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Planning

Addendum to Review of Environmental Factors

Sewage Treatment Plant and Sewage Reticulation Network, Catherine Hill Bay Part 5 EPA Act 1979

Property:

Lot 100, 101 & 106 DP 1129872, Lot 1 DP 1141989, Lot 1 DP 1129299, Lot 103 DP 1194707, Lot 101 and 102 DP 1194707, Lot 213 DP 883941, Lot 1 Section I DP 163, Lot 1 Section K DP 163, Flowers Drive Road Reserve, Montefiore Street Road Reserve

85 & 95 Flowers Drive, 6 Keene Street & 12 Montefiore Street, Catherine Hill Bay

Applicant:
Solo Water Pty. Limited

Date:
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Working Beyond Expectations

Document Control Sheet

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ACRONYMS AND ABBREVIATIONS

CHB	Catherine Hill Bay
CHBWU	Catherine Hill Bay Water Utility Pty Ltd
EIS	Environmental Impact Statement
EPA	Environment Protection Authority
EP&A Act	Environmental Planning and Assessment Act 1979
EP&A Reg	Environmental Planning and Assessment Regulation 2000
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPI	Environmental Planning Instrument
EPL	Environmental Pollution Licence under the POEO Act
FM Act	Fisheries Management Act 1994
KL	Kilolitre (1 thousand litres)
LEP	Local Environmental Plan
ML	Megalitre (1 million litres)
MNES	Matter of National Environmental Significance
NPW Act	National Parks and Wildlife Act 1974
NPWS	National Parks and Wildlife Service (part of OEH)
OEH	Office of Environment and Heritage
POEO	Protection of the Environment Operations Act 1997
REF	Review of Environmental Factors
SCA	State Conservation Area
SDRW	Surplus-to-Demand Recycled Water
SEPP	State Environmental Planning Policy
SIS	Species Impact Statement
TSC Act	Threatened Species Conservation Act 1995
WICA Act	Water Industry Competition Act 2016

Executive Summary

The sewage treatment plant (STP) planned as part of the *Beaches* subdivision at Catherine Hill Bay will generate excess recycled water. The excess quantity varies depending on climate conditions. Under the current approvals, disposal is via onsite irrigation.

The excess recycled water proposed for disposal will be to the highest quality recycling standard. The water is suitable for all domestic use except drinking and bathing. Ingestion of very small quantities can occur without adverse human health effects.

Irrigation was an interim solution to the disposal of excess water. The preferred option is disposal to the environment. At the time of the original STP licence application, the effects of disposal of excess recycled water to the downstream environment had not been assessed. Documentation provided for the STP licence approval made it clear that a further application covering disposal of excess recycling water to the environment would be likely.

Disposal of excess recycled water to the environment engages a complex interplay of climatic, hydrologic and ecological considerations. Release of the water to the environment can only occur under a licence issued in accordance with the New South Wales POEO Act. The relevant sections of the POEO Act are administered by the New South Wales EPA. Consultation about licence approval requirements resulted in nomination of a range of assessment requirements by the EPA.

In addition to the EPA requirements, there is a range of statutory requirements under the Environmental Planning and Assessment Act 1979 which must be addressed prior to gaining an approval. To satisfy the environmental assessment requirements for recycled water release, specific hydrological, ecological and coastal processes assessments have been undertaken.

The hydrological assessment includes estimation of excess water volumes, the natural hydrology of the receiving catchment and various on-site operations of the STP. The assessment utilises modelling to establish the capacity of the receiving environment to accept additional flows. The modelling uses 35 years of climate data to assess and refine the requirements for release. The modelling is conservative, and for the purposes of environmental assessment, overestimates volumes off excess water by some 20%. The basis of the assessment is thus a worst case.

Based on the hydrological assessment, a system of release incorporating ‘wet’ (during high catchment flows) and ‘dry’ (during low catchment flows) is proposed to mitigate potential impacts. Also proposed are a range of measures identified during the assessment to improve the STP management of excess water release. These measures include removal of the previously approved reverse osmosis treatment system, addition of wetland polishing of excess recycled water to improve water quality, and additional on-site storage to provide greater control over the timing of proposed releases.

The guiding principle behind the proposed wet and dry release strategy is protection of the environment. The adjoining lands to which water would be released are zoned for conservation and are managed by the New South Wales National Parks and Wildlife Service. Excess water has the potential to cause ecological problems if the quality and volumes don’t match the receiving capacity of the environment.

An aquatic ecological assessment has been undertaken of the receiving environment. The study found the environment is already degraded due to the catchment history of mining and other development. Despite the degradation, some reasonable quality aquatic habitat was identified as being potentially affected. The 'wet' release of excess recycled water will occur at the same time as surface water flows in the downstream waterways. The effect of increased stormwater flows from the *Beaches* subdivision, plus the release of excess water, has been assessed as part of the aquatic ecology report. It was concluded there would be no measurable ecological impact arising directly from the increased flows. The lagoon already receives unmanaged drainage directly from CHB village, and the receiving waters were found to have likely adapted to the pollution loads, and as such no significant effects were likely. A number of mitigation measures are proposed to address existing water quality and environmental problems in the catchment.

A coastal processes assessment was carried out to ensure that Middle Camp Beach would not be affected by the proposed additional flows. The excess water will flow through a coastal lagoon which has been estimated to be open to the ocean some 73% of the time. The only minor impact of additional flow was a 1% increase in the likelihood of over topping of the beach shoal during periods when the lagoon was closed. The proposed stormwater increases and recycled water releases are not expected to have significant effects on coastal processes. Subsequently, no mitigation measures are proposed.

Two release points are proposed, one for 'wet' and one for 'dry' release. 'Wet' release will be within the *Beaches* subdivision at the stormwater outlet of Stages 6 and 7. 'Dry' release will be at Lindsley Street in the existing CHB village, at a location where *Beaches* subdivision stormwater works are required. 'Wet' release will flow through the creek system to the lagoon. 'Dry' release will be made directly to the lagoon to protect aquatic environments during periods where storage is exhausted and there are not sufficient surface water flow triggers for 'wet' release.

Detailed assessment of the proposed changes found no significant impacts are likely, but a number of mitigation measures are still needed to manage or avoid potential problems. Generally, the quality of recycled water release, its low volume and infrequent release, plus the short detention times in the system are consistent with low levels of impact. Also, assessment based on the worst case and conservative modelling estimates increases the level of confidence in the findings.

All the proposed changes to the STP and the associated sewage reticulation works are permissible under ISEPP 2007 as development without consent. The release of water is ancillary to the STP but must be subject to environmental assessment because of the potential for impacts. Assessment under the broad range of applicable statutory requirements and related policy finds no likelihood of significant impacts. The proposal can be approved under Part 5 of the EPA Act 1979 without an EIS.

A recommendation for approval of the proposed changes to the STP and its operations is made subject to a range of conditions that will provide for the ongoing management of the STP and mitigation of potential impacts. The conditions cover a range of issues including on-going monitoring, STP management, adaptive management of releases if required, catchment improvements and protection of the environment.

