Proposed Kariong Sand and Soil Supplies Facility – SSD8660

Water Cycle Impact Asessment and Soil and Water Management Plan

Report Prepared for: Kariong Sand and Soil Supplies

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Project No. 197

Prepared by:

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EXECUTIVE SUMMARY

The Sustainability Workshop (TSW) was commissioned by Kariong Sand and Soil Supplies (KSSS) to undertake a water cycle impact assessment and soil and water management plan of a proposed sand, soil and building materials recycling facility located at 90 Gindurra Road at Kariong, NSW. The development is on Lot 4, DP 227279 and the developable area is 6.05 hectares (ha).

This report supersedes previous work and the treatment train proposed is a robust world class water management approach.

This report addresses the SEARs, identifies contaminants of concern, pollutant transport mechanisms and describes mitigation measures and predicted water quality performance in detail.

The proposal is for a state of the art recycling facility that will make a meaningful contribution to protecting water quality off the site by reducing the demand for virgin materials which can have a very negative impact on the water cycle at the point of extraction.

Incoming waste will be inspected in a covered and bunded tip and spread building. Accepted raw waste is then to be stored in storage bays, moved to a processing area and processed or transformed into a building product which will then be stored in product storage bays and sold.

The proposed development will see a combination of concrete hardstand areas and flexible pavement constructed from recycled crushed concrete to form a stable, non-erosive working environment. In accordance with EPA best practice guidelines, a geomembrane will be placed below all unsealed pavements to protect local groundwater resources.

From a land-use planning perspective, considering the 400m distance to the nearest waterway, the 4 hectare vegetated buffer offered by the site itself together with the flood free elevation of the site it is concluded that the proposed land use is well suited to this parcel of land and has few constraints.

Key sources of stormwater pollution will arise from the diverse range of activities on the site noting that some of them will see pollution generated which will need to be mitigated.

Key pollutants of concern have been identified in the report and modelled in accordance with best practice approaches to establish likely load rates.

The discharge point for the proposed development is located 400m away from a waterway. The largest potential impacts are the impacts on the health and stability of the bushland downstream of the proposed discharge point rather than off the site.

In this instance it is proposed that a neutral or beneficial effect test (NorBE) should be applied. This is the most stringent test applied by any regulator in NSW and is typically applicable to drinking water catchments – which we note this catchment is not.

Frequency of site discharge is considered an indicator of geomorphic impacts. If the frequency of site discharge can remain close to predevelopment conditions, then it is likely that the discharge will have few geomorphic (erosional) impacts.

Ensuring the discharges from the site, when they do occur, remain below erosive thresholds is also critical as is the need to ensure that the development does not increase flood risk by increasing peak flow rates or flow volumes for a range of storms and exceedance probabilities. Here the 1 in 1 year event and 1 in 100 year event are used as benchmarks.

Harvested stormwater should comply with the NSW stormwater harvesting guidelines[1] and Australian Guidelines for Water Recycling[2]. As this stormwater is not be supplied to any other party i.e. is to remain on site, these remain the only applicable guidelines.

Proposed Mitigation Measures

The site will comply with the requirements of the Blue Book during construction and this will ensure that construction phase sediment impacts are minimised.

The site has been broken into low, medium and high risk sub-catchments.

The northern part of the site which includes the warehouse is deemed a low risk catchment. This is treated in rainwater tanks and then piped to a gross pollutant trap before being piped to a large 5ML water quality pond which includes floating treatment wetlands. The pond overflows to a level spreader where additional infiltration will occur. Treated water from the pond will be used to irrigate the site to suppress dust to maintain good air quality once the water has been further treated in a membrane filtration system. This treatment system is a state of the art, world class stormwater management system that is on the cutting edge.

Wherever possible, the medium risk areas of the site first drain to a GPT then to a linear bioswale located on the western side of the development. These medium risk areas are the areas which include storage of products and where blending or processing activities occur.

The bioretention system will provide a high degree of tertiary treatment to the runoff.

The high risk part of the site is that part that contains the waste storage area and the timber processing area. This is the part of the site which affords the best opportunity to intervene to limit unusually high pollutant loads. If a potential water quality problem is going to occur on the site it is most likely to occur in this area as it stores unprocessed materials that may escape the rigorous tip and spread screening and rejection process.

In the high risk area continuous 24/7 real time water quality and flow monitoring will occur.

In addition to the 5 ML water quality pond, an emergency spill pond of 500 m^3 volume will be provided. This will enable up to 60 mm of runoff to be contained in the spill pond from the high risk catchment.

Predicted Results

Water Quantity

Results are predicted as follows:

[1] NSW DECC, Managing Urban Stormwater: Harvesting and Reuse, 2006.

[2] NWQMS, Australian Guidelines for water recycling: managing health and environmental risks (phase 2) stormwater harvesting and reuse, July 2009

Storm Probability – 1 in X years	Predevelopment peak flow (100% pervious) m³/s	Post Development peak flow (100% impervious) m³/s	Peak velocity over level spreader
1 in 1	0.312	0.218	0.26m/s
1 in 10	0.917	0.911	0.45 m/s
1 in 100	1.88	1.48	0.55 m/s

Peak velocities to occur in a 50m wide channel below the level spreader are predicted to be below erosive thresholds for all storms up to the 10% AEP. Storms rarer than the 10% AEP might result in minor temporary erosion. These storms occur so infrequently that this erosion would have time to self-repair through natural revegetation.

Water Quality Results

		Treatment-train Effectiveness (% Reduction of Pollutants)			% Reduction	Target
	(1) Pre-European (forested land use)	(2) Pre-development or existing loads	(3) Post Development without treatment in place	(4) Post-development (with proposed treatment system)	Reduction from column (3) to column (4).	
Frequency of discharge into bushland	5	80	80	8	90	
Flow (ML/yr)	9.76	31.6	45.2	13.4	70.4	
Total Suspended Solids (kg/yr)	950	3840	7540	567	92.1	80
Total Phosphorus (kg/yr)	1.19	6.57	12.9	1.94	84.2	45
Total Nitrogen (kg/yr)	16.9	55.5	96.3	21.3	77.9	45

MUSIC water quality model results clearly show the site will exceed its best practice target and deliver water quality that is better than what is currently discharged from the site.

Assessing concentration at the 99th percentile it is likely that the proposal will be able to meet typical licence limits for waste management facilities.

In conclusion the development will address both chronic and acute water quality risks through a best practice state of the art water cycle management system. The development will attenuate peak flows for the whole range of events – from 1 year to 100 year.

Based on the best practice system proposed it is highly probable that the development would not cause environmental harm or pollution either in terms of total loads or absolute concentrations or in terms of alterations to flow regimes.

It is recommended the development be approved subject to the proposed mitigation measures being implemented and to conduct on-going monitoring, maintenance and management of the proposed system. A licence is likely to be required for TSS and may, subject to the EPA, be required for TP and TN.

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TABLE OF ABBREVIATIONS

Abbreviation	Definition
µg/L	Micrograms per litre
1% AEP	1 in 100 year flood event
1EY	1 in 1 year flood event
AEP	Annual exceedance Probability
AGWR	Australia Guidelines for Water Recycling
ANZECC	Australian and New Zealand Environment Conservation Council
CFU	Coliform Units
CRP	Current Recommend Practices – these are legal obligations under the Drinking Water Catchment SEPP
Cu	Copper
DCP	Development Control Plan
EIS	Environmental Impact Statement
EMC	Event mean concentration – refers to average water quality from a land-use
EPA	Environmental Protection Authority
ET	Evapotranspiration
Floodplain	That part of the land that is flooded in a PMF event.
GPT	Gross Pollutant Trap
GV	Guideline value
kL	Kilolitre or 1,000 litres
LEP	Local Environment Plan
LTV and STV	Long term and short-term value
M. Biconvexa	Melaleuca Biconvexa
m^3	Cubic metre or 1,000 litres
mg/L	Milligrams per litre
ML	Megalitre or million litres

MUS	Managing Urban Stormwater publication by NSW EPA
MUSIC	Model for Stormwater Improvement Conceptualisation
NorBE	Neutral or Beneficial Effect – refers to water quality needing to be better after development than it is before development
NSW	New South Wales
NTU	Nephelometric unit
OEH	Office of the Environment and Heritage
OSD	On site detention
OSR	On site retention
Pb	Lead
PET	Potential Evapotranspiration
PMF	Probable Maximum Flood
RL	Reduced Level or level measured against the Australia Height Datum.
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environment Planning Policy
TN	Total Nitrogen
TP	Total phosphorus
TSS	Total suspended solids – is the weight of solids captured on filter paper after oven drying.
UV	Ultra violet
WHS	Work Health and Safety
yr	year
Zn	Zinc

1.0 INTRODUCTION

1.1. Background and Context

The Sustainability Workshop (TSW) was commissioned by Kariong Sand and Soil Supplies (KSSS) to undertake a water cycle impact assessment and soil and water management plan of a proposed sand, soil and building materials recycling facility located at 90 Gindurra Drive at Kariong, NSW. The development is on Lot 4, DP 227279 and the developable area is 6.05 hectares (ha).

This report supersedes all previous water cycle management plans and soil and water management plans by Cardno. This additional work will also result in the regrading of the proposed development site.

This report addresses the SEARs, identifies contaminants of concern, pollutant transport mechanisms, describes mitigation measures and predicted water quality performance in detail.

The nearest watercourse to the site is a first order water course, located 400m from the southern limit of works. The southern portion of the site, 4 hectares in area, will remain undeveloped and while it will provide a significant natural vegetated buffer to the nearest watercourse, it is considered that the proposed development should aim to protect this vegetation and treat it as if it is a sensitive receiving water.

The first order water course 400m from the site eventually drains into Piles Creek, a fourth order creek with significant ecological and recreational value, inside Brisbane River National Park and ultimately into Mooney Mooney Creek, a major tributary of the Hawkesbury River. These are all considered sensitive receiving waters.

The intent of the facility is to provide a best practice, sustainable and well-designed facility to enable the recycling and reuse of sand, soil and building materials including crushed concrete and timber. The facility will transform incoming waste streams into products using specialist plant and equipment. All processing plant and equipment will be housed inside buildings to limit noise, air and water quality impacts from the waste processing activity. By recycling concrete and sand, which would have otherwise been extracted from a natural source with numerous environmental impacts, this facility has a very positive external water cycle impact – it protects waterways in others areas by reducing the demand for virgin materials which are frequently extracted from creeks and rivers causing irreversible (unsustainable) damage.

1.2. Scope of Works

Sustainability Workshop has been commissioned to assess the water quality impacts of the proposed development. This document assesses the following water cycle impacts:

- Long term surface water quality impacts associated with the development

- Recommended mitigation measures to comply with an environmental protection licence (EPL) required to ensure the site does not breach the Protection of the Environment Operations Act.
- Assessing the impacts of the proposed development on the stability of the discharge point.
- Flood risk and drainage – the on-site stormwater detention has been designed to retard post development flows to match predevelopment flows for rainfall annual exceedance probabilities from the 1 year to the 100 year.
- Soils and water management during construction – the proposal will comply with the Blue Book during construction.

The scope of works also included a direction to consider and assess all regulator comments made in relation to the Draft EIS. Key issues identified were by EPA and OEH. EPA dismissed the use of its own load based approach to water quality management and instead described the need to limit discharge from the site to a very few number of events per year. The EPA referred to the Blue Book extensively for management of operational impacts.

OEH has identified a range of issues notably the validity of water balance, the need to check erosion and scour at the point of discharge etc. This revised assessment attempts to address all identified issues.

1.3. Secretary's Environmental Assessment Requirements

The Secretary's Environmental Assessment Requirements (SEARS) detail what is required to be included in the Environmental Impact Assessment (EIS).

Table 1 summarises the relevant requirements (pertaining to water issues) and identifies the location in this report where each SEAR has been addressed.

Table 1: SEARS pertaining to water issues

SEARs	Relevant report section
Identify any soil or water contamination on the site	Section 2
Describe existing water and soil resources, topography, hydrology, riparian lands etc	Section 2 describes existing conditions and natural resources
Provide a detailed site water balance with a focus on water conservation and secure water supply	Section 5 and 6 describe impacts and mitigation

SEARs	Relevant report section
Characterisation of water quality at point of discharge against the relevant water quality criteria. Identify contaminants of concern and proposed mitigation measures	Section 4 discussed relevant water quality criteria Section 5, 6 ,7 and 8 describe impacts and mitigation
Details of stormwater/wastewater/leachate management systems including on site detention and measures to treat and reuse or dispose of water	Section 7
A description of erosion and sediment controls	Section 9 presents a Soil and Water Management Plan
An assessment of potential impacts to soil and water resources etc on or nearby the site	Section 5,6
Consideration of Salinity and Acid Sulphate soils	Section 2

1.4. EPA SEAR's Response

The EPA provided the following SEAR's response:

- Provide details of the project that are essential for predicting and assessing impacts to waters including:
  a) the quantity and physio-chemical properties of all potential water pollutants and the risks they pose to the environment and human health, including the risks they pose to Water Quality Objectives in the ambient waters (as defined on http://www.environment.nsw.gov.au/ieo/index.htm, using technical criteria derived from *the Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, ANZECC 2000)
  b) the management of discharges with potential for water impacts
  c) drainage works and associated infrastructure; land-forming and excavations; working capacity of structures; and water resource requirements of the proposal.

- Outline site layout, demonstrating efforts to avoid proximity to water resources (especially for activities with significant potential impacts e.g. effluent ponds) and showing potential areas of modification of contours, drainage etc.
- Outline how total water cycle considerations are to be addressed showing total water balances for the development (with the objective of minimising demands and impacts on water resources). 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.

1.5. Previous Cardno Design Superseded

A review of the previous Cardno design by various State Government agencies and by the Proponent found that the Cardno design was unlikely to achieve the development targets and mitigate its impact in a satisfactory manner. Sustainability Workshop was requested to comprehensively review the design and amend it to ensure that all water cycle impacts were mitigated to sustainable levels.

Key issues of concern were:

1) The volume of proposed on-site retention was insufficient
2) The volume of proposed on-site detention was insufficient
3) The hydraulic configuration, i.e. devices were proposed in locations where they were not going to perform as expected due to hydraulic reasons. An example of this was the proposal to include a Jellyfish water quality treatment device. The Jellyfish was proposed downstream of the storage pond where it would have conflicted with outlet control from the detention basin.
4) Maintenance was not a key consideration in the design – for example, the proposed Jellyfish was proposed in a location where it could not have been maintained by the Proponent
5) The proposed surface levels were not consistent between the civil design and the hydraulic design and as a result no effective on site detention would have been achieved
6) The size of the level spreader did not appear to be based on a rigorous analysis
7) No real effort to reduce the frequency of discharge from the site was undertaken and it is likely there would have been significant scour downstream as a result
8) The site water balance underestimated demand for water significantly

All of these issues have now been comprehensively addressed in this report.

A summary of some of the key design changes is included below.

Table 2 Comparison of Cardno and Sustainability Workshop Systems

System Element	Cardno Proposed Size	Sustainability Workshop Proposed Size	% change
Rainwater Tank volume	10 kL	230 kL	23 times larger
OSD volume	685m3	2,500 m3	6.5 times larger
Pond storage volume	About 550m3	5,000 m3	10 times larger
Pond overflow frequency (less is better – natural system is about 5 to 8/year)	35/year	8/year	Reduced by 4.5 times.

1.6. Response to Submissions

Appendix 4 includes the Response to Submissions. The submissions responded to the Cardno design. Following the public exhibition process, the proposed system was redesigned and remodelled to assess its impact. Each submission has been addressed in the current design.

2.0 EXISTING ENVIRONMENT

2.1. Description of Existing Environment

The existing site is shown in Figure 1 below:

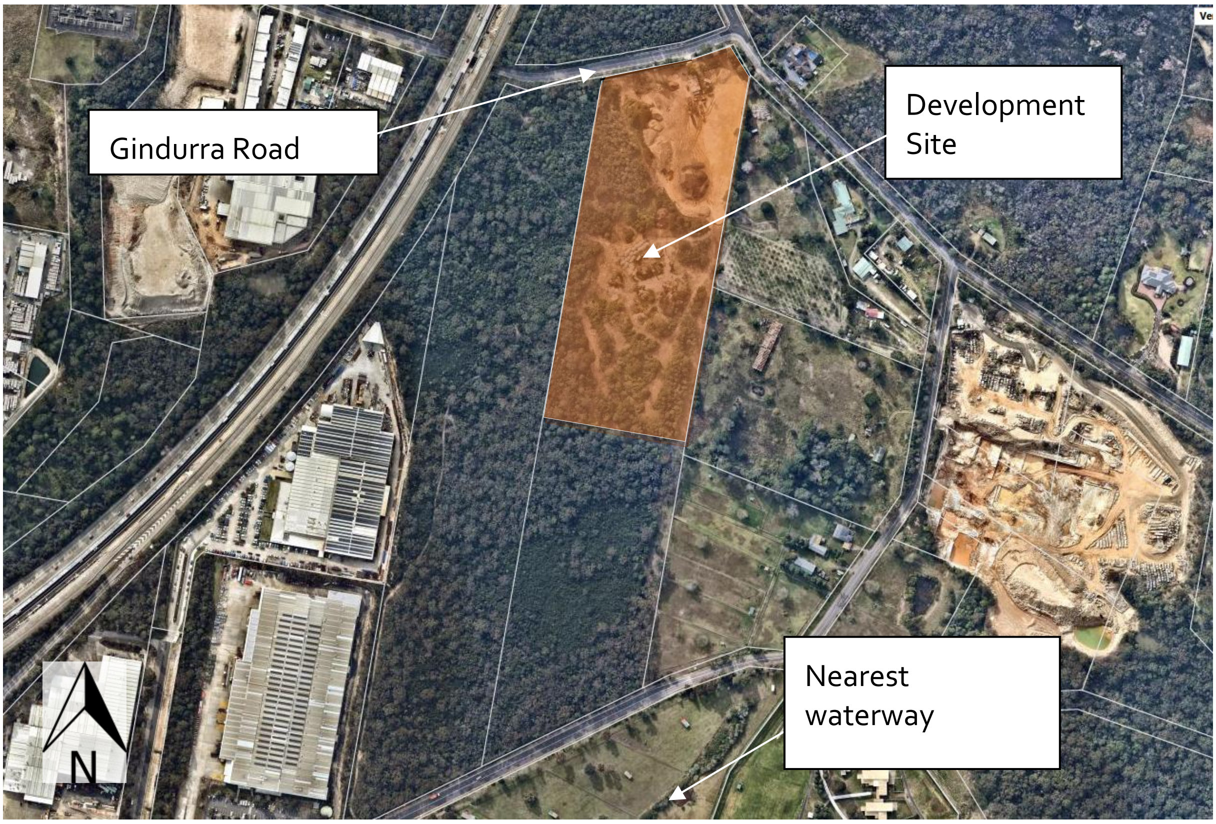

Figure 1: Proposed Recycling Facility at Kariong (in orange)

Figure 1 shows the existing industrial context at Kariong with the proposed development site shown covering about 60% of its lot in orange.

Figure 2 shows the proposed development area more closely. Existing, approved activities are visible including the commencement of earthworks for the construction of the approved warehouse located in the north east of the site.

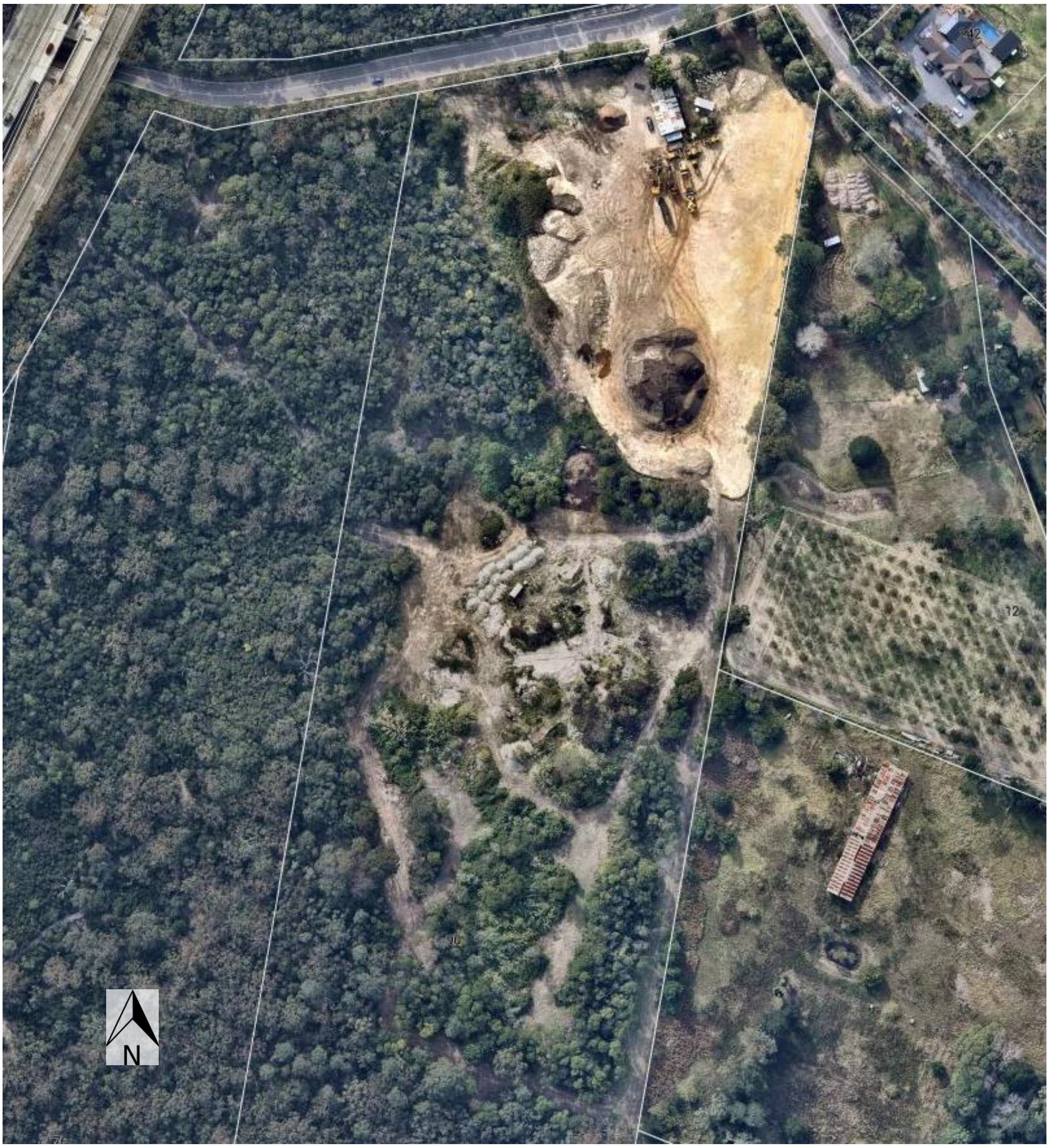

Figure 2 Close up of proposed development site.

2.2. Existing Conditions

The development site is currently partially cleared with no incised flow paths. Overland flows would be characterised as broad shallow, low velocity flows. It would be of value to maintain the broad shallow overland flows and to avoid creation of an incised high velocity drain through the site.

The distance between the point of discharge from the proposed development and the nearest waterfront land is approximately 400m. The flow path to the creek is well vegetated with a mix of native vegetation on the development site and grass. Kangoo Road has recently been upgraded with the installation of kerb and gutter and drainage. Flows from the site would be conveyed, along with road runoff, in the Council drainage system.

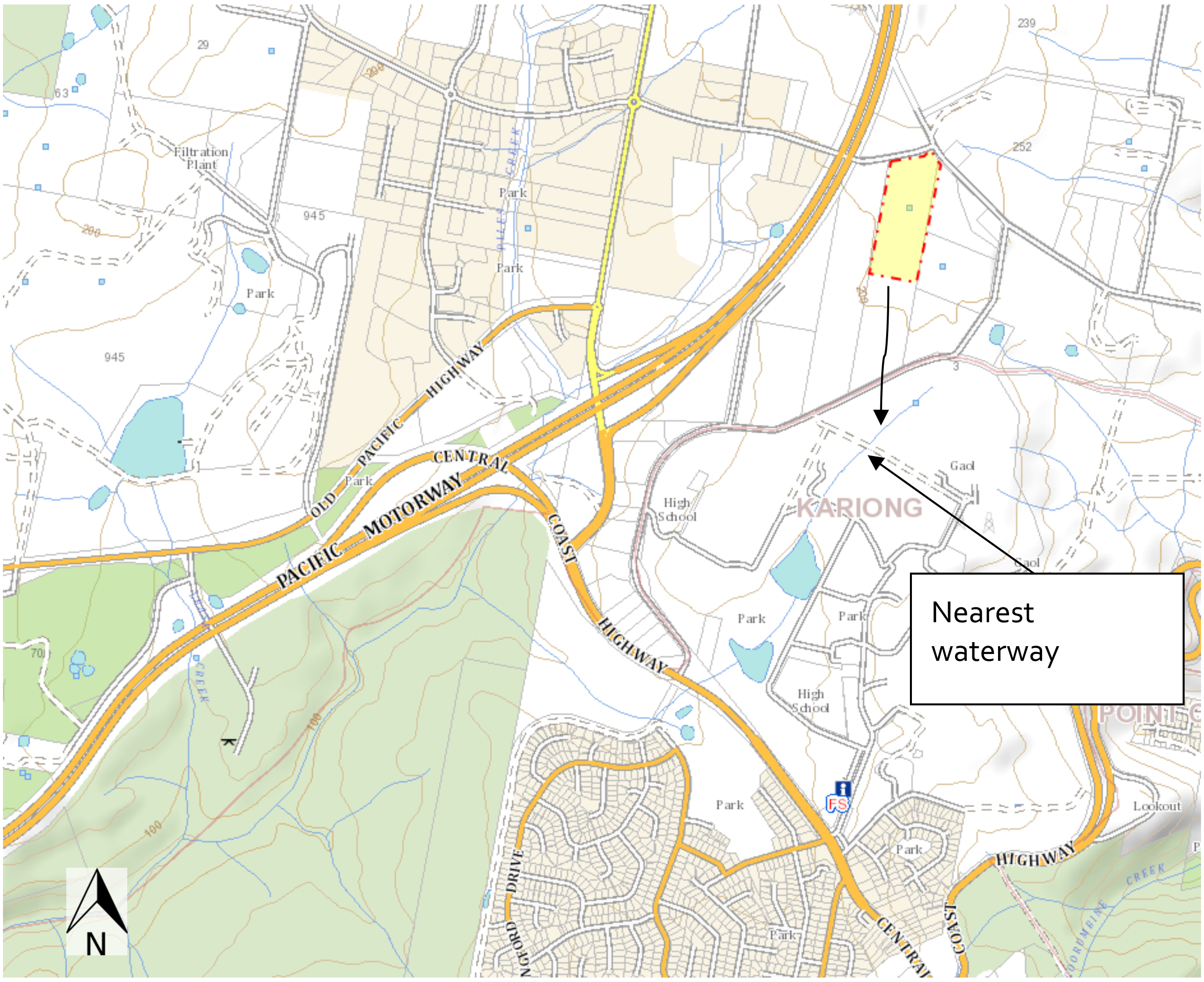

Figure 3 Overland flow paths from the site (shown in yellow) to the nearest waterway

The approximate discharge point is shown below in **Plate 1**.

Plate 1 Looking south west at the proposed discharge location.

2.3. Soils

This section is repeated from the Cardno Report (Cardno 2018).

A review of the NSW Office of Environment and Heritage, eSPADE V2.0 Mapping System (NSW Office of Environment and Heritage, 2016) indicates that the site is situated within the Sydney Town landscape (9130st) typically comprising undulating to rolling low hills and moderately inclined slopes on quartz sandstone of the Terrigal and Hawksbury sandstone formations with typical slope gradients of between 5-25%.

A review of the 1:100,000 Gosford-Lake Macquarie Geological Map (New South Wales Trade and Investment, Resource and Energy) indicates that the site is situated on the Hawksbury Sandstone (Rh) formation comprising medium to coarse grained quartz sandstone with minor laminated mudstone and siltstone lenses.

Douglas and Partners (Douglas and Partners, 2019) were commissioned to carry out drilling works to construct three groundwater wells on the site. A description of the site soils is copied from the Douglas and Partners Report below:

- Topsoil and Silty Sand: Fine to medium grained grey-brown silty sand soil was encountered in all bores to relatively shallow depths (0.35 m to 0.5 m below ground level (bgl)).
- Weathered Sandstone: Fine to medium grained generally light grey-brown to dark red-brown weathered sandstone with iron cemented bands were encountered in all bores to the termination depth of the bores (3.5 m to 8.5 m bgl).

2.4. Ambient Water Quality

Some recent testing of surface water quality from a dam on the site was undertaken by Cardno (Cardno 2018).

The test results found that:

- There were no detectable levels of pesticides, BTEX or hydrocarbons on the sites.
- NO_X and Ammonia was well below ANZECC default guideline values (DGVs).
- TSS was not tested.
- Turbidity was about 3.4 NTU indicating clear water with slight discolouration.
- Salts were low.
- The water was slightly alkaline – pH of 7.7
- Manganese, Arsenic and Zinc were the only metals detected. They were detected at very low concentrations and all at concentrations below the 95% level of protection[3] while Manganese was at concentrations below the 99% level of protection.

2.5. Acid Sulphate Soils and Salinity

Douglas and Partners, based on acid sulphate soil mapping and a site geological and groundwater analysis have identified the acid sulphate risk of the site as negligible.

Surface water testing and groundwater testing has shown very low levels of salinity in both surface and groundwaters.

The proposed development will be connected to the sewerage system and no disposal of effluent on site will occur. Reuse of stormwater, which is typically very low in salinity will occur.

Neither acid sulphate soils nor salinity poses a risk or constraint to development and consequently will not be considered further.

[3] ANZECC 2000 Guidelines for Aquatic Ecosystems – on-line toxicity tool.

2.6. Existing Groundwater Data – Depth and Quality

Douglas Partners (Douglas Partners 2019) were commissioned to establish 3 groundwater bores on the site and to collect baseline data from those bores.

Their report identified a considerable number of groundwater bores surrounding the subject development. Protection of groundwater must be undertaken to protect regional groundwater which is a locally important resource.

All 3 bores were drilled through topsoils – silty sands and into Hawkesbury sandstone to refusal. The bores vary in depth from 3.5 m to 8.5 m.

Groundwater was found to be present in two bores with bore logs for Bore 3 registering that there was no goundwater seepage. The water quality in the bores was tested and found to be free of pesiticides. Low levels of dissolved zinc and lead were detected in the groundwater. Douglas Partners concluded zinc concentrations are likely to be consistent with background levels for Hawkesbury sandstone – i.e. naturally occuring. Lead concentrations in Well 2 located in the middle of the site below some of the disturbed parts of the site were found at concentrations of 0.004 µg/L. This is at a concentration that exceeds the AZNECC 95th percentile level of protection for aquatic ecosystems but is below, i.e. meets the 90th percentile level of protection.

For reference lead concentrations were well below drinking water guidelines, which are 10 µg/L.

In conclusion, there is some evidence of a minor impact of past activities on groundwater and no evidence of systematic pollution. It is clear that stockpiles of metals have the potential to leach into groundwater and inclusion of geomembrane to protect groundwater is justified.

2.7. Floodplain Risk Assessment

A Flood Information Letter for the lot was obtained from Central Coast Council and indicates the site is not subject to 1% AEP flooding.

Interrogation of Council’s on-line mapping tool shows that there are floodplains to the east and west of the site however the lot in question is not subject to flooding.

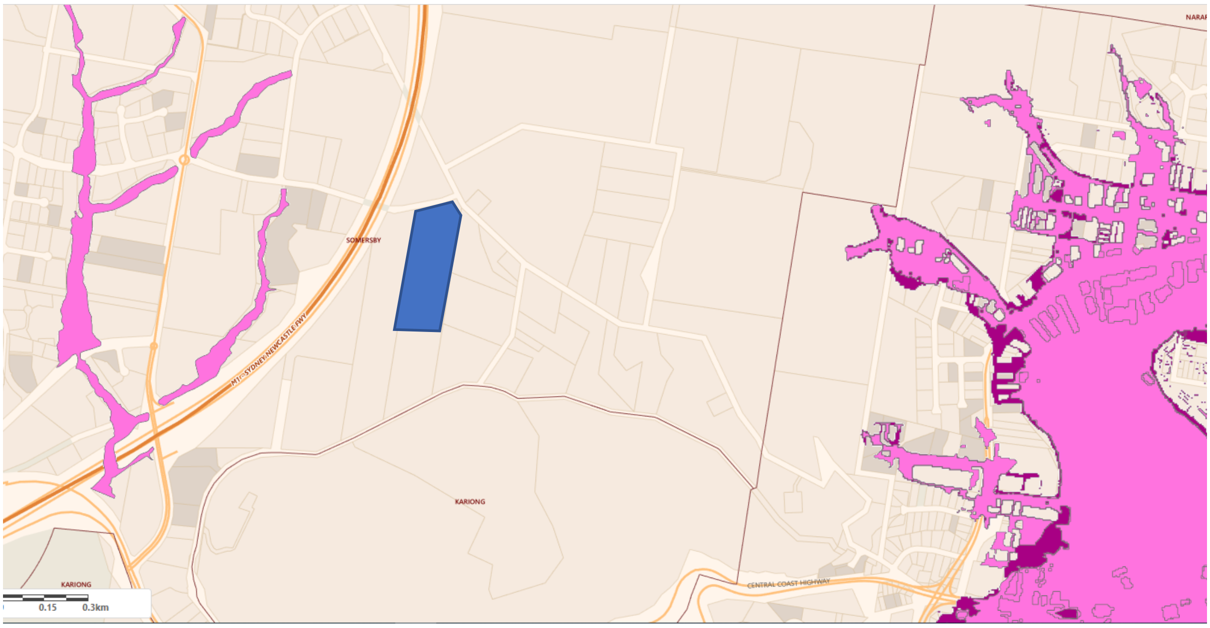

Figure 4 1% AEP Flood Precincts for 90 Gindurra Road – site in blue

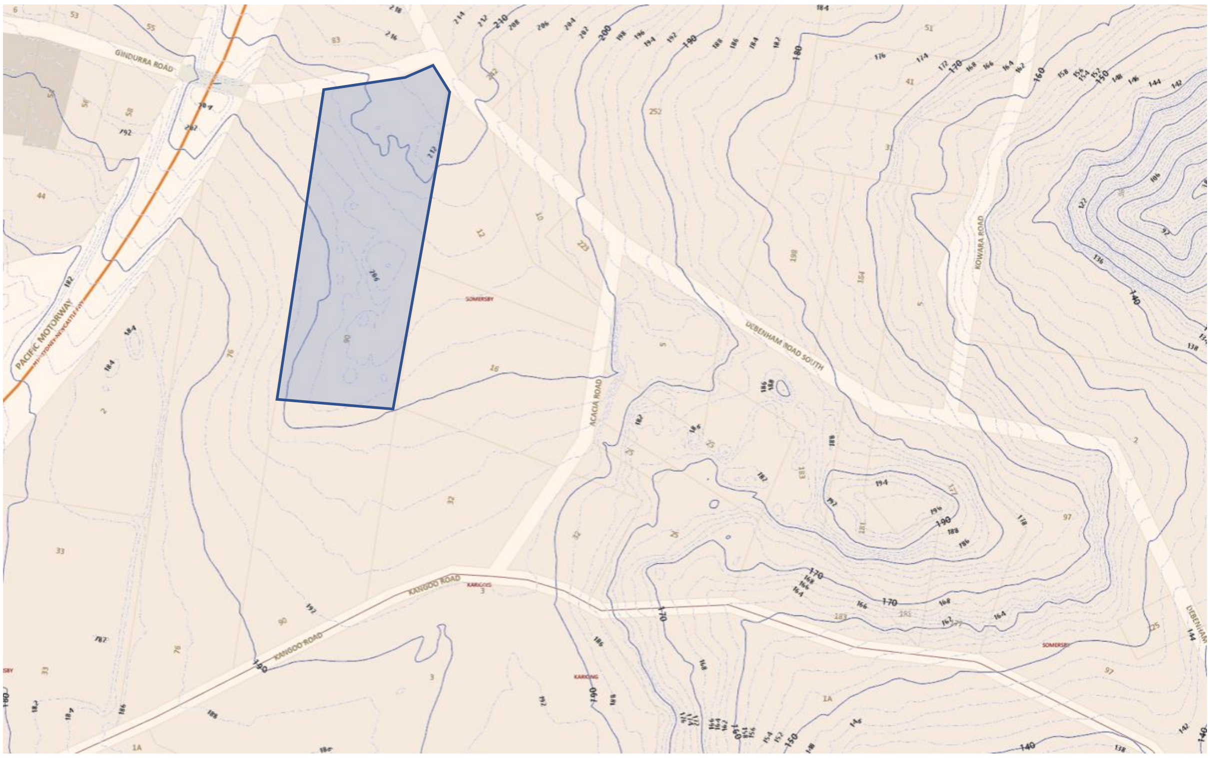

Figure 5 Regional Contours (with proposed development footprint shown in blue)

Figure 5 Shows the site is located on the ridge line close to Mount Penang at an elevation of nominally 220m above sea level. The contours demonstrate the site, if developed will not obstruct any overland flow paths nor push water onto an adjoining block. There is ample grade across the site, from north to south, with a 20m change in elevation from the northern boundary to the southern boundary.

This proposal sees any runoff from the site directed south where it is to remain on the lot and not onto any adjoining lot.

We conclude there is a very low probability of the site being subject to either the 1% AEP flood or the PMF flood. We conclude there is a negligible probability of the site causing a change in flood behaviour, change in flood velocity or any alteration to the existing flood regime or flood risk.

Being located on the ridge line, elevated above surrounding land and in addition, subject to filling to raise the southern part of the site, the site has a negligible probability of experiencing flooding.

Kangoo Road is located to the south of the lot. It is important to ensure that post development peak flows do not exceed predevelopment peak flows for the full range of events, from the 1EY (1 year storm event) up to the 1% AEP event to ensure that there would not be any impact on Kangoo Road.

Apart from the need to implement on site detention to achieve the above outcome, floodplain risk management is not considered further in this EIS.

3.0 OVERVIEW OF PROPOSED DEVELOPMENT

The following information has been prepared by Jackson Environment and Planning Pty Ltd.

3.1. Project Description

The Kariong Sand and Soil Supplies development will involve the construction and operation of a best practice recycling and landscape supplies facility that will enable the receipt of up to 200,000 tonnes of sand, soil and building materials each year. The project will transform the site into a state-of-the-art facility turning sand, soil and building materials into 100% recycled building and landscaping supplies. The facility aims to produce a number of building and landscape products, providing them for re-use mainly in the Central Coast region.

The proposed development will seek to expand the current facility into a best-practice recycling plant that will assist the Central Coast in achieving the NSW Government's target of an 80% recycling rate for construction and demolition waste by 2021.

The project will involve the development of a largely undeveloped industrial site, to enable the facility to be used to receive, process and recycle construction and demolition waste, as well as supply building and landscape supplies for local projects. All waste materials will be received and processed indoors, to minimise impacts on the environment and neighbours.

The front part that will be visible from Gindurra Rd will be the landscaping supply operations, including landscaping along the road frontage and landscape storage bays behind the set-back area. A fully enclosed warehouse where sorting and recycling operations will be conducted will be visible from the front of the site. Along the eastern boundary, a noise barrier and a native landscape buffer will be planted to avoid noise impacts on nearly rural dwellings, and to provide an aesthetically pleasing interface between the edge of the Somersby Industrial Estate and nearby rural zone lots and dwellings.

Waste processing and recycling operations for selected materials, including crushing and mulching will be done on the southern section of the site, where processing will also be done in dedicated buildings to avoid any impacts on nearby land uses. These operations are to be conducted at maximum distance from any sensitive receptors. The southern section of the site will be retained as bushland to provide a natural buffer between the development and other residential areas more than a kilometre away from the southern boundary of the site.

Advanced water capture, rainwater and stormwater harvesting, water treatment and dust suppression systems will be integrated in all buildings and outdoor areas to prevent dust being formed. The site will also include an advanced membrane filtration plant to enable much of the water captured from the site to be fully reused across the site for operational uses. The site will also include its own weather monitoring station, high volume air samplers for continuous air quality and dust analysis, and continuous noise loggers to confirm compliance with consent and licence conditions. The site will be fully serviced with fire suppression systems.

Flow charts providing an operational overview of the proposed development is provided in Figure E1 (recycling operations) and Figure E2 (landscaping and building supplies operation).

Figure E1. Process flow chart for recycling operations.

Entry

- Trucks enter in the forward direction via the site entrance gate off Gindura Rd and follow the internal roadway
- Trucks weigh onto the 26m weighbridge and mass of the vehicle is weighed in accordance with the *Protection of the Environment Operations (Waste) Regulation* 2014
- Driver is interviewed to confirm contents of load and materials can be permitted on site, and surface of contents of truck is inspected to ensure presence of compliant materials only

Inspection and unloading

- Trucks move through designated internal roadway to the Tip and Spread Waste Receival Building'
- Trucks tip into waste inspection area in the Tip and Spread Waste Receival Building
- Any dust is controlled with ceiling mounted misting system
- Loader / excavator spreads load to a depth of approximately 100mm
- Any hazardous items or contamination is removed by operational staff and stored in skip bins in the building
- Materials are loaded via front end loader into an appropriate concrete bay within the 'Waste Storage Area'
- All bays will be fitted with sprinklers for dust control when required

Exit

- Vehicles then exit the 'Tip and Spread Receival Building' area and move towards the exit
- Vehicles weigh off the weighbridge and mass is recorded
- Vehicles exit in the forward direction onto Gindurra Rd (left hand turn only) through the Somersby Business Park

Primary Sorting and Processing

- Waste materials are moved from waste storage bunkers into the 'Processing Area' via front end loader, as required.
- Concete / masonry is processed in the Crusher Building. The sorted products are removed to the Products Storage Area
- Wood and timber is processed in the Mulcher Building, with the mulch product removed to the Products Storage Area
- Clean soil will be tested and transferred to a product storage bay for sale
- Crusher and Mulcher building fitted with internal water sprays for dust control

Secondary Sorting Warehouse

- Mixed building waste is transferred from the Waste Storage Area via front end loader to the 'Secondary Sorting Warehouse' The front end loader then exits from the building in the forward direction
- Waste materials are loaded into an electric feed hopper and then onto a conveyor, which will then screen fine soils for separation into a hooklift bin
- Remaining materials pass onto a trommel screen for separation of masonry and aggregate, then a magnet for the separation of ferrous / steel materials
- Materials drop onto a conveyor, onto an elevated picking line with six persons to sort and deposit separated timber, plastics, concrete / aggregate and non-ferrous materials. Prior to entry onto the conveyor, a blower will be used to separate light materials, such as paper and cardboard. This will be directed to a hooklift bin for disposal
- Remaining materials will be deposited into chutes and into separate hooklift bins beneath the sorting line
- The material remaining after the picking line will be directed to a hook lift bin for disposal at a licenced landfill facility
- Sorted hooklift bins of plastics, cardboard, ferrous and non-ferrous materials will be transferred off-site for further recycling
- Timber and concrete / aggregate will be transferred to the Waste Storage Bays, awaiting processing
- Warehouse is fully fitted out with a misting system for dust control

Product Blending Manufacturing and Sale of product

- Recovered materials from the Processing Area will be stored in separate piles within the dedicated Product Blending Area. Here, materials will be blended as needed to manufacture specific products for building and landscaping applications
- Products, once blended, will be stored in separate piles and sampled / tested to confirm compliance with an appropriate EPA Resource Recovery Order
- Products will then be moved by front end loader to the ‘Landscape Storage Bays’ or the ‘Aggregate Storage Bays’, awaiting sale. Bays are fitted with sprinklers to ensure dust control at all times
- Recovered metals will be removed off-site for recycling

Figure E2. Process flow chart for landscaping and building supplies part of the operation.

Entry

- Trucks enter in the forward direction via the site entrance gate off Gindura Rd and follow the internal roadway
- Trucks weigh onto the weighbridge and mass of the vehicle is weighed in accordance with the *Protection of the Environment Operations (Waste) Regulation* 2014

Landscaping and Building Supplies

- Tipper trucks move through designated internal roadway to the 'Landscaping Supplies' and 'Aggregate Storage' area
- All bays are kept moist with bay mounted sprinklers to avoid dust generation during loading
- Loader loads the truck
- Larger trucks such as semi-trailers and B-doubles move through designated internal roadway to the 'Processing Area' and are loaded with larger bulk batches of product that are ready for sale and off-site use

Exit

- Vehicles then exit the 'Landscape Supplies' or 'Processing Area' area and move towards the exit
- Vehicles weigh off the weighbridge and mass is recorded
- Vehicles exit in the forward direction onto Gindurra Rd (left hand turn only) through the Somersby Business Park

Table 3. Summary of construction activities under Stage 1 and 2 on the site.

Stage		Description	Consent status
1	i.	Demolish existing corrugated iron sheds	Approved under DA52541/2017 and modified under DA52541/2017.2
	ii.	Construct office building and warehouse	
	iii	Construct car park next to buildings and new entrance	
	iv.	Install fence at front of site	
2	a.	Clear selected vegetation from the front half of the site as determined by the Fauna and Flora and Vegetation Management Plan	Approval sought under State Significant Development application SSD8660
	b.	Construct sediment control basin to capture run-off during construction	
	c.	Grading of site. Construct retaining walls. Install water, power and recycled water services across the site. Install hardstand across the operational areas of the site	
	d.	Install noise wall along eastern side of the site	
	e.	Construct onsite roads, new entrance and modifications to Gindurra Rd (turning lane).	

