PL, SO, CN PT, 10°, IR, SO, CO - CL Clay PT, 10°, IR, SO, CO - CL Clay PT, 10°, IR, SO, CO - CL Clay PT, 10°, PL, RO, CN
			5.0								
			6.0		Borehole 101 terminated at 6.00 m Target depth						
			7.0								

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method & support
- AS auger screwing
- AD auger drilling
- CB claw or blade bit
- W washbore
- NMLC NMLC core (51.9 mm)
- NQ wireline core (47.6mm)
- HQ wireline core (63.5mm)
- PQ wireline core (85.0mm)
- SPT standard penetration test
- HA hand auger

water
- 10/10/12, water level on date shown
- water inflow
- complete drilling fluid loss
- partial drilling fluid loss
- 25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
- core recovered (graphic symbols indicate material)
- no core recovered

core run & RQD
- barrel withdrawn
- RQD = Rock Quality Designation (%)

weathering & alteration*
- RS residual soil
- XW extremely weathered
- HW highly weathered
- DW distinctly weathered
- MW moderately weathered
- SW slightly weathered
- FR fresh

*W replaced with A for alteration

strength
- VL very low
- L low
- M medium
- H high
- VH very high
- EH extremely high

defect type
- PT parting
- JT joint
- SZ shear zone
- SS shear surface
- CO contact
- CS crushed seam
- SM seam

planarity
- PL planar
- CU curved
- UN undulating
- ST stepped
- IR Irregular

roughness
- SL slickensided
- POL polished
- SO smooth
- RO rough
- VR very rough

coating
- CN clean
- SN stain
- VN veneer
- CO coating

D&N Geotechnical

BH101

Core Photograph

Job No: C-0760.00
Office: Canberra

Client: Hunter H20 Holdings Pty Ltd	Date: 18 February 2021
Principal:	By: AW
Project: Moss Vale Sewage Treatment Plant	Location: Moss Vale, NSW



D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**102**
sheet:	1 of 2
project no.	**C-0760.00**
client:	***Hunter H20 Holdings Pty Ltd***
date started:	***18 Feb 2021***
principal:	***Wingecarribee Shire Council***
date completed:	***19 Feb 2021***
project:	***Moss Vale Sewage Treatment Plant Upgrades***
logged by:	***AP & AW***
location:	***Moss Vale, NSW***
checked by:	***DB***

position: E: 257327; N: 6174534 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.: Canb01

drill model: Hanjin DB8, Track mounted | drilling fluid: Water | casing diameter : HW

drilling information | **material substance**

method & support	penetration	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa)	DCP (blows/ 100 mm)	structure and additional observations
AD/T; HW casing	1 2 3	Not Observed	B		0.0		Cl	**Silty CLAY**: medium plasticity, brown, with fine to medium sand and rootlets.	~Wp		100 200 300 400	2 4 6 8 10 12	**TOPSOIL**
							Cl	**Sandy CLAY**: medium plasticity, orange-brown, fine to medium sand, with fine to medium, sub-angular gravel.	~Wp	St			**ALLUVIUM**
			SPT 5, 7, 9 N*=16		1.0		Cl	**ORGANIC CLAY**: low to medium plasticity, black, hydrocarbon odour.	<Wl	F			
							Cl-CH	**Sandy CLAY**: medium to high plasticity, orange-brown, mottled grey, fine to medium sand.	~Wp	VSt			**RESIDUAL SOIL**
			SPT 5, 7, 10 N*=17		2.0			**SILTSTONE**: grey, orange-brown, extremely weathered, inferred soil strength.					**BEDROCK**
			SPT 6, 14, 10 N*=24		3.0			**SILTSTONE**: layered, grey, orange-brown, highly to moderately weathered, inferrred low to medium strength.					
			SPT 15/120mm/ HB N*=R		4.0			Borehole 102 continued as cored hole					

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
- 1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

D&N Geotechnical

Engineering Log - Cored Borehole

Borehole ID.	**102**
sheet:	2 of 2
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**18 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**19 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AP & AW**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257327; N: 6174534 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted | drilling fluid: Water | casing diameter : HW | vane id.:

drilling information				material substance						rock mass defects		
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 X = axial; O = diametral VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
			1.0								
			2.0								
			3.0								
			4.0		start coring at 4.00m						
NMLC	Not Observed		5.0		**SILTSTONE**: dark grey, pale grey, with oange-brown iron staining through substance and along joints and defects.	MW MW to SW		a=1.13 d=0.60	96%		SM, 20°, PL, Cl Clay PT, 10°, UN, RO, CO - Cl Clay
			6.0					a=1.36 d=0.57			PT, 10°, UN, RO, CN PT, 10°, UN, RO, CO - Cl Clay JT, 45°, UN, RO, CN JT, 45°, UN, RO, CN
			7.0		Borehole 102 terminated at 6.50 m Target depth						

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method & support
- AS auger screwing
- AD auger drilling
- CB claw or blade bit
- W washbore
- NMLC NMLC core (51.9 mm)
- NQ wireline core (47.6mm)
- HQ wireline core (63.5mm)
- PQ wireline core (85.0mm)
- SPT standard penetration test
- HA hand auger

water
- 10/10/12, water level on date shown
- water inflow
- complete drilling fluid loss
- partial drilling fluid loss
- 25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
- core recovered (graphic symbols indicate material)
- no core recovered

core run & RQD
- barrel withdrawn

RQD = Rock Quality Designation (%)

weathering & alteration*
- RS residual soil
- XW extremely weathered
- HW highly weathered
- DW distinctly weathered
- MW moderately weathered
- SW slightly weathered
- FR fresh

*W replaced with A for alteration

strength
- VL very low
- L low
- M medium
- H high
- VH very high
- EH extremely high

defect type
- PT parting
- JT joint
- SZ shear zone
- SS shear surface
- CO contact
- CS crushed seam
- SM seam

planarity
- PL planar
- CU curved
- UN undulating
- ST stepped
- IR Irregular

roughness
- SL slickensided
- POL polished
- SO smooth
- RO rough
- VR very rough

coating
- CN clean
- SN stain
- VN veneer
- CO coating

D&N Geotechnical

BH102

Core Photograph

Job No: C-0760.00 Sheet 1 of 1
Office: Canberra

Client: Hunter H20 Holdings Pty Ltd	Date: 18 February 2021
Principal:	By: AW
Project: Moss Vale Sewage Treatment Plant	Location: Moss Vale, NSW



D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**103**
sheet:	1 of 2
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**18 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**18 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AW**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257352; N: 6174511 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.: Canb01

drill model: Hanjin DB8, Track mounted | drilling fluid: Water | casing diameter : HW

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	DCP (blows/ 100 mm) 2 4 6 8 10 12	structure and additional observations
AD/T; HW casing		Not Observed			0.0		Cl	**Sandy Silty CLAY**: medium plasticity, brown, mottled orange-brown, fine to coarse sand.	~Wp	F			**ALLUVIUM**
													HP 50 - 100 kPa
			SPT 0, 0, 1 N*=1		1.0		Cl	**Silty CLAY**: medium plasticity, grey, mottled brown, with fine to medium sand and rootlets.	>Wp				
													HP 50 - 100 kPa
							Cl	**Sandy CLAY**: medium plasticity, orange-brown, mottled dark grey, fine to medium sand.	~Wp	VSt to H			**RESIDUAL SOIL**
			SPT 6, 10, 15 N*=25		2.0								
											>>		HP 550 kPa
								SANDSTONE: fine to medium grained, orange-brown, grey, pale brown, extremely weathered, inferred soil strength.					**BEDROCK**
			SPT 5, 12, 19 N*=31		3.0								
					4.0								
			SPT 25 HB N*=R					Borehole 103 continued as cored hole					
					5.0								
					6.0								
					7.0								

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

D&N Geotechnical

Engineering Log - Cored Borehole

Borehole ID.	**103**
sheet:	2 of 2
project no.	**C-0760.00**
client:	***Hunter H20 Holdings Pty Ltd***
principal:	***Wingecarribee Shire Council***
project:	***Moss Vale Sewage Treatment Plant Upgrades***
location:	***Moss Vale, NSW***
date started:	***18 Feb 2021***
date completed:	***18 Feb 2021***
logged by:	***AW***
checked by:	***DB***

position: E: 257352; N: 6174511 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted | drilling fluid: Water | casing diameter : HW | vane id.:

drilling information | **material substance** | **rock mass defects**

method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 X = axial; O = diametral VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
			1.0								
			2.0								
			3.0								
			4.0		start coring at 4.15m						
NMLC	Not Observed		5.0		**SANDSTONE**: fine to medium grained, dark grey, with orange-brown iron staining through substance and along joints and defects.	XW to HW		a=0.31 d=0.48			PT, 20°, PL, SO, CN JT, 30°, IR, RO, CN PT, 20°, PL, SO, CN JT, 45°, PL, RO, CN
					SILTSTONE: layered, dark grey, with orange-brown iron staining through substance and along joints and defects.	MW to SW		a=0.62 d=0.68	95%		Drilling Break, 10°, PL, SO, CN PT, 10°, PL, SO, CN PT, 10°, PL, SO, CN JT, 60°, ST, RO, SN - Fe PT, 10°, PL, SO, CN
			6.0					a=0.53 d=0.35			PT, 10°, PL, RO, CN
					Borehole 103 terminated at 6.50 m Target depth						
			7.0								

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method & support
- AS auger screwing
- AD auger drilling
- CB claw or blade bit
- W washbore
- NMLC NMLC core (51.9 mm)
- NQ wireline core (47.6mm)
- HQ wireline core (63.5mm)
- PQ wireline core (85.0mm)
- SPT standard penetration test
- HA hand auger

water
- 10/10/12, water level on date shown
- water inflow
- complete drilling fluid loss
- partial drilling fluid loss
- 25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
- core recovered (graphic symbols indicate material)
- no core recovered

core run & RQD
- barrel withdrawn
- RQD = Rock Quality Designation (%)

weathering & alteration*
- RS residual soil
- XW extremely weathered
- HW highly weathered
- DW distinctly weathered
- MW moderately weathered
- SW slightly weathered
- FR fresh

*W replaced with A for alteration

strength
- VL very low
- L low
- M medium
- H high
- VH very high
- EH extremely high

defect type
- PT parting
- JT joint
- SZ shear zone
- SS shear surface
- CO contact
- CS crushed seam
- SM seam

planarity
- PL planar
- CU curved
- UN undulating
- ST stepped
- IR Irregular

roughness
- SL slickensided
- POL polished
- SO smooth
- RO rough
- VR very rough

coating
- CN clean
- SN stain
- VN veneer
- CO coating

D&N Geotechnical

BH103

Core Photograph

Job No: C-0760.00
Office: Canberra

Sheet 1 of 1

Client: Hunter H20 Holdings Pty Ltd	Date: 18 February 2021
Principal:	By: AW
Project: Moss Vale Sewage Treatment Plant	Location: Moss Vale, NSW



D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**104**
sheet:	1 of 2
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**17 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**18 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AW**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257381; N: 6174492 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.:

drill model: Hanjin DB8, Track mounted | drilling fluid: Water | casing diameter : NW

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description **SOIL TYPE**: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	hand penetro-meter (kPa) 100 200 300 400	DCP (blows/ 100 mm) 2 4 6 8 10 12	structure and additional observations
AD/T NW casing		▶						**FILL**: **GRAVEL AND COBBLES:** fine to coarse, sub-angular to angular, dark grey.	M to W				**FILL**
							CI-CH	**Sandy CLAY**: medium to high plasticity, orange-brown, mottled pale grey, pale brown, fine to medium sand.	<Wp	VSt to H			**RESIDUAL SOIL**
			SPT 4, 7, 8 N*=15		1.0						>>		HP >600 kPa
			SPT 5, 7, 9 N*=16		2.0						>>		HP >600 kPa
			SPT 7, 6, 6 N*=12		3.0				>Wp	VSt			
									<Wp	VSt to H	>>		HP 350 kPa HP >600 kPa
			SPT 27/120mm HB N*=R		4.0			**SILTSTONE**: dark grey, pale grey, with orange-brown iron staining through substance and along joints and defects.					**BEDROCK**
			SPT 10/20mm HB N*=R		5.0			Borehole 104 continued as cored hole					
					6.0								
					7.0								

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

D&N Geotechnical

Engineering Log - Cored Borehole

Borehole ID.	**104**
sheet:	2 of 2
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**17 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**18 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AW**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257381; N: 6174492 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted | drilling fluid: Water | casing diameter : NW | vane id.:

drilling information				material substance						rock mass defects		
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 X = axial; O = diametral VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
			1.0								
			2.0								
			3.0								
			4.0								
			5.0		start coring at 5.02m						
NMLC			6.0		**SILTSTONE**: layered, grey and brown, with orange-brown iron staining along joints and defects.	XW to HW HW		a=0.42 d=0.14 a=0.19 d=0.10	66%		PT, 20°, PL, RO, Silt VN JT, 45°, ST, RO, CN JT, 10°, IR, SO, CN JT, 10°, IR, SO, CN PT, 10°, PL, SO, Silt VN JT, 30°, IR, SO, CN JT, 30°, IR, SO, CN JT, 20°, ST, SO, CN
			7.0		Borehole 104 terminated at 6.50 m Target depth						

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method & support
- AS auger screwing
- AD auger drilling
- CB claw or blade bit
- W washbore
- NMLC NMLC core (51.9 mm)
- NQ wireline core (47.6mm)
- HQ wireline core (63.5mm)
- PQ wireline core (85.0mm)
- SPT standard penetration test
- HA hand auger

water
- 10/10/12, water level on date shown
- water inflow
- complete drilling fluid loss
- partial drilling fluid loss
- 25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
- core recovered (graphic symbols indicate material)
- no core recovered

core run & RQD
- barrel withdrawn
- RQD = Rock Quality Designation (%)

weathering & alteration*
- RS residual soil
- XW extremely weathered
- HW highly weathered
- DW distinctly weathered
- MW moderately weathered
- SW slightly weathered
- FR fresh

*W replaced with A for alteration

strength
- VL very low
- L low
- M medium
- H high
- VH very high
- EH extremely high

defect type
- PT parting
- JT joint
- SZ shear zone
- SS shear surface
- CO contact
- CS crushed seam
- SM seam

planarity
- PL planar
- CU curved
- UN undulating
- ST stepped
- IR Irregular

roughness
- SL slickensided
- POL polished
- SO smooth
- RO rough
- VR very rough

coating
- CN clean
- SN stain
- VN veneer
- CO coating

D&N Geotechnical

BH104

Core Photograph

Job No: C-0760.00
Office: Canberra

Sheet 1 of 1

Client: Hunter H20 Holdings PTY Ltd	Date: 18 February 2021
Principal:	By: AW
Project: Moss Vale Sewage Treatment Plant	Location: Moss Vale, NSW



D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**105**
sheet:	1 of 1
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**17 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**17 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AW**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257408; N: 6174450 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.:

drill model: Hanjin DB8, Track mounted | drilling fluid: N/A | hole diameter : 100 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	DCP (blows/ 100 mm) 2 4 6 8 10 12	structure and additional observations
AD/T, N		▶			0.0			**FILL**: **GRAVEL AND COBBLES:** fine to coarse, sub-angular to angular, dark grey.	M				**FILL**
					1.0				W				
					2.0								
							SC	**CLAYEY SAND**: fine to coarse grained, orange-brown, medium plasticity clay fines.		L			**ALLUVIUM**
			SPT 4, 1, 2 N=3		3.0								
			SPT 6, 23, 15/70mm HB N*=R		4.0			**SILTSTONE**: grey, orange-brown, extremely weathered, inferred soil strength to very low strength.					**BEDROCK**
			SPT 15/70mm, /0mm, /0mm HB N*=R		5.0			**SILTSTONE**: grey, orange-brown, highly weathered, inferred low strength.					
					6.0			Borehole 105 terminated at 6.0 m Target depth					
					7.0								

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**106**
sheet:	1 of 1
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**18 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**18 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AW**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257360; N: 6174481 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.: Canb01

drill model: Hanjin DB8, Track mounted | drilling fluid: N/A | hole diameter : 100 mm

drilling information | **material substance**

method & support	penetration	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa)	DCP (blows/ 100 mm)	structure and additional observations
AD/T — N	1 2 3	▶			0.0		Cl	**FILL: Sandy Silty CLAY**: medium plasticity, brown, pale-brown, fine to coarse sand, trace fine to medium, sub-angular gravel and cobble sized rock fragments.	~Wp		100 200 300 400	2 4 6 8 10 12	**TOPSOIL / FILL**
							Cl		>Wp				**FILL** DCP HB (12/30mm)
					1.0		Cl	**FILL: Sandy Gravelly CLAY**: medium plasticity, grey, fine to coarse, sub-rounded to angular gravel, fine to coarse sand.					
							Cl	**Sandy CLAY**: medium plasticity, orange-brown, pale-brown, fine to medium sand, trace fine to medium, sub-angular gravel.	~Wp	VSt	×		**RESIDUAL SOIL** HP 300 kPa
					2.0			Borehole 106 terminated at 2.0 m Target depth					
					3.0								
					4.0								
					5.0								
					6.0								
					7.0								

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**107**
sheet:	1 of 1
project no.	**C-0760.00**
client:	***Hunter H20 Holdings Pty Ltd***
principal:	***Wingecarribee Shire Council***
project:	***Moss Vale Sewage Treatment Plant Upgrades***
location:	***Moss Vale, NSW***
date started:	***17 Feb 2021***
date completed:	***17 Feb 2021***
logged by:	***AW***
checked by:	***DB***

position: E: 257392; N: 6174458 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.:

drill model: Hanjin DB8, Track mounted | drilling fluid: N/A | hole diameter : 100 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	DCP (blows/ 100 mm) 2 4 6 8 10 12	structure and additional observations
AD/T, N		▶			0.0		Cl	**FILL: Silty CLAY**: medium plasticity, brown, orange.	~Wp				**FILL**
								FILL: **GRAVEL AND COBBLES:** fine to coarse, sub-angular to angular, dark grey.	M				
					1.0				W				
					2.0		Cl	**Sandy CLAY**: medium to high plasticity, orange-brown, fine to medium sand.	~Wp	VSt			**RESIDUAL SOIL**
					3.0								
			SPT 11, 21, 15/100mm N*=R		4.0			**SILTSTONE**: grey, orange-brown, extremely weathered, inferred very low strength.					**BEDROCK**
			SPT 25, 15/40mm, /0mm N*=R		5.0								
					6.0			Borehole 107 terminated at 6.0 m Target depth					
					7.0								

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration: 1 2 3 — no resistance ranging to refusal

water: 10-Oct-12 water level on date shown; water inflow; water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**108**
sheet:	1 of 1
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**18 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**18 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AW**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257339; N: 6174453 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.: Canb01

drill model: Hanjin DB8, Track mounted | drilling fluid: N/A | hole diameter : 100 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (**SOIL TYPE**: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	DCP (blows/100 mm) 2 4 6 8 10 12	structure and additional observations
AD/T, N		Not Observed			0.0		Cl / ML	**Silty CLAY**: medium plasticity, pale-brown, with fine to coarse sand, trace rootlets. **FILL: Sandy SILT**: low liquid limit, pale-brown, fine to coarse sand.	~Wp / <Wl				**TOPSOIL / FILL** **FILL**
			SPT 3, 4, 3 N*=7		1.0		Cl	**Sandy CLAY**: medium plasticity, orange-brown, pale-brown, mottled grey, with fine to medium sand, trace fine to medium, sub-angular gravel.	~Wp	St			**RESIDUAL SOIL**
			SPT 5, 5, 4 N*=9		2.0								
			SPT 6, 9, 12 N*=21		3.0					VSt			
			SPT 5, 9, 12 N*=21		4.0					VSt to H			
			SPT 9, 21, 21 N*=42		5.0			**SILTSTONE**: orange-brown, grey, extremely to highly weathered, inferred very low to low strength.					**BEDROCK**
					6.0			Borehole 108 terminated at 6.0 m Target depth					
					7.0								

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**109**
sheet:	1 of 1
project no.	**C-0760.00**
date started:	**18 Feb 2021**
date completed:	**18 Feb 2021**
logged by:	**AW**
checked by:	**DB**

client: ***Hunter H20 Holdings Pty Ltd***

principal: ***Wingecarribee Shire Council***

project: ***Moss Vale Sewage Treatment Plant Upgrades***

location: ***Moss Vale, NSW***

position: E: 257363; N: 6174446 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.: Canb01

drill model: Hanjin DB8, Track mounted | drilling fluid: N/A | hole diameter : 100 mm

drilling information | **material substance**

method & support	penetration	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa)	DCP (blows/ 100 mm)	structure and additional observations
HA, N		Not Observed			0.0		CI	**Sandy CLAY**: medium plasticity, dark brown, fine to coarse sand, trace fine roots.	~Wp				**TOPSOIL**
							CI	**Sandy CLAY**: medium plasticity, orange-brown, fine to medium sand.		F to St	100 200 300 400	2 4 6 8 10 12	**COLLUVIUM** HP 100 kPa
					1.0		CI-CH	**Silty CLAY**: medium to high plasticity, orange-brown, mottled grey, trace fine to medium sand.		St to VSt			**RESIDUAL SOIL** HP 200 kPa
					2.0			Borehole 109 terminated at 2.0 m Target depth					
					3.0								
					4.0								
					5.0								
					6.0								
					7.0								

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration

1 2 3 — no resistance ranging to refusal

water

10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**110**
sheet:	1 of 1
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**18 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**18 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AW**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257387; N: 6174440 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.: Canb01

drill model: Hanjin DB8, Track mounted | drilling fluid: N/A | hole diameter : 100 mm

drilling information | **material substance**

method & support	penetration	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa)	DCP (blows/ 100 mm)	structure and additional observations
HA, N	1 2 3	Not Observed			0.0		CI	**Silty CLAY**: medium plasticity, dark brown, with some fine roots.	~Wp	F to St			**TOPSOIL**
							CI	**Sandy CLAY**: medium plasticity, orange-brown, fine to coarse sand.	>Wp				**COLLUVIUM**
					1.0								HP 100 kPa
							CI-CH	**Silty CLAY**: medium to high plasticity, orange-brown, mottled pale grey, pale brown, with fine to medium sand.	~Wp	St			**RESIDUAL SOIL**
					2.0			Borehole 110 terminated at 2.0 m Target depth					HP 150 kPa
					3.0								
					4.0								
					5.0								
					6.0								
					7.0								

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration



no resistance ranging to refusal

water



10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**111**
sheet:	1 of 1
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**17 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**17 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AW**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257403; N: 6174429 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.: Canb01

drill model: Hanjin DB8, Track mounted | drilling fluid: N/A | hole diameter : 100 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (**SOIL TYPE**: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	DCP (blows/100 mm) 2 4 6 8 10 12	structure and additional observations
AD/T — N		Not Observed	SPT 7, 3, 4 N=7		1.0		CI	**Silty Sandy CLAY**: medium plasticity, orange-brown, mottled grey, fine to coarse sand, trace fine to medium, sub-angular gravel.	~Wp	F to St			**COLLUVIUM**
													HP 160 kPa
							CH	**Silty CLAY**: high plasticity, grey, mottled brown, trace fine to medium sand.					
			SPT 2, 2, 3 N=5		2.0								HP 150 kPa
							CI-CH	**Sandy CLAY**: medium to high plasticity, orange-brown, mottled grey, fine to medium sand.	<Wp	St to VSt			**RESIDUAL SOIL**
			SPT 1, 4, 5 N=9		3.0								HP 400 kPa
			SPT 8, 16, 16/100mm HB N=R		4.0			**SANDSTONE**: fine to medium grained, orange-brown, grey, extremely weathered, inferred soil strength to very low strength.					**BEDROCK**
			SPT 5, 13, 13 N=26		5.0								
			SPT 4, 16, 16/100mm HB N=R		6.0			Borehole 111 terminated at 5.91 m Target depth					
					7.0								

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**112**
sheet:	1 of 1
project no.	**C-0760.00**
client:	***Hunter H20 Holdings Pty Ltd***
principal:	***Wingecarribee Shire Council***
project:	***Moss Vale Sewage Treatment Plant Upgrades***
location:	***Moss Vale, NSW***
date started:	***17 Feb 2021***
date completed:	***17 Feb 2021***
logged by:	***AW***
checked by:	***DB***

position: E: 257385; N: 6174402 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.: Canb01

drill model: Hanjin DB8, Track mounted | drilling fluid: N/A | hole diameter : 100 mm

drilling information | **material substance**

method & support	penetration	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa)	DCP (blows/ 100 mm)	structure and additional observations
AD/T, N	1 2 3	Not Observed	SPT 4, 4, 4 N=8		1.0		CI	**Silty CLAY**: medium plasticity, brown, with some fine to coarse sand, trace fine to medium, sub-angular gravel.	~Wp				**TOPSOIL**
							CI-CH	**Sandy CLAY**: medium to high plasticity, orange-brown, fine to medium sand.	<Wp	St to VSt			**RESIDUAL SOIL** HP 500 kPa
			SPT 5, 7, 8 N=15		2.0					VSt			HP 350 kPa
			SPT 7, 11, 8 N=19		3.0			**SANDSTONE**: fine to medium grained, orange-brown, grey, extremely to highly weathered, inferred soil strength to very low strength.					HP 400 kPa **BEDROCK**
			SPT 6, 12, 15/50mm HB N=R		4.0								
			SPT 12, 21, 16/60mm HB N=R		5.0								
					6.0			Borehole 112 terminated at 6.0 m Target depth					
					7.0								

D&N_AU_LIBRARY.GLB rev:AM Log COF BOREHOLE: NON CORED + DCP C-0760.00 MOSS VALE.GPJ <<DrawingFile>> 30/03/2021 07:20

method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

D&N Geotechnical

Engineering Log - Borehole

Borehole ID.	**113**
sheet:	1 of 3
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**16 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**16 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AW**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257442; N: 6174421 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90° | DCP id.: Canb01

drill model: Hanjin DB8, Track mounted | drilling fluid: Water | casing diameter : HW

drilling information | **material substance**

method & support	penetration	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa)	DCP (blows/ 100 mm)	structure and additional observations
AD/T; HW casing	1 2 3	Not Observed			0.0		CI	**Silty CLAY**: medium plasticity, dark brown, with fine to coarse sand, trace fine roots and fine to medium, sub-angular gravel.	~Wp				**TOPSOIL**
							CI-CH	**Sandy CLAY**: medium to high plasticity, orange-brown, mottled grey, fine to medium sand.	<Wp	H	>>		**RESIDUAL SOIL** HP 550 kPa
			SPT 3, 6, 5 N=11		1.0								
									>Wp	St to VSt			
			SPT 1, 4, 3 N=7		2.0						X		HP 150 kPa
			SPT 4, 6, 8 N=14		3.0								
			SPT 3, 3, 4 N=7		4.0				<Wp		X		HP 350 kPa
										VSt to H			
			SPT 3, 6, 13 N=19		5.0						>>X		HP >600 kPa
			SPT 10, 20/80mm HB N=R		6.0			**SANDSTONE**: fine to medium grained, grey, orange-brown, extremely weathered, inferred soil strength to very low strength.					**BEDROCK**
					7.0			Borehole 113 continued as cored hole					

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method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HA hand auger

* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration: 1 2 3 — no resistance ranging to refusal

water: 10-Oct-12 water level on date shown; water inflow; water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

classification symbol & soil description based on Unified Classification System

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

D&N Geotechnical

Engineering Log - Cored Borehole

Borehole ID.	**113**
sheet:	2 of 3
project no.	**C-0760.00**
client:	***Hunter H20 Holdings Pty Ltd***
date started:	***16 Feb 2021***
principal:	***Wingecarribee Shire Council***
date completed:	***16 Feb 2021***
project:	***Moss Vale Sewage Treatment Plant Upgrades***
logged by:	***AW***
location:	***Moss Vale, NSW***
checked by:	***DB***

position: E: 257442; N: 6174421 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted | drilling fluid: Water | casing diameter : HW | vane id.:

drilling information				material substance						rock mass defects		
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 X = axial; O = diametral VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
			1.0								
			2.0								
			3.0								
			4.0								
			5.0								
			6.0								
			7.0		start coring at 7.00m						
NMLC	Not Observed				**SANDSTONE**: fine to medium grained, massive, grey, orange-brown, brown.	XW to HW HW		a=0.14 d=0.08	75%		PT, 45°, PL, RO, CN JT, 10°, IR, RO, CO - Silt

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method & support
- AS auger screwing
- AD auger drilling
- CB claw or blade bit
- W washbore
- NMLC NMLC core (51.9 mm)
- NQ wireline core (47.6mm)
- HQ wireline core (63.5mm)
- PQ wireline core (85.0mm)
- SPT standard penetration test
- HA hand auger

water
- 10/10/12, water level on date shown
- water inflow
- complete drilling fluid loss
- partial drilling fluid loss
- 25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
- core recovered (graphic symbols indicate material)
- no core recovered

core run & RQD
- barrel withdrawn

RQD = Rock Quality Designation (%)

weathering & alteration*
- RS residual soil
- XW extremely weathered
- HW highly weathered
- DW distinctly weathered
- MW moderately weathered
- SW slightly weathered
- FR fresh

*W replaced with A for alteration

strength
- VL very low
- L low
- M medium
- H high
- VH very high
- EH extremely high

defect type
- PT parting
- JT joint
- SZ shear zone
- SS shear surface
- CO contact
- CS crushed seam
- SM seam

planarity
- PL planar
- CU curved
- UN undulating
- ST stepped
- IR Irregular

roughness
- SL slickensided
- POL polished
- SO smooth
- RO rough
- VR very rough

coating
- CN clean
- SN stain
- VN veneer
- CO coating

D&N Geotechnical

Engineering Log - Cored Borehole

Borehole ID.	**113**
sheet:	3 of 3
project no.	**C-0760.00**
client:	**Hunter H20 Holdings Pty Ltd**
date started:	**16 Feb 2021**
principal:	**Wingecarribee Shire Council**
date completed:	**16 Feb 2021**
project:	**Moss Vale Sewage Treatment Plant Upgrades**
logged by:	**AW**
location:	**Moss Vale, NSW**
checked by:	**DB**

position: E: 257442; N: 6174421 (MGA94) | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB8, Track mounted | drilling fluid: Water | casing diameter : HW | vane id.:

drilling information				material substance					rock mass defects		
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
NMLC					**SANDSTONE**: fine to medium grained, massive, grey, orange-brown, brown. *(continued)*	HW		a=0.20 d=0.18	75%		PT, 45°, UN, RO, CN PT, 45°, UN, RO, CN PT, 45°, UN, RO, CN
			9.0		Borehole 113 terminated at 8.50 m Target depth						
			10.0								
			11.0								
			12.0								
			13.0								
			14.0								
			15.0								

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method & support
- AS auger screwing
- AD auger drilling
- CB claw or blade bit
- W washbore
- NMLC NMLC core (51.9 mm)
- NQ wireline core (47.6mm)
- HQ wireline core (63.5mm)
- PQ wireline core (85.0mm)
- SPT standard penetration test
- HA hand auger

water
- 10/10/12, water level on date shown
- water inflow
- complete drilling fluid loss
- partial drilling fluid loss
- 25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
- core recovered (graphic symbols indicate material)
- no core recovered

core run & RQD
- barrel withdrawn
- RQD = Rock Quality Designation (%)

weathering & alteration*
- RS residual soil
- XW extremely weathered
- HW highly weathered
- DW distinctly weathered
- MW moderately weathered
- SW slightly weathered
- FR fresh