1.0 Background

The purpose of this REF addendum is to assess the impacts of a proposed release of surplus recycled water from the *Beaches* subdivision to adjoining land. Proposed are a number of changes to the approved sewage treatment plant (STP) and its operations (refer to plans in **Appendix 1**).

The irrigation area over stages 6 and 7 of the *Beache*s subdivision will be removed as a consequence of the changes included in this addendum to the REF. Stages 6 and 7 will return to the approved residential use and require a recycled water reticulation system. As the stages 6 and 7 recycled water reticulation is not specifically covered by either of the original REF or the subdivision approval it is included and assessed as part of this addendum.

The New South Wales Planning and Assessment Commission approved the *Beaches* subdivision at Catherine Hill Bay in 2010. In March 2016, the Catherine Hill Bay Water Utility Pty Ltd (CHBWU) was granted a licence under the Water Industry Competition Act 2016 (WICA Act) (refer to **Appendix 2**). This WICA licence provides for the establishment and operation of a utility for water supply, sewage treatment and water recycling utility for the *Beaches* subdivision.

Under the subdivision approval, a range of standard infrastructure works are under construction including water, sewer and stormwater services.

The WICA licence allows for the establishment of the water utility services and its operations. The approval is for a STP but includes the water recycling capacity. Ancillary to the utility operations is the disposal of surplus to demand recycled water (SDRW) by irrigation on the *Beaches* subdivision site. The irrigation was approved as an initial solution to SDRW disposal. Alternatives to irrigation are preferred in the circumstances as the land proposed for irrigation is required for housing to provide economies of scale for the subdivision and utility.

As a conservative approach, the volume of recycled water has been assumed equivalent to the volume of wastewater received at the STP from households. Recycling water back to households is the primary pathway for disposal of recycled water. Demand for recycled water is estimated to vary by a factor of six due to climatic conditions (ie. seasonality of rainfall and evapotranspiration). This variability means recycled water is fully utilised during periods of high demand, but SDRW is to be managed when demand is low. As onsite storage that could store all excess SDRW for future use is impractical, the proposed recycled water management strategy involves a high volume onsite tank storage component, in conjunction with offsite disposal of SDRW.

The Advance Water Treatment Plant component of the STP includes ultrafiltration, ultraviolet disinfection and chlorination, which will generate recycled water to *Fire Fighting* standard – the most stringent recycled water quality standard as per *National guidelines for water recycling: managing health and environmental risks*. This class of recycled water is suitable for “ingestion water and sprays”, however, at the *Beaches* development it will be used for domestic use, but not recommended for drinking, cooking and bathing.

Despite the high-quality of the SDRW, there remains potential for off-site disposal to have adverse impacts on the downstream environment. Changes to local hydrology and nutrient loadings can have physical and ecological effects on receiving lands and waters. The currently approved disposal method is a dedicated irrigation area. This approach has its own set of management issues, including the level of storage required to cover periods of low evaporation when irrigation can result in direct runoff to the environment.

The initial WICA licence application covered the CHB utility's progressive operational development. The utility operation was to be increased incrementally over three stages as the subdivision and demand for utility services developed. The third stage was inclusion of the existing villages of Catherine Hill Bay and Middle Camp.

The initial proposal for disposal of SDRW to the downstream environment was rejected due to insufficient environmental assessment. Released SDRW must flow through local creeks to the north then via a beach lagoon on Middle Camp Beach, and ultimately to the ocean. Additional assessment was needed to satisfy a separate licensing procedure under the NSW Protection of the Environment Operations Act (POEO). The granted WICA approval is for 470 lots with onsite irrigation, with allowance for expansion to 550 lots subject to EPA discharge licence approval. The initial approval permitted subdivision works and construction of the water utility to proceed.

The environmental assessment for the WICA licence (refer to **Appendix 3**) required *Beaches* subdivision Stages 6 and 7 (residentially zoned land) to act as an irrigation area for disposal of SDRW, but with no direct release of SDRW to the environment. The economics of the utility are improved by establishing the full 550 lots capacity of the subdivision. It was anticipated at the time of approval that the licence and the water utility operations would be revised to accommodate disposal of water to the local environment subject to adequate environmental assessment.

The *Beaches* subdivision and the water utility construction are well advanced. Any WICA licence changes need to be amended during the construction phase to provide certainty prior to commencement of STP operation.

The required environmental assessment to justify the disposal of SDRW to the environment is provided by this report, and this forms an addendum to the final REF which accompanied the CHBWU WICA licence application. This is as provided for by the original REF.

A range of nine options was developed for disposal of SDRW to the local environment. The preliminary feasibility of each option was assessed, and disposal of SDRW in conjunction with approved stormwater system flows from Stages 6 and 7 of the Beaches subdivision was recommended as the preferred method. The recommendation was then put to the New South Wales Environment Protection Authority (EPA) for discussion. The EPA responded with a request for assessment of the three highest ranked options, and also requested consideration of retaining an area of irrigation at the proposed Stages 6 and 7 of the Beaches subdivision.

The EPA response also included a range of assessment requirements for any proposed discharge to local waters. Based on those assessment requirements, detailed investigations of the local hydrology, aquatic ecology and beach dynamics have been carried out. The EPA also required that worst case assumptions be the basis of the assessment. In addition, a detailed assessment of the benefits of a wetland on the treatment plant site also has been undertaken.

There is a complex interaction of climate, hydrological, ecological and coastal process factors to be accommodated by any SDRW disposal strategy consistent with minimising health and environmental impacts. These are further emphasised by the location of conservation lands adjoining the *Beaches* subdivision. Protection of local conservation values is thus the primary management goal for SDRW release.

Following preliminary assessment and several iterations of hydrological modelling, a range of opportunities to improve the SDRW release efficiency were identified. The primary control is the establishment of a total of 5 ML of onsite tank storage of recycled water, which includes the currently approved 2 ML of recycled water storage after the advanced water treatment plant, plus an additional 3 ML of SDRW storage after the wetland treatment phase. Based on modelling covering 35 years of climate data, a minimum ecological impact strategy was devised. These efficiencies make the water recycling plant more sustainable without significant impacts on the receiving environment. The addition of a subsurface flow wetland treatment system for the SDRW has been identified as providing significant nutrient and pathogen reduction prior to SDRW discharge. The wetland also provides a de-chlorination function.

Significant and extensive hydrological modelling (refer to **Appendix 5**) of the capacity of the receiving environment (described in **Appendix 6**) to accommodate SDRW has provided a minimal impact release strategy. The strategy is one of minimal natural cycle disturbance via a system of 'wet' and 'dry' releases.

'Wet' release parallels flow in the catchment creeks and benefits from dilution via stormwater runoff and baseflow. Wet release will be managed firstly to protect conservation values and secondly to minimise site storage of SDRW.