Stage		Description	Consent status
	f.	Construct stormwater drainage system, including pond, floating wetland, level rock spreader, emergency spill pond, isolation valves, continuous water quality testing apparatus, bioswales, gross pollutant traps and a packaged recycled water plant	
	g.	Construct crusher building	
	h.	Construct mulcher building	
	i.	Construct tip and spread waste receival building, rainwater harvesting tanks and misting system	
	j.	Install dust and fire suppression systems across the site, including the Secondary Sorting Warehouse	
	l.	Construct waste storage bays, aggregate and landscape supply concrete bays, including bay mounted sprinkler system	
	m.	Install processing equipment in crusher building, mulcher building and secondary sorting warehouse	
	n.	Install weighbridges, traffic control lights and boom gates on site	
	o.	Install environmental monitoring equipment (weather station, high volume air samplers, dust gauges, sound meters)	
	p.	Complete landscaping works	
	q.	Commissioning and testing of site plant, equipment and environmental control systems	
	r.	Commence formal operations for receival and recycling of waste materials up to 100,000 tonnes per annum	
	s.	Waste receival to increase to 150,000 tonnes per annum subject to the site demonstrating compliance with consent and EPA licence conditions and satisfactory environmental performance	
	t.	Waste receival to increase to a maximum of 200,000 tonnes per annum subject to the site demonstrating compliance with consent and EPA licence conditions	

4.0 PROPOSED ASSESSMENT CRITERIA AND TARGETS

4.1. Brisbane Water Estuary Water Quality Objectives

Gosford Council (reported in its 2015 Waterway Health Report) has prepared TP and TN trigger or guideline values (GVs) for ambient water quality in the Brisbane Water Estuary and tributaries. The proposed development doesn't drain to Brisbane Water estuary, it drains to Mooney Mooney Creek which is also an estuary adjacent to Brisbane Water. It is considered appropriate to use the Brisbane Water estuary GVs for Mooney Mooney Creek and its tributaries given its proximity, identical climate, soils, vegetation and similar land use. The GVs reflect local knowledge and conditions and have seen ANZECC default GVs modified to become GVs.

ANZECC guidelines for toxicants (copper, lead and zinc) have been developed and are reported in the lower three rows of Table 4 below. Copper and Zinc have been chosen because they have been shown to be the metals of concern in stormwater both in Australia and the UK. Lead was included in the table below because it was found in the groundwater and therefore has a possibility of being detected in stormwater. Note chromium was not included in this table because it was not detected in either stormwater or groundwater and it is not typically recognised as metal of concern in stormwater.

Table 4 Default Guideline Values

Parameter	Guideline Value or DGV
Total Nitrogen measured at low flows	< 1 mg/L
Total Phosphorus measured at low flows	< 0.05 mg/L
Copper – measured at any flow	< 1.3 µg/L (DGV)
Lead – measured at any flow	< 4.4 µg/L (DGV)
Zinc – measured at any flow	< 15 µg/L (DGV)

Note there is no DGV for TSS.

ANZECC DGVs objectives include turbidity and dissolved oxygen objectives too and while these are certainly important there is currently no way of assessing the impact of the proposed development on either of these except qualitatively.

It is also stated on page 8.2-9 within the ANZECC Guidelines that river flow objectives for N and P are to be applied to the median concentration occurring during low flows. Low flows are not defined in the ANZECC guidelines, however the 10^{th} percentile flow is frequently considered to be a low flow indicator. More importantly however "ambient" water quality is defined as follows:

"Ambient water quality refers to the quality of water when all the effects that can impact on a waterbody are considered not just the effects of a particular discharge."

Applying these guidelines and WQOs to a relatively small impervious development is for practical reasons not feasible. This is explained further. With stormwater harvesting, the development in question has no discharge more than 90% of the time. Even if one only considers periods of flow generation greater than 1 L/s, i.e. during rainfall runoff events, more than 45% of the time it is raining, there is no discharge from the site. The 45^{th} percentile site flow (which is considered much more than a low flow event) median concentrations are therefore zero. Strictly, this indicates that the site would discharge water quality compliant with the DGVs.

It would therefore be feasible to demonstrate compliance with the DGVs because there is no low or even medium flow discharge from the site due to harvesting of stormwater.

This however would be a somewhat misleading approach and serves to demonstrate why DGVs should not be used to guide assessment of water quality impacts from such developments.

To assess the impact on ambient water quality we must assess the impact from flows greater than the 50^{th} percentile outflow, i.e. flows above 1 L/s as these will carry any pollutant load from the site. WQOs are therefore discarded in favour of a body of evidence approach to risk assessment as demanded by the ANZECC guidelines.

4.2. Water Quality - Overseas and Local Guidelines & Legislation

Overseas guidelines are not applicable to Australian waterways which can be particularly susceptible to nutrients and algal growth. As a case in point, adoption of UK Highways Agency guidelines would see only Copper and Zinc criteria applied to this site and ignore TSS, TP and TN which remain the main pollutants of concern and for which we have an accepted scientifically based method for predicting pollutant loads before and after mitigation.

It is however of note that the UK Highways Agency has developed a method for assessing the impact of a proposed development on ambient water quality. They do this through application of volume of flow to allow for dilution of site discharge.

The NSW Department of Environment and Climate Change published a Consultation DRAFT (2007) *Managing Urban Stormwater: environmental targets* which they considered reflected a "cost effective level of treatment". This is the same series of Managing Urban Stormwater documents which include the Blue Book and its volumes.

These Draft guidelines were broadly adopted by many Councils across Sydney and revised for adoption by the Growth Centres Commission. The growth centres guidelines specified 85% removal of TSS and 65% removal of TP and 45% removal of TN.

An earlier variant of these guidelines has been adopted by Central Coast Council in its DCP and they remain the only published stormwater guidelines for the operational phase of the proposed project. Arguably they remain the only legally applicable guidelines for the project too. Certainly, the NSW State Government has elected to allow Councils to set the standard for stormwater management in their LGAs and it has clearly devolved responsibility for this having no published guidelines, apart from the DRAFT guidelines, of its own.

These are load based guidelines, with the load-based requirement applied to stormwater because it is unusual for concentrations at toxic levels to be exported and focussing on loads is critical to the prevention of the most common water quality problems, i.e. nuisance plant growth.

The NSW Office of Environment and Heritage and EPA, having carried out its own detailed risk assessment of development discharge into Lake Illawarra[4], a sensitive estuary like Brisbane Water Estuary and tributaries, decided to implement the same load based policy being applied by Central Coast Council to large parts of the urban release areas near Lake Illawarra while applying a NorBE policy to the remainder of the land release. This is a critical recognition of the potency of Council's DCP guidelines and speaks to the best practice position adopted by most NSW Councils to protect their waterways. If NorBE or the best practice approach is good enough for the EPA at Lake Illawarra it should be good enough for application to other estuaries too.

Best practice accepts that some impacts will occur whilst allowing for urban development and economic growth. This is the same position stated unequivocally in Section 3.1 of Volume 2E of the Blue Book.

It is unclear how this position is reconcilable with the Protection of the Environment Operations Act (POEO Act) which adopts a neutral or beneficial effect approach to stormwater management, i.e. a development shall not be allowed to cause a negative change in waterway health. It is observed that the NSW State Government has established a policy that construction phase water quality is subject to POEO Act while operational phase water quality is typically not subject to POEO Act. The exceptions to this are the growth centres where a best practice target is mandated through LEPs and DCPs.

The Sydney Drinking Water Catchment SEPP applies a neutral or beneficial effect (NorBE) test on development. This test aims to apply the principles enshrined in the POEO Act to "maintain water quality at current levels" or ideally to see an improvement. This is the most stringent regulatory water quality test applied to development in NSW.

In conclusion, outside of the Drinking Water Catchments which apply a neutral or beneficial effect test to stormwater management, if a policy is applicable, it would be the growth centres load based targets which are marginally more stringent than Central Coast Council's targets.

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[4] Jocelyn De La Cruz, Anthony Pik, Paul Wearne, 2017, Risk Based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions, NSW OEH and EPA, Sydney.

The Biodiversity Conservation Act which applies to parts of this development site includes a list of key threatening process in Schedule 4 which must be considered when assessing a development activity. These include:

- "Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands ……"

This Act then places a legal responsibility on the Approval Authority to ensure that there are no alterations to flow regimes of rivers, streams and floodplains.

Given the likelihood of an endangered ecological community being present downstream combined with the need to prevent alteration to the natural flow regimes it is clear that prevention of alteration of a natural flow regime is a development requirement.

4.3. Flow Frequency and Volume

The NSW OEH is in the process of developing guidelines for the South Creek catchment. These guidelines are reportedly examining flow frequency and duration in an attempt to manage flows which can impact on waterways in a more profound manner than water quality. This is an emerging area of regulation with its origins in the development of flow criteria for development above sensitive central coast wetlands which suffer from a change in wetting and drying. This arises from the creation of large directly connected impervious areas which convey flows every time it rains into waterways.

In this context the proposal is considering discharging site runoff via a level spreader into the bushland at the southern limit of works. In order to assess the impact of discharges to the bushland it is necessary to consider the frequency and volume of such a discharge.

Reference could be made to a forested land use for example which typically sees surface runoff occur 5 times per year on average. It is suggested that if surface water discharge could be limited to something approximating 5 times per year then this would more or less replicate what would happen if this site was in a forested condition prior to European settlement, i.e. in a pristine ecological condition.

Maintaining predevelopment or pre-European runoff volume is also considered a target – substantially increasing the volume of runoff could cause a dramatic change to wetting and drying of the bushland and change the bushland considerably. This may have already occurred, and this project brings an excellent opportunity to restore the ecosystem.

4.4. Discharge Velocity

It is essential to limit discharge velocity from the level spreader proposed at the point of discharge to threshold erosive levels for the 1 in 10 year storm event[5]. Beyond this, it is accepted that some erosion may occur in larger, rarer events but that the bush can recover in the interim period as it is so rare. This position reflects the understanding that the small everyday events cause the most geomorphic impacts, and these are the ones which result in a decline in bushland. Limiting erosive forces to the 10% AEP probability event will allow bushland to recover between events and generally to remain stable in the longer term.

4.5. Construction Phase Criteria

The NSW Soils and Construction – Blue Book shall be used to govern the design of construction phase sediment basins for the site.

Soils on the site have been tested by Alliance Geotechnical to determine if they are classified as dispersible. The soils were found to be not dispersive. Plate 2 below shows one of the samples in the lab – clearly it is not dispersible, and no slaking is evident.

Plate 2 Soil Dispersion Testing

[5] US Department of Agriculture, Part 654 Stream Restoration Design National Engineering Handbook, Chapter 8 Threshold Channel Design.

In accordance with the Blue Book, it is then feasible to construct a Type C flow through basin which allows water to be detained long enough to settle a 0.2mm diameter particle size. This type of basin would allow water to discharge from the basin in every storm event. This result accords with the understanding the site is largely underlain by weathered sandstone and sandy soils should be expected to be found. Sandy soils settle well without prolonged detention.

However, due to the need to construct a permanent water quality pond on the site, it is recommended that a type D pump out basin is constructed and sized at least for the 85th percentile 5 day storm event. Flocculant is unlikely to be required.

4.6. Licence Limits

Licences for scheduled activities are required under Schedule 1 of POEO Act. They apply to the operational phase of a development while the Blue Book applies to the construction phase of the development.

A number of other NSW waste management facilities have licences which limit TSS to less than 50 mg/L. On occasion, where high loads of TN and TP are also likely to be present, they may have an EPL limit of 10 and 0.3 mg/L respectively applied at the 100th percentile. The EPL limits will vary from site to site and depend on the expected pollutant concentrations.

There is a need for this development to comply with these maximum concentration limits as well as its load based targets – compliance with load based targets does not infer compliance with the abovementioned EPL limits and vice versa.

4.7. On Site Stormwater Detention

Central Coast Council and OEH have expressed the desire for the site to retain peak flows in an on-site stormwater detention system.

It is proposed that the post development site peak flow discharge for the 1EY, 10% AEP and 1% AEP does not exceed the predevelopment discharge for the same events.

4.8. Stormwater Harvesting and Reuse Guidelines

4.8.1. Australian Guidelines for Water Recycling (AGWR)

The *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2): Stormwater Harvesting and Reuse (NRMCC-EPHC-NHMRC, 2009)* is one of the three modules that comprise the second phase of the Australian Guidelines for Water Recycling.

"The guidelines as a whole, are designed to provide an authoritative reference that can be used to support beneficial and sustainable recycling of waters generated from sewage, grey water and stormwater, which represent an underused resource. The guidelines describe and support a broad range of recycling options, without advocating particular choices. It is up to communities as a whole to make decisions on uses of recycled water at individual locations. The intent of these guidelines is simply to provide the scientific basis for implementing those decisions in a safe and sustainable manner" (NRMCC-EPHC-NHMRC, 2009).

The guidelines take a risk-based management approach to provide guidance on managing potential public health and environmental risks for proposed water harvesting and reuse schemes drawing source water from stormwater systems.

The *National Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) (NRMCC-EPHC-AHMC, 2006)* includes a risk-based framework for managing the quality and use of recycled water. This is based on the framework in the Australian Drinking Water Guidelines (2004) which identifies key steps when conducting a risk assessment.

4.8.1. NSW DEC - Managing Urban Stormwater

The NSW Department of Environment and Conservation (DEC, now DECCW) have published *Managing Urban Stormwater: Harvesting and Reuse* (2006) which outlines the requirements for the capturing and harvesting of urban stormwater for reuse to contribute to water conservation, water quality and streamflow objectives.

Subsequently, the State guidelines produced by DEC present specific levels of stormwater quality criteria depending on reuse application. More stringent criteria apply (i.e. lower levels of pathogens) where the potential for human contact and ingestion of water is higher, i.e. in this case.

The stormwater quality criteria for public health risk management for reticulated non-potable industrial water for dust suppression suggest that these uses are not high risk. Despite this guideline noting that water for dust suppression may not need any extra treatment the risk arises from exposure of workers to stormwater runoff from a waste management facility. The water is to be spray irrigated where it may volatilize and expose workers to pathogens. It is considered that the cost of treating this water to an equivalent standard for residential reuse outweighs the risk of not treating the water. WHS legislation demands that all work sites are safe, and it is not acceptable to expose workers to pathogens when it would not be acceptable to expose residents to pathogens.

4.8.2. Recommended Combined Criteria

A summary of all relevant water quality criteria including the National and State guidelines and are provided in Table 5.

Table 5: Stormwater Reuse Quality Criteria for Reticulated non-potable residential uses

Risk	Parameter	Units	Target	Compliance	Max	Source
Health	Recycled Water Turbidity	NTU	≤2	95%	5	NSWDEC
Health	pH		6.5-8.5	95%	NA	NSWDEC
Health	E.coli	CFU/ 100mL	<1	95%	NA	NSWDEC / AGWR
Health	Cl_2 residual after 30min[1]	mg/L	1	99%	-	NSWDEC
Health	Virus	Log reduction	2.4	*	-	AGWR
Health	Parasites	Log reduction	1.9	*	-	AGWR
Health	Bacteria	Log reduction	2.4	-	-	AGWR
Operation	Suspended Solids	mg/L	50	95%	-	AGWR
Operation	Iron (total)	mg/L	10	95%	-	AGWR
Operation	Phosphorous	mg/L	0.8	95%	-	AGWR
Operation	Hardness ($CaCo_3$)	mg/L	350	95%	-	AGWR

[1] or equivalent pathogen reduction

* Note: guideline suggests "indicative exposure reduction (log reduction)" of 2 for viruses and parasites

Source - Australian Guidelines for Water Recycling: Stormwater Harvesting and Reuse (AGWR) and Managing Urban Stormwater: Harvesting and Reuse (NSW DEC).

We note that the targets shown in the table above will become the targets for the proposed development from a WHS perspective.

<u>These criteria represent the most stringent human health water quality targets</u> – far more stringent than water that is to be used for irrigation of crops because they are based on the risk of harm from direct exposure of humans to the water rather than indirect exposure.

In terms of metal concentrations (which generally do not feature as a risk to human health) in irrigation water quality, long term values should be within the long and short term values presented in Table 4.2.10 in Chapter 4 of the ANZECC 2000 Guidelines. However the values in Table 4.2.10 must first be modified by the assumed loading rates – ANZECC has assumed a loading rate of 1000mm/year while it is proposed to irrigate enough water over the Melaleuca area to replace the volume of run on water lost as a result of the proposed development. The long term loading rates can be factored upward by 10% to account for reduced irrigation depth of 905mm/annum.

4.8.3. Water Quality for Melaleuca Biconvexa

Water that is to be irrigated on the M. Biconvexa community shall have the following criteria:

1) Pathogens are not relevant as the plants are not to be consumed.
2) Nutrients levels (within the limits of what is experienced on this site are not relevant). As we are applying only very high quality stormwater which is relatively low in nutrients this will not stress the plants.
3) Salinity – as above – stormwater is low in salt and this is not an issue.
4) Metals and metalloids do however need consideration in order to ensure that there is not a long term build-up of metals in soils. The long and short term loading rates in Table 4.2.10 of the ANZECC Guidelines should be factored upward by 10% and then applied to the site.

5.0 POTENTIAL IMPACTS

This report assesses both chronic and acute impacts. Chronic impacts are those that arise from the day to day operation of the site and which would occur over the life of the development. Acute impacts are those where a single event can result in ecosystem stress – for example an accidental spill of a chemical (or fire-fighting foam) or sedimentation arising from construction.

5.1. Water Quality

5.1.1. Chronic water quality hazards

Risk is a combination of hazard and frequency. In this section we identify the hazards but not the frequency. Frequency of discharge is discussed in detail in Sections 6, 7 and 8. We urge the reader to refrain from forming an opinion of the risk that this development poses until they have also read Section 6 to 8.

We note that the nearest waterway is 400m from the site. In order for stormwater to get to the waterway it would need to travel overland across 4 hectares of undeveloped bushland. In most storm events the bushland is likely to absorb low levels of site runoff. As is shown later in this assessment, the frequency of stormwater leaving the site is predicted to be low (due to internal reuse of the water). Consequently, the frequency of occurrence of hazard would also be low. When stormwater does leave the site, it will occur after prolonged rainfall where substantial dilution and attenuation of pollutants will occur.

Key sources of chronic (everyday) stormwater pollution will arise from:

- An increase in impervious areas of 6 hectares – here volume of runoff is considered a pollutant but is described in more detail later under geomorphic impacts.
- Atmospheric deposition of nitrogen on impervious surfaces (this occurs whenever impervious surfaces are created and is not peculiar to this development).
- Storage of raw materials and blended landscape and building products in open areas
- Handling and transport of raw materials and products including metals, sands, soils, crushed concrete aggregate, recycled aggregates and shredded timber
- Processing of waste materials into a saleable product e.g. crushing and shredding.
- Vehicular traffic – truck and plant and equipment such as front-end loaders and trucks bringing waste and transporting products from the site
- Timber treated with copper chromate arsenic (CCA) shall not be processed on the site (it is illegal to do so) and will be rejected at the tip and spread building and temporarily held in a skip bin under the cover of the tip and spread building pending disposal to a lawful facility. This will reduce the risk of leaching copper, chromate and arsenic.

The key chronic stormwater pollutants of concern will be:

- Volume of runoff – a pollutant is defined as anything that can cause an ecosystem to become stressed. In this context volume of runoff can become an ecosystem stressor especially where it causes erosion.
- TSS during operation - especially from handling sands, soils, shredded timber, crushed concrete etc.
- Phosphorus species – considered to be mostly particulate though dissolved phosphate will also be present.
- Nitrogen species – mostly particulate (60%) but dissolved nitrogen (N) will also be present due to the creation of impervious surfaces. Little ammonia should be produced as gross pollutants will keep captured solids in a dry state. Dissolved N would be in the nitrate and nitrite form (NOx). Organic, particulate N would be the dominant form of N while some organic nitrogen will be dissolved for example tannins.
- Fertilisers – are added to soils and can leach from soils. They key risk here is nutrient enrichment of waterways. Fertilisers can be present in many forms but all include derivatives of phosphorus and nitrogen. Note that this is not a composting facility where green waste is composted though timber will be shredded.
- Heavy metals – (refer to research paper included in Appendix 2) the following is based on a comprehensive literature review of international water quality standards, effectiveness of water treatment systems in removing both heavy metals and other pollutant indicators and ecotoxicity research undertaken by Liebman et al, 2009.

  Site testing has detected Manganese, Zinc and Lead. These metals are therefore likely to be present on the site once developed. These metals may also occur naturally in sandstone soils and we note their low concentrations in surface water and groundwater might reflect background conditions.

  Zinc and Copper tend to be the metals that occur at concentrations that have the potential to cause harm [6] [7] while other metals are likely to be present but not at concentrations that have the potential to cause harm. Lead is already at detectable levels in groundwater and surface waters at the site at low levels though high enough to cause some aquatic ecosystem toxicity to the most sensitive aquatic biota (should they be present). The NSW EPA has noted chromium appears to be of concern, we have not found any evidence of chromium on the site or in groundwater

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[6] Crabtree B, Dempsey P, Johnson I, Whitehead M, The Development of a Risk Assessment Approach to Manage Pollution from Highway Runoff, 11th International Conference on Urban Drainage, 2008

[7] Kumar A, Woods M, El Merhibi A, Bellifemine D, Hobbs D and Doan H, The Toxicity of Arterial Road runoff in Metropolitan Adelaide Stage 2 Final Report for Transport SA, 2002

below the site or known it to be a metal of concern in literature review. Both Whitehead et al (2008) and Kumar et al (2002) did not detect chromium in stormwater runoff at toxic levels.

Zinc and Copper on the other hand are likely to be present and sometimes at levels that can cause a decline in aquatic ecosystems and that is why they are the primary pollutant indicators in Europe.

Other metals could include iron, lead from building waste, mercury and uranium which are used in batteries and fire alarms and microwave ovens. It is critical that the site rejects any waste that contains microwave ovens, batteries or other electronic waste forms.

- Pesticides and herbicides –rarely found in soils and not expected to be present in runoff with any frequency. These are more likely to be found in soils from Council managed parks. It is suggested that the proposed facility demands any soils from Councils be tested for the presence of pesticides and herbicides and rejected if warranted. Pesticides can also be present in soils from termiticide injection systems which may leak and result in contaminated soils.
- MBAS – methylene blue active substances including PFAS and surfactants. These could be present in surface waters if they become polluted by degreasing agents or fire- fighting foams. Covering of vehicle wash bays and sending waste to trade waste is therefore important to manage this risk as is separating fire-fighting water wherever possible. PFAS may be inadvertently brought onto the site via importing contaminated soils.
- Polychlorinated biphenyls (PCBs) (banned in the late 1970s) are possibly present in soils that were contaminated in the 1960s and 1970s and brough on to the site.
- A range of ions including fluoride, potassium, sodium, calcium, magnesium, potassium, chlorine.

Table 6 Likely Pollutant Generation and associated water quality hazard by waste type

Waste Management Activity	Likely pollutants	Severity of hazard (expected concentrations X likelihood of generation)
Crushed concrete, tiles and bricks	• TSS • Calcium ions • Alkalinity	• TSS – high • Calcium and alkalinity- medium

Waste Management Activity	Likely pollutants	Severity of hazard (expected concentrations X likelihood of generation)
Shredding timber, stumps and rootballs	• TSS • Nitrogen species – dissolved and particulate • Phosphorus species – dissolved and particulate • Tannins (organic acids)	• TSS high • Nitrogen – high • Tannins – medium • Phosphorus - medium
Sand and VENM	• TSS • TN and TP • Contaminants	• TSS – high • TN and TP – low • Contaminants – very low given need for test certificates prior to acceptance.
Soil – non putrescible solid waste meeting the CT1 threshold.	• TSS • Nitrogen and phosphorus species • Tannins • Trace elements – calcium, magnesium • organic carbon	• TSS – high • TN and TP – low • Tannins – medium • Trace elements – low • Organic carbon – low
Asphalt	• hydrocarbons • dissolved phosphorus • TSS	• Hydrocarbons – low • TSS – high • Dissolved phosphorus – medium
Metal	• Dissolved metals – most likely to be copper, zinc, aluminium, lead, iron, tin. These metals are commonly used in building products which	• Dissolved metals – medium • Particulate metals - high

Waste Management Activity	Likely pollutants	Severity of hazard (expected concentrations X likelihood of generation)
	will be the principle source of waste metals. • Particulate metals	
Mixed Building Waste (5% by weight) not covered above: Such as plasterboard, plastics, paper, cardboard and vegetation.	• TSS • Tannins from vegetation • Cellulose fibres from timbers, paper and cardboard • Nutrients from and vegetation • Altered pH from plasterboard • Calcium from plasterboard • Microplastics • Lead and chemicals used to preserve timber	• TSS medium (high hazard low volume). • Tannins – low risk due to expected low volumes in mixed building waste • Cellulose – low risk. Papers and cardboard – low volumes to be placed in skip bin and sent off site. • Nutrients – low risk associated with expected small volumes. Shredded to produce mulch. <u>No composting on site.</u> • Calcium – low risk – plasterboard to be placed in skips and then sent off site for reuse. • Microplastics – low risk – plastic to be sorted and stored in skip bins and taken off site for either landfill or recycling. • Lead and chemicals used to preserve timber – Low risk.

Waste Management Activity	Likely pollutants	Severity of hazard (expected concentrations X likelihood of generation)
		Painted timbers, and timbers treated with CCA or other preservatives shall be separated on site. These will be temporarily stored on site and then disposed lawfully, they will not be reprocessed on site.

Table 6 shows that TSS, TN, TP and heavy metals pose the highest potential hazard to water quality.

Timber treated with copper chromate arsenic (CCA) shall not be shredded (it is illegal to do so) and will be rejected at the tip and spread building and temporarily held in a skip bin under the cover of the tip and spread building pending disposal to a lawful facility. This will reduce the risk of leaching copper, chromate and arsenic.

In this assessment (and in stormwater management more widely) TSS, TP and TN are used as surrogate pollutant indicators. Liebman et al, 2009, found that if stormwater was treated to best practice, i.e. to achieve 80% removal of TSS and 45% removal of nutrients then it was most likely that metals would also be treated to concentrations below the ANZECC 99th percentile level of protection, i.e. the highest level of protection. Liebman et al observed that if a treatment train approach was adopted and some form of biological treatment, i.e. wetlands, ponds or bioretention occurred then removal of heavy metals to benign levels was most likely to occur.

Liebman et al also explored the flawed practice of assessing heavy metal toxicity in Australia where the toxicity is not modified for water hardness and furthermore where total metal concentrations are considered versus consideration of only filtered samples. Filtered samples indicate dissolved metal concentrations which are bioavailable while particle bound metals are not considered to be bioavailable. Furthermore, ecotoxicological methods developed for wastewater have been applied to stormwater and this is not appropriate for the reasons identified in the paper included in Appendix 2. For example, immersing a water flea in a first flush stormwater sample for 12 hours to test its survival does not in fact reflect a first flush of stormwater whereby dirty water is shortly followed by typically much cleaner water.

Moreover, MUSIC does not allow for the specific decay modelling of heavy metals within specific treatment types and so it is essential that TSS, TP and TN are used as surrogate pollutant indicators for heavy metals. Liebman et al (2009) found that most metals are present in stormwater in particulate form and as such removal of high levels of TSS will consequently see removal of high levels of particulate metals. Removal of dissolved metals does not occur easily and requires an ion exchange process if it is to happen at all.

The presence of the lead in groundwater beneath the site indicates the potential for activities to pollute groundwater if not mitigated. The inclusion of a geomembrane under the site or use of concrete pavements will protect groundwater and transform the risk from a groundwater risk to a surface water risk.

The TN in the hardstand runoff will be in two forms. Firstly, in a dissolved form at lower concentrations associated with atmospheric deposition. Secondly the TN will be in particulate form associated with the timber shredding and landscape (soil) waste handling activities on site.

Good air quality in the region is likely to see lower levels of nitrogenous pollutants emitted from the hardstand areas. Mostly, organic particulate nitrogen is a potential risk on this site. It is very important to keep this particulate form as dry as possible to prevent it from nitrifying and converting into a dissolved N. This is relevant for gross pollutant trapping.

The impact of the key pollutants on river health are as follows:

- TSS can smother benthic organisms found in the benthos and result in siltation of creeks and an increase in turbidity of stormwater. By smothering benthos and benthic organisms TSS disrupts the natural exchange processes that occur in creeks. These processes see nutrients and sediment exchanged in different forms. Smothering of creeks with sediment reduces available habitat (pers comm with Carl Tippler, aquatic ecologist).
- TP and TN in the bioavailable forms (dissolved forms) contribute to the eutrophication of water bodies and waterways potentially leading to algal outbreaks and a change in the assemblage of the aquatic ecosystems from ones dominated by low nutrient levels to ones dominated by high nutrient levels. Increased nutrients can also lead to reduced dissolved oxygen levels (Australian Runoff Quality, 2006).
- Tannic acids can discolour water and the impact is mainly aesthetic. There are many natural ecosystems (e.g. Melaleuca swamps) which have very high loads of tannic acids and which remain healthy and productive. It is also possible lower light penetration will mitigate against growth of algae.
- Heavy metals at relatively low concentrations can be lethal to aquatic organisms and result in bioaccumulation.
- Pesticides and herbicides are unlikely to be present in the waste stream coming onto the site and it is not proposed to treat any products with either pesticides or herbicides.
- Benzene, toluene and xylene– are unlikely to be present in the waste stream and not to be stored on the site.

- Recoverable hydrocarbons are unlikely to be present in the waste stream though it is possible there will be some residual emulsion arising from asphalt waste. Diesel is to be stored on the site in an EPA compliant self-bunded facility where the refuelling area is to be under cover within the warehouse.

5.1.2. Acute Water Quality Risks

Short term water quality risks associated with the development would include:

- Soil and water management during construction.
- The risk of an accidental spill of a chemical during operation of the plant. It is noted apart from storage of diesel fuel and fleet maintenance fluids (oils, hydraulic fluid etc), few other chemicals will be stored on site.
- Firefighting foams

The management of soil and water during construction can have significant impacts and is often overlooked. It is known that the impacts of poor soil and water management during construction can have the same effect as water quality discharged from an operation over its entire life.

The transport of sediment from the site is the key risk during construction. It is certain that more than 1 hectare of land will be disturbed during construction and therefore the risks of sediment transport off the site (if left unmitigated) are significant. Because the nearest receiving water is 400m from the site and flows will have to travel overland before they enter the waterway it is unlikely that TSS from this sandy site will be carried as far as the receiving water. None the less adherence to the Blue Book would see soil and water impacts mitigated.

Firefighting foams which may contain PFAS pose a potential risk from this development. These will need to be kept on site and prevented from contaminating ground and surface water. It is not feasible to construct an automated control facility however it would be possible to install water tight penstocks which can be closed in an emergency to contain firefighting water on site, for later pump out and off site treatment at a licensed facility.

5.2. Water Quantity/Flow Regime

The addition of approximately 6 Hectares of impervious area would, if unmitigated, result in a manifold increase in the volume and frequency of runoff leaving the site. This would have an impact on the stability of the bushland at the point of discharge resulting in erosion of the bushland and in the formation of an incised flow path away from the development to cater for the extra water being conveyed into the creek. This in turn would result in increased sediment transport and an increase in TSS.

This should be mitigated by targeting frequent flows as well as erosive flows at the 10% AEP limit.

It is possible to reduce frequent flows off the site through harvesting of the runoff which would reduce both the frequency and the volume of runoff and theoretically prevent a decline in bushland health (Walsh et al, 2004). At least matching post development runoff volume to predevelopment runoff volume and limiting site discharge frequency to less than 10 events per year would mitigate the impact of frequent flow discharges. Typical undisturbed bushland would have a surface runoff frequency of about 5 occurrences per year depending on climate and soils (Willing and Partners and Cloustons quote Wright, Buckney and Mitrovic in Middle Harbour Stormwater Management Plan, 1999).

The soils at the point of discharge, together with existing vegetation were found to be sandy soils (typical of scrubby bush) with a thick matted layer of leaf litter and woody debris, understorey grasses, shrubs and trees.

It is conservatively estimated that the Manning value of this surface is about 0.04 based on nomographs in the Brisbane City Council Natural Channel Design Guidelines (2000).

This is an important observation as it will be necessary to size a level spreader to ensure that erosive velocities remain below an erosive threshold for this surface. If leaf litter is scoured and grasses smothered, then soils will erode more readily.

A target maximum velocity of 0.53 m/s for sandy loam soils with clear water flowing over them is recommended for the 10% AEP design event (Table 3, Chapter 8, Threshold Channel Design – Part 654 Stream Restoration Design National Engineering Handbook, USDA, 2007).

5.3. Flooding

The catchment downstream of the proposed development is a sparsely populated rural catchment where the creek flows through an incised channel eventually to join Piles Creek a few kilometres downstream of the site.

The site will need an on-site stormwater detention system to both:

- Protect downstream properties from increased peak flows, and
- Protect downstream bushland and creeks from increased peak flows which could result in erosion at the outlet point. It is understood that frequent storm events have a more significant influence on shaping creek systems because they have some tractive power and occur frequently. From a geomorphic perspective it is necessary to focus on smaller frequent events while from a floodplain risk perspective it would be necessary to focus on larger rarer events. In conclusion – any OSD for the site should cover the whole range of storm events – from frequent to rare to avoid potential geomorphic and floodplain risk impacts.
- A recent upgrade to Kangoo Road (this is the road which is south of the proposed development site) by Central Coast Council including the installation of kerb and gutter and drainage will see any surface runoff conveyed via the drainage system. If peak flows, velocities, volumes and frequencies of flow are maintained at levels less than the predevelopment state then it can be said that the development will not alter the flow regime and will not impact on Kangoo Road to any greater extent than it does now.

5.4. Water Resources

5.4.1. Water Supply

The proposed development will see an increase in demand for water which could be sourced from either:

- Town water.
- Harvested stormwater runoff. The impervious areas on the site are extensive and lend themselves to a stormwater harvesting scheme.

In the future it is hoped that a non-potable supply becomes available for the site and this could be used to supply additional water for dust suppression. Being 100% impervious, the proposed development should provide a reasonable proportion of its non-potable water demand to reduce its impact on the potable water supply. This is discussed further in Section 6.0 of this report.

5.4.2. Wastewater

A sewer will be installed on site with wastewater pumped to the Council's wastewater treatment plant.

A treatment plant will be installed to treat stormwater prior to reuse. This will concentrate particulates. The reject water from the plant would be discharged to the town sewer through a trade waste agreement.

Oil and grease separator would be used at the truck wash bay with filtered water sent to trade waste to help reduce nutrient and surfactant content of the site's stormwater. They may also foul the membrane proposed for the stormwater treatment plant.

5.4.3. Groundwater

There are no expected water quality impacts to ground water caused by the proposed development as a result of required and proposed control measures mainly being the need to seal the site from the groundwater to comply with EPA waste management facility guidelines[8].

We note that covering of 6 hectares of land with a geomembrane will prevent infiltration of water over this area. This will reduce recharge of this aquifer. In this context, the proposed development is no different to other industrial developments in Somersby (or anywhere else in Australia). This is what happens when large impervious areas are created. To its credit the proponent will retain over 4 hectares of bushland – an area in which substantial recharge will continue to occur.

Critical control measures include:

[8] Environmental Guidelines – Composting and Related Organics Processing Facilities, DECC, 2003.

1) Ensuring the proposed development remains above the ground table to avoid cutting into the groundwater table. It is noted that other groundwater users around this site could be impacted if groundwater is not protected.
2) Constructing concrete hardstand areas with sealed joints.
3) Installing a drainage layer under the hardstand areas with subsoil drainage which would discharge into the stormwater collection system.
4) Draining the said hardstand areas to a drainage system which would either be piped or conveyed in a lined bioswale. It will be necessary to pipe some of the bioswale to keep surface flows at safe depths and velocities.
5) Sealing the sub-base of the pavements with a geomembrane to prevent infiltration in accordance with the EPA guidelines.
6) Ensuring the refuelling area uses a self-bunded tank and that the refuelling area is located undercover in the warehouse.
7) Having a stormwater pond lined with clay or geo-composite clay liner or HDPE both to retain water but also to protect groundwater.
8) Ensuring that irrigation of stockpiles, pervious, landscaped areas only occurs when it is not raining and by using soil moisture probes or similar to measure the demand for irrigation.
9) Installing penstocks to ensure that fire-fighting water is captured on site and does not overflow from the facility into the catchment and groundwater.

6.0 PREDICTED IMPACTS

This section describes the methodology used to assess impacts and then presents the results.

6.1. Water Quality Methodology

Because no groundwater impacts are expected predicted impacts on surface water only was assessed.

A MUSIC (Model for Urban Stormwater Improvement Conceptualisation) water quality model for the site was constructed. MUSIC was developed by the Cooperative Research Centre for Catchment Hydrology in 2001 and the program is now widely used across Australia to predict water quality impacts arising from a proposed development, and to then design appropriate stormwater mitigation strategies.

The following sections of this report describe the MUSIC models that were created to simulate both the existing site (pre-development model, i.e. a disturbed site), the proposed development for the site (post development model), and the site as it would be Pre European occupation if in a forested undisturbed land use.

The method used to create the climate file which contains historical rainfall data and which was used to run the MUSIC models is described below.

The NSW Office of Water's publication titled "Modelling MUSIC in the Drinking Water Catchments" has been adopted to guide the modelling methods. These are Current Recommended Practices (CRPs) and are included in legislation for developments located in the Sydney drinking water catchments. While not directly applicable to this site they provide a conservative, peer reviewed approach to water quality modelling and assurance to regulators that the MUSIC models are sufficiently conservative and provide the best comparative assessment possible (a comparative assessment is the test required by the POEO Act).

We note the Drinking Water SEPP also sets the most stringent water quality guidelines in the State. These are to maintain existing water quality and to demonstrate a neutral or beneficial effect. This standard has been adopted in this project.

In a 2009 research paper titled "How sustainable are stormwater management practices with respect to heavy metals? A multinational perspective", Liebman et al examined if TSS, TP and TN, as modelled in MUSIC, are reasonably used as surrogate pollutant indicators.

A surrogate pollutant indicator is a way of modelling the fate of one or many pollutants based on the fate of another pollutant. For example, we know that metals are mostly present in the attached or particulate form. So instead of modelling the fate of all metals we would model particulates. It is logical to say that by removing particulates, we would be removing metals too and so it is said that TSS is a very good surrogate pollutant indicator for heavy metals.

Surrogate pollutant modelling is a typical industry practice in Australia and its practice is embodied in the MUSIC water balance and water quality model, developed with funding from the Commonwealth Government and which will allows the fate of all pollutants to be modelled by modelling only three key pollutants. In Australia the three most risky pollutants associated with stormwater are TSS, TP and TN and so these are used to indicate the fate of all contaminants. This allows for designers to model the effect of mitigation measures and to indirectly assess the fate of all pollutants/contaminants.

If it was possible to model the fate of all known pollutants it would be done however the request of the NSW EPA to model the fate of all known pollutants including the impacts of mitigation is not possible given the current level of scientific knowledge of how pollutants decay inside various forms of mitigation. Most importantly using other pollutants as indicators means that it is not necessary to model the fate of all pollutants but is necessary to model TSS, TP and TN which has been done.

The 2009 research paper titled "How sustainable are stormwater management practices with respect to heavy metals? A multinational perspective" questioned if it was reasonable to adopt a surrogate pollutant indicator approach. The paper, based on evidence from several research projects in Australia and abroad concluded that it was reasonable to adopt such an approach and therefore such an approach is justified for use in this report.

We conclude that current industry practice which uses MUSIC, widely regarded as the best practice in the world, is an acceptable approach to provide an indication of the fate of all contaminants. This approach has not just been wholly accepted by OEH, EPA and DPIE, it has been widely used by each organisation to help measure and implement sustainable development across NSW. To single out this proposal for individual contaminant fate modelling would represent a substantial departure from what has become a quasi-policy for NSW.

6.1.1. Pre-development MUSIC model

The predevelopment model represents the existing, approved land uses including the approved sorting shed. We have assumed that cleared parts of the site are 50% impervious in accordance with WaterNSW CRPs and have an industrial land use consistent with existing activities on the site and existing development consents.

The configuration of the pre-development model can be seen below in Figure 6.

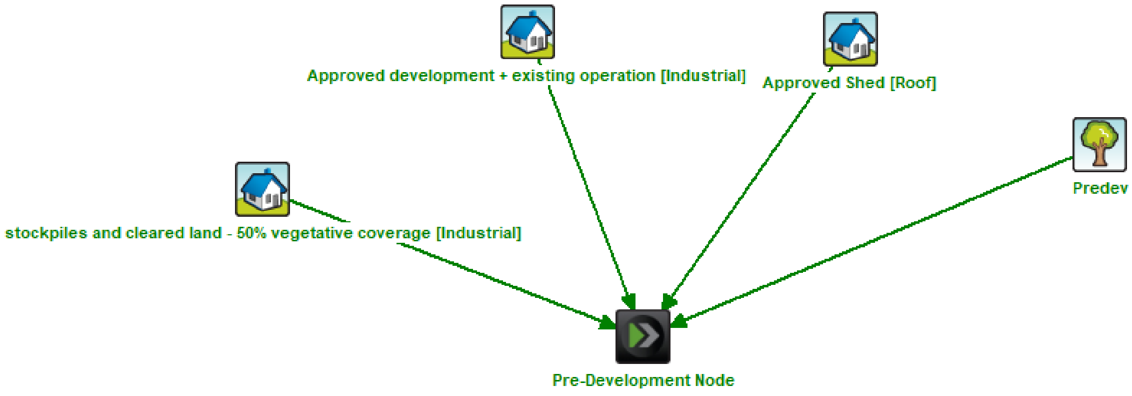

Figure 6: Predevelopment MUSIC model configuration

The event mean concentration (EMC) values adopted for this land use were based on those defined in Tables 2.43, 2.44 and 2.45 in Fletcher et al (2004) and which are the same as those in the WaterNSW CRPs.

In accordance with CRPs, the existing development, having substantially compacted unsealed surfaces has been modelled with 50% imperviousness. This generates runoff nearly every time it rains from heavily tracked or compacted areas. Refer to Table 4.2 of the CRP.

The site land use was split into developed land, forested land and roof areas. Each was modelled with EMC values reflective of their land use.

Land use	Land use modelled	Area (6.05 hectares total)
Undisturbed parts of the site which are vegetated	Forest	2.75
Stockpile areas	Industrial	1.7
Approved development including curtilage around warehouse.	Industrial	1.312
Approved warehouse	Roof	0.288

Please refer to Table 8 below which includes the EMC and standard deviation values adopted for forested, industrial and roof land uses.

6.1.2. Post-development MUSIC model

A post development model was produced to reflect the post development site conditions with 6.05 ha of impervious hardstand, landscaped areas and drainage easements.

Key features of this models are:

- Total impervious area: The nodes that represents that part of the site to be developed, were modified to reflect the addition of another approximately 6 hectares of impervious area. Landscaped areas each side of the development were modelled as revegetated land in accordance with the CRP.

- EMC values for the operational area were obtained from the CRPs and Fletcher et al (2004) as noted above and tabulated below. The predominant land use was assumed to be industrial with roof areas modelled as roofs. Refer to Table 7 and Table 8 below.

Land use	% Impervious	Area (Ha) (6.05)	MUSIC land use (EMC)
Roof areas	100%	0.3126	Roofs
Landscaped areas including M. Biconvexa buffer	0%	0.58	Revegetated areas
Trafficked areas	100%	2.513	Industrial
Stockpiles, blending areas and storage areas	50%	2.3	Industrial
Pond and Emergency Spill Pond	N/A	0.344	N/A

Table 7 Adopted Land uses, imperviousness and EMC values

Land use and baseflow or storm flow	TSS EMC (log mg/L)	TSS Std Dev (Log mg/L)	TP (EMC (log mg/L)	TP Std Dev (Log mg/L)	TN EMC (log mg/L)	TN Std Dev (Log mg/L)
Forest – base flow	0.78	0.13	-1.52	0.13	-0.52	0.13
Forest – storm flow	1.6	0.2	-1.1	0.22	-0.05	0.24
Roof – storm flow	1.3	0.32	-0.89	0.25	0.3	0.19
Industrial – storm flow	2.15	0.32	-0.6	0.25	0.3	0.19
Industrial base flow (for stockpiles)	1.2	0.17	-0.85	0.19	0.11	0.12
Landscaped areas (modelled as revegetated land) storm flow	1.95	0.32	-0.66	0.25	0.3	0.19
Landscaped areas (modelled as revegetated land) base flow	1.15	0.17	-1.22	0.19	-0.05	0.12

Table 8 Adopted EMC and Standard Deviation Values for MUSIC modelling

- Stockpile areas were modelled in a somewhat complex manner assuming that they were 50% impervious however with all baseflows directed directly to the pond which reflects the reality of an impermeable geomembrane liner underlying the site. In other words, stockpiles were simulated to absorb some water and lose some water through evaporation however there is no loss of water to the ground as all baseflows are directed to the pond. Any water in excess of field capacity is directed to the pond and not lost from the system. This will happen through a system of subsoil drains located above the geomembrane but below the pavement surface.

- The post development model included 6 GPTs placed strategically through the site to minimise maintenance as much as possible. The preferred GPTs for this development application are Barramy vane traps which deflect gross pollutants and sediment out of the flow column where it is stored in a dry state and can be readily recovered and put back into the product stockpiles. These GPTs will be sized to treat 100% of the flow and unlike other GPTs continuously deflect flow and pollutants into the screening area even in very high flows. Most importantly these GPTs are easy to maintain.

These GPTs included reductions in TSS, TP and TN of 30%, 20% and 20% respectively. These are considered conservative values based on extensive long term statistically significant field measured values achieved by other GPTs including SPEL Stormsacks and Enviropods which are equivalent dry systems. The author of this report has peer reviewed the performance of numerous GPTs for Blacktown Council which is recognised as a leader of water sensitive urban design in the State. Further, the author of this report is engaged by Stormwater Australia to be an Independent Evaluator under the new Stormwater Australia SQID Evaluation Protocol – this is a national evaluation scheme that vets the field performance of new stormwater quality improvement devices. A repeatable, defendable, scientifically based approach is adopted to give the community confidence in manufacturer's claims.