*W replaced with A for alteration

strength
- VL very low
- L low
- M medium
- H high
- VH very high
- EH extremely high

defect type
- PT parting
- JT joint
- SZ shear zone
- SS shear surface
- CO contact
- CS crushed seam
- SM seam

planarity
- PL planar
- CU curved
- UN undulating
- ST stepped
- IR Irregular

roughness
- SL slickensided
- POL polished
- SO smooth
- RO rough
- VR very rough

coating
- CN clean
- SN stain
- VN veneer
- CO coating

D&N Geotechnical

BH113

Core Photograph

Job No: C-0760.00 Sheet 1 of 1
Office: Canberra

Client: Hunter H20 Holdings PTY Ltd	Date: 16 February 2021
Principal:	By: AW
Project: Moss Vale Sewage Treatment Plant	Location: Moss Vale, NSW



Appendix B - Dynamic Cone Penetrometer Test Results

D&N Geotechnical

Dynamic Cone Penetrometer Test Results

Client:	Hunter H20 Holdings Pty Ltd
Principal:	Wingecarribee Shire Council
Project:	Moss Vale Sewage Treatment Plant
Location:	Moss Vale, NSW
Job No:	C-0760.00
Date	22/02/2021

Test procedure: **Test date:**

Depth below surface (mm)	Test Numbers / Readings recorded in blows per 100mm								
	101	102	103	106	108	109	110	111	Test location/Remarks
100	1	2	1	1	2	1	2	1	
200	3	3	0	3	**2**	1	3	2	
300	7	3	1	5	2	0	4	2	
400	4	3	1	8HB	7	1	4	3	
500	4	4	0		5	1	2	3	
600	8	4	1		5	0	2	3	
700	6	4	2		2	1	1	4	
800	4	3	3		2	2	2	3	
900	6	3	2		3	1	2	3	
1000	2	3	2		4	2	3	3	
1100	3	3	2		5	8	5	3	
1200	4	3	2		4	3	5	4	
1300	3	2	4		5	4	6	5	
1400	1	3	4			4			
1500	2	3	7						
1600									
1700									
1800									
1900									
2000									
2100									
2200									
2300									
2400									
2500									
2600									
2700									
2800									
2900									
3000									
3100									
3200									
3300									
3400									
3500									
3600									
3700									
3800									
3900									
4000									

Remarks

General Information

AS 1289 6.3.2

- ■ Drop height 510mm ± 5
- ■ Cone tip
- □ Blunt tip

AS 1289 6.3.3

- □ Drop height 600mm ± 5

D&N Geotechnical

Dynamic Cone Penetrometer Test Results

Client:	Hunter H20 Holdings PTY Ltd
Principal:	
Project:	Moss Vale Sewage Treamtnet Plant
Location:	Moss Vale, NSW
Job No:	C-0760.00
Date	22/02/2021

Test procedure: **Test date:**

Depth below surface (mm)	Test Numbers		Readings recorded in blows per 100mm						
	112	113							Test location/Remarks
100	1	1							
200	1	3							
300	3	2							
400	2	1							
500	5	1							
600	6	5							
700	7	5							
800	10	4							
900	10	4							
1000	10	5							
1100	7	6							
1200	5	6							
1300									
1400									
1500									
1600									
1700									
1800									
1900									
2000									
2100									
2200									
2300									
2400									
2500									
2600									
2700									
2800									
2900									
3000									
3100									
3200									
3300									
3400									
3500									
3600									
3700									
3800									
3900									
4000									

Remarks

General Information

AS 1289 6.3.2

- ■ Drop height 510mm ± 5
- ■ Cone tip
- ☐ Blunt tip

AS 1289 6.3.3

- ☐ Drop height 600mm ± 5

Appendix C - Laboratory Test Certificates

Canberra Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
16 Mildura Street
Fyshwick ACT 2609

Phone: +61 2 8876 0550

Material Test Report

Report No: ASM:CANB21W00412
Issue No: 1

Client: D&N Geotechnical Pty Ltd
16 Broadsmith Street
Scullin ACT 2614

Principal:
Project No.: TESTCANB00249AA
Project Name: C-0760.00 - MossVale STP
Lot No.: **TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Jason McGurgan
(Laboratory Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 19/03/2021

Material Details

Location	Moss Vale, NSW		
Source	Insitu	**Sampled From**	
Description	Subgrade	**Specification**	Investigation
Sampling Method	Submitted by client		

Sample Details

Sample ID	CANB21S-01181	CANB21S-01182	CANB21S-01183	CANB21S-01184	CANB21S-01185	CANB21S-01186
Field Sample ID	00003	00004	00005	00006	00007	00008
Date Sampled	21/02/2021	21/02/2021	21/02/2021	21/02/2021	21/02/2021	21/02/2021
Date Submitted:	3/03/2021	3/03/2021	3/03/2021	3/03/2021	3/03/2021	3/03/2021
Sample Location:	BH101	BH101	BH103	BH108	BH111	BH111
	0.2 - 1.0m	2.0 - 2.45m	1.0 - 1.45m	1.0 - 1.45m	0.5 - 0.6m	2.0 - 2.45m

Other Test Results

Description	Method	Results		Limits
Moisture Content (%)	AS 1289.2.1.1	21.8	13.3	
Date Tested		6/03/2021	6/03/2021	
Standard MDD (t/m³)	AS 1289.5.1.1	1.67		
Standard OMC (%)		18.5		
Retained Sieve (mm)		19		
Oversize Material (%)		0		
Curing Time (h)		48		
LL Method		Visual / Tactile		
Date Tested		9/03/2021		
CBR at 5.0mm (%)	AS 1289.6.1.1	9		
Dry Density before Soaking (t/m³)		1.69		
Density Ratio before Soaking (%)		101.0		
Moisture Content before Soaking (%)		17.9		
Moisture Ratio before Soaking (%)		97.0		
Dry Density after Soaking (t/m³)		1.68		
Density Ratio after Soaking (%)		100.5		
Swell (%)		0.0		
Moisture Content of Top 30mm (%)		19.0		
Moisture Content of Remaining Depth (%)		18.4		
Compaction Hammer Used		Standard		
Surcharge Mass (kg)		4.50		
Period of Soaking (Days)		4		
Retained on 19 mm Sieve (%)		0		
CBR Moisture Content Method		AS 1289.2.1.1		
Sample Curing Time (h)		72		
Plasticity Method		Visual/Tactile		
Sample Moisture Content		AS 1289.2.1.1		
Date Tested		16/03/2021		

Comments

N/A

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Canberra Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
16 Mildura Street
Fyshwick ACT 2609

Phone: +61 2 8876 0550

Material Test Report

Report No: ASM:CANB21W00412
Issue No: 1

Client: D&N Geotechnical Pty Ltd
16 Broadsmith Street
Scullin ACT 2614

Principal:
Project No.: TESTCANB00249AA
Project Name: C-0760.00 - MossVale STP
Lot No.: **TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Jason McGurgan
(Laboratory Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 19/03/2021

Material Details

Location	Moss Vale, NSW		
Source	Insitu	**Sampled From**	
Description	Subgrade	**Specification**	Investigation
Sampling Method	Submitted by client		

Sample Details

Sample ID	CANB21S-01181	CANB21S-01182	CANB21S-01183	CANB21S-01184	CANB21S-01185	CANB21S-01186
Field Sample ID	00003	00004	00005	00006	00007	00008
Date Sampled	21/02/2021	21/02/2021	21/02/2021	21/02/2021	21/02/2021	21/02/2021
Date Submitted:	3/03/2021	3/03/2021	3/03/2021	3/03/2021	3/03/2021	3/03/2021
Sample Location:	BH101	BH101	BH103	BH108	BH111	BH111
	0.2 - 1.0m	2.0 - 2.45m	1.0 - 1.45m	1.0 - 1.45m	0.5 - 0.6m	2.0 - 2.45m

Other Test Results

Description	Method	Results					Limits
Sample History	AS 1289.1.1	Oven-dried	Oven-dried	Oven-dried	Oven-dried	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	Dry Sieved	Dry Sieved	Dry Sieved	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	11.0	10.0	8.5	13.0	17.5	
Mould Length (mm)		254	254	254	254	254	
Crumbling		No	No	No	No	No	
Curling		No	No	No	No	No	
Cracking		No	No	No	No	No	
Liquid Limit (%)	AS 1289.3.1.2	51	38	30	47	72	
Plastic Limit (%)	AS 1289.3.2.1	22	19	15	20	23	
Plasticity Index (%)	AS 1289.3.3.1	29	19	15	27	49	
Date Tested		12/03/2021	12/03/2021	12/03/2021	13/03/2021	13/03/2021	

Comments

N/A

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Canberra Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
16 Mildura Street
Fyshwick ACT 2609

Phone: +61 2 8876 0550

Material Test Report

Report No: ASM:CANB21W00412
Issue No: 1

Client: D&N Geotechnical Pty Ltd
16 Broadsmith Street
Scullin ACT 2614

Principal:
Project No.: TESTCANB00249AA
Project Name: C-0760.00 - MossVale STP
Lot No.: **TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Jason McGurgan
(Laboratory Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 19/03/2021

Material Details

Location	Moss Vale, NSW		
Source	Insitu	**Sampled From**	
Description	Subgrade	**Specification**	Investigation
Sampling Method	Submitted by client		

Sample Details

Sample ID	CANB21S-01187	CANB21S-01188
Field Sample ID	00009	00010
Date Sampled	21/02/2021	21/02/2021
Date Submitted:	3/03/2021	3/03/2021
Sample Location:	BH111	BH113
	3.0 - 3.45m	0.3 - 1.0m

Other Test Results

Description	Method	Results		Limits
Sample History	AS 1289.1.1	Oven-dried		
Preparation	AS 1289.1.1	Dry Sieved		
Linear Shrinkage (%)	AS 1289.3.4.1	12.0		
Mould Length (mm)		254		
Crumbling		No		
Curling		No		
Cracking		No		
Liquid Limit (%)	AS 1289.3.1.2	47		
Plastic Limit (%)	AS 1289.3.2.1	18		
Plasticity Index (%)	AS 1289.3.3.1	29		
Date Tested		13/03/2021		
Moisture Content (%)	AS 1289.2.1.1		24.1	
Date Tested			6/03/2021	
Standard MDD (t/m³)	AS 1289.5.1.1		1.64	
Standard OMC (%)			23.5	
Retained Sieve (mm)			19	
Oversize Material (%)			0	
Curing Time (h)			48	
LL Method			Visual / Tactile	
Date Tested			9/03/2021	

Comments

N/A

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Canberra Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
16 Mildura Street
Fyshwick ACT 2609

Phone: +61 2 8876 0550

Material Test Report

Report No: ASM:CANB21W00412
Issue No: 1

Client: D&N Geotechnical Pty Ltd
16 Broadsmith Street
Scullin ACT 2614

Principal:
Project No.: TESTCANB00249AA
Project Name: C-0760.00 - MossVale STP
Lot No.: **TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection and proficiency testing scheme providers reports.

Approved Signatory: Jason McGurgan
(Laboratory Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 19/03/2021

Material Details

Location	Moss Vale, NSW		
Source	Insitu	**Sampled From**	
Description	Subgrade	**Specification**	Investigation
Sampling Method	Submitted by client		

Sample Details

Sample ID	CANB21S-01187	CANB21S-01188
Field Sample ID	00009	00010
Date Sampled	21/02/2021	21/02/2021
Date Submitted:	3/03/2021	3/03/2021
Sample Location:	BH111	BH113
	3.0 - 3.45m	0.3 - 1.0m

Other Test Results

Description	Method	Results	Limits
CBR at 2.5mm (%)	AS 1289.6.1.1	3.5	
Dry Density before Soaking (t/m³)		1.62	
Density Ratio before Soaking (%)		99.0	
Moisture Content before Soaking (%)		22.7	
Moisture Ratio before Soaking (%)		97.0	
Dry Density after Soaking (t/m³)		1.61	
Density Ratio after Soaking (%)		98.5	
Swell (%)		1.0	
Moisture Content of Top 30mm (%)		25.2	
Moisture Content of Remaining Depth (%)		23.9	
Compaction Hammer Used		Standard	
Surcharge Mass (kg)		4.50	
Period of Soaking (Days)		4	
Retained on 19 mm Sieve (%)		0	
CBR Moisture Content Method		AS 1289.2.1.1	
Sample Curing Time (h)		72	
Plasticity Method		Visual/Tactile	
Sample Moisture Content		AS 1289.2.1.1	
Date Tested		16/03/2021	

Comments

N/A

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SYDNEY LABORATORY
Coffey Testing Pty Ltd
ABN 92 114 364 046
31 Hope Street, Melrose Park NSW 2114 Australia
ph: +61 2 8876 0500

Test report - uniaxial compressive strength

client:	*COFFEY TESTING PTY LTD*	job no:	***TESTSYDS 00069AA***
Principal:	*D&N GEOTECHNICAL PTY*		
project:	*TESTCANB00249AA - MOSS VALE*	report date:	*26 March 2021*
location:	*MOSS VALE NSW*	borehole:	***BH101***
	test procedure: *AS 4133.1.1.1 and 4133.4.2.1*	date received:	*5 March 2021*
	test apparatus: *Avery with 200 kN CAS load cell 4222*		*page 1 of 1*

All samples were tested in an "As Received" condition.

Top platen 228 mm, Bottom platen 120 mm

QESTLab work order ID / depth / QESTLab sample ID	date tested / test duration	height / average diameter / height/dia ratio	uniaxial compressive strength MPa	wet density / moisture content	sample description / bedding/foliation	Client's Sample ID / failure mechanism
SYDS21W00044 / ***4.50 to 4.78 m*** / *SYDS21S00488*	*24 Mar 21* / *5.03 min*	*147 mm* / *51.5 mm* / *2.86:1*	***13.8***	***2.5 t/m³*** / ***3.2 %***	*Sandstone with shale* / *Bedding planes are at an angle of 70° to the axis of loading*	***CANB21S-01029*** / *Shear & bedding*





4.50 to 4.78 m

SYDS_001R

\\Ct-fs\zct\Sydney\Data\50. ROCK TESTING_TESTSYD-Rocks-2021\TESTSYDS00069AA - Moss Vale STP\[BH101.xlsm]Data Entry

Accredited for compliance with ISO/IEC 17025 - Testing
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/national standards.

NATA Accredited Laboratory No. 431

Date: *26 Mar 2021*

Authorised Signature:

Alan Cocks
Rock Testing Manager

SYDNEY LABORATORY
Coffey Testing Pty Ltd
ABN 92 114 364 046
31 Hope Street, Melrose Park NSW 2114 Australia
ph: +61 2 8876 0500

Test report - uniaxial compressive strength

client:	*COFFEY TESTING PTY LTD*	job no:	***TESTSYDS 00069AA***
Principal:	*D&N GEOTECHNICAL PTY*		
project:	*TESTCANB00249AA - MOSS VALE*	report date:	*26 March 2021*
location:	*MOSS VALE NSW*	borehole:	***BH102***
	test procedure: *AS 4133.1.1.1 and 4133.4.2.1*	date received:	*5 March 2021*
	test apparatus: *Avery with 200 kN CAS load cell 4222*		*page 1 of 1*

All samples were tested in an "As Received" condition.

Top platen 228 mm, Bottom platen 120 mm

QESTLab work order ID / depth / QESTLab sample ID	date tested / test duration	height / average diameter / height/dia ratio	uniaxial compressive strength MPa	wet density / moisture content	sample description / bedding/foliation	Client's Sample ID / failure mechanism
SYDS21W00044 / ***6.22 to 6.45 m*** / *SYDS21S00489*	*24 Mar 21* / *5.54 min*	*136 mm* / *51.5 mm* / *2.63:1*	***17.6***	***2.6 t/m³*** / ***3.6 %***	*sandstone with shale* / *Bedding planes are at an angle of 80° to the axis of loading*	***CANB21S-01028*** / *Shear/bedding*





6.22 to 6.45 m

SYDS_001R

Accredited for compliance with ISO/IEC 17025 - Testing
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/national standards.

NATA Accredited Laboratory No. 431

Date: *26 Mar 2021*

Authorised Signature:

Alan Cocks

Rock Testing Manager

CERTIFICATE OF ANALYSIS

Work Order	: **CA2101338**	Page	: 1 of 2
Client	: **D&N Geotechnical**	Laboratory	: ALS Water Resources Group
Contact	: Mr Liam Crossby	Contact	: Client Services
Address	: PO BOX 4359 Hawker ACT 2614	Address	: 16B Lithgow Street Fyshwick ACT Australia 2609
Telephone	: ----	Telephone	: +61 2 6202 5404
Project	: Soil Agressivity	Date Samples Received	: 01-Mar-2021 15:40
Order number	: ----	Date Analysis Commenced	: 04-Mar-2021
C-O-C number	: ----	Issue Date	: 15-Mar-2021 14:30
Sampler	: Alex Weaver		
Site	: ----		
Quote number	: ----		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 992
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Geetha Ramasundara	Chemistry Teamleader	Inorganics, Fyshwick, ACT

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- **For samples collected by ALS WRG, sampling was carried out in accordance with Procedure EN67**

Analytical Results

Sub-Matrix: **SOLID** (Matrix: **SOLID**)			Sample ID	**BH101 CLAY, COLLUVIUM**	**BH111 SANDY SILTY CLAY, COLLUVIUM**	**BH113 SANDY CLAY, BEDROCK**	**BH104 SANDY CLAY, RESIDUAL**	**----**
			Sampling date / time	21-Feb-2021 00:00	20-Feb-2021 00:00	19-Feb-2021 00:00	20-Feb-2021 00:00	----
Compound	*CAS Number*	*LOR*	*Unit*	**CA2101338-001**	**CA2101338-002**	**CA2101338-003**	**CA2101338-004**	**--------**
				Result	Result	Result	Result	----
EA002CA: pH in Soil								
ø pH Value	----	0.1	pH Unit	**6.4**	**6.8**	**7.3**	**7.8**	**----**
EA010CA: Conductivity								
ø Electrical Conductivity @ 25°C	----	0.01	dS/m	**0.12**	**0.05**	**0.05**	**0.05**	**----**
EA080CA: Resistivity								
Resistivity at 25°C	----	1	ohm cm	**8160**	**18400**	**18700**	**20100**	**----**
ED009CA: Anions								
Chloride	16887-00-6	1	mg/kg	**22**	**32**	**45**	**22**	**----**
Sulfate	14808-79-8	2	mg/kg	**176**	**30**	**31**	**31**	**----**

Appendix D – AS2159-2009 Risk Assessment for Geotechnical Reduction Factor

D&N Geotechnical

AS2159-2009: Piling - Design and installation - Geotechnical Risk and Reduction Factor Assessment per Section 4.3.1 and 4.3.2

Job No	C-0760.00 R1 Rev1		
Sheet	1 of 1		
Client	Hunter H20 Pty Ltd		
Principal		**Date**	19/04/2021
Project	Moss Vale STP	**By**	RV
Location	Moss Vale, NSW	**Checked**	DB

	Weighting	Typical description of risk circumstances for IRR	Individual Risk Rating	Override (e.g. IRR = 2 or 4)	Weigted IRR
Site Factors					
Geologcal Complexity of site	2	3 - Some variability over site, but without abrupt changes in stratigraphy	3		6
Extent of Ground Investigation	2	3 - Some boreholes extending at least 5 pile diameters below the base of the proposed pile foundation level	3	4	8
Amount and quality of Geotechnical data	2	5 - Limited amount of simple in situ testing (e.g., SPT) or index tests only	5		10
Design Factors					
Designer's Experience with similar foundations in similar conditions	1	3 - Limited	3	2	2
Method of Assessment of geotechnical parameters for design	2	5 - Based on non-sitespecific correlations with (for example) SPT data	5		10
Design method adopted	1	3 - Simplified methods with well-established basis	3		3
Method of utilising results of in-situ test data and installation data	2	5 - No in situ test and installation data available	5		10
Installation Factors					
Level of Construction control	2	3 - Limited degree of professional geotechnical involvement in supervision, conventional construction procedures	3		6
Level of performance monitoring of the supported structure during and after construction	0.5	5 - No monitoring	5		2.5
				Totals	57.5
System redundancy		2 - Systems with a low level of redundancy would include isolated heavily loaded piles and piles set out at large spacings.	**Average Risk Rating**	**ARR**	**3.97**
			Overall risk category		Moderate to High
			Basic Geotechnical Strength Reduction Factor	ϕ_{gb}	0.45
Intrinsic test factor		0.00 - No testing		ϕ_{tf}	0.00
Type of load testing to be performed		0.00 - No testing			
Proportion of piles tested (%)		0	Testing benefit Factor	K	0.00
			Geotechnical Strength Reduction Factor	**ϕ_g**	**0.45**

Provided Requirements of AS2159-2009 Section 8.2.4 are met, Otherwise, ϕ_g= 0.40

Preliminary Groundwater Quality Assessment

Moss Vale Sewage Treatment Plant,
Kennedy Close, Moss Vale NSW 2577

Report prepared for –
Hunter H2O Holdings Pty Ltd
c/- D&N Geotechnical Pty Ltd

10 March 2021
BPE21011-R02

Quality information

Revision history

Item	Description
Revision	Original
Description	Preliminary Groundwater Quality Assessment – Moss Vale Sewage Treatment Plant, Moss Vale NSW
Date	10 March 2021
Report Author	Joel Parkin – Ballpark Environmental Pty Ltd
Technical Reviewer	Andrew Ballard – Ballpark Environmental Pty Ltd CEnvP

Distribution

Report Status	No. of copies	Format	Distributed to	Date
Original	1	PDF	D&N Geotechnical Pty Ltd	10 March 2021
Original	1	PDF	Ballpark Environmental Pty Ltd	10 March 2021

10 March 2021

Our ref: BPE21011-R02

Hunter H2O Holdings Pty Ltd
c/- D&N Geotechnical Pty Ltd
PO Box 4359
HAWKER ACT 2614

Sent via email: dan@dngeotechnical.com

Attention: Dan Butterworth – Geotechnical Lead

Dear Dan,

RE: Preliminary Groundwater Quality Assessment – Moss Vale Sewage Treatment Plant

1. Introduction

D&N Geotechnical Pty Ltd were engaged by Hunter H2O Holdings Pty Ltd to undertake a geotechnical investigation including groundwater monitoring and water quality assessment present in two existing groundwater monitoring wells at the Moss Vale Sewage Treatment Plant (STP), Kennedy Close, Moss Vale NSW, the site, see Figure 1.

D&N Geotechnical carried out the geotechnical investigation of the site during February 2021. As part the investigation the two existing groundwater monitoring wells, B20 and B25 on this site were gauged and sampled. The groundwater samples were analysed by a NATA accredited laboratory and the results reviewed to assess if groundwater contamination was present.

D&N Geotechnical asked Ballpark Environmental Pty Ltd to review the groundwater contamination laboratory results and to prepare this letter report. The purpose of this letter report is to present the findings from the preliminary groundwater quality assessment for the two existing monitoring wells located on this site.

2. Scope of Works

The objective of the preliminary groundwater quality assessment is to assess if contamination is present within the groundwater at the two monitoring wells on this site.

The following scope of works was carried out for this investigation:

- A site walkover, observations and photographs were taken by an engineering geologist from D&N Geotechnical on the 16 February 2021.

- Prior to the collection of the groundwater samples each monitoring well was dipped and the depth to groundwater was recorded as 3.53m (BH20) and 0.9m (BH25) below ground surface.
- A single use clean disposable bailer was used to collect the groundwater samples. A sample was collected from each of the groundwater monitoring wells.
- Samples were placed directly into the appropriate laboratory supplied containers and stored in a chilled insulated container during fieldwork and transport to the laboratory under chain of custody.
- Groundwater samples were submitted to Eurofins MGT Sydney laboratory, National Association of Testing Authorities (NATA) accredited, for testing for contaminants of potential concern (CoPC), as follows:
  - Metals suite (arsenic, cadmium, chromium, copper, lead, mercury, nickel, & zinc)
  - Benzene, Toluene, Ethylbenzene & Xylene (BTEX) compounds
  - Total recoverable hydrocarbons (TRH)
  - Polycyclic aromatic hydrocarbons (PAH) compounds
  - Organochlorine pesticides (OCP)
  - Polychlorinated biphenyls (PCB)
  - pH
  - Electrical conductivity (EC)
- Ballpark Environmental has compared the laboratory results with the groundwater investigation levels (GILs) provided in Table 1C *Groundwater Investigation Levels* and Table 1A(4) *Groundwater HSLs for vapour intrusion* of the *National Environment Protection (Assessment of Site Contamination) Measure 1999 (Amended April 2013)*, EPHC 2013, Canberra (ASC NEPM, 2013). The ASC NEPM is the primary guideline approved for use by NSW EPA when setting GILs for chemical concentrations in groundwater.

3. Field Investigation

Field investigation work for the collection of the groundwater samples from BH20 and BH25 was undertaken on Tuesday 16 February 2021 by an engineering geologist from D&N Geotechnical. The sampling methodology followed is summarised in Table 1.

Table 1: Groundwater Sampling Methodology

Activity	Detail / Comments
Groundwater Sampling	Groundwater samples were collected from two existing monitoring wells BH20 and BH25, see Figure 1. Each monitoring well was gauged prior to sampling to record the depth to groundwater. A new disposable bailer was used to check for visual presence of Non-Aqueous Phase Liquid (NAPL). No NAPL was detected in the wells. Measured groundwater standing water levels from monitoring well BH20 was 3.53 metres below ground surface (mbgs) and BH25 was 0.9 mbgs.
Sample Handling and Transportation	A clean pair of disposable nitrile gloves was used to collect each sample. The groundwater sample was immediately placed into laboratory supplied bottles with appropriate preservatives and placed into a chilled

Activity	Detail / Comments
	cooler. Metals samples were pre-filtered in the field using a new disposable 0.45µm filter and syringe. The samples were couriered to NATA accredited laboratory (Eurofins/ mgt laboratory in Sydney) under chain of custody documentation, see attached laboratory certificates.
Decontamination of sampling equipment	For each groundwater sample a dedicated single use disposable bailer and new pair of nitrile gloves were used to collect the samples from each of the monitoring wells which does not require decontamination.
QA/QC Samples	To measure the accuracy and precision of the data generated by the field and laboratory procedures for this assessment, an additional intra-laboratory duplicate water sample (QC05) was collected and analysed.

4. Quality Assurance / Quality Control

Samples were transported under chain of custody (CoC) documentation and in chilled insulated containers to Eurofins mgt Environmental Sydney Laboratory which is NATA certified for the analysis performed. A copy of the CoC is included with the laboratory analytical reports presented in Attachment A.

The laboratory conducted internal quality control using laboratory duplicates, spikes, and method blanks. The results are shown with laboratory analytical report, see Attachment A. Analytical methods used for the laboratory testing are also indicated on the laboratory report sheets. The results of laboratory quality control testing are assessed to be within acceptable limits.

For QA/QC purposes 1 duplicate groundwater sample, QC05, was submitted for analysis for CoPC. The results of the duplicate testing for this groundwater sample are summarised in Table LR1.

There were no reported exceedances of the relative percentage difference (RPD) 50% control limit for the duplicate sample. Based on these results it is considered that the field and laboratory methods are appropriate, and that the data obtained is usable and considered to reasonably represent the concentrations at the sampling points at the time of sampling.

5. Results

The laboratory analytical results for the groundwater samples collected on the 16 February 2021 are summarised in Table LR2 and laboratory certificates of analysis are provided in Attachment A. Comparison of groundwater concentrations in BH20 and BH25 to the adopted GILs discussed in section 2 and provided in Table LR2 is as follows:

- Concentrations of BTEX, PAH, OCP pesticides, and PCBs in water were below the adopted investigation levels, the laboratory's limit of reporting (LOR) or were not detected in the samples analysed.
- Concentrations of the following metals exceeded the adopted GILs as follows:
  - Copper exceeded the GIL of 1.4 µg/L in sample B25, reporting a concentration of 4 µg/L.
  - Concentrations of Nickel exceeded the GIL of 11 µg/L in sample BH20, reporting a concentration of 34µg/L.
  - Concentrations of Zinc exceeded the GIL of 8 µg/L in both samples, reporting concentrations of 34 µg/L (BH20) and 32 µg/L (BH25).
- Concentrations of TRH >C_{10}-C_{40}, and TRH >C_{16}-C_{34} were reported above the laboratory LOR in BH20 (200 µg/L), and BH25 (100 µg/L). BH25 also reported TRH C_6-C_{10} (20 µg/L) marginally above the laboratory LOR. Note. Table 1C of the ASC NEPM does not include GILs for TRH.

6. Conclusion

The groundwater monitoring event on the 16 February 2021 was undertaken to assess if contamination was present in groundwater at the two monitoring wells, BH20 and BH25, on this site, see Figure 1.

The laboratory results show metals; copper, nickel and zinc recorded concentrations above the adopted GILs. The presence of these metals may be attributed to natural mineralisation in local soils and rock and is assessed to be a low risk.

It is assessed that there is a low potential risk from groundwater contamination to human health or the environment in groundwater at these two monitoring wells on this site.

Subject to obtaining all the necessary approvals surplus groundwater from this site may be permitted to be discharged to the nearby Moss Vale Sewage Treatment Plant or to stormwater during proposed construction activities.

7. References

ANZG (2018). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. www.waterquality.gov.au/anz-guidelines/about/how-to-use

ANZECC (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand. Artarmon.

DUAP/ EPA (1998). *Managing Land Contamination Planning Guidelines, SEPP 55 – Remediation of Land*. Department of Urban Affairs and Planning & Environmental Protection Authority NSW, Sydney

NEPC (2013). *National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended by the National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No.1)* (ASC NEPM). National Environment Protection Council, Canberra

NSW DEC (2007). *Contaminated Sites: Guidelines for Assessment and Management of Groundwater Contamination*. Department of Environment and Conservation NSW, Sydney

NSW EPA (2020). *Contaminated Land Guidelines: Consultants Reporting on Contaminated Land*. Environmental Protection Authority NSW, Sydney

NSW EPA (2017). *Contaminated Land Management: Guidelines for the NSW Site Auditor Scheme (3rd Edition)*. Environment Protection Authority NSW, Sydney

NSW EPA (2015). *Contaminated Sites: Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*. Environment Protection Authority NSW, Sydney

NSW EPA (1995). *Contaminated Sites: Sampling Design Guidelines*. Environment Protection Authority NSW, Sydney.

8. Limitations

The findings contained in this letter report are the result of discrete/specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points. If material is observed during construction that does not conform to that described in this letter report, or is suspicious in nature, then an environmental consultant should be contacted, and further assessments undertaken.

In preparing this letter report, current guidelines for assessment and management of contaminated land were followed. This work has been conducted in good faith in accordance with Ballpark Environmental understanding of the client's brief and general accepted practice for environmental consulting.

The objective of the preliminary groundwater quality assessment was to assess if contamination is present within the groundwater at the two monitoring wells on this site.