'Dry' release will occur only when the onsite 5 ML of recycled water storage (includes 2 ML of recycled water tank storage plus 3 ML of SDRW tank storage) is exhausted and there is low or no flow in the natural catchment creeks. Dry release will be to the beach lagoon at a rate at which inflow of the SDRW matches the beach lagoon outflow. Dry release is proposed to ensure that there is minimal disturbance of good quality aquatic environment during periods of naturally low or no flow. This provides for maintenance of wetting and drying cycles, an important aspect of the aquatic ecology. Modelling indicates that dry release has a worst case of 4 ML/year and a mean of only 0.7 ML/year.

2.0 The Proposal

The (STP) managed by the Catherine Hill Bay Water Utility Pty Ltd (the utility) will treat all wastewater generated by the *Beaches* subdivision to *Fire Fighting* recycled water standard. The treatment standard adopted is the most stringent recycled water quality standard as per National guidelines for water recycling: managing health and environmental risks. This class of recycled water is suitable for 'ingestion water and sprays', and is proposed for all non-potable household uses. The standard is that up to 20 ML of this quality water can be ingested up to 50 times per year without human health effects.

It will be mandatory for all households in *Beaches* Stages 1 to 7 to connect to the recycled water reticulation system. When household demand for recycled water falls below the production rate, surplus-to-demand recycled water will be generated (SDRW). This water will be prepared for offsite release by treatment via a constructed sub-surface flow wetland at the STP site. The overall process will produce wetland-treated recycled water, which will be temporarily stored prior to offsite discharge.

Plans of the STP site, access road and wetlands arrangement is provided as **Appendix 1**. A process flow diagram for the STP site is also included in **Appendix 1**.

The 188 ha study area catchment is shown in **Figure 1**. The location of the proposed SDRW release points is as shown in **Appendix 1** and in **Figure 2**.

The STP treatment process is described in detail in the original REF (refer to **Appendix 3**). The amended treatment process removes reverse osmosis (RO), and includes a wetland treatment step and additional dechlorinated SDRW storage.

Proposed Changes from WICA Licence Approval

The current proposal will involve changes to the STP site layout and additions to the sewage reticulation system to include SDRW release points. One release point will be below the Stage 6 and 7 stormwater basin (for wet release) and the other adjacent to the existing stormwater flow path in Lindsley Street in the CHB village (for dry release). Both these release points and their construction will be done as part of stormwater work required under the *Beaches* subdivision MP10_204 approval. The Lindsley Street works are associated with stormwater for the intersection upgrade of the Lindsley Street / Hale Street / Flowers Drive intersection.

The proposal also involves changes to water management. The proposed irrigation area over the Stages 6 and 7 of the *Beaches* subdivision will be omitted, and an SDRW treatment subsurface flow wetland will be included on the STP site. Recycled water storage will be increased to include an additional 3 ML for wetland treated SDRW (2 ML of storage is already approved for recycled water produced by the advanced water treatment plant, and the additional 3 ML of SDRW storage will increase total storage of recycled water to 5 ML – refer to the process flow diagram in **Appendix 1** for details). No water will be released to the environment without first passing through the wetland and the 3 ML of SDRW storage in tanks. This will provide a high level of control over SDRW release volumes and quality.

A key change to the treatment process is the removal of RO capacity. RO extracts salts but produces a high salinity wastewater. The approved RO reject waste storage ponds are to be repurposed as subsurface flow wetlands for treatment of SDRW.

Removal of the RO enhances the sustainability of the plant by removing a high energy demand process and the need to transport high salinity waste from the site for disposal elsewhere. The risks are therefore removed regarding the storage of highly saline water in an area adjoining, and draining to conservation lands.

The wetland treatment of SDRW will provide additional treatment for nutrients, pathogens and free chlorine removal.

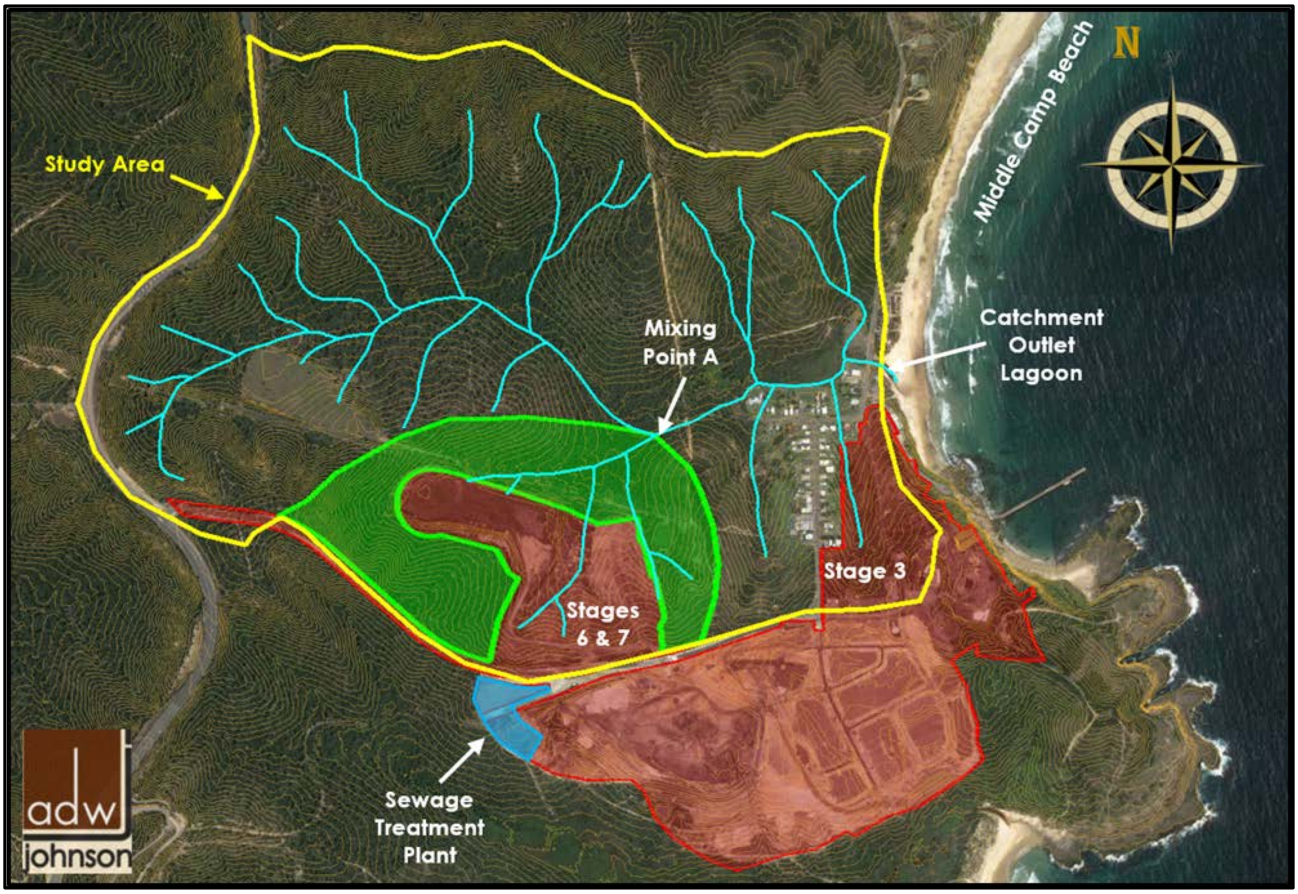


Figure 1: The proposed receiving catchment for excess recycled water showing the Beaches subdivision location in red. Mixing Point A and the lagoon are key locations for release management assessment.