Because the particulate loading of TP and TN would be high relative to dissolved levels of nutrients, these removal rates are likely to be conservative.

Catchment L1 was drained to a CDS unit and this was included in the model as was catchment M3. The CDS units were modelled in accordance with the Blacktown City Council adopted node.

- Addition of a new 5ML stormwater treatment pond which has a minimum surface area of 1,667m^2.
- Please note that we have proposed 165m^2 of floating wetlands for the pond which makes up 10% of the vegetative coverage of the pond. The pond has not been modelled as a floating wetland but instead conservatively modelled as a pond. Research by Drs Darren Drapper and Terry Lucke and others based on floating wetland systems installed in Queensland are showing that 1% coverage of a pond is providing substantial benefits both during construction and operation[9].
- Addition of bioretention swales conveying runoff toward the pond. The swales were modelled conservatively in accordance with the CRP as follows. The surface infiltration rate was estimated and became the high flow bypass rate for the bioretention node. High flows were then directed into a surface swale while low flows up to the limit of surface infiltration into the filter media were directed to the bioretention system. Note the bioretention system is a lined system to prevent groundwater contamination.
- Stormwater harvesting from the pond was included in the model with annual demands of 48,162 m^3/year, scaled by potential evapotranspiration minus rainfall (water deficit)

[9] Walker, C., Drapper, D., Nichols, P., Reeves, K., Lucke, T. (2014b). Treating Urban Runoff in Australia using Floating Wetlands, Stormwater Australia National Conference, 13-17 October, 2014, Adelaide, Australia.

drawn from the pond when water was available. Derivation of the water demand is described in more detail in the next section.

- It is proposed to install a 50KL rainwater tank on the main warehouse roof. Roofwater will be reused for truck washing. Demand was estimated to be 1 kL/day.
- It is proposed to install ten, 18 kL rainwater tanks along the southern or rear side of the tip and spread building. These tanks will supply rainwater for the tip and spread dust suppression system. Following storage in the rainwater tanks the water will need to be filtered and treated in a UV disinfection system to ensure it is fit for purpose. Demand for the dust suppression system in the tip and spread roofed area was estimated to be about 624 kL/annum or 2 kL/day assuming 6 days operation per week. The roof area is 1,250 m^2 and this equates to an average depth of misting of 1.5 mm/per day over the year. This will be higher in summer when it is hotter and greater evaporation from the floor of the tip and spread shed is possible and lower in winter. This system will be adjusted by personnel to reduce the time it is operational to ensure there is no leaching and that accepted waste is not significantly increased in moisture content. The system will only be operational when waste is received – this was assumed to be 25% of the time.
- After treatment in the pond and detention in the OSD system, the stormwater is to be directed to a 50m wide level spreader. This will be designed as a shallow infiltration system with one level side to evenly disperse flows. This will allow some flows to be infiltrated into the sandy soils while excess flows will flow overland until they can infiltrate or in larger events, flow off the site. It was assumed the spreader would be filled with inert rock such as sandstone (not concrete) and be 1m wide and 1m deep and allow up to 300mm depth of water to be ponded before it overflows.

  It should be noted that the water *quality* analysis is conducted at the site boundary after flowing out of the level spreader. The level spreader was assumed to be 50m long to control peak velocities to be below erosive thresholds for a surface with an estimated Manning n value of 0.04 and flow depth of less than 0.054 m in a 1 in 100 year storm event.
- Pollutant assimilation downstream of the developed part of the site was not modelled as the objective here is to protect the downstream native bushland.

The proposed mitigation measures, namely GPT, swales and pond are described in more detail in Section 7.0 and the revised site drawings prepared by Sustainability Workshop and which are included in Appendix 1.

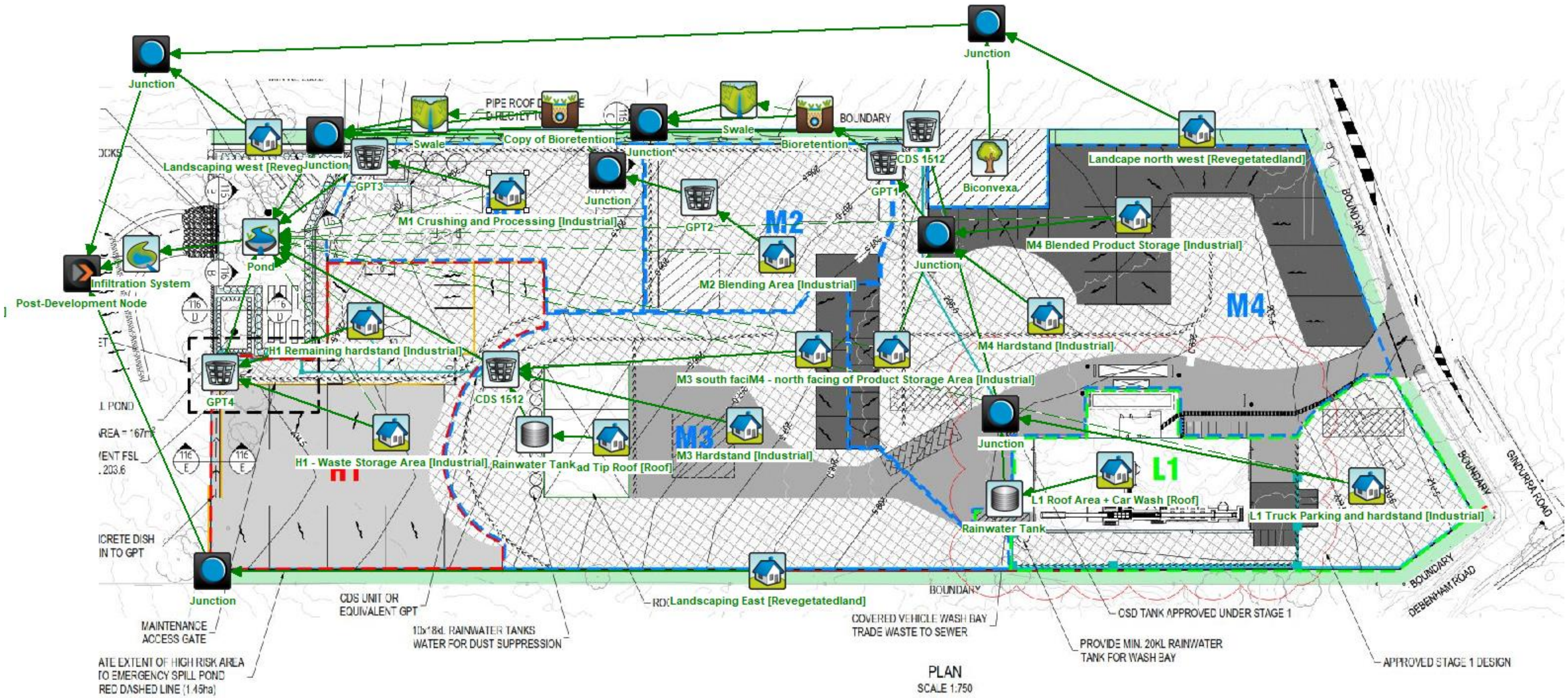

Figure 7: Post Development MUSIC model configuration

6.1.3. Non-Potable Water Demand

Stormwater harvesting from the pond was included in the MUSIC model with annual demands of 48,162 m^3/year being pulled from the proposed pond when available, scaled by potential evapotranspiration minus rainfall (water deficit) drawn from the pond when water was available.

This estimate is based on:

- Measuring the annual average number of days with rain. This was 82 days per annum meaning there are 283 days per annum when it does not rain and when the road or stockpile surface will dry due to evaporation and require irrigation to supress dust.
- We then considered the average daily evaporation rate from the site based on monthly annual evaporation depths. This is 3.2mm/day/annum.
- We multiplied 3.2mm X 283 to estimate the annual depth per m^2 of irrigation water required which is 905mm/annum. Please note this depth of irrigation won't result in water leaching from the stockpiles or road surfaces as it simply replaces a proportion of water lost through evaporation. Annual evaporation is about 1170mm/annum.
- This can be implemented through an irrigation controller developed by Dr Bernie Omodie, called "measured irrigation" [10]or a similar set up. Dr Omodie has specifically modified his product so that it can be applied to this project using float switches to turn on the irrigation system. The exact controller used would need to be considered further during detailed design.
- The 3.2mm depth lost through evaporation was assumed to need to be replaced to ensure there was no net loss of moisture from the surface of the stockpile or road which would then allow soils to dry out and become dusty. We then counted the areas which would have stockpiles and trafficable areas needing dust suppression including product blending and processing areas. We then multiplied 905mm/annual depth over an area of 5.1 hectares – i.e. most of the site - to get an annual water demand for dust suppression.
- To benchmark the estimated depth of 3.2mm/m^2/day a basic literature review was undertaken and revealed 2 other estimates. The first estimate is 4 l/m^2/day which is used by the mining industry for estimating water demand for dust suppression on mining haul roads in the Pilbara which is hotter and drier. The second estimate comes from the US EPA and is 2.2l/m^2/day which equates to 2.2 mm/m^2/day depth of irrigation. The US could be both colder and wetter depending on where the estimate was derived.

[10] Refer to https://www.measuredirrigation.com/

- The literature review provided confidence in the 3.2mm/m^2/day average annual estimate, being approximately the average of the 2 other estimates but derived from first principles.
- Please note when this is modelled in MUSIC it is scaled by potential aerial evapotranspiration (PET) minus rainfall. This means that on days when it is raining it is reasonably assumed there is no irrigation. Scaling by PET means that in summer when PET is high the depth of irrigation is greater than 3.2mm and in winter when it is cold and PET is low it is lower than 3.2mm. 4.6mm/day is summer peak evaporation and 1.6mm/day is mid-winter lowest evaporation.
- We also investigated the water consumption of the screening machine and crusher machine which have their own dust suppression equipment. These were found to be 1.765 ML/year for both machines.
- The total demand for non-potable water from the pond was then found to be equal to 48,162 m^3/annum. Note that this does not include the 624 kL/a demand for rainwater for the tip and spread building dust suppression system which is in addition. The total of both demands would be 48.8 ML/a.
- Please note this also includes irrigation of landscaped areas which helps to keep them healthy as well as helping to limiting site discharge. If supply dwindles – ceasing to irrigate landscape areas should be the first water saving action.
- Please note rainwater tanks are not considered an option for the main warehouse roof and that dust suppression water for the main shed will be supplied by the potable system due to health concerns as it is sprayed into the room into a very fine particle size which could be inhaled by staff. It is essential that that water is high quality, fit for purpose and comes from the potable system. The potable demand for dust suppression water in the main warehouse was estimated to be in the order of 3ML/year and equate to 65 litres per minute peak demand.

  Please note further that communication with the dust suppression equipment supplier as well as with a large waste management organisation who use their equipment extensively across many waste management sites has shown that leaching does not occur as the system up time (operating time) is adjusted to reflect site conditions. Water does not accumulate on the floor – once it hits the floor it evaporates off the floor of the building leaving the dust particle on the ground and not in the air. If a building cools too much, then the system is turned off for a while giving the floor time to heat up again and so on. The system needs active management and training of staff in its operation to ensure no leaching.
- As described above the tip and spread building roof will drain to ten, 18 kL rainwater tanks which will retain and reuse 98% of the roof runoff.

6.1.4. Rainfall data selection

Several rainfall gauges were analysed to ascertain what rainfall data exists for this location. Peats Ridge has an automatic weather station which collects 6 minute pluviograph data and which is suitable for MUSIC modelling.

The Peats Ridge data was analysed firstly for completeness and then for representativeness. A 20 year record of rainfall from 1989 to 2008 was found to be reasonably complete with few missing periods. The 20 year record contains both wet and dry periods and enables a detailed simulation of rainfall across the site. The length of record is also important due to the need to generate stochastic concentrations from the EMC mean and standard deviation values. A 20 year record is long enough to include some very highly polluting events which adequately stress test the proposed system.

The average rainfall for the 20 year period was found to be 1114mm/annum which it is acknowledged is likely to be lower than local rainfall however it was a complete rainfall record in a 6 minute time step. Use of daily rainfall for this task is considered inappropriate and would significantly underestimate pollutant loads. We note there was not a better more representative period of data that was also complete – i.e. we used the best rainfall data available.

The best long-term daily rainfall gauge (daily is not suitable for use in MUSIC but provides a comparison of adopted rainfall to local rainfall) was found to be the Gosford gauge, 2.7 km from the site, which had rainfall records from 1877 to 1993. A summary of statistics for this gauge is included below:

Statistic	Annual (mm)
Mean	1307.0
Lowest	491.4
5th %ile	804.4
10th %ile	906.0
Median	1274.9
90th %ile	1768.9
95th %ile	2024.5
Highest	2354.0

Table 9 Gosford Daily Rainfall Gauge Statistics

This shows the average of the adopted rainfall was about 100mm below the median value for Gosford.

The fact the adopted 6 minute rainfall record had a below average depth is not considered significant because the analytical methods employed involve a comparative assessment.

If we adopt a load-based approach it is noted that it is harder to achieve compliance with lower rainfall due to diminishing returns (logically it is harder to reduce a clean load by 85% relative to a dirty load). If we adopt a NorBE approach, then the same rainfall is used predevelopment and post development and there is little difference except to note that again lower rainfall means treatment systems have to work harder to achieve a beneficial effect. This is due to the first order kinetic decay equations inherent in MUSIC which adopt K (rate of decay) and C* values which reflect the background concentrations.

Areal potential evapotranspiration data for the site was modelled as 1298mm per annum based also on BOM data monthly distribution.

6.1.5. Stochastic Model

Because the stochastic function in MUSIC was used to randomly generate a pollutant concentration value from a log normal distribution of pollutants (based around a specified mean and standard deviation), each model run has slightly different results.

Because it is expected that an EPL for the site specifies the maximum upper limit at the 100th percentile, the maximum concentration values predicted by MUSIC become the key parameter for assessment.

There is therefore some degree of uncertainty with respect to the maximum values generated in MUSIC, i.e. the maximum values can vary considerably from run to run. We have reduced this uncertainty in two ways:

1) By having a climate file that covers 20 years of 6 minute data – this is discussed further later, i.e. a climate file that spans a very long time making it highly probable that a very high value would be generated within this very long time period, and
2) By reporting the maximum value as the 99^{th} percentile. The 99^{th} percentile values don't vary considerably between each model run. We have adopted the 99^{th} percentile value because MUSIC adopts an asymptotic pollutant generation bell curve which pushes the predicted maximum values out to unrealistic values. The model was not intended to be used to predict maximum concentration values but focussed more on predicting loads.

   The 99^{th} percentile however provides a highly conservative (i.e. will ensure highest levels of protection) measure of performance whilst accepting that 1 in 20 years there is going to be a large flood event that is going to mobilise significant loads of pollution. We suggest that the predicted 99^{th} percentile concentrations are equivalent to the EPA's 100^{th} percentile limits.

6.2. DRAINS Computer Model

6.2.1. Predevelopment DRAINS model

The site was modelled using the following parameters and method:

1) Laurenson (RAFTS) hydrology was used within DRAINS.
2) The site was 6.05 Ha in area and 100% pervious.
3) Initial loss of 10mm and continuing loss of 2mm/hour.

4) A single node was used.

6.2.2. Post development DRAINS model

The site was modelled again as a single node with the following parameters:

1) Laurenson hydrology within DRAINS.
2) The site was modelled as pervious and impervious with the following initial and continuing losses:
    a. Impervious area initial loss = 1
    b. Impervious area continuing loss = 0 mm/hour
    c. Pervious area initial loss = 10mm
    d. Pervious area continuing loss = 0 mm/hour.

    This approach effectively models the whole site as impervious with 0 continuing loss but allows a larger initial loss to occur from areas designated in the model as "pervious" which are areas that would have stockpiles on them. The post development model was therefore effectively 100% impervious.
3) A detention basin node was added to the model which had 1,666 m^2 of storage occurring over an elevation difference of 1.5m, i.e. had 2,500 m^3 of storage between RL201.5 and RL 203m. A weir height of 300mm is recommended for extreme events beyond the 1 in 100 year event.
4) Multiple orifice outlets from the basin corresponding to:
    a. Low flow outlet at RL 201.5 which was modelled as a 375mm diameter pipe.
    b. Second outlet at RL 202 which was modelled as a 525mm diameter pipe.
    c. Third outlet at RL 202.18 which was modelled as a 525mm diameter pipe.
5) The model was run and the orifice sizes and levels adjusted until post development flows were below predevelopment flows for all storms from the 1 year to 1 in 100 year and also ensuring that the basin water level did not exceed RL 203m in the 1 in 100 year event or RL 202m in the 1 in 1 year event.

6.3. Results

6.3.1. Surface water quality impacts

6.3.1.1. Load based results

The predevelopment and post development MUSIC models were run, and the results obtained.

Pre and post development average annual loads and treatment performance are shown below in Table 10. Table 10 has sources columns, residual load columns and percentage reductions columns. The sources columns describe the unmitigated pollutant loads running off the land surface. The residual load is the pollutant load after mitigation. The percentage reduction columns report the percentage reduction from source to residual load, i.e. the effectiveness of the treatment systems. It needs to be appreciated that this is the predicted performance for the whole site in its entirety and not just for the additional impervious area proposed as part of this development, i.e. a wholistic approach to water management on the entire site is being undertaken as part of this assessment.

Neutral or Beneficial Effect (NorBE) Load Test			
	Pre-development average annual load	Post-development average annual load	% Reduction from pre to post development
Total Suspended Solids (kg/yr)	3840	567	85%
Total Phosphorus (kg/yr)	6.58	1.94	70%
Total Nitrogen (kg/yr)	55.7	21.3	61%

Table 10: Annual Pollutant Export Loads and Treatment Train Performance

Table 10 shows that with the reuse of stormwater and the proposed treatment measures, the proposed development is predicted to have a beneficial effect on its catchment. There is a substantial margin here with the minimum improvement being a 61% reduction in pollution when compared to the predevelopment state.

Council requires removal of 80% of TSS, and 45% of TP and TN. Growth Centres Commission Best practice stormwater treatment is as follows:

Removal of:

- 85% of the average annual load of TSS
- 65% of the average annual load of TP
- 45% of the average annual load of TN

Table 11 Treatment Train Effectiveness of the Proposed Treatment System

Treatment-train Effectiveness (% Reduction of Pollutants)				
	Post Development without treatment in place	Post-development with proposed treatment system	% reductions	Council Best Practice Target
Total Suspended Solids (kg/yr)	7180	567	92.1	80
Total Phosphorus (kg/yr)	12.3	1.94	84.4	45
Total Nitrogen (kg/yr)	96.3	21.3	77.9	45

Table 11 shows that the proposed development would substantially exceed best practice using Council's DCP target and it would also exceed the Growth Centres Commission best practice target being 85 65 45 retention of TSS, TP and TN respectively.

6.3.1.2. Concentration based results

A typical Environmental Protection Licence (EPL) for facility of this kind would specify pollutant discharge limits in terms of concentrations rather than annual loads. Although there is less confidence in MUSIC's ability to predict concentration based results (versus load based results), it remains the best tool available for doing so, and thus enabling a comparison with the EPL limits.

For the reasons identified earlier the 99th percentile values for each pollutant are presented below in Table 12.

Table 12: Predicted maximum discharge concentrations from the MUSIC model

Parameter	99th percentile MUSIC concentrations (mg/L)	99th percentile values for a pre European forested land use (mg/L)
Total Suspended Solids	30	170
Total Phosphorus	0.133	0.204
Total Nitrogen	1.6	2.5

If an EPL limit of 50 mg/L would be imposed on the development, the modelling indicates this target would be achieved.

Table 12 clearly shows the maximum discharge concentrations emitted from the site would remain lower than a forested land use of the same area.

We conclude that both pollutant loads and concentrations would be less than predevelopment case and give rise to a beneficial effect on water quality.

This result also implies that the proposed stormwater treatment system is highly likely to treat metals and other pollutants to an extremely high degree. Based on an extensive literature review by Liebman et al (2009) (which is included in Appendix 2) the predicted results indicate that the site will discharge metals at levels of concentrations that would enable compliance with the 99th percentile level of protection, i.e. have lethal effects on only 1% of populations if those populations were in fact present. This is the highest level of protection and should provide the EPA confidence that this development will not alter the chemical or biological characteristics in the receiving waters and can therefore be approved subject to the physical characteristics also remaining unaltered.

Moreover, if one assumed that nominally 80% of metal loads are particulate bound and that 92% of TSS is predicted to be removed, it follows that at least 74% of metal loads will be reduced and it is most likely that additional dissolved metal loads will also be reduced by the proposed bioretention swales, water quality pond and floating wetlands.

Liebman et al, 2009, notes that in order to removal metals effectively, a robust treatment train is required and in addition some form of best practice biological treatment is required. The proposed system includes a robust treatment train with GPTs, bioswales which filter out particulate bound metals and a water quality pond with floating wetland which will provide biological uptake of metals as they adhere to the biofilms on the submerged roots of the floating wetland.

At this time there is insufficient data to model the decay of metals in a treatment system but the EPA and others should be assured, based on the evidence presented and the predicted performance, the system will render metal concentrations to benign levels. Ecotoxicity is very unlikely to occur if this development is approved.

We have also assessed the likely impact on alkalinity of using crushed concrete and making crushed concrete. With reference to the Bingo Kembla Grange site which has approval to recycle up to 230,000 tpa of similar waste. pH testing of their water quality pond has so far shown pH to be fairly neutral at 6.9 and 7.3[11].

In conclusion the biological and chemical impacts on water quality are likely to be acceptable without even considering any dilution and decay that would occur on the property prior to reaching Kangoo Road. The following section describes physical impacts of discharging water to the bushland.

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[11] from: https://www.bingoindustries.com.au/recycling-centres/recycling-centres-sydney-and-surrounds/kembla-grange . See the link to 'Pollutant Monitoring Results EPL20601 , for the water quality test data.

6.3.2. Surface water quantity impacts

In order to examine the predicted impacts of the proposed development on the bushland in terms of water quantity, the post development case is compared with the predevelopment and pre European (forested) case. The purpose of modelling the pre European case, is to determine how much extra runoff is generated by the proposed development beyond that which a pristine site would generate.

Table 13 below shows the results of the predevelopment and pre European site simulation compared with the post development simulation, both with and without the reuse of the stormwater that is generated on the site.

It can be seen in Table 13 that by harvesting and reusing the stormwater, rather than disposing it to the creek, the mean annual volume of surface runoff and frequency of surface runoff can be reduced closer to the pre European runoff volume and frequency, thereby maintaining soil stability and protecting the bushland from any adverse effects.

While we are unable to reduce the volume of runoff or frequency of discharge back down to pre European levels we can come close to that target and certainly substantially reduce the volume of runoff and frequency of discharge compared to the current or predevelopment land use.

Table 13: Mean annual flow comparison

	Pre European	Pre development	Post development (without treatment)	Post development (with treatment and harvesting)
Mean Annual Surface Flow (ML/year)	9.76	31.6	45.2	13.4
Frequency of discharge (average number of days per year)	5	80	80	8

The SEARs indicate a need to demonstrate that all practical measures are being taken to reduce, as much as possible the volumes of polluted runoff from this site. It is clearly demonstrated that this development proposal will now achieve this requirement.

Up to 26 ML of water will be harvested from the pond and a further 600 kL from the tip and spread building, 1 ML of which is used to irrigate the M. Biconvexa buffer area to maintain post development flows. Note 2 ML of water is lost from the pond as evaporation and 3.5 ML water is lost into groundwater from the level spreader while 13.4 ML flows out over it. This is summarised below.

Table 14 Water Demand Summary

Water Demands	Annual volume (ML)
Dust Suppression and landscape irrigation demand	49
Dust suppression in warehouse – to be supplied from potable system	3
Additional non-descript site demand such as toilet flushing, truck washing (1kl/day) etc	< 0.565 ML
Total potable and non-potable demand	52.565 ML/a

Table 15 Water Balance Summary Table

	Pre European	Pre Development	Post Development without treatment	Post development with treatment
Annual Rainfall Volume (ML/a)	79	79	79	79
Annual Runoff Volume (ML/a) from level spreader	9.76	31.6	45.2	13.4
Pond evaporative loss (ML/a)				2
Loss due to infiltration at spreader (ML/a)	20.57	10.90		2.6
Stormwater harvesting supply volume (ML/a)	N/A	N/A	0	26.0
Rainwater harvesting supply volume (ML/a)	N/A	N/A	0	0.96
Sub-total (excluding rainfall)				45.2
ET loss from site	48.67	36.50	33.8	33.8

Peak potable demand for the site would be in the order of 200 kL/day which is about 7 l/s peak. Note that fire-fighting demand exceeds this and remains the dominant peak demand.

6.3.3. DRAINS Peak Flow Results

The DRAINS model results are as follows:

Table 16 DRAINS Peak Flow Results

Storm Probability – 1 in X years	Predevelopment peak flow (100% pervious) m^3/s	Post Development peak flow (100% impervious) m^3/s	Peak velocity over 50m wide level spreader
1 in 1	0.312	0.218	0.26m/s
1 in 10	0.917	0.911	0.45 m/s
1 in 100	1.88	1.48	0.55 m/s

Note that these peak flow results are based on assumed volume of storage of 2,500m^3 and reflect a site which is 6.05 hectares and nominally 100% impervious. This equates to 413 m^3 of storage per hectare of development and is comparable to the volumes of storage prescribed by Blacktown City Council for new urban developments in that LGA which require 455 m^3 of storage /hectare of development.

6.3.4. Level Spreader Velocities and Threshold Design Results

Table 16 shows the predicted peak velocities for a 50m wide channel on a site with a 2.4% bed slope.

The peak velocities for all storms up to the 10% AEP are predicted to be below 0.53 m/s which is the assumed threshold velocity for a sandy loam non colloidal soils without any vegetation cover. Our site has some vegetative cover along with substantial leaf litter which would substantially slow down flows.

In accordance with the Soil Conservation Service methods described in the USDA Threshold Channel Design document used, application of correction factors such as a depth correction factor and flood frequency correction factor have been made when deriving the 0.53 m/s allowable velocity. We note there is no correction factor for storms less frequent than the 10% AEP due to the very rare occurrence of these events in geomorphological time scales.

In conclusion, if the level spreader is 50m wide it will allow sufficiently low velocities to be developed to avoid scour of the native bushland. With the high degrees of leaf litter and vegetative and woody debris present on site there is a minimal risk of scour.

Routine monitoring of the area downstream of the level spreader should be undertaken and any erosion stemmed ASAP.

In conclusion the inclusion of a stormwater harvesting and reuse scheme helps to mitigate the impacts that this site will have on both adjoining bushland also on Kangoo Road. We conclude that post development volumes of runoff remain less than predevelopment, post development frequency of runoff is close to a pre European state and peak flows have all been retarded to levels less than predevelopment. We have included a broad level spreader to ensure we do not get concentrated erosive flows occurring.

As a result, the hydrological regime will not alter as a result of this development and therefore we conclude that water quantity impacts on adjoining land will be negligible.

7.0 PROPOSED MITIGATION MEASURES

The proposed mitigation measures and strategy is shown in Appendix 1.

The proposed long-term water quality and quantity treatment measures include:

- Risk based controls including emergency spill pond
- Preventative measures including buildings, site grading and separation of flows from working areas
- Rainwaters tanks
- GPTs
- Swales
- Pond with floating wetlands
- Stormwater Harvesting and Reuse
- On Site stormwater Detention Basin which also provides for fire-fighting water storage.
- Level Spreader

These are discussed in more detail below.

7.1. Risk Management Approach

It is suggested that a risk based approach to management of stormwater would deliver better water quality outcomes. The proposed development has been divided into six distinct sub-catchments and given a risk assessment based on the proposed activity that would occur in the sub-catchment.

These sub-catchments are shown on Drawing Sheet 115 in detail but repeated below for ease of reference in this document.

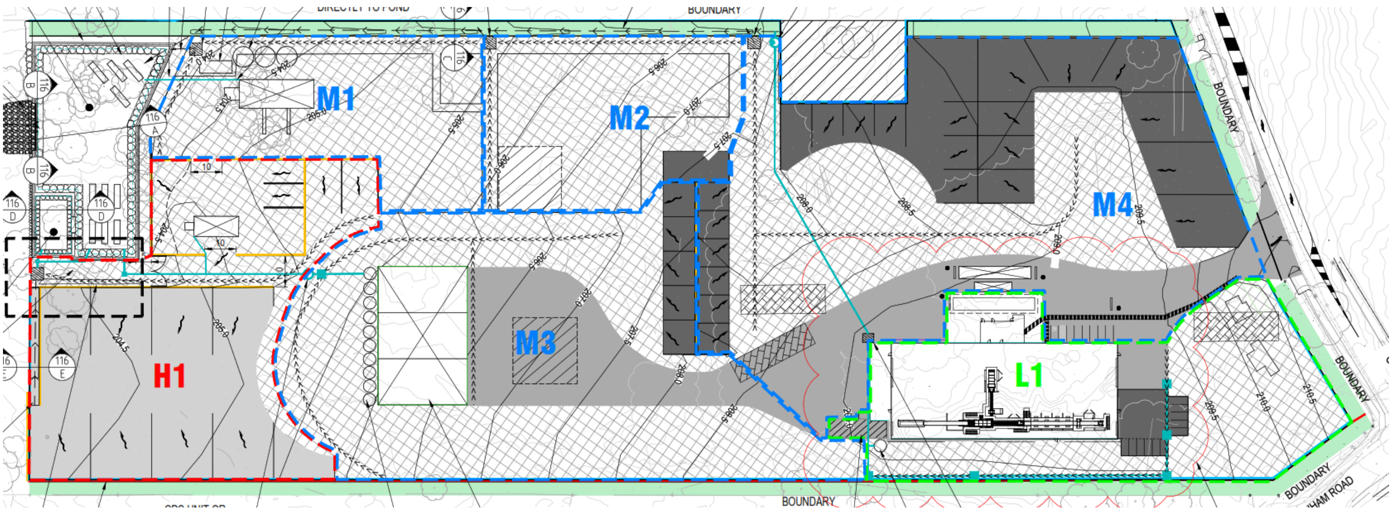


Figure 8 Sub-catchment Risk Break up.

Each of the sub-catchments and their activities are described below:

Table 17 Sub-Catchment Water Quality Risk Description

Sub-catchment Descriptor	*Risk (Low, medium, high)*	*Proposed Activity and potential pollutants*	*Treatment Measures Proposed*
L1	Low	Truck parking, transport, warehouse: Generate TSS, metal runoff from roof, nitrogen runoff from roof.	1. Rainwater tanks for roof runoff. 2. CDS unit to treat sub-catchment runoff including roof. 3. Pond including floating treatment wetland.
M1	Medium	Concrete crusher: generate TSS, alkaline runoff, calcium salts.	1. House concrete crusher inside building to reduce dust generation. 2. Barramy gross pollutant trap to treat whole catchment. 3. Pond including floating treatment wetland.
M2	Medium	Blending area + minor Landscape storage: Generate TSS, nutrients, trace elements. Organic matter from blended landscape products, TPH, metals from use of plant and equipment including loaders.	1. Barramy gross pollutant trap to treat whole catchment. 2. Bioswale to carry out tertiary treatment 3. Pond including floating treatment wetland.
M3	Medium	Tip and spread roof, blended landscape product storage and transport: Will generate TSS, organic matter from landscape products, nutrients in runoff. Metals from transport and shed roof.	1. Rainwater tanks for roof runoff. 2. CDS unit to treat sub-catchment runoff including roof. 3. Pond including floating treatment wetland.

Sub-catchment Descriptor	Risk (Low, medium, high)	Proposed Activity and potential pollutants	Treatment Measures Proposed
M4	Medium	Product storage bays and transport: Will generate TSS, nutrients from stored soils, organic matter from soils, calcium from crushed concrete.	1. Barramy gross pollutant trap to treat whole catchment. 2. Bioswale to carry out tertiary treatment 3. Pond including floating treatment wetland.
H1	High	Waste storage Bays and Timber Shredding area. This is deemed high risk due to both chronic and acute risks. Chronic risks include potential leaching of soils, metals, tannins, salts (ions). Acute risks consider that this area has the greatest risk of having a fire and therefore during a fire emergency it would be necessary to contain runoff from this area separately to all other areas. Refer also the drawings for the proposal as well as Section 7.12 which describes an emergency spill pond.	1. Barramy gross pollutant trap to treat whole catchment. 2. Pond including floating treatment wetland. 3. Emergency Spill Pond if required.

7.2. Preventative Measures

The following measures are adopted in the site design:

- Place all heavy processing and dust generating activities inside buildings with dust suppression to reduce generation of particulates which once settled can become water borne after rain.
- Carry out waste acceptance in accordance with the waste management plan which, amongst other things, would see rejection of CCA treated timber and asbestos. This will significantly reduce the risk of CCA leaching and needing to be treated in the treatment system.
- Cover the vehicle washbay and send wastewater to trade waste not stormwater
- Send stormwater treatment plant reject water to trade waste not back to the pond
- The site is graded so that water is to flow out of storage bays and not into them.
- Use graded depressions/swales on the site to help divert run-on water around product blending and storage areas keeping them as dry as possible.
- Pipe main warehouse roof runoff and associated sealed parking directly to the pond in a pipeline routed toward the west of the site and under the bioswale.
- Roof runoff from the spread and tip shed will be stored in rainwater tanks and the overflow piped to the pond after treatment in a GPT.
- Roof runoff from the timber processing shed and crusher shed will also be piped to the pond.
- Direct flows to GPTs for treatment first before directing flows to swales.

7.3. Installation of geomembrane

The whole site is to be sealed either by using concrete pavement or by using a geomembrane to protect groundwater. This will necessitate extensive use of subsoil drains across the site which shall be directed to the pond.

The 150mm thick drainage layer under the pavement is a typical drainage layer. It will need to be designed in detail but will include:

- A 5mm gravel layer
- Subsoil drainage pipes within the gravel layer. Subsoil pipe strength class will need to be sufficiently high to ensure pipes are not crushed by all plant and equipment.

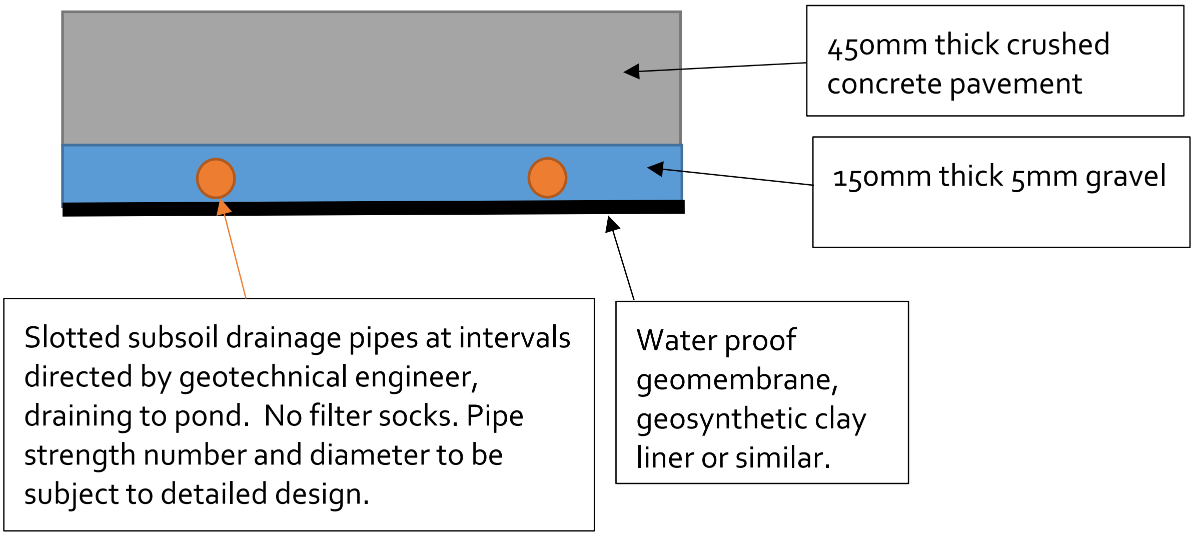


Figure 9 Pavement Drainage and Geomembrane layer

7.4. Filtration of Metals at Source

It is proposed to place filter sausages across the metals storage bay where the risk of exporting metal contaminants is highest.

Star Water produces a technologically advanced treatment product called reactive filter media, developed with NSW EPA funding. It uses recycled waste materials as part of the constituents of a customised filter media. This media can be placed inside a filter sock and placed across a flow path to filter out targeted pollutants at source. Star Water has the technology to specifically design the media to target metals (amongst other pollutants).

It uses a combination of filtration and ion exchange to remove dissolved metals. It is proposed to use these filter sausages to filter the runoff from the metal storage bay. The sausages may also be used more widely on the site to target other specific areas.

The media in the sausages would need to be replaced in accordance with the supplier recommendations, which can only be known once the site becomes operational.

Claimed performance is for over 90% metal removal.

Filter sausages may be used elsewhere as an adaptive management technique to help improve localised water quality hot spots.

Figure 10 Star Water Filter Sausages (Safe Sox) used to filter metals and other pollutants

7.5. Rainwater Harvesting

It is proposed to include a 50 KL rainwater tank on the main warehouse roof. This water will be used to wash trucks in the truck wash bay.

It is also proposed to include ten, 18 kL rainwater tanks to collect runoff from the tip and spread building roof and use it for dust suppression within the building.

In order to ensure the harvested rainwater is fit for purpose it will need to be filtered in a 5 micron filter and disinfected in a UV system immediately prior to use. All downpipes shall be fitted with a first flush device to ensure the first flush of stormwater is bypassed from the tanks for health reasons. The first flush system will need to be routinely maintained by cleaning it out. On a site where dust could be generated this becomes an important critical control.

Pollutant removal processes that occur in rainwater tanks include:

1) Settlement of sediment.
2) Removal of some particulate matter which settles in the tank.

7.6. Barramy GPTs

Four (4) Barramy GPTs are recommended because they have been designed for environments such as the proposed development. They work to keep organic matter dry and prevent leaching of dissolved nutrients. They are easy to maintain using a back-hoe or small loader.

The photos below show a recent installation in the Blue Mountains World Heritage Area.

Plate 3 Barramy Gross Pollutant Trap

Plate 3 shows the trap with vanes moving gross pollutants and solids to the left hand side. When flows build up water is able to flow between the vanes.

The material moved into the trap is allowed to dry as the trap slopes toward the right hand flow bypass channel. The screen at the end of the device also allows debris to be pushed to the back of the trap so that is becomes self-stacking. The debris is pushed against the screen and the debris itself forms a blinding layer which stops further debris from being washed through the screen.

Four traps are proposed to treat runoff from catchments M4, M2, M1 and H1.

Traps treating runoff from catchment M4 and M2 are required to reduce the loading of sediment and gross pollutants on the bioswale. This will enable the bioswales to be easily maintained into the future.

Traps treating runoff from M1 and H1 are required to keep sediment and gross pollutants out of the pond and will reduce the maintenance burden of the pond.

Plate 4 Showing a side view of the Barramy Trap.

Plate 4 shows how the trapped material can dry out against the maximesh screen.

The material caught in this trap includes very fine wood fibres less than 1mm in size, sands and silts, leaves and litter. The trap in these plates was emptied 2 weeks prior to this photo being taken and the contents were conveyed in 2 storm events from a steep catchment.

Processes which occur in the Barramy GPTs include:

1) Removal of gross pollutants – about 97%
2) Removal of TSS – about 30% to 50%
3) Removal of particulate nitrogen and phosphorus
4) Removal of attached metals
5) Removal of hydrocarbons bound to sediment

7.7. CDS GPTs

The site plan shows two (2) CDS GPT to be installed. The first treats catchment L1. The second treats catchment M3.

This CDS unit will collect and treat hardstand runoff the area to the north of the unit. It is expected this unit will mostly collect sediment and some coarser particles. The units will need to have Class D trafficable lids.

Treated water from this unit will be directed to the pond and it will bypass the "high risk" flow area which is defined as the waste storage bays and timber shredder area.

CDS units are widely used in the industry for their very good water quality performance and ease of maintenance.

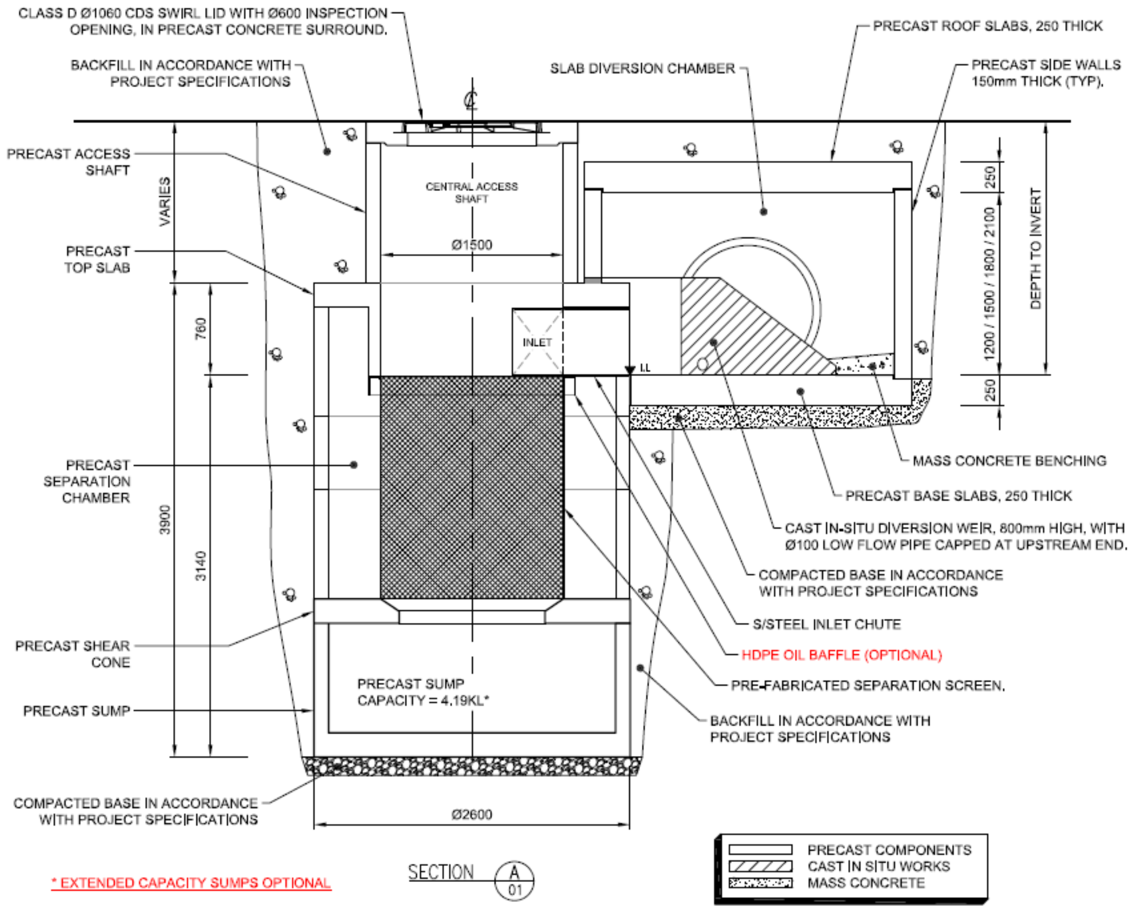


Figure 11 Typical CDS unit technical drawing

Processes which occur in the CDS GPTs include:

1) Removal of gross pollutants – about 97%
2) Removal of TSS – about 35% to 50%
3) Removal of particulate bound phosphorus
4) Removal of attached metals
5) Removal of hydrocarbons bound to sediment

7.8. Grassed Bioswales

Grassed swales have been included in the treatment train. Evidence from a Borgs Manufacturing site at Oberon is that these swales perform well to reduce TSS, TP, TN and tannins (pers comm with Mr Victor Bendevski, Environmental Manager for Borgs). Over time however, as they are designed to be a depositional tool, their depth will reduce and they will need to be maintained to reinstate their design depths.

A typical bioswale is shown below in Figure 12

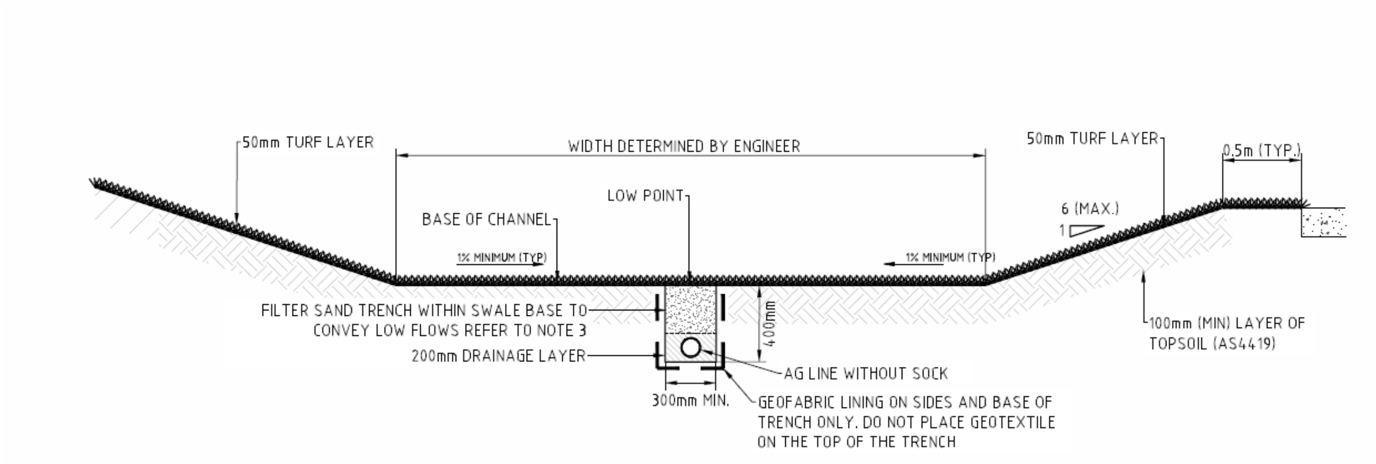


Figure 12 Typical grass swale

The design bioswale dimensions adopted in this project are:

- 1 in 4 side slopes
- 1m wide base
- 0.3m deep and 3.4m wide at the top
- 3% maximum longitudinal slope
- 300mm deep filter media overlying a transition zone and gravel drainage.
- The swales would need to have subsoil drainage as shown because there will be an impermeable liner under the swales preventing groundwater impacts.