No warranty, expressed or implied, is made as to the information and professional advice included in this letter report. Anyone relying on this document with reference to a particular development concept does so at their own risk and should satisfy themselves concerning its applicability and, where necessary, should seek expert advice in relation to the particular situation.

I trust that this letter report meets with your requirements. If you require further information or assistance, please do not hesitate to contact us on (02) 6658 0585.

For and on behalf of Ballpark Environmental Pty Ltd

Andrew Ballard
Principal Environmental Scientist
Licensed Asbestos Assessor
Certified Environmental Practitioner

Joel Parkin
Associate Environmental Engineer
Licensed Asbestos Assessor

Attachments: Figure 1: Groundwater Well Location Plan

Table LR1: Results of Quality Control Groundwater Samples

Table LR2: Summary of Laboratory Results for Groundwater Samples

Attachment A: Laboratory Certificate of Analysis

Figure



Image sourced from Google Earth 2021

Client:	Hunter H2O Holdings c/- D&N Geotechnical			Drawn:	JP
Project:	Groundwater Quality Assessment – Moss Vale Sewage Treatment Plant, Moss Vale NSW			Approved:	AB
				Date:	10 March 2021
Title:	Groundwater Well Location Plan			Scale:	NTS
project no:	BPE21011-R02	Figure no:	Figure 1	Original Size:	A4

BALLPARK ENVIRONMENTAL

Tables

Table LR1: Results of Quality Control Groundwater Samples

All results in mg/L, unless otherwise stated.

	Primary Sample	Duplicate Sample	RPD (%)
Sample ID	BH20	QC05	
Depth (m)	3.53	3.53	%RPD between
Material	Water	Water	BH20 and QC05
Date of Sampling	16-Feb-21	16-Feb-21	
Metals			
Arsenic	0.002	0.002	0
Cadmium	< 0.0002	< 0.0002	NA
Chromium	< 0.001	<0.001	NA
Copper	0.001	0.001	0
Lead	< 0.001	< 0.001	NA
Mercury	< 0.0001	< 0.0001	NA
Nickel	0.034	0.035	3
Zinc	0.034	0.038	11
Total Recoverable Hydrocarbons			
Naphthalene	< 0.01	< 0.01	NA
TRH >C_{10}-C_{16}	< 0.05	< 0.05	NA
TRH >C_{10}-C_{16} (F2)	< 0.05	< 0.05	NA
TRH >C_{10}-C_{40}	0.2	0.2	0
TRH >C_{16}-C_{34}	0.2	0.2	0
TRH >C_{34}-C_{40}	< 0.1	< 0.1	NA
TRH C_6-C_{10}	< 0.02	< 0.02	NA
TRH C_6-C_{10} (F1)	< 0.02	< 0.02	NA
BTEX			
Benzene	< 0.001	< 0.001	NA
Ethylbenzene	< 0.001	< 0.001	NA
m&p-Xylenes	< 0.002	< 0.002	NA
o-Xylene	< 0.001	< 0.001	NA
Toluene	< 0.001	0.005	NA
Xylenes - Total	< 0.003	< 0.003	NA
Polycyclic Aromatic Hydrocarbons			
PAH (Total)	< LOR	< LOR	NA
Polychlorinated biphenyls			
PCBs (Total)	< LOR	< LOR	NA
Organochlorine Pesticides			
OCP (Total)	< LOR	< LOR	NA
Physico Chemical			
pH (pH units)	6.4	6.3	2
Conductivity (uS/cm)	730	720	1

Notes:

Value	RPD exceeds control limit of 50%
NA	At least one sample has concentration below laboratory's Limit of Reporting
< LOR	Concentrations below the Laboratory's Limit of Reporting

[illegible] [illegible] [illegible] [

Attachment A

Laboratory Certificate of Analysis

Ballpark Environmental
BPE21011-R02
10 March 2021

Ballpark Environmental Pty Ltd
PO Box 36
Nana Glen
NSW 2450

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Attention: **-ALL SRAs & Results - Andrew Ballard & Joel Parkin**

Report **776348-W**
Project name BPE21011 C-0760-.00
Received Date Feb 24, 2021

Client Sample ID			**B20**	**B25**	**QC05**
Sample Matrix			**Water**	**Water**	**Water**
Eurofins Sample No.			**S21-Fe49946**	**S21-Fe49947**	**S21-Fe49948**
Date Sampled			**Feb 16, 2021**	**Feb 16, 2021**	**Feb 16, 2021**
Test/Reference	LOR	Unit			
Total Recoverable Hydrocarbons - 1999 NEPM Fractions					
TRH C6-C9	0.02	mg/L	< 0.02	< 0.02	< 0.02
TRH C10-C14	0.05	mg/L	< 0.05	< 0.05	< 0.05
TRH C15-C28	0.1	mg/L	0.2	0.1	0.2
TRH C29-C36	0.1	mg/L	< 0.1	< 0.1	< 0.1
TRH C10-C36 (Total)	0.1	mg/L	0.2	0.1	0.2
BTEX					
Benzene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Toluene	0.001	mg/L	< 0.001	0.005	0.005
Ethylbenzene	0.001	mg/L	< 0.001	< 0.001	< 0.001
m&p-Xylenes	0.002	mg/L	< 0.002	< 0.002	< 0.002
o-Xylene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Xylenes - Total*	0.003	mg/L	< 0.003	< 0.003	< 0.003
4-Bromofluorobenzene (surr.)	1	%	91	91	100
Total Recoverable Hydrocarbons - 2013 NEPM Fractions					
Naphthalene[N02]	0.01	mg/L	< 0.01	< 0.01	< 0.01
TRH C6-C10	0.02	mg/L	< 0.02	0.02	< 0.02
TRH C6-C10 less BTEX (F1)[N04]	0.02	mg/L	< 0.02	< 0.02	< 0.02
TRH >C10-C16	0.05	mg/L	< 0.05	< 0.05	< 0.05
TRH >C10-C16 less Naphthalene (F2)[N01]	0.05	mg/L	< 0.05	< 0.05	< 0.05
TRH >C16-C34	0.1	mg/L	0.2	0.1	0.2
TRH >C34-C40	0.1	mg/L	< 0.1	< 0.1	< 0.1
TRH >C10-C40 (total)*	0.1	mg/L	0.2	0.1	0.2
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Acenaphthylene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Anthracene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Benz(a)anthracene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Benzo(a)pyrene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Benzo(b&j)fluoranthene[N07]	0.001	mg/L	< 0.001	< 0.001	< 0.001
Benzo(g.h.i)perylene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Benzo(k)fluoranthene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Chrysene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Dibenz(a.h)anthracene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Fluoranthene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Fluorene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Indeno(1.2.3-cd)pyrene	0.001	mg/L	< 0.001	< 0.001	< 0.001

Client Sample ID			B20	B25	QC05
Sample Matrix			Water	Water	Water
Eurofins Sample No.			S21-Fe49946	S21-Fe49947	S21-Fe49948
Date Sampled			Feb 16, 2021	Feb 16, 2021	Feb 16, 2021
Test/Reference	LOR	Unit			
Polycyclic Aromatic Hydrocarbons					
Naphthalene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Phenanthrene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Pyrene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Total PAH*	0.001	mg/L	< 0.001	< 0.001	< 0.001
2-Fluorobiphenyl (surr.)	1	%	INT	INT	INT
p-Terphenyl-d14 (surr.)	1	%	71	65	53
Organochlorine Pesticides					
Chlordanes - Total	0.002	mg/L	< 0.002	< 0.002	< 0.002
4.4'-DDD	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
4.4'-DDE	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
4.4'-DDT	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
a-BHC	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Aldrin	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
b-BHC	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
d-BHC	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Dieldrin	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Endosulfan I	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Endosulfan II	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Endosulfan sulphate	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Endrin	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Endrin aldehyde	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Endrin ketone	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
g-BHC (Lindane)	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Heptachlor	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Heptachlor epoxide	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Hexachlorobenzene	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Methoxychlor	0.0002	mg/L	< 0.0002	< 0.0002	< 0.0002
Toxaphene	0.001	mg/L	< 0.001	< 0.001	< 0.001
Aldrin and Dieldrin (Total)*	0.0002	mg/L	< 0.0002	< 0.0002	< 0.0002
DDT + DDE + DDD (Total)*	0.0002	mg/L	< 0.0002	< 0.0002	< 0.0002
Vic EPA IWRG 621 OCP (Total)*	0.002	mg/L	< 0.002	< 0.002	< 0.002
Vic EPA IWRG 621 Other OCP (Total)*	0.002	mg/L	< 0.002	< 0.002	< 0.002
Dibutylchlorendate (surr.)	1	%	74	59	52
Tetrachloro-m-xylene (surr.)	1	%	INT	INT	INT
Polychlorinated Biphenyls					
Aroclor-1016	0.005	mg/L	< 0.005	< 0.005	< 0.005
Aroclor-1221	0.001	mg/L	< 0.001	< 0.001	< 0.001
Aroclor-1232	0.005	mg/L	< 0.005	< 0.005	< 0.005
Aroclor-1242	0.005	mg/L	< 0.005	< 0.005	< 0.005
Aroclor-1248	0.005	mg/L	< 0.005	< 0.005	< 0.005
Aroclor-1254	0.005	mg/L	< 0.005	< 0.005	< 0.005
Aroclor-1260	0.005	mg/L	< 0.005	< 0.005	< 0.005
Total PCB*	0.001	mg/L	< 0.001	< 0.001	< 0.001
Dibutylchlorendate (surr.)	1	%	74	59	52
Tetrachloro-m-xylene (surr.)	1	%	INT	INT	INT
Conductivity (at 25°C)	10	uS/cm	730	1200	720
pH (at 25 °C)	0.1	pH Units	6.4	6.9	6.3

Client Sample ID			B20	B25	QC05
Sample Matrix			**Water**	**Water**	**Water**
Eurofins Sample No.			**S21-Fe49946**	**S21-Fe49947**	**S21-Fe49948**
Date Sampled			**Feb 16, 2021**	**Feb 16, 2021**	**Feb 16, 2021**
Test/Reference	LOR	Unit			
Heavy Metals					
Arsenic (filtered)	0.001	mg/L	0.002	< 0.001	0.002
Cadmium (filtered)	0.0002	mg/L	< 0.0002	< 0.0002	< 0.0002
Chromium (filtered)	0.001	mg/L	< 0.001	< 0.001	< 0.001
Copper (filtered)	0.001	mg/L	0.001	0.004	0.001
Lead (filtered)	0.001	mg/L	< 0.001	< 0.001	< 0.001
Mercury (filtered)	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001
Nickel (filtered)	0.001	mg/L	0.034	0.009	0.035
Zinc (filtered)	0.005	mg/L	0.034	0.032	0.038

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Total Recoverable Hydrocarbons - 1999 NEPM Fractions	Sydney	Feb 25, 2021	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
BTEX	Sydney	Feb 25, 2021	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Sydney	Feb 25, 2021	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Sydney	Feb 25, 2021	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Polycyclic Aromatic Hydrocarbons	Sydney	Feb 25, 2021	7 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Metals M8 filtered	Sydney	Feb 25, 2021	28 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Organochlorine Pesticides	Sydney	Feb 25, 2021	7 Days
- Method: LTM-ORG-2220 OCP & PCB in Soil and Water			
Polychlorinated Biphenyls	Sydney	Feb 25, 2021	7 Days
- Method: LTM-ORG-2220 OCP & PCB in Soil and Water			
Conductivity (at 25°C)	Sydney	Feb 26, 2021	28 Days
- Method: LTM-INO-4030 Conductivity			
pH (at 25 °C)	Sydney	Feb 26, 2021	1 Days
- Method: LTM-GEN-7090 pH in water by ISE			

eurofins | Environment Testing

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IANZ # 1290

Company Name: Ballpark Environmental Pty Ltd
Address: PO Box 36
Nana Glen
NSW 2450

Project Name: BPE21011 C-0760-.00

Order No.:
Report #: 776348
Phone: 0400 566 088
Fax:

Received: Feb 24, 2021 8:40 AM
Due: Mar 3, 2021
Priority: 5 Day
Contact Name: -ALL SRAs & Results - Andrew

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Conductivity (at 25°C)	pH (at 25 °C)	Suite B13: OCP/PCB	Eurofins Suite B7 (filtered metals)
Melbourne Laboratory - NATA Site # 1254 & 14271									
Sydney Laboratory - NATA Site # 18217						X	X	X	X
Brisbane Laboratory - NATA Site # 20794									
Perth Laboratory - NATA Site # 23736									
Mayfield Laboratory									
External Laboratory									
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**				
1	B20	Feb 16, 2021		Water	S21-Fe49946	X	X	X	X
2	B25	Feb 16, 2021		Water	S21-Fe49947	X	X	X	X
3	QC05	Feb 16, 2021		Water	S21-Fe49948	X	X	X	X
Test Counts						3	3	3	3

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram

mg/L: milligrams per litre

ug/L: micrograms per litre

ppm: Parts per million

ppb: Parts per billion

%: Percentage

org/100mL: Organisms per 100 millilitres

NTU: Nephelometric Turbidity Units

MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	mg/L	< 0.02			0.02	Pass	
TRH C10-C14	mg/L	< 0.05			0.05	Pass	
TRH C15-C28	mg/L	< 0.1			0.1	Pass	
TRH C29-C36	mg/L	< 0.1			0.1	Pass	
Method Blank							
BTEX							
Benzene	mg/L	< 0.001			0.001	Pass	
Toluene	mg/L	< 0.001			0.001	Pass	
Ethylbenzene	mg/L	< 0.001			0.001	Pass	
m&p-Xylenes	mg/L	< 0.002			0.002	Pass	
o-Xylene	mg/L	< 0.001			0.001	Pass	
Xylenes - Total*	mg/L	< 0.003			0.003	Pass	
Method Blank							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	mg/L	< 0.01			0.01	Pass	
TRH C6-C10	mg/L	< 0.02			0.02	Pass	
TRH >C10-C16	mg/L	< 0.05			0.05	Pass	
TRH >C16-C34	mg/L	< 0.1			0.1	Pass	
TRH >C34-C40	mg/L	< 0.1			0.1	Pass	
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/L	< 0.001			0.001	Pass	
Acenaphthylene	mg/L	< 0.001			0.001	Pass	
Anthracene	mg/L	< 0.001			0.001	Pass	
Benz(a)anthracene	mg/L	< 0.001			0.001	Pass	
Benzo(a)pyrene	mg/L	< 0.001			0.001	Pass	
Benzo(b&j)fluoranthene	mg/L	< 0.001			0.001	Pass	
Benzo(g.h.i)perylene	mg/L	< 0.001			0.001	Pass	
Benzo(k)fluoranthene	mg/L	< 0.001			0.001	Pass	
Chrysene	mg/L	< 0.001			0.001	Pass	
Dibenz(a.h)anthracene	mg/L	< 0.001			0.001	Pass	
Fluoranthene	mg/L	< 0.001			0.001	Pass	
Fluorene	mg/L	< 0.001			0.001	Pass	
Indeno(1.2.3-cd)pyrene	mg/L	< 0.001			0.001	Pass	
Naphthalene	mg/L	< 0.001			0.001	Pass	
Phenanthrene	mg/L	< 0.001			0.001	Pass	
Pyrene	mg/L	< 0.001			0.001	Pass	
Method Blank							
Organochlorine Pesticides							
Chlordanes - Total	mg/L	< 0.002			0.002	Pass	
4.4'-DDD	mg/L	< 0.0001			0.0001	Pass	
4.4'-DDE	mg/L	< 0.0001			0.0001	Pass	
4.4'-DDT	mg/L	< 0.0001			0.0001	Pass	
a-BHC	mg/L	< 0.0001			0.0001	Pass	
Aldrin	mg/L	< 0.0001			0.0001	Pass	
b-BHC	mg/L	< 0.0001			0.0001	Pass	
d-BHC	mg/L	< 0.0001			0.0001	Pass	
Dieldrin	mg/L	< 0.0001			0.0001	Pass	
Endosulfan I	mg/L	< 0.0001			0.0001	Pass	
Endosulfan II	mg/L	< 0.0001			0.0001	Pass	

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Endosulfan sulphate	mg/L	< 0.0001			0.0001	Pass	
Endrin	mg/L	< 0.0001			0.0001	Pass	
Endrin aldehyde	mg/L	< 0.0001			0.0001	Pass	
Endrin ketone	mg/L	< 0.0001			0.0001	Pass	
g-BHC (Lindane)	mg/L	< 0.0001			0.0001	Pass	
Heptachlor	mg/L	< 0.0001			0.0001	Pass	
Heptachlor epoxide	mg/L	< 0.0001			0.0001	Pass	
Hexachlorobenzene	mg/L	< 0.0001			0.0001	Pass	
Methoxychlor	mg/L	< 0.0002			0.0002	Pass	
Toxaphene	mg/L	< 0.001			0.001	Pass	
Method Blank							
Polychlorinated Biphenyls							
Aroclor-1016	mg/L	< 0.005			0.005	Pass	
Aroclor-1221	mg/L	< 0.001			0.001	Pass	
Aroclor-1232	mg/L	< 0.005			0.005	Pass	
Aroclor-1242	mg/L	< 0.005			0.005	Pass	
Aroclor-1248	mg/L	< 0.005			0.005	Pass	
Aroclor-1254	mg/L	< 0.005			0.005	Pass	
Aroclor-1260	mg/L	< 0.005			0.005	Pass	
Total PCB*	mg/L	< 0.001			0.001	Pass	
Method Blank							
Conductivity (at 25°C)	uS/cm	< 10			10	Pass	
Method Blank							
Heavy Metals							
Arsenic (filtered)	mg/L	< 0.001			0.001	Pass	
Cadmium (filtered)	mg/L	< 0.0002			0.0002	Pass	
Chromium (filtered)	mg/L	< 0.001			0.001	Pass	
Copper (filtered)	mg/L	< 0.001			0.001	Pass	
Lead (filtered)	mg/L	< 0.001			0.001	Pass	
Mercury (filtered)	mg/L	< 0.0001			0.0001	Pass	
Nickel (filtered)	mg/L	< 0.001			0.001	Pass	
Zinc (filtered)	mg/L	< 0.005			0.005	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	%	89			70-130	Pass	
TRH C10-C14	%	105			70-130	Pass	
LCS - % Recovery							
BTEX							
Benzene	%	103			70-130	Pass	
Toluene	%	102			70-130	Pass	
Ethylbenzene	%	102			70-130	Pass	
m&p-Xylenes	%	101			70-130	Pass	
o-Xylene	%	106			70-130	Pass	
Xylenes - Total*	%	102			70-130	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	%	120			70-130	Pass	
TRH C6-C10	%	90			70-130	Pass	
TRH >C10-C16	%	110			70-130	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	110			70-130	Pass	
Acenaphthylene	%	90			70-130	Pass	
Anthracene	%	99			70-130	Pass	

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Benz(a)anthracene	%	113			70-130	Pass	
Benzo(a)pyrene	%	95			70-130	Pass	
Benzo(b&j)fluoranthene	%	93			70-130	Pass	
Benzo(g.h.i)perylene	%	87			70-130	Pass	
Benzo(k)fluoranthene	%	94			70-130	Pass	
Chrysene	%	90			70-130	Pass	
Dibenz(a.h)anthracene	%	83			70-130	Pass	
Fluoranthene	%	106			70-130	Pass	
Fluorene	%	115			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	83			70-130	Pass	
Naphthalene	%	87			70-130	Pass	
Phenanthrene	%	98			70-130	Pass	
Pyrene	%	116			70-130	Pass	
LCS - % Recovery							
Organochlorine Pesticides							
Chlordanes - Total	%	99			70-130	Pass	
4.4'-DDD	%	102			70-130	Pass	
4.4'-DDE	%	115			70-130	Pass	
4.4'-DDT	%	112			70-130	Pass	
a-BHC	%	98			70-130	Pass	
Aldrin	%	102			70-130	Pass	
b-BHC	%	100			70-130	Pass	
d-BHC	%	108			70-130	Pass	
Dieldrin	%	101			70-130	Pass	
Endosulfan I	%	96			70-130	Pass	
Endosulfan II	%	92			70-130	Pass	
Endosulfan sulphate	%	107			70-130	Pass	
Endrin	%	102			70-130	Pass	
Endrin ketone	%	101			70-130	Pass	
g-BHC (Lindane)	%	102			70-130	Pass	
Heptachlor	%	111			70-130	Pass	
Heptachlor epoxide	%	89			70-130	Pass	
Hexachlorobenzene	%	91			70-130	Pass	
Methoxychlor	%	113			70-130	Pass	
LCS - % Recovery							
Polychlorinated Biphenyls							
Aroclor-1016	%	98			70-130	Pass	
Aroclor-1260	%	110			70-130	Pass	
LCS - % Recovery							
Conductivity (at 25°C)	%	94			70-130	Pass	
LCS - % Recovery							
Heavy Metals							
Arsenic (filtered)	%	94			80-120	Pass	
Cadmium (filtered)	%	95			80-120	Pass	
Chromium (filtered)	%	94			80-120	Pass	
Copper (filtered)	%	96			80-120	Pass	
Lead (filtered)	%	90			80-120	Pass	
Mercury (filtered)	%	91			80-120	Pass	
Nickel (filtered)	%	94			80-120	Pass	
Zinc (filtered)	%	91			80-120	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Spike - % Recovery									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1					
TRH C10-C14	S21-Fe48592	NCP	%	80			70-130	Pass	
Spike - % Recovery									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1					
TRH >C10-C16	S21-Fe48592	NCP	%	83			70-130	Pass	
Spike - % Recovery									
Heavy Metals				Result 1					
Arsenic (filtered)	S21-Fe49948	CP	%	94			75-125	Pass	
Cadmium (filtered)	S21-Fe49948	CP	%	94			75-125	Pass	
Chromium (filtered)	S21-Fe49948	CP	%	89			75-125	Pass	
Copper (filtered)	S21-Fe49948	CP	%	87			75-125	Pass	
Lead (filtered)	S21-Fe49948	CP	%	86			75-125	Pass	
Mercury (filtered)	S21-Fe49948	CP	%	92			75-125	Pass	
Nickel (filtered)	S21-Fe49948	CP	%	83			75-125	Pass	
Zinc (filtered)	S21-Fe49948	CP	%	83			75-125	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1	Result 2	RPD			
TRH C10-C14	S21-Fe49389	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
TRH C15-C28	S21-Fe49389	NCP	mg/L	0.4	0.3	45	30%	Fail	Q15
TRH C29-C36	S21-Fe49389	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
TRH >C10-C16	S21-Fe49389	NCP	mg/L	0.18	0.12	40	30%	Fail	Q15
TRH >C16-C34	S21-Fe49389	NCP	mg/L	0.2	< 0.1	160	30%	Fail	Q15
TRH >C34-C40	S21-Fe49389	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
Conductivity (at 25°C)	S21-Ma03240	NCP	uS/cm	1700	1700	<1	30%	Pass	
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic (filtered)	S21-Ma03240	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Cadmium (filtered)	S21-Ma03240	NCP	mg/L	< 0.0002	< 0.0002	<1	30%	Pass	
Chromium (filtered)	S21-Ma03240	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Copper (filtered)	S21-Ma03240	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Lead (filtered)	S21-Ma03240	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Mercury (filtered)	S21-Ma03240	NCP	mg/L	< 0.0001	< 0.0001	<1	30%	Pass	
Nickel (filtered)	S21-Ma03240	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Zinc (filtered)	S21-Ma03240	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N01	F2 is determined by arithmetically subtracting the "naphthalene" value from the ">C10-C16" value. The naphthalene value used in this calculation is obtained from volatiles (Purge & Trap analysis).
N02	Where we have reported both volatile (P&T GCMS) and semivolatile (GCMS) naphthalene data, results may not be identical. Provided correct sample handling protocols have been followed, any observed differences in results are likely to be due to procedural differences within each methodology. Results determined by both techniques have passed all QAQC acceptance criteria, and are entirely technically valid.
N04	F1 is determined by arithmetically subtracting the "Total BTEX" value from the "C6-C10" value. The "Total BTEX" value is obtained by summing the concentrations of BTEX analytes. The "C6-C10" value is obtained by quantitating against a standard of mixed aromatic/aliphatic analytes.
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs
Q15	The RPD reported passes Eurofins Environment Testing's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

Authorised by:

Ursula Long	Analytical Services Manager
Andrew Sullivan	Senior Analyst-Organic (NSW)
Charl Du Preez	Senior Analyst-Inorganic (NSW)
John Nguyen	Senior Analyst-Metal (NSW)



Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

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Sample Receipt Advice

Company name:	Ballpark Environmental Pty Ltd
Contact name:	-ALL SRAs & Results - Andrew Ballard & Joel Parkin
Project name:	BPE21011 C-0760-.00
Project ID:	Not provided
Turnaround time:	5 Day
Date/Time received	Feb 24, 2021 8:40 AM
Eurofins reference	776348

Sample Information

✓	A detailed list of analytes logged into our LIMS, is included in the attached summary table.
✓	All samples have been received as described on the above COC.
✓	COC has been completed correctly.
✓	Attempt to chill was evident.
✓	Appropriately preserved sample containers have been used.
✓	All samples were received in good condition.
✓	Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.
✓	Appropriate sample containers have been used.
✓	Sample containers for volatile analysis received with zero headspace.
X	Split sample sent to requested external lab.
X	Some samples have been subcontracted.
N/A	Custody Seals intact (if used).

Notes

Contact

If you have any questions with respect to these samples, please contact your Analytical Services Manager:

Ursula Long on phone : or by email: UrsulaLong@eurofins.com

Results will be delivered electronically via email to -ALL SRAs & Results - Andrew Ballard & Joel Parkin - info@ballparkenv.com.au.

Global Leader - Results you can trust

BALLPARK ENVIRONMENTAL

Suite 2, 192 Pacific Highway
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M: 0400 566 088
E. info@ballparkenv.com.au

Chain of Custody	Laboratory Quotation/ Order No:	**Price Book 2017-18**	**Project No.:**	**BPE21011** C-0760.00	Sheet 1 of 1
Dispatch to: Sample Receipt - Eurofins Unit F3, Bldg F 16 Mars Road LANE COVE NSW 2066	Sampled By:	Alex Weaver, Adam Phillips	Consigning Officer	*Alex Weaver*	
			Date Dispatched	22-Feb-21	
Attention: Sample receipt	Project Manager: (report results to)	info@ballparkenv.com.au	Courier Service:	TOLL	
			Consignment Note No.:		

Relinquished By:	Date:	Time:	Received By:	Date:	Time:
Alex Weaver Canberra	***22/02/2021***		Suzanne Ford	24/2/2021	8:40am

Comments:	Sample Matrix	Container Type & Preservative	Sample No.	Sample Depth (m)	Date Sampled:	Analyses Required: Suite B7 (TRH, BTEXN, PAH, M8)	Suite B13 (OCP/PCB)	pH	Conductivity (EC)							Send to Eurofins Melbourne	HOLD	Sample Condition on Receipt
	Water	Plastic, Glass Amber, 2 x vials, Metals (filtered)	B20		16-Feb-21	X	X	X	X									
	Water	Plastic, Glass Amber, 2 x vials, Metals (filtered)	B25		16-Feb-21	X	X	X	X									
	Water	Plastic, Glass Amber, 2 x vials, Metals (filtered)	QC05		16-Feb-21	X	X	X	X									

Special Laboratory Instructions:

Detection Limits: Normal

Turnaround Required: Standard TAT Requested

Preliminary In-Situ Waste Classification Assessment

Moss Vale Sewage Treatment Plant

Report prepared for –
Hunter H2O Holdings Pty Ltd
c/- D&N Geotechnical Pty Ltd

10 March 2021
BPE21011-R01

Quality information

Revision history

Item	Description
Revision	Original
Description	Preliminary *In-situ* Waste Classification Assessment – Moss Vale Sewage Treatment Plant, Moss Vale NSW
Date	10 March 2021
Report Author	Joel Parkin – Ballpark Environmental Pty Ltd
Technical Reviewer	Andrew Ballard – Ballpark Environmental Pty Ltd CEnvP

Distribution

Report Status	No. of copies	Format	Distributed to	Date
Original	1	PDF	D&N Geotechnical Pty Ltd	10 March 2021
Original	1	PDF	Ballpark Environmental Pty Ltd	10 March 2021

10 March 2021

Our ref: BPE21011-R01

Hunter H2O Holdings Pty Ltd
c/- D&N Geotechnical Pty Ltd
PO Box 4359
HAWKER ACT 2614

Sent via email: dan@dngeotechical.com

Attention: Dan Butterworth – Geotechnical Lead

Dear Dan,

RE: Preliminary In-Situ Waste Classification Assessment – Moss Vale STP

Executive Summary

D&N Geotechnical Pty Ltd were engaged by Hunter H2O Holdings Pty Ltd (Hunter H2O) to undertake a geotechnical investigation for a portion of the Moss Vale Sewage Treatment Plant (STP), 27B Kennedy Close, Moss Vale NSW, (the site), see Figure 1.

A preliminary *in-situ* waste classification assessment was undertaken concurrently with the geotechnical investigation to assess the *in-situ* waste classification of soils proposed to be excavated during the planned STP upgrade works.

The objective of the preliminary waste classification was to provide an *in-situ* waste classification by chemical assessment of the fill soils present within the site in general accordance with the NSW EPA Waste *Classification Guidelines, Part 1: Classifying Waste (2014).*

The site is located to the south of the existing STP in the general location of three former trickling filters. These trickling filters have previously been demolished and ballast media from the filter tanks was likely to have been buried *in-situ* and was observed to be present on this site.

For this preliminary waste classification assessment, a desktop review of publicly available historical aerial photography and a review of available previous investigation reports prepared for this site was also undertaken. In summary, the desktop review identified the following points of interest:

- The three trickling filters were visible within the site in the 1969 aerial photograph. A review of PWA (2020) report previously undertaken for the site indicated that the original STP was constructed in circa 1939.
- The 1997 aerial photograph shows that the trickling filters had been abandoned with the two western filter structures demolished and only the remnants of the eastern filter still observed to be present. Infrastructure and buildings associated with the former trickling filters had also been demolished. The new STP was constructed to the north of the location of the former trickling filters. This is consistent with information provided in the PWA (2020) report indicating that the current STP was constructed to the north of the site in circa 1993.

- The PWA (2020) report for this site encountered extensive fill material during the test pitting program within the location of the former trickling filters. Waste material observed included: terracotta pipes, geotextile, bituminous gravel and road base, bricks, steel pipe, reinforced concrete slabs, fibre fragments, wet waste, sludge and cement pipes and cobble and gravel sized trickling filter media.

- Asbestos containing material (ACM) debris were identified and analysed in test pits T2 and T4, with samples collected from 0.8m and 1m below ground surface (bgs), respectively. These test pits were both located within the former tickling filter site. A review of the engineering logs preparing for the PWA (2020) investigation identified fibre cement and fibre cement pipe in two other test pit locations T10B and T17, both located within the former trickling filter area. Refer to Figure 2 which shows the approximate test pit locations where ACM debris was observed.

Field investigation for the current works undertaken by D&N Geotechnical included the drilling of 13 boreholes, 9 within the location of the former tickling filter area and 3 to the west and 1 to the north of the site, refer to Figure 1. The stratigraphy encountered during the geotechnical field investigation consisted of areas of fill, overlain residual soils overlying bedrock. The fill appeared to be associated with basalt ballast likely to have been previously used in the former trickling filters previously located within the site.