Figure 2: Proposed pipeline routes to the wetland-treated recycled water 'wet' release location adjacent to the stormwater outlet of Stages 6 and 7, and the wetland-treated recycled water 'dry' release location at Lindsley Street.

The treatment and release of SDRW will be managed as follows:

- Passage of chlorinated SDRW through wetland;
- De-chlorination and 'polishing' of SDRW water quality in the wetland;
- 3 ML of storage of dechlorinated SDRW; and
- Managed SDRW release from storage tanks as follows:
  - Wet release to creeks triggered by stormwater flows from *Beaches* Stages 6 and 7; and
  - Dry release to beach lagoon in absence of catchment flows and when storage tanks approach capacity.

Wet release will achieve SDRW dilution first with stormwater then with natural flows from the catchment. Dry release will occur when the STP SDRW storage approaches capacity (i.e. near 5 ML).

Once released, SDRW will flow through the local creek system to the ocean. The SDRW wet release will flow with stormwater from the Stages 6 and 7 area along a non-perennial water course to Mixing Point A. From Mixing Point A, the SDRW will flow along the perennial main creek, which supports aquatic environments, to the upper lagoon. The upper lagoon is west of Flowers Drive and is adjoined by riparian vegetation. East of Flowers Drive the lagoon is over beach sands. Dry release will occur directly to the upper lagoon by way of the drainage channel downstream of the Lindsley Street stormwater culvert.

A summary of changes addressed by this REF addendum is provided in **Table 1**.

Table 1: Summary of changes to STP and operations

Change	Justification
Delete SDRW irrigation area and add Recycled Water Reticulation System	Allow completion of Stages 6 and 7 of the approved subdivision. Allow reasonable economic operation of the water utility.
Dispose of SDRW to environment	Provide for sustainable alternative to irrigation area for SDRW disposal.
Install wetland SDRW treatment	Improve quality of SDRW including free chlorine removal.
Increase onsite SDRW storage to 5 ML	Optimise SDRW release for minimal environmental effect.
Delete utility RO capacity	Reduce energy use of treatment plant and avoid RO waste storage, transport and disposal issues.
Remove RO waste ponds	Provide area for SDRW wetland treatment capacity.
Install release points for SDRW	Allow for controlled release of surplus recycled water to the environment.
Revised utility water management	Improve management and sustainability of water utility and protect conservation lands.

Table 2: Summary of Additional Risk and Environmental Impacts of Proposed Changes

Change	Additional Risk / Impact
Delete SDRW irrigation area	Potential for changed impacts on downstream receiving environment.
Add recycled water reticulation system to stages 6 and 7	Positive impact being an essential component of the proposed water recycling service, very low additional construction risk as it can be installed as part of the subdivision works.
Dispose of SDRW to aquatic environment	Potential for increased downstream environmental impacts including flooding, physical changes to water courses, ecological effects, eutrophication, decreased recreational amenity.
Install wetland	None identified subject to adequate wetland management.
Install additional SDRW storage capacity	Possibility of visual impact/water, reduced potential for downstream impacts.
Remove reverse osmosis capacity	Increased salinity load downstream but lower risk of onsite storage ponds over flow / breaching / groundwater impacts. Eliminates risks of RO storage transport and waste disposal.

Change	Additional Risk / Impact
Install SDRW release points	Nil additional construction risk - within scope and management of subdivision stormwater works, additional risks avoided by inclusion as part of proposed subdivision works, no downstream construction impacts.
Revised water management	Proposed to address potential for downstream environmental impacts.

2.1 THE RECYCLED WATER BUDGET

The demand for recycled water will vary depending on climate conditions. Demand will be higher in dry periods and lower in wet periods.

The generation rates and the likely demand for recycled water are addressed in detail in the Hydrology Assessment refer to **Section 3.7** and **Appendix 5**.

For assessment of SDRW disposal, a conservative mean surplus of 100 kL/day has been adopted for modelling purposes. This is a conservative generation rate, which is ~10% greater than the mean daily surplus of 90.2 kL/day estimated from a recycled water demand model (see **Appendix 5**).

2.2 RECYCLED WATER QUALITY

Pollutants in SDRW which warranted assessment include:

- Total nitrogen (TN);
- Total phosphorus (TP);
- Total suspended solids (TSS);
- Faecal coliforms (FC);
- Total dissolved solids (TDS);
- Biochemical oxygen demand (BOD); and
- Free chlorine (Cl).

For this assessment, recycled water quality is based on Membrane Bioreactor (MBR) permeate, pollutant load analysis of which is provided in the Integrated Water Management Plan (Solo Water 2015). The adopted concentrations of pollutants in SDRW required for treatment by the wetland are shown in **Table 3**.

Table 3: SDRW Quality Adopted for Treatment by the Subsurface Flow Wetland

Parameter	Units	50th-percentile adopted as mean	95th-percentile adopted as mean	Maximum concentration
TN	mg/L	10	-	20
TP	mg/L	0.3	-	2.0
TSS	mg/L	-	5	10
BOD	mg/L	-	-	20
FC	cfu/100 ml	-	-	100*
TDS	mg/L	-	-	1,000
Free Cl	mg/L	-	-	2

* MBR effluent FC concentrations are used as wetland input to demonstrate the wetland's effectiveness at FC removal. In practice, the STP's AWTP process will reduce FC to <1 cfu/100ml, and the wetland will instead receive recycled water of this quality.

Free Cl will off-gassed at wetland entry and utilised in the oxidation of organic materials, and as such, is not considered a pollutant of concern.

To determine offsite pollutant load discharges, representative pollutant concentrations and flow rates were determined for SDRW following wetland treatment (refer Section 9.5 of **Appendix 5**). For the seasonal peak daily flow rate of 139.1 kL/day (June), estimated pollutant concentrations (**Table 4**) have been calculated for all pollutants of concern (based on means for TN, TP and TSS and maxima for BOD, FC and TDS). The effectiveness of the subsurface flow wetland at reducing pollutant loads is also described in **Table 4**.

Table 4: SDRW Water Quality Summary Post Wetland Treatment Across Full Flow Range

Parameter	Units	Mean	Wetland Removal Effectiveness
Biochemical Oxygen Demand	mg/L	4.56	77% reduction
Total Suspended Solids	mg/L	8.12	Increase due to natural system
Total Nitrogen	mg/L as N	3.31	67% reduction
Total Phosphorus	mg/L as P	0.16	46% reduction
Faecal Coliforms	cfu/100 mL	4.91*	95% reduction
Total Dissolved Solids	mg/L	1,000	No salinity reduction afforded by wetland

* MBR effluent FC concentrations are used as wetland input to demonstrate the wetland's effectiveness at FC removal. In practice, the STP's AWTP process will reduce FC to <1 cfu/100ml, and the wetland will instead receive recycled water of this quality.