During detailed design, the maximum permissible flows in the swales will need to be checked and where the flow capacity is exceeded flow will need to be piped from that point.

Pollutant removal processes that occur in bioswales include:

1) Removal of fine TSS
2) Removal of particulate bound nitrogen, phosphorus, metals and hydrocarbons
3) Uptake of nutrients and trace elements by grass – grass clippings MUST be removed from the swales to prevent leaching of nutrients back into the media.
4) Ion exchange in the media to remove ions including metals and ammonia
5) Absorbing of large volumes of flow to reduce volumes of runoff.

7.9. Water Quality Pond

The design pond dimensions adopted for this project are:

- Surface area of 1,666 m^2.
- Maximum depth of 3.0 m – stratification unlikely to occur due to constant water demand drawn from the pond, i.e. the water level will flux up and down frequently.
- Volume of 5,000 m^3.

- Maximum drawdown depth of 2.4m leaving 600mm as a minimum depth for the floating wetlands to survive.
- Lined with no infiltration.
- The proposed pond has steep sides – near vertical sides and will require safety fencing.
- The pond is to be maintained by excavators and plant that are on site. A 5m wide working area for maintenance around the northern side of the pond will need to be set aside. A 2m tall koala fence with floppy top will need to be erected around outside of the maintenance working area and the southern side of the pond to prevent fauna and people from accidentally entering the steeply sided pond. An emergency ladder would be fitted to the walls. An alternative would be to pump sludge out of the pond into a sludge filter bag which dewaters the sludge. We estimate the pond would need to be emptied of sludge every 5 years and after 300mm depth of sludge was built up.
- In order to contain the firefighting water on site, water-tight penstock(s) would need to be included to ensure that no flows leave the site. How this is arranged would be determined during detailed design. Possible configurations include headwall mounted penstocks with manual spindles left permanently in place. Suggested manufacturers of the penstocks would be either SPEL or AWMA.

Pollutant removal processes that occur in water quality ponds include:

1) Removal of very fine TSS
2) Removal of very high levels of particulate bound nitrogen, phosphorus, metals and hydrocarbons
3) Long residence times to facilitate nitrification and denitrification to remove dissolved nitrogen
4) Absorbing of large volumes of flow to reduce volumes of runoff
5) UV exposure to remove pathogens
6) Volatilisation of hydrocarbons

7.10. Floating Wetlands

Up to 165 m^2 of floating treatment wetlands (FTWs) are proposed for the pond to make up the 10% assumed vegetation coverage. Wetlands provided by SPEL Stormwater are recommended as robust field tested devices. Indicative costs for this project are around $120k including installation.

Floating wetlands are a new technology with very promising performance both during construction and operation. Essentially the floating wetlands are a buoyant raft of macrophyte plant material with a root zone in the water column. This allows for substantial biofilm growth on the roots.

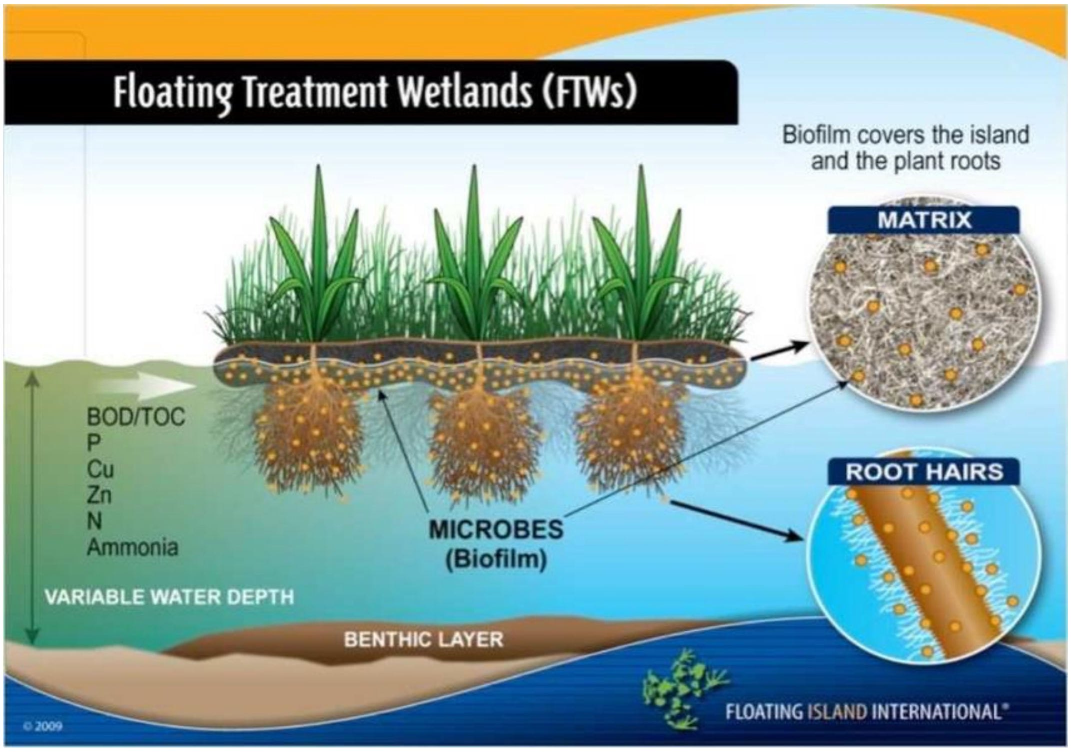


Plate 5 Floating Wetland Schematic (image from Walker et al, 2017 on SPEL website).

The technology in this context is used to save space and deliver a superior water quality outcome. It is likely the area of floating wetlands adopted will deliver substantial water quality impacts though they have not been accounted for in the modelling except to justify the choice of a water quality pond as modelled in MUSIC.

Additional information on the performance of a floating wetlands is included in Appendix 3.

We note that we have not modelled the benefit of the proposed floating wetlands in the MUSIC model because it is believed that the science behind the FTWs is still in its infancy and needs further research under a broader range of conditions prior to the models being considered rigorous. Research to date has not measured the performance under a configuration such as the one proposed in this project where the pond is also used for stormwater harvesting. Research to date has focussed on measuring performance in a water quality pond where the water level was mostly static. In this project the water level in the pond will fluctuate considerably.

Based on the research by Nichols et al (2016)[12] included in Appendix 3, where they monitored a floating wetland which covered 0.1% of the catchment it is feasible the floating wetlands would improve TSS by 80%, TP by 53% and TN by 15%. We note this proposal sees an area equal to 0.3% of the catchment covered with floating treatment wetlands (i.e. three times as much coverage) but it also sees the FTWS located in a much larger water quality pond with much dirtier inflow water and a greater vertical range in operating water levels. In conclusion at this time there is a lack of suitable scientific data available with which to model FTWs as proposed on this project. Results in this report are therefore to be considered somewhat conservative.

[12] Nichols P, Lucke T, Drapper D, Walker C, Performance Evaluation of a Floating Treatment Wetland in an Urban Catchment, MDPI Journal, Water 2016, 8, 24.

Pollutant removal processes that occur in floating treatment wetlands include:

- Removal of fine TSS through adsorption onto root mass
- Settlement of fine TSS below root mass
- Removal of particulate bound nitrogen, phosphorus, metals and hydrocarbons
- Uptake of nutrients and trace elements by plants
- Ion exchange on the biofilms on the root mass to remove ions including metals and ammonia
- Oxygenation of the water column to enhance BOD and COD removal.

7.11. Fire Fighting Water Storage

Note the proposed on site stormwater detention basin is to be 2,500 m^3 in volume and provided the fire did not occur during a storm event (very unlikely) the OSD basin could easily contain any fire-fighting volume with substantial spare capacity.

Penstocks are water-tight gates that can open and close to completely block off flow. They are widely used in the wastewater and irrigation industries.

An example of a penstock is shown below.

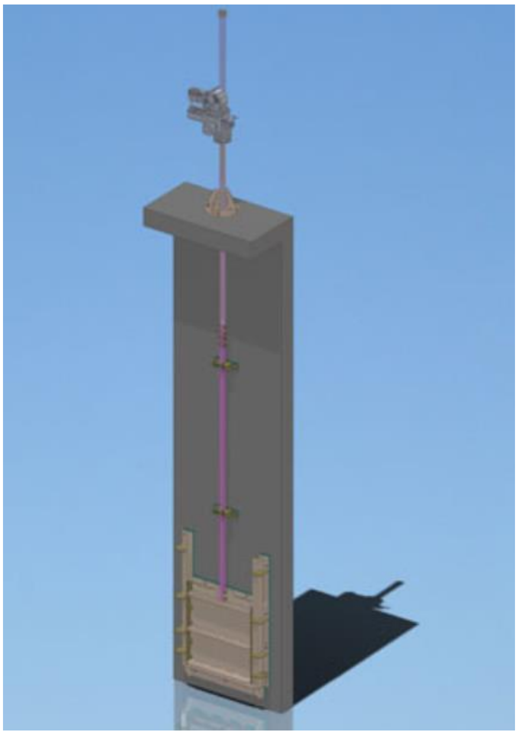


Figure 13 Example of a penstock

During a fire emergency or emergency spill event, the penstocks to the main water quality pond would be closed manually. This would require a trained operator to walk along a gangway located on the pond wall and to then close the penstocks. A portable battery powered drill can be used to close them rapidly or they can be manually wound and achieve a water-tight seal.

The penstocks would be located over each outlet opening in the pond outlet wall and therefore three would be required.

7.12. Emergency Spill Pond

The design includes an emergency spill pond located adjacent to the 1.45 Ha high risk area. The high risk area is shown on Sheet 115 in Appendix 1 and includes the waste storage area and the timber shredding area. Only the high risk area drains to the emergency spill pond.

A fire or accidental spill is most likely to occur within the high risk area and less likely to occur outside of this area.

If a spill occurs inside the high risk area or there is a fire in the high risk area, then runoff from this area will be drained to the emergency spill pond where it will be captured and contained. The emergency spill pond is designed to spill into the main water quality pond as a final opportunity for capturing runoff before discharge from the site.

The proposed emergency water quality pond volume is to be 500 m^3, which will allow it to capture up to 90% percentile 5 day rainfall event without any discharge. This would allow 60 mm of either fire water/foam or polluted runoff to be fully contained in the pond without mixing with any other site runoff. This would allow fire-fighting water to be contained and removed from the emergency spill pond. This would prevent the fire water or emergency spill from mixing with water that is in the 5ML water quality pond and therefore it will potentially prevent the need to remove up to 7.5 ML of contaminated water from the site.

In the highly unlikely event that the emergency spill pond does not have enough capacity, additional capacity is available in the main water quality pond as described above.

It is proposed to install a water quality probe into a sump to monitor water quality leaving the high risk area. The probe would monitor multiple parameters such as EC, TSS, NOx, and turbidity. The probe would be connected to a logic controller which would be trained to identify when either unusually dirty water is being discharged or when there is an accidental spill or during a fire emergency where foam is used. These events are described as out of range events, meaning that water quality entering the pond would be of abnormally poor quality and should be isolated and stored and then investigated further if required.

The proposed system would automatically monitor water quality in real time (24/7) and then if an out of range parameter was detected a penstock leading to the main water quality pond would be closed and divert water to the emergency spill pond.

The emergency spill pond would, during normal operations need to be pumped out of rainwater to keep it dry. The same pump system could be used to pump low quality water either to sewer under a trade waste agreement if it could be demonstrated the water would meet trade waste criteria (i.e. after testing) or if very poor quality, would need to be transported off site to a lawful facility.

Trade waste agreements have strict criteria. For example, the wastewater must not contain more than 5 ppm of oil and grease. Salinity and chemical criteria also apply and would need to be established and agreed with the Water Authority during detailed design. If a trade waste agreement can't be obtained the emergency spill water would need to be tankered off-site and disposed of in a lawful facility.

It is not anticipated that this pond will be a normal part of the operating regime on the site. It is expected that it will operate only during an emergency (fire or spill) or following runoff of unusually dirty stormwater from the high risk area.

It is proposed to link the logic controller with a modem which would send an SMS to the site manager to alert him to the fact that either an emergency has occurred, or very dirty stormwater is running off and needs immediate investigation. Careful programming of the normal operating range of parameters is critical to ensure that the scheme only operates in a genuine emergency. A similar approach has been employed on a large stormwater harvesting scheme in western Sydney, to warn operators of poor water quality or a spill in the catchment and has worked well to date.

We have obtained quotes and advice from John Morris Scientific who are recognised for their high quality robust monitoring equipment.

For a detailed explanation of the components of the system please refer to the inset on Sheet 115 in Appendix 1.

7.13. Stormwater Harvesting

It is proposed to draw approximately 48,162 kL/year from the pond. This water would be used to keep product storage bay areas containing product at optimum moisture content. In addition to irrigating products and traffic areas for dust suppression, drawing water from the pond to irrigate landscaped areas would help to reduce the mean annual volume of runoff from the site considerably.

Drawing 48,162 kL/year would allow for:

- irrigation to a depth of 900mm of 5.1 hectares of the site.
- As well as irrigation of 1,040 m^2 of M. Biconvexa buffer area (to replace water lost from the catchment due to development) and irrigation of 2,230 m^2 of landscaped areas including the site swales. Irrigation of swales and adjoining areas would ensure optimum grass growth and optimum water quality outcomes. Water to irrigate landscaped areas would also assist in maintaining high quality, drought resistant landscape features and reduce fire risk.

It will be necessary to optimise the reuse of harvested water so that it can be allocated preferentially to products and dust suppression when water levels get low.

Sustainability Workshop has worked with MAK Water to develop an appropriate treatment process to ensure the stormwater would be fit for purpose and safe for use. It would need to be disinfected prior to irrigation. Because of the tannins likely to be present UV alone is not a disinfection option though both UV and chlorination are proposed.

Ultrafiltration is proposed together with UV and chlorination to ensure that guidelines (AGWR and MUS Harvesting and Reuse guidelines) identified in Section 4 are complied with.

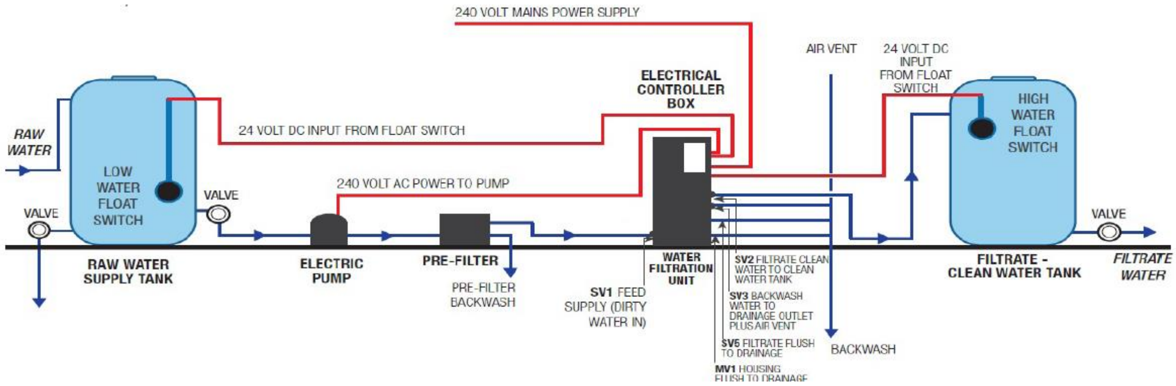


Figure 14 Schematic of Ultrafiltration (UF-B-80) Treatment system.

The treatment plant would come on a skid mounted 20 ft container and need to be connected to electricity. The feed pump should include a self-cleansing intake.

The UF-B-80 system is capable of treating up to 80 m^3/day and so would be scaled to meet peak site day demand which would occur in summer and be around 240 m^3/day. Three units would need to be installed to meet this peak demand.

Standard specifications for the treatment plant are included below:

Parameter	Units	UF-B-20	UF-B-40	UF-B-60	UF-B-80
Filtrate Flow Rate(varies according to feed water quality)	m^3/day	20	40	60	80
Filtrate Recovery Rate	%	90 – 98% (varies according to feed water quality)			
Membrane Type	-	Outside in, dead end			
Filtrate Turbidity	NTU	<0.1 (typical)			
Raw Water Turbidity (max)	NTU	<50			
Raw Water TSS (max)	mg/L	<100			
Feed pH range	pH	6 – 9 (exposure to chlorine or chloramines is not recommended in feeds below pH 6.5)			
Allowable pH range for chemical cleaning (by others)	pH	2 - 10			
Raw Water Temperature	°C	15 ~ 35			
Ambient Design Temperature	°C	5 ~ 45 (-15 ~ 50 for insulated containerized system)			
Feed-Pre Screen Requirements	micron	500 or finer (unscreened or coarsely screened raw water may reduce membrane operating life)			
Feed Water Inlet Pressure (min)	kPa	100 kPa			
Feed Water Inlet Pressure (Max)	kPa	200 kPa (recommend <150)			
Filtrate Discharge Pressure Drop	kPa	~30			
Backwash Discharge Pressure Drop	kPa	~20			
Power Supply	-	AC 110/240 V, 1 Phase, 50/60 Hz			
Power Consumption	kW	0.5	0.5	0.5	0.5
No. Containers (Optional)	-	1 x 10'	1 x 10'	1 x 10'	1 x 10'

Table 18 Ultrafiltration UF-B-80 Treatment Plant Specifications.

In addition to the treatment plant it would be necessary to store treated water for 2 days which would need to be about 480 m^3. Because the chlorination will have a residual effect it will be safe to store the water in the tanks for shorter periods. If not used, nominally within a week, the water would need to be released back into the pond (subject to design).

Hypochlorite would need to be replenished and stored on site in a refillable, bunded container. Some WHS equipment would be required adjacent to the store – such as an emergency shower. This may require a potable water supply to the treatment plant location. The potable supply would be required anyway to make up any deficit in supply needed during very dry times when the pond was empty.

Indicative costs for the equipment would be in the order of $200,000 for the Ultrafiltration plant ($150k) and storage tanks ($50k). A trade waste agreement with Council would need to be entered to accept the filter backwash.

During detailed design the exact plant requirements would need to be established.

An irrigation controller and moisture probes will be needed to help schedule irrigation mainly to ensure that over irrigation does not occur.

A local rainfall gauge would need to be connected to the irrigation controller to ensure that irrigation does not occur when it is raining.

7.13.1. Stormwater Treatment Performance

The final design of the stormwater treatment system will be undertaken to ensure the system meets all regulatory requirements including those identified earlier in this report.

All water produced by the treatment system, which includes the rainwater tanks, swales, GPTs, pond, storage tanks, ultrafiltration plant, and disinfection system, will be fit for purpose as required by legislation. It will be safe for workers and the public and its quality will exceed the requirements for survival and good health of the Biconvexa community, i.e. low in nutrients, low hardness, low metals, practically no TSS.

The proposed stormwater treatment plant is an ultrafiltration plant capable of filtering down to 80 nanometres. A combination of ultrafiltration together with Chlorination and UV disinfection will ensure that the plant will meet all the human health performance criteria stated earlier in Table 5. As a result, the plant operator can have confidence that all WHS obligations would be met.

Risk	Parameter	Units	Target	Performance of Treatment Plant
Health	Recycled Water Turbidity	NTU	≤2	<0.1
Health	pH		6.5-8.5	7.0
Health	E.coli	CFU/ 100mL	<1	<1
Health	Cl_2 residual after 30min[1]	mg/L	1	>1 and < 2
Health	Virus	Log reduction	2.4	4 log as a system

Risk	Parameter	Units	Target	Performance of Treatment Plant
Health	Parasites	Log reduction	1.9	4 log as a system
Health	Bacteria	Log reduction	2.4	4 log as a system
Operation	Suspended Solids	mg/L	50	< 1 mg/L
Operation	Iron (total)	mg/L	10	<2 mg/L (to prevent fouling of pipes etc and plant etc)
Operation	Phosphorous	mg/L	0.8	<0.5 mg/L
Operation	Hardness ($CaCo_3$)	mg/L	350	<100 mg/L

Table 19 Predicted Stormwater Treatment Plant Performance and compliance with all relevant human health criteria

7.13.1.1. M. Biconvexa Irrigation Water Quality

Please note with respect to the irrigation of the M. Biconvexa area the long and short term values shown in Table 4.2.10 of Chapter 4 of Volume 1 of the ANZECC Guidelines (2000) shall be applied. It will therefore be necessary to ensure that irrigation water contains for example levels of Lead and Zinc at less than 2.2 mg/L while iron should be less than 0.22 mg/L. The full list of metals is not repeated herein but is accessible on-line at: https://www.waterquality.gov.au/sites/default/files/documents/anzecc-armcanz-2000-guidelines-vol1.pdf .

Actual treated stormwater would need to be tested for compliance with these guideline values. If the treated stormwater is found to contain levels of metals that exceed the long term values cited in Chapter 4, Volume 1 of the ANZECC Guidelines then either:

1) Additional treatment of the stormwater will be undertaken to reduce metal concentrations – typically an ion-exchange process will achieve this as it is dissolved metals that would need to be targeted. The extra space required for this process is in the order of $3m^2$ and so this can be resolved during the site establishment phase and commissioning process once actual site water quality is known.

   Or if this is not viable then:

2) Potable water will need to be used to irrigate the Biconvexa – approximately 0.95 ML of water would be needed to replace the lost run on water.

In line with NSW EPA recommendations, it is recommended to test for the build-up of metals in the soils in the Biconvexa irrigation area as well as downstream of the point of discharge of the site to validate rates of actual metal accumulation in the soil and these should be compared to background conditions as well as safe long term accumulation rates.

ANZECC assumes a 100 year loading rate. Predevelopment soil testing in the Biconvexa area and downstream of the point of discharge is recommended prior to construction to provide some baseline data

7.14. Level Spreader

It is proposed to construct a level spreader at the outlet from the pond.

A typical detail showing a level spreader is provided below. The width of the spreader should be 50m and the height of the spreader should be 300mm. On the upstream side of the spreader a gravel filled trench 1m wide and 50m long is to be included to facilitate as much infiltration as possible at that location.

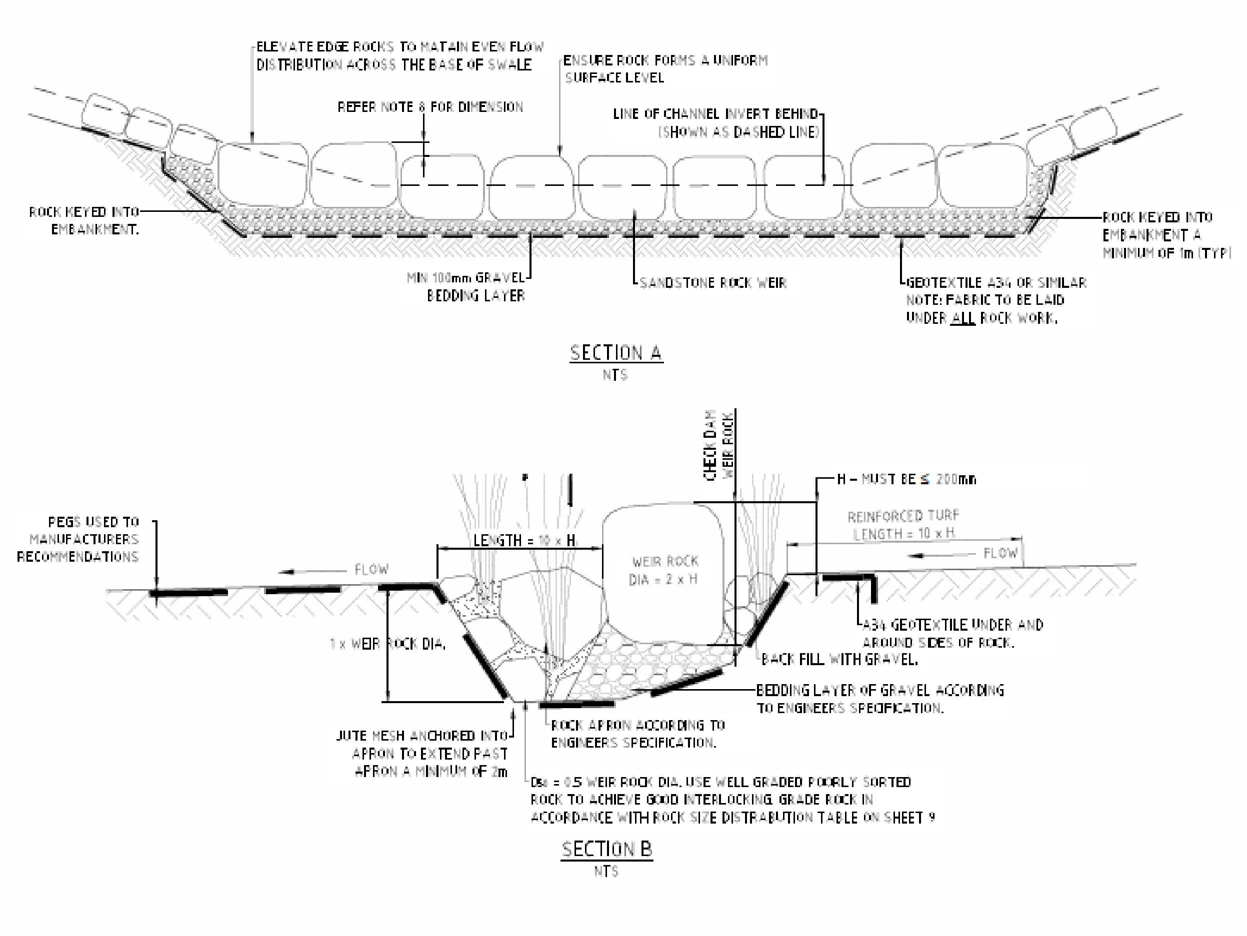


Figure 15 Level Spreader Typical Detail

7.15. On Site Stormwater Detention Basin

An on-site stormwater detention basin is proposed to be co-located above the water quality pond for the purpose of detaining peak flows.

The configuration of the basins should be as follows:

1) Provide storage of 2,500 m^3 between RL 201.5m and RL203m. A weir height of 300mm and weir width of 10m is recommended for extreme events beyond the 1 in 100 year event.
2) The invert level of subsoil drains discharging into the basin shall be no lower than RL203m. Based on a preliminary pavement design of 450mm plus an allowance of 150mm for subsoil drainage, this places the lowest pavement surface levels at approximately RL203.6m. This will ensure backflow into the subsoil drains does not occur – if it did it would prevent drainage of the pavement and result in substantial pollution generation.
3) Three orifice outlets from the basin corresponding to:
    a. Low flow outlet at RL 201.5 which was modelled as a 375mm diameter pipe.
    b. Second outlet at RL 202 which was modelled as a 525mm diameter pipe.
    c. Third outlet at RL 202.18 which was modelled as a 525mm diameter pipe.

7.16. Risk and Operation and Maintenance Plans

It is critical that a detailed operation and maintenance plan for the stormwater and recycling system is prepared and adopted. In addition to that, in accordance with Australian Recycled Water Guidelines, a risk management plan for the stormwater harvesting and reuse scheme, which includes every aspect of the stormwater treatment train on site should also be prepared together with staff so that risk management (WHS management) becomes a shared responsibility.

The treatment plant will need to go through a proving period which will require monitoring of both influent and effluent to ensure that it is performing to specification and that the risk of using the water is as expected.

In addition, it is proposed to monitor the site discharge water for a range of parameters including any licenced parameters during the commissioning of the site and all of its water quality management systems.

It is noted it will take the site probably over 1 year to settle down and for water quality to be optimised. For example, it will take time for the bioretention swale to grow sufficient cover and for roots to penetrate to a good depth.

Monitoring of site discharge water quality should be undertaken through a **water quality validation programme** whenever there is a discharge from the site. Section 10.6 includes details of the proposed water quality validation programme.

The monitoring results should be discussed with the site operator, the system designer and the site environmental officer. If the system is not performing in accordance with the modelling adaptive management measures will need to be taken. These usually take the form of prevent, source control and then end of line control. Preventative measures might be a change in operations so that for example clay based soils are always stored behind sandy soils to prevent clay based runoff.

An example of source control would be use of media filled filter sausage placed across the waste storage bin to filter out pollutants close to their source.

It is recommended that training of staff takes place once the works are commissioned. Staff will need to maintain and clean out the GPTs (minimal training required), clean out swales, nominally every 5 years or if they lose capacity then sooner, the pond will need its sludge removed and the floating wetlands will need some replanting and renewal over time.

The level spreader will need checking to ensure erosion is not occurring downstream. Culverts will need to be checked after every storm event to ensure they are not blocked.

Rainwater tanks will need first flush systems maintained and UV disinfection lamps will need replacing. Hypochlorite will need to be stored on site and will need to be topped up from time to time. Safety showers and eye wash equipment around the hypochlorite self-bunded storage vessel will need to be maintained.

The membrane filtration plant will also need to be operated and maintained and from time to time this will include replacement of membranes. If the operator wishes to extend the replacement time of membranes, then the stormwater management system will need to be maintained to a high standard. Conversely if the stormwater system is not maintained then the membranes will need to be replaced more frequently.

Establishment of good quality vegetation in the wetlands and over the swales and landscaping areas is critical to achieve expected stormwater performance. Providing staff with nominally a one day training course to explain how the system works and what needs to be done is critical. Substantial savings in avoided rectification will be made from this training investment.

8.0 WATER QUALITY ASSESSMENT

This section of the report assesses the proposed water quality management system against the relevant criteria and also on a qualitative risk basis.

8.1. Best Practice Approach

. This includes ensuring that each and every part of the treatment train has been designed to work together as a well-considered best practice treatment train.

The treatment train starts with source controls, these are preventative measures which help to reduce and minimise pollutant export wherever possible. For example designing flow paths to ensure that they do not run through processing areas, that storage bays grade outward not inward, by carrying out risky dirty activities such as sorting waste indoors.

The treatment train hierarchy then progresses as follows:

1) Rainwater is harvested to reduce roof runoff wherever possible. This occurs from the main warehouse roof and the tip and spread roof. This helps to reduce TSS and captures some metalloid runoff. The rainwater tanks help to reduce the load on the whole system and keep relatively clean water separate from site runoff.

2) Gross pollutant traps are then used to remove coarse sediment and gross pollutants from the system. This will keep the bioswale and pond free of a large volume of sediment and gross pollutants. Every part of the site drains to a gross pollutant trap and they are a key part of the treatment train. Gross pollutants remove gross pollutants, TSS and attached hydrocarbons if present. They will also remove attached metals and phosphorus as well as particulate nitrogen.

3) The bioswale is used to treat Catchments M4 and M2. This will reduce fine sediment, metals and nutrients. Removal of sediment and gross pollutants upstream of the swale will help to protect the swale and keep it functioning through the life of the facility.

   The hydraulic loading rate (volume of water treated/ surface area of device) on the swale is predicted to be 100m/year for the first segment and 30 m/year for the second segment. It is considered that a bioretention systems sized at 150m/year or less will achieve their expected design outcomes.

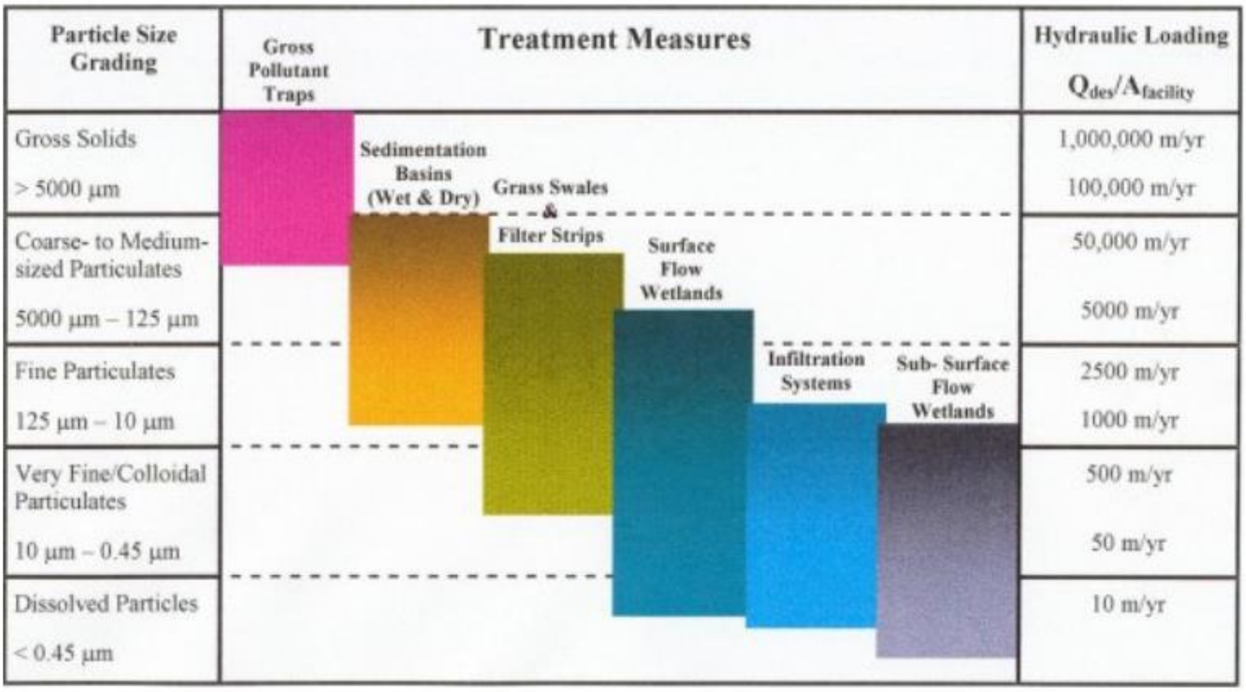


Figure 16 (from Wong and Breen, 2009 in the MUSIC Help File) Hydraulic loading rates versus water quality performance

Figure 16 shows that with a hydraulic load rate of 100m/year the proposed bioswale is likely to perform at the highest level and will be lightly loaded ensuring good outcomes in the long term.

4) The pond has been sized to perform as a long term, high performance water quality treatment device. The pond has a hydraulic loading rate of just 27m/year. This is at the very low end of hydraulic load rates and as the modelling confirms, the pond will deliver excellent water quality outcomes removing everything down to very fine sediment and dissolved pollutants including dissolved metals and nutrients.

   Figure 16 shows that with a hydraulic load rate of 27m/year the proposed pond is likely to perform at the highest level. This does not consider the benefits of the proposed constructed floating wetlands which would assist with removal of additional dissolved pollutants and see the pond perform as a very best practice approach.

5) Stormwater harvesting and reuse further enhances the treatment train by literally pulling pollutants out of the system. This happens through the proposed ultrafiltration system followed by use of the water for dust suppression.

6) The level spreader completes the treatment train by helping to infiltrate additional stormwater. This will see further flow lost, sediment removed, nutrients and metals stripped from the flow.

In conclusion highly polished water is expected from this treatment train.

8.2. Criteria Based Assessment

All known criteria for the assessment of water quality and quantity were identified in Section 4.0. The proposal has been developed specifically to address the applicable criteria.

As demonstrated in Section 6.3 the modelling results show the proposal is predicted to exceed all applicable criteria including the most stringent of these being the need to ensure the project achieves a beneficial effect on water quality.

Not only will the project achieve a beneficial effect it will see the water quality performance of the site almost taken back to pre-European water quality, i.e. a completely undisturbed catchment.

The proposed ultrafiltration plant complete with chlorine and UV disinfection will ensure that ALL human health risks are managed in accordance with the Australian Guidelines for Recycled Water and the NWQMS.

In conclusion the proposal is predicted to achieve excellent water quality based on a comparison of predicted performance against all applicable criteria.

9.0 SOIL AND WATER MANAGEMENT DURING CONSTRUCTION

9.1. Contractor to Prepare Final Soil and Water Management Plan

As the proposed development is a significant development of about 6 hectares in area, it would require a Soil and Water Management Plan (as opposed to a sediment and erosion control plan for minor works).

It is essential, prior to construction, that a detailed Soil and Water Management Plan is prepared by the appointed Contractor and reflects all stages of works as they are intended to be undertaken. No construction drawings have been prepared for the works at this early pre-approval stage, so it is not possible nor desirable to prepare a Soil and Water Management Plan. What is presented herein are critical elements of a future Soil and Water Management Plan which must be modified to reflect proposed construction methods, staging and materials once known in accordance with the Blue Book.

The Soil and Water Management Plan must be prepared and submitted for approval prior to construction at Construction Certificate stage.

9.2. Soils

Soils on the site have been described in Section 2. In brief they are comprised of sandy topsoil overlying weathered sandstone, i.e. sandy soils. Tops soils were earlier described as silty sand and soils as weathered sandstone with iron indurations.

Based on the site visit and description of soils the likelihood of encountering dispersible soils on the site is low.

9.3. Soil testing

Alliance Geotechnical was commissioned to collect 2 soil samples on the 24/9/2019 and test them in a lab for dispersibility. The first sample was collected from the warehouse earth pad and the second sample was collected from an area with undisturbed topsoil. The first sample reflects the soils that will be mostly exposed during construction as topsoils would be stripped and stockpiled.

The test results are shown below:

Sample Number	Date	Material Description	Results
1	24/09/2019	Sandy GRAVEL – Yellow	No dispersion
2	24/09/2019	Silty Gravelly SAND – Brown	No dispersion, suspended in water

Table 20 Soil test results

The results indicate non-dispersive soils. Topsoils, which were silty gravelly sand may cause some cloudiness in water and require longer settlement times. Soils below the topsoils are sandy gravels and would require very little settlement time. It is very unlikely that flocculants will need to be used on this site.

9.4. Staging

The site will require the net importation of earth for fill and see some areas excavated and other areas filled. The site will need to be stripped of vegetation and topsoil in one go because bulk earthworks will need to take place to construct the main working platform. This cant occur in staged manner as earth will need to be won from one area and filled in another.

The warehouse pad is currently under construction and the warehouse will soon follow. This will mean the warehouse and the curtilage area around the warehouse will be sealed by the time earthworks for the main project commence. This will reduce the exposed area by approximately 0.5 Ha. As there is a need to place a geomembrane and subsoil drainage in areas with unsealed pavement no further work can take place around the building until such time as the detailed design for the whole site is complete and levels are fully resolved.

Roof runoff from the warehouse will need to be directed to the approved warehouse OSD tank and it is recommended that the OSD tank be used as a temporary stormwater tank during construction with overflows directed in a swale to the sediment basin. Check dams or deep mulch windrows in the swale will help to limit erosion of the temporary swale.

Retaining walls will need to be constructed on the southern and western sides of the site and as these walls progress upward it will be necessary to provide a diversion drain along-side each wall and to keep lifting these diversion drains. This is required to ensure that:

1) Stormwater is direct to the end of line sediment basin.
2) Keep water from flowing over the retaining walls.

The following staging is recommended:

1) A recycled concrete site access pad is created to shake off soil and sand from vehicles exiting the site and to provide a stable site entry.
2) The sediment basin and level spreader are constructed prior to any other work occurring.
3) Floating wetlands are to be installed to assist with construction stage sediment control.
4) The basin is to become actively managed from this stage.

5) Diversion drains are put in place to direct flows to the basin.
6) Vegetation from the area of the site which is to be disturbed, is stripped, shredded and stockpiled. Note that 2.7 hectares of area will need to be stripped of vegetation as part of the site is already cleared.
7) Topsoil is stripped.
8) Bulk earthworks is to occur.
9) Geomembrane is to be put in place.
10) Recycled concrete is to be put in place in areas under proposed hardstand.
11) Pavement subsoil drainage and drainage pipes from buildings need to be put in place on top of the geomembrane.
12) Pavements, storage bays and concrete hardstand is to be constructed.
13) Landscaped areas are to be sealed and landscaped.
14) The sediment basin is to be converted into the permanent basin stage which allows for 1.5m of air space for detention. The floating wetlands are to be adjusted so that they can float to the top of the OSD basin and down to 600mm off the bottom of the pond.
15) The stormwater harvesting scheme is to be commissioned and the irrigation and dust suppression systems are to be commissioned.
16) Works reach practical completion.

9.5. Site Access

During construction access should be restricted only to disturbed areas. The southern limit of disturbance will be the level spreader and associated works. The western limit of works should be limited to the site boundary.

The proposed site access will be located off 90 Gindurra Road.

Loads to and from the site shall be covered at all times.

9.6. Sediment Basin Design

The site does not have dispersible soils and the soils on the site lend themselves to a type C flow through basin. Because a 5 ML permanent water quality pond is to be constructed it is recommended that the sediment basin for the site be constructed as a 5ML basin that can also serve as a sediment basin and water source for dust suppression during construction. The size of the basin lends itself to a type D, pump out basin, that is, sediment laden runoff would enter the basin, the flows would be allowed to settle for up to 5 days and then pumped out once the water column was clear.

Note that the Blue Book requires that TSS be < 50 mg/L during. The water may need to be tested to measure TSS prior to discharge. If the water column is very clear and obviously free of TSS it may discharged at the Contractors risk.

Minimum basin volumes have been checked to ensure the 5ML basin proposed would exceed the volume required under the Blue Book.

Blue Book design parameters adopted for checking are:

1) 5 day, 85th percentile rainfall event.
2) Type D or pump out basin.

The sediment basin would therefore need to be designed to contain the 85th percentile, 5 day rainfall event. This allows for a construction period of more than 6 months.

Calculations indicate the following minimum sediment basin volumes would be required:

Volume of Sediment basin = Settling Zone + Sediment storage zone		
Settling Zone Volume (TypeD/F) = $10*C_v*A*R$		
Parameter	**Value**	**Comment**
Soil Hydrologic group	B	Assumed moderate runoff potential – crushed sandstone will be used to form the earthworks with a moderate runoff potential.
Mean annual rainfall (mm)	1300mm – noting actual site rainfall may be closer to 1200mm.	
$R_{(85\%, 5day)}$	45.8	This value is the 85th percentile 5 day rainfall event for Narara.
C_v	0.5	0.42 Read from chart in appendix F but 0.5 adopted to be conservative due to unknown levels of compaction.
Area (Hectares)	6.05	This is the total disturbed area draining to the basin including the basin.
Settling Zone volume (m^3)	1385	m^3
Storage zone volume (m^3)	692	m^3
Total Volume (m^3)	2078	m^3

From these calculations it is clear that the proposed 5,000 m^3 (5 ML) permanent water quality pond would be much larger than the required construction phase sediment basin.

On that basis it is recommended that the 5,000m^3 pond volume be constructed as a sediment basin prior to site clearing. This will allow for a low maintenance basin to be developed though it will still be necessary to operate the basin as pump out basin once the stormwater is clear enough to discharge from the site. It is suggested the basin could also be used to supply water for dust suppression during construction instead of pumping out and wasting the water. Nominally, 3,000 m^3 of water could be stored whilst still providing the minimum required sediment storage and settling volume.

Diversion drains will then need to be installed along the southern and western boundary of the site to ensure flow from disturbed areas is directed to the sediment basins.

The basin will need to be cleaned out when the sediment storage zone is approaching its limit. A depth marker shall be installed in the basin so sediment depths can be monitored and the basin cleaned out when necessary.

If a flocculant is required, based on soil tests it shouldn't, use of chitosan is highly recommended as a non-toxic effective flocculant. Vital industries can supply the chitosan.

9.1. Stripping and Mulching

Trees should be stripped and mulched. Mulch windrows are used effectively by road building contractors and make excellent filters while also slowing down velocities.

9.2. Topsoil Management

This section is repeated from Cardno's (2019) Soil and Water Management Plan.

Topsoil is to be stripped from the site after the establishment of erosion and sediment controls and stored in nominated stockpiles. Stockpiles are to be free draining at all times and located a minimum distance of 5 metres from diversion drains.

As shown on the Erosion and Sediment Control Plan drawing, sediment fences are to be placed downslope of each stockpile. Mulch bunds may be used instead of sediment fencing, if approved by the Site Superintendent.

Stockpiles are to be stabilised if unused for longer than 14 days. Stabilisation requires a minimum ground cover of 50% on each stockpile. Spray with bitumen emulsion first and then seed with grass.

Topsoil is to be re-spread over the landscaped areas of the site.

9.3. Site Covering

Once bulk earth works is complete, covering of exposed areas is required as soon as possible after filling/regrading. Cover is to be with:

1) a geomembrane in areas not to be covered with concrete hardstand and
2) by use of crushed concrete under areas to be covered with concrete hardstand.

Once this has taken place the site would be effectively sealed again.

9.4. Revegetation of Landscaping Areas

All erosion and sediment controls are to remain in place until stabilisation / revegetation of earthworks is established. All stabilised areas are to be free of vehicle and pedestrian traffic to prevent disturbance of stabilisation measures.

Areas proposed for landscaping are to be topsoiled to a depth of 200mm with a topsoil compliant with AS4419 and seeded with a native seed mix as well as tube-stock in accordance with any landscape designs. Site topsoils are silty and may need improvement by mixing with lime to improve fertility.

Jute mat will be required to stabilise soils in the bioswales until vegetation has been well established. A mix of native reeds, grasses and sedges will be used in the bioswales. Turf can be used as a vegetative buffer strip between the developed parts of the site and the swales. Swales may also be grassed with a hardy buffalo grass as an alternative to bioretention plants. This can be resolved during detailed design.