No ACM debris was identified during the current drilling program; however borehole drilling can limit the ability to fully observe the presence of buried fill materials and reduces the likelihood of discovery of ACM debris when compared to a test pitting investigation.

A total of 13 primary soil samples were submitted to a National Association of Testing Authorities (NATA) accredited chemical laboratory for analysis of the adopted contamination suite.

Waste Classification Assessment – Based on the laboratory analysis results for the samples analysed the *in-situ* fill soil material is classified as **general solid waste**. However, as ACM debris has previously been identified and confirmed by laboratory analysis at various locations within the site of the former trickling filters the fill material is classified as **special waste – asbestos waste**.

Virgin Excavated Natural Material (VENM) Assessment – As the underlying soils beneath the fill material are natural soils they may potentially be classified as VENM.

To pre-classify the natural soil materials then additional investigation would be required to satisfy the NSW EPA requirements for VENM classification.

During construction works the upper fill materials will need to be carefully excavated and stockpiled separately from the underlying natural soil materials to avoid cross contamination as this fill material does not meet the requirements for VENM classification.

Unexpected Finds Protocol – An unexpected fines protocol is recommended to be included as part of the Construction Environment Management Plan or as a stand-alone document if potentially contaminated fill material or buried unexpected finds, are encountered during construction earthworks on this site.

1. Introduction

D&N Geotechnical Pty Ltd were engaged by Hunter H2O Pty Ltd to undertake a geotechnical investigation for proposed upgrades to the existing Moss Vale Sewage Treatment Plant at 27B Kennedy Close Moss Vale NSW, (the site).

A preliminary *in-situ* waste classification assessment was also undertaken concurrently with the geotechnical investigation. The objective of the preliminary waste classification was to provide an *in-situ* waste classification by chemical assessment of the fill soils present within the site in general accordance with the NSW EPA Waste *Classification Guidelines, Part 1: Classifying Waste (2014).*

A preliminary groundwater quality assessment was also undertaken concurrently with the geotechnical investigation for two existing groundwater monitoring wells located within the site. The findings from the preliminary groundwater quality assessment have been provided in a separate Ballpark Environmental letter report, ref; BPE21011-R02, dated 10 March 2021.

2. Methodology

The scope of work carried out for the preliminary *in-situ* waste classification assessment is summarised below.

- A site walkover, observations and photographs were taken by an engineering geologist from D&N Geotechnical during the borehole drilling program from the 16 to 19 February 2021.
- Desktop review of historical aerial photography and provided previous reports for the site.
- Hunter H2O nominated the 13 borehole locations within the site, see Figure 2. An engineering geologist from D&N Geotechnical observed borehole drilling activities for signs of potential contamination, including staining of soils, changes in soil media, or presence of foreign materials during the drilling program.
- Soil samples were collected from varying depths and media within the boreholes.
- Selected soil samples (13 primary samples) were submitted to a National Association of Testing Authorities (NATA) accredited laboratory for testing for contaminants of potential concern (CoPC), as follows:
    - Metals screen (arsenic, cadmium, chromium (total), copper, lead, mercury, nickel and zinc);
    - Total recoverable hydrocarbons (TRH);
    - Benzene, toluene, ethylbenzene, and xylene (BTEX) compounds;
    - Polycyclic aromatic hydrocarbons (PAH) compounds;
    - Organochlorine pesticides (OCP);
    - Polychlorinated biphenyls (PCB);
    - pH;
    - Electrical conductivity (EC); and
    - Asbestos identification in soil.

- One sample was also analysed for leachable concentration (TCLP) of metals and BTEX screen.
- For QA/QC purposes additional duplicate/ triplicate soil samples were also submitted for laboratory analysis.
- Preparation of this preliminary *in-situ* waste classification report which summarises the findings of the desktop site history review, and compares the laboratory results with values provided in NSW EPA (2014) Waste Classification Guidelines.

3. Adopted Guidelines

NSW EPA – Waste Classification Guidelines 2014

The below Table 1 summarises the 6-step process followed to determine the waste classification of the *in-situ* soils within this site.

For Step 1, the presence of asbestos and ACM debris has previously been identified and confirmed by laboratory analysis at various locations to be present within the site, (PWA 2020). The surplus fill materials are pre-classified as **special waste – asbestos waste**.

For Step 5, to assess the waste classification of the *in-situ* soils, the results of the laboratory analysis were compared with the specific contaminant concentration (SCC) and the leachable TCLP concentration for general solid waste provided in Table 2 of the Waste Classification Guidelines.

The Waste Classification Guidelines provides acceptable contaminant concentrations for liquid and non-liquid wastes that are to be disposed of to landfill. These concentrations are divided into the categories general solid waste (GSW) and restricted solid waste (RSW) based on total contaminant concentrations and on leachable concentrations using the TCLP procedure.

Table 1: Classifying Waste Steps

Steps	Yes/No
Step 1: Is the waste special waste?	Yes
Step 2: Is the waste liquid waste?	No
Step 3: Is the waste pre-classified?	No
Step 4: Does the waste possess hazardous characteristics?	No
Step 5: Determining a waste's classification using chemical assessment	Yes
Step 6: Is the waste putrescible or non-putrescible?	Non-putrescible

NSW EPA – Virgin Excavated Natural Material (VENM)

Natural undisturbed soils may be classified as virgin excavated natural material (VENM). The *Protection of the Environment Operations Act 1997* (POEO Act) defines virgin excavated natural material (VENM) as:

> *'natural material (such as clay, gravel, sand, soil or rock fines):*
>
> *a. that has been excavated or quarried from areas that are not contaminated with manufactured chemicals or process residues, as a result of industrial, commercial, mining, or agricultural activities; and*
>
> *b. That does not contain sulphidic ores of soils and includes excavated natural material that meets such criteria for virgin excavated natural material as may be approved for the time being pursuant to an EPA Gazettal notice.'*

For excavated soil material to be classified as VENM it must meet all aspects of the above definition. VENM is a waste that has been pre-classified as general solid waste (non-putrescible).

4. Desktop Review

4.1. Aerial Photography

Selected publicly available historical aerial photography dating back to 1963 were reviewed for this site, see Attachment A. A summary of the aerial photography review is provided in Table 1.

Table 1: Summary of available Historical Aerial Photographs

Year of Photo	Site
1963	The aerial photograph is in black and white. Two trickling filters have been constructed within the site. There appears to be some structures and infrastructure associated with these units adjacent to the south and north.
1969	The aerial photograph is in black and white. A third tricking filter has now been constructed to the east of the existing filters. An additional structure has been constructed to the southwest of the trickling filters.
1974	The aerial photograph is in black and white. Structure visible to the southwest of the trickling filters in the 1969 aerial photograph have been removed. Appears to be small sludge drying beds or primary sedimentation tanks visible to the north and south of the existing trickling filters.

Year of Photo	Site
1989	The aerial photograph is in color. Small sludge drying beds on the southern side of the trickling filters have been removed. No other significant changes from the 1974 aerial photograph.
1991	The aerial photograph is in color. Appears to have been minor earthworks adjacent to the southwest of the trickling filters, potentially some additional structures within this area.
1997	The aerial photograph is in color. The trickling filters have been abandoned with the two western filters removed and remnants of the eastern filter still present. Infrastructure and buildings associated with the former trickling filters have been demolished. The current STP has been constructed to the north of the former trickling filters.
2006 (Google Earth)	The Google Earth image is in color. No remnants of the former trickling filters are visible. Site is cleared grass land. Five water tanks were visible in the northwest portion of the site. These were also observed during the site walkover of the site.
2013 (Google Earth)	The Google Earth image is in color. No significant changes from the 2006 Google Earth imagery.
2019 (Google Earth)	The Google Earth image is in color. There is an area of bare earth in the southwest portion of the site. No other significant changes from the 2013 Google Earth imagery.

4.2. Previous Report

NSW PWA (2020). *Moss Vale Sewerage – Sewage Treatment Plant Upgrade Concept Design Geotechnical Investigation.* Public Works Advisory report number ISR18106, dated February 2020.

Purpose of this concept design geotechnical investigation was to prepare a concept design for the proposed upgrades to the Moss Vale Sewage Treatment Plant.

Following a review of the Public Works Advisory report the following points of interest were noted with regards to geotechnical investigation within the former trickling filter site:

- Original 2 trickling filters were constructed in circa 1939. This system was demolished in the circa late 1990's with the new STP constructed to the north of the site in circa 1993.
- During the test pitting program extensive fill material was identified within the former trickling filter STP location with inert waste materials including; terracotta pipes, geotextile, bituminous gravel and road base, bricks, steel pipe, reinforced concrete slabs, fibre fragments, wet waste, sludge, cement pipes, cobble, and gravel sized trickling filter media.
- Asbestos containing material (ACM) debris was identified in test pits T2 and T4 and confirmed with laboratory analysis identifying chrysotile and amosite asbestos in both samples analysed. The samples were collected from depth of 0.8m (T2) and 1m (T4) below ground surface (bgs), with both test pits located within the former trickling filter area. Refer to Figure 2 for approximate test pit locations where ACM debris was observed.
- A review of the engineering logs preparing for this investigation identified "fibre cement and fibre cement pipe" in two other test pit locations T10B and T17, both located within the former trickling filter STP site. The observed fibre cement is likely to have also been ACM debris. Refer to Figure 2 for approximate test pit locations where ACM debris was observed.

5. Field Investigation & Sampling Methodology

The geotechnical field investigation included the drilling of 13 boreholes, consisting of 9 within the former trickling filter STP, 3 to the west along the existing access road and 1 to the east of the former STP site. The field investigation was undertaken from the 16 to 19 February 2021 by a D&N Geotechnical engineering geologist, refer to D&N Geotechnical report ref: C-0760.00 R1 for site details and subsurface ground conditions encountered on site. The sampling methodology followed is summarised in Table 2.

Table 2: Sampling Methodology

Activity	Detail / Comments
Borehole Drilling Program	As part of the geotechnical investigation 13 boreholes were drilled, see attached Figure 2. Where areas of fill were identified during the drilling program samples were collected. Boreholes were extended to depths ranging between 2.0m and 6.5m bgs. Fill was identified in 4 of the 13 boreholes, with depths of fill ranging from 0.5m to 2.6m bgs. The areas of fill were located within the former trickling filters area, with layers of basalt rock fill identified in BH104, BH105 & BH106. The findings were consistent with the test pitting program previously undertaken within the site, (PWA 2020). No ACM debris were observed during the drilling program.
Sample Handling and Transportation	Soil samples were collected for screening purposes directly from the auger and standard penetration tests (SPT). A clean pair of disposable nitrile gloves were used to collect each soil sample. Samples were placed into laboratory prepared and supplied glass jars, fitted with Teflon lined seals to limit possible volatile loss. Sample jars were filled to minimise headspace. The soil samples were placed into a chilled insulated cooler during fieldwork and then temporarily stored in a refrigerator. Samples were then dispatched to National Association of Testing Authorities (NATA) accredited laboratory for analysis under chain of custody (CoC).
Decontamination of sampling equipment	Multi-use sampling equipment, including auger SPT, were decontaminated by brush scrubbing with Decon 90™ detergent solution and rinsed with clean potable water between investigation locations.
Quality Assurance / Quality Control (QA/QC)	To measure the accuracy and precision of the data generated by the field and laboratory procedures for this assessment, additional samples were collected and analysed, including the following quality assurance / quality control (QA/QC) samples: • Two intra-laboratory duplicate soil samples (QC01 & QC03) • One inter-laboratory triplicate soil sample (QC02)

Soil samples were submitted for laboratory analysis for a suite of CoPC discussed in Section 2. The CoPC and number of samples collected and analysed during the field investigation are provided in the below Table 3.

Table 3: Sampling Analysis Quality Plan for Preliminary *in-situ* waste classification assessment

Media	CoPC	Primary Samples	QA/QC Samples	TOTAL
Soil	Metals suite	13	3	16
	TRH	13	3	16
	BTEX	13	3	16

PAH	13	3	16
OCPs	13	3	16
PCBs	13	3	16
pH	13	-	13
EC	13	-	13
Asbestos ID in soil	13	-	13
TCLP (metals & BTEX)	1	-	1

6. Quality Assurance / Quality Control

Samples were transported under chain of custody (CoC) documentation and in chilled insulated containers to Eurofins mgt Environmental Laboratory which is NATA accredited for the analysis performed. A copy of the CoC is included with the laboratory analytical report in Attachment B to this letter report.

The laboratory conducted internal quality control using laboratory duplicates, spikes, and method blanks. The results are shown with laboratory analytical report, see Attachment B. Analytical methods used for the laboratory testing are also indicated on the laboratory report sheets. The results of laboratory quality control testing are within acceptable limits.

For QA/QC purposes 2 duplicate and 1 triplicate sample were submitted for analysis. The results of the duplicate and triplicate testing are summarised in Table LR1. Reported exceedances of the relative percentage difference (RPD) 50% control limits were found in duplicate pair (soil) BH113: 1.0m / QC01 reporting concentration for nickel (56%) and zinc (60%); triplicate pair BH113 / QC02 for arsenic (80%), copper (51%), nickel (91%) and zinc (89%). The RPD exceedances are considered to be due to the heterogeneous nature of metals in the soil samples.

Based on these results it is considered that the field and laboratory methods are appropriate, and that the data obtained is usable and considered to reasonably represent the concentrations at the sampling points at the time of sampling.

7. Results

The laboratory analytical results are summarised in Table LR2, see attached.

To assess the waste classification of the *in-situ* soils the laboratory test results were compared with the SCC provided in Table 2 of the NSW EPA (2014) Waste Classification Guidelines.

The following points are noted from these results:

- Concentrations of metals were below the SCC1 – General Solid Waste or the laboratory's limit of reporting (LOR).
- Concentrations of TRH were below the SCC1 or the laboratory's limit of reporting (LOR).
- Concentrations of BTEX, PAH, OCP and PCB compounds were below the laboratory's LOR in the samples analysed.
- Concentrations of metals and BTEXN were below the values for leachable concentration, TCLP1 – General Solid Waste.
- No asbestos was identified in the soil samples analysed.

8. Conclusions

D&N Geotechnical Pty Ltd were engaged by Hunter H2O Holdings Pty Ltd (Hunter H2O) to undertake a geotechnical investigation for a portion of the Moss Vale Sewage Treatment Plant (STP), 27B Kennedy Close, Moss Vale NSW, (the site).

A preliminary *in-situ* waste classification assessment was undertaken concurrently with the geotechnical investigation to assess the *in-situ* waste classification of soils proposed to be excavated during the planned STP upgrade works.

The objective of the preliminary waste classification was to provide an *in-situ* waste classification by chemical assessment of the fill soils present within the site in general accordance with the NSW EPA Waste *Classification Guidelines, Part 1: Classifying Waste (2014)*.

The site is located to the south of the existing STP in the general location of three former trickling filters. These trickling filters have previously been demolished and ballast media from the filter tanks was likely to have been buried *in-situ* and was observed to be present on this site.

For this preliminary waste classification assessment, a desktop review of publicly available historical aerial photography and a review of available previous investigation reports prepared for this site was also undertaken. In summary, the desktop review identified the following points of interest:

- The three trickling filters were visible within the site in the 1969 aerial photograph. A review of PWA (2020) report previously undertaken for the site indicated that the original STP was constructed in circa 1939.
- The 1997 aerial photograph shows that the trickling filters had been abandoned with the two western filter structures demolished and only the remnants of the eastern filter still observed to be present. Infrastructure and buildings associated with the former trickling filters had also been demolished. The new STP was constructed to the north of the location of the former trickling filters. This is consistent with information provided in the PWA (2020) report indicating that the current STP was constructed to the north of the site in circa 1993.
- The PWA (2020) report for this site encountered extensive fill material during the test pitting program within the location of the former trickling filters. Waste material observed included: terracotta pipes, geotextile, bituminous gravel and road base, bricks, steel pipe, reinforced concrete slabs, fibre fragments, wet waste, sludge and cement pipes and cobble and gravel sized trickling filter media.
- Asbestos containing material (ACM) debris were identified and analysed in test pits T2 and T4, with samples collected from 0.8m and 1m below ground surface (bgs), respectively. These test pits were both located within the former tickling filter site. A review of the engineering logs preparing for the PWA (2020) investigation identified fibre cement and fibre cement pipe in two other test pit locations T10B and T17, both located within the former trickling filter area. Refer to Figure 2 which shows the approximate test pit locations where ACM debris was observed.

Field investigation for the current works undertaken by D&N Geotechnical included the drilling of 13 boreholes, 9 within the location of the former tickling filter area and 3 to the west and 1 to the north of the site, refer to Figure 1. The stratigraphy encountered during the geotechnical field investigation consisted of areas of fill, overlain residual soils

overlying bedrock. The fill appeared to be associated with basalt ballast likely to have been previously used in the former trickling filters previously located within the site.

No ACM debris was identified during the current drilling program; however borehole drilling can limit the ability to fully observe the presence of buried fill materials and reduces the likelihood of discovery of ACM debris when compared to a test pitting investigation.

A total of 13 primary soil samples were submitted to a National Association of Testing Authorities (NATA) accredited chemical laboratory for analysis of the adopted contamination suite.

Waste Classification Assessment – Based on the laboratory analysis results for the samples analysed the *in-situ* fill soil material is classified as **general solid waste**. However, as ACM debris has previously been identified and confirmed by laboratory analysis at various locations within the site of the former trickling filters the fill material is classified as **special waste – asbestos waste**.

Virgin Excavated Natural Material (VENM) Assessment – As the underlying soils beneath the fill material are natural soils they may potentially be classified as VENM.

To pre-classify the natural soil materials then additional investigation would be required to satisfy the NSW EPA requirements for VENM classification.

During construction works the upper fill materials will need to be carefully excavated and stockpiled separately from the underlying natural soil materials to avoid cross contamination as this fill material does not meet the requirements for VENM classification.

Unexpected Finds Protocol – An unexpected fines protocol is recommended to be included as part of the Construction Environment Management Plan or as a stand-alone document if potentially contaminated fill material or buried unexpected finds, are encountered during construction earthworks on this site.

9. References

Australian Standard (2005) *Guide to the Sampling and Investigation of Sites with Potentially Contaminated Soil. Part 1: Non-Volatile and Semi volatile Compounds.* AS 4482.1-2005.

D&N Geotechnical (2021). *Moss Vale Sewage Treatment Plant Geotechnical Investigation.* D&N Geotechnical report ref: C-0760.00 R1, dated March 2021.

DUAP EPA (1998). *Managing Land Contamination Planning Guidelines, SEPP 55 – Remediation of Land.* Department of Urban Affairs and Planning & Environmental Protection Authority NSW, Sydney

NEPC (2013). *National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended by the National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No.1)* (ASC NEPM). National Environment Protection Council, Canberra

NSW EPA (2020). *Contaminated Land Guidelines: Consultants Reporting on Contaminated Land*. Environmental Protection Authority NSW, Sydney

NSW EPA (2017). *Contaminated Land Management: Guidelines for the NSW Site Auditor Scheme (3rd Edition).* Environment Protection Authority NSW, Sydney

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NSW EPA (2014). *Waste Classification Guidelines - Part 1: Classifying Waste.* Environment Protection Authority NSW, Sydney

NSW EPA (1995). *Contaminated Sites: Sampling Design Guidelines.* Environment Protection Authority NSW, Sydney.

NSW PWA (2020). *Moss Vale Sewerage – Sewage Treatment Plant Upgrade Concept Design Geotechnical Investigation.* Public Works Advisory report number ISR18106, dated February 2020.

EPA Victoria (2010), *Industrial Waste Resource Guidelines (7), Sampling and Analysis: Soil Sampling*, Environmental Protection Authority, Melbourne.

10. Limitations

The findings contained in this letter report are the result of discrete/specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points. If material is observed during construction that does not conform to that described in this letter report, or is suspicious in nature, then an environmental consultant should be contacted, and further assessments undertaken.

In preparing this letter report, current guidelines for assessment and management of contaminated land were followed. This work has been conducted in good faith in accordance with Ballpark Environmental understanding of the client's brief and general accepted practice for environmental consulting.

The objective of the preliminary waste classification is to provide an *in-situ* waste classification by chemical assessment of the fill soils present within the site in general accordance with the NSW EPA Waste *Classification Guidelines, Part 1: Classifying Waste (2014).*

No warranty, expressed or implied, is made as to the information and professional advice included in this letter report. Anyone relying on this document with reference to a particular development concept does so at their own risk and should satisfy themselves concerning its applicability and, where necessary, should seek expert advice in relation to the particular situation.

I trust that this letter report meets with your requirements. If you require further information or assistance, please do not hesitate to contact us on (02) 6658 0585.

For and on behalf of Ballpark Environmental Pty Ltd





Andrew Ballard
Principal Environmental Scientist
Licensed Asbestos Assessor
Certified Environmental Practitioner

Joel Parkin
Associate Environmental Engineer
Licensed Asbestos Assessor

Attachments: Figure 1: Site Locality

Figure 2: Borehole & Test pit Location Plan

Table LR1: Results of Quality Control Soil Sample

Table LR2: Summary of Laboratory Results for Soil Samples

Attachment A: Historical Imagery

Attachment B: Laboratory Certificates of Analysis

Figures



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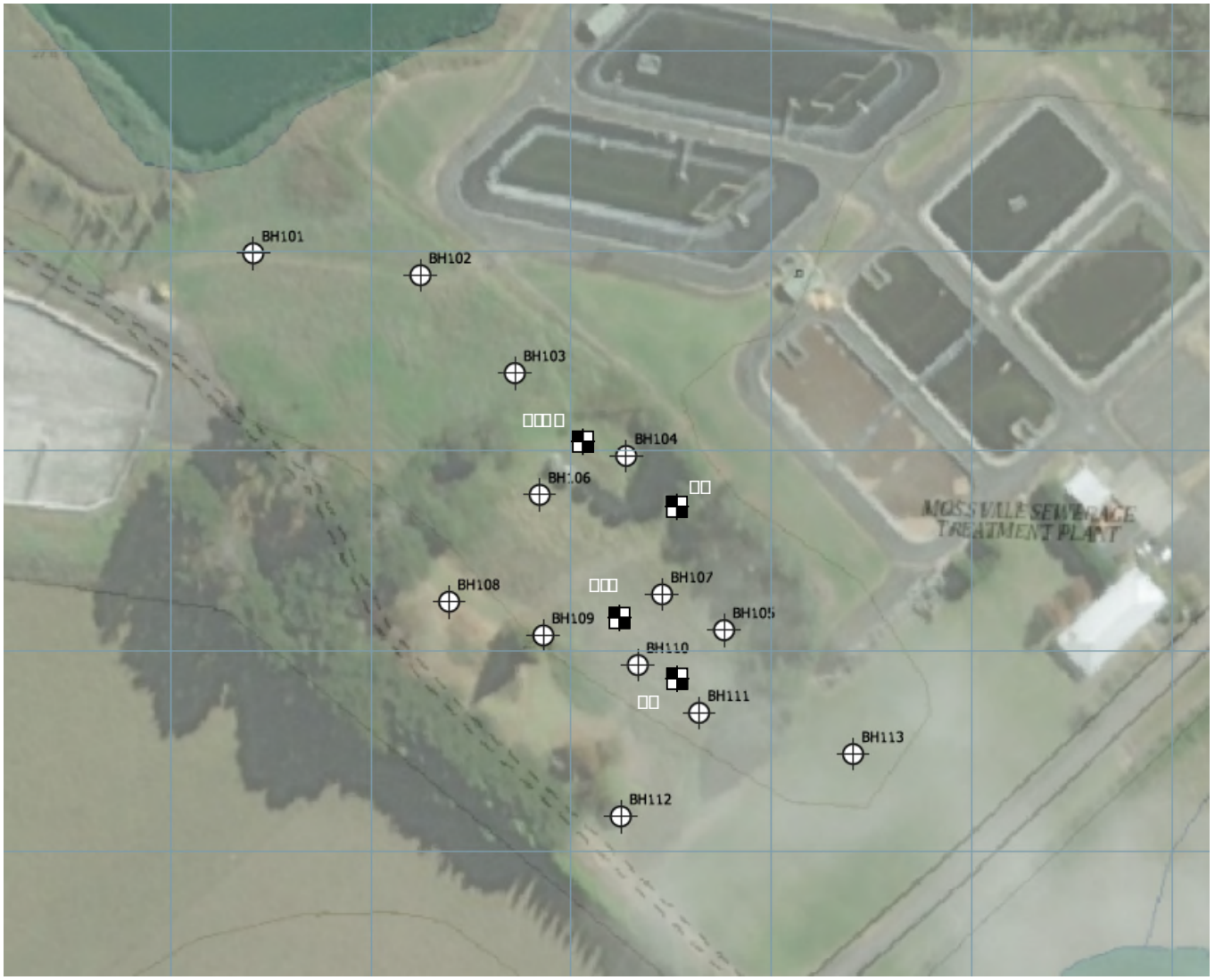

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Tables

Table LR1: Results of Quality Control Soil Samples

Sample ID	Primary Sample BH113	Duplicate Sample QC01	RPD (%)	Primary Sample BH113	Triplicate Sample QC02	RPD (%)	Primary Sample BH104	Duplicate Sample QC03	RPD (%)
Depth (m)	1	1	%RPD between	1	1	%RPD between	0.5-1	0.5-1	%RPD between
Material	Soil	Soil	BH113 and QC01	Soil	Soil	BH113 and QC02	Soil	Soil	BH104 and QC03
Date of Sampling	16-Feb-21	16-Feb-21		16-Feb-21	16-Feb-21		17-Feb-21	17-Feb-21	
Metals									
Arsenic	8.4	5.9	35	8.4	3.6	**80**	5.1	6.9	30
Cadmium	< 0.4	< 0.4	NA	< 0.4	< 0.4	NA	< 0.4	< 0.4	NA
Chromium	73	71	3	73	64	13	42	48	13
Copper	27	20	30	27	16	**51**	44	32	32
Lead	19	18	5	19	15	24	16	17	6
Mercury	< 0.1	< 0.1	NA	< 0.1	< 0.1	NA	< 0.1	< 0.1	NA
Nickel	48	27	**56**	48	18	**91**	26	30	14
Zinc	52	28	**60**	52	20	**89**	34	30	13
Total Recoverable Hydrocarbons									
Naphthalene	< 0.5	< 0.5	NA	< 0.5	< 0.5	NA	< 0.5	< 0.5	NA
TRH >C_{10}-C_{16}	< 50	< 50	NA	< 50	< 50	NA	< 50	< 50	NA
TRH >C_{10}-C_{16} (F2)	< 50	< 50	NA	< 50	< 50	NA	< 50	< 50	NA
TRH >C_{10}-C_{40}	< 100	< 100	NA	< 100	< 100	NA	< 100	< 100	NA
TRH >C_{16}-C_{34}	< 100	< 100	NA	< 100	< 100	NA	< 100	< 100	NA
TRH >C_{34}-C_{40}	< 100	< 100	NA	< 100	< 100	NA	< 100	< 100	NA
TRH C_6-C_{10}	< 20	< 20	NA	< 20	< 20	NA	< 20	< 20	NA
TRH C_6-C_{10} (F1)	< 20	< 20	NA	< 20	< 20	NA	< 20	< 20	NA
BTEX									
Benzene	< 0.1	< 0.1	NA	< 0.1	< 0.1	NA	< 0.1	< 0.1	NA
Ethylbenzene	< 0.1	< 0.1	NA	< 0.1	< 0.1	NA	< 0.1	< 0.1	NA
m&p-Xylenes	< 0.2	< 0.2	NA	< 0.2	< 0.2	NA	< 0.2	< 0.2	NA
o-Xylene	< 0.1	< 0.1	NA	< 0.1	< 0.1	NA	< 0.1	< 0.1	NA
Toluene	< 0.1	< 0.1	NA	< 0.1	< 0.1	NA	< 0.1	< 0.1	NA
Xylenes - Total	< 0.3	< 0.3	NA	< 0.3	< 0.3	NA	< 0.3	< 0.3	NA
Polycyclic Aromatic Hydrocarbons									
PAH (Total)	< LOR	< LOR	NA	< LOR	< LOR	NA	< LOR	< LOR	NA
Polychlorinated biphenyls									
PCBs (Total)	< LOR	< LOR	NA	< LOR	< LOR	NA	< LOR	< LOR	NA
Organochlorine Pesticides									
OCP (Total)	< LOR	< LOR	NA	< LOR	< LOR	NA	< LOR	< LOR	NA

Notes:

Value	RPD exceeds control limit of 50%
NA	At least one sample has concentration below laboratory's Limit of Reporting (LOR)
< LOR	Concentrations below the Laboratories Limit of Reporting

Table LR2 - Summary of Laboratory Results for Soil Samples

All results in mg/kg, unless otherwise stated.

Sample ID	Depth (m)	Material	Date of Sampling	Metals								Total Recoverable Hydrocarbons							
				Arsenic	Cadmium	Chromium (Total)	Copper	Lead	Mercury	Nickel	Zinc	Naphthalene	TRH $>C_{10}$-C_{16}	TRH $>C_{10}$-C_{16} (F2)	TRH $>C_{10}$-C_{40}	TRH $>C_{16}$-C_{34}	TRH $>C_{34}$-C_{40}	TRH C_6-C_{10}	TRH C_6-C_{10} (F1)
BH101	1.5-1.7	Soil	19-Feb-21	7.6	0.6	35	190	38	1.3	12	210	< 0.5	83	83	1443	1100	260	< 20	< 20
BH104	0.5-1	Soil	17-Feb-21	5.1	< 0.4	42	44	16	< 0.1	26	34	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
BH106	0.2-0.3	Soil	18-Feb-21	3.1	< 0.4	41	20	20	0.6	12	46	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
BH106	1	Soil	18-Feb-21	5	< 0.4	5	20	9	0.1	< 5	150	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
BH108	0.3-0.4	Soil	18-Feb-21	2.9	< 0.4	19	19	23	0.2	< 5	63	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
BH108	1	Soil	18-Feb-21	2.8	< 0.4	22	9.7	11	< 0.1	6.4	29	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
BH109	0.5	Soil	18-Feb-21	6	< 0.4	27	26	24	0.2	11	54	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
BH109	1	Soil	18-Feb-21	7.6	< 0.4	36	26	31	0.1	13	56	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
BH110	0.2-0.3	Soil	18-Feb-21	5.8	< 0.4	58	19	22	< 0.1	17	41	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
BH110	1	Soil	18-Feb-21	< 2	< 0.4	14	< 5	8.7	< 0.1	< 5	7.2	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
BH111	0.5-0.6	Soil	17-Feb-21	5.2	< 0.4	38	14	15	< 0.1	18	26	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
BH112	0.5-0.6	Soil	17-Feb-21	6.5	< 0.4	29	11	12	< 0.1	7.7	17	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
BH113	1	Soil	16-Feb-21	8.4	< 0.4	73	27	19	< 0.1	48	52	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
BH106*	0.2-0.3	Leachate	18-Feb-21	< 0.01	< 0.005	< 0.05	< 0.05	< 0.01	< 0.001	0.02	0.21	-	-	-	-	-	-	-	-
Summary Stats^	No. Observations			13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	Average			5.15	NA	33.77	32.94	19.13	0.22	13.74	60.40	NA	NA	NA	NA	NA	NA	NA	NA
	Maximum			8.4	0.6	73	190	38	1.3	48	210	< 0.5	83	83	1443	1100	260	< 20	< 20
	Minimum			< 2	NA	5	< 5	8.7	< 0.1	< 5	7.2	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
	Standard Deviation			2.2	NA	18.1	48.3	8.7	0.4	12.4	56.8	NA	NA	NA	NA	NA	NA	NA	NA
Guidelines																			
NSW EPA (2014) Waste Classification Guidelines	General Solid Waste - TCLP1 (See Table 2 - TCLP & SCC values for classifying waste by chemical assessment)			5	1			5	0.2	2									
	General Solid Waste - SCC1 (See Table 2 - TCLP & SCC values for classifying waste by chemical assessment)			500	100			1,500	50	1,050									
	Restricted Solid Waste - TCLP2 (See Table 2 - TCLP & SCC values for classifying waste by chemical assessment)			20	4			20	0.8	8									
	Restricted Solid Waste - SCC2 (See Table 2 - TCLP & SCC values for classifying waste by chemical assessment)			2,000	400			6,000	20	4,200									

Notes:

BOLD Concentrations exceeds the acceptance criteria
NAD No Asbestos Detected
< LOR Concentrations below the Laboratories Limit of Reporting
NA Not applicable
- Not analysed
^ Summary stats were calculated when more then 5 values exceeded the laboratories LOR. A value of half of the LOR was adopted for statistical calculation.
* Concentrations for leachate are reported in mg/L

Table LR2 - Summary of Laboratory Results for Soil Samples

All results in mg/kg, unless otherwise stated.