3.0 The Site & Catchment

The 188 ha study area catchment is shown in **Figure 1**. The history of the catchment is one of coal mining. The village of Catherine Hill Bay was established in the late 1800s when coal mining commenced. Coal mining ceased in 2003. Mining left unsealed roads, shallow mine workings, infrastructure corridors, altered drainage, altered topography and the village within the catchment

Part of the approved 550 lot *Beaches* subdivision is situated north of Montefiore Street (being Stages 3, 6 and 7), and this area will deliver managed stormwater into the study area catchment. The existing CHB village is unsewered and stormwater discharges directly to the beach lagoon.

The STP and incorporated water recycling plant (the CHB Utility), is located south of Montefiore Street within the existing *Beaches* subdivision. It is proposed to pump SDRW from the CHB utility into the 188 ha study area catchment, which has an outlet at an unnamed coastal creek and beach lagoon on Middle Camp Beach.

The proposed wet and dry release locations of SDRW are shown in **Figure 2**. Wet releases of SDRW will be delivered by underground pipeline to the outlet of Stages 6 and 7, where it will flow via Mixing Point A and along the main creek line to the lagoon. Dry releases of SDRW will be delivered by underground pipeline to the downstream side of the Lindsley Street culvert crossing of an unnamed waterway, which flows directly into the lagoon. Commentary on the proposed releases and system is provided progressively as it relates to the information provided.

Flowers Drive passes over the lagoon at the beach outlet, and the road culvert divides the lagoon. East of the culvert, the lagoon is over the beach (see **Image 1**) and varies considerably in extent depending on prior rainfall and coastal processes. West of the culvert, the lagoon is relatively stable with surrounding vegetation and only a small area of open water (see **Image 2**).

Image 1: Beach section of lagoon April 2016.

Image 2: Lagoon immediately upstream of Flowers Drive Culvert April 2016.

For the purpose of SDRW release, the important components of the receiving waters are the local freshwater creeks, adjoining wetland areas lower in the catchment and the brackish lagoon located on and behind Middle Camp Beach in the lowest section of the catchment.

The SDRW wet release surface water path has previously drained the coal reject storage areas now proposed for subdivision and unsealed roads. The dry release path is over an existing stormwater flow path, serving part of the CHB village and part of the former coal washery, to the beach lagoon. The beach lagoon also receives untreated urban stormwater and drainage from the CHB village via a second flow path further to the west.

Historical photos from the 1920's and 1940's show that the lower creek and lagoon, already disturbed by road and rail culverts, was filled and re-channelled west of the culverts. Currently the configuration of the creek above the lagoon is that of a drain bordering the residential development of the village. The location of the creek and lagoon entrance to the beach which would have moved both and south is now fixed by the culvert on Flowers Drive and the old railway embankments.

3.1 SUBJECT LAND

The *Beaches* subdivision site is bounded by the Munmorah State Conservation Area to the south and west, and by the Munmorah State Conservation Area and Pacific Ocean to the east. The site is adjoined to the north by the existing village of Catherine Hill Bay and conservation lands dedicated as part of the *Beaches* subdivision approval process.

The STP site as approved was located within and at the western extent of Lot 101 DP 1129872. Since the WICA licence was granted the *Beaches* subdivision has proceeded with new lots created.

Due to ongoing *Beaches* subdivision, the STP site is now located on Lot 1120 DP 1219395 (**Figure 3**).

The full description of the land under the *Beaches* subdivision approval and subject to WICA licence (July 2017) is:

Lot 100, 101 & 106 DP 1129872, Lot 1 DP 1141989, Lot 1 DP 1129299, Lot 103 DP 1194707, Lot 101 and 102 DP 1194707, Lot 213 DP 883941, Lot 1 Section I DP 163, Lot 1 Section K DP 163, Flowers Drive road reserve, Montefiore Street road reserve, 85 and 95 Flowers Drive, 6 Keene Street and 12 Montefiore Street, Catherine Hill Bay.