9.5. Maintenance of Controls During Construction

It is essential that the soil and water management plan is adhered to until the site is effectively sealed. This will require regular:

1) Maintenance of the sediment basin – removal of sediment, pumping out of clean water.
2) Maintenance of stockpiles and sediment fences around stockpiles – these will need to be removed of sediment following large storm events.
3) Maintenance of swales during construction to ensure that erosion does not occur at a critical time when vegetation has not had a chance to be established.
4) Monitoring of the level spreader to ensure that it is performing as expected and that any erosion is stopped as soon as it is noticed. Consider placing a deep layer of shredded timber mulch in the area around the level spreader if erosion is noticed and especially after any bushfires.
5) Ensure that revegetated areas are irrigated for at least 6 weeks to establish healthy vegetation.

10.0 CONCLUSIONS AND RECOMMENDATIONS

It is recommended that the development can proceed without detrimental water quality impacts provided that the recommended mitigation measures are put in place.

10.1. Predicted Water Quality & Quantity Results

This report finds that the proposal will achieve a decrease in all parameters modelled when compared to the existing or predevelopment case though not compared to the pre European case. This proposal, if it were proposed in a drinking water catchment would be subject to a NorBE test and it would find the proposal would result in a beneficial effect. This is the most stringent water quality test applied to any development in NSW.

Reductions could be beneficial to aquatic health and see an improvement in the catchment.

In terms of achieving best practice load targets prescribed by Central Coast Council the proposal exceeds these targets with a large margin. The proposal even exceeds the growth centres load based targets with a good margin.

Heavy metals are most likely able to be treated in the robust biological treatment train to a degree high enough to make them benign.

We conclude that the impact of the proposal on water quality is likely to be positive, i.e. it will see a substantial improvement over existing water quality being discharged from the site.

In terms of being able to meet any imposed licence conditions, the 99^{th} percentile concentrations have been used as a surrogate for the 100^{th} percentile concentrations likely to be imposed in a licence. We conclude that the proposed treatment system will comply with typical licence conditions for waste management developments.

This report documents a thorough and complete stormwater risk assessment process.

To evaluate this risk, we have measured the volumes of discharge and the frequency of flow from the site as well as assessing on site stormwater detention effectiveness at retarding peak flows and keeping them at or below predevelopment levels for all storms from the 1EY to the 1% AEP event.

We found that the site would discharge approximately 8 times per year after development while in a forested, pre European state this would occur about 5 times per year. This is considered close enough to indicate the discharge should not result in erosion caused purely by the frequency of flow. This should in turn protect bushland from degradation.

In terms of volumes – the total volumes remain more than pre European volumes but substantially below total predevelopment site discharge. To address this, we propose the use of a 50m wide level spreader with an infiltration trench along its length. This will help to increase the volumes of water conveyed as interflow through the soils.

The level spreader will reduce velocities of discharge to less than threshold levels defined by reference to USDA Threshold Channel Design methods.

The proposed detention basin is designed to work hard in small frequent events and limit the discharge from the site to a single 375mm pipe for all storms up to the 1EY. The flow will then be spread out across 50m and discharged into the adjoining bushland.

A stormwater harvesting scheme is proposed which will have the most dramatic effect on the site by reducing the volume and frequency of discharge from the site down levels which will not cause harm. The harvested water will be treated in a treatment plant and disinfected prior to use to ensure it complies with all relevant guidelines.

In conclusion it is highly likely that:

1) There will be no decline or detectable change in aquatic health either locally within Piles Creek or within the broader catchment.
2) There will be no discernible deterioration in any measurable water quality parameters at any point in the catchment.

The harvesting of stormwater would reduce operating costs when compared to the cost of purchasing the water from Council. Therefore, there is an economic incentive to pursue this action. It is however noted that it is not essential that harvesting is undertaken to meet any potential EPL limits. However, there would be load based water quality and geomorphological benefits from harvesting and therefore it is to be considered a core component of the mitigation measures.

What this means in practice is that if the pumps or filters were to break down and there is no harvesting for say a month then the proponent should still be able to meet anticipated EPL limits. Provided that harvesting resumes once the plant is repaired then the load based and geomorphic benefits of the proposal would be restored. Should no harvesting occur at all then the proposal is likely to have additional unacceptable geomorphic and load based water quality impacts.

It is therefore recommended that the proposed mitigation measures are adopted. The economic and environmental incentive to do so is certainly present given current drought conditions.

10.2. Groundwater

The proposal is unlikely to have any groundwater quality or quantity impacts.

10.3. Emergency Spill Control

It is recommended that spill control procedures be developed, staff trained, and the procedures practiced annually. Fuel storage and Chlorine storage must only be within bunded containers. Refuelling must only occur under a covered awning/canopy.

A penstock or tilting weir may be used to “seal off” the site and prevent any kind of spill including fire-fighting water from leaving the site. A total of 330 m^3 of fire-fighting water shall be capable of being stored within the proposed water quality pond.

An emergency spill pond is proposed to accept runoff from the high risk part of the site only. This emergency spill pond is to be 500m^3 in volume and have inflows monitored in real time. It will automatically close in the event of poor water quality.

10.4. Geomorphology Impacts

The proposed mitigation measures and mainly the harvesting and reuse scheme will see the volume of runoff from the site reduced by about two thirds. This will see both the frequency and volume of runoff from the site reduced. This in turn will limit geomorphic and bushland health impacts arising from this project (Walsh et al, 2005 & Tippler et al 2012). None the less the health of the floodplain between the level spreader and the downstream boundary at Kangoo Road should be monitored twice a year. If it is found that erosion is occurring, then adaptive management measures to stem that should be put in place immediately.

10.5. Soil and Water Management during Construction

It is recommended that the proposed pond be constructed prior to site stripping and used as a temporary sediment basin and converted to a permanent water quality pond once the site has been effectively sealed. Small scale sediment and erosion control measures would be needed to manage local erosion issues. A detailed staged Soil and Water Management Plan shall be prepared in close consultation with the Contractor prior to construction.

10.6. Water Quality Validation Programme

1) In accordance with ANZECC guidelines, a water quality monitoring programme needs to be developed for the site. **Water quality analytes are defined in the next section.**

In addition to water quality testing this should include recording:

2) Volumes of material removed from the GPTs (by weight).
3) Maintenance of the swales.
4) Maintenance of the water quality pond including volumes of any material removed.
5) Maintenance of the stormwater harvesting scheme including recording volumes of water harvested and reused on-site.
6) The water quality test results need to be assessed annually to determine the performance of the entire treatment system.
7) The floodplain should also be inspected for erosion twice per year and if needed measures put in place to stem the erosion. Indicators would be loss of vegetation associated with high velocity flows (scour) and the commencement of erosional channels or rills. These should be arrested as soon as possible to prevent them spreading. Mitigation measures would include placing jute matt over scoured areas and the placement of leaky weirs (from coir fibre logs) downstream of the erosion to make them depositional environments instead.

10.6.1. Water Quality Testing Programme

The following are recommended analytes for the proposed water quality validation programme. Samples will be collected monthly from the pond and also in accordance with any licence conditions such as during a discharge. Please note that this list does not include the analytes that will need to be tested for the stormwater treatment plant. This list of analytes is designed to carry out a broad assessment of water quality on the site to indicate if there is any kind of discharge that is occurring that may cause pollution. We do not expect the majority of these analytes to be present at detectable levels and if they are it would indicate that there needs to be further investigation to firstly identify the concentration is at levels that might be toxic and if that is the case then to determine the source.

Table 21 List of Analytes for Water Quality Validation Programme

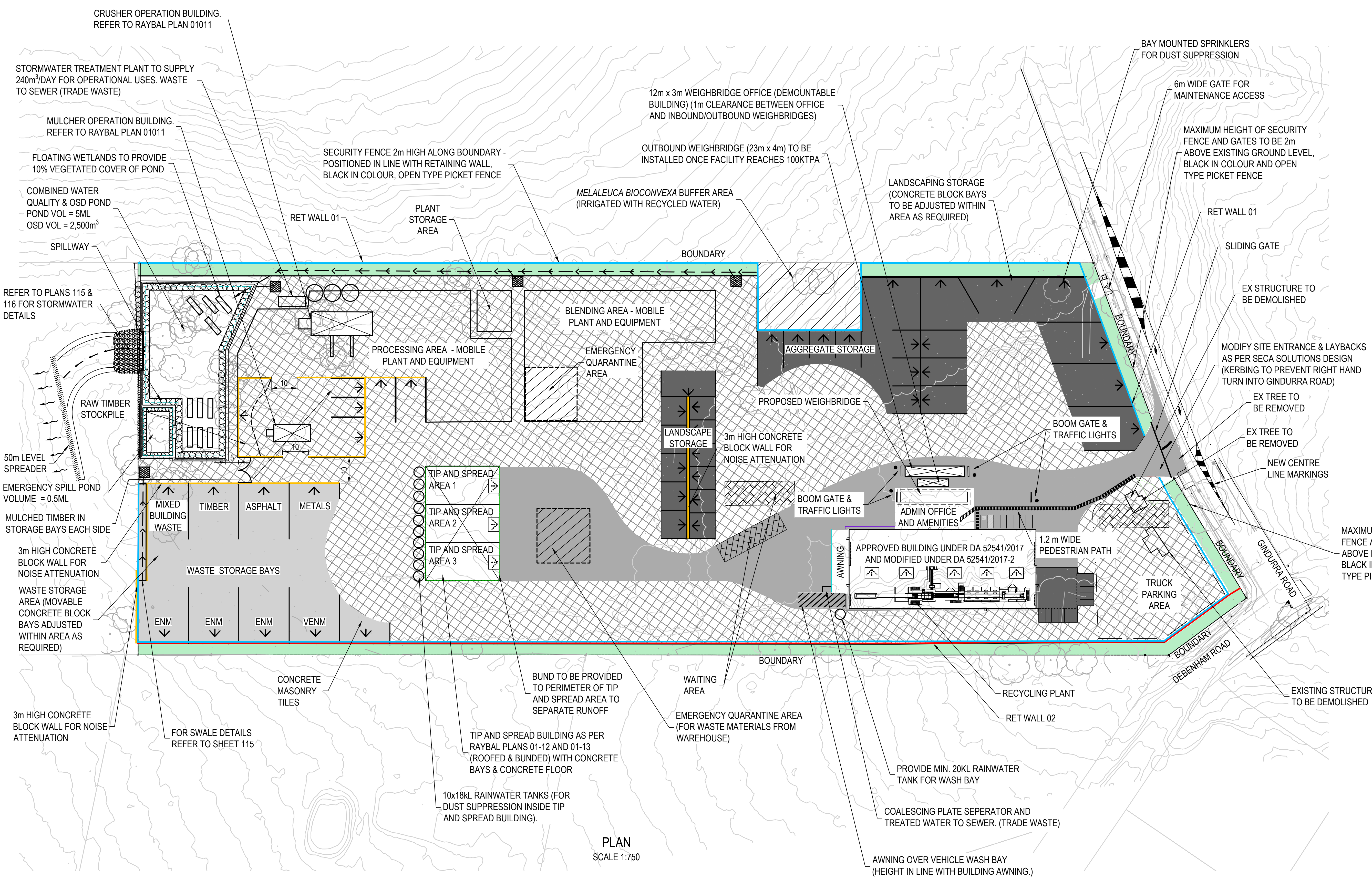
BTEX	Benzene	Toluene	Ethylbenzene	Xylene (m & p)	Xylene (o)												
TPH	C6 - C9	C10 - C14	C15 - C28	C29-C36													
TPH Core Fractions	C6-C10	C10-C16	C16-C34	C34-C40	F1: C6-C10 less BTEX	F2: >C10-C16 less Naphthalene											
PAH	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(a)pyrene TEQ (WHO)	Benzo(b+j) & Benzo(k)fluoranthene	Benzo(g,h,i) perylene	Chrysene	Dibenz(a,h) anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)pyrene	Naphthalene	PAHs (Sum of total)	Phenanthrene	Pyrene
Metals	Arsenic	Cadmium	Calcium (Filtered)	Chromium (III+VI)	Copper	Lead	Magnesium (Filtered)	Manganese	Mercury	Nickel	Zinc	Chromium					
Anions and Cations	Potassium (Filtered)	Sodium (Filtered)	Alkalinity (Bicarbonate as CaCO3)	Alkalinity (Hydroxide) as CaCO3	Alkalinity (total) as CaCO3	Chloride	Ionic Balance	Sulphate	Alkalinity (Carbonate)								
Nutrients	Ammonia	Nitrate (as N)	Nitrite (as N)	TKN	Phosphorus	Ortho P											
Physical Parameters	pH (Lab)	TDS	Turbidity	Colour													
Organo Chlorine Pesticides	4,4-DDE	a-BHC	Aldrin	b-BHC	Chlordane (cis)	Chlordane (trans)											
Organo Chlorine Pesticides	d-BHC	DDD	DDT	Dieldrin	Endosulfan I	Endosulfan II	Endosulfan sulphate	Endrin	Endrin aldehyde	g-BHC (Lindane)	Heptachlor	Heptachlor epoxide	Hexachlorobenzene	Methoxychlor			

Appendix 1

Civil Engineering Plan Set

NOTES:

1. ALL DIMENSIONS IN METRES UNO.
2. HP GAS MAIN PRESENT ON GINDURRA ROAD.
3. EXISTING CONTOURS ARE AT 0.5m INTERVALS



PLAN
SCALE 1:750

LEGEND

- 5m HIGH CONCRETE PANEL NOISE WALL
- IRRIGATED LANDSCAPED BUFFER (5m) - SEE LANDSCAPE ARCHITECTURAL PLANS
- MELALEUCA BICONVEXA PROTECTION AREA - APZ
- PAVEMENT AREA (CONCRETE)
- SEALED SURFACE (ASPHALT)
- RECYCLED CRUSHED CONCRETE ROADBASE WITH GEOTEXTILE MEMBRANE
- CONCRETE KERB AND GUTTER
- PROPOSED RETAINING WALL
- 3m HIGH CONCRETE BLOCK WALL FOR NOISE ATTENUATION
- DISH DRAIN
- TRUCK PARKING AREA
- WAITING AREA
- PROPOSED SPRINKLER OUTLET FOR DUST SUPPRESSION.
- PROPOSED MISTING OUTLET FOR DUST SUPPRESSION.
- BARRAMY GROSS POLUTANT TRAP (4 OFF)
- PROPOSED BUILDINGS
- BIOSWALE. REFER TO SHEET 115 FOR DETAILS

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3	27/03/2020	REVISED FOR DA	AB	ML
2	20/01/2020	REVISED FOR DA	GA	ML
1	16/12/2019	FOR DA	GA	ML

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PROJECT: PROPOSED KARIONG SAND & SOIL SUPPLIES FACILITY - SSD8660
GENERAL ARANGEMENT PLAN
CLIENT: KARIONG SAND & SOIL SUPPLIES
JOB REF No: 197
DESIGNED: G. ABDULAHED
DRAWN: G. ABDULAHED
CHECKED: M. LIEBMAN
SHEET: 106
SHEET No: 1 OF 9
SCALE: 1:750
COORD. ORIGIN:
DATE: 07/04/2020
SIZE: A1
DATUM: AHD

NOTES:

1. ALL DIMENSIONS IN METRES UNO.
2. HP GAS MAIN PRESENT ON GINDURRA ROAD.

LEGEND

- 5m HIGH CONCRETE PANEL NOISE WALL
- IRRIGATED LANDSCAPED BUFFER (5m) - SEE LANDSCAPE ARCHITECTURAL PLANS
- MELALEUCA BICONVEXA PROTECTION AREA - APZ
- PAVEMENT AREA (CONCRETE)
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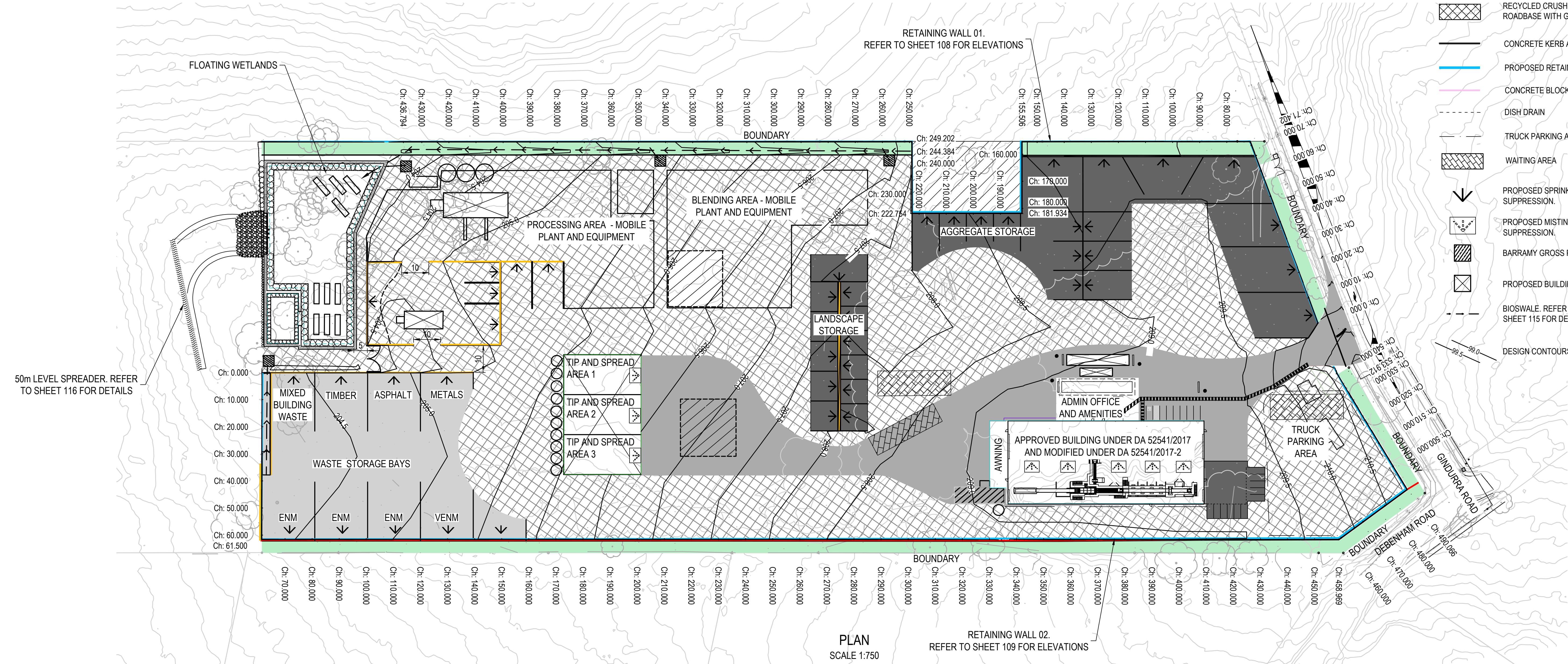
- DISH DRAIN
- TRUCK PARKING AREA
- WAITING AREA
- PROPOSED SPRINKLER OUTLET FOR DUST SUPPRESSION.
- PROPOSED MISTING OUTLET FOR DUST SUPPRESSION.
- BARRAMY GROSS POLUTANT TRAP (4 OFF)
- PROPOSED BUILDINGS
- BIOSWALE. REFER TO SHEET 115 FOR DETAILS
- DESIGN CONTOURS (0.5m INTERVALS)



PLAN
SCALE 1:750

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SCALE 1:750 (A1) SCALE 1:1500 (A3)

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2	20/01/2020	REVISED FOR DA	GA	ML
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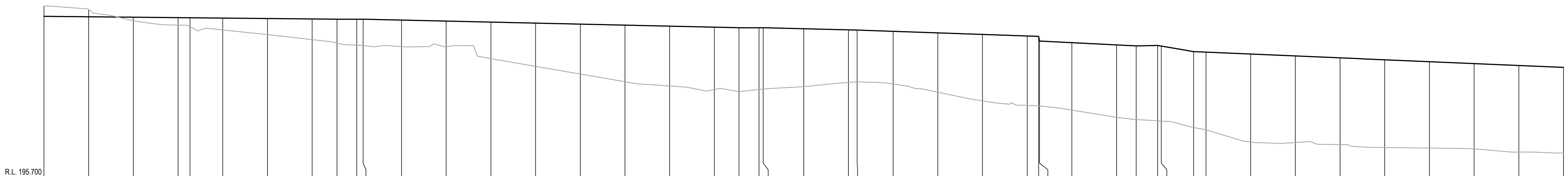
CIVIL WORKS PLAN
CLIENT: KARIONG SAND & SOIL SUPPLIES
JOB REF No: 197
DESIGNED: G. ABDULAHED
DRAWN: G. ABDULAHED
CHECKED: M. LIEBMAN
SHEET: 107
SHEET No: 2 OF 9
SCALE: 1:750
COORD. ORIGIN:
DATE: 07/04/2020
SIZE: A1
DATUM: AHD

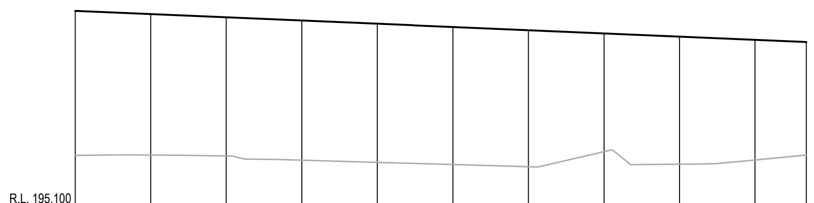


R.L. 195.700

Chainage	Wall Height	Design Levels	Existing Levels
0.000	-0.937	210.000	210.937
10.000	-0.641	209.961	210.602
20.000	+0.318	209.922	209.604
30.000	+0.664	209.883	209.219
32.682	+0.789	209.872	209.083
40.000	+1.059	209.844	208.785
50.000	+1.434	209.805	208.371
60.000	+1.844	209.766	207.922
65.570	+2.145	209.744	207.599
70.000	+2.316	209.744	207.428
71.402	+2.336	209.744	207.408
80.000	+2.368	209.666	207.298
90.000	+2.273	209.576	207.303
100.000	+3.263	209.485	206.222
110.000	+3.864	209.395	205.531
120.000	+4.460	209.304	204.844
130.000	+5.057	209.214	204.157
140.000	+5.345	209.123	203.778
150.000	+5.568	209.033	203.465
155.506	+5.708	208.983	203.275
160.000	+5.515	208.983	203.468
160.921	+5.476	208.983	203.507
170.000	+5.169	208.892	203.723
180.000	+4.697	208.792	204.095
181.934	+4.623	208.773	204.150
190.000	+4.705	208.661	203.956
200.000	+5.298	208.523	203.225
210.000	+5.933	208.384	202.451
220.000	+6.202	208.245	202.043
222.563	+6.203	208.210	202.007
222.754	+5.789	207.793	202.004
230.000	+6.023	207.647	201.624
240.000	+6.467	207.447	200.980
244.384	+6.578	207.360	200.782
249.202	+6.728	207.400	200.672
250.000	+6.704	207.345	200.641
257.234	+6.774	206.850	200.076
260.000	+6.946	206.803	199.857
270.000	+7.856	206.632	198.776
280.000	+7.726	206.462	198.736
290.000	+7.746	206.292	198.546
300.000	+7.838	206.121	198.283
310.000	+7.713	205.951	198.238
320.000	+7.624	205.780	198.156
330.000	+7.733	205.610	197.877
340.000	+7.643	205.439	197.796

WALL01 ELEVATION (CH0.000 - CH340.000)

SCALES H 1:500
V 1:200



R.L. 195.100

Chainage	Wall Height	Design Levels	Existing Levels
340.000	+7.643	205.439	197.796
350.000	+7.461	205.269	197.808
360.000	+7.337	205.099	197.762
370.000	+7.391	204.928	197.537
380.000	+7.336	204.758	197.422
390.000	+7.280	204.587	197.307
400.000	+7.225	204.417	197.192
410.000	+6.262	204.247	197.985
420.000	+6.751	204.076	197.325
430.000	+6.356	203.906	197.550
436.794	+5.983	203.790	197.807

WALL01 ELEVATION (CH340.000 - CH436.794)

SCALES H 1:500
V 1:200

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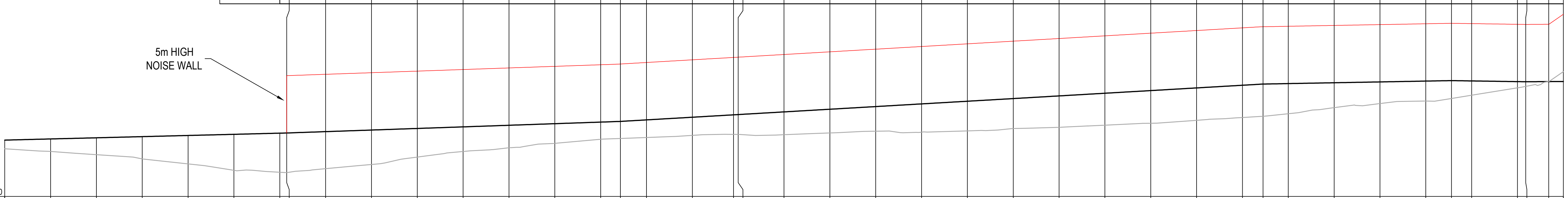
PROJECT: PROPOSED KARIONG SAND & SOIL SUPPLIES FACILITY - SSD8660
RETAINING WALL LONG SECTIONS - SHEET 1 OF 2
CLIENT: KARIONG SAND & SOIL SUPPLIES
JOB REF No: 197
DESIGNED: G. ABDULAHED
DRAWN: G. ABDULAHED
CHECKED: M. LIEBMAN
SHEET: 108
SHEET No: 3 OF 9
SCALE:
COORD. ORIGIN:
DATE: 07/04/2020
SIZE: A1
DATUM: AHD

5m HIGH
NOISE WALL



Chainage	Top of Noise Wall	Wall Height	Design Levels	Existing Levels
0.000		+0.755	203.709	202.954
10.000		+1.088	203.810	202.722
20.000		+1.473	203.911	202.438
30.000		+1.943	204.012	202.069
40.000		+2.477	204.113	201.636
50.000		+3.141	204.214	201.073
60.000		+3.413	204.315	200.902
61.500	209.33	+3.462	204.330	200.868
70.000	209.45	+3.231	204.448	201.217
80.000	209.59	+3.005	204.587	201.582
90.000	209.73	+2.497	204.725	202.228
100.000	209.86	+2.148	204.864	202.716
110.000	210	+1.964	205.003	203.039
120.000	210.14	+1.717	205.142	203.425
130.000	210.28	+1.500	205.280	203.780
134.304	210.34	+1.486	205.340	203.854
140.000	210.47	+1.534	205.472	203.938
150.000	210.71	+1.585	205.705	204.120
158.987	210.91	+1.706	205.914	204.208
160.000	210.94	+1.734	205.938	204.204
170.000	211.17	+1.991	206.170	204.179
180.000	211.4	+2.071	206.403	204.332
190.000	211.64	+2.153	206.635	204.482
200.000	211.87	+2.465	206.868	204.403
210.000	212.1	+2.586	207.100	204.514
220.000	212.33	+2.610	207.333	204.723
230.000	212.57	+2.737	207.565	204.828
240.000	212.8	+2.784	207.798	205.014
250.000	213.03	+2.849	208.030	205.181
260.000	213.26	+2.829	208.263	205.434
270.000	213.5	+2.812	208.495	205.683
274.498	213.6	+2.807	208.600	205.793
280.000	213.64	+2.631	208.640	206.009
290.000	213.71	+2.170	208.713	206.543
300.000	213.79	+1.889	208.786	206.897
310.000	213.86	+1.737	208.859	207.122
315.592	213.9	+1.557	208.900	207.343
320.000	213.87	+1.246	208.873	207.627
330.000	213.81	+0.540	208.812	208.272
331.801	213.8	+0.404	208.801	208.397
336.801	213.82	-0.012	208.816	208.828
340.000	214.69	-0.862	208.825	209.687

R.L. 198.800

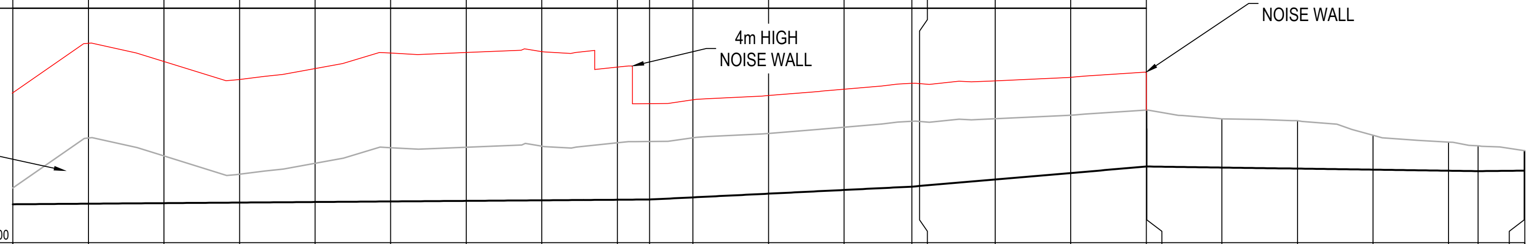
WALL02 ELEVATION (CH0.000 - CH340.000)

SCALES H 1:500
V 1:200

LOCALISED EARTHWORTHS TO BE
UNDERTAKEN AS REQUIRED TO REDUCE
UNDULATION OF TOP OF NOISE WALL

4m HIGH
NOISE WALL

2m HIGH
NOISE WALL



Chainage	Top of Noise Wall	Wall Height	Design Levels	Existing Levels
340.000	214.69	-0.862	208.825	209.687
350.000	217.33	-3.470	208.855	212.325
360.000	216.38	-2.491	208.885	211.376
370.000	215.41	-1.496	208.915	210.411
380.000	215.99	-2.044	208.945	210.989
390.000	216.81	-2.837	208.975	211.812
400.000	216.84	-2.832	209.005	211.837
410.000	216.89	-2.860	209.034	211.894
420.000	216.07	-3.006	209.064	212.070
424.252	214.14	-3.061	209.077	212.138
430.000	214.34	-3.149	209.189	212.338
440.000	214.57	-3.183	209.385	212.568
450.000	214.9	-3.317	209.581	212.898
458.969	215.21	-3.455	209.756	213.211
460.000	215.2	-3.409	209.791	213.200
470.000	215.34	-3.211	210.133	213.344
480.000	215.53	-3.053	210.476	213.529
490.000	215.81	-2.987	210.818	213.805
490.066		-2.986	210.820	213.806
500.000		-2.572	210.764	213.336
510.000		-2.530	210.709	213.239
520.000		-1.816	210.653	212.469
530.000		-1.512	210.597	212.109
533.912		-1.338	210.575	211.913
540.000		-1.061	210.600	211.661
540.089				211.655

R.L. 206.800

WALL02 ELEVATION (CH340.000 - CH540.089)

SCALES H 1:500
V 1:200

REV	DATE	DESCRIPTION	BY	CKD
4	07/04/2020	REVISED FOR DA	AB	ML
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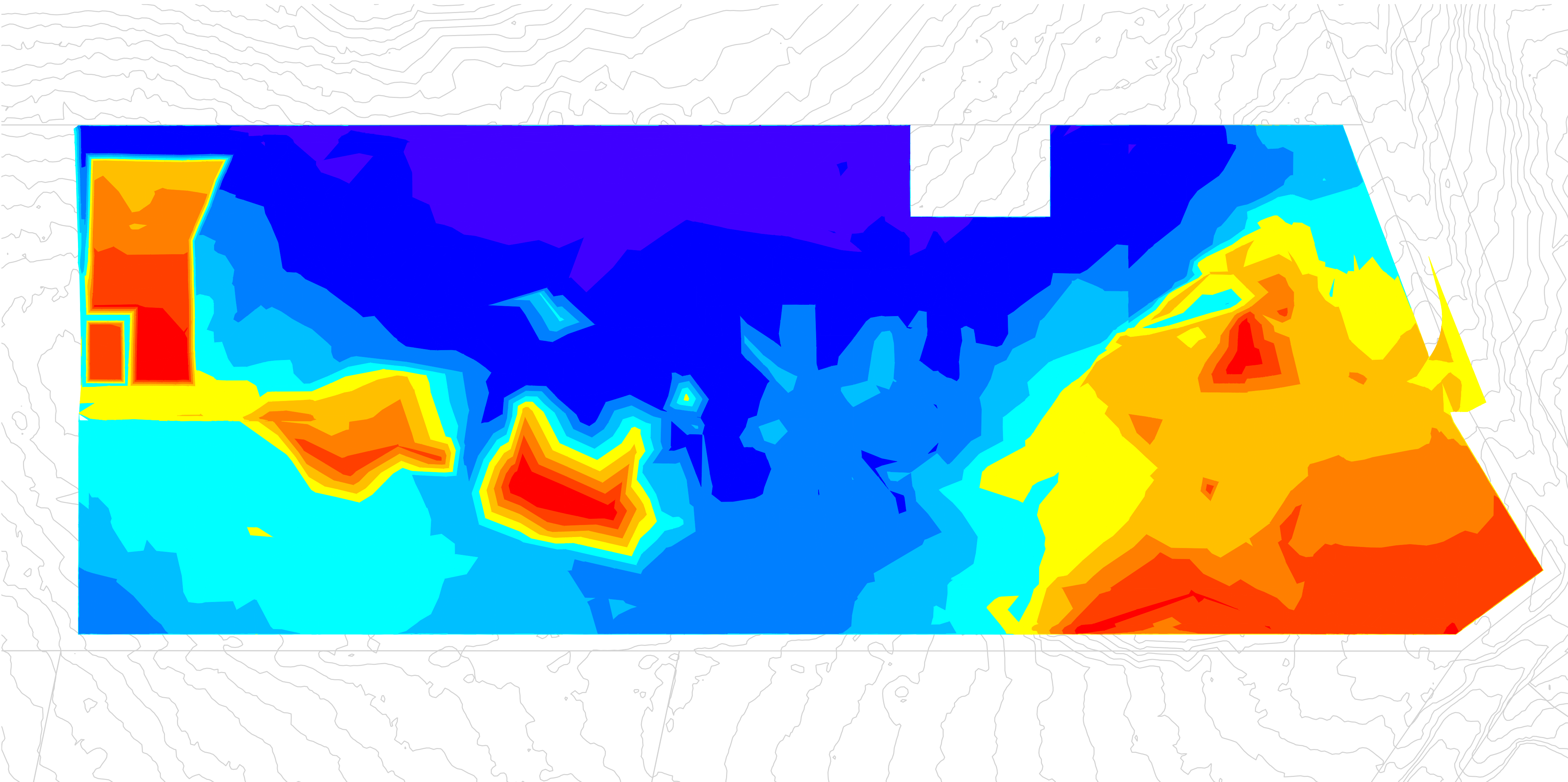
PROJECT: PROPOSED KARIONG SAND & SOIL SUPPLIES FACILITY - SSD8660
RETAINING WALL LONG SECTIONS - SHEET 2 OF 2
CLIENT: KARIONG SAND & SOIL SUPPLIES
JOB REF No: 197
DESIGNED: G. ABDULAHED
DRAWN: G. ABDULAHED
CHECKED: M. LIEBMAN
SHEET: 109
SHEET No: 4 OF 9
SCALE:
COORD. ORIGIN:
DATE: 07/04/2020
SIZE: A1
DATUM: AHD

NOTES:

1. NET FILL VOLUME ABOVE EXISTING SURFACE = 107,200m³
2. NET CUT VOLUME BELOW EXISTING SURFACE = 35,900m³
3. BALANCE OF CUT : FILL = (107,200m³ - 35,900m³) = 71,300m³ FILL REQUIRED
4. PAVEMENT VOLUME = 25,200m³
5. DRAINAGE LAYER VOLUME = 8,400m³
6. CONCRETE AREA = 6,600m²
7. ASPHALT AREA = 11,500m²
8. UNSEALED PAVEMENT AREA = 30,500m²
9. ALL ABOVE AREAS ARE EXCLUDING BUILDINGS



PLAN
SCALE 1:750

Levels Table

Number	Minimum Level	Maximum Level	Colour
1	-6.000	-4.000	red
2	-4.000	-3.000	red-orange
3	-3.000	-2.000	orange
4	-2.000	-1.000	light orange
5	-1.000	0.000	yellow
6	0.000	1.000	cyan
7	1.000	2.000	light blue
8	2.000	3.000	blue
9	3.000	5.000	dark blue
10	5.000	8.000	violet

0 7.5 15 22.5 30 37.5 45 52.5 60
SCALE 1:750 (A1) SCALE 1:1500 (A3)

REV	DATE	DESCRIPTION	BY	CKD
4	07/04/2020	REVISED FOR DA	AB	ML
3	27/03/2020	REVISED FOR DA	AB	ML
2	20/01/2020	REVISED FOR DA	GA	ML
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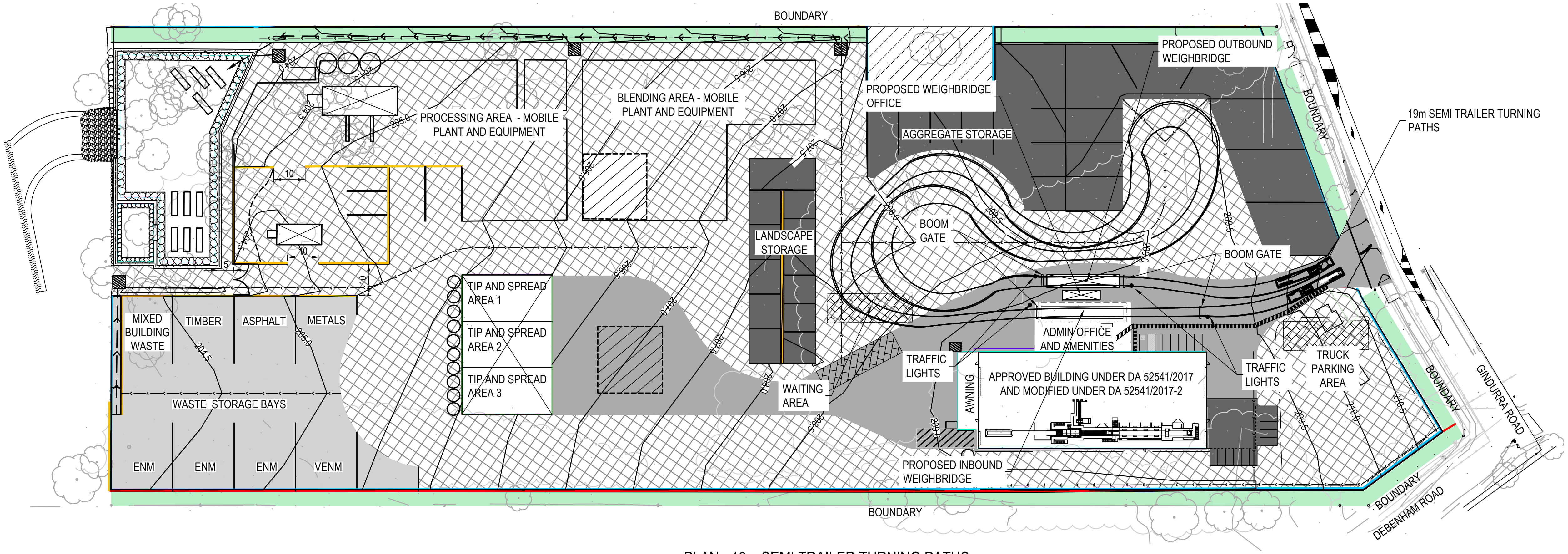
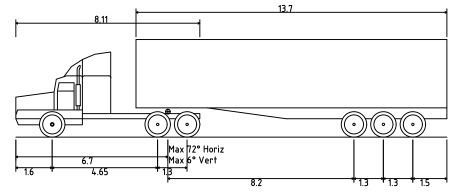
PROJECT: PROPOSED KARIONG SAND & SOIL SUPPLIES FACILITY - SSD8660
BULK EARTHWORKS PLAN
CLIENT: KARIONG SAND & SOIL SUPPLIES
JOB REF No: 197
DESIGNED: G. ABDULAHED
DRAWN: G. ABDULAHED
CHECKED: M. LIEBMAN
SHEET: 110
SHEET No: 5 OF 9
SCALE: 1:750
DATE: 07/04/2020
SIZE: A1
DATUM: AHD
COORD. ORIGIN:



PLAN - 19m SEMI TRAILER TURNING PATHS

SCALE 1:750

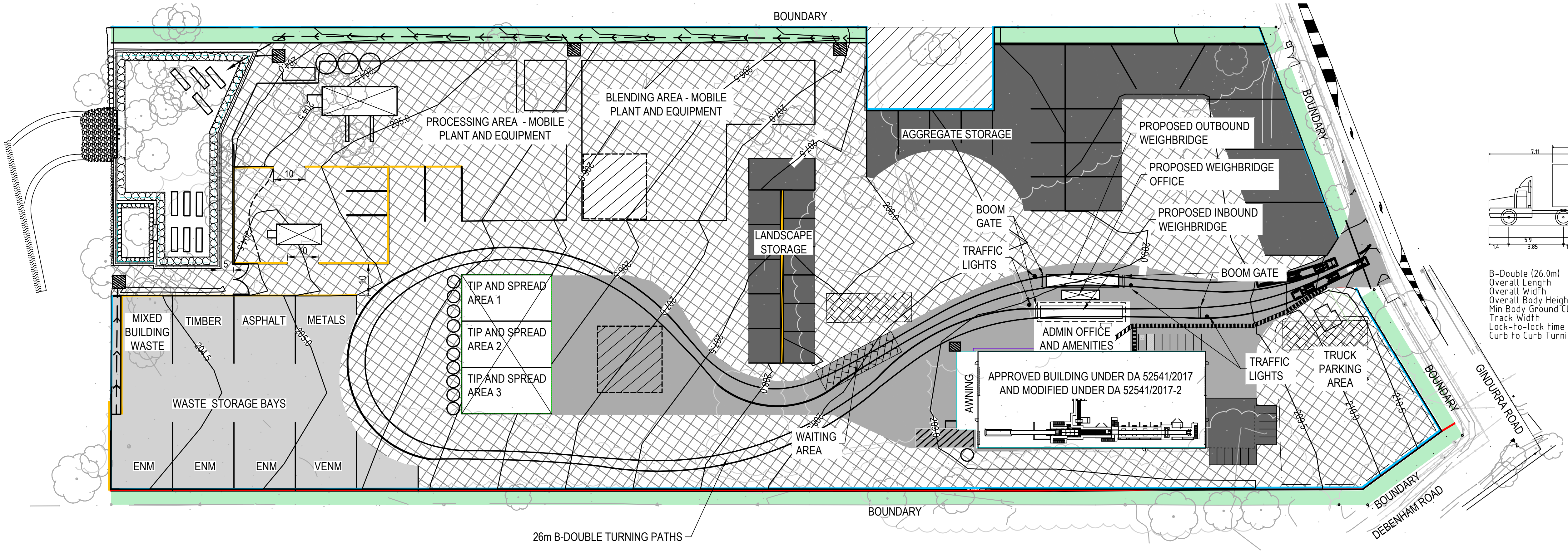


Prime mover and semi-trailer (19 m)

Overall Length	19.000m
Overall Width	2.500m
Overall Body Height	4.300m
Min Body Ground Clearance	0.540m
Track Width	2.500m
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	12.500m

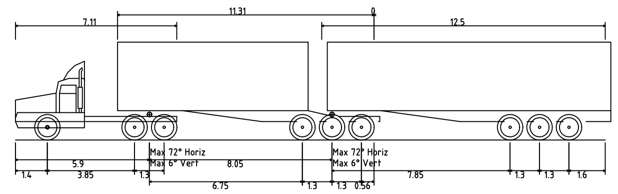
LEGEND

99.0 / 99.5 DESIGN CONTOURS (0.5m INTERVALS)



PLAN - 26m B-DOUBLE TURNING PATHS

SCALE 1:750



B-Double (26.0m)

Overall Length	26.000m
Overall Width	2.500m
Overall Body Height	4.300m
Min Body Ground Clearance	0.540m
Track Width	2.500m
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	15.000m

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SCALE 1:750 (A1) — SCALE 1:1500 (A3)

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4	07/04/2020	REVISED FOR DA	AB	ML
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1	16/12/2019	FOR DA	GA	ML