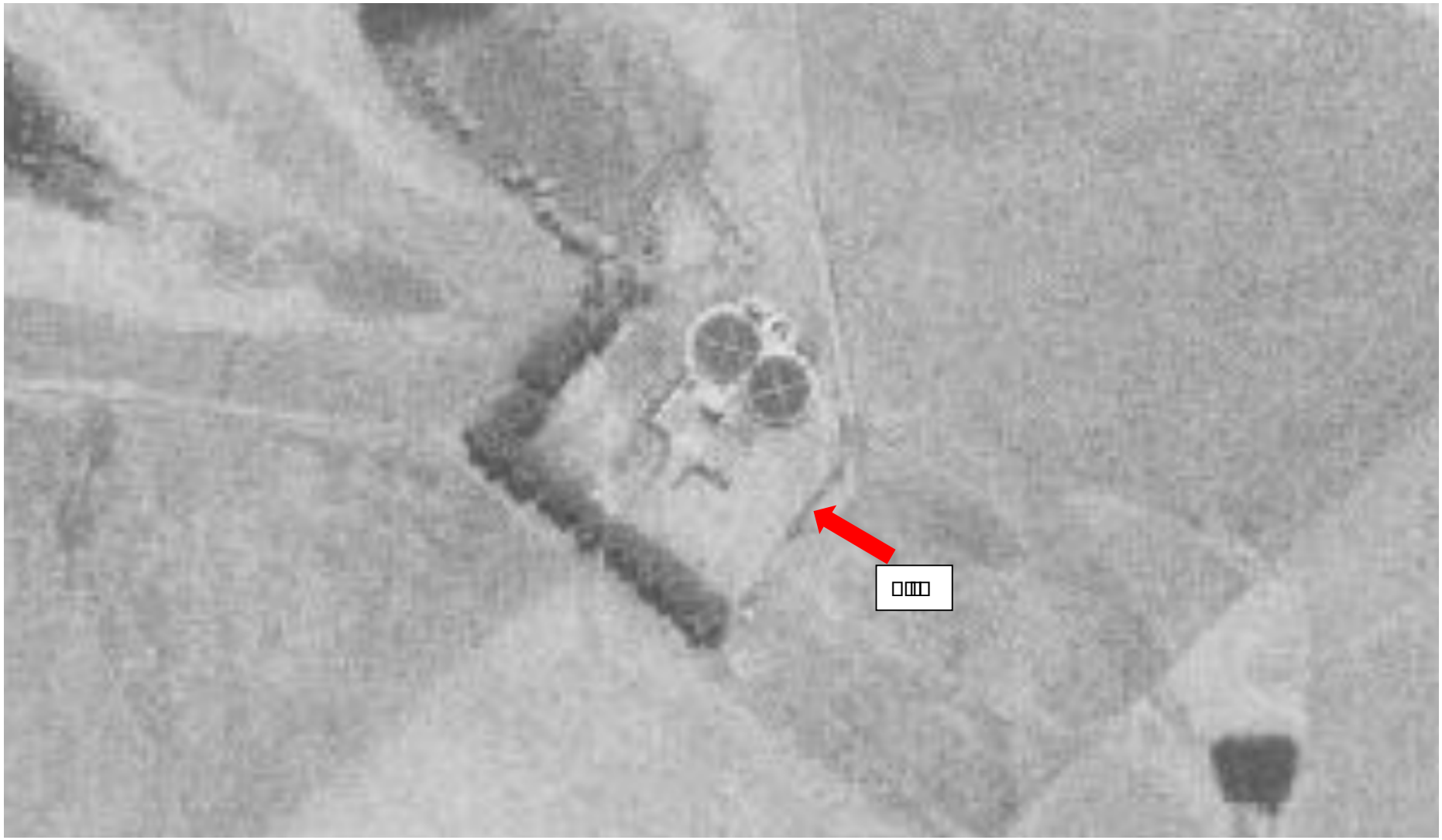
Sample ID	Depth (m)	Material	Date of Sampling	Total Recoverable Hydrocarbons - 1999 NEPM Fractions					BTEX						Polycyclic Aromatic Hydrocarbons	Organochlorine Pesticides	Polychlorinated biphenyls	pH	EC	Asbestos in Soils
				TRH C_{10}-C_{14}	TRH C_{10}-C_{36} (Total)	TRH C_{15}-C_{28}	TRH C_{29}-C_{36}	TRH C_6-C_9	Benzene	Ethylbenzene	m&p-Xylenes	o-Xylene	Toluene	Xylenes - Total	PAH (Total)	OCP (Total)				
BH101	1.5-1.7	Soil	19-Feb-21	57	1467	510	900	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	6.6	270	NAD
BH104	0.5-1	Soil	17-Feb-21	< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	9.1	110	NAD
BH106	0.2-0.3	Soil	18-Feb-21	< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	5.8	33	NAD
BH106	1	Soil	18-Feb-21	< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	8	110	NAD
BH108	0.3-0.4	Soil	18-Feb-21	< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	5.6	180	NAD
BH108	1	Soil	18-Feb-21	< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	4.3	230	NAD
BH109	0.5	Soil	18-Feb-21	< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	7.1	42	NAD
BH109	1	Soil	18-Feb-21	< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	7.1	37	NAD
BH110	0.2-0.3	Soil	18-Feb-21	< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	6.3	28	NAD
BH110	1	Soil	18-Feb-21	< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	6.8	22	NAD
BH111	0.5-0.6	Soil	17-Feb-21	< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	7	23	NAD
BH112	0.5-0.6	Soil	17-Feb-21	< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	5.9	12	NAD
BH113	1	Soil	16-Feb-21	< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	< LOR	< LOR	< LOR	6.2	120	NAD
BH106*	0.2-0.3	Leachate	18-Feb-21	-	-	-	-	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.06	-	-	-	-	-	-
Summary Stats^	No. Observations			13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	Average			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Maximum			57	1467	510	900	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9.1	270	NA
	Minimum			< 20	< 50	< 50	< 50	< 20	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	NA	NA	NA	4.3	12	NA
	Standard Deviation			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Guidelines																				
NSW EPA (2014) Waste Classification Guidelines	General Solid Waste - TCLP1 (See Table 2 - TCLP & SCC values for classifying waste by chemical assessment)								0.5	30			14.4	50						
	General Solid Waste - SCC1 (See Table 2 - TCLP & SCC values for classifying waste by chemical assessment)			10,000				650	18	1,080			518	1,800						
	Restricted Solid Waste - TCLP2 (See Table 2 - TCLP & SCC values for classifying waste by chemical assessment)								2	120			57.6	200						
	Restricted Solid Waste - SCC2 (See Table 2 - TCLP & SCC values for classifying waste by chemical assessment)			40,000				2,600	72	4,320			2,073	7,200						

Notes:

BOLD Concentrations exceeds the acceptance criteria
NAD No Asbestos Detected
< LOR Concentrations below the Laboratories Limit of Reporting
NA Not applicable
- Not analysed
^ Summary stats were calculated when more then 5 values exceeded the laboratories LOR. A value of half of the LOR was adopted for statistical calculation.
# Concentrations for leachate are reported in mg/L

Attachment A

Historical Imagery



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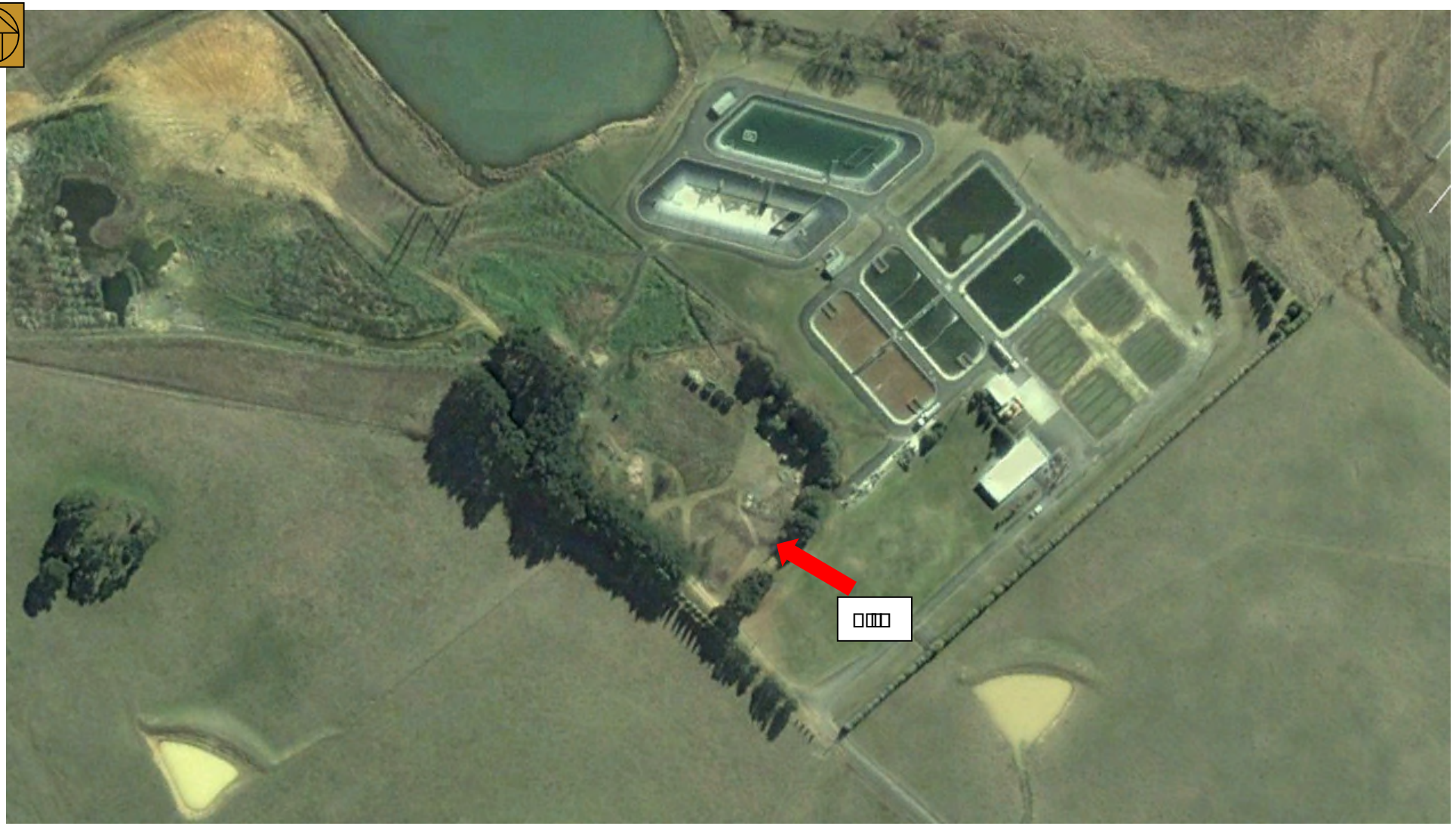

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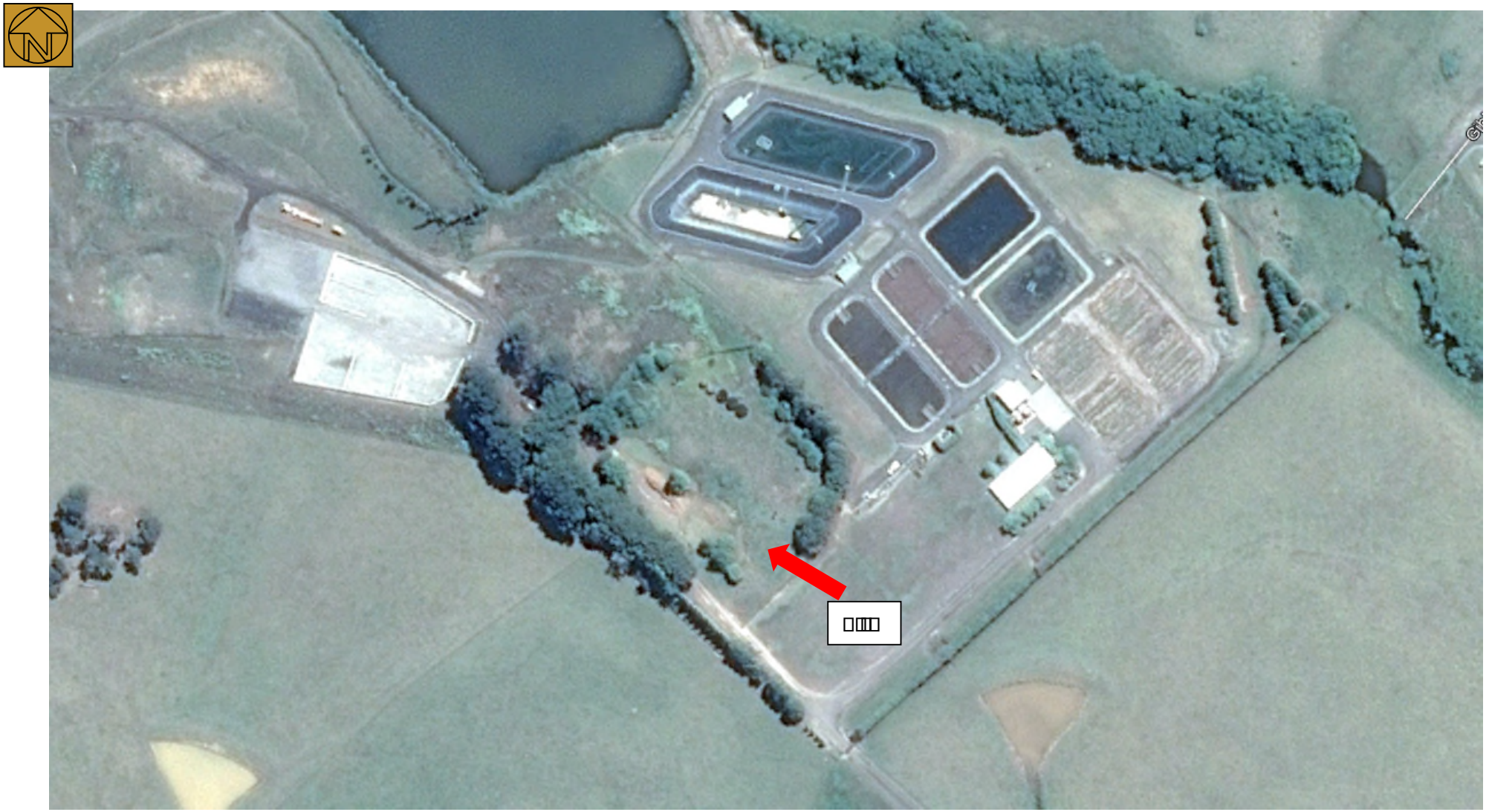


Gibbons Rd

Attachment B

Laboratory Certificates of Analysis

Ballpark Environmental Pty Ltd
PO Box 36
Nana Glen
NSW 2450

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Attention: **-ALL SRAs & Results - Andrew Ballard & Joel Parkin**

Report **776231-S**
Project name BPE21011
Project ID C-0760.00
Received Date Feb 24, 2021

Client Sample ID			**BH101 1.5-1.7**	**BH104 0.5-1**	**BH106 0.2-0.3**	**BH106 1**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**S21-Fe48616**	**S21-Fe48617**	**S21-Fe48618**	**S21-Fe48619**
Date Sampled			**Feb 19, 2021**	**Feb 17, 2021**	**Feb 18, 2021**	**Feb 18, 2021**
Test/Reference	LOR	Unit				
Total Recoverable Hydrocarbons - 1999 NEPM Fractions						
TRH C6-C9	20	mg/kg	< 20	< 20	< 20	< 20
TRH C10-C14	20	mg/kg	57	< 20	< 20	< 20
TRH C15-C28	50	mg/kg	510	< 50	< 50	< 50
TRH C29-C36	50	mg/kg	900	< 50	< 50	< 50
TRH C10-C36 (Total)	50	mg/kg	1467	< 50	< 50	< 50
BTEX						
Benzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Toluene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Ethylbenzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
m&p-Xylenes	0.2	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
o-Xylene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Xylenes - Total*	0.3	mg/kg	< 0.3	< 0.3	< 0.3	< 0.3
4-Bromofluorobenzene (surr.)	1	%	66	113	133	138
Total Recoverable Hydrocarbons - 2013 NEPM Fractions						
Naphthalene[N02]	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
TRH C6-C10	20	mg/kg	< 20	< 20	< 20	< 20
TRH C6-C10 less BTEX (F1)[N04]	20	mg/kg	< 20	< 20	< 20	< 20
TRH >C10-C16	50	mg/kg	83	< 50	< 50	< 50
TRH >C10-C16 less Naphthalene (F2)[N01]	50	mg/kg	83	< 50	< 50	< 50
TRH >C16-C34	100	mg/kg	1100	< 100	< 100	< 100
TRH >C34-C40	100	mg/kg	260	< 100	< 100	< 100
TRH >C10-C40 (total)*	100	mg/kg	1443	< 100	< 100	< 100
Polycyclic Aromatic Hydrocarbons						
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	0.6	0.6	0.6	0.6
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	1.2	1.2	1.2	1.2
Acenaphthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benz(a)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(b&j)fluoranthene[N07]	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(g.h.i)perylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(k)fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Chrysene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5

Client Sample ID			BH101 1.5-1.7	BH104 0.5-1	BH106 0.2-0.3	BH106 1
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S21-Fe48616	S21-Fe48617	S21-Fe48618	S21-Fe48619
Date Sampled			Feb 19, 2021	Feb 17, 2021	Feb 18, 2021	Feb 18, 2021
Test/Reference	LOR	Unit				
Polycyclic Aromatic Hydrocarbons						
Dibenz(a.h)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Fluorene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Naphthalene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Phenanthrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Total PAH*	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
2-Fluorobiphenyl (surr.)	1	%	126	117	114	109
p-Terphenyl-d14 (surr.)	1	%	137	126	118	114
Organochlorine Pesticides						
Chlordanes - Total	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
4.4'-DDD	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
4.4'-DDE	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
4.4'-DDT	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
a-BHC	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Aldrin	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
b-BHC	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
d-BHC	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Dieldrin	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endosulfan I	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endosulfan II	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endosulfan sulphate	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endrin	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endrin aldehyde	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endrin ketone	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
g-BHC (Lindane)	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Heptachlor	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Heptachlor epoxide	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Hexachlorobenzene	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Methoxychlor	0.2	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
Toxaphene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aldrin and Dieldrin (Total)*	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
DDT + DDE + DDD (Total)*	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Vic EPA IWRG 621 OCP (Total)*	0.1	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
Vic EPA IWRG 621 Other OCP (Total)*	0.1	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
Dibutylchlorendate (surr.)	1	%	91	122	123	123
Tetrachloro-m-xylene (surr.)	1	%	119	99	101	104
Polychlorinated Biphenyls						
Aroclor-1016	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1221	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1232	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1242	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1248	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1254	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1260	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Total PCB*	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Dibutylchlorendate (surr.)	1	%	91	122	123	123
Tetrachloro-m-xylene (surr.)	1	%	119	99	101	104

Client Sample ID			BH101 1.5-1.7	BH104 0.5-1	BH106 0.2-0.3	BH106 1
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S21-Fe48616	S21-Fe48617	S21-Fe48618	S21-Fe48619
Date Sampled			Feb 19, 2021	Feb 17, 2021	Feb 18, 2021	Feb 18, 2021
Test/Reference	LOR	Unit				
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	270	110	33	110
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	6.6	9.1	5.8	8.0
% Moisture	1	%	21	20	18	24
Heavy Metals						
Arsenic	2	mg/kg	7.6	5.1	3.1	5.0
Cadmium	0.4	mg/kg	0.6	< 0.4	< 0.4	< 0.4
Chromium	5	mg/kg	35	42	41	5.0
Copper	5	mg/kg	190	44	20	20
Lead	5	mg/kg	38	16	20	9.0
Mercury	0.1	mg/kg	1.3	< 0.1	0.6	0.1
Nickel	5	mg/kg	12	26	12	< 5
Zinc	5	mg/kg	210	34	46	150

Client Sample ID			BH108 0.3-0.4	BH108 1	BH109 0.5	BH109 1
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S21-Fe48620	S21-Fe48621	S21-Fe48622	S21-Fe48623
Date Sampled			Feb 18, 2021	Feb 18, 2021	Feb 18, 2021	Feb 18, 2021
Test/Reference	LOR	Unit				
Total Recoverable Hydrocarbons - 1999 NEPM Fractions						
TRH C6-C9	20	mg/kg	< 20	< 20	< 20	< 20
TRH C10-C14	20	mg/kg	< 20	< 20	< 20	< 20
TRH C15-C28	50	mg/kg	< 50	< 50	< 50	< 50
TRH C29-C36	50	mg/kg	< 50	< 50	< 50	< 50
TRH C10-C36 (Total)	50	mg/kg	< 50	< 50	< 50	< 50
BTEX						
Benzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Toluene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Ethylbenzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
m&p-Xylenes	0.2	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
o-Xylene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Xylenes - Total*	0.3	mg/kg	< 0.3	< 0.3	< 0.3	< 0.3
4-Bromofluorobenzene (surr.)	1	%	72	59	62	54
Total Recoverable Hydrocarbons - 2013 NEPM Fractions						
Naphthalene[N02]	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
TRH C6-C10	20	mg/kg	< 20	< 20	< 20	< 20
TRH C6-C10 less BTEX (F1)[N04]	20	mg/kg	< 20	< 20	< 20	< 20
TRH >C10-C16	50	mg/kg	< 50	< 50	< 50	< 50
TRH >C10-C16 less Naphthalene (F2)[N01]	50	mg/kg	< 50	< 50	< 50	< 50
TRH >C16-C34	100	mg/kg	< 100	< 100	< 100	< 100
TRH >C34-C40	100	mg/kg	< 100	< 100	< 100	< 100
TRH >C10-C40 (total)*	100	mg/kg	< 100	< 100	< 100	< 100
Polycyclic Aromatic Hydrocarbons						
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	0.6	0.6	0.6	0.6
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	1.2	1.2	1.2	1.2
Acenaphthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5

Client Sample ID			BH108 0.3-0.4	BH108 1	BH109 0.5	BH109 1
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S21-Fe48620	S21-Fe48621	S21-Fe48622	S21-Fe48623
Date Sampled			Feb 18, 2021	Feb 18, 2021	Feb 18, 2021	Feb 18, 2021
Test/Reference	LOR	Unit				
Polycyclic Aromatic Hydrocarbons						
Benz(a)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(b&j)fluoranthene[N07]	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(g.h.i)perylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(k)fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Chrysene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Dibenz(a.h)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Fluorene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Naphthalene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Phenanthrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Total PAH*	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
2-Fluorobiphenyl (surr.)	1	%	92	94	89	101
p-Terphenyl-d14 (surr.)	1	%	89	94	99	106
Organochlorine Pesticides						
Chlordanes - Total	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
4.4'-DDD	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
4.4'-DDE	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
4.4'-DDT	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
a-BHC	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Aldrin	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
b-BHC	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
d-BHC	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Dieldrin	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endosulfan I	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endosulfan II	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endosulfan sulphate	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endrin	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endrin aldehyde	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endrin ketone	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
g-BHC (Lindane)	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Heptachlor	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Heptachlor epoxide	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Hexachlorobenzene	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Methoxychlor	0.2	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
Toxaphene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aldrin and Dieldrin (Total)*	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
DDT + DDE + DDD (Total)*	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Vic EPA IWRG 621 OCP (Total)*	0.1	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
Vic EPA IWRG 621 Other OCP (Total)*	0.1	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
Dibutylchlorendate (surr.)	1	%	118	115	101	148
Tetrachloro-m-xylene (surr.)	1	%	88	97	90	102
Polychlorinated Biphenyls						
Aroclor-1016	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1221	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1232	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1242	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5

Client Sample ID			BH108 0.3-0.4	BH108 1	BH109 0.5	BH109 1
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S21-Fe48620	S21-Fe48621	S21-Fe48622	S21-Fe48623
Date Sampled			Feb 18, 2021	Feb 18, 2021	Feb 18, 2021	Feb 18, 2021
Test/Reference	LOR	Unit				
Polychlorinated Biphenyls						
Aroclor-1248	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1254	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1260	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Total PCB*	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Dibutylchlorendate (surr.)	1	%	118	115	101	148
Tetrachloro-m-xylene (surr.)	1	%	88	97	90	102
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	180	230	42	37
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	5.6	4.3	7.1	7.1
% Moisture	1	%	11	12	17	16
Heavy Metals						
Arsenic	2	mg/kg	2.9	2.8	6.0	7.6
Cadmium	0.4	mg/kg	< 0.4	< 0.4	< 0.4	< 0.4
Chromium	5	mg/kg	19	22	27	36
Copper	5	mg/kg	19	9.7	26	26
Lead	5	mg/kg	23	11	24	31
Mercury	0.1	mg/kg	0.2	< 0.1	0.2	0.1
Nickel	5	mg/kg	< 5	6.4	11	13
Zinc	5	mg/kg	63	29	54	56

Client Sample ID			BH110 0.2-0.3	BH110 1	BH111 0.5-0.6	BH112 0.5-0.6
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S21-Fe48624	S21-Fe48625	S21-Fe48626	S21-Fe48627
Date Sampled			Feb 18, 2021	Feb 18, 2021	Feb 17, 2021	Feb 17, 2021
Test/Reference	LOR	Unit				
Total Recoverable Hydrocarbons - 1999 NEPM Fractions						
TRH C6-C9	20	mg/kg	< 20	< 20	< 20	< 20
TRH C10-C14	20	mg/kg	< 20	< 20	< 20	< 20
TRH C15-C28	50	mg/kg	< 50	< 50	< 50	< 50
TRH C29-C36	50	mg/kg	< 50	< 50	< 50	< 50
TRH C10-C36 (Total)	50	mg/kg	< 50	< 50	< 50	< 50
BTEX						
Benzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Toluene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Ethylbenzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
m&p-Xylenes	0.2	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
o-Xylene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Xylenes - Total*	0.3	mg/kg	< 0.3	< 0.3	< 0.3	< 0.3
4-Bromofluorobenzene (surr.)	1	%	73	58	72	74
Total Recoverable Hydrocarbons - 2013 NEPM Fractions						
Naphthalene[N02]	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
TRH C6-C10	20	mg/kg	< 20	< 20	< 20	< 20
TRH C6-C10 less BTEX (F1)[N04]	20	mg/kg	< 20	< 20	< 20	< 20
TRH >C10-C16	50	mg/kg	< 50	< 50	< 50	< 50
TRH >C10-C16 less Naphthalene (F2)[N01]	50	mg/kg	< 50	< 50	< 50	< 50
TRH >C16-C34	100	mg/kg	< 100	< 100	< 100	< 100
TRH >C34-C40	100	mg/kg	< 100	< 100	< 100	< 100
TRH >C10-C40 (total)*	100	mg/kg	< 100	< 100	< 100	< 100

Client Sample ID			BH110 0.2-0.3	BH110 1	BH111 0.5-0.6	BH112 0.5-0.6
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S21-Fe48624	S21-Fe48625	S21-Fe48626	S21-Fe48627
Date Sampled			Feb 18, 2021	Feb 18, 2021	Feb 17, 2021	Feb 17, 2021
Test/Reference	LOR	Unit				
Polycyclic Aromatic Hydrocarbons						
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	0.6	0.6	0.6	0.6
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	1.2	1.2	1.2	1.2
Acenaphthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benz(a)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(b&j)fluoranthene[N07]	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(g.h.i)perylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(k)fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Chrysene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Dibenz(a.h)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Fluorene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Naphthalene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Phenanthrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Total PAH*	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
2-Fluorobiphenyl (surr.)	1	%	86	90	95	83
p-Terphenyl-d14 (surr.)	1	%	91	96	98	95
Organochlorine Pesticides						
Chlordanes - Total	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
4.4'-DDD	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
4.4'-DDE	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
4.4'-DDT	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
a-BHC	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Aldrin	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
b-BHC	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
d-BHC	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Dieldrin	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endosulfan I	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endosulfan II	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endosulfan sulphate	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endrin	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endrin aldehyde	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Endrin ketone	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
g-BHC (Lindane)	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Heptachlor	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Heptachlor epoxide	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Hexachlorobenzene	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Methoxychlor	0.2	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
Toxaphene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aldrin and Dieldrin (Total)*	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
DDT + DDE + DDD (Total)*	0.05	mg/kg	< 0.05	< 0.05	< 0.05	< 0.05
Vic EPA IWRG 621 OCP (Total)*	0.1	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
Vic EPA IWRG 621 Other OCP (Total)*	0.1	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
Dibutylchlorendate (surr.)	1	%	100	108	120	95
Tetrachloro-m-xylene (surr.)	1	%	96	99	105	100

Client Sample ID			BH110 0.2-0.3	BH110 1	BH111 0.5-0.6	BH112 0.5-0.6
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S21-Fe48624	S21-Fe48625	S21-Fe48626	S21-Fe48627
Date Sampled			Feb 18, 2021	Feb 18, 2021	Feb 17, 2021	Feb 17, 2021
Test/Reference	LOR	Unit				
Polychlorinated Biphenyls						
Aroclor-1016	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1221	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1232	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1242	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1248	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1254	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Aroclor-1260	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Total PCB*	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Dibutylchlorendate (surr.)	1	%	100	108	120	95
Tetrachloro-m-xylene (surr.)	1	%	96	99	105	100
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	28	22	23	12
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	6.3	6.8	7.0	5.9
% Moisture	1	%	17	17	17	11
Heavy Metals						
Arsenic	2	mg/kg	5.8	< 2	5.2	6.5
Cadmium	0.4	mg/kg	< 0.4	< 0.4	< 0.4	< 0.4
Chromium	5	mg/kg	58	14	38	29
Copper	5	mg/kg	19	< 5	14	11
Lead	5	mg/kg	22	8.7	15	12
Mercury	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	5	mg/kg	17	< 5	18	7.7
Zinc	5	mg/kg	41	7.2	26	17