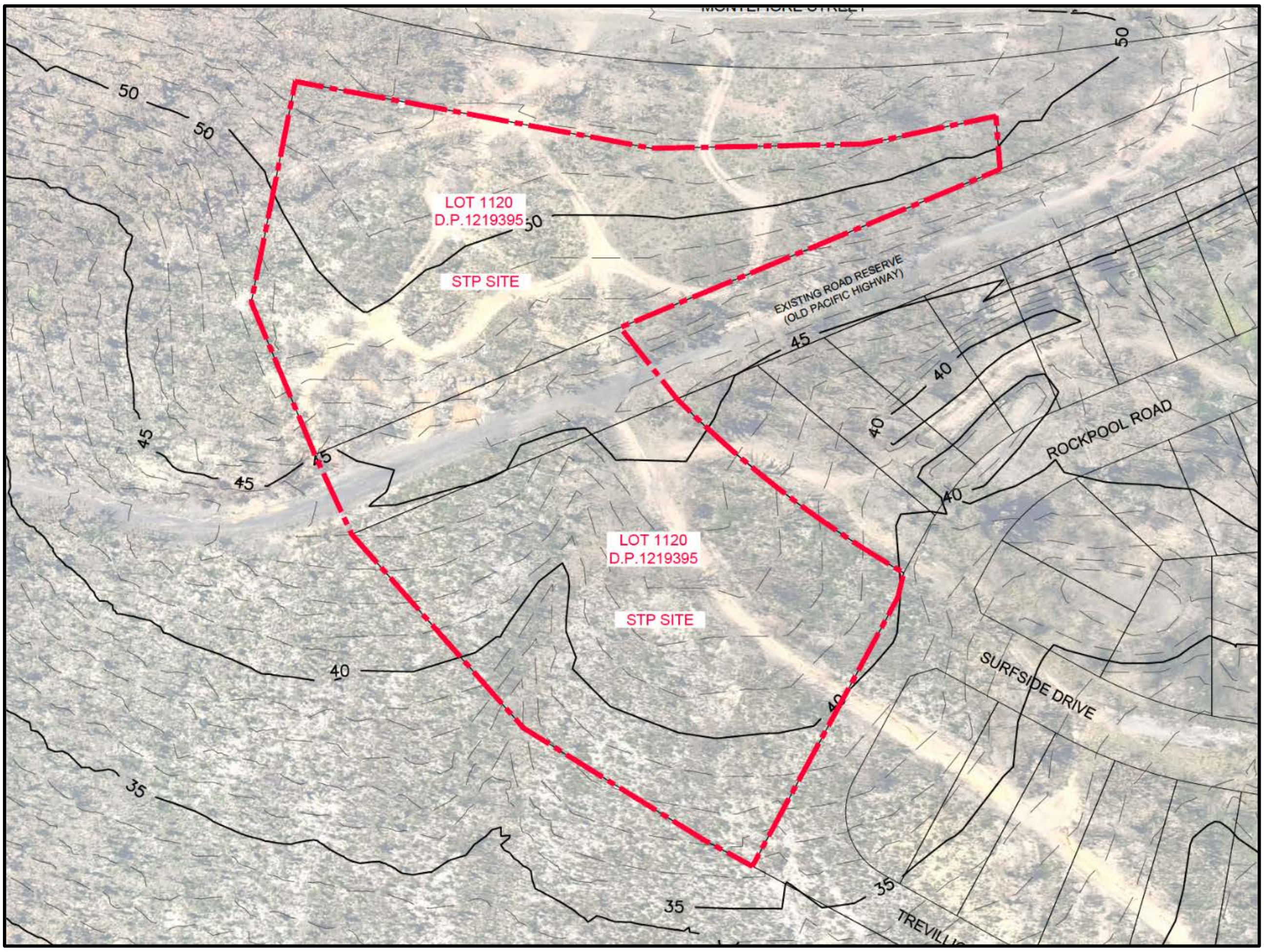


Figure 3: The STP site.

3.2 TOPOGRAPHY

Drainage from Stages 6 and 7 of the subdivision and SDRW will flow approximately northeast through local creeks and the beach lagoon to the ocean. Initially the drainage is through areas with no defined banks, then through minor streams, to a lowland area including wetlands and then to the lagoon and to the ocean across the beach. The lagoon has largely been reduced to the configuration of a drain and opens to the sea after any substantial rain event. The majority of historical aerial imagery shows the lagoon as either draining directly to the ocean, or as recently draining to the ocean (refer to the WBM Report in **Appendix 7**). The lagoon thus appears to be a well-flushed system.

The flow length for Stages 6 and 7 stormwater and SDRW wet releases is approximately 900m to the beach lagoon. There is a fall of over 10 m along this path with steeper grades towards the subdivision and low grades as the culvert and beach are approached. Surface elevation contours are shown in **Figure 1**.

3.3 SOILS

The 1:100,000 Soil Landscapes map Gosford Wyong 9131-9231 includes the subject catchment (**Figure 4**).

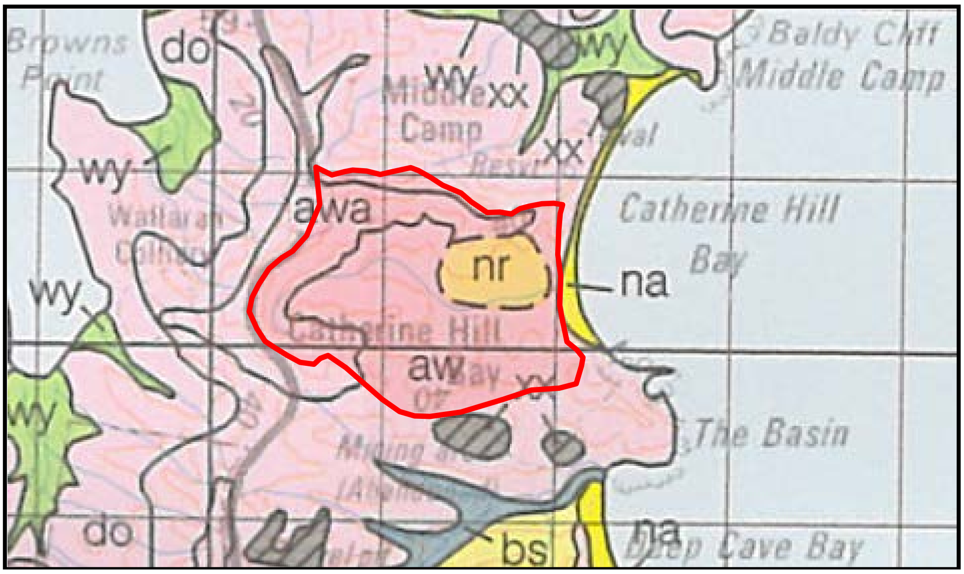


Figure 4: Extract of Gosford Soil Landscapes Map. Study Area catchment boundary is shown in red.

The map shows the upper reaches of the catchment as erosional Awaba soils of high erosion hazard, low fertility and strong acidity (mapped as "aw" and "awa"). These soils support forest and open forest.

Around the lower areas of the coastal creek the soils are a Norah Head Aeolian landscape of windblown sands (mapped as "nr"). The soils are deep, of high permeability, of low fertility and have a high water and wind erosion hazard. Such soils support heath, scrub and occasionally woodland.

The beach lagoon is located in and over beach sands (mapped as "na").

The Aquatic Ecology Report (**Appendix 6**) notes the impact of the high erodibility soils on the creeks and provides more detailed vegetation assessments.

3.4 WATER QUALITY

Historical water quality monitoring was carried out in the Study Area catchment and the adjoining catchment to the south (Moonee Beach Lagoon) as part of EPL 1558. There has also been more recent monitoring in these catchments as part of the *Beaches* subdivision approval.

The Moonee Beach catchment has similar soil types and mining history, but contains extensive wetland areas protected under SEPP 14. There is an apparently unmodified beach lagoon in this catchment although it is bounded to the west by an extensive area of fill from the former colliery.

Table 5: Results of EPL 1558 Monitoring for 2010

Parameter	Study Area Creek and Lagoon	Creek Leading into Moonee Beach Lagoon
Conductance µs/cm	366 – 22,300 generally > 1000	437-15,100 generally > 500
pH	5.8 - 7.1	6.5 - 7
Turbidity (NTU)	6 - 54	<1 - 88
Suspended solids (mg/l)	<1 - 81	<1 - 13

The EPL monitoring was conducted post mining and pre subdivision works. All water management structures on the former mining areas were retained intact until replaced by subdivision stormwater control works. The monitoring covered rainfall events of up to 42 mm in one day and up to 122 mm in one month.

The very high maximum conductance levels of the Study Area creek and lagoon is probably due to direct marine influence. By way of example, the lagoon was observed to be subject to ocean wave inundation in June 2016.

More recent monitoring of the Moonee Beach lagoon has taken place as part of *Beaches* subdivision construction management.

Table 6: Summary of Surface Water Field Measurements – Moonee Beach lagoon

Parameter	23/05/2014	29/10/2014	12/01/2016	4/07/2016
Temp	16.3	23.1	30	3.6
EC	1227	446	734	291
pH	6.6	6.6	7.27	6.74
DO	6.98	4.9	7.09	10.5
ORP	120	190	126	99
NTU	-	-	13	14.2
Comments	-	-	Brown, low turbidity	Slight brown-brown, low turbidity

While the more recent subdivision works monitoring is consistent with the ranges established as part of the EPL monitoring, the results can only provide general indications for the subject catchment. It appears that the more intense period of EPL monitoring in 2010 is representative of longer term conditions in the lower creek and beach lagoon. The ecology report in **Appendix 6** contains further discussion of water quality monitoring data in the Study Area catchment.