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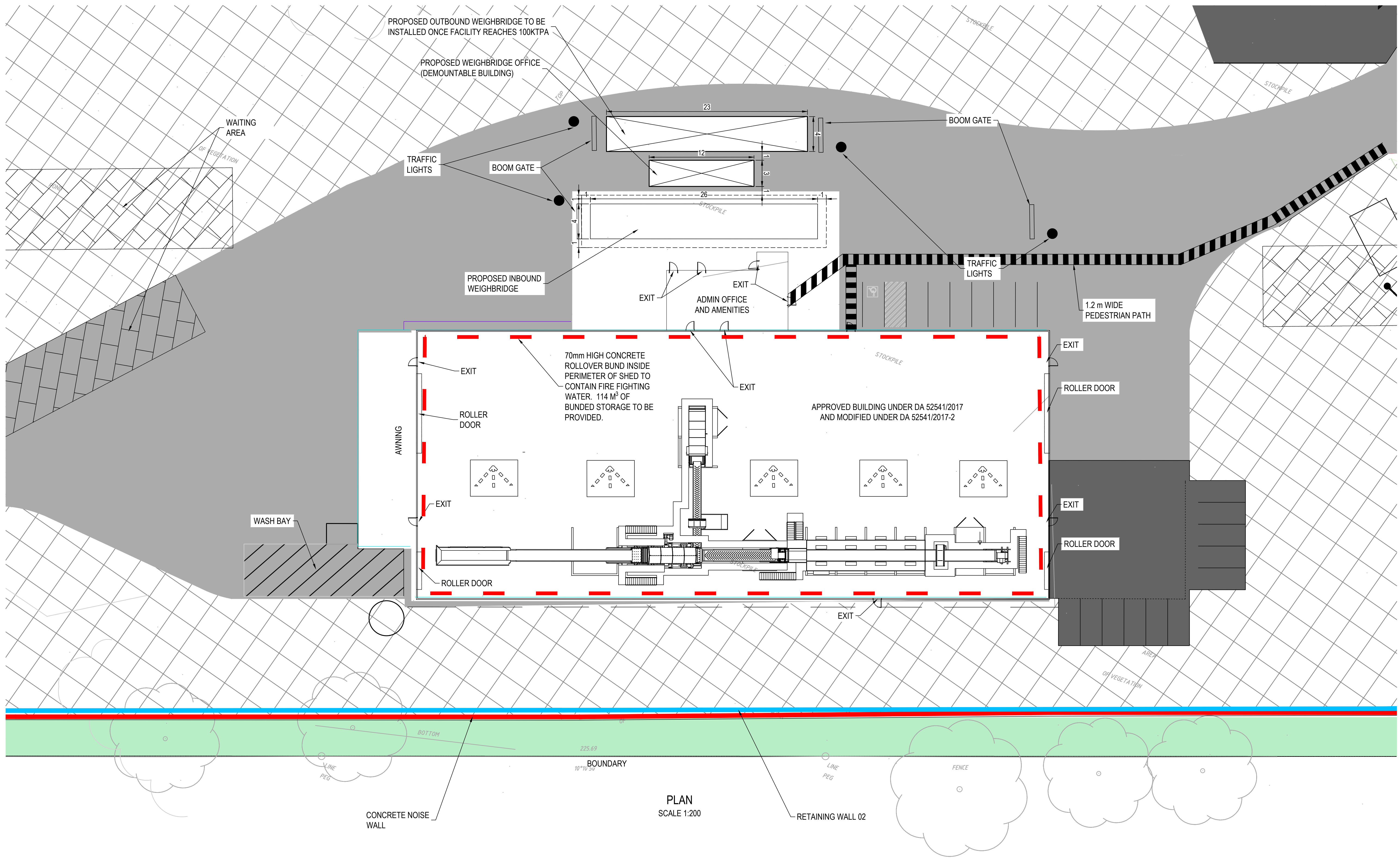
PROJECT:	PROPOSED KARIONG SAND & SOIL SUPPLIES FACILITY - SSD8660
	TURNING MOVEMENTS PLAN
CLIENT:	KARIONG SAND & SOIL SUPPLIES
JOB REF No:	197
DESIGNED:	G. ABDULAHED
DRAWN:	G. ABDULAHED
CHECKED:	M. LIEBMAN
SHEET:	111
SHEET No:	6 OF 9
SCALE:	1:750
COORD. ORIGIN:	
DATE:	07/04/2020
SIZE:	A1
DATUM:	AHD



PLAN
SCALE 1:200

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SCALE 1:200 (A1) — SCALE 1:400 (A3)

REV	DATE	DESCRIPTION	BY	CKD
5	20/04/2020	REVISED FOR DA	AB	ML
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3	23/01/2020	REVISED FOR DA	GA	ML
2	20/01/2020	FOR DA	GA	ML

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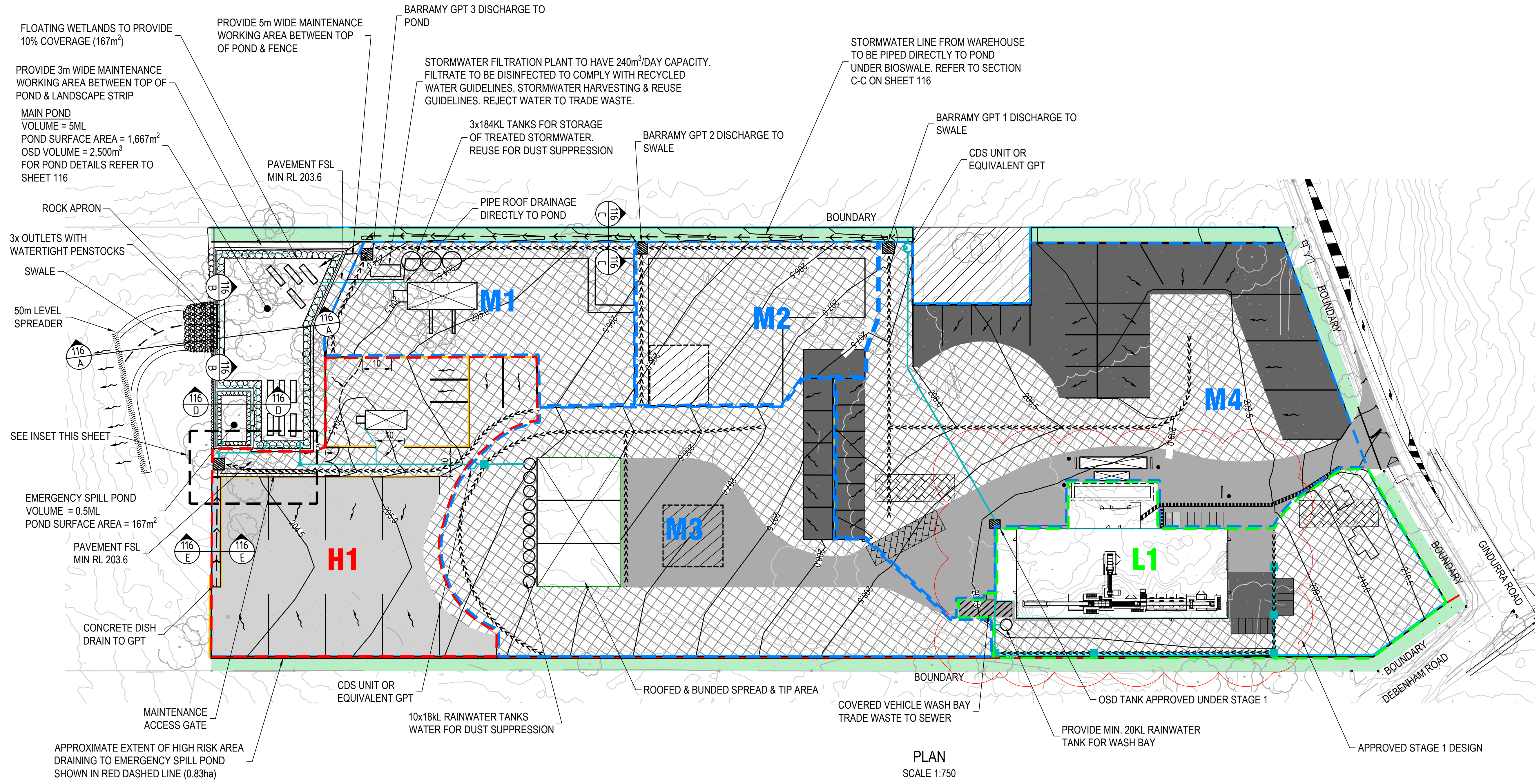
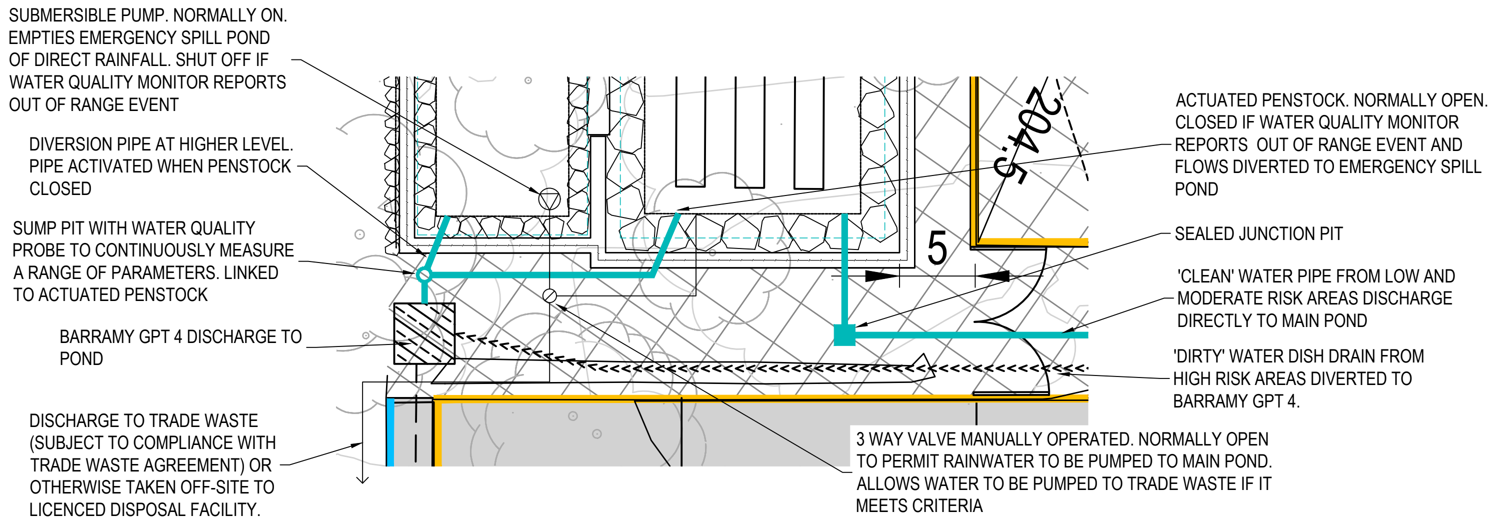
PROJECT:	PROPOSED KARIONG SAND & SOIL SUPPLIES FACILITY - SSD8660 DETAILED SECONDARY PROCESSING BUILDING PLAN
CLIENT:	KARIONG SAND & SOIL SUPPLIES
JOB REF No:	197
DESIGNED:	G. ABDULAHED
DRAWN:	G. ABDULAHED
CHECKED:	M. LIEBMAN
SHEET:	113
SHEET No:	7 OF 9
SCALE:	1:200
COORD. ORIGIN:	
DATE:	20/04/2020
SIZE:	A1
DATUM:	AHD



PLAN
SCALE 1:750



INSET
SCALE 1:250

LEGEND

- DISH DRAIN
- 2m HIGH CHAIN WIRE FENCE WITH FAUNA FRIENDLY "FLOPPY TOP" AROUND POND
- DIRECTION OF FALL
- DESIGN CONTOURS (0.5m INTERVALS)
- RCP AT 1% MIN. GRADE
- BARRAMY GROSS POLUTANT TRAP (4 OFF)
- 1200 x1200 CLASS D GRATED PIT
- H1 APPROX EXTENT OF HIGH RISK AREAS
- M1 APPROX EXTENT OF MEDIUM RISK AREAS
- L1 APPROX EXTENT OF LOW RISK AREAS

NOTES:

1. ALL UNSEALED AREAS TO HAVE EITHER HDPE OR GCL LINER BELOW TO PROTECT GROUNDWATER

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SCALE 1:750 (A1) SCALE 1:1500 (A3)

REV	DATE	DESCRIPTION	BY	CKD
4	07/04/2020	REVISED FOR DA	AB	ML
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2	20/01/2020	REVISED FOR DA	GA	ML
1	16/12/2019	FOR DA	GA	ML

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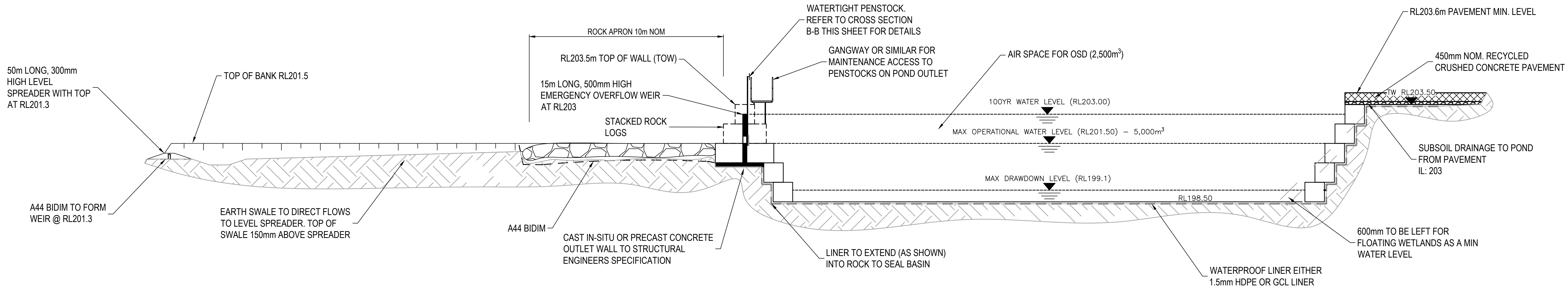
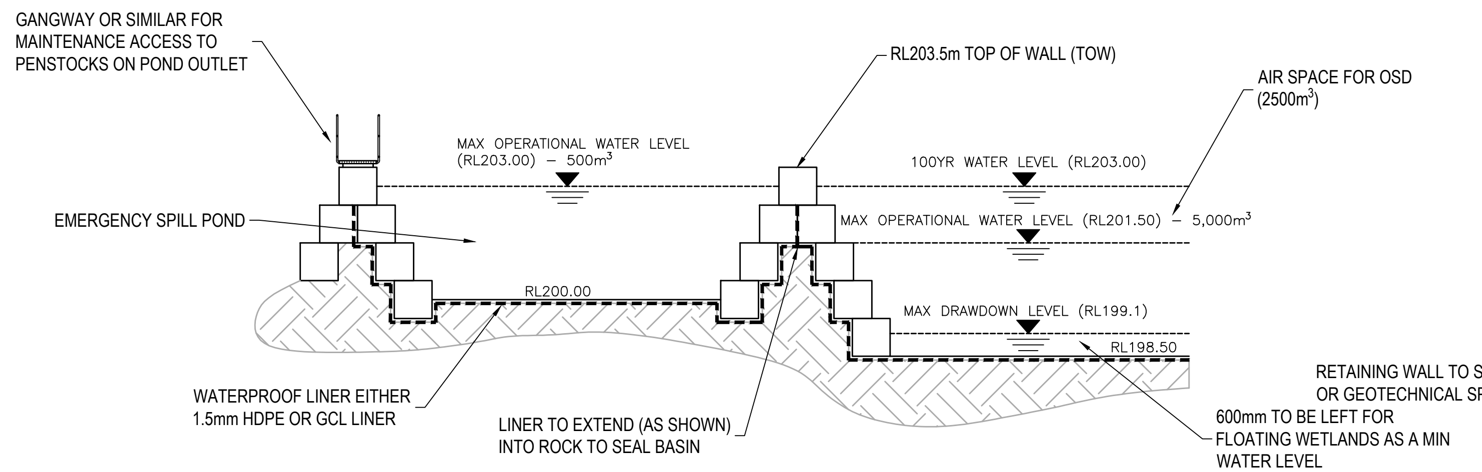
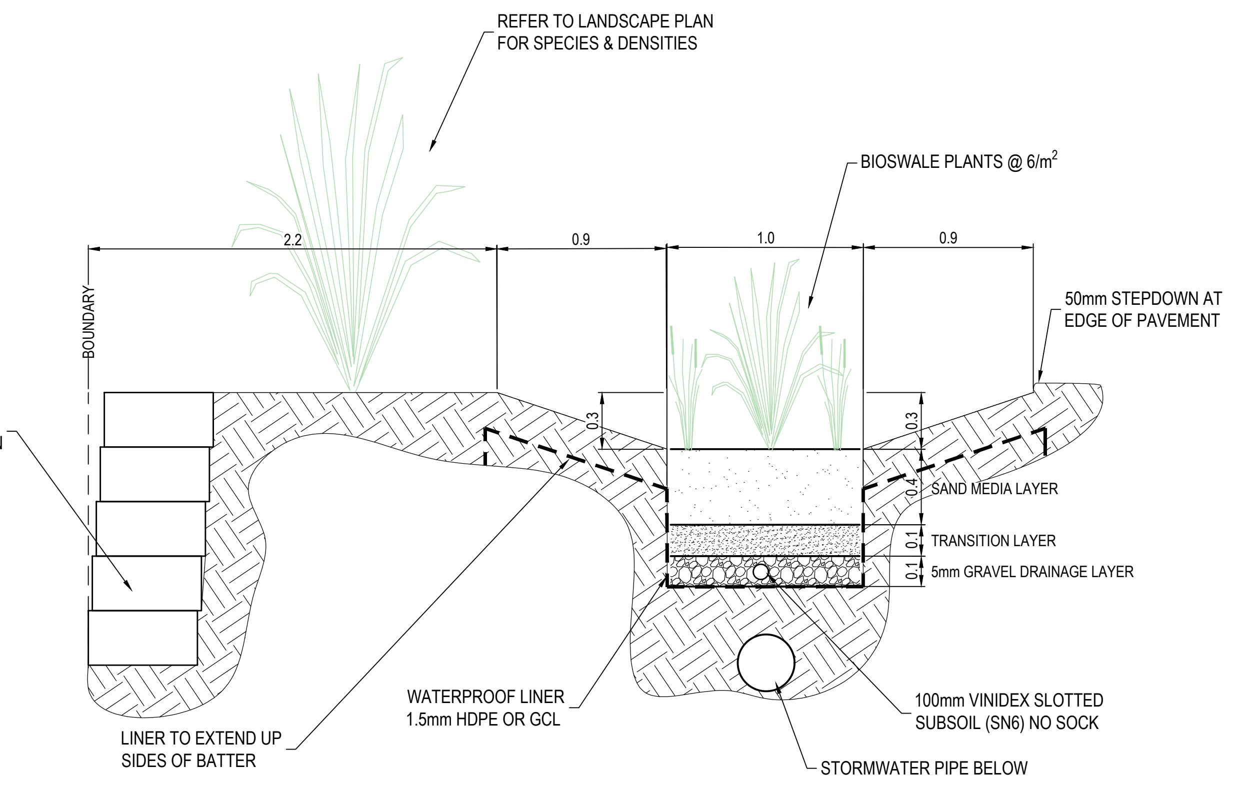
PROJECT:	PROPOSED KARIONG SAND & SOIL SUPPLIES FACILITY - SSD8660
	STORMWATER PLAN
CLIENT:	KARIONG SAND & SOIL SUPPLIES
JOB REF No:	197
DESIGNED:	G. ABDULAHED
DRAWN:	G. ABDULAHED
CHECKED:	M. LIEBMAN
SHEET:	115
SHEET No:	8 OF 9
SCALE:	AS SHOWN
COORD. ORIGIN:	
DATE:	07/04/2020
SIZE:	A1
DATUM:	AHD



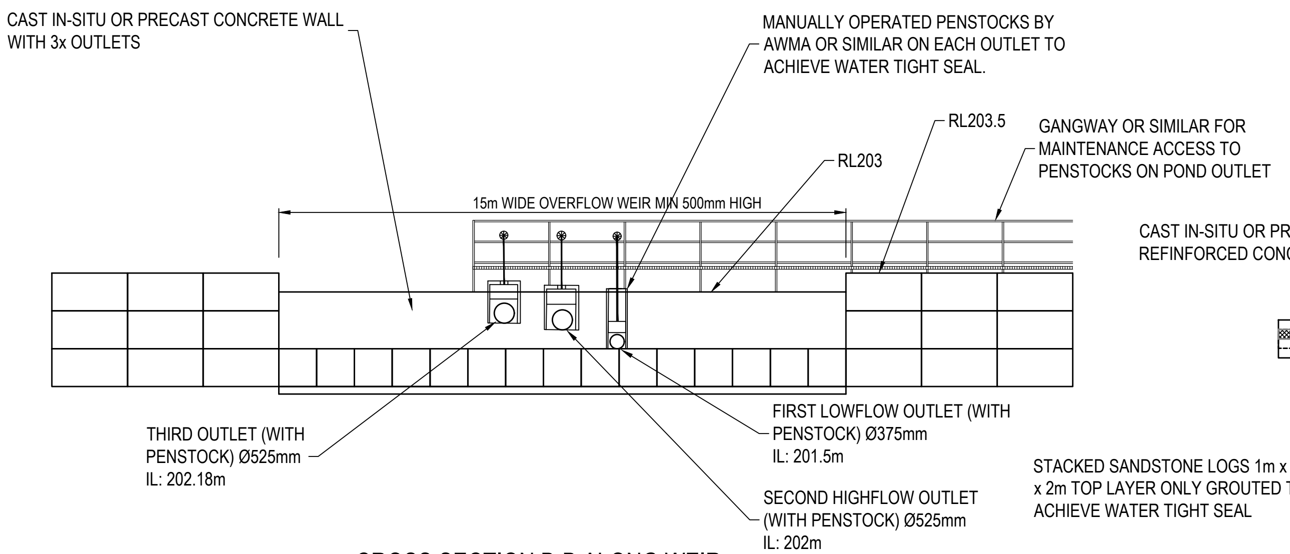
CROSS SECTION A-A THROUGH POND & WEIR
SCALE: NTS



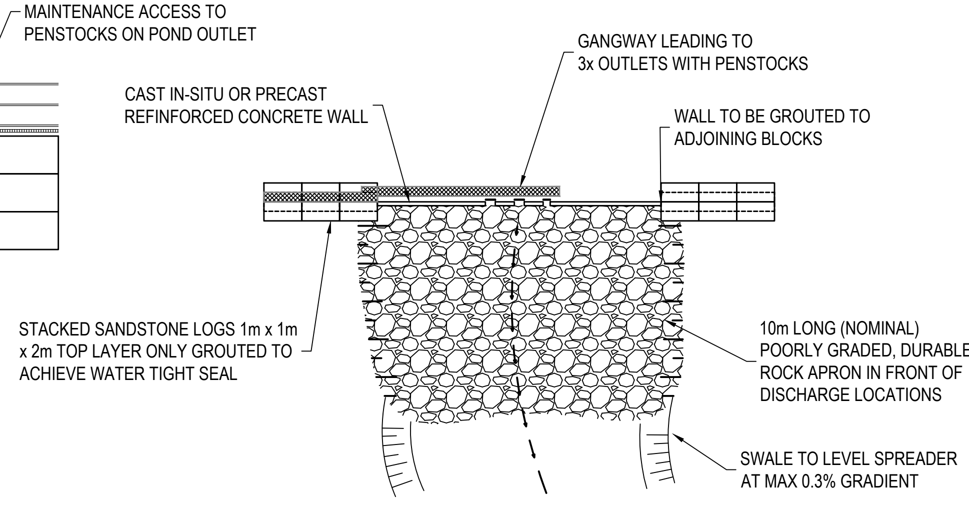
CROSS SECTION D-D THROUGH POND (NOT AT WEIR)
SCALE: NTS



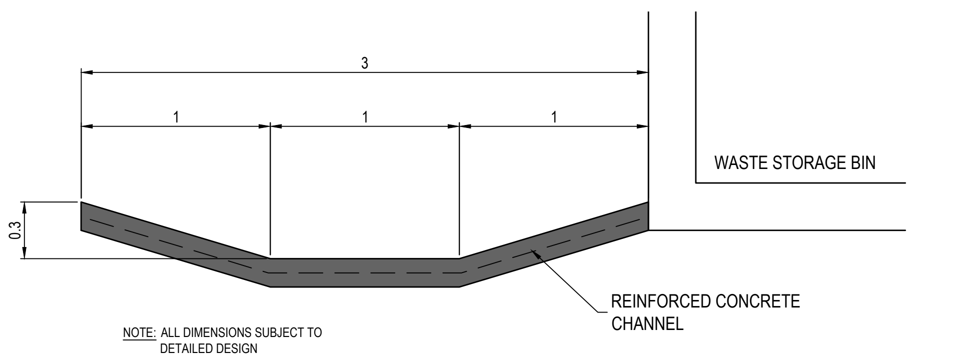
CROSS SECTION C-C THROUGH BIOSWALE
SCALE: NTS



CROSS SECTION B-B ALONG WEIR
SCALE: NTS



WEIR PLAN DETAIL
SCALE: NTS



CROSS SECTION E-E THROUGH CONCRETE DISH DRAIN
SCALE: NTS

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NOTES:

1. WATERTIGHT PENSTOCKS TO BE FITTED TO EACH OUTLET
2. REFER TO OUTLET PLAN VIEW FOR MORE INFORMATION

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PROJECT: PROPOSED KARIONG SAND & SOIL SUPPLIES FACILITY - SSD8660 STORMWATER SECTIONS & DETAILS	DESIGNED: G. ABDULAHED	SHEET: 116	DATE: 07/04/2020
	DRAWN: G. ABDULAHED	SHEET No: 9 OF 9	SIZE: A1
CLIENT: KARIONG SAND & SOIL SUPPLIES · JOB REF No: 197	CHECKED: M. LIEBMAN	SCALE:	DATUM: AHD
		COORD. ORIGIN:	

Appendix 2

LITERATURE REVIEW: HOW SUSTAINABLE ARE STORMWATER MANAGEMENT PRACTICES WITH RESPECT TO HEAVY METALS? A MULTINATIONAL PERSPECTIVE, LIEBMAN ET AL (2009)

HOW SUSTAINABLE ARE STORMWATER MANAGEMENT PRACTICES WITH RESPECT TO HEAVY METALS? A MULTINATIONAL PERSPECTIVE.

Liebman, M.B.[1], Jonasson, O.J.[2]
The Sustainability Workshop Ltd[1], Ku-ring-gai Council, NSW[2]

Introduction

The purpose of this paper is to explore stormwater management targets or policies and to question aspects of their sustainability.

A multinational review of stormwater management targets in Australia, New Zealand, USA and UK has shown that stormwater management approaches vary considerably amongst these countries.

The different approaches used can be defined as:

- No performance targets.
- Concentration based targets, e.g. total suspended solids must have a yearly average concentration of less than 35 mg/L.
- Load based targets, e.g. retain 80% of the average annual load of total suspended solids.
- Or a combination of the above.

We found the most common approach to the management of stormwater pollution is to adopt load based targets which apply to the development in question.

Specifically we wish to test the hypothesis that stormwater management policies in the Australia, New Zealand and the USA (ANZUS) tend to focus on long term or chronic impacts while potentially ignoring short term or acute impacts. We compare typical ANZUS policies against the UK Highways Agency approach where chronic or long term impacts are ignored and management focuses on acute stormwater toxicity.

The multinational review of stormwater management policies shows that where targets are adopted, they are predominantly load based and focus on the management of suspended solids and to a lesser extent on the removal of nutrients. We suggest that the dominant paradigm is to consider that suspended solids (usually measured as total suspended solids (TSS) and nutrients (usually measured as total nitrogen (TN) or total phosphorus (TP)) are the major pollutants of concern and serve as surrogates to indicate the presence of “other” pollutants that are also to be removed. An exception to the dominant paradigm is the UK.

The review of international water quality standards found that the UK is the only country within the study sample where water quality targets exist to assess the impact of acute toxicity on receiving waters. Research in the UK has shown that it is the presence of the heavy metals, Zinc (Zn) and Copper (Cu) in stormwater runoff which make it toxic (Crabtree et al, 2008) and this has been supported by similar findings in Australia (Kumar et al, 2002).

Relative to suspended solids and nutrients very little information is known about the treatment and removal processes of metals. This is also true in the UK despite mandatory assessment of dissolved metal loadings in highway runoff.

Through a literature review, we aim to determine if the use of suspended solids and nutrients are acceptable surrogates on which to base an assessment of the likely removal of heavy metals. This is important to know because if it is found that suspended solids and nutrients are a viable surrogate for toxic heavy metals then it justifies the current dominant paradigm. It could also mean that water quality modelling programmes such as the Model for Stormwater Improvement Conceptualisation (MUSIC) which have developed algorithms to model the decay of TSS, TN and TP can also be relied upon to provide an assessment of the removal of heavy metals despite the fact that these parameters are not implicitly modelled.

Conversely if suspended solids and nutrients are not adequate surrogates then it means that acute impacts (from Zn and Cu) are being ignored and that despite significant expenditure on the construction of stormwater treatment devices they could still be failing to deliver a sustainable outcome, i.e. the loss of macroinvertebrate communities in creeks receiving urban or highway runoff containing toxic levels of Zn and Cu is by definition considered to be unsustainable.

This paper also aims to highlight some of the problems and issues associated with the assessment of acute stormwater impacts.

Method

International Practice

Stormwater management targets from ANZUS and the UK where reviewed to identify their key performance criteria. The findings are summarised below.

United States of America
Of the 50 States and one District in the USA, 18 States explicitly require removal of total suspended solids. This is generally expressed as removal of a fraction of the average annual load. This is typically 80% removal but varies from 70% to 95%. Alaska requires removal down to 0.2mm diameter particle size for a given storm event. Neutral or beneficial effect policies are also adopted in some States.

In addition to sediment removal, nutrient removal is also explicitly required by 7 states, with the State of Maine being the only known case where phosphorus budgets have been developed for lake watersheds and which limit the export of phosphorus on new developments according to a phosphorus budget calculated for the new development. Elsewhere typically the average annual load of TP to be removed is in the range of 20% to 65% for new developments. Total Nitrogen removal is less commonly specified at 40% removal.

In conclusion 80% TSS removal is the most typical water quality requirement. No examples could be found where the removal of heavy metals is explicitly required.

Australia and New Zealand
An assessment of 20 Councils and various State Agency requirements in Australia and New Zealand revealed that requirements for stormwater treatment for new developments vary greatly.

We estimate from our sample that 60% of coastal NSW Council's adopt the NSW Department of Environment and Climate Change recommendation of requiring new urban development (over a certain size) to achieve 85% removal/retention of TSS, 65% removal of TP and 45% removal of TN. These targets have also been adopted by the Growth Centres Commission which is responsible for much of the green field development in Sydney. Melbourne Water requires 80% removal of TSS and 45% removal of TP and TN. Brisbane City Council has similar requirements. Auckland Regional Council in New Zealand requires 75% retention of TSS.

The most common treatment requirements relate to Gross Pollutants (GPs), TSS, TP and TN with some requiring percent removal of Hydrocarbons (HC). The removal percentage required of the respective pollutants varies between Councils but is generally 70-90% for GPs, 80-85% for TSS, 45-65% for TP and 45% for TN. Councils that required removal of HC specified a 90% removal.

None of the Councils assessed had explicit treatment requirements for metals although reference to removal of metals were made by two Councils.

In conclusion, Australian and New Zealand requirements tend to be similar to those in the USA i.e. they explicitly require about 80% removal of TSS, but in Australia nutrients are more commonly required for removal. Requirements for the treatment and removal of heavy metals are rare and practically non-existent.

The United Kingdom
The Water Framework Directive (WFD) requires an improvement in waterways in all European Economic Community member countries by 2015. To date in the UK it is only the Highways Agency (HA) which has developed a response to the WFD while River Basin Management Plans are currently being developed by the remainder of government. This implies that it is only the HA which stipulates water quality treatment on new developments in the UK at this point in time.

The HA has included requirements for the assessment of water quality impacts from new highway developments in their Design Manual for Roads and Bridges (DMRB, 2008). The work underpinning the DMRB was based on ecotoxicological and highway water quality monitoring studies in the UK which identified that the greatest risks to water quality (from highways) occur from dissolved Zn and Cu. Not surprisingly the same findings have been reached in Australia using Australian data (Kumar et al, 2002). The UK data has recently been bolstered with what is likely to be the most extensive water quality monitoring programme of highway runoff ever undertaken (Crabtree et al, 2008).

The DMRB water quality impact assessment process aims to determine if a new development requires stormwater treatment. Initially the expected loads of dissolved Cu and Zn are calculated. The calculations then assess any likely dilution in the receiving water.

The calculations consider:

- Traffic volumes – greater traffic volumes are equated with greater loads of metals. The monitoring work by the HA has enabled them to confidently estimate expected loads of dissolved Cu and Zn (amongst others) according to traffic volumes.
- Water Hardness – water hardness is a critical factor affecting the bioavailability of heavy metals in receiving waters. As hardness increases dissolved metals tend to become less bioavailable. This fact is also recognised in the Australian and New Zealand Environment and Conservation Council (ANZECC) Aquatic Ecosystem Protection Guidelines (NWQMS, 2000) and yet few (if any) practitioners modify the ANZECC trigger values to account for the impacts of hardness.
- Background or receiving water concentrations (assumed concentration if no data is available) under typical wet weather conditions. This allows for dilution of the discharge flows to estimate the concentration in the receiving water by summing the highway metal load and receiving water metal load and dividing by the total flow (receiving water and stormwater discharge) to derive a combined concentration.

The DMRB calculations may be a little simplistic in that calculations do not consider mixing zones and simply assume that stormwater readily mixes with the receiving waters.

If the concentration of the metals in the receiving water is estimated to be higher than the runoff specific threshold for that pollutant then treatment is required. Despite the relatively sophisticated approach for highway impact assessment in the UK, if treatment is required, reliance is made on the use of the CIRIA SUDS Manual by Woods Ballad et al (2007) to determine how to treat the flow. The CIRIA SUDs Manual is a typical BMP manual. Here for example wetlands are still designed using a design storm approach rather than through the use of continuous simulation methods and treatment trains are modelled assuming pollutants decay infinitely. Finally the actual treatment techniques developed to remove the heavy metals may or may not achieve the required criteria.

In conclusion ANZUS countries have followed a similar path in specifying that typically 80% of TSS is to be removed on new developments. Australia and some parts of the USA go further and also specify that nutrients are to be removed. It is believed that this approach originally developed from an understanding of what levels of performance could be achieved by Best Management Practices (BMPs) rather than on the ability of the receiving water to tolerate the discharge. The UK assesses highway impacts on water quality by examining likely heavy metal concentrations in the receiving water. However where treatment is required in the UK, because a standard BMP approach is adopted, compliance with heavy metal based water quality objectives may or may not be achieved.

Characteristics and Ecotoxicity of Stormwater

Crabtree et al (2008) characterised highway runoff across 4 climactic regional areas of the UK with a range of traffic volumes. Initially 10 events at 4 sites were monitored for a full range of parameters and then a further 10 events at 24 sites were monitored for specific pollutants. The monitoring also included pollutograph monitoring or intra-event monitoring of 10 events to enable first flush or other characteristics to be determined.

Crabtree et al (2008) reported that extensive monitoring of highway runoff found the presence of polyaromatic hydrocarbons (PAHs) and Cadmium (Cd) but at levels which were not toxic to receiving waters however Zn and Cu were found at levels toxic to receiving waters. MTBE (a lead replacement in petrol) was detected above the limit of detection in one sample but cyanide was not. Most PAHs were not detected at limits above the limit of detection but Pyrene and Fluoranthene were detected but not at toxic levels. PAHs, Lead (Pb) and Chromium (Cr) were tested by both Kumar et al (2002) and Crabtree et al (2008) and in both cases found at levels which are not toxic to receiving waters.

In describing the toxic characteristics of stormwater we therefore focus on Cu and Zn as they have been shown to be the most toxic constituents of stormwater (Kumar et al, 2002), (Crabtree et al, 2008).

It is known that heavy metals exist in receiving waters in several forms. There is the particulate bound form which can be suspended in the water column (i.e. attached to suspended solids) or which forms parts of the benthic sediments (i.e. attached to sediments which have fallen out of solution) and the dissolved fraction which exists in ionic form. ANZECC (2000) suggests that in order to test the acute toxicity of stormwater one could first filter the water (to remove suspended solids) and then test for dissolved Zn or Cu. The logic here is that the particulate bound fraction of metals is thought to be biologically unavailable and therefore not toxic while the dissolved fraction is thought to be easily absorbed by fish and therefore to be bioavailable and potentially toxic. Kumar et al (2002) found that both particulate bound forms and dissolved forms of Zn and Cu bioaccumulate in fish and must therefore both be bioavailable. Bioaccumulation is associated with chronic toxicity or long term risks. The finding by Kumar et al (2002) therefore supports the long term need to treat stormwater to remove suspended solids *and* particulate bound metals. The findings by Crabtree et al (2008) and Kumar et al (2002) support the need to remove the dissolved fraction of Zn and Cu in stormwater to protect receiving waters from acute toxicity.

With respect to Zn and Cu Crabtree et al (2008) found that dissolved event mean concentration (EMC) values for both Cu and Zn were about one third of the total Cu and Zn EMC values. In terms of the total loading Crabtree et al (2008) found that the dissolved fraction of Cu was about 25% of the total Cu load and dissolved Zn comprised about 20% of the total Zn load. Through typical extraction methods, Dierkes and Geiger (1999) determined that about 40% to 45% of Cu and Zn are bioavailable in highway runoff.

Crabtree et al (2008) found that there was no visible first flush of dissolved metals and concentrations of dissolved metals appeared to increase toward the end of the storm event. Kumar et al (2002) found that the first flush of stormwater contained elevated levels of dissolved metals.

Barry et al (2004) through synthesizing rainfall established that there is a first flush of suspended solids. However Crabtree et al (2008) through examination of 10 pollutographs found that there is no correlation between suspended solids and total or dissolved metals and suspended solids can’t be used as a surrogate for predicting the presence of heavy metals. This conflicts with the findings of Kumar et al (2002).

Heavy Metal Removal by BMPs

Dunphy et al (2008) analysed the effectiveness of two different types of stormwater filters, one at Kiama in NSW and the other in Hornsby, NSW. Both systems used HydroCon pipes embedded in a filter media to treat stormwater runoff. The Hornsby filter which is sub-surface loaded relied on HydroCon pipes which were deliberately modified through the addition of iron oxides to assist with the removal of Cu. The Kiama site which is both a subsurface and surface loaded system used unmodified HydroCon pipes. Kiama is a busy rural town with a 6.5 hectare tourist dominated CBD catchment while Hornsby had a 0.16 hectare car park catchment. Results of the monitoring showed significant removal of Zn at both sites. The average concentration of Zn in the treated stormwater at Kiama was found to be 0.0256 mg/L and this equated to a 90% effective removal rate. It is strongly suspected that stormwater which is piped in concrete pipes is much harder than receiving waters where hardness may be typically less than 100. Without knowing the hardness of the stormwater at Kiama or Hornsby it is impossible to assess how toxic the stormwater was and benchmarking against unmodified ANZECC criteria which assumes a hardness of 30 will normally produce overly conservative results.

It is interesting to note that neither Kumar et al (2002) nor Dunphy et al (2008) modified the ANZECC toxicity data to account for hardness. Research by Hatt et al (2007) did not report if hardness was measured but it appears that hardness is not one of the parameters of their investigations and yet if one is measuring metal removal by bioretention systems hardness may well be one of the parameters which affects performance. Moreover the hardness of the semi-synthetic stormwater used by Hatt et al (2007) may account for changes in the speciation of metals.

The Kiama filter has also been shown to reduce TSS by almost 80% and TN and TP by 45% (Dunphy et al, 2005).

We highlight this example because:

1. The monitoring undertaken was extensive (Dunphy et al, 2005)
2. It shows that bioretention systems which can remove 80% of TSS and 45% of TN are also likely to remove significant quantities of toxic heavy metals with the discharge likely to deliver at least an 80% level of protection against heavy metal toxicity (based on overly conservative assumptions). In this case TSS and TN at retention rates that are typical of regulations in the countries we surveyed appear to be viable surrogates with which to also estimate the removal of toxic heavy metals.

Elsewhere laboratory tests of the treatment effectiveness of sand filters and bioretention systems has concluded that high levels of metal removal can be achieved using such systems (Hatt et al 2007), with removal rates close to 100% reported. These filters are especially efficient in removing the particle bound fraction of metals, as these are mainly removed through physical processes such as mechanical straining. It has been reported that metals found in stormwater are largely particulate bound (Muthukamaran et al, 2002 in Fletcher et al, 2004), so it should be expected that metal removal would follow that of TSS removal.

Many studies on the effectiveness of bioretention systems and sand filters do not make any distinction between the particulate bound fraction and the dissolved fraction of metals in stormwater. Where such a distinction has been made the removal rates of dissolved metals vary considerably (Hatt et al, 2007). The removal rates in bioretention systems of the dissolved fraction are consistently reported as being lower than that of the particulate bound metals (Fletcher et al, 2004). Dissolved Cu is particularly difficult to remove due to organic complexing (Dierkes and Geiger, 1999) but Dunphy et al (2008) has shown that treatment systems can be designed to enhance Cu removal.

Yousef et al (1987) found high rates of Zn removal (90% of the dissolved fraction) but in that study infiltration was an important part of the treatment in the Florida highway swales tested.

We do note that swales alone are unlikely to achieve an 80% reduction in TSS or a 45% reduction in TN and should be considered as part of a treatment train.

Constructed wetland and ponds are also commonly adopted BMPs in the countries sampled. Wet basins are the preferred treatment measure of the NSW Road and Traffic Authority for treatment of highway runoff though this preference is driven by maintenance costs rather than water quality objectives. Fletcher et al (2004) reports on the expected range of treatment of ponds, wetlands and sediment basins and shows that metal removal can be high but removal is likely to be greatest where biological process can occur. Wetlands, ponds and sediment basins are ranked in decreasing order of metal removal:

1. wetlands (with large areas of macrophytes),
2. ponds (with only fringing vegetation) and
3. sediment basins (without any vegetation or biological uptake).

Removal processes for particulate bound metals will occur through sedimentation and removal of the dissolved fraction may be through uptake by plants or biofilms. It is reasonable to conclude that where removal of each of TSS, TN and TP are greatest, removal of metals will also be greatest. 80% removal of TSS while nutrient removal remains low (as in the case of a well sized sediment basin) is not to be used as a surrogate to estimate high rates of metal removal. It is likely that when removal of sediments and nutrients exceeds 80% and 45% respectively removal of metals will be high. Bioretention systems or wetlands should be preferred to both ponds and sediment basins for heavy metal removal in terms of removing the dissolved fraction of metals.

Discussion

Difficulties associated with assessing the toxicity of stormwater

This paper has highlighted how Australian industry researchers appear not to take account of water hardness when assessing the toxicity of stormwater while those in the UK and U.S appear to do so. This is also compounded by the fact that some researchers also fail to measure the bioavailable fraction of metals in stormwater and then benchmark performance using ANZECC toxicity guidelines. Use of unfiltered samples, i.e. measurements of total metals, can be made however this will significantly overestimate the toxicity of the stormwater.

Assessing the toxicity of the first flush of stormwater as Kumar et al (2002) did by immersing aquatic organisms (Water Flea and Rainbow Fish) in the first flush (which by definition implies that it is a short lived phenomenon) for 48 hours is questionable. The same principle applies to assessing acute impacts by immersing organisms in a composite stormwater runoff sample for 4 days. It is known that many of the practices developed to assess aquatic toxicity have been developed in response to waste water discharges which have a completely different loading or exposure pattern to stormwater. The HA in the UK has relied on 6 hour and 24 hour bioassays and these are likely to be much more representative of real world exposure patterns of aquatic organisms to stormwater.

Time Scale Effects of Stormwater Runoff

Hvitved-Jacobsen et al (1994) produced a figure which plots the time scale effect of various pollutants. This is reproduced in Figure 1.

Figure 1 shows that nutrients have an accumulative effect on receiving waters. This is also supported in the ANZECC Guidelines for Aquatic Ecosystem protection (NWQMS, 2000) where it is stated that although it is key nutrient concentrations that stimulate algal growth it is the load of nutrients that is responsible for the final biomass of aquatic plants.

Suspended solids also impact on ecosystems in a load based manner with smothering of benthic organisms being related to the total load of sediment on the receiving water (NWQMS, 2000). Bioaccumulation of particulate bound heavy metals may also occur as a result of sediment loading where additional input (over a threshold value) accumulates over time.

Figure 1 shows that heavy metals can have both acute and accumulative or chronic effects.

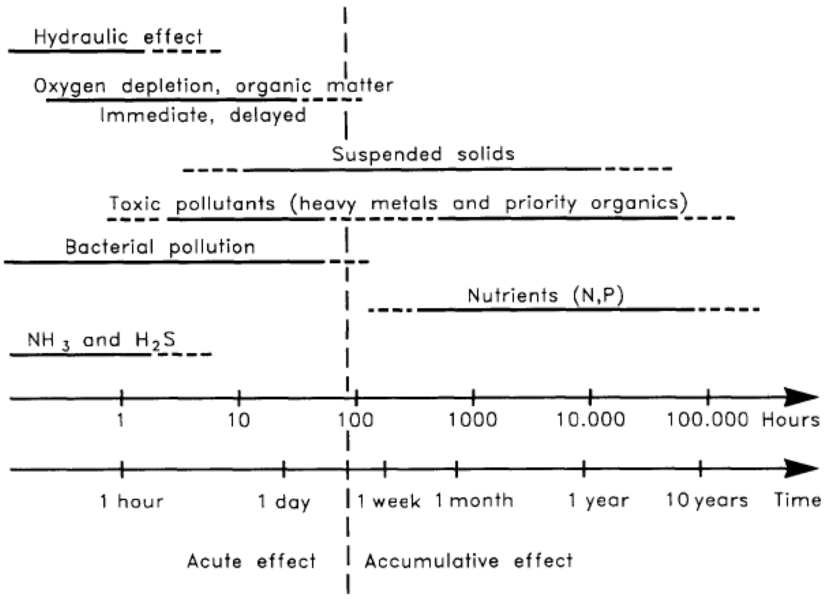

Figure 1 Time scale effects of water pollution (reproduced from Hvitved-Jacobsen et al (1994)).

Australia is a very large and generally dry country. Water that falls as rain in some parts of Australia may not reach the sea for several months. The same applies to the U.S. The UK on the other hand is a small country with a relatively short hydrological turn over time and frequent rainfall. Water that falls as rain is likely to reach the sea within a day in most parts of the UK. In Australia and the USA where the hydrological regime is a long regime cumulative stormwater impacts from chronic pollutants are thought likely to predominate. In Australia and the USA flushing is often limited and nutrients and sediment may be the principal pollutants of concern.

The opposite is true in the UK where turnover is frequent and flushing of both sediment and nutrients within waterways is high and nutrient related pollution occurs mainly in artificial reservoirs but generally not in rivers or lakes. Therefore in the UK acute stormwater impacts such as heavy metal pollution are the dominant driver behind regulations. Conversely in Australia and the USA nutrients and suspended solids are regulated while heavy metal discharges aren't.