Client Sample ID			BH113 1	QC01	QC03
Sample Matrix			Soil	Soil	Soil
Eurofins Sample No.			S21-Fe48628	S21-Fe48629	S21-Fe48631
Date Sampled			Feb 16, 2021	Feb 16, 2021	Feb 17, 2021
Test/Reference	LOR	Unit			
Total Recoverable Hydrocarbons - 1999 NEPM Fractions					
TRH C6-C9	20	mg/kg	< 20	< 20	< 20
TRH C10-C14	20	mg/kg	< 20	< 20	< 20
TRH C15-C28	50	mg/kg	< 50	< 50	< 50
TRH C29-C36	50	mg/kg	< 50	< 50	< 50
TRH C10-C36 (Total)	50	mg/kg	< 50	< 50	< 50
BTEX					
Benzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1
Toluene	0.1	mg/kg	< 0.1	< 0.1	< 0.1
Ethylbenzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1
m&p-Xylenes	0.2	mg/kg	< 0.2	< 0.2	< 0.2
o-Xylene	0.1	mg/kg	< 0.1	< 0.1	< 0.1
Xylenes - Total*	0.3	mg/kg	< 0.3	< 0.3	< 0.3
4-Bromofluorobenzene (surr.)	1	%	69	63	58
Total Recoverable Hydrocarbons - 2013 NEPM Fractions					
Naphthalene[N02]	0.5	mg/kg	< 0.5	< 0.5	< 0.5
TRH C6-C10	20	mg/kg	< 20	< 20	< 20
TRH C6-C10 less BTEX (F1)[N04]	20	mg/kg	< 20	< 20	< 20
TRH >C10-C16	50	mg/kg	< 50	< 50	< 50

Client Sample ID			BH113 1	QC01	QC03
Sample Matrix			Soil	Soil	Soil
Eurofins Sample No.			S21-Fe48628	S21-Fe48629	S21-Fe48631
Date Sampled			Feb 16, 2021	Feb 16, 2021	Feb 17, 2021
Test/Reference	LOR	Unit			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions					
TRH >C10-C16 less Naphthalene (F2)[N01]	50	mg/kg	< 50	< 50	< 50
TRH >C16-C34	100	mg/kg	< 100	< 100	< 100
TRH >C34-C40	100	mg/kg	< 100	< 100	< 100
TRH >C10-C40 (total)*	100	mg/kg	< 100	< 100	< 100
Polycyclic Aromatic Hydrocarbons					
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	0.6	0.6	0.6
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	1.2	1.2	1.2
Acenaphthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Benz(a)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Benzo(b&j)fluoranthene[N07]	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Benzo(g.h.i)perylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Benzo(k)fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Chrysene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Dibenz(a.h)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Fluorene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Naphthalene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Phenanthrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Total PAH*	0.5	mg/kg	< 0.5	< 0.5	< 0.5
2-Fluorobiphenyl (surr.)	1	%	80	79	84
p-Terphenyl-d14 (surr.)	1	%	91	92	94
Organochlorine Pesticides					
Chlordanes - Total	0.1	mg/kg	< 0.1	< 0.1	< 0.1
4.4'-DDD	0.05	mg/kg	< 0.05	< 0.05	< 0.05
4.4'-DDE	0.05	mg/kg	< 0.05	< 0.05	< 0.05
4.4'-DDT	0.05	mg/kg	< 0.05	< 0.05	< 0.05
a-BHC	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Aldrin	0.05	mg/kg	< 0.05	< 0.05	< 0.05
b-BHC	0.05	mg/kg	< 0.05	< 0.05	< 0.05
d-BHC	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Dieldrin	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Endosulfan I	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Endosulfan II	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Endosulfan sulphate	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Endrin	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Endrin aldehyde	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Endrin ketone	0.05	mg/kg	< 0.05	< 0.05	< 0.05
g-BHC (Lindane)	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Heptachlor	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Heptachlor epoxide	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Hexachlorobenzene	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Methoxychlor	0.2	mg/kg	< 0.2	< 0.2	< 0.2
Toxaphene	0.1	mg/kg	< 0.1	< 0.1	< 0.1

Client Sample ID			BH113 1	QC01	QC03
Sample Matrix			Soil	Soil	Soil
Eurofins Sample No.			S21-Fe48628	S21-Fe48629	S21-Fe48631
Date Sampled			Feb 16, 2021	Feb 16, 2021	Feb 17, 2021
Test/Reference	LOR	Unit			
Organochlorine Pesticides					
Aldrin and Dieldrin (Total)*	0.05	mg/kg	< 0.05	< 0.05	< 0.05
DDT + DDE + DDD (Total)*	0.05	mg/kg	< 0.05	< 0.05	< 0.05
Vic EPA IWRG 621 OCP (Total)*	0.1	mg/kg	< 0.2	< 0.2	< 0.2
Vic EPA IWRG 621 Other OCP (Total)*	0.1	mg/kg	< 0.2	< 0.2	< 0.2
Dibutylchlorendate (surr.)	1	%	107	98	106
Tetrachloro-m-xylene (surr.)	1	%	98	94	100
Polychlorinated Biphenyls					
Aroclor-1016	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Aroclor-1221	0.1	mg/kg	< 0.1	< 0.1	< 0.1
Aroclor-1232	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Aroclor-1242	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Aroclor-1248	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Aroclor-1254	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Aroclor-1260	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Total PCB*	0.5	mg/kg	< 0.5	< 0.5	< 0.5
Dibutylchlorendate (surr.)	1	%	107	98	106
Tetrachloro-m-xylene (surr.)	1	%	98	94	100
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	120	-	-
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	6.2	-	-
% Moisture	1	%	14	11	19
Heavy Metals					
Arsenic	2	mg/kg	8.4	5.9	6.9
Cadmium	0.4	mg/kg	< 0.4	< 0.4	< 0.4
Chromium	5	mg/kg	73	71	48
Copper	5	mg/kg	27	20	32
Lead	5	mg/kg	19	18	17
Mercury	0.1	mg/kg	< 0.1	< 0.1	< 0.1
Nickel	5	mg/kg	48	27	30
Zinc	5	mg/kg	52	28	30

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Total Recoverable Hydrocarbons - 1999 NEPM Fractions	Sydney	Feb 26, 2021	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
BTEX	Sydney	Feb 26, 2021	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Sydney	Feb 26, 2021	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Sydney	Feb 26, 2021	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Polycyclic Aromatic Hydrocarbons	Sydney	Feb 26, 2021	14 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Metals M8	Sydney	Feb 26, 2021	180 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Organochlorine Pesticides	Sydney	Feb 26, 2021	14 Days
- Method: LTM-ORG-2220 OCP & PCB in Soil and Water			
Polychlorinated Biphenyls	Sydney	Feb 26, 2021	28 Days
- Method: LTM-ORG-2220 OCP & PCB in Soil and Water			
Conductivity (1:5 aqueous extract at 25°C as rec.)	Sydney	Feb 26, 2021	7 Days
- Method: LTM-INO-4030 Conductivity			
pH (1:5 Aqueous extract at 25°C as rec.)	Sydney	Feb 26, 2021	7 Days
- Method: LTM-GEN-7090 pH in soil by ISE			
% Moisture	Sydney	Feb 24, 2021	14 Days
- Method: LTM-GEN-7080 Moisture			

eurofins | Environment Testing

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Company Name: Ballpark Environmental Pty Ltd
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NSW 2450

Project Name: BPE21011
Project ID: C-0760.00

Order No.:
Report #: 776231
Phone: 0400 566 088
Fax:

Received: Feb 24, 2021 8:40 AM
Due: Mar 3, 2021
Priority: 5 Day
Contact Name: -ALL SRAs & Results - Andrew

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Asbestos - AS4964	Conductivity (1:5 aqueous extract at 25°C as rec.)	HOLD	pH (1:5 Aqueous extract at 25°C as rec.)	Suite B13: OCP/PCB	Moisture Set	Eurofins Suite B7
Melbourne Laboratory - NATA Site # 1254 & 14271												
Sydney Laboratory - NATA Site # 18217						X	X	X	X	X	X	X
Brisbane Laboratory - NATA Site # 20794												
Perth Laboratory - NATA Site # 23736												
Mayfield Laboratory												
External Laboratory												
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**							
1	BH101 1.5-1.7	Feb 19, 2021		Soil	S21-Fe48616	X	X		X	X	X	X
2	BH104 0.5-1	Feb 17, 2021		Soil	S21-Fe48617	X	X		X	X	X	X
3	BH106 0.2-0.3	Feb 18, 2021		Soil	S21-Fe48618	X	X		X	X	X	X
4	BH106 1	Feb 18, 2021		Soil	S21-Fe48619	X	X		X	X	X	X
5	BH108 0.3-0.4	Feb 18, 2021		Soil	S21-Fe48620	X	X		X	X	X	X
6	BH108 1	Feb 18, 2021		Soil	S21-Fe48621	X	X		X	X	X	X
7	BH109 0.5	Feb 18, 2021		Soil	S21-Fe48622	X	X		X	X	X	X
8	BH109 1	Feb 18, 2021		Soil	S21-Fe48623	X	X		X	X	X	X
9	BH110 0.2-0.3	Feb 18, 2021		Soil	S21-Fe48624	X	X		X	X	X	X

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IANZ # 1290

Company Name: Ballpark Environmental Pty Ltd
Address: PO Box 36
Nana Glen
NSW 2450

Project Name: BPE21011
Project ID: C-0760.00

Order No.:
Report #: 776231
Phone: 0400 566 088
Fax:

Received: Feb 24, 2021 8:40 AM
Due: Mar 3, 2021
Priority: 5 Day
Contact Name: -ALL SRAs & Results - Andrew

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Asbestos - AS4964	Conductivity (1:5 aqueous extract at 25°C as rec.)	HOLD	pH (1:5 Aqueous extract at 25°C as rec.)	Suite B13: OCP/PCB	Moisture Set	Eurofins Suite B7
Melbourne Laboratory - NATA Site # 1254 & 14271												
Sydney Laboratory - NATA Site # 18217						X	X	X	X	X	X	X
Brisbane Laboratory - NATA Site # 20794												
Perth Laboratory - NATA Site # 23736												
Mayfield Laboratory												
External Laboratory												
10	BH110 1	Feb 18, 2021		Soil	S21-Fe48625	X	X		X	X	X	X
11	BH111 0.5-0.6	Feb 17, 2021		Soil	S21-Fe48626	X	X		X	X	X	X
12	BH112 0.5-0.6	Feb 17, 2021		Soil	S21-Fe48627	X	X		X	X	X	X
13	BH113 1	Feb 16, 2021		Soil	S21-Fe48628	X	X		X	X	X	X
14	QC01	Feb 16, 2021		Soil	S21-Fe48629					X	X	X
15	QC03	Feb 17, 2021		Soil	S21-Fe48631					X	X	X
16	QC04	Feb 17, 2021		Soil	S21-Fe48632			X				
17	BH102 1.65	Feb 18, 2021		Soil	S21-Fe48636			X				
18	BH103 0.6-0.7	Feb 18, 2021		Soil	S21-Fe48637			X				
19	BH103 1	Feb 18, 2021		Soil	S21-Fe48638			X				
20	BH103 2	Feb 18, 2021		Soil	S21-Fe48639			X				

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Company Name: Ballpark Environmental Pty Ltd
Address: PO Box 36
Nana Glen
NSW 2450

Project Name: BPE21011
Project ID: C-0760.00

Order No.:
Report #: 776231
Phone: 0400 566 088
Fax:

Received: Feb 24, 2021 8:40 AM
Due: Mar 3, 2021
Priority: 5 Day
Contact Name: -ALL SRAs & Results - Andrew

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Asbestos - AS4964	Conductivity (1:5 aqueous extract at 25°C as rec.)	HOLD	pH (1:5 Aqueous extract at 25°C as rec.)	Suite B13: OCP/PCB	Moisture Set	Eurofins Suite B7
Melbourne Laboratory - NATA Site # 1254 & 14271												
Sydney Laboratory - NATA Site # 18217						X	X	X	X	X	X	X
Brisbane Laboratory - NATA Site # 20794												
Perth Laboratory - NATA Site # 23736												
Mayfield Laboratory												
External Laboratory												
21	BH104 1	Feb 17, 2021		Soil	S21-Fe48640			X				
22	BH104 2	Feb 17, 2021		Soil	S21-Fe48641			X				
23	BH106 2	Feb 18, 2021		Soil	S21-Fe48642			X				
24	BH107 4	Feb 17, 2021		Soil	S21-Fe48643			X				
25	BH108 2	Feb 18, 2021		Soil	S21-Fe48644			X				
26	BH109 2	Feb 18, 2021		Soil	S21-Fe48645			X				
27	BH110 2	Feb 18, 2021		Soil	S21-Fe48646			X				
28	BH111 1	Feb 17, 2021		Soil	S21-Fe48647			X				
29	BH111 2	Feb 17, 2021		Soil	S21-Fe48648			X				
30	BH112 1	Feb 17, 2021		Soil	S21-Fe48649			X				
31	BH113 0.2-0.3	Feb 16, 2021		Soil	S21-Fe48650			X				

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Address: PO Box 36
Nana Glen
NSW 2450

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Project ID: C-0760.00

Order No.:
Report #: 776231
Phone: 0400 566 088
Fax:

Received: Feb 24, 2021 8:40 AM
Due: Mar 3, 2021
Priority: 5 Day
Contact Name: -ALL SRAs & Results - Andrew

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Asbestos - AS4964	Conductivity (1:5 aqueous extract at 25°C as rec.)	HOLD	pH (1:5 Aqueous extract at 25°C as rec.)	Suite B13: OCP/PCB	Moisture Set	Eurofins Suite B7
Melbourne Laboratory - NATA Site # 1254 & 14271												
Sydney Laboratory - NATA Site # 18217						X	X	X	X	X	X	X
Brisbane Laboratory - NATA Site # 20794												
Perth Laboratory - NATA Site # 23736												
Mayfield Laboratory												
External Laboratory												
32	BH113 2	Feb 16, 2021		Soil	S21-Fe48651			X				
33	BH113 3	Feb 16, 2021		Soil	S21-Fe48652			X				
34	BH102 2.0-2.45	Feb 17, 2021		Soil	S21-Fe48844			X				
Test Counts						13	13	19	13	15	15	15

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram

mg/L: milligrams per litre

ug/L: micrograms per litre

ppm: Parts per million

ppb: Parts per billion

%: Percentage

org/100mL: Organisms per 100 millilitres

NTU: Nephelometric Turbidity Units

MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	mg/kg	< 20			20	Pass	
TRH C10-C14	mg/kg	< 20			20	Pass	
TRH C15-C28	mg/kg	< 50			50	Pass	
TRH C29-C36	mg/kg	< 50			50	Pass	
Method Blank							
BTEX							
Benzene	mg/kg	< 0.1			0.1	Pass	
Toluene	mg/kg	< 0.1			0.1	Pass	
Ethylbenzene	mg/kg	< 0.1			0.1	Pass	
m&p-Xylenes	mg/kg	< 0.2			0.2	Pass	
o-Xylene	mg/kg	< 0.1			0.1	Pass	
Xylenes - Total*	mg/kg	< 0.3			0.3	Pass	
Method Blank							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	mg/kg	< 0.5			0.5	Pass	
TRH C6-C10	mg/kg	< 20			20	Pass	
TRH >C10-C16	mg/kg	< 50			50	Pass	
TRH >C16-C34	mg/kg	< 100			100	Pass	
TRH >C34-C40	mg/kg	< 100			100	Pass	
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/kg	< 0.5			0.5	Pass	
Acenaphthylene	mg/kg	< 0.5			0.5	Pass	
Anthracene	mg/kg	< 0.5			0.5	Pass	
Benz(a)anthracene	mg/kg	< 0.5			0.5	Pass	
Benzo(a)pyrene	mg/kg	< 0.5			0.5	Pass	
Benzo(b&j)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Benzo(g.h.i)perylene	mg/kg	< 0.5			0.5	Pass	
Benzo(k)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Chrysene	mg/kg	< 0.5			0.5	Pass	
Dibenz(a.h)anthracene	mg/kg	< 0.5			0.5	Pass	
Fluoranthene	mg/kg	< 0.5			0.5	Pass	
Fluorene	mg/kg	< 0.5			0.5	Pass	
Indeno(1.2.3-cd)pyrene	mg/kg	< 0.5			0.5	Pass	
Naphthalene	mg/kg	< 0.5			0.5	Pass	
Phenanthrene	mg/kg	< 0.5			0.5	Pass	
Pyrene	mg/kg	< 0.5			0.5	Pass	
Method Blank							
Organochlorine Pesticides							
Chlordanes - Total	mg/kg	< 0.1			0.1	Pass	
4.4'-DDD	mg/kg	< 0.05			0.05	Pass	
4.4'-DDE	mg/kg	< 0.05			0.05	Pass	
4.4'-DDT	mg/kg	< 0.05			0.05	Pass	
a-BHC	mg/kg	< 0.05			0.05	Pass	
Aldrin	mg/kg	< 0.05			0.05	Pass	
b-BHC	mg/kg	< 0.05			0.05	Pass	
d-BHC	mg/kg	< 0.05			0.05	Pass	
Dieldrin	mg/kg	< 0.05			0.05	Pass	
Endosulfan I	mg/kg	< 0.05			0.05	Pass	
Endosulfan II	mg/kg	< 0.05			0.05	Pass	

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Endosulfan sulphate	mg/kg	< 0.05			0.05	Pass	
Endrin	mg/kg	< 0.05			0.05	Pass	
Endrin aldehyde	mg/kg	< 0.05			0.05	Pass	
Endrin ketone	mg/kg	< 0.05			0.05	Pass	
g-BHC (Lindane)	mg/kg	< 0.05			0.05	Pass	
Heptachlor	mg/kg	< 0.05			0.05	Pass	
Heptachlor epoxide	mg/kg	< 0.05			0.05	Pass	
Hexachlorobenzene	mg/kg	< 0.05			0.05	Pass	
Methoxychlor	mg/kg	< 0.2			0.2	Pass	
Toxaphene	mg/kg	< 0.1			0.1	Pass	
Method Blank							
Polychlorinated Biphenyls							
Aroclor-1016	mg/kg	< 0.5			0.5	Pass	
Aroclor-1221	mg/kg	< 0.1			0.1	Pass	
Aroclor-1232	mg/kg	< 0.5			0.5	Pass	
Aroclor-1242	mg/kg	< 0.5			0.5	Pass	
Aroclor-1248	mg/kg	< 0.5			0.5	Pass	
Aroclor-1254	mg/kg	< 0.5			0.5	Pass	
Aroclor-1260	mg/kg	< 0.5			0.5	Pass	
Total PCB*	mg/kg	< 0.5			0.5	Pass	
Method Blank							
Conductivity (1:5 aqueous extract at 25°C as rec.)	uS/cm	< 10			10	Pass	
Method Blank							
Heavy Metals							
Arsenic	mg/kg	< 2			2	Pass	
Cadmium	mg/kg	< 0.4			0.4	Pass	
Chromium	mg/kg	< 5			5	Pass	
Copper	mg/kg	< 5			5	Pass	
Lead	mg/kg	< 5			5	Pass	
Mercury	mg/kg	< 0.1			0.1	Pass	
Nickel	mg/kg	< 5			5	Pass	
Zinc	mg/kg	< 5			5	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	%	85			70-130	Pass	
TRH C10-C14	%	73			70-130	Pass	
LCS - % Recovery							
BTEX							
Benzene	%	98			70-130	Pass	
Toluene	%	91			70-130	Pass	
Ethylbenzene	%	94			70-130	Pass	
m&p-Xylenes	%	95			70-130	Pass	
o-Xylene	%	99			70-130	Pass	
Xylenes - Total*	%	96			70-130	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	%	110			70-130	Pass	
TRH C6-C10	%	85			70-130	Pass	
TRH >C10-C16	%	72			70-130	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	93			70-130	Pass	
Acenaphthylene	%	98			70-130	Pass	
Anthracene	%	90			70-130	Pass	

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Benz(a)anthracene	%	99			70-130	Pass	
Benzo(a)pyrene	%	97			70-130	Pass	
Benzo(b&j)fluoranthene	%	90			70-130	Pass	
Benzo(g.h.i)perylene	%	98			70-130	Pass	
Benzo(k)fluoranthene	%	85			70-130	Pass	
Chrysene	%	96			70-130	Pass	
Dibenz(a.h)anthracene	%	96			70-130	Pass	
Fluoranthene	%	87			70-130	Pass	
Fluorene	%	96			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	95			70-130	Pass	
Naphthalene	%	93			70-130	Pass	
Phenanthrene	%	89			70-130	Pass	
Pyrene	%	87			70-130	Pass	
LCS - % Recovery							
Organochlorine Pesticides							
Chlordanes - Total	%	85			70-130	Pass	
4.4'-DDD	%	88			70-130	Pass	
4.4'-DDE	%	88			70-130	Pass	
4.4'-DDT	%	95			70-130	Pass	
a-BHC	%	84			70-130	Pass	
Aldrin	%	85			70-130	Pass	
b-BHC	%	90			70-130	Pass	
d-BHC	%	86			70-130	Pass	
Dieldrin	%	87			70-130	Pass	
Endosulfan I	%	83			70-130	Pass	
Endosulfan II	%	89			70-130	Pass	
Endosulfan sulphate	%	84			70-130	Pass	
Endrin	%	85			70-130	Pass	
Endrin aldehyde	%	99			70-130	Pass	
Endrin ketone	%	93			70-130	Pass	
g-BHC (Lindane)	%	88			70-130	Pass	
Heptachlor	%	90			70-130	Pass	
Heptachlor epoxide	%	82			70-130	Pass	
Hexachlorobenzene	%	88			70-130	Pass	
Methoxychlor	%	113			70-130	Pass	
LCS - % Recovery							
Polychlorinated Biphenyls							
Aroclor-1016	%	98			70-130	Pass	
Aroclor-1221	%	0.0000000			70-130	Fail	
Aroclor-1232	%	0.0000000			70-130	Fail	
Aroclor-1242	%	0.0000000			70-130	Fail	
Aroclor-1248	%	0.0000000			70-130	Fail	
Aroclor-1254	%	0.0000000			70-130	Fail	
Aroclor-1260	%	107			70-130	Pass	
Total PCB*	%	0			70-130	Fail	
LCS - % Recovery							
Conductivity (1:5 aqueous extract at 25°C as rec.)	%	99			70-130	Pass	
LCS - % Recovery							
Heavy Metals							
Arsenic	%	94			80-120	Pass	
Cadmium	%	98			80-120	Pass	
Chromium	%	100			80-120	Pass	
Copper	%	100			80-120	Pass	
Lead	%	102			80-120	Pass	

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Mercury			%	105			80-120	Pass	
Nickel			%	99			80-120	Pass	
Zinc			%	96			80-120	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1					
TRH C10-C14	S21-Ma03588	NCP	%	79			70-130	Pass	
Spike - % Recovery									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1					
TRH >C10-C16	S21-Ma03588	NCP	%	79			70-130	Pass	
Spike - % Recovery									
Polycyclic Aromatic Hydrocarbons				Result 1					
Acenaphthene	S21-Fe48617	CP	%	81			70-130	Pass	
Acenaphthylene	S21-Fe48617	CP	%	89			70-130	Pass	
Anthracene	S21-Fe48617	CP	%	85			70-130	Pass	
Benz(a)anthracene	S21-Fe48617	CP	%	91			70-130	Pass	
Benzo(a)pyrene	S21-Fe48617	CP	%	95			70-130	Pass	
Benzo(b&j)fluoranthene	S21-Fe48617	CP	%	89			70-130	Pass	
Benzo(g.h.i)perylene	S21-Fe48617	CP	%	88			70-130	Pass	
Benzo(k)fluoranthene	S21-Fe48617	CP	%	93			70-130	Pass	
Chrysene	S21-Fe48617	CP	%	87			70-130	Pass	
Dibenz(a.h)anthracene	S21-Fe48617	CP	%	81			70-130	Pass	
Fluoranthene	S21-Fe48617	CP	%	83			70-130	Pass	
Fluorene	S21-Fe48617	CP	%	81			70-130	Pass	
Indeno(1.2.3-cd)pyrene	S21-Fe48617	CP	%	82			70-130	Pass	
Naphthalene	S21-Fe48617	CP	%	83			70-130	Pass	
Phenanthrene	S21-Fe48617	CP	%	80			70-130	Pass	
Pyrene	S21-Fe48617	CP	%	83			70-130	Pass	
Spike - % Recovery									
Organochlorine Pesticides				Result 1					
Chlordanes - Total	S21-Fe48617	CP	%	89			70-130	Pass	
4.4'-DDD	S21-Fe48617	CP	%	110			70-130	Pass	
4.4'-DDE	S21-Fe48617	CP	%	106			70-130	Pass	
a-BHC	S21-Fe48617	CP	%	103			70-130	Pass	
Aldrin	S21-Fe48617	CP	%	100			70-130	Pass	
b-BHC	S21-Fe48617	CP	%	95			70-130	Pass	
d-BHC	S21-Fe48617	CP	%	104			70-130	Pass	
Dieldrin	S21-Fe48617	CP	%	103			70-130	Pass	
Endosulfan I	S21-Fe48617	CP	%	106			70-130	Pass	
Endosulfan II	S21-Fe48617	CP	%	91			70-130	Pass	
Endosulfan sulphate	S21-Fe48617	CP	%	85			70-130	Pass	
Endrin	S21-Fe48617	CP	%	84			70-130	Pass	
Endrin ketone	S21-Fe48617	CP	%	88			70-130	Pass	
g-BHC (Lindane)	S21-Fe48617	CP	%	96			70-130	Pass	
Heptachlor	S21-Fe48617	CP	%	83			70-130	Pass	
Heptachlor epoxide	S21-Fe48617	CP	%	90			70-130	Pass	
Hexachlorobenzene	S21-Fe48617	CP	%	95			70-130	Pass	
Spike - % Recovery									
Polychlorinated Biphenyls				Result 1					
Aroclor-1016	S21-Fe48617	CP	%	105			70-130	Pass	
Aroclor-1260	S21-Fe48617	CP	%	96			70-130	Pass	
Spike - % Recovery									
Organochlorine Pesticides				Result 1					
4.4'-DDT	S21-Ma03590	NCP	%	122			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Endrin aldehyde	S21-Ma03590	NCP	%	117			70-130	Pass	
Methoxychlor	S21-Fe48824	NCP	%	94			70-130	Pass	
Spike - % Recovery									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1					
TRH C6-C9	S21-Fe48626	CP	%	77			70-130	Pass	
Spike - % Recovery									
BTEX				Result 1					
Benzene	S21-Fe48626	CP	%	85			70-130	Pass	
Toluene	S21-Fe48626	CP	%	81			70-130	Pass	
Ethylbenzene	S21-Fe48626	CP	%	84			70-130	Pass	
m&p-Xylenes	S21-Fe48626	CP	%	87			70-130	Pass	
o-Xylene	S21-Fe48626	CP	%	86			70-130	Pass	
Xylenes - Total*	S21-Fe48626	CP	%	86			70-130	Pass	
Spike - % Recovery									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1					
Naphthalene	S21-Fe48626	CP	%	93			70-130	Pass	
TRH C6-C10	S21-Fe48626	CP	%	78			70-130	Pass	
Spike - % Recovery									
Heavy Metals				Result 1					
Arsenic	S21-Fe48627	CP	%	93			75-125	Pass	
Cadmium	S21-Fe48627	CP	%	100			75-125	Pass	
Chromium	S21-Fe48627	CP	%	97			75-125	Pass	
Copper	S21-Fe48627	CP	%	100			75-125	Pass	
Lead	S21-Fe48627	CP	%	101			75-125	Pass	
Mercury	S21-Fe48627	CP	%	109			75-125	Pass	
Nickel	S21-Fe48627	CP	%	101			75-125	Pass	
Zinc	S21-Fe48627	CP	%	99			75-125	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1	Result 2	RPD			
TRH C10-C14	S21-Fe49094	NCP	mg/kg	< 20	< 20	<1	30%	Pass	
TRH C15-C28	S21-Fe49094	NCP	mg/kg	< 50	< 50	<1	30%	Pass	
TRH C29-C36	S21-Fe49094	NCP	mg/kg	< 50	< 50	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
TRH >C10-C16	S21-Fe49094	NCP	mg/kg	< 50	< 50	<1	30%	Pass	
TRH >C16-C34	S21-Fe49094	NCP	mg/kg	< 100	< 100	<1	30%	Pass	
TRH >C34-C40	S21-Fe49094	NCP	mg/kg	< 100	< 100	<1	30%	Pass	
Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Acenaphthene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Acenaphthylene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Anthracene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benz(a)anthracene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(a)pyrene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(b&j)fluoranthene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(g.h.i)perylene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(k)fluoranthene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Chrysene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Dibenz(a.h)anthracene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluoranthene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluorene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Indeno(1.2.3-cd)pyrene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Naphthalene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	

Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Phenanthrene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Pyrene	S21-Fe48616	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Duplicate									
Organochlorine Pesticides				Result 1	Result 2	RPD			
Chlordanes - Total	S21-Fe48616	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
4.4'-DDD	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
4.4'-DDE	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
4.4'-DDT	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
a-BHC	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Aldrin	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
b-BHC	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
d-BHC	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Dieldrin	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Endosulfan I	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Endosulfan II	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Endosulfan sulphate	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Endrin	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Endrin aldehyde	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Endrin ketone	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
g-BHC (Lindane)	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Heptachlor	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Heptachlor epoxide	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Hexachlorobenzene	S21-Fe48616	CP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Methoxychlor	S21-Fe48616	CP	mg/kg	< 0.2	< 0.2	<1	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
Conductivity (1:5 aqueous extract at 25°C as rec.)	S21-Fe48619	CP	uS/cm	110	100	4.0	30%	Pass	
pH (1:5 Aqueous extract at 25°C as rec.)	S21-Fe48619	CP	pH Units	8.0	8.1	Pass	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
Conductivity (1:5 aqueous extract at 25°C as rec.)	S21-Fe48623	CP	uS/cm	37	28	28	30%	Pass	
pH (1:5 Aqueous extract at 25°C as rec.)	S21-Fe48623	CP	pH Units	7.1	6.9	Pass	30%	Pass	
% Moisture	S21-Fe48623	CP	%	16	17	6.0	30%	Pass	
Duplicate									
Organochlorine Pesticides				Result 1	Result 2	RPD			
Toxaphene	S21-Fe42407	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Duplicate									
Polychlorinated Biphenyls				Result 1	Result 2	RPD			
Aroclor-1016	S21-Fe42449	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Aroclor-1221	S21-Fe42449	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1232	S21-Fe42449	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Aroclor-1242	S21-Fe42449	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Aroclor-1248	S21-Fe42449	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Aroclor-1254	S21-Fe42449	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Aroclor-1260	S21-Fe42449	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Total PCB*	S21-Fe42449	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1	Result 2	RPD			
TRH C6-C9	S21-Fe48625	CP	mg/kg	< 20	< 20	<1	30%	Pass	