3.5 LOCAL CLIMATE

Relevant local climate information is summarised in **Table 7**. A portion of the information is based on Bureau of Meteorology (BoM) online climate data maps. The "equivalent rainfall" and the "likelihood of rainfall exceeding evapotranspiration" data have been derived separately.

Table 7: Climate Information Summary

Month	ET (mm/ month)	Equiv. Rainfall %-ile to ET	Rain Days >10mm	Rain Days >5mm	Lowest %-ile Rainfall (mm)	10%-ile Rainfall	Likelihood of Monthly Rainfall Exceeding Monthly ET
Jan	110 -120	70	3-5	5-10	5-10	25-50	30%
Feb	90-100	70	3-5	5-10	1-5	10-25	50%
Mar	90-100	50	3-5	5-10	5-10	25-50	50%
Apr	50-60	50	3-5	3-5	1-5	5-10	50%
May	40-50	20	2-3	3-5	1-5	10-25	80%
Jun	30-40	20	3-5	3-5	5-10	10-25	80%
July	20-30	10	0-2	2-3	0	10-25	90%
Aug	30-40	30	0-2	5-10	1-5	5-10	70%
Sep	50-60	30	0-2	5-10	1-5	10-25	70%
Oct	80-90	70	2-3	5-10	1-5	10-25	30%
Nov	90-100	70	2-3	5-10	1-5	10-25	30%
Dec	100-110	80	2-3	5-10	5-10	10-25	20%

Householders will use recycled water partly for irrigation of lawns, it is assumed that irrigation will not occur during periods when rainfall exceeds evaporation. **Table 7** provides an estimate of the likelihood of surplus water due to low irrigation demand. Water that is not used for irrigation will need be stored or disposed of, thereby contributing to stream flows in the downstream catchment. Based on the climate data, it is clear that irrigation demands can be sufficiently low during any month for there to be SDRW requiring disposal.

The climate information indicated a highly complex and variable situation requiring detailed modelling based actual rainfall data to understand catchment flows and the potential effects of SDRW release.

3.6 CLIMATE CHANGE

The Hunter Climate Change Snapshot (OEH 2014) summarises the results of a range of climate models for the Hunter Region. The relevant short-term climate predictions through to 2039 are increased temperatures, wetter autumns and drier springs.

In the near future (2020 to 2039), the range of modelled rainfall changes are: summer –16% to +9%, autumn –19% to +48%, winter –15% to +16%, and spring –22% to 24%.

In the far future (2060 to 2079), the range of projected rainfall changes are: summer –8% to +22%, autumn –4% to +46%, winter –25% to +30%, and spring –18% to +39% .

By 2030, mean annual rainfall projections for the region range from a decrease (drying) of 13% to an increase (wetting) of 16%. By 2070, and still span both drying and wetting scenarios (–7% to +19%)

The climate change predictions suggest an increasingly uncertain demand for recycled water.

The adopted sea level rise scenario for Lake Macquarie LGA is 0.9 metres by 2100. The effects on beach morphology are addressed by WBM (refer to **Appendix 7**). Also, there may be a gradual rise in lagoon water levels corresponding with rising sea levels. Associated adjustments in riparian vegetation around the lagoon may also occur. Marine influences could extend inland along the lagoon and creek channel.

3.7 HYDROLOGY AND WETLAND TREATMENT OF SDRW

A detailed investigation of the hydrology of the catchment, *Beaches* subdivision stormwater, and potential impact of releases of SDRW has been undertaken by ADW Johnson (refer to **Appendix 5**). The receiving catchment is as shown in **Figure 1**.

Release of SDRW will affect the hydrology of the catchment which is largely land dedicated to conservation. Management of release to protect the hydrological and ecological integrity of the catchment is a priority. The situation is complex due to a variety of receiving environments within the catchment, variable demand for recycled water, natural rainfall and runoff patterns and proposed development within the receiving catchment.

Baseflow (ongoing catchment flows generated from groundwater rather than direct rainfall) in the catchment is estimated to be 95ML per annum. This averages out at 0.26 ML (260 kL) per day minimum flow to the lagoon. Rainfall adds to this minimum flow. At Mixing Point A baseflow is considerably less than the overall catchment baseflow so might be disproportionately affected by SDRW release. Rainfall events are required to generate significant flows in the catchment. Modelling tools are available that allow release effects to be estimated. Mixing Point A is significant because below this point there is permanent good quality aquatic habitat (refer to **Appendix 6**) with a higher potential for adverse effects form SDRW release. Above Mixing Point A the SDRW flow path is a non- perennial watercourse with no defined bed or banks.

Modelling using MUSIC and 35 years of Williamtown rainfall records has been used to develop an appreciation of recycled water demands and natural system variability. This was then used to assess potential water quality and quantity effects of SDRW release downstream of the subdivision. The modelling covers a range from extremely dry years (e.g. 1980 with 531 mm of rainfall) and extremely wet years (e.g. 1990 with 1738 mm of rainfall). The modelling thus covers a representative range of rainfall variation.

Multiple modelling iterations were used to develop a management and release strategy to minimise adverse flow impacts and protect aquatic ecology. Based on this work the proposed system of system of wet and dry SDRW releases was developed and refined.

The hydrology work also provided opportunities to review utility operations with a view to improving the sustainability of the utility and SDRW releases. This led to increased storage for SDRW on the site and the addition of wetland treatment of effluent to improve water quality. The potential for use of a wetland on the CHB utility site to improve SDRW water quality has been investigated by Whiteheads and Associates (refer to **Appendix 8**).

A wetland on the treatment plant site can provide water quality improvements, including de-chlorination and nutrient and pathogen removal, prior to tank storage and release of SDRW. In particular, the wetland treatment will remove nutrients and all free chlorine from SDRW release. Free chlorine is highly toxic to many aquatic species. The wetland assessment includes both the likely hydraulic and pollutant loadings with allowances for direct rainfall on to the wetland and evaporation.

The wetland treatment significantly reduces the pollutant load in the SDRW but complicates the hydrology of release.

The modelling has adopted a conservative SDRW quantity assumptions (i.e. approx. 10 % refer to **Table 8**) to ensure that potential hydrological impacts and pollutant loads are not underestimated. The modelling also separates the effects of the proposed SDRW release, for which approval is sought, from the effects of the already approved stormwater release under the *Beaches* subdivision approval. The *Beaches* approval was on the basis of dwellings having rainwater tanks but these are to be discontinued due to the availability of recycled water. The modelling addresses the effect of rainwater tank removal.

The SDRW volume calculations are summarised in **Table 8**.

Table 8: Recycled Water Demand for Proposed 550 ET Development

Recycled Water Demand	Units	Min 'Wet Day'	Mean	Max 'Dry Day'
Baseline Recycled Water Demand	kL/day	110.0	110.0	110.0
Climate-based Recycled Water Demand		0	82.5	495.0
Total Recycled Water Demand		110.0	192.5	605
Surplus-to-demand Recycled Water		162.3	90.2	0 (-326.7*)
Conservative Surplus-to-demand Recycled Water		162.3	100.0	0

*Negative indicates a shortfall in recycled water availability which will be met by potable supply.

The breakup of recycled water demand for in the subdivision is provided in **Table 8**. There is a base demand for recycled water that doesn't change on top of the base demand is climate based change which varies depending on the weather. Wet (rainy) days are assumed to have no climate based demand. Dry days are assumed to have a demand estimated to peak at 495 kL/day. Overall, a daily excess of 90.2 kL/day is estimated, but is increased to 100 kL/day for conservative assessment purposes. Storage of up to 5 ML for SDRW will be provided on the STP site to optimise managed release.

The SDRW will be 'wet' released with stormwater from the *Beaches* subdivision which will provide an initial dilution. Once the SDRW reaches Mixing Point A it will be further diluted by flows in the main creek of the catchment. Further dilutions will occur as other catchment flows join the main stream with maximum dilution achieved at the lagoon. The overall dilutions achieved are shown in **Table 9**.

Dry release will occur as the storage limits for SDRW are approached and will be direct to the lagoon. Dry release will be required because of the absence of adequate diluting flows.

Table 9: Dilution of Proposed SDRW Wet release

Section of Flow Path	Mean stormwater flows (ML/yr)	Mean stormwater flows + SDRW (ML/yr)	SDRW Mean flow proportion	Dilution achieved
To Stages 6 & 7	86.8	119.5	34%	3:1
To Mixing Point A	132.2	165.0	20%	5:1
To lagoon	478.1	511.5	7%	14:1

Overall, significant dilutions are achieved within the system. However, the effect of individual releases and the likely extremes also need to be considered.

Table 10: Modelled SDRW release maxima

Peak SDRW Releases			
Year	**Volume ML**	**Catchment Flow ML/yr**	**Comment**
Maximum Wet release 1976 & 1999	39.5	> 593	>1350 mm rainfall in consistently wet years
Maximum Dry release2004	4.0	> 211	periods of lower rainfall (but not dry) over 2 to 3 months

The wettest year in the modelling period was 1990 with 1,738 mm of rain at Williamtown. For 1990 there was 38 modelled wet releases during an annual flow of 754 ML.

The driest year was 1980 with 541 mm of rainfall at Williamtown. Despite the extremely dry year zero modelled dry release occurred while still requiring 23 wet releases.

The maximum modelled wet release is 40.9 ML and occurred in two calendar years. The rainfall and flows for these two years were 1382 mm for a 593 ML flow and 1541 mm for a 754 ML flow. The wet release maximum for the modelled years represents 6.8% and 5.4% of annual flows through the lagoon.

The maximum modelled annual dry release is 4.0 ML and occurred for 2004. In 2004 catchment flow was 303 ML from 1,115 mm of rainfall. In 2004 the dry release followed 73 days and 57 mm of rain without wet release. For the year of maximum dry release, the volumes represent 1% of annual flow through the lagoon. No dry release was required for 23 of the 35 year modelling period.

Wet release is related to a lack of demand for recycled water while dry release is due to an extended absence of rainfall events sufficient to generate stormwater/baseflow and therefore streamflow in the catchment.

Table 11: Modelled SDRW release averages over 35 years

Mean SDRW release			
	Volume (ML/yr)	**Frequency (pa)**	**Total over 35 years**
wet release	32.8	28 to 40	1,147
dry release	0.7	< 1	14

The dry releases, at the volumes and frequency required, are a minor proportion of flows through the lagoon.

Table 12: Modelled Monthly Dry Release Totals During 1974-2008

Number of SDRW Dry Releases							
Month	**May**	**Jun**	**July**	**Aug**	**Sept**	**Oct**	**Total**
Number	1	2	6	8	6	2	25

The modelling shows dry release occurring in cooler and generally drier months. This is consistent with the local climate information and hydrology. This is a drier period and mostly cooler.

The STP treatment processes and wetlands will remove the majority of the pollutant load from the *Beaches* subdivision wastewater. The removed pollutants will be disposed of as sludge from the MBR process. Some will also be removed as wetland vegetation.

The wetland treated SDRW will still have the potential to effect catchment water quality. Both concentrations and annual loads in the SDRW are relevant for assessment and licensing purposes. The scale of change in concentrations and loads is shown in **Tables 13** and **14** for Mixing Point A and the lagoon. Mixing Point A is just above where the SDRW enters confirmed aquatic habitat (refer to **Appendix 6**).

The “approved” column in **Tables 13** and **14** shows modelled pollutant loads based on the stormwater from residential Stages 6 and 7 under the *Beaches* subdivision approval (ie, with rain water tanks). The “proposed” column adds the effect of rain water tank removal, plus SDRW releases.

Table 13: Average pollutant concentrations and loads at Mixing Point A

Parameter	Units	Development Scenario		% Change
		Approved	Proposed	
Flow	ML/day	0.327	0.452	38
	ML/yr	119.2	165.0	
TN	mg/L	1.57	1.96	25
	kg/yr	202	323	60
TP	mg/L	0.118	0.128	8
	kg/yr	15.1	21.1	40
TSS	mg/L	29.3	24.6	-16
	kg/yr	3,790	4,060	7
TDS	mg/L	200	359	80
	kg/yr	25,800	47,500	84

Table 14: Average pollutant concentrations and loads at the lagoon

Parameter	Units	Development Scenario		% Change
		Approved	Proposed	
Flow	ML/day	1.27	1.4	10
	ML/yr	465	511.5	
TN	mg/L	1.22	1.38	13
	kg/yr	566	704	24
TP	mg/L	0.13	0.132	2
	kg/yr	61	67.6	12
TSS	mg/L	51.3	47.9	-7
	kg/yr	23,900	24,500	3
TDS	mg/L	200	252	26
	kg/yr	93,000	129,000	39

Tables 13 and **14** show the modelled changes in water quality at key points in the catchment. **Table 14** shows inflows from the catchment to the lagoon but takes no account of marine influences. Seawater has a TDS of 35,000 mg/l and occasionally floods the lagoon. The lagoon is described as "brackish" by the aquatic ecology report which is generally considered to be waters having TDS above 500 mg/l. SDRW at the modelled levels would be likely to have a diluting effect on the TDS levels in the lagoon.

3.8 AQUATIC ECOLOGY ASSESSMENT

An investigation of the aquatic ecology of the watercourses and catchment between the *Beaches* subdivision and the ocean has been undertaken by Marine Pollution Research (refer to **Appendix 6**). The report assesses both aquatic and riparian habitat quality, aquatic species assemblage, likelihood of effects on threatened species, and effects of the proposed SDRW release from both quality and quantity perspectives. Recommendations for ongoing monitoring and for habitat quality improvement are provided.

Figure 5 below is an extract from the aquatic ecology report showing approximate extent of relevant habitats in and adjacent to the lagoon.

Figure 5: Vegetation adjoining Lagoon.

In **Figure 5,** red is fresh water swamp and EEC