We question if heavy metal pollution does not also pose a serious threat to waterway health in both Australia and the U.S. This effect is much less obvious than an algal bloom caused by excessive levels of nutrients however its consequences can be just as dramatic in terms of aquatic ecosystem health. Macroinvertebrates form the bottom of the food chain in aquatic ecosystems and as such their presence is essential to maintaining the biodiversity of a waterway.

We therefore question the relative importance given to the treatment of nutrients and suspended solids and aimed to establish if these are adequate surrogates for the treatment of stormwater and if they do also result in the effective removal of heavy metals. We ask if by specifying that suspended solids and nutrients are to be removed at say 85% for TSS and 45% for TN what level of protection will this deliver in terms of heavy metal toxicants?

Using the Kiama bioretention system as a case study we have shown that under typical conditions a bioretention system which achieves 80% removal of TSS and 45% removal of TP and TN will also remove 90% of the Zn load. At Kiama the total Cu load was fairly low and removal was therefore minor. At Kiama an 80% level of protection was estimated by Dunphy et al (2008). Testing for the bioavailable fraction of metals (as opposed to total metals) and measuring water hardness would have shown the level of protection to have increased significantly.

We suggest that accounting for dilution of stormwater in the receiving water is generally the main reason that concentration based targets are not widely adopted. The UK HA method assumes that the receiving water will be flowing under typical low flow conditions during the runoff event. This approach enables dilution to be accounted for. One then also needs to test the hardness and metal concentrations in the receiving water to establish background levels to assess the impact of the current (untreated) and proposed situations.

This method could be applied to ANZUS conditions to assess the potential impact of heavy metals on receiving waters however we question the need to do this. In ANZUS the purpose of this would not be to determine if treatment is required (as it is in the UK) – indeed treatment is required to manage the long term cumulative impacts of TSS and nutrients. Therefore treatment will be provided in any case. This method however may have application where development is proposed in sensitive ecological or pristine areas such as drinking water catchments, alpine areas, National Parks, above protected wetlands or rivers etc or wherever it is necessary to demonstrate the ability to treat stormwater runoff to achieve high levels of aquatic ecosystem protection.

Conclusion

A review of regulatory requirements in the ANZUS countries showed that these countries regulate stormwater runoff on new developments by requiring about 80% removal of the annual load of TSS. Australia and the some parts of the USA go further and require TP and TN to be treated too. The UK was the only country in the sample which assesses the potential impacts of a development against receiving water quality and ecosystem tolerance.

This paper questioned whether the typical regulatory requirements in ANZUS of 80% TSS removal and 45% nutrient removal were viable surrogates on which reliance could be made to conclude that high levels of retention of heavy metals would also occur. For well designed and constructed bioretention and artificial wetland systems this appears to be the case with Zn retention typically in the order of 85% to 95% removal and Cu less reliably removed. Ponds, swales and gross pollutant traps will need to be used as part of a treatment train if they are needed to remove heavy metals which will ideally include some form of bioretention or wetland in the treatment train.

This paper also questioned if the ANZUS country regulators are ignoring heavy metal impacts where others seem to focus on metals. We found that the different hydrological regimes that exist in those countries may explain why acute effects dominate regulation in the UK and why chronic or long term effects dominate in Australia and the USA. It is concluded that until designers have sufficient information to specifically design for acute toxicity that reliance on TSS and nutrients is an acceptable interim approach and one that is likely to provide reasonable levels of protection to aquatic ecosystems.

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Appendix 3

PERFORMANCE EVALUATION OF A FLOATING TREATMENT WETLAND IN AN URBAN CATCHMENT NICHOLS ET AL (2016)

water

MDPI

Article

Performance Evaluation of a Floating Treatment Wetland in an Urban Catchment

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Abstract: Floating Treatment Wetland (FTW) systems are purpose-built devices designed to replicate the water treatment processes that occur in and around naturally occurring floating vegetated islands. FTWs can be used to improve the water quality of water storage ponds by contributing to water treatment processes through adhesion, filtration, nutrient uptake (direct use by plants), and sequestration. This paper presents the results of a twelve-month investigation into the pollution removal performance of a FTW receiving stormwater runoff from a 7.46 ha urban residential catchment. As anticipated, there was a high degree of variation in FTW treatment performance between individual rainfall events. Overall pollution removal performance was calculated to be 80% for Total Suspended Solids (TSS), 53% for Total Phosphorous (TP), and 17% for Total Nitrogen (TN) for a FTW footprint of 0.14% of the contributing catchment. TSS and TP concentrations were found to be significantly reduced after FTW treatment. The minimum FTW footprint to catchment size ratio required to achieve regulated nutrient removal rates was calculated to be 0.37%. Sum of loads calculations based on flow resulted in pollution load reductions of TSS 76%, TP 55%, and TN 17%. Pollution treatment performance (particularly for TN) was found to be affected by low influent concentrations, and highly-variable inflow concentrations. The study demonstrated that FTWs are an effective treatment solution for the removal of pollution from urban stormwater runoff.

Keywords: floating treatment wetland; stormwater pollution; urban stormwater

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1. Introduction

Naturally occurring floating vegetated islands are found in freshwater lakes and ponds, and are comprised of a matrix of floating organic material and plant associations growing at the water surface. The buoyancy of a naturally occurring floating island is a result of gasses (Nitrogen-N and Carbon dioxide-CO_2 in aerobic conditions, and additionally Methane-CH_4 in anoxic conditions) trapped beneath the organic mat, and the air stored within the roots and leaves of vegetation growing on the island [1,2]. The size of naturally occurring floating islands can change organically over time, increasing via the accumulation of trapped floating organic material, and decreasing because of temporary higher velocity flows, wave action, or strong winds [1]. The inherent habitat value (especially to avifauna) of floating islands has been recognised for decades [3]. For example, the UK Royal Society for the Protection of Birds constructed artificial islands for the conservation of threatened species as early as the 1960's [4].

Following these early successes, FTWs have since been used for a variety of purposes including treatment of pollution emanating from mine tailings [4–7], and pollution removal from stormwater [8–14].

FTWs make positive contributions to the health of their aquatic environment by reducing flow velocity which promotes the settlement of suspended solids. FTWs also mechanically filter suspended solids though the interaction of plant roots in the water column (Figure 1) which can grow to a depth of 3 m [3]. Complex microbial communities (biofilm) also assemble on, and throughout the root mass below the water surface, and contribute to water treatment processes through adhesion, filtration, nutrient uptake (direct use by plants), and sequestration [15,16]. FTWs have also been acknowledged to contribute to the aesthetic quality of an area [4]. As FTWs do not require additional earthworks or land uptake, they can also offer increased pollution removal performance at a substantially lower cost compared to alternatives such as constructed wetlands.

Figure 1. Specially fabricated removable planter boxes to assess root length.

Contemporary artificial FTWs are typically constructed using a combination of woven plastic, organic based matting, and fibreglass [8,10]. Juvenile plants are established directly into this floating matrix, and the roots grow into the water column below (Figure 2).

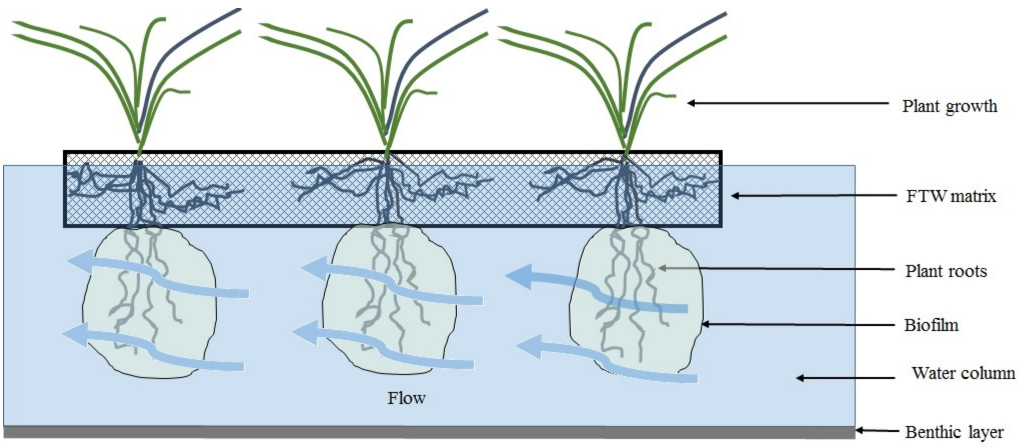

Figure 2. Schematic of Floating Treatment Wetland (FTW) system.

Studies undertaken in the United States and New Zealand [10–16] have found that FTW can provide an effective, low cost, and low maintenance means of treating domestic and agricultural wastewater and stormwater. Tanner *et al*. [10] found that FTW were capable of reducing wastewater TSS by up to 81%, total nitrogen (TN) by up to 34%, and total phosphorus (TP) by up to 19%. Borne [11] observed significant reductions in TP as a result of a FTW installation in a stormwater pond. Similarly Borne *et al*. [12] in NZ found FTW retrofitted stormwater ponds to be more efficient at removing TSS. However, there are currently few field studies on the performance of FTW in treating urban stormwater runoff [9] and their treatment performance remains largely unknown. This paper describes the results of a twelve-month field study undertaken to evaluate the pollution removal performance of a FTW designed to treat stormwater runoff from an existing urban development in Queensland, Australia.

2. Site Description

The study site was located on Bribie Island, Queensland, Australia (Figure 3). The entire site is zoned low-density residential, and has a total area of 42.3 ha. The contributing catchment area of the development site treated by the FTW is 7.46 ha (Figure 3), with 2.2 ha comprised of a development under construction. The FTW installation (101 m^2) was sized as approximately 0.14% of the contributing catchment area.

Figure 3. (**a**) Bribe Island location; (**b**) Study site catchment area.

Rainfall and runoff from the catchment is directed via road kerb inlets (catch basins), and a piped drainage network to a stormwater channel leading to the lake containing the FTW. Flow from the channel was immediately directed to the FTW treatment zone with flexible, impermeable polyvinyl chloride (PVC) curtains which were secured to the sides of the FTW and the pond bed. This was done to prevent short-circuiting of the flows (a problem identified in previous studies). Water samples were taken at the FTW inlet and outlet points shown in Figure 4.

The modular FTW was constructed using four, 50 mm thick layers of recycled plastic fibre, with injected marine grade foam to provide buoyancy (Figure 4). This matrix was then covered with a natural coir mat, and initially planted out with a sedge mono-culture (*Carex appressa*) at a density of approximately three plants/m^2. Each of the 11 individual FTW modules was 9.2 m^2 in area (total area of 101 m^2). The size of the forebay area during testing was 130 m^2. Because of the installation of the impermeable baffles, the FTW covered 100% of the treated surface area. The overall size of the pond was 5048 m^2.

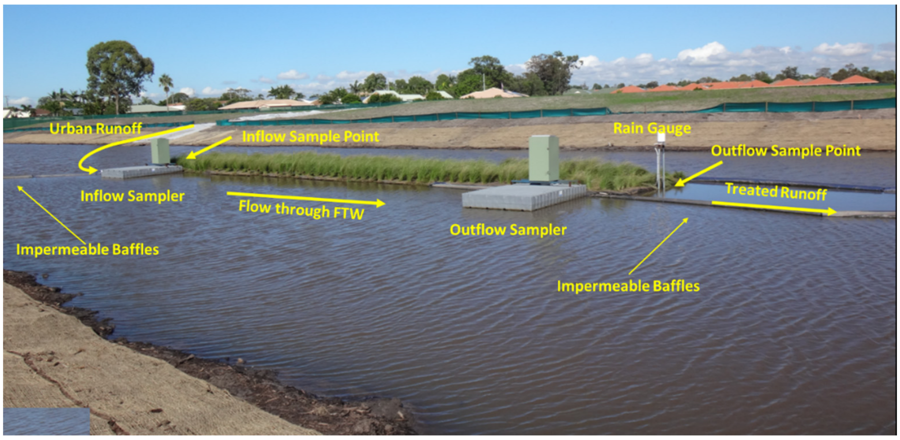

Figure 4. FTW experimental setup.

3. Sampling Protocol and Methodology

A predetermined sampling protocol was used to identify qualifying rainfall events (Table 1). This protocol was developed in order to support an objective evaluation of the FTW pollution removal performance, which could be viewed as "representative performance" across the wide range of variable inflow pollution concentration likely to be experienced by the FTW in an urban residential setting. This protocol was developed based on the protocol methodology prescribed by the United States Environmental Protection Agency's (USEPA) Stormwater BMP Monitoring Manual [17] and Auckland Regional Council's Proprietary Device Evaluation Protocol (PDEP) for Stormwater Quality Treatment Devices [18].

Table 1. Sampling protocol.

Parameter	Bribie Lakes
Minimum storm duration	5 min
Catchment type	Urban Residential
Stormwater treatment device type	Floating Treatment Wetlands (101.2 m^2) (variable water depth, 1.5 m)
Desired number of valid sampling events	15
Minimum rainfall depth	2.0 mm
Minimum antecedent dry period	6 h, depending on influent concentrations
Minimum hydrograph sampling	First 60% of hydrograph
Desired number of water sub-samples	Minimum 8 influent and 8 effluent subsamples per event
Sampling method	Auto-sampler (ISCO), flow-weighted in 5000 L intervals
Data management	Campbell Scientific CR800 Data logger with Ethernet Modem
Total suspended solids (TSS)	APHA (2005) 2540 D
Total Nitrogen and species	APHA (2005) 4500 N, APHA (2005) 4500 NH_3, APHA (2005) 4500 NO_3
Total Phosphorus and Orthophosphate	APHA (2005) 4500 P

Note: APHA = American Public Health Association.

Automatic sampling equipment was triggered when a tipping bucket rain gauge recorded >2 mm rainfall in 30 min, and the flow meter (Starflow ultrasonic probe) simultaneously recorded >0.5 L/s. Samples were collected by the auto-samplers at 5000 L intervals thereafter until flow ceased. To account for the potential lag in flow beneath the FTW, a further two sub-samples were taken after flow had dropped below 0.5 L/s for 60 min. Sample aliquots (200 mL) were composited within the automatic sampler in a nine litre glass bottle for analysis.

Performance Metrics

A range of metrics were used in order to provide a representative performance evaluation to account for the highly-variable results that were expected in the study. These included: Event Mean Concentration (EMC) (Equation (1)), Concentration Removal Efficiency (CRE) (Equation (2)), and Efficiency Ratio (ER) (Equation (3)). The value of CRE as an effective metric has been reduced as a reliable metric since minor variation (±1 mg/L) observed in the analytical variability has significant influence on the metric at low influent concentrations, and so ER has been used as the primary metric in this study [19]. Prior to statistical testing, concentrations of TN and TP were log transformed (Equation (4)) to achieve normal distribution (Shapiro-Wilks $p > 0.05$ alpha).

$$EMC = \frac{\sum_{i=1}^{n} V_i C_i}{\sum_{i=1}^{n} V_i} \tag{1}$$

where: V_i = Volume of flow during period I, C_i = Concentration associated with period I, n = Total number of aliquots collected during event.

$$\text{Avg.CRE} = \frac{\sum \left[\frac{\text{EMC}_{\text{in}} - EMC_{out}}{EMC_{in}}\right]}{no.\ of\ events} \tag{2}$$

$$ER = \frac{Mean\ EMC_{out}}{Mean\ EMC_{in}} \tag{3}$$

$$X' = \log_{10}(X+1) \tag{4}$$

The average reduction of pollutant mass was calculated using a Sum of Load equation, based on pollutant loads from multiple storm events. The Sum of Loads for both influent and effluent samples was calculated using Equation (5).

$$M = \sum_{i-1}^{n} V_i C_i \tag{5}$$

where: M = total mass of pollutant (kg), V_i = discharge amount corresponding to sample I (m^3 or L), C_i = pollutant concentration in sample I (mg/L), i = sample number.

Calculations to estimate the number of samples required for statistical validation given the high variability in the data followed Burton and Pitt [20] (Equation (6)).

$$n = 2\left[\frac{Z_{1-\alpha} + Z_{1-\beta}}{\mu_1 - \mu_2}\right]^2 \sigma^2 \tag{6}$$

where: n = number of sample pairs needed; α = false positive rate ($1 - \alpha$ is the degree of confidence. A value of α of 0.05 is usually considered statistically significant, corresponding to a $1 - \alpha$ degree of confidence or 95%); β = false negative rate ($1 - \beta$ is the power. If used, a value of β of 0.2 is common but it is frequently ignored, corresponding to a β of 0.5); $Z_{1-\alpha}$ = Z score (associated with area under normal curve) corresponding to $1 - \alpha$; $Z_{1-\beta}$ = Z score corresponding to $1 - \beta$ value; μ_1 = mean of dataset one; μ_2 = mean of dataset two; σ = standard deviation (same for both datasets, assuming normal distribution).

4. Results and Discussion

During twelve months of monitoring, 10 qualifying events were recorded (Tables 2 and 3) with rainfall depths ranging between 2.0 mm and 25.6 mm. As expected, the observed pollution removal efficiencies were highly-variable between individual rainfall events for the parameters measured. The measured pollution removal performance (ER) of the FTW was calculated to be 80% for TSS, 53% for TP, and 17% for TN (Table 2. These removal rates are encouraging when compared to findings of previous stormwater FTW pond studies [11–14]. The improved removal rates are believed to be the result of the unique experimental design that excluded potential short-circuiting and specifically focused on evaluating the pollution removal performance of the field-scale FTW alone, rather than as part of a stormwater treatment train. The calculated pollution removal proportions from outflows were found to be less than the values specified by the local Queensland State Planning Policy and regulations (TSS 80%, TP 60%, and TN 45%) [21], and this is likely a reflection of the small FTW footprint as a percentage of the contributing catchment [22]. Calculations of the ER for TN were particularly variable. This may have been due to very low pollution influent concentrations during some of the qualifying events and the strong dependence of nutrient removal rate on loading rate as found in previous studies [11].

Table 2. FTW pollution removal performance.

Event Date	Parameter	TSS		TP		TN	
		In (mg/L)	Out (mg/L)	In (mg/L)	Out (mg/L)	In (mg/L)	Out (mg/L)
LOD (mg/L)	**Rain Depth (mm)**	**1**		**0.005**		**0.1**	
28 September 2015	2.0	323	51	0.28	0.1	1.00	0.25
23 October 2015	3.8	11	4	0.03	0.02	0.70	0.30
7 November 2015	13.2	414	24	0.28	0.03	3.20	0.70
14 November 2015	16.6	26	16	0.05	0.05	1.10	0.70
29 November 2015	12.4	270	28	0.14	0.02	2.20	1.30
30 January 2016	3.4	50	26	0.04	0.04	1.10	2.20
1 February 2016	20.4	19	36	0.04	0.07	0.80	1.60
6 February 2016	10.8	19	24	0.05	0.03	0.60	0.80
13 February 2016	25.6	37	19	0.05	0.03	1.40	2.10
6 March 2016	6.2	56	15	0.10	0.11	1.20	1.10
Mean	–	122.5	24.3	0.106	0.05	1.33	1.105
Efficiency Ratio	–	80%		53%		17%	

Note: LOD, Limit of detection.

Table 3. FTW Rainfall volume and flow.

Event	Peak Flow (L/s)	Volume (kL)
28 September 2015 [1]	–	–
23 October 2015	100	279.3
7 November 2015	1340	511.9
14 November 2015	2335	531.0
29 November 2015	1160	361.0
30 January 2016	24	234.9
1 February 2016	93	281.0
6 February 2016	126	611.6
13 February 2016	320	563.0
6 March 2016	151	148.6

Note: [1] Data not recorded.

Rainfall, peak flow rates and cumulative flow volumes were used to calculate the Sum of Loads for evaluating the performance of the FTW in removing pollution loads from urban stormwater from the study site (Table 4). The low load removal for TN is thought to be a result of the highly variable TN inflows. More qualifying sampling events (> 150) are required to fully incorporate this variability.

Table 4. Sum of Loads.

TSS	TP	TN
76%	55%	17%

A paired Student's *t* test (log transformed data) was performed to test for differences between inflow and outflow pollution concentrations. The results showed that TSS and TP outflow concentrations were significantly lower than inflow concentrations ($p < 0.05$) (Table 5).

Table 5. Student's *t* test (log-transformed) ($\alpha = 0.05$).

FTW	*p*-Value (Two-Tailed)		
Parameter	TSS 0.015 *	TP 0.042 *	TN 0.35

* Significant ($p < 0.05$).

These results demonstrate how highly-variable environmental data may require very large datasets to establish pollution removal efficiencies that are statistically significant using the traditional calculations [22]. Equation (6) was used to estimate the number of samples required to ensure a statistical relevant result (Table 6).

Table 6. Number of samples required to ensure statistically relevant results.

Parameter	TSS	TP	TN
Number of samples required	26	36	150

An estimated 23-year period would be required to adequately demonstrate statistical significance for the results of the full range of parameters investigated in this study (Table 6). Given the high establishment and running costs of research projects such as this, and the low proportion of qualifying events arising from natural rainfall that were able to be successfully sampled (<20%), this time frame was considered to be unrealistic.

5. Conclusions

This research investigated the pollution removal performance of a FTW receiving stormwater runoff from a 7.46 ha urban residential catchment. The FTW installation (101 m^2) was sized as approximately 0.14% of the contributing catchment. The FTW was initially planted with a sedge mono-culture (*Carex appressa*). The installation of impermeable baffles ensured the FTW covered 100% of the water treatment zone, and also prevented short-circuiting of the flows.

As anticipated, there was a high degree of variation in FTW treatment performance between individual rainfall events. Overall Efficiency Ratio was calculated to be 80% TSS removal, 53% TP removal and 17% TN removal for a FTW footprint of 0.14% of the contributing catchment. TSS and TP outflow concentrations were found to be significantly reduced after FTW treatment ($p < 0.05$). Sum of loads calculations based on flow resulted in pollution load reductions of TSS 76%, TP 55%, and TN 17%. Treatment performance (particularly for TN) was found to be affected by very low and highly variable inflow concentrations. Because of this high degree of variability, an estimated 23-year period would be required to adequately demonstrate statistical significance for the full range of parameters investigated in this study.

This study has demonstrated that FTWs are an effective treatment solution for the removal of pollution from urban stormwater runoff, though may need to be larger than 0.14% of the contributing catchment to achieve 80% TSS, 60% TP and 45% TN locally regulated water quality objectives. Using a simple linear assumption mathematical model, the minimum proportional size of the FTW to catchment required to achieve the required pollution removal rates was calculated to be 0.37% or at this site, 124 m^2. As FTWs do not require additional earthworks or land uptake, they may also offer pollution removal at substantially lower costs than other more traditional treatment options. It is expected that the performance of FTWs could be even further improved when used in conjunction with additional treatment components as part of a "treatment train" approach.

Given the potential for FTWs to successfully treat stormwater runoff and the few reported field studies specifically relating the performance of FTWs and nutrient removal [9,10], this study makes a notable contribution to the current body of knowledge in this area. The Stormwater Research Group University of the Sunshine Coast currently has a number of additional study trials underway which are investigating the long-term pollution removal performance of FTW systems in urban settings. It is anticipated that the effective pollution removal performance of FTWs will be clearly demonstrated in future as more results from these ongoing studies are evaluated.

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Appendix 4

RESPONSES TO SUBMISSIONS

Original Response to Submission table – Response to Government Agencies - Water Quality comments only

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
1	General Operations	NSW EPA – Waste Compliance (1st submission)	The application proposes several different hours of operation for different activities at the premises. The proponent must clarify the intended hours of operation for the undertaking of scheduled activities for the environment protection licence.	Hours of operation have been clarified and are consistent throughout the EIS and attached studies.	Chapter 2 of the EIS report
9	Water Quality	NSW EPA – Waste Compliance (1st submission)	Provide the manufacturer, model and specifications for the proposed jellyfish filter in place prior to discharge of waters from the sediment pond to the spreader.	The stormwater capture and treatment system, including the water treatment unit, has been re-designed and the proposed Jellyfish filter is no longer part of the proposal. The reasons for removing the Jellyfish are described in Section 1.5 of the report.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
10	Water Quality	NSW EPA – Waste Compliance (2nd submission)	The EIS states that waste handled will include mixed building waste, asphalt, timber, metals and excavated natural material (ENM). The EIS then states that the primary contaminant expected in stormwater runoff from the site is sediment based, i.e. concrete dust from processing the recycled concrete, and sediment runoff from soils to be stored on site. The EIS fails to assess potential levels of dissolved contaminants in stormwater runoff known to be associated with the types of material proposed to be handled. This assessment also fails to adequately consider potential risks associated with contaminants attached to sediment which require greater controls than clean sediment in stormwater. Based on data from other building and construction waste recycling sites there can be a wide range of potential water pollutants in site runoff at levels requiring mitigation. Assessment methods could include, for example:	The WCIA Report has been comprehensively updated to address all potential forms of pollutants alongside a detailed description and modelling of how those pollutants are to be treated. A range of methods including literature reviews, other site performance data as well as detailed modelling has been undertaken to understand the potential risk and effectiveness of measures proposed to mitigate the impacts of the development. The WCIA considers both attached and dissolved pollutants and addresses each. The WCIA provides pollutant concentrations at the point of discharge for three key indicator pollutants. Justification of the adopted water quality modelling framework which considers three key indicator pollutants rather than every pollutant and which is adopted across NSW by all State Government and Local Governments was also included in the report	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			• data from similar operations • literature reviews of potential contaminants in wastewater • provision and assessment of representative leachability test data from material that would be handled and stored on site • a comparison of proposed discharge quality against national water quality guidelines for the full range of potential pollutants in runoff and consideration of all downstream environmental values • considering all practical measures to mitigate the risk identified from the potential for a wide range of pollutants that may be in discharges. As well as the potential impacts of individual contaminant concentrations, the potential additive, cumulative and loading impacts of contaminants should also be considered, including: • antagonistic toxic effects from two or more pollutants • bioaccumulation in downstream waters (e.g. metals or PAHs) • loading of nutrients, metals and other pollutants in downstream waters, groundwater or soils • concentration effects of chemicals due to reuse of wastewater on site. The EPA recommends that: • Additional information be provided on the full range of potential pollutants in site discharges,	via way of detailed explanation and a peer review published paper. It also provides reference to long term values for irrigation water quality to ensure there is no long term accumulation of metals in soils. The WCIA also provides indicative water quality coming from a proposed ultrafiltration membrane filtration treatment plant on the site. Stormwater will be treated to the most stringent standards to ensure that it is safe for both workers and the environment.	

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			including potential water discharge concentrations from any proposed treatment system under relevant water quality and flow conditions (i.e. both controlled discharges and managed overflows) • the discharge assessment referenced above compare potential concentrations of pollutants in discharges with the national water quality guidelines or available international guidelines; and consider all relevant downstream environmental values • additive, cumulative and bioaccumulative impacts of the proposal be assessed.		
11	Water Quality	NSW EPA – Waste Compliance (2nd submission)	The EIS has not adequately identified all practical measures that could be taken to prevent, control, abate or mitigate water pollution from the operation of the proposed facility. The EPA recommends that: • All practical measures to prevent, control, abate or mitigate water pollution be assessed. These measures could include, but are not be limited to: o Preventing and minimising generation of polluted runoff (roofing, covering, at source controls) o Considering alternatives to discharge such as collection and disposal to sewer or tankering to a facility licenced to receive the wastewater from higher risk parts of the site o Optimising alternatives to discharge such as reuse (e.g. onsite storage tanks for first flush runoff)	The stormwater capture and treatment system has been comprehensively re-designed and is described in detail in the Water Cycle Impact Assessment report. The development proposal adopts an approach of containment – that is, it seeks to contain as much stormwater runoff as possible and reuse it to the maximum extent possible on the site. This will limit the export of any pollutants from the site. These pollutants will be treated in a robust stormwater treatment strategy that can be easily maintained through good provision of access and simplicity of design. On the eight occasions each year when stormwater is discharged from the site it will exceed all licensing criteria. The average concentration of pollutants in the flow from the site would be lower after development than the current state. As a result, the proposal will achieve a significant beneficial effect on stormwater quality and it will	Stormwater Management Plan – EIS Appendix E(i). Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			o Installing appropriate treatment systems.	protect the downstream native bushland to the highest degree.	
12	Water Quality	NSW EPA – Waste Compliance (2nd submission)	The EIS proposes a sediment inlet pond to be used at the entry to the proposed pond storage to capture sediment from site runoff. The pond is proposed to consist of a permanent pool for re-use purposes and an on-site detention component designed to meet Council requirements. As noted above, Council water quality targets for urban stormwater are not relevant to wastewater management at a licensed premises. The stated overflow frequency of "about 35" overflows per year on average is not consistent with best practice guidelines for clean sediment containment e.g. 6-8 spills/year (Blue Book Volume 1 site, > 6 months, 80th percentile); or 2-4 spills/year (Blue Book Volume 2, > 6 months, 901h percentile for managing clean sediment at waste landfills and mines and quarries). It is noted that the EIS states that overflows are directed to a Jellyfish sediment-treatment device and Appendix I states that overflows occur over the spillway from the pond. It is not clear what proportion of discharges occur via the proposed Jellyfish filter versus the overflow structure, or the height of the Jellyfish inflow and outflow levels compared to the overflow structure level. Sediment basins are proposed to be cleaned out when 60% full of sediment. The overflow frequency when the ponds are up to 60% filled with sediment are also not adequately assessed. Subject to a characterisation of site discharges, due to the nature of the material onsite and potential for contaminants to be associated with	The water cycle balance and water cycle management plan have been extensively revised to consider the EPA's comments, and to incorporate other mitigation measures and site design changes. Mainly this sees volumes of storage increased by 10 times over the initial proposal. These changes are described in the Water Cycle Impact Assessment report. Overflow has been reduced from 35 down to 8 times per year and nearly attains pre European runoff characteristics/regime. A 5 million litre water quality pond with floating wetland will store water for reuse. This storage volume is much larger than that prescribed in the Blue Book and was determined based on the need to reduce the frequency of overflow frequency down to levels that the bushland can sustain in perpetuity. The Jellyfish has been removed from the design for a number of reasons including inaccessibility for maintenance and the hydraulic configuration being problematic at the pond outlet. We understand the EPA has reviewed the revised WCIA report and is completely satisfied with only one additional requirement being the need to test the soils at the point of discharge for metal and contaminant accumulation. This requirement is welcomed by the Proponent and has been included in the revised WCIA along with a recommendation to also monitor soils in the M. Bicovexa irrigation area to ensure metal accumulation remains below (within) long term acceptable values.	Stormwater Management Plan – EIS Appendix E(i). Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			sediments, the 2-4 spill per year or equivalent environmental outcome is likely to be considered minimum best practice for clean sediment (i.e. no attached contaminants). A greater containment may be needed depending on the assessment of dissolved and sediment attached pollutants and the mix of other mitigation measures that may be proposed, e.g. at-source controls. Managing Urban Stormwater- Soils and Construction Volume 2E Mines and quarries (Blue Book Volume 2E) has been used as a basis for assessing similar sites due to the known risks in stormwater runoff and therefore provides an initial basis for determining whether overflow frequency requirements are commensurate with risk. The EPA recommends that the applicant: • Revises the water balance assessment and, as a starting point, relate all references to the Blue Book Volume 2E. • Provides an equivalent environmental outcome for sediment, Blue Book Volume 2E, at a minimum, and any additional risks of sediment attached pollutants and dissolved contaminants should be accounted for through either additional capture and treatment or other mitigation measures such as at-source controls.		
13	Water Quality	NSW EPA – Waste Compliance (2nd submission)	The EIS proposes to install a Stormwater 360 Jellyfish filter (or approved equivalent) on the outlet pipe from the pond to ensure that any discharges from the pond are appropriately filtered prior to discharge to the vegetated area to the south of the premises.	The stormwater capture and treatment system has been comprehensively re-designed and is described in detail in the Water Cycle Impact Assessment report.	Stormwater Management Plan – EIS Appendix E(i). Water Cycle Impact Assessment and

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			The EPA recommends that the applicant: • provide the performance of the proposed "Jellyfish" treatment system, including: o TSS concentrations that can be achieved over the life of the maintenance schedule o the percentage of flows that are treated through the device verses the percentage that may bypass the treatment device o the storage levels at which discharges occur through the Jellyfish filter verses storage levels that may cause overflow.	The Jellyfish has been removed from the design for a number of reasons which made it an inappropriate choice for the location proposed. Refer to Section 1.5 of the report for more details.	Soil and Water Management Plan report – EIS Appendix I
14	Water Quality	NSW EPA – Waste Compliance (2nd submission)	The discharge is proposed to flow over a vegetated paddock for about 280 metres to the road drainage system. There may be some further filtering and attenuation of pollutants across the paddock, in terms of water pollution, however, this is not an appropriate treatment method for water quality and pollutants may also build up in soils on site. The potential for channelled flow is not considered which could mean there is limited overland flow filtration effect and the site conditions may change over time. Once flows reach the road drainage system, they may be directly transported to downstream waterbodies with little change in pollutant levels. It is also noted that there may be recreational water bodies downstream. The EPA recommends that the applicant ensures the fate of any residual pollutants in discharges are	The stormwater capture and treatment system has been re-designed. Details are provided in the Water Cycle Impact Assessment report. The predicted discharge from the site has been dramatically decreased, both in frequency of overflow and peak flow rate and of course volume of water released. The frequency of overflow events has been reduced to be consistent with pre-developed levels. Further, the level spreader has been increased to 50m wide to ensure that flows remain dispersed and do not cause any erosion of downstream bushland. The discharge from the spreader flows through natural bushland where most of the water will infiltrated into the ground and very little, if any, water will leave the site. In this project we have assumed the point of discharge is equivalent to a natural creek which needs the highest level of protection. This project	Stormwater Management Plan – EIS Appendix E(i). Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			adequately assessed and appropriate monitoring and mitigation measures implemented.	does not rely on any attenuation after the point of discharge even though it will happen. Discharge water quality has been assessed at the point of discharge from the water quality pond and does not rely on any further on-site attenuation. The discharge has been assessed against a range of relevant criteria and against the most stringent criteria being a neutral or beneficial effect test as is applied to a drinking water catchment. The proposal, because of its significant treatment of stormwater is likely to result in a benefit to regional water quality. The Water Cycle Impact Assessment report states that a recent upgrade to Kangoo Road (this is the road which is south of the proposed development site) by Central Coast Council including the installation of kerb and gutter and drainage will see any surface runoff conveyed via the drainage system. If peak flows, velocities, volumes and frequencies of flow are maintained at levels less than the predevelopment state then it can be said that the development will not alter the flow regime and will not impact on Kangoo Road to any greater extent than it does now.	
15	Water Quality	NSW EPA – Waste Compliance (2nd submission)	Licence analytes, limits or monitoring are not provided in the EIS. The EPA recommends that the applicant undertakes an appropriate characterisation and mitigation assessment of any water proposed to be discharged so that licence limits and licence monitoring (location, frequency methods) can be proposed for all non-trivial pollutants in wastewater.	The Water Cycle Impact Assessment report now provides a detailed list of potential contaminants. It still relies on the use of indicator pollutants to predict reduction levels resulting from the treatment methods. This list is consistent with the contaminants listed for monitoring in the licences of other similar facilities. A comprehensive water quality validation and risk assessment programme will need to be undertaken to ensure the site performs as is expected and if it doesn't then additional mitigation measures will be	Stormwater Management Plan – EIS Appendix E(i). Water Cycle Impact Assessment and Soil and Water Management

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
				required. However the development proposal has been modelled very conservatively and it is concluded that it is most likely the site will achieve excellent water quality outcomes.	Plan report – EIS Appendix I
16	Water Quality	NSW EPA – Waste Compliance (2nd submission)	The EIS states that a 25 kilolitre collection and storage tank will be provided for the waste receival and storage area which will also be bunded. Collected runoff is proposed to be disposed of-site. The rainfall conditions under which the bunded area or the tanks may be bypassed, or overflow is not assessed. The EIS states that overflows from the waste receival tank will be piped or flow as surface flow to the pond. The frequency of overflows has not been assessed and the full range of potential pollutant risks and mitigation measures should be assessed to avoid or manage potential water pollution impacts. A wider suite of potential contaminants than discussed above may be present in wastewater from the receival area including highly toxic chemicals. The EPA recommends that the applicant ensures all risk factors associated with overflows from the tanks or by-pass of the bunded area are adequately assessed and the potential impact on site discharge quality accounted are for.	The waste receiving area, including the Tip and Spread area has been re-designed. The Tip and Spread area will be covered, to minimise stormwater run-off. There will no longer be an underground tank to capture run-off from this area; any run-off will be collected as part of the re-designed stormwater drainage system. All stormwater will be treated. Roof water will be collected in 10 x 18 kL rainwater harvesting tanks which will be used to supply the misting system in the building for dust control. These tanks will be provided with a town water top-up supply. Details are provided in the Water Cycle Impact Assessment report, and the hydraulic services plan.	Stormwater Management Plan – EIS Appendix E(i). Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I Hydraulic services plan – EIS Appendix E(iii)
17	Water Quality	NSW EPA – Waste Compliance (2nd submission)	The EIS states that a grassed swale along the western boundary will be used to pre-treat sediment runoff from the working areas of the site. It is not clear if this swale is lined to protect groundwater or, if it is not lined, what is the potential impact on groundwater or nearby surface	The grass swales will be lined with a waterproof membrane sub-surface. In addition, all areas that are not covered in concrete hardstand or asphalt will have a waterproof membrane in the sub-surface. Details are provided in the Water Cycle	Water Cycle Impact Assessment and Soil and Water Management

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			water, e.g. subsurface lateral flow to a possible drainage line immediately to the west of the site. The EPA recommends that the applicant ensures potential water pollution impacts associated with the grassed swale are fully considered and where necessary assess what impact mitigation measures will be implemented.	Impact Assessment and Soil and Water Management Plan report. The WCIA plan has been revised to ensure that sediment is removed from the flow before it is allowed to flow over the swale. This will protect the bioswale and give it a long life. A continuous review of water quality performance on the site will be undertaken to validate the on-going performance of the treatment plant. This will indicate if any element of the treatment train is not performing and needs rectification or maintenance.	Plan report – EIS Appendix I. Civil plans – EIS Appendix E(i)
18	Water Quality	NSW EPA – Waste Compliance (2nd submission)	The EPA recommends that the applicant consider the potential human health and occupational health risks related to proposed wastewater reuse at the site.	The WCIA Report includes references to both Commonwealth guidelines for water recycling as well as State Guidelines. The treatment plant proposed will include a range of treatment processes including membrane filtration as well as disinfection measures to ensure workers are kept safe. In addition soils will be monitored to assess the accumulation of metals within the soils to ensure they remain below long term values. If treatment plant effluent is found to contain levels of metals that would exceed long term values then additional treatment (ion exchange) to remove metals will be applied.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I Hydraulic services plan – EIS Appendix E(iii)
19	Water Quality	NSW EPA – Waste Compliance (2nd submission)	Misting dust suppression is proposed for processing inside the shed, using internal sprinklers, with water applied at a rate of 2.1kl/day. This water use and any other water use within the warehouse could result in leachate requiring management. The EPA recommends that the applicant identifies the fate and potential impacts of any leachate generated inside the warehouse and where	The amount of water use in dust misting systems, and the capture and treatment of any leachate/run-off is considered in the updated water cycle management plan. Details are provided in the Water Cycle Impact Assessment report.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			applicable outline how the impacts will be appropriately managed.		
20	Water Quality	NSW Health	To avoid potential impacts on health and the environment, the site should be connected to Council's sewerage system in preference to an onsite sewage management system (septic system). We also suggest that the use of potable water for non-potable uses such as dust suppression should be avoided as much as possible, in order to conserve this resource.	The site will be connected to the sewer. Sewage from the office building and trade waste from the vehicle wash and packaged membrane filtration plant will be discharged to sewer. Details are provided in the Water Cycle Impact Assessment and Soil and Water Management Plan report. As much non potable water will be reused on the site as possible to conserve water. This also helps to keep any contaminants on the site very significantly reducing any export of pollutants.	Stormwater Management Plan – EIS Appendix E(i). Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
21	Water Quality	NSW Department of Industry - Water and the Natural Resources Access Regulator	As part of any post approval management plan requirements, the proponent should include a detailed Groundwater Monitoring and Management Plan in an updated version of the Soil and Water Plan and provide it to the Department of Industry – Water for review.	A Groundwater Monitoring and Management Plan will be prepared prior to the site becoming operational. It is anticipated that groundwater monitoring will form a condition of the Environment Protection Licence.	Chapter 7 & 18 of the EIS
22	Water Quality	NSW Department of Industry - Water and the Natural Resources Access Regulator	The proponent must install three piezometers after construction activities and prior to commencement of operational activities to enable the monitoring of the underlying groundwater system(s) for the purposes of identifying impacts from the operation. a. Monitoring points are to be installed that are suitable to obtain representative groundwater level and quality information. b. Monitoring points are to be situated as follows; one up-gradient of the site and two	Three piezometers have been installed as part of the base-level sampling and testing. Details are provided in the Groundwater Baseline Investigation report.	Groundwater Baseline Investigation report – EIS Appendix K.