Duplicate									
BTEX				Result 1	Result 2	RPD			
Benzene	S21-Fe48625	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Toluene	S21-Fe48625	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Ethylbenzene	S21-Fe48625	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
m&p-Xylenes	S21-Fe48625	CP	mg/kg	< 0.2	< 0.2	<1	30%	Pass	
o-Xylene	S21-Fe48625	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Xylenes - Total*	S21-Fe48625	CP	mg/kg	< 0.3	< 0.3	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
Naphthalene	S21-Fe48625	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
TRH C6-C10	S21-Fe48625	CP	mg/kg	< 20	< 20	<1	30%	Pass	
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic	S21-Fe48626	CP	mg/kg	5.2	5.1	2.0	30%	Pass	
Cadmium	S21-Fe48626	CP	mg/kg	< 0.4	< 0.4	<1	30%	Pass	
Chromium	S21-Fe48626	CP	mg/kg	38	38	1.0	30%	Pass	
Copper	S21-Fe48626	CP	mg/kg	14	15	4.0	30%	Pass	
Lead	S21-Fe48626	CP	mg/kg	15	16	3.0	30%	Pass	
Mercury	S21-Fe48626	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Nickel	S21-Fe48626	CP	mg/kg	18	18	4.0	30%	Pass	
Zinc	S21-Fe48626	CP	mg/kg	26	26	2.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N01	F2 is determined by arithmetically subtracting the "naphthalene" value from the ">C10-C16" value. The naphthalene value used in this calculation is obtained from volatiles (Purge & Trap analysis).
N02	Where we have reported both volatile (P&T GCMS) and semivolatile (GCMS) naphthalene data, results may not be identical. Provided correct sample handling protocols have been followed, any observed differences in results are likely to be due to procedural differences within each methodology. Results determined by both techniques have passed all QAQC acceptance criteria, and are entirely technically valid.
N04	F1 is determined by arithmetically subtracting the "Total BTEX" value from the "C6-C10" value. The "Total BTEX" value is obtained by summing the concentrations of BTEX analytes. The "C6-C10" value is obtained by quantitating against a standard of mixed aromatic/aliphatic analytes.
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs

Authorised by:

Ursula Long	Analytical Services Manager
Andrew Sullivan	Senior Analyst-Organic (NSW)
Charl Du Preez	Senior Analyst-Inorganic (NSW)
John Nguyen	Senior Analyst-Metal (NSW)



Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

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Certificate of Analysis

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NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025–Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Ballpark Environmental Pty Ltd
PO Box 36
Nana Glen
NSW 2450

Attention:	-ALL SRAs & Results - Andrew Ballard & Joel Parkin
Report	776231-AID
Project Name	BPE21011
Project ID	C-0760.00
Received Date	Feb 24, 2021
Date Reported	Mar 03, 2021

Methodology:

Asbestos Fibre Identification	Conducted in accordance with the Australian Standard AS 4964 – 2004: Method for the Qualitative Identification of Asbestos in Bulk Samples and in-house Method LTM-ASB-8020 by polarised light microscopy (PLM) and dispersion staining (DS) techniques. *NOTE: Positive Trace Analysis results indicate the sample contains detectable respirable fibres.*
Unknown Mineral Fibres	Mineral fibres of unknown type, as determined by PLM with DS, may require another analytical technique, such as Electron Microscopy, to confirm unequivocal identity. *NOTE: While Actinolite, Anthophyllite and Tremolite asbestos may be detected by PLM with DS, due to variability in the optical properties of these materials, AS4964 requires that these are reported as UMF unless confirmed by an independent technique.*
Subsampling Soil Samples	The whole sample submitted is first dried and then passed through a 10mm sieve followed by a 2mm sieve. All fibrous matter greater than 10mm, greater than 2mm as well as the material passing through the 2mm sieve are retained and analysed for the presence of asbestos. If the sub 2mm fraction is greater than approximately 30 to 60g then a sub-sampling routine based on ISO 3082:2009(E) is employed. *NOTE: Depending on the nature and size of the soil sample, the sub-2 mm residue material may need to be sub-sampled for trace analysis, in accordance with AS 4964-2004.*
Bonded asbestos-containing material (ACM)	The material is first examined and any fibres isolated for identification by PLM and DS. Where required, interfering matrices may be removed by disintegration using a range of heat, chemical or physical treatments, possibly in combination.The resultant material is then further examined in accordance with AS 4964 - 2004. *NOTE: Even after disintegration it may be difficult to detect the presence of asbestos in some asbestos-containing bulk materials using PLM and DS. This is due to the low grade or small length or diameter of the asbestos fibres present in the material, or to the fact that very fine fibres have been distributed intimately throughout the materials. Vinyl/asbestos floor tiles, some asbestos-containing sealants and mastics, asbestos-containing epoxy resins and some ore samples are examples of these types of material, which are difficult to analyse.*
Limit of Reporting	The performance limitation of the AS 4964 (2004) method for non-homogeneous samples is around 0.1 g/kg (equivalent to 0.01% (w/w)). Where no asbestos is found by PLM and DS, including Trace Analysis, this is considered to be at the nominal reporting limit of 0.01% (w/w). The NEPM screening level of 0.001% (w/w) is intended as an on-site determination, not a laboratory Limit of Reporting (LOR), per se. Examination of a large sample size (e.g. 500 mL) may improve the likelihood of detecting asbestos, particularly AF, to aid assessment against the NEPM criteria. Gravimetric determinations to this level of accuracy are outside of AS 4964 and hence NATA Accreditation does not cover the performance of this service (non-NATA results shown with an asterisk). *NOTE: NATA News March 2014, p.7, states in relation to AS 4964: "This is a qualitative method with a nominal reporting limit of 0.01 % " and that currently in Australia "there is no validated method available for the quantification of asbestos".This report is consistent with the analytical procedures and reporting recommendations in the NEPM and the WA DoH.*

Accredited for compliance with ISO/IEC 17025–Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Project Name BPE21011
Project ID C-0760.00
Date Sampled Feb 16, 2021 to Feb 19, 2021
Report 776231-AID

Client Sample ID	Eurofins Sample No.	Date Sampled	Sample Description	Result
BH101 1.5-1.7	21-Fe48616	Feb 19, 2021	Approximate Sample 43g Sample consisted of: Brown fine-grained soil and organic debris	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.
BH104 0.5-1	21-Fe48617	Feb 17, 2021	Approximate Sample 498g Sample consisted of: Brown coarse-grained clayey soil and rocks	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.
BH106 0.2-0.3	21-Fe48618	Feb 18, 2021	Approximate Sample 317g Sample consisted of: Brown coarse-grained clayey-sandy soil and rocks	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.
BH106 1	21-Fe48619	Feb 18, 2021	Approximate Sample 191g Sample consisted of: Brown coarse-grained clayey-sandy soil and rocks	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.
BH108 0.3-0.4	21-Fe48620	Feb 18, 2021	Approximate Sample 127g Sample consisted of: Brown coarse-grained sandy soil, organic debris and rocks	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.
BH108 1	21-Fe48621	Feb 18, 2021	Approximate Sample 141g Sample consisted of: Brown coarse-grained clayey-sandy soil	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.
BH109 0.5	21-Fe48622	Feb 18, 2021	Approximate Sample 186g Sample consisted of: Brown coarse-grained clayey-sandy soil organic debris	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.
BH109 1	21-Fe48623	Feb 18, 2021	Approximate Sample 246g Sample consisted of: Brown coarse-grained clayey-sandy soil, organic debris and rocks	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.

Client Sample ID	Eurofins Sample No.	Date Sampled	Sample Description	Result
BH110 0.2-0.3	21-Fe48624	Feb 18, 2021	Approximate Sample 252g Sample consisted of: Brown coarse-grained clayey soil	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.
BH110 1	21-Fe48625	Feb 18, 2021	Approximate Sample 231g Sample consisted of: Brown coarse-grained clayey soil	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.
BH111 0.5-0.6	21-Fe48626	Feb 17, 2021	Approximate Sample 129g Sample consisted of: Brown coarse-grained clayey soil	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.
BH112 0.5-0.6	21-Fe48627	Feb 17, 2021	Approximate Sample 136g Sample consisted of: Red-brown coarse-grained clayey-sandy soil	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.
BH113 1	21-Fe48628	Feb 16, 2021	Approximate Sample 122g Sample consisted of: Brown coarse-grained clayey soil and sandstone	No asbestos detected at the reporting limit of 0.01% w/w. Organic fibre detected. No trace asbestos detected.

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Asbestos - LTM-ASB-8020	Sydney	Feb 24, 2021	Indefinite

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Company Name: Ballpark Environmental Pty Ltd
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Project Name: BPE21011
Project ID: C-0760.00

Order No.:
Report #: 776231
Phone: 0400 566 088
Fax:

Received: Feb 24, 2021 8:40 AM
Due: Mar 3, 2021
Priority: 5 Day
Contact Name: -ALL SRAs & Results - Andrew

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Asbestos - AS4964	Conductivity (1:5 aqueous extract at 25°C as rec.)	HOLD	pH (1:5 Aqueous extract at 25°C as rec.)	Suite B13: OCP/PCB	Moisture Set	Eurofins Suite B7
Melbourne Laboratory - NATA Site # 1254 & 14271												
Sydney Laboratory - NATA Site # 18217						X	X	X	X	X	X	X
Brisbane Laboratory - NATA Site # 20794												
Perth Laboratory - NATA Site # 23736												
Mayfield Laboratory												
External Laboratory												
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**							
1	BH101 1.5-1.7	Feb 19, 2021		Soil	S21-Fe48616	X	X		X	X	X	X
2	BH104 0.5-1	Feb 17, 2021		Soil	S21-Fe48617	X	X		X	X	X	X
3	BH106 0.2-0.3	Feb 18, 2021		Soil	S21-Fe48618	X	X		X	X	X	X
4	BH106 1	Feb 18, 2021		Soil	S21-Fe48619	X	X		X	X	X	X
5	BH108 0.3-0.4	Feb 18, 2021		Soil	S21-Fe48620	X	X		X	X	X	X
6	BH108 1	Feb 18, 2021		Soil	S21-Fe48621	X	X		X	X	X	X
7	BH109 0.5	Feb 18, 2021		Soil	S21-Fe48622	X	X		X	X	X	X
8	BH109 1	Feb 18, 2021		Soil	S21-Fe48623	X	X		X	X	X	X
9	BH110 0.2-0.3	Feb 18, 2021		Soil	S21-Fe48624	X	X		X	X	X	X

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Project Name: BPE21011
Project ID: C-0760.00

Order No.:
Report #: 776231
Phone: 0400 566 088
Fax:

Received: Feb 24, 2021 8:40 AM
Due: Mar 3, 2021
Priority: 5 Day
Contact Name: -ALL SRAs & Results - Andrew

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Asbestos - AS4964	Conductivity (1:5 aqueous extract at 25°C as rec.)	HOLD	pH (1:5 Aqueous extract at 25°C as rec.)	Suite B13: OCP/PCB	Moisture Set	Eurofins Suite B7
Melbourne Laboratory - NATA Site # 1254 & 14271												
Sydney Laboratory - NATA Site # 18217						X	X	X	X	X	X	X
Brisbane Laboratory - NATA Site # 20794												
Perth Laboratory - NATA Site # 23736												
Mayfield Laboratory												
External Laboratory												
10	BH110 1	Feb 18, 2021		Soil	S21-Fe48625	X	X		X	X	X	X
11	BH111 0.5-0.6	Feb 17, 2021		Soil	S21-Fe48626	X	X		X	X	X	X
12	BH112 0.5-0.6	Feb 17, 2021		Soil	S21-Fe48627	X	X		X	X	X	X
13	BH113 1	Feb 16, 2021		Soil	S21-Fe48628	X	X		X	X	X	X
14	QC01	Feb 16, 2021		Soil	S21-Fe48629					X	X	X
15	QC03	Feb 17, 2021		Soil	S21-Fe48631					X	X	X
16	QC04	Feb 17, 2021		Soil	S21-Fe48632			X				
17	BH102 1.65	Feb 18, 2021		Soil	S21-Fe48636			X				
18	BH103 0.6-0.7	Feb 18, 2021		Soil	S21-Fe48637			X				
19	BH103 1	Feb 18, 2021		Soil	S21-Fe48638			X				
20	BH103 2	Feb 18, 2021		Soil	S21-Fe48639			X				

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IANZ # 1290

Company Name: Ballpark Environmental Pty Ltd
Address: PO Box 36
Nana Glen
NSW 2450

Project Name: BPE21011
Project ID: C-0760.00

Order No.:
Report #: 776231
Phone: 0400 566 088
Fax:

Received: Feb 24, 2021 8:40 AM
Due: Mar 3, 2021
Priority: 5 Day
Contact Name: -ALL SRAs & Results - Andrew

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Asbestos - AS4964	Conductivity (1:5 aqueous extract at 25°C as rec.)	HOLD	pH (1:5 Aqueous extract at 25°C as rec.)	Suite B13: OCP/PCB	Moisture Set	Eurofins Suite B7
Melbourne Laboratory - NATA Site # 1254 & 14271												
Sydney Laboratory - NATA Site # 18217						X	X	X	X	X	X	X
Brisbane Laboratory - NATA Site # 20794												
Perth Laboratory - NATA Site # 23736												
Mayfield Laboratory												
External Laboratory												
21	BH104 1	Feb 17, 2021		Soil	S21-Fe48640			X				
22	BH104 2	Feb 17, 2021		Soil	S21-Fe48641			X				
23	BH106 2	Feb 18, 2021		Soil	S21-Fe48642			X				
24	BH107 4	Feb 17, 2021		Soil	S21-Fe48643			X				
25	BH108 2	Feb 18, 2021		Soil	S21-Fe48644			X				
26	BH109 2	Feb 18, 2021		Soil	S21-Fe48645			X				
27	BH110 2	Feb 18, 2021		Soil	S21-Fe48646			X				
28	BH111 1	Feb 17, 2021		Soil	S21-Fe48647			X				
29	BH111 2	Feb 17, 2021		Soil	S21-Fe48648			X				
30	BH112 1	Feb 17, 2021		Soil	S21-Fe48649			X				
31	BH113 0.2-0.3	Feb 16, 2021		Soil	S21-Fe48650			X				

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Company Name: Ballpark Environmental Pty Ltd
Address: PO Box 36
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Project ID: C-0760.00

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Report #: 776231
Phone: 0400 566 088
Fax:

Received: Feb 24, 2021 8:40 AM
Due: Mar 3, 2021
Priority: 5 Day
Contact Name: -ALL SRAs & Results - Andrew

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Asbestos - AS4964	Conductivity (1:5 aqueous extract at 25°C as rec.)	HOLD	pH (1:5 Aqueous extract at 25°C as rec.)	Suite B13: OCP/PCB	Moisture Set	Eurofins Suite B7
Melbourne Laboratory - NATA Site # 1254 & 14271												
Sydney Laboratory - NATA Site # 18217						X	X	X	X	X	X	X
Brisbane Laboratory - NATA Site # 20794												
Perth Laboratory - NATA Site # 23736												
Mayfield Laboratory												
External Laboratory												
32	BH113 2	Feb 16, 2021		Soil	S21-Fe48651			X				
33	BH113 3	Feb 16, 2021		Soil	S21-Fe48652			X				
34	BH102 2.0-2.45	Feb 17, 2021		Soil	S21-Fe48844			X				
Test Counts						13	13	19	13	15	15	15

Internal Quality Control Review and Glossary

General

1. QC data may be available on request.
2. All soil results are reported on a dry basis, unless otherwise stated.
3. Samples were analysed on an 'as received' basis.
4. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
5. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the Sample Receipt Advice.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

Units

% w/w: weight for weight basis	grams per kilogram
Filter loading:	fibres/100 graticule areas
Reported Concentration:	fibres/mL
Flowrate:	L/min

Terms

Dry	Sample is dried by heating prior to analysis
LOR	Limit of Reporting
COC	Chain of Custody
SRA	Sample Receipt Advice
ISO	International Standards Organisation
AS	Australian Standards
WA DOH	Reference document for the NEPM. Government of Western Australia, Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia (2009), including supporting document Recommended Procedures for Laboratory Analysis of Asbestos in Soil (2011)
NEPM	National Environment Protection (Assessment of Site Contamination) Measure, 2013 (as amended)
ACM	Asbestos Containing Materials. Asbestos contained within a non-asbestos matrix, typically presented in bonded and/or sound condition. For the purposes of the NEPM, ACM is generally restricted to those materials that do not pass a 7mm x 7mm sieve.
AF	Asbestos Fines. Asbestos containing materials, including friable, weathered and bonded materials, able to pass a 7mm x 7mm sieve. Considered under the NEPM as equivalent to “non-bonded / friable”.
FA	Fibrous Asbestos. Asbestos containing materials in a friable and/or severely weathered condition. For the purposes of the NEPM, FA is generally restricted to those materials that do not pass a 7mm x 7mm sieve.
Friable	Asbestos-containing materials of any size that may be broken or crumbled by hand pressure. For the purposes of the NEPM, this includes both AF and FA. It is outside of the laboratory’s remit to assess degree of friability.
Trace Analysis	Analytical procedure used to detect the presence of respirable fibres in the matrix.

Comments

S21-Fe48616: The sample received was not collected in an approved asbestos bag and was therefore sub-sampled from the 250mL glass jar. Valid sub-sampling procedures were applied so as to ensure that the sub-sample to be analysed accurately represented the sample received.

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N/A	Not applicable

Asbestos Counter/Identifier:

Sayeed Abu	Senior Analyst-Asbestos (NSW)

Authorised by:

Chamath JHM Annakkage	Senior Analyst-Asbestos (NSW)



Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Eurofins shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall Eurofins be liable for consequential damages including, but not limited to, lost profits, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested. Unless indicated otherwise, the tests were performed on the samples as received.

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Sample Receipt Advice

Company name:	Ballpark Environmental Pty Ltd
Contact name:	-ALL SRAs & Results - Andrew Ballard & Joel Parkin
Project name:	BPE21011
Project ID:	C-0760.00
Turnaround time:	5 Day
Date/Time received	Feb 24, 2021 8:40 AM
Eurofins reference	776231

Sample Information

✓	A detailed list of analytes logged into our LIMS, is included in the attached summary table.
✓	All samples have been received as described on the above COC.
✓	COC has been completed correctly.
✓	Attempt to chill was evident.
✓	Appropriately preserved sample containers have been used.
✓	All samples were received in good condition.
✓	Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.
✓	Appropriate sample containers have been used.
✓	Sample containers for volatile analysis received with zero headspace.
X	Split sample sent to requested external lab.
X	Some samples have been subcontracted.
N/A	Custody Seals intact (if used).

Notes

Sample bag not received for BH101 1.5-1.7, subsample was taken from jar for asbestos. Subsample bag not received for BH107 4. Sample BH102 2.0-2.45 (Jar, Bag) received extra - logged on hold.

Contact

If you have any questions with respect to these samples, please contact your Analytical Services Manager:

Ursula Long on phone : or by email: UrsulaLong@eurofins.com

Results will be delivered electronically via email to -ALL SRAs & Results - Andrew Ballard & Joel Parkin - info@ballparkenv.com.au.

Global Leader - Results you can trust

Ballpark Environmental Pty Ltd
PO Box 36
Nana Glen
NSW 2450

NATA Accredited
Accreditation Number 1261
Site Number 1254

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Attention: **-ALL SRAs & Results - Andrew Ballard & Joel Parkin**

Report **777868-S**
Project name BPE21011
Project ID C-0760.00
Received Date Feb 24, 2021

Client Sample ID			**QC02**
Sample Matrix			**Soil**
Eurofins Sample No.			**M21-Fe48630**
Date Sampled			**Feb 16, 2021**
Test/Reference	LOR	Unit	
Total Recoverable Hydrocarbons - 1999 NEPM Fractions			
TRH C6-C9	20	mg/kg	< 20
TRH C10-C14	20	mg/kg	< 20
TRH C15-C28	50	mg/kg	< 50
TRH C29-C36	50	mg/kg	< 50
TRH C10-C36 (Total)	50	mg/kg	< 50
BTEX			
Benzene	0.1	mg/kg	< 0.1
Toluene	0.1	mg/kg	< 0.1
Ethylbenzene	0.1	mg/kg	< 0.1
m&p-Xylenes	0.2	mg/kg	< 0.2
o-Xylene	0.1	mg/kg	< 0.1
Xylenes - Total*	0.3	mg/kg	< 0.3
4-Bromofluorobenzene (surr.)	1	%	52
Total Recoverable Hydrocarbons - 2013 NEPM Fractions			
Naphthalene[N02]	0.5	mg/kg	< 0.5
TRH C6-C10	20	mg/kg	< 20
TRH C6-C10 less BTEX (F1)[N04]	20	mg/kg	< 20
TRH >C10-C16	50	mg/kg	< 50
TRH >C10-C16 less Naphthalene (F2)[N01]	50	mg/kg	< 50
TRH >C16-C34	100	mg/kg	< 100
TRH >C34-C40	100	mg/kg	< 100
TRH >C10-C40 (total)*	100	mg/kg	< 100
Polycyclic Aromatic Hydrocarbons			
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	< 0.5
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	0.6
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	1.2
Acenaphthene	0.5	mg/kg	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5
Anthracene	0.5	mg/kg	< 0.5
Benz(a)anthracene	0.5	mg/kg	< 0.5
Benzo(a)pyrene	0.5	mg/kg	< 0.5
Benzo(b&j)fluoranthene[N07]	0.5	mg/kg	< 0.5
Benzo(g.h.i)perylene	0.5	mg/kg	< 0.5
Benzo(k)fluoranthene	0.5	mg/kg	< 0.5
Chrysene	0.5	mg/kg	< 0.5

Client Sample ID			QC02
Sample Matrix			Soil
Eurofins Sample No.			M21-Fe48630
Date Sampled			Feb 16, 2021
Test/Reference	LOR	Unit	
Polycyclic Aromatic Hydrocarbons			
Dibenz(a.h)anthracene	0.5	mg/kg	< 0.5
Fluoranthene	0.5	mg/kg	< 0.5
Fluorene	0.5	mg/kg	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	< 0.5
Naphthalene	0.5	mg/kg	< 0.5
Phenanthrene	0.5	mg/kg	< 0.5
Pyrene	0.5	mg/kg	< 0.5
Total PAH*	0.5	mg/kg	< 0.5
2-Fluorobiphenyl (surr.)	1	%	69
p-Terphenyl-d14 (surr.)	1	%	61
Organochlorine Pesticides			
Chlordanes - Total	0.1	mg/kg	< 0.1
4.4'-DDD	0.05	mg/kg	< 0.05
4.4'-DDE	0.05	mg/kg	< 0.05
4.4'-DDT	0.05	mg/kg	< 0.05
a-BHC	0.05	mg/kg	< 0.05
Aldrin	0.05	mg/kg	< 0.05
b-BHC	0.05	mg/kg	< 0.05
d-BHC	0.05	mg/kg	< 0.05
Dieldrin	0.05	mg/kg	< 0.05
Endosulfan I	0.05	mg/kg	< 0.05
Endosulfan II	0.05	mg/kg	< 0.05
Endosulfan sulphate	0.05	mg/kg	< 0.05
Endrin	0.05	mg/kg	< 0.05
Endrin aldehyde	0.05	mg/kg	< 0.05
Endrin ketone	0.05	mg/kg	< 0.05
g-BHC (Lindane)	0.05	mg/kg	< 0.05
Heptachlor	0.05	mg/kg	< 0.05
Heptachlor epoxide	0.05	mg/kg	< 0.05
Hexachlorobenzene	0.05	mg/kg	< 0.05
Methoxychlor	0.05	mg/kg	< 0.05
Toxaphene	0.1	mg/kg	< 0.1
Aldrin and Dieldrin (Total)*	0.05	mg/kg	< 0.05
DDT + DDE + DDD (Total)*	0.05	mg/kg	< 0.05
Vic EPA IWRG 621 OCP (Total)*	0.1	mg/kg	< 0.1
Vic EPA IWRG 621 Other OCP (Total)*	0.1	mg/kg	< 0.1
Dibutylchlorendate (surr.)	1	%	95
Tetrachloro-m-xylene (surr.)	1	%	70
Polychlorinated Biphenyls			
Aroclor-1016	0.1	mg/kg	< 0.1
Aroclor-1221	0.1	mg/kg	< 0.1
Aroclor-1232	0.1	mg/kg	< 0.1
Aroclor-1242	0.1	mg/kg	< 0.1
Aroclor-1248	0.1	mg/kg	< 0.1
Aroclor-1254	0.1	mg/kg	< 0.1
Aroclor-1260	0.1	mg/kg	< 0.1
Total PCB*	0.1	mg/kg	< 0.1
Dibutylchlorendate (surr.)	1	%	95
Tetrachloro-m-xylene (surr.)	1	%	70

Client Sample ID			QC02
Sample Matrix			**Soil**
Eurofins Sample No.			**M21-Fe48630**
Date Sampled			**Feb 16, 2021**
Test/Reference	LOR	Unit	
Heavy Metals			
Arsenic	2	mg/kg	3.6
Cadmium	0.4	mg/kg	< 0.4
Chromium	5	mg/kg	64
Copper	5	mg/kg	16
Lead	5	mg/kg	15
Mercury	0.1	mg/kg	< 0.1
Nickel	5	mg/kg	18
Zinc	5	mg/kg	20
% Moisture	1	%	12

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Eurofins Suite B7			
Total Recoverable Hydrocarbons - 1999 NEPM Fractions	Melbourne	Mar 01, 2021	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
BTEX	Melbourne	Mar 01, 2021	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Mar 01, 2021	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Mar 01, 2021	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Polycyclic Aromatic Hydrocarbons	Melbourne	Mar 01, 2021	14 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Metals M8	Melbourne	Mar 01, 2021	180 Days
- Method:			
Suite B13: OCP/PCB			
Organochlorine Pesticides	Melbourne	Mar 01, 2021	14 Days
- Method: LTM-ORG-2220 OCP & PCB in Soil and Water (USEPA 8270)			
Polychlorinated Biphenyls	Melbourne	Mar 01, 2021	28 Days
- Method: LTM-ORG-2220 OCP & PCB in Soil and Water (USEPA 8082)			
% Moisture	Melbourne	Feb 24, 2021	14 Days
- Method: LTM-GEN-7080 Moisture			

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Project Name: BPE21011
Project ID: C-0760.00

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Phone: 0400 566 088
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Received: Feb 24, 2021 8:40 AM
Due: Mar 3, 2021
Priority: 5 Day
Contact Name: -ALL SRAs & Results - Andrew

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Suite B13: OCP/PCB	Moisture Set	Eurofins Suite B7
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X
Sydney Laboratory - NATA Site # 18217								
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
Mayfield Laboratory								
External Laboratory								
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**			
1	QC02	Feb 16, 2021		Soil	M21-Fe48630	X	X	X
Test Counts						1	1	1

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram
mg/L: milligrams per litre
ug/L: micrograms per litre
ppm: Parts per million
ppb: Parts per billion
%: Percentage
org/100mL: Organisms per 100 millilitres
NTU: Nephelometric Turbidity Units
MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	mg/kg	< 20			20	Pass	
TRH C10-C14	mg/kg	< 20			20	Pass	
TRH C15-C28	mg/kg	< 50			50	Pass	
TRH C29-C36	mg/kg	< 50			50	Pass	
Method Blank							
BTEX							
Benzene	mg/kg	< 0.1			0.1	Pass	
Toluene	mg/kg	< 0.1			0.1	Pass	
Ethylbenzene	mg/kg	< 0.1			0.1	Pass	
m&p-Xylenes	mg/kg	< 0.2			0.2	Pass	
o-Xylene	mg/kg	< 0.1			0.1	Pass	
Xylenes - Total*	mg/kg	< 0.3			0.3	Pass	
Method Blank							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	mg/kg	< 0.5			0.5	Pass	
TRH C6-C10	mg/kg	< 20			20	Pass	
TRH >C10-C16	mg/kg	< 50			50	Pass	
TRH >C16-C34	mg/kg	< 100			100	Pass	
TRH >C34-C40	mg/kg	< 100			100	Pass	
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/kg	< 0.5			0.5	Pass	
Acenaphthylene	mg/kg	< 0.5			0.5	Pass	
Anthracene	mg/kg	< 0.5			0.5	Pass	
Benz(a)anthracene	mg/kg	< 0.5			0.5	Pass	
Benzo(a)pyrene	mg/kg	< 0.5			0.5	Pass	
Benzo(b&j)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Benzo(g.h.i)perylene	mg/kg	< 0.5			0.5	Pass	
Benzo(k)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Chrysene	mg/kg	< 0.5			0.5	Pass	
Dibenz(a.h)anthracene	mg/kg	< 0.5			0.5	Pass	
Fluoranthene	mg/kg	< 0.5			0.5	Pass	
Fluorene	mg/kg	< 0.5			0.5	Pass	
Indeno(1.2.3-cd)pyrene	mg/kg	< 0.5			0.5	Pass	
Naphthalene	mg/kg	< 0.5			0.5	Pass	
Phenanthrene	mg/kg	< 0.5			0.5	Pass	
Pyrene	mg/kg	< 0.5			0.5	Pass	
Method Blank							
Organochlorine Pesticides							
Chlordanes - Total	mg/kg	< 0.1			0.1	Pass	
4.4'-DDD	mg/kg	< 0.05			0.05	Pass	
4.4'-DDE	mg/kg	< 0.05			0.05	Pass	
4.4'-DDT	mg/kg	< 0.05			0.05	Pass	
a-BHC	mg/kg	< 0.05			0.05	Pass	
Aldrin	mg/kg	< 0.05			0.05	Pass	
b-BHC	mg/kg	< 0.05			0.05	Pass	
d-BHC	mg/kg	< 0.05			0.05	Pass	
Dieldrin	mg/kg	< 0.05			0.05	Pass	
Endosulfan I	mg/kg	< 0.05			0.05	Pass	
Endosulfan II	mg/kg	< 0.05			0.05	Pass	