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			down-gradient (southwest and south) of the site.		
23	Water Quality	NSW Department of Industry - Water and the Natural Resources Access Regulator	The proponent should undertake monitoring of groundwater level every month and groundwater quality (field testing and chemical analyses) every three months, or at more frequent intervals if necessary, for the purpose of identifying, managing or rectifying groundwater impacts. a. A technical groundwater assessment report of possible impacts is to be prepared after each quarterly monitoring activity, which includes all raw data to the date of the report. b. The technical groundwater assessment reports are to be retained by the proponent for the life of the activity and made available on a project-specific website within a reasonable period after their completion.	Groundwater monitoring minimum requirements will be set as a condition of the Environment Protection Licence.	Chapter 7 & 18 of the EIS
24	Water Quality	Department of Planning and Environment	The Water Cycle Management Plan (WCMP) notes overflows occur over the spillway from the pond and are directed via a level spreader to the existing vegetation located in the southern portion of the site. The WCMP addresses pollution reduction for TSS, TP, TN and Gross Pollutants. However, the WCMP does not provide a characterisation of water quality at the point of discharge including contaminants of concerns. Please update the WCMP to include characterisation of water quality at the point of discharge, including heavy metals and chromium among others.	The updated Water Cycle Management Plan includes peer reviewed published scientific research on the expected contaminants in stormwater and the reduction expected as a result of the mitigation measures. The details are provided in the Water Cycle Impact Assessment report provided as an appendix to the EIS.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
25	Water Quality	Department of Planning	The WCMP states every year approximately 35 overflows from the stormwater detention pond	The stormwater system has been re-designed to overflow approximately 8 times per year which is equal to the predevelopment frequency of discharge and close to the pre European or	Water Cycle Impact Assessment and Soil and Water

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
		and Environment	would occur. The Department requests clarification to explain triggers for discharging stormwater.	forested discharge frequency. The expected overflows are now substantially reduced. The details are provided in the Water Cycle Impact Assessment and Soil and Water Management Plan report provided as an appendix to the EIS.	Management Plan report – EIS Appendix I
26	Water Quality	Department of Planning and Environment	(c) Section 8.3 of the WCMP states a 25 kilolitre (kL) collection and storage tank has been provided to the waste receival and storage area. The Site Plan shows the 25 kL storage tank is for waste receival area only. Clarification is requested to address the discrepancy. Should the storage tank receive surface runoff from the waste storage area, clarification is required to show how runoff from the waste storage area would travel to the storage tank considering the ground level difference.	The underground storage tank has been removed from the site design. The Tip and Spread area will be covered with a 3-sided building to prevent stormwater contamination from this area. All stormwater will be directed to the stormwater capture and treatment system.	Stormwater Management Plan – EIS Appendix E(i). Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
27	Water Quality	Department of Planning and Environment	The WCMP does not include details of firefighting water retention system. The WCMP must be updated to include firefighting water retention system including but not limited to type(s) of retention system, discharge/disposal methods and any pollutant control measures.	An emergency spill pond is now included in the proposal and it has 500 m3 capacity. It can collect any runoff from the high risk area which is the area most likely to have a spill or to have a fire. The emergency spill pond is fully contained so water will not flow out unless it is deliberately pumped out. In addition to the emergency spill pond, the OSD basin will have penstocks which can be closed if needed to ensure it can capture up to 2,500 m3 of fire-fighting water. When combined – both systems can capture over 3 ML of fire water which is far in excess of any requirements. A full fire safety study and provisions for capture of firewater in the Secondary Sorting Warehouse and in the OSD pond have been made.	Stormwater Management Plan – EIS Appendix E(i). Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I Fire Safety Study – EIS Appendix Q

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
28	Water Quality	Department of Planning and Environment	(e) The Department notes the facility includes a wash bay adjacent to the processing building. Please clarify how will waste water from the wash bay be collected and discharged into the stormwater management system? What are pollutant controls for wash bay waste water discharge?	The wash bay will be connected to sewer. Water will be treated prior to discharge via a coalescing plate separator. The wash bay is part of the Stage 1 approvals. Details are provided in the Hydraulic Services plans and the updated Water Cycle Management Plan.	Hydraulic Services Plans for Stage 1 – EIS Appendix E(iii) Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
29	Water Quality	Department of Planning and Environment	(f) The site was previously operated as a sand and metal recycling facility that has the potential impacts on the groundwater quality. The Department notes the EIS does not include a Baseline Groundwater Quality Assessment (BGQA). The RtS must include a BGQA to determine the baseline groundwater quality across the site, provide background concentrations of contaminants of potential concerns and obtain an understanding of the potential impacts of the development on the groundwater quality.	A Baseline Groundwater Quality Assessment has been conducted. No indication of groundwater contamination was found.	Baseline Groundwater Quality Assessment – EIS Appendix K
30	Water Quality	Office of Environment and Heritage	OEH recommends that the size of the on-site storage is reassessed to ensure that stormwater capture and re-use at the site is maximised.	The size of the On-site Detention (OSD) Basin has been remodelled using ARR2016 rainfall and resized to be 2,500m^3 of storage. A key difference is the assumption this time that the site is to be nearly 100% impervious (apart from some peripheral landscaping) to account for the waterproof liner proposed under the site. The performance of the basin has been assessed under a range of flow conditions – from the 1 year to the 100 year rainfall events. There will be 3 outflow pipes to restrict the flow under different conditions with very frequent flows highly restricted	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
				to ensure the level spreader is protected as much as possible from peak flows. The site area is 6 hectares and the volume of storage provided is 2,500 m3. This is a rate of 416m^3/hectare which is comparable to rates adopted by developing Councils such as Blacktown which mandate a rate of 455 m^3/hectare.	
31	Water Quality	Office of Environment and Heritage	OEH recommend that the size of the on-site storage be reassessed and increased to ensure that overflow from the on-site storage is matched to the capacity of the receiving environment	The sizing of the pond has been comprehensively assessed and is now based on the need to reduce overflow events to the pre-developed conditions. A 5 ML pond is proposed. This is predicted to reduce overflows to 8 times per year (on average). This is just above natural state (forested) runoff conditions which are 5 times per year and effectively limits runoff to the capacity of that environment to receive it. We note the soils on the site are sandy soils and they will absorb much runoff though attenuation beyond the point of discharge is not relied on in the assessment.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
32	Water Quality	Office of Environment and Heritage	OEH recommends that calculations relating to water retention be reviewed to ensure the impervious area used is accurate and relates to the disturbed portion of the site only.	It is acknowledged that previous modelling by Cardno had some unconservative and questionable assumptions. This has been amended to reflect industry best practice. The 6 Ha site will have a drained waterproof membrane covering the majority of the operational area. It has therefore now been modelled as 100% impervious with some allowance for stockpiles of materials to absorb rainfall. Refer to the WCIA report for details of modelling assumptions.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
33	Water Quality	Office of Environment and Heritage	OEH recommends that the post development impervious area used for modelling of on-site detention storage be reviewed. All “Drains” model inputs and results should be provided for review once this is completed	Details of all modelling are provided in the Water Cycle Impact Assessment and Soil and Water Management Plan report. The post development assumptions now reflect a site that is to be effectively 100% impervious with some relatively	Water Cycle Impact Assessment and Soil and Water Management

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
				minor allowance for initial losses from areas covered with stockpiles. Please refer to the WCIA report for more details.	Plan report – EIS Appendix I
34	Water Quality	Office of Environment and Heritage	OEH recommends that the on-site detention modelling be carried out for the required design events, inclusive of the 2-year ARI event which will assist in determining the impacts of discharges to adjacent bushland areas	Details of all modelling are provided in the Water Cycle Impact Assessment and Soil and Water Management Plan report. The 1 year ARI event has been adopted as the lower limit for matching pre-development and post development flows and the 100 year ARI as the upper limit. Flows at the 10 year ARI have also been checked as these can frequently govern OSD system design.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
35	Water Quality	Office of Environment and Heritage	OEH recommends that flow velocities from the level spreader are determined to demonstrate that discharges will not result in scour and damage to downstream areas.	Details of all modelling are provided in the Water Cycle Impact Assessment report. We have adopted stream restoration guidelines to assess the risk of scour downstream of the level spreader. As a result, the spreader has been designed so that no scour occurs up to the 10 year ARI. The revised spreader is to be 50m wide with velocities limited to about 0.5m/s which reflects the sandy non-cohesive nature of the site. An infiltration system is also proposed at the spreader to further help reduce runoff and to return rainfall to the soil profile.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
36	Water Quality	Office of Environment and Heritage	OEH recommends that: • potential impacts to neighbouring properties from discharges of stormwater are confirmed and the EIS amended to reflect this • additional contour information be provided for the lower portion of the development.	Council has been contacted to ascertain available flood data as well as drainage system information on Kangoo Road where flows would ultimately end up. Kangoo Road has a new kerb and gutter and drainage system that has been designed to accept runoff from the KSSS site under predeveloped conditions. It is therefore imperative that the OSD system was designed to ensure predeveloped runoff conditions prevail. A 50m wide level	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
				spreader will help to spread flows evenly from where they will follow their predevelopment flow path down to Kangoo Road. The revised report shows Council contour data down to Kangoo Road. In terms of flooding and potential impacts from directing flows onto adjoining sites: The proposal will not direct any flows onto adjoining land that doesn't already flow onto adjoining land. There are not likely to be any flow or velocity related adverse impacts on adjoining land from the development.	
37	Water Quality	Office of Environment and Heritage	OEH recommends that an impact assessment is carried out for the downstream vegetated areas to determine the sensitivity of these areas to changes in frequency, volume and velocity of flow of water.	The impacts have been considered in the Biodiversity Assessment and the Water Cycle Impact Assessment. However, it is expected that the vegetated area will not experience any significant change in run-off due to the 5 ML storage pond and proposed reuse of stormwater. The number of overflow events have been dramatically reduced by increasing the size of the pond. The size of the spreader has also been increased to reduce velocities to sustainable levels. The overflow impacts on bushland are expected to be minimal. The sizing of the pond has also been based on reducing overflow events to the equivalent of pre-developed (forested catchment) conditions. This has been done to simulate the natural wetting and drying of soils downstream of the development, to ensure that the integrity of the downstream plant communities are maintained or enhanced.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
				Details of all modelling are provided in the Water Cycle Impact Assessment and Soil and Water Management Plan report.	
38	Water Quality	Office of Environment and Heritage	OEH recommends that consideration be given to provision of primary sediment removal points prior to vegetated systems to improve performance and maintainability of the water quality management system	The stormwater and drainage system has been thoroughly reviewed and re-designed to achieve this outcome. This includes sedimentation capture measures upstream of all secondary treatment devices. The use of both Barramy Traps and CDS units is proposed.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
39	Water Quality	Office of Environment and Heritage	OEH recommends that all input parameters used for water quality modelling and justification for parameters be provided to OEH to enable a review of the proposed treatment train	Comprehensive details of all modelling are provided in the Water Cycle Impact Assessment and Soil and Water Management Plan report.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
40	Water Quality	Office of Environment and Heritage	OEH recommends that additional details are provided of the suitability of any proposed proprietary membrane filter that is to be used as part of the water quality treatment train for the proposal. This should include any information required under Gosford City Council DCP Chapter 6.7	Details of the proposed water treatment systems are provided in the Water Cycle Impact Assessment and Soil and Water Management Plan report. The Jellyfish has been removed from the proposal as it was not appropriate in that location and that context. Access for maintenance and inappropriate hydraulic configuration were the key reasons for its removal.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
41	Water Quality	Office of Environment and Heritage	OEH recommends that provision of a cover be considered for the waste sorting area, or the size of the pump-out tank is reviewed to ensure it is adequate in size to prevent overflows	The Tip and Sort area will be covered with a three-sided building. The building will have 10 x 18 kL rainwater tanks to capture rainwater from the roof. The underground sump has been removed from the design. All stormwater will be captured by the site's stormwater and drainage system. Details are provided in the Water Cycle Impact Assessment and Soil and Water Management Plan report.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
42	Water Quality	Office of Environment and Heritage	OEH recommends that staging of clearing and filling operations be considered to minimise exposed areas at any time and reduce risk to the receiving environment	A Stormwater Plan has been prepared and is provided with the Civil Plans in the EIS Appendix. The OSD basin will be installed prior to extensive clearing and filling at the site. This will ensure sediment is captured on site.	Civil Plans – EIS Appendix E(i)
43	Water Quality	Office of Environment and Heritage	OEH recommends that consideration is given to the potential impacts to Kangoo Road from stormwater discharges that originate from the proposed development.	With the increased on-site capture of run-off and the increase in the spreader size, there is minimal risk that run-off will reach Kangoo Rd. This has been confirmed in the Water Cycle Impact Assessment and Soil and Water Management Plan report. Council has been contacted to ascertain the drainage capacity on Kangoo Road and this has confirmed that the road has a drainage system with capacity to accept predevelopment rates of runoff from the KSSS site.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
44	Water Quality	Water NSW	As the subject site is not located in close proximity to WaterNSW land or infrastructure, the potential for the proposal to impact water supply infrastructure has been assessed as low. WaterNSW therefore does not have any particular requirements or comments.	Noted. Groundwater and stormwater run-off will be monitored.	Chapter 7 Water Impact Assessment and Chapter 18 Mitigation Measures and Statements of Commitment in EIS Report.
45	Water Quality	Central Coast Council	Flooding Council's records do not indicate that the site is affected by flooding· or flood planning controls.	Noted. A flood advice letter and first principles assessment has been undertaken. Based on Council mapping and a first principles analysis, the risk of flooding is considered extremely low.	Section 2.2.4 Riparian areas and waterways in EIS report.
46	Water Quality	Central Coast Council	Drainage The site generally grades towards the south-west. Kangoo Road is located along the southern boundary, however, the development will not extend to that area.	Based on the comments received from the NSW EPA, the On-site Detention Basin and stormwater capture system has been re-designed. The expected overflows are now substantially reduced. The details are provided in the Water Cycle Impact	Water Cycle Impact Assessment and Soil and Water Management

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			A Water Cycle Management Plan (WCMP) prepared by Cardno (NSW/ACT Pty Ltd) accompanied the EIS as Appendix I - (report reference 80518002 Version 6 dated 11 January 2019). Review of this document indicates that stormwater for the proposed development is to be managed through the following provisions: • Water conservation. Stormwater from the proposed developed area within the site will be directed to storage pond where it can be utilised for dust suppression within the site. • Water retention. A permanent retention volume of 250m^3 is proposed within the on- site detention basin which is far in excess of the minimum volume in this instance required under Council's DCP. Rainwater from the site shed will also be stored in a 10,000 litre tank for dust suppression within the shed. • Water Quality. The following measures are proposed for mitigate the additional nutrients & pollutants that could be generated by the development: - A 25 kl collection and storage tank has been provided to the waste receiving and storage area. This area is bunded and any runoff from this area is collected within the storage tank and disposed off-site. In this manner, the potential for contaminants from mixed waste sources to enter the stormwater system for the site is reduced through management and containment; - A 10kL rainwater tank will be used to capture runoff from the shed roof associated	Assessment and Soil and Water Management Plan report provided as an appendix to the EIS.	Plan report – EIS Appendix I

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			with Stage 1. Stored rainwater will be used for dust suppression within the enclosed workshop; - A grassed swale located within the western side of the site will be used to pre- treat runoff from the working areas of the site. - Sediment inlet ponds will be used at the entry to the proposed pond storage to capture sediment from site runoff; - A storage pond will be used to capture runoff from the site. The pond will consist of a permanent pool for re-use purposes, and an on-site detention component to ensure site discharge meets Council's requirements. - A Jellyfish filter from Stormwater 360 (or approved equivalent) will be installed on the outlet pipe from the pond to ensure that any discharges from the pond are appropriately filtered prior to discharge to the vegetated area to the south of the site. The report indicates that the reduction targets required in chapter 6.7 of Council's Gosford DCP2013 have been exceeded as modelled through MUSIC modelling. • On-site Detention (OSD). OSD is proposed in the basin to limit post development flows for all storms up to and including the 1%AEP storm recurrence interval. A runoff routing method (DRAIN S) has been used in the design modelling. The OSD basin is proposed in the south western corner of the proposed developed area of the site and will have a storage volume		

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			of 685m^3 at a storage depth of 1.14m. Outflows from the basin will be discharged from a 675mm diameter pipeline with a 10m wide weir, and then directed to a level spreader arrangement to discharge non-concentrated stormwater flows into the undeveloped southern portion of the site that is proposed to be retained in its natural state. A Stormwater 360® Jellyfish™ device (or similar device will also be provided to further treat the discharges from the basin.) This WCMP is satisfactory for the purposes of review of the stormwater management for this development proposal. A concept stormwater management plan prepared by Cardno (NSW/ACT) Pty Ltd was also submitted which details the concepts for the above mentioned stormwater management associated with the associated abovementioned WCMP. These details appear to be satisfactory for the purposes of review of the stormwater management for this development proposal.		
47	Water Quality	Central Coast Council	Water & Sewer Comments from Council's Water Assessment Unit have indicated that water and sewer are available to the land. A section 307 certificate shall be required. There are no additional water or sewer developer contributions as these have been paid in accordance with the SIE Agreement and Council negotiation.	The site will be connected to the sewer and town water supply. It is anticipated that the water supply will need to be upgraded to accommodate the proposed fire hydrants. A Hydraulic Services diagram is provided with the civil plans attached to the EIS.	Hydraulic Services Plan – EIS Appendix E(iii).
48	Water Quality	Central Coast Council	Groundwater The Environmental Impact Statement prepared by Jackson Environment and Planning dated 15 January 2019 ("the EIS') states the main access	Noted. The proponent is confident that the combination of waterproof membrane under-layer and hardstands will provide protection to the groundwater from activities on the site.	Water Cycle Impact Assessment and Soil and Water Management

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			driveway and the waste tip and spread inspection area will comprise a fully engineered and bunded hardstand (waste tipping and inspection area), to avoid movement of any pollutants into groundwater. A flexible asphalt pavement will be provided beneath the waste storage bays, the landscaping storage bays and the aggregate storage bays to further protect groundwater. The other operational areas of the site will be paved in recycled crushed concrete, with an engineered bentonite geotextile layer (impermeable barrier) to prevent any infiltration moving into groundwater. Groundwater impacts will be included in the EPL as the NSW EPA are the ARA Conditions have been applied.		Plan report – EIS Appendix I
49	Water Quality	Central Coast Council	Water A new OSD and stormwater storage basin is proposed to be constructed to capture stormwater and sediment. The site will be contoured to capture stormwater and sediment. Stored water will be used on site for dust suppression. Overflows from the OSD will be treated through a jellyfish membrane filtration system and released via a level spreader into grassed area. Surface water impacts will be included in the EPL as the NSW EPA are the ARA. Conditions have been applied	Noted. The new design of the OSD basin will provide more than adequate storage for stormwater at the site. Stormwater will be treated and re-used on-site.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I
53	Soils and Site Contamination	Central Coast Council	Soils The site is relatively flat, however gently slopes to the South-West. A watercourse and number of ponds /dams are located on the site which is a tributary of Piles Creek.	No natural watercourses intersect with the proposed development site. The existing man-made dams will be replaced with the lined pond and OSD basin. It is expected that the development will have no impact on the closest natural waterbodies.	Water Cycle Impact Assessment and Soil and Water Management

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
			The area of soil disturbance is expected to be approximately 40,000m^2 Cut and fill will occur during the construction phase, with approx. 12,000m^3 of the excess material expected to be used as product. The Soil and Water Management Plan Report prepared by Cardno dated 11 January 2019 ("the SWMP") has not been prepared in accordance with the minimum requirements of the Blue Book and the Gosford DCP. Council would be the ARA during the construction phase of the development.	It should be noted that the cut and fill plan has been re-designed to account for the revised OSD basin design. To accommodate the proposed drainage plan, it is proposed to import additional fill to the site. This will be managed in accordance with the revised Soil and Water Management Plan.	Plan report – EIS Appendix I
81	Biodiversity	Office of Environment and Heritage	The impact of changes to hydrology resulting from the proposal should be assessed for the *Melaleuca biconvexa* community adjacent to the site and appropriate mitigation measures should be provided where required.	The impact of hydrology on the *Melaleuca biconvexa* community was investigated as part of the Biodiversity Assessment and the Water Cycle Impact Assessment. Additional measures have been proposed to ensure the hydrology of this conservation area is maintained including irrigation of the area to make up for some of the upstream catchment area being developed. The depth of irrigation is to provide an equivalent volume of water lost and equates to a depth of irrigation of about 950mm year. The water used to irrigate the area will first be treated in a ultrafiltration membrane plant. It is recommended that soils in the area of irrigation be tested to assess the levels of metal accumulation to ensure they remain below long term values. Treated water quality will also be assessed during commissioning and if required, additional treatment to remove metals will be included. This will ensure the long term health and survival of the Melaleuca.	Biodiversity Assessment report – EIS Appendix P. Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I

No.	Issue	Agency	Comment	How addressed	Where addressed in Studies / EIS
94	Fire Safety	Fire and Rescue NSW	The waste facility is to have effective and automatic means of containing fire water run-off, with primary containment having a net capacity not less than the total hydraulic discharge of the worst-case fire scenario. The total hydraulic discharge is the discharge from both the fire hydrant system and automatic fire sprinkler system for a duration of four hours. Failure to contain fire water run-off can result in pollution of the environment and require a protracted hazardous materials response.	Fire water run-off will be captured and contained in the Secondary Sorting Warehouse with 70mm bunding around door openings. An isolation value will be installed in the southern most pit in the Secondary Sorting Warehouse, and on the outlet of the on-site detention basin. The size of the water quality basin (5ML of storage plus an additional 2.5 ML for OSD which can be used to store water if penstocks are closed) has been designed to contain all firewater in the event of a large fire at the site. After a fire, the water will be tested, and removed and disposed off-site if necessary. In addition to this an emergency spill pond of 500m3 volume is proposed to intercept runoff from what is deemed a high risk area. This is the area most likely to have a fire or spill. This will prevent the need to mix fire water or a spill with water in the water quality pond. In conclusion ample provision for spill and fire water capture has been made. Details are provided in the Fire Safety Study and the Water Cycle Impact Assessment provided in the appendix of the EIS.	Fire Safety Study – EIS Appendix Q Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I Civil and layout plans – EIS Appendix E(i)

Original Response to Comments - Comments from the public

Issue	Source	Comment	How addressed	Where addressed in Studies / EIS
Water quality	Individual submissions	Concerns about impact on groundwater quality	A Groundwater Baseline Investigation has been undertaken to determine the current state of the groundwater at the site. The investigation found that it was not contaminated. As part of the mitigation measures for the site, the site will have impervious concrete or asphalt hardstands, or a layer of waterproof membrane installed beneath the crushed recycled	Groundwater Baseline Investigation report – EIS Appendix K.

			concrete hardstand. This will protect the groundwater from any contamination sources at the site. Three piezometers have been installed as part of the base-level sampling and testing. A Groundwater Monitoring and Management Plan will be prepared prior to the site becoming operational. It is anticipated that groundwater monitoring will form a condition of the Environment Protection Licence. Details are provided in the Groundwater Baseline Investigation report.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I Stormwater Management Plan – EIS Appendix E(i).
Water quality	Individual submissions	Concerns about impact on surface water quality	A comprehensive stormwater drainage and capture system will be installed at the site. The aim is to capture and re-use as much water as possible for dust suppression. Impacts on surface water quality are expected to be negligible. Modelling shows that the amount of water leaving the development area will be minimal and contain only low levels of potential contaminants. It also shows it will be better than the current approved development which itself is benign.	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I Stormwater Management Plan – EIS Appendix E(i).
Water quality	Individual submissions	Concerns about water use and water conservation.	A comprehensive stormwater drainage and capture system will be installed at the site. The aim is to capture and re-use as much water as possible for dust suppression. A 5ML storage pond will be provided and 26 ML of water will be harvested. Water tanks will be installed to capture rainwater from the roof of the Tip and Spread building and the Secondary Warehouse building. The water will be re-used for dust suppression and to irrigate the area of *Melaleuca biconvexa.*	Water Cycle Impact Assessment and Soil and Water Management Plan report – EIS Appendix I Stormwater Management Plan – EIS Appendix E(i).

Kariong Sand and Soil Supplies Facility (SSD 8660)
Water Cycle Impact Assessment (WCIA) and Soil and Water Management Plan
26 May 2020 – Proponent Response

Item	Department's Review Comments (February 2020)	WCIA Report Response (April 2020)	Department's Review Comments (May 2020)	Response from Proponent
General				
1	It is recommended each technical report should not only address SEARs requirements but also include responses to concerns/requirements raised in submissions to justify any changes to the development.	No response provided	The Department's February 2020 comments remains valid.	Section 1.6 has been added to the report to document responses to concerns raised in submissions. The report also explains the reasons for each part of the proposal as well as Section 1.5 explaining the reasons for the revising the approach from the original Cardno approach.
Water Quality Impact Assessment Report				
1	It is acknowledged that the water management system has been redesigned for the revised development. However, the Department notes the EPA requested additional information for the originally proposed jellyfish filter, there is a lack of justification for not proceeding with the jellyfish filter but with a new stormwater management system, comparison of the new system with the previously proposed system to prove the suitability and effectiveness of the currently proposed water management system.	No response provided	The Department's February 2020 comments remains valid.	Section 1.5 has been added to the report to explain some of inadequacies of the previous design. Justification for the revised proposed treatment train is provided throughout the whole report.

Item	Department's Review Comments (February 2020)	WCIA Report Response (April 2020)	Department's Review Comments (May 2020)	Response from Proponent
2	The WQIA report does not consider the PMF events as required by the SEARs in terms of stormwater velocity and quality.	**Executive Summary** The site is close to a ridge line and there are no overland flow paths coming onto the site. Analysis of Council flood mapping indicates the site is not subject to a 1% AEP flood event and further it is estimated with a high probability that the site is not within a floodplain and is therefore not flood prone, i.e. is not subject to PMF flooding.	Noted	Noted with thanks.
3	The WQIA does not include an impact assessment for the downstream vegetated areas to determine the sensitivity of these areas to changes in frequency, volume and velocity of flow of water as required by the Biodiversity and Conservation Division of the Department (former OEH).	**Executive Summary (p. xviii)** This development is predicted to exceed its best practice water quality targets, to achieve a substantial water quality beneficial effect and to closely match runoff flow frequencies with that of a forested land-use. **Section 6.3.2 Surface water quantity impacts (p. 52)** It can be seen in Table 12 that by harvesting and reusing the stormwater, rather than disposing it to the creek, the mean annual volume of surface runoff and frequency of surface runoff can be reduced closer to the pre European runoff volume and frequency, thereby maintaining soil stability and protecting the bushland from any adverse effects.	Noted The Department will refer the WCIA report to the Biodiversity and Conservation Division during exhibition of the revised EIS and RtS.	Noted with thanks.

Item	Department's Review Comments (February 2020)	WCIA Report Response (April 2020)	Department's Review Comments (May 2020)	Response from Proponent
4	The WQIA report states the site would discharge approximately 8 times per year after development. Item No 14, Comments from Government Agencies table in the RtS report fails to address the EPA's comments regarding the characterisation and fate of any residual contaminants in discharged stormwater.	No response provided	February 2020 comments remains valid. It is acknowledged that the development would have relatively low occurrence of stormwater discharge. However, the EPA's comments remain valid and should be addressed. If the Applicant considered no response would need to be provided, please provide justification for doing so.	Section 5.1.1 of the report notes that: "In this assessment (and in stormwater management more widely) TSS, TP and TN are used as surrogate pollutant indicators. Liebman et al, 2009, found that if stormwater was treated to best practice, i.e. to achieve 80% removal of TSS and 45% removal of nutrients then it was most likely that metals would also be treated to concentrations below the ANZECC 99th percentile level of protection, i.e. the highest level of protection. Liebman et al observed that if a treatment train approach was adopted and some form of biological treatment, i.e. wetlands, ponds or bioretention occurred then removal of heavy metals to benign levels was most likely to occur." The treatment train proposed includes a very large water quality pond with very substantial reductions in the three indicator pollutants – well below best practice levels – we therefore conclude, based on the research and the proposed treatment train that all other pollutants are also likely to be reduced to benign levels. Where it is possible to estimate the pollutant concentrations for a range of parameters for water treated in the proposed microfiltration plant these are included in Table 18 of the WCIA report.

Item	Department's Review Comments (February 2020)	WCIA Report Response (April 2020)	Department's Review Comments (May 2020)	Response from Proponent
				Table 18 identifies the discharge concentrations/values from the treatment plant for a range of critical human health and chemical parameters. This shows for example that TSS would be less than 1 mg/L which would be indicative of exceedingly high-quality water which would exceed ANZECC guidelines for irrigation. Table 11 in Section 6.3 of the report identifies the concentrations of key indicator pollutants being TSS, TN and TP at the point of discharge. These are the only three pollutants that can be modelled using the MUSIC model at the current time. This was also further explained in the report in Section 6.3.1.2 and via inclusion of a peer reviewed scientific publication included in Appendix 2 of the report. Should the Department require that all pollutants be modelled and predicted (**while the EPA is satisfied that this does not need to occur**) it is requested that the Department provide a reference to suitable EMC and treatment train pollutant decay data and computer or conceptual models with which to undertake this work. For reference purposes, we also request an example of another development where this has been undertaken

Item	Department's Review Comments (February 2020)	WCIA Report Response (April 2020)	Department's Review Comments (May 2020)	Response from Proponent
				and the Department and EPA have been satisfied with the work. Based on the modelling to date, discharge water quality is likely to be exceedingly high. However, to prove this during operation, a water quality validation programme has been recommended and approved by the EPA in their comments to characterize pollutant concentrations albeit at very low concentrations in the discharge water. As part of the water quality validation programme, levels of metals will be tested and compared with ANZECC Irrigation Guidelines – long term values to ensure that any bushland and Melaleuca Biconvexa area remains healthy and free from metal pollution. In the unlikely event that metals are found to exceed the long term values then additional treatment in the form of ion exchange will be added to the treatment system to reduce dissolved metal concentrations to acceptable levels. At that point the discharge water quality would be practically fit for human consumption let alone ensuring bushland plant health.
5	The WQIA does not provide pollutant concentration criteria at the point of discharge of the OSD pond for treated stormwater discharged onto bushland and of Stormwater Treatment Plant (STP) for recycled stormwater used for dust suppression and *Melaleuca*	**Executive Summary** (p. xiv) Part of the proposed development reduces a small catchment flowing to a *Melaleuca Biconvexa* plant community. Treated water will be used to irrigate land draining to this plant community aiming to supply the same annual volume of water	The Department's February 2020 comments remain valid. Please respond to the request of providing pollutant concentration criteria.	Section 5.1.1 of the report notes that: "In this assessment (and in stormwater management more widely) TSS, TP and TN are used as surrogate pollutant indicators. Liebman et al, 2009, found that if stormwater was treated to best practice, i.e. to achieve 80% removal

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	Biconvexa plant irrigation.	that would have flowed to this community under predevelopment conditions. The WCIA report does not include the requested pollutant concentration criteria.		of TSS and 45% removal of nutrients then it was most likely that metals would also be treated to concentrations below the ANZECC 99th percentile level of protection, i.e. the highest level of protection. Liebman et al observed that if a treatment train approach was adopted and some form of biological treatment, i.e. wetlands, ponds or bioretention occurred then removal of heavy metals to benign levels was most likely to occur." Where it is possible to estimate the pollutant concentrations for a range of parameters for water treated in the proposed microfiltration plant these are included in Table 18 of the WCIA report. Table 18 identifies the discharge concentrations/values from the treatment plant for a range of critical human health and chemical parameters. This shows for example that TSS would be less than 1 mg/L which would be indicative of exceedingly high-quality water which would exceed ANZECC guidelines for irrigation. Table 11 in Section 6.3 of the report identifies the concentrations of key indicator pollutants being TSS, TN and TP at the point of discharge. These are the only three pollutants that can be modelled using the MUSIC model at the current time.

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				This was also further explained in the report in Section 6.3.1.2 and via inclusion of a peer reviewed scientific publication included in Appendix 2 of the report. Should the Department require that all pollutants be modelled and predicted (while the EPA is satisfied that this does not need to occur) it is requested that the Department provide a reference to suitable EMC and treatment train pollutant decay data and computer or conceptual models with which to undertake this work. For reference purposes, we also request an example of another development where this has been undertaken and the Department and EPA have been satisfied with the work. Based on the modelling to date, discharge water quality is likely to be exceedingly high. However, to prove this during operation, a water quality validation programme has been recommended and approved by the EPA in their comments to characterize pollutant concentrations albeit at very low concentrations in the discharge water. As part of the water quality validation programme, levels of metals will be tested and compared with ANZECC Irrigation Guidelines – long term values to ensure that any bushland

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				and Melaleuca Biconvexa area remains healthy and free from metal pollution. In the unlikely event that metals are found to exceed the long term values then additional treatment in the form of ion exchange will be added to the treatment system to reduce dissolved metal concentrations to acceptable levels. At that point the discharge water quality would be practically fit for human consumption let alone ensuring bushland plant health.
6	The EPA requested additional information be provided on the full range of potential pollutants in site discharges, including potential water discharge concentrations from any proposed treatment system under relevant water quality and flow conditions (i.e. both controlled discharges and managed overflows). The WQIA did not provide the requested full range of potential pollutants.	Section 5 describes pollutants of concern but does not provide potential water discharge concentrations from any proposed treatment system.	The Department's February 2020 comments remain valid.	The NSW EPA have reviewed the revised report and had one comment on the revised report which was a requirement to monitor soils at the point of discharge for accumulation of contaminants. The NSW EPA is therefore satisfied that their requirement has been fully met. As the NSW EPA (and not Planning NSW) is the arbiter of water quality technical matters we consider that this matter has been assessed in full and addressed in full. This issue has been addressed above in Issue 5.
7	Appendix E(i) Civil Plans shows there are two dish drains proposed (western and southern), however please clarify how stormwater will be diverted to the OSD pond for the hardstand internal road, parking and processing areas. It is noted that the Fire Safety Study report states the OSD pond will	The civil plans have been updated to show the proposed drains.	Noted	Noted with thanks.

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	collect stormwater from the site through dish drains collecting from the north and east and grassed swale along the western boundary. The eastern dish drains are missing from the Civil Plans. Also, Section 5.4.3 of the WQIA report states 'installing a drainage layer under the hardstand areas with subsoil drainage which would discharge into the stormwater collection system'. Please provide further details of the proposed drainage layer.			
8	The submitted civil and hydraulic plans only show town water supply, collected and recycled stormwater will be connected to the waste receival area (i.e. tip and spread building), crushing area and secondary processing warehouse for dust suppression. It is unclear how stormwater runoff from roofs of these covered areas would be collected, treated and discharged, how mist suppression wastewater be separated from the roof collected stormwater, treated and disposed.	Section 7.1 Risk Management Approach states: • waste receival area (tip and spread building) within M3 risk area: rainwater tanks for roof runoff, CDS unit to treat sub-catchment runoff including roof and pond including floating treatment wetland • crushing area within M1 risk area, waste storage area within H1 risk area: house concreate crusher inside building to reduce dust generation, Barramy gross pollutant trap to treat whole catchment, pond including floating treatment wetland, emergency spill pond if required. • secondary processing warehouse: rainwater tanks for roof runoff, CDS unit to treat sub-catchment runoff	The WCIA report does not explain how wastewater generated from dust suppression would be collected, treated and discharged.	Section 6.1.2 of the WCIA notes that the misting system will not generate leachate. Section 6.1.3 of the WCIA report explains this further and notes that "Please note further that communication with the dust suppression equipment supplier as well as with a large waste management organisation who use their equipment extensively across many waste management sites has shown that leaching does not occur as the system up time (operating time) is adjusted to reflect site conditions. Water does not accumulate on the floor – once it hits the floor it evaporates off the floor of the building leaving the dust particle on the ground and not in the air. If a building cools too much, then the system is turned off for a while

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		including roof and pond including floating treatment wetland. Section 7.2 states roof runoff from the timber processing shed and crusher shed will also be piped to the pond after treatment in a GPT.		giving the floor time to heat up again and so on. The system needs active management and training of staff in its operation to ensure no leaching."
9	Please provide details of firefighting water retention system for collecting, treating and discharging contaminated firefighting water within the Secondary Processing Warehouse and outdoor processing areas. It is noted Section 6.3 of the FSS report states the volume of contaminated firefighting water required to be captured within the bunded area is 144 m^3 with a bund wall height of 70 mm. It is unclear where the bunded area will be. Section 5.4.3 of the WQIA report states installing penstocks to ensure that firefighting water is captured on site and does not overflow from the facility into the catchment and groundwater. It is unclear where the proposed penstocks will be installed.	Section 7.11 describes firefighting water storage: the WCIA report states during a fire emergency the penstocks to the main water quality pond would be closed manually. This would require a trained operator to walk along a gangway located on the pond wall and to then close the penstocks. A portable battery powered drill can be used to close them rapidly or they can be manually wound and achieve a water-tight seal. The penstocks would be located over each outlet opening in the pond outlet wall and therefore three would be required. Section 7.12 Emergency Spill Pond: the proposed emergency water quality pond volume is to be 500 m^3. This would allow 60 mm of either firewater/foam or polluted runoff to be fully contained in the pond without mixing with any other site runoff. This would allow fire-fighting water to be contained and removed from the riskiest part of the site without the need to treat and remove up to 5	Please explain the relationship between the water quality pond and the emergency spill pond: • will the water quality pond collect firefighting water? Or the emergency spill pond will solely collect firefighting water during a fire event. • if the water quality pond will collect firefight water, then please clarify that it is only when the water quality pond reaches its capacity, the collected firefighting water would flow into the emergency spill pond from the water quality pond? The report indicates that the purpose of the emergency pond is to contain fire water/foam or polluted run-off without mixing with other site runoffs. It is inferred that in a worst-case scenario, should the emergency pond not have enough capacity, that contained firefighting/pollutant water within the emergency pond will flow into the main pond – essentially mixing with other site runoff contained in the main pond. Please clarify how fire water will be managed in this scenario, as it is no longer	If there is a fire in sub-catchment H1 which is the high risk area of operations then the fire fighting water will be collected in the Emergency Spill pond. If the emergency spill pond overflows – it will overflow into the water quality pond. If there is a fire in any other sub-catchment then the fire water will flow to the water quality pond, the penstocks closed and the water will be pumped into a tanker and treated at a lawful facility. First dot point on page XV of the WCIA identifies that "water from the detention basin would be pumped out and treated at a lawful treatment facility". The wording in the report has been simplified to aid comprehension.

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		ML of pond water contaminated with foam.	contained separately.	
10	The WQIA does not provide detailed assessment of the potential water pollution impacts associated with the grassed swale and what impact mitigation measures will be implemented as requested by the EPA. Section 7.4 of the WQIA report only states evidence from a Borgs Manufacturing site at Oberon is that these swales perform well to reduce TSS, TP, TN and tannins.	Section 7.8 states 1) Pollutant removal processes that occur in bioswales include: 2) Removal of fine TSS Removal of particulate bound nitrogen, phosphorus, metals and hydrocarbons 3) Uptake of nutrients and trace elements by grass – grass clippings MUST be removed from the swales to prevent leaching of nutrients back into the media. 4) Ion exchange in the media to remove ions including metals and ammonia 5) Absorbing of large volumes of flow to reduce volumes of runoff.	There is lack of an assessment of the potential water pollution impacts associated with the grassed swale. Please provide additional information in this regard. Further details also required on how frequently the swales will be monitored and replaced.	The previous assessment by the EPA identified understandable concern that the proposed swale by Cardno would be smothered with sediment. We considered that this was a valid concern. As a result, the proposal was modified significantly to ensure that before any water flows onto the swale it is first treated in a gross pollutant trap to remove the sediment. This has required modification of both the catchment plan and site grading plan, inclusion of dish drains to divert all flows to GPTs first and then inclusion of GPTs. Section 7.6 of the report states "Traps treating runoff from catchment M4 and M2 are required to reduce the loading of sediment and gross pollutants on the bioswale. This will enable the bioswales to be easily maintained into the future." Section 8.1, point 2) of the WCIA report notes that "Gross pollutant traps are then used to remove coarse sediment and gross pollutants from the system. This will keep the bioswale and pond free of a large volume of sediment and gross pollutants" Section 8.1, point 3 also notes "The bioswale is used to treat Catchments M4 and M2. This will reduce fine sediment, metals and nutrients. Removal of sediment and gross

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				pollutants upstream of the swale will help to protect the swale and keep it functioning through the life of the facility. The hydraulic loading rate (volume of water treated/ surface area of device) on the swale is predicted to be 100m/year for the first segment and 30 m/year for the second segment. It is considered that a bioretention systems sized at 150m/year or less will achieve their expected design outcomes. Figure 16 shows that with a hydraulic load rate of 100m/year the proposed bioswale is likely to perform at the highest level and will be lightly loaded ensuring good outcomes in the long term.” Section 9.4 of the report also identifies how to best establish a non erosive cover over the swale as follows ”Jute mat will be required to stabilise soils in the bioswales until vegetation has been well established. A mix of native reeds, grasses and sedges will be used in the bioswales. Turf can be used as a vegetative buffer strip between the developed parts of the site and the swales. Swales may also be grassed with a hardy buffalo grass as an alternative to bioretention plants. This can be resolved during detailed design.” Section 7.16 of the WCIA identifies that a risk and operation and maintenance plan for the whole system needs to be developed and this would include the bioswale. This plan will comprehensively identify all

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				of the maintenance activities that are needed for the bioswale and every other part of the treatment train. Further identification of specific maintenance requirements at this stage of the development process are not considered appropriate. We also note the likelihood of ongoing licence and reporting conditions which will provide an indication of poor water quality and the need for rectification in the unlikely event that it does occur.
11	The WQIA does not consider the potential human health and occupational health risks related to proposed wastewater reuse at the site as requested by the EPA.	Section 5.4.2 states a sewer will be installed on site with wastewater pumped to the Council's wastewater treatment plant. Section 7.2 states covering the vehicle wash bay and send wastewater to trade waste not stormwater.	It seems wastewater would not be reused on site and would be discharged to sewer under Trade Waste Agreement. Please provide confirmation in the WCIA. Please provide details of where human health target values/criteria in Table 18 have been derived from, i.e. guideline reference. Will other pollutants (section 5.1.1) also be considered in the human health assessment?	Section 5.4.2 of the WCIA states that "A sewer will be installed on site with wastewater pumped to the Council's wastewater treatment plant." Table 18 includes targets that were identified in Table 4 of the report. Table 4 of the report is based on the two key guideline documents described in Section 4.8. For convenience these are "Managing Urban Stormwater: Harvesting and Reuse (2006)" and "Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2): Stormwater Harvesting and Reuse (NRMCC-EPHC-NHMRC, 2009). The risk assessment process is comprehensive and requires that all risks are assessed including from exposure to any other pollutants.

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12	The WQIA does not identify the fate and potential impacts of any leachate generated inside the warehouse and where applicable outline how the impacts will be appropriately managed as requested by the EPA.	Not addressed in the WCIA	The Department's February 2020 comments remain valid. Please clarify if any leachate would be generated inside the warehouse/enclosed areas. If so, please identify the fate, potential impacts and responding mitigation measures as requested by the EPA.	This issue has been addressed at Issue 8.
13	Please explain why the proposed Stage 1 vehicle wash bay and trade waste treatment facility is located at upstream of the wash bay. It is also unclear how wastewater from the wash bay will be drained to the treatment facility.	Wastewater collected from wash bay will be discharged into sewer under a Trade Waste Agreement.	Please clarify if there is any treatment (or testing) prior to discharge wash bay wastewater to ensure the discharged water would meet the Trade Waste Agreement criteria.	Page XV of the WCIA states that "A covered vehicle wash bay will use a coalescing plate separator to firstly treat dirty water (separating oils and grease) and then to discharge this water to trade waste." Typically, a vehicle wash bay would see the installation of an approved coalescing plate separator and no testing is required as the approved device has already proven its performance. It is unlikely but possible that Council may require testing, and if they do, this will be included as a condition of the trade waste agreement.
14	Please include a site water balance with average water volume in the WQIA report.	Site water balance is provided in Executive Summary (page xvii), shown in Table 14 in Section 6.3.2 of the WCIA report.	• Table 14 is inconsistent with the executive summary. Frequency of discharge into bushland and ET loss from site in pre- European and Pre-Development scenarios are missing from Table 14. Please update Table 14 to align with the water balance table in the	Table 12 identifies the frequency of discharge into bushland and it was therefore not repeated in Table 14. Table 14 is updated to include the ET loss from the site so that it is consistent with the Executive Summary. ET loss is a common abbreviation

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			executive summary. Please clarify the meaning of ET loss.	for evapotranspiration loss.
15	Provide details in the EIS and/or PIRMP regarding controls to be implemented with the capture systems during an emergency, including overflow.	The proposed water management system has been amended to include an emergency spill pond. Section 7.12 details the proposed emergency spill pond.	• Please update the WCIA report to ensure consistent terminology is provided (e.g. emergency spill pond and emergency water quality pond coexist in the report, water quality pond and main pond coexist in the report). • Please explain the relationship between the water quality pond and the emergency spill pond: – will the water quality pond collect firefighting water? Or the emergency spill pond will solely collect firefighting water during a fire event. – if the water quality pond will collect firefight water, then please clarify that it is only when the water quality pond reaches its capacity, the collected firefighting water would flow into the emergency spill pond from the water quality pond? The report indicates that the purpose of the emergency pond is to contain fire water/foam or polluted run-off	The terminology will be updated to be consistent. The other points have been addressed at Issue 9.

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			without mixing with other site runoffs. It is inferred that in a worst-case scenario, should the emergency pond not have enough capacity, that contained firefighting/pollutant water within the emergency pond will flow into the main pond – essentially mixing with other site runoff contained in the main pond. Please clarify how fire water will be managed in this scenario, as it is no longer contained separately.	
16	Reference has been made to a literature review "How sustainable are stormwater management practices with respect to heavy metals? A multinational perspective (Liebman & Jonasson, 2009)." The literature review is a generalised study on stormwater treatment, however, is not specific to the potential pollutants present in stormwater runoff typically associated with waste management facilities, which is appropriate to this this development. Clarification needs to be provided regarding whether the suitability of the stormwater management practices adopted from the research referenced in Liebman & Jonasson (2009) are appropriate for the site.	No response provided	The Department's February 2020 comments remain valid. There is an emphasis in the report of stormwater management for the treatment/removal of TP, TN and TSS (as per Section 6.3.1.2) of the report. However, other contaminants highlighted in Section 5.1.1 as potential pollutants identified on waste facilities have not been addressed.	This issue has been addressed comprehensively earlier at Issue 5. We further note that when SEARs are issued that they are generic and in this instance it is understood by the development industry that compliance to this SEAR can be demonstrated through the use of MUSIC modelling as has been done in this case and it is a deemed to comply solution to the specific SEAR. We further note the Department has dismissed the applicability of the research seemingly without understanding the key finding of the research being related to the degree of metal removal achieved by specific treatment trains. The Department simplistically dismisses the research because it was not carried out on a waste management facility that handles exactly the same type of waste and therefore it maintains it could not be applicable

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				to the site. The Department ignores the fact that much of the research was based on highway runoff where heavy metal pollution is a well documented chronic risk. The Department has incorrectly dismissed this evidence and maintains that the data requested must be provided without providing an acceptable method or guidance on how the data should be provided when it has been identified in the report that it is not possible to provide the data requested at this point in time.
17	Floating wetlands have been identified as a proposed technology adopted for sediment control and stormwater treatment during the construction and operations of the development. Provide further specification on the types of pollutants that this treatment technology filters / attenuates (including rates/capacity), and frequency of replacement.	Section 7.10 provides details of the proposed floating wetlands.	The WICA report only provides a research of Nichols et al in 2016, the research result is generic in nature and does not respond to the Department's comments regarding development specific assessment, including how effective the proposed floating wetland would filter/attenuate TSS, nitrogen, phosphorus, metals and hydrocarbons, what are the concertation rates of each contaminant before and after the wetland treatment, will the treated water meet the relevant water management policies/guidelines criteria? The research study (Appendix 3) focuses on the use of FTW as a potentially effective technology for low density residential development. It also refers to the treatment of pollutants typically seen in general stormwater	Section 6.1.2 of the report describes the methodology for the MUSIC model. This section notes that "we have proposed 165m2 of floating wetlands for the pond which makes up 10% of the vegetative coverage of the pond. The pond has not been modelled as a floating wetland but instead conservatively modelled as a pond. There is an assumption in the MUSIC model that a water quality pond must have 10% of its surface area covered with vegetation. The proposed pond has vertical sides and it is not possible to plant vegetation in the pond. Therefore, it is proposed to include a floating wetland to achieve the 10% vegetative coverage assumed in the MUSIC model. The Department questions if the floating wetland can treat fire water? It is unlikely that fire water will be in the pond long enough to be treated. The wetland is unlikely to treat fire

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			catchments e.g. nutrients, with no reference to heavy metals or hydrocarbons. Section 7.10 further states that the FTWs still require further research under a broader range of conditions, and its performance has not been configured such as a nature of the waste facility development, which includes fluctuations in water levels. The Applicant needs to demonstrate why this technology should still be considered for this development, given there is no supporting data that this technology is appropriate for the nature of the development. If the water quality pond/main pond would receive firefighting water, then will the floating wetland treat firefighting water? If so, then what are the potential contaminants, what is the treatment process, how effective the wetland's treatment will be?	water. We don't know how effective the floating wetland will be and we state again that the floating wetland has not been included in our water quality model except to justify the choice of a pond node which requires 10% vegetative coverage. To be very clear – the water quality model includes a water quality pond model node and it doesn't include a floating wetland model node. However we are confident that the floating wetland will significantly improve water quality above and beyond what has been modelled and claimed in the WCIA Report.

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1. The WCIA must include a table outlining how does the WCIA report response to each comment/requirement made by the EPA, the Department and other agencies (i.e. in which section of the report addresses a specific comment/requirement) 2. The WCIA report must include a table of abbreviation to provide clear definition. 3. It is recommended adjusting the report to fit the purpose of being a technical report supporting a development application targeting at readers with limited technical background knowledge of water management. *4.* Section 7.6 of the WCIA report includes incomplete sentence: *The Barramy GPTs will treat runoff from* *Responses to points above:* *1. This is included in Section 1.6 and Appendix 4* *2. This has been done.* *3. This will not be done because it is a technical report that is intended for review by an experienced and appropriately qualified assessor. The EIS document will summarise the key findings of WCIA in plain english.* *4. This was amended.*			