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Endosulfan sulphate	mg/kg	< 0.05			0.05	Pass	
Endrin	mg/kg	< 0.05			0.05	Pass	
Endrin aldehyde	mg/kg	< 0.05			0.05	Pass	
Endrin ketone	mg/kg	< 0.05			0.05	Pass	
g-BHC (Lindane)	mg/kg	< 0.05			0.05	Pass	
Heptachlor	mg/kg	< 0.05			0.05	Pass	
Heptachlor epoxide	mg/kg	< 0.05			0.05	Pass	
Hexachlorobenzene	mg/kg	< 0.05			0.05	Pass	
Methoxychlor	mg/kg	< 0.05			0.05	Pass	
Toxaphene	mg/kg	< 0.1			0.1	Pass	
Method Blank							
Polychlorinated Biphenyls							
Aroclor-1016	mg/kg	< 0.1			0.1	Pass	
Aroclor-1221	mg/kg	< 0.1			0.1	Pass	
Aroclor-1232	mg/kg	< 0.1			0.1	Pass	
Aroclor-1242	mg/kg	< 0.1			0.1	Pass	
Aroclor-1248	mg/kg	< 0.1			0.1	Pass	
Aroclor-1254	mg/kg	< 0.1			0.1	Pass	
Aroclor-1260	mg/kg	< 0.1			0.1	Pass	
Total PCB*	mg/kg	< 0.1			0.1	Pass	
Method Blank							
Heavy Metals							
Arsenic	mg/kg	< 2			2	Pass	
Cadmium	mg/kg	< 0.4			0.4	Pass	
Chromium	mg/kg	< 5			5	Pass	
Copper	mg/kg	< 5			5	Pass	
Lead	mg/kg	< 5			5	Pass	
Mercury	mg/kg	< 0.1			0.1	Pass	
Nickel	mg/kg	< 5			5	Pass	
Zinc	mg/kg	< 5			5	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	%	122			70-130	Pass	
TRH C10-C14	%	108			70-130	Pass	
LCS - % Recovery							
BTEX							
Benzene	%	102			70-130	Pass	
Toluene	%	111			70-130	Pass	
Ethylbenzene	%	112			70-130	Pass	
m&p-Xylenes	%	119			70-130	Pass	
Xylenes - Total*	%	120			70-130	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	%	105			70-130	Pass	
TRH C6-C10	%	119			70-130	Pass	
TRH >C10-C16	%	98			70-130	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	74			70-130	Pass	
Acenaphthylene	%	81			70-130	Pass	
Anthracene	%	71			70-130	Pass	
Benz(a)anthracene	%	73			70-130	Pass	
Benzo(a)pyrene	%	76			70-130	Pass	
Benzo(b&j)fluoranthene	%	73			70-130	Pass	

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Benzo(g.h.i)perylene	%	78			70-130	Pass	
Benzo(k)fluoranthene	%	83			70-130	Pass	
Chrysene	%	88			70-130	Pass	
Dibenz(a.h)anthracene	%	85			70-130	Pass	
Fluoranthene	%	80			70-130	Pass	
Fluorene	%	70			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	78			70-130	Pass	
Naphthalene	%	78			70-130	Pass	
Phenanthrene	%	76			70-130	Pass	
Pyrene	%	81			70-130	Pass	
LCS - % Recovery							
Organochlorine Pesticides							
Chlordanes - Total	%	82			70-130	Pass	
4.4'-DDD	%	107			70-130	Pass	
4.4'-DDE	%	80			70-130	Pass	
4.4'-DDT	%	90			70-130	Pass	
a-BHC	%	94			70-130	Pass	
Aldrin	%	77			70-130	Pass	
b-BHC	%	99			70-130	Pass	
d-BHC	%	91			70-130	Pass	
Dieldrin	%	83			70-130	Pass	
Endosulfan I	%	76			70-130	Pass	
Endosulfan II	%	87			70-130	Pass	
Endosulfan sulphate	%	83			70-130	Pass	
Endrin	%	72			70-130	Pass	
Endrin aldehyde	%	86			70-130	Pass	
Endrin ketone	%	99			70-130	Pass	
g-BHC (Lindane)	%	80			70-130	Pass	
Heptachlor	%	93			70-130	Pass	
Heptachlor epoxide	%	76			70-130	Pass	
Hexachlorobenzene	%	80			70-130	Pass	
Methoxychlor	%	98			70-130	Pass	
LCS - % Recovery							
Polychlorinated Biphenyls							
Aroclor-1260	%	109			70-130	Pass	
LCS - % Recovery							
Heavy Metals							
Arsenic	%	109			80-120	Pass	
Cadmium	%	112			80-120	Pass	
Chromium	%	116			80-120	Pass	
Copper	%	109			80-120	Pass	
Lead	%	112			80-120	Pass	
Mercury	%	120			80-120	Pass	
Nickel	%	110			80-120	Pass	
Zinc	%	109			80-120	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Spike - % Recovery									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1					
TRH C6-C9	M21-Ma00944	NCP	%	110			70-130	Pass	
TRH C10-C14	M21-Fe53387	NCP	%	85			70-130	Pass	
Spike - % Recovery									
BTEX				Result 1					
Benzene	M21-Ma00944	NCP	%	107			70-130	Pass	
Toluene	M21-Ma00944	NCP	%	112			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Ethylbenzene	M21-Ma00944	NCP	%	108			70-130	Pass	
m&p-Xylenes	M21-Ma00944	NCP	%	77			70-130	Pass	
o-Xylene	M21-Ma00944	NCP	%	77			70-130	Pass	
Xylenes - Total*	M21-Ma00944	NCP	%	77			70-130	Pass	
Spike - % Recovery									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1					
Naphthalene	M21-Ma00944	NCP	%	123			70-130	Pass	
TRH C6-C10	M21-Ma00944	NCP	%	106			70-130	Pass	
TRH >C10-C16	M21-Fe53387	NCP	%	97			70-130	Pass	
Spike - % Recovery									
Polycyclic Aromatic Hydrocarbons				Result 1					
Acenaphthene	M21-Fe48863	NCP	%	76			70-130	Pass	
Acenaphthylene	M21-Fe48863	NCP	%	85			70-130	Pass	
Anthracene	M21-Fe48863	NCP	%	77			70-130	Pass	
Benz(a)anthracene	M21-Fe48863	NCP	%	78			70-130	Pass	
Benzo(a)pyrene	M21-Fe48863	NCP	%	109			70-130	Pass	
Benzo(b&j)fluoranthene	M21-Fe48863	NCP	%	109			70-130	Pass	
Benzo(g.h.i)perylene	M21-Fe48863	NCP	%	80			70-130	Pass	
Benzo(k)fluoranthene	M21-Fe48863	NCP	%	83			70-130	Pass	
Chrysene	M21-Fe48863	NCP	%	87			70-130	Pass	
Dibenz(a.h)anthracene	M21-Fe48863	NCP	%	90			70-130	Pass	
Fluoranthene	M21-Fe48863	NCP	%	77			70-130	Pass	
Fluorene	M21-Fe48863	NCP	%	73			70-130	Pass	
Indeno(1.2.3-cd)pyrene	M21-Fe48863	NCP	%	79			70-130	Pass	
Naphthalene	M21-Fe48863	NCP	%	77			70-130	Pass	
Phenanthrene	M21-Fe48863	NCP	%	78			70-130	Pass	
Pyrene	M21-Fe48863	NCP	%	75			70-130	Pass	
Spike - % Recovery									
Organochlorine Pesticides				Result 1					
Chlordanes - Total	M21-Fe51810	NCP	%	83			70-130	Pass	
4.4'-DDD	M21-Fe51810	NCP	%	120			70-130	Pass	
4.4'-DDE	M21-Fe51810	NCP	%	90			70-130	Pass	
4.4'-DDT	M21-Fe51810	NCP	%	88			70-130	Pass	
a-BHC	M21-Fe51810	NCP	%	105			70-130	Pass	
Aldrin	M21-Fe51810	NCP	%	80			70-130	Pass	
b-BHC	M21-Fe51810	NCP	%	99			70-130	Pass	
d-BHC	M21-Fe51810	NCP	%	79			70-130	Pass	
Dieldrin	M21-Fe51810	NCP	%	82			70-130	Pass	
Endosulfan I	M21-Fe51810	NCP	%	84			70-130	Pass	
Endosulfan II	M21-Fe51810	NCP	%	87			70-130	Pass	
Endosulfan sulphate	M21-Fe51810	NCP	%	81			70-130	Pass	
Endrin	M21-Fe51810	NCP	%	91			70-130	Pass	
Endrin aldehyde	M21-Fe51810	NCP	%	93			70-130	Pass	
Endrin ketone	M21-Fe51810	NCP	%	114			70-130	Pass	
g-BHC (Lindane)	M21-Fe51810	NCP	%	77			70-130	Pass	
Heptachlor	M21-Fe51810	NCP	%	82			70-130	Pass	
Heptachlor epoxide	M21-Fe51810	NCP	%	86			70-130	Pass	
Hexachlorobenzene	M21-Fe51810	NCP	%	72			70-130	Pass	
Methoxychlor	M21-Fe51810	NCP	%	90			70-130	Pass	
Spike - % Recovery									
Polychlorinated Biphenyls				Result 1					
Aroclor-1016	M21-Fe53400	NCP	%	100			70-130	Pass	
Aroclor-1260	M21-Fe53400	NCP	%	122			70-130	Pass	
Spike - % Recovery									

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Heavy Metals				Result 1					
Arsenic	M21-Fe51030	NCP	%	103			75-125	Pass	
Cadmium	M21-Fe51030	NCP	%	109			75-125	Pass	
Chromium	M21-Fe51030	NCP	%	106			75-125	Pass	
Copper	M21-Fe51030	NCP	%	104			75-125	Pass	
Lead	M21-Fe51030	NCP	%	108			75-125	Pass	
Mercury	M21-Fe51030	NCP	%	120			75-125	Pass	
Nickel	M21-Fe51030	NCP	%	102			75-125	Pass	
Zinc	M21-Fe51030	NCP	%	98			75-125	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1	Result 2	RPD			
TRH C6-C9	M21-Fe49329	NCP	mg/kg	< 20	< 20	<1	30%	Pass	
TRH C10-C14	M21-Fe53556	NCP	mg/kg	< 20	< 20	<1	30%	Pass	
TRH C15-C28	M21-Fe53556	NCP	mg/kg	< 50	< 50	<1	30%	Pass	
TRH C29-C36	M21-Fe53556	NCP	mg/kg	< 50	< 50	<1	30%	Pass	
Duplicate									
BTEX				Result 1	Result 2	RPD			
Benzene	M21-Fe49329	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Toluene	M21-Fe49329	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Ethylbenzene	M21-Fe49329	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
m&p-Xylenes	M21-Fe49329	NCP	mg/kg	< 0.2	< 0.2	<1	30%	Pass	
o-Xylene	M21-Fe49329	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Xylenes - Total*	M21-Fe49329	NCP	mg/kg	< 0.3	< 0.3	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
Naphthalene	M21-Fe49329	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
TRH C6-C10	M21-Fe49329	NCP	mg/kg	< 20	< 20	<1	30%	Pass	
TRH >C10-C16	M21-Fe53556	NCP	mg/kg	< 50	< 50	<1	30%	Pass	
TRH >C16-C34	M21-Fe53556	NCP	mg/kg	< 100	< 100	<1	30%	Pass	
TRH >C34-C40	M21-Fe53556	NCP	mg/kg	< 100	< 100	<1	30%	Pass	
Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Acenaphthene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Acenaphthylene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Anthracene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benz(a)anthracene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(a)pyrene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(b&j)fluoranthene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(g.h.i)perylene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(k)fluoranthene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Chrysene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Dibenz(a.h)anthracene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluoranthene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluorene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Indeno(1.2.3-cd)pyrene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Naphthalene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Phenanthrene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Pyrene	S21-Fe48603	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	

Duplicate									
Organochlorine Pesticides				Result 1	Result 2	RPD			
Chlordanes - Total	S21-Fe48603	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
4.4'-DDD	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
4.4'-DDE	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
4.4'-DDT	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
a-BHC	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Aldrin	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
b-BHC	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
d-BHC	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Dieldrin	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Endosulfan I	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Endosulfan II	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Endosulfan sulphate	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Endrin	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Endrin aldehyde	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Endrin ketone	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
g-BHC (Lindane)	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Heptachlor	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Heptachlor epoxide	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Hexachlorobenzene	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Methoxychlor	S21-Fe48603	NCP	mg/kg	< 0.05	< 0.05	<1	30%	Pass	
Toxaphene	S21-Fe48603	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Duplicate									
Polychlorinated Biphenyls				Result 1	Result 2	RPD			
Aroclor-1016	S21-Fe48603	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1221	S21-Fe48603	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1232	S21-Fe48603	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1242	S21-Fe48603	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1248	S21-Fe48603	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1254	S21-Fe48603	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1260	S21-Fe48603	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Total PCB*	S21-Fe48603	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic	M21-Fe51030	NCP	mg/kg	2.4	2.2	7.0	30%	Pass	
Cadmium	M21-Fe51030	NCP	mg/kg	< 0.4	< 0.4	<1	30%	Pass	
Chromium	M21-Fe51030	NCP	mg/kg	28	26	7.0	30%	Pass	
Copper	M21-Fe51030	NCP	mg/kg	21	20	5.0	30%	Pass	
Lead	M21-Fe51030	NCP	mg/kg	17	17	2.0	30%	Pass	
Mercury	M21-Fe51030	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Nickel	M21-Fe51030	NCP	mg/kg	11	10	7.0	30%	Pass	
Zinc	M21-Fe51030	NCP	mg/kg	11	10	6.0	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	S21-Fe48603	NCP	%	22	23	<1	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N01	F2 is determined by arithmetically subtracting the "naphthalene" value from the ">C10-C16" value. The naphthalene value used in this calculation is obtained from volatiles (Purge & Trap analysis).
N02	Where we have reported both volatile (P&T GCMS) and semivolatile (GCMS) naphthalene data, results may not be identical. Provided correct sample handling protocols have been followed, any observed differences in results are likely to be due to procedural differences within each methodology. Results determined by both techniques have passed all QAQC acceptance criteria, and are entirely technically valid.
N04	F1 is determined by arithmetically subtracting the "Total BTEX" value from the "C6-C10" value. The "Total BTEX" value is obtained by summing the concentrations of BTEX analytes. The "C6-C10" value is obtained by quantitating against a standard of mixed aromatic/aliphatic analytes.
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs

Authorised by:

Ursula Long	Analytical Services Manager
Emily Rosenberg	Senior Analyst-Metal (VIC)
Joseph Edouard	Senior Analyst-Organic (VIC)
Vivian Wang	Senior Analyst-Volatile (VIC)



Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

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IANZ # 1290

Sample Receipt Advice

Company name:	Ballpark Environmental Pty Ltd
Contact name:	-ALL SRAs & Results - Andrew Ballard & Joel Parkin
Project name:	BPE21011
Project ID:	C-0760.00
Turnaround time:	5 Day
Date/Time received	Feb 24, 2021 8:40 AM
Eurofins reference	777868

Sample Information

✓	A detailed list of analytes logged into our LIMS, is included in the attached summary table.
✓	All samples have been received as described on the above COC.
✓	COC has been completed correctly.
✓	Attempt to chill was evident.
✓	Appropriately preserved sample containers have been used.
✓	All samples were received in good condition.
✓	Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.
✓	Appropriate sample containers have been used.
✓	Sample containers for volatile analysis received with zero headspace.
X	Split sample sent to requested external lab.
X	Some samples have been subcontracted.
N/A	Custody Seals intact (if used).

Notes

Contact

If you have any questions with respect to these samples, please contact your Analytical Services Manager:

Ursula Long on phone : or by email: UrsulaLong@eurofins.com

Results will be delivered electronically via email to -ALL SRAs & Results - Andrew Ballard & Joel Parkin - info@ballparkenv.com.au.

Global Leader - Results you can trust

Ballpark Environmental Pty Ltd
PO Box 36
Nana Glen
NSW 2450

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Attention: **-ALL SRAs & Results - Andrew Ballard & Joel Parkin**

Report **778002-L**
Project name ADDITIONAL - BPE21011
Project ID C-0760.00
Received Date Mar 04, 2021

Client Sample ID			**BH106 0.2-0.3**
Sample Matrix			**US Leachate**
Eurofins Sample No.			**S21-Ma08427**
Date Sampled			**Feb 18, 2021**
Test/Reference	LOR	Unit	
Total Recoverable Hydrocarbons - 2013 NEPM Fractions			
Naphthalene[N02]	0.02	mg/L	< 0.1
BTEX			
Benzene	0.02	mg/L	< 0.02
Toluene	0.02	mg/L	< 0.02
Ethylbenzene	0.02	mg/L	< 0.02
m&p-Xylenes	0.02	mg/L	< 0.02
o-Xylene	0.02	mg/L	< 0.02
Xylenes - Total*	0.06	mg/L	< 0.06
4-Bromofluorobenzene (surr.)	1	%	133
Heavy Metals			
Arsenic	0.01	mg/L	< 0.01
Cadmium	0.005	mg/L	< 0.005
Chromium	0.05	mg/L	< 0.05
Copper	0.05	mg/L	< 0.05
Lead	0.01	mg/L	< 0.01
Mercury	0.001	mg/L	< 0.001
Nickel	0.01	mg/L	0.02
Zinc	0.05	mg/L	0.21
USA Leaching Procedure			
Leachate Fluid[C01]		comment	1.0
pH (initial)	0.1	pH Units	5.6
pH (off)	0.1	pH Units	5.0
pH (USA HCl addition)	0.1	pH Units	1.7
USA Leaching Procedure - ZHE			
Leachate Fluid		comment	1.0
pH (Leachate Fluid)	0.1	pH Units	5.0
pH (USA ZHE - off)	0.1	pH Units	5.3

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
BTEX	Sydney	Mar 04, 2021	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Metals M8	Sydney	Mar 05, 2021	180 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
USA Leaching Procedure	Sydney	Mar 04, 2021	14 Days
- Method: LTM-GEN-7010 Leaching Procedure for Soils & Solid Wastes			

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IANZ # 1290

Company Name: Ballpark Environmental Pty Ltd
Address: PO Box 36
Nana Glen
NSW 2450

Project Name: ADDITIONAL - BPE21011
Project ID: C-0760.00

Order No.:
Report #: 778002
Phone: 0400 566 088
Fax:

Received: Mar 4, 2021 9:35 AM
Due: Mar 5, 2021
Priority: 1 Day
Contact Name: -ALL SRAs & Results - Andrew

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						USA Leaching Procedure	Metals M8	USA Leaching Procedure - ZHE	BTEX and Naphthalene
Melbourne Laboratory - NATA Site # 1254 & 14271									
Sydney Laboratory - NATA Site # 18217						X	X	X	X
Brisbane Laboratory - NATA Site # 20794									
Perth Laboratory - NATA Site # 23736									
Mayfield Laboratory									
External Laboratory									
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**				
1	BH106 0.2-0.3	Feb 18, 2021		US Leachate	S21-Ma08427	X	X	X	X
Test Counts						1	1	1	1

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Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram | **mg/L:** milligrams per litre | **ug/L:** micrograms per litre

ppm: Parts per million | **ppb:** Parts per billion | **%:** Percentage

org/100mL: Organisms per 100 millilitres | **NTU:** Nephelometric Turbidity Units | **MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	mg/L	< 0.02			0.02	Pass	
Method Blank							
BTEX							
Benzene	mg/L	< 0.02			0.02	Pass	
Toluene	mg/L	< 0.02			0.02	Pass	
Ethylbenzene	mg/L	< 0.02			0.02	Pass	
m&p-Xylenes	mg/L	< 0.02			0.02	Pass	
o-Xylene	mg/L	< 0.02			0.02	Pass	
Xylenes - Total*	mg/L	< 0.06			0.06	Pass	
Method Blank							
Heavy Metals							
Arsenic	mg/L	< 0.01			0.01	Pass	
Cadmium	mg/L	< 0.005			0.005	Pass	
Chromium	mg/L	< 0.05			0.05	Pass	
Copper	mg/L	< 0.05			0.05	Pass	
Lead	mg/L	< 0.01			0.01	Pass	
Mercury	mg/L	< 0.001			0.001	Pass	
Nickel	mg/L	< 0.01			0.01	Pass	
Zinc	mg/L	< 0.05			0.05	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	%	89			70-130	Pass	
LCS - % Recovery							
BTEX							
Benzene	%	84			70-130	Pass	
Toluene	%	91			70-130	Pass	
Ethylbenzene	%	90			70-130	Pass	
m&p-Xylenes	%	93			70-130	Pass	
o-Xylene	%	94			70-130	Pass	
Xylenes - Total*	%	93			70-130	Pass	
LCS - % Recovery							
Heavy Metals							
Arsenic	%	101			80-120	Pass	
Cadmium	%	94			80-120	Pass	
Chromium	%	94			80-120	Pass	
Copper	%	88			80-120	Pass	
Lead	%	88			80-120	Pass	
Mercury	%	91			80-120	Pass	
Nickel	%	91			80-120	Pass	
Zinc	%	93			80-120	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Spike - % Recovery									
Heavy Metals				Result 1					
Arsenic	S21-Ma00080	NCP	%	108			75-125	Pass	
Cadmium	S21-Ma00080	NCP	%	113			75-125	Pass	
Chromium	S21-Ma00080	NCP	%	101			75-125	Pass	
Copper	S21-Ma00080	NCP	%	91			75-125	Pass	
Lead	S21-Ma00080	NCP	%	95			75-125	Pass	
Mercury	S21-Ma00080	NCP	%	95			75-125	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Nickel	S21-Ma00080	NCP	%	97			75-125	Pass	
Zinc	S21-Ma00080	NCP	%	99			75-125	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic	S21-Ma00080	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
Cadmium	S21-Ma00080	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Chromium	S21-Ma00080	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Copper	S21-Ma00080	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Lead	S21-Ma00080	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
Mercury	S21-Ma00080	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Nickel	S21-Ma00080	NCP	mg/L	0.01	0.02	37	30%	Fail	Q15
Zinc	S21-Ma00080	NCP	mg/L	0.10	0.13	23	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
C01	Leachate Fluid Key: 1 - pH 5.0; 2 - pH 2.9; 3 - pH 9.2; 4 - Reagent (DI) water; 5 - Client sample, 6 - other
N02	Where we have reported both volatile (P&T GCMS) and semivolatile (GCMS) naphthalene data, results may not be identical. Provided correct sample handling protocols have been followed, any observed differences in results are likely to be due to procedural differences within each methodology. Results determined by both techniques have passed all QAQC acceptance criteria, and are entirely technically valid.
Q15	The RPD reported passes Eurofins Environment Testing's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

Authorised by:

Asim Khan	Analytical Services Manager
John Nguyen	Senior Analyst-Metal (NSW)



Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

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Sample Receipt Advice

Company name:	Ballpark Environmental Pty Ltd
Contact name:	-ALL SRAs & Results - Andrew Ballard & Joel Parkin
Project name:	ADDITIONAL - BPE21011
Project ID:	C-0760.00
Turnaround time:	1 Day
Date/Time received	Mar 4, 2021 9:35 AM
Eurofins reference	778002

Sample Information

✓	A detailed list of analytes logged into our LIMS, is included in the attached summary table.
✓	All samples have been received as described on the above COC.
✓	COC has been completed correctly.
✓	Attempt to chill was evident.
✓	Appropriately preserved sample containers have been used.
✓	All samples were received in good condition.
✓	Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.
✓	Appropriate sample containers have been used.
✓	Sample containers for volatile analysis received with zero headspace.
X	Split sample sent to requested external lab.
X	Some samples have been subcontracted.
N/A	Custody Seals intact (if used).

Notes

Contact

If you have any questions with respect to these samples, please contact your Analytical Services Manager:

Ursula Long on phone : or by email: UrsulaLong@eurofins.com

Results will be delivered electronically via email to -ALL SRAs & Results - Andrew Ballard & Joel Parkin - info@ballparkenv.com.au.

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ENVIRONMENTAL

776231

Suite 2, 192 Pacific Highway
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NSW 2450 Australia
M: 0400 566 088
E. info@ballparkenv.com.au

Chain of Custody	Laboratory Quotation/ Order No:	**Price Book 2017-18**	**Project No.:**	**BPE21011** **C-0760.00**	Sheet 1 of 1
Dispatch to: Sample Receipt - Eurofins Unit F3, Bldg F 16 Mars Road LANE COVE NSW 2066	Sampled By:	Alex Weaver, Adam Phillips	Consigning Officer	*Alex Weaver*	
			Date Dispatched	22-Feb-21	
Attention: Sample receipt	Project Manager: (report results to)	info@ballparkenv.com.au	Courier Service:	TOLL	
			Consignment Note No.:		

Relinquished By:		Date:	Time:	Received By:	Date:	Time:
Alex Weaver				Suzanne Ford	24/2/21	8:46AM
Canberra		22/02/2021				

Comments:	Sample Matrix	Container Type & Preservative	Sample No.	Sample Depth (m)	Date Sampled:	Analyses Required: Suite B7 (TRH, BTEXN, PAH, M8)	Suite B13 (OCP/PCB)	pH	Conductivity (EC)	Asbestos ID in Soil	TCLP (M8, BTEXN)					Send to Eurofins Melbourne	HOLD	Sample Condition on Receipt
	Soil	250ml Glass Jar / snaplock bag	BH101	1.5-1.7	19-Feb-21	X	X	X	X	X								
	Soil	250ml Glass Jar / snaplock bag	BH102	1.65	18-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH103	0.6-0.7	18-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH103	1	18-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH103	2	18-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH104	0.5-1	17-Feb-21	X	X	X	X	X								
	Soil	250ml Glass Jar / snaplock bag	BH104	1	17-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH104	2	17-Feb-21												X	

Special Laboratory Instructions:

Detection Limits: Normal

Turnaround Required: Standard TAT Requested

BALLPARK ENVIRONMENTAL

Suite 2, 192 Pacific Highway
Coffs Harbour
NSW 2450 Australia
M: 0400 566 088
E. info@ballparkenv.com.au

Chain of Custody	Laboratory Quotation/ Order No:	Price Book 2017-18	Project No.:	BPE21011 C-0760.00	Sheet 1 of 1
Dispatch to: Sample Receipt - Eurofins Unit F3, Bldg F 16 Mars Road LANE COVE NSW 2066	Sampled By:	Alex Weaver, Adam Phillips	Consigning Officer	*Alex Weaver*	
			Date Dispatched	22-Feb-21	
Attention: Sample receipt	Project Manager: (report results to)	info@ballparkenv.com.au	Courier Service:	TOLL	
			Consignment Note No.:		

Relinquished By:	Date:	Time:	Received By:	Date:	Time:
Alex Weaver Canberra	***22/02/2021***		Lynne Ford	24/2/2021	8:40am

Comments:	Sample Matrix	Container Type & Preservative	Sample No.	Sample Depth (m)	Date Sampled:	Analyses Required: Suite B7 (TRH, BTEXN, PAH, M8)	Suite B13 (OCP/PCB)	pH	Conductivity (EC)	Asbestos ID in Soil	TCLP (M8, BTEXN)					Send to Eurofins Melbourne	HOLD	Sample Condition on Receipt
	Soil	250ml Glass Jar / snaplock bag	BH106	0.2-0.3	18-Feb-21	X	X	X	X	X	X							
	Soil	250ml Glass Jar / snaplock bag	BH106	1	18-Feb-21	X	X	X	X	X								
	Soil	250ml Glass Jar / snaplock bag	BH106	2	18-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH107	4	17-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH108	0.3-0.4	18-Feb-21	X	X	X	X	X								
	Soil	250ml Glass Jar / snaplock bag	BH108	1	18-Feb-21	X	X	X	X	X								
	Soil	250ml Glass Jar / snaplock bag	BH108	2	18-Feb-21												X	

Special Laboratory Instructions:

Detection Limits: Normal

Turnaround Required: Standard TAT Requested

BALLPARK ENVIRONMENTAL

Suite 2, 192 Pacific Highway
Coffs Harbour
NSW 2450 Australia
M: 0400 566 088
E. info@ballparkenv.com.au

Chain of Custody		Laboratory Quotation/ Order No:	Price Book 2017-18	Project No.: BPE21011 C-0760.00	Sheet 1 of 1
Dispatch to:	Sample Receipt - Eurofins Unit F3, Bldg F 16 Mars Road LANE COVE NSW 2066	Sampled By:	Alex Weaver, Adam Phillips	Consigning Officer	*Alex Weaver*
				Date Dispatched	22-Feb-21
Attention:	Sample receipt	Project Manager: (report results to)	info@ballparkenv.com.au	Courier Service:	TOLL
				Consignment Note No.:	

Relinquished By:	Alex Weaver	Date:	Time:	Received By:	Date:	Time:
	Canberra	22/02/2021		Suzanne Ford	24/2/2021	8.40AM

Comments:	Sample Matrix	Container Type & Preservative	Sample No.	Sample Depth (m)	Date Sampled:	Analyses Required: Suite B7 (TRH, BTEXN, PAH, M8)	Suite B13 (OCP/PCB)	pH	Conductivity (EC)	Asbestos ID in Soil	TCLP (M8, BTEXN)					Send to Eurofins Melbourne	HOLD	Sample Condition on Receipt
	Soil	250ml Glass Jar / snaplock bag	BH109	0.5	18-Feb-21	X	X	X	X	X								
	Soil	250ml Glass Jar / snaplock bag	BH109	1	18-Feb-21	X	X	X	X	X								
	Soil	250ml Glass Jar / snaplock bag	BH109	2	18-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH110	0.2-0.3	18-Feb-21	X	X	X	X	X								
	Soil	250ml Glass Jar / snaplock bag	BH110	1	18-Feb-21	X	X	X	X	X								
	Soil	250ml Glass Jar / snaplock bag	BH110	2	18-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH111	0.5-0.6	17-Feb-21	X	X	X	X	X								
	Soil	250ml Glass Jar / snaplock bag	BH111	1	17-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH111	2	17-Feb-21												X	

Special Laboratory Instructions:

Detection Limits: Normal

Turnaround Required: Standard TAT Requested

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Chain of Custody			Laboratory Quotation/ Order No:	Price Book 2017-18	Project No.: BPE21011 C-0760.00	Sheet 1 of 1
Dispatch to:	Sample Receipt - Eurofins Unit F3, Bldg F 16 Mars Road LANE COVE NSW 2066		Sampled By:	Alex Weaver, Adam Phillips	Consigning Officer	*Alex Weaver*
					Date Dispatched	22-Feb-21
Attention:	Sample receipt		Project Manager: (report results to)	info@ballparkenv.com.au	Courier Service:	TOLL
					Consignment Note No.:	
Relinquished By:	Alex Weaver	Date:	Time:	Received By:	Date:	Time:
	Canberra	***22/02/2021***			22/2/2021	8.40AM

Comments:	Sample Matrix	Container Type & Preservative	Sample No.	Sample Depth (m)	Date Sampled:	Analyses Required: Suite B7 (TRH, BTEXN, PAH, M8)	Suite B13 (OCP/PCB)	pH	Conductivity (EC)	Asbestos ID in Soil	TCLP (M8, BTEXN)					Send to Eurofins Melbourne	HOLD	Sample Condition on Receipt
	Soil	250ml Glass Jar / snaplock bag	BH112	0.5-0.6	17-Feb-21	X	X	X	X	X								
	Soil	250ml Glass Jar / snaplock bag	BH112	1	17-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH113	0.2-0.3	16-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH113	1	16-Feb-21	X	X	X	X	X								
	Soil	250ml Glass Jar / snaplock bag	BH113	2	16-Feb-21												X	
	Soil	250ml Glass Jar / snaplock bag	BH113	3	16-Feb-21												X	
	Soil	250ml Glass Jar	QC01		16-Feb-21	X	X											
	Soil	250ml Glass Jar	QC02		16-Feb-21	X	X									X		
	Soil	250ml Glass Jar	QC03		17-Feb-21	X	X											
	Soil	250ml Glass Jar	QC04		17-Feb-21												X	

Special Laboratory Instructions:

Detection Limits: Normal

Turnaround Required: Standard TAT Requested

Public Works
Department of Regional NSW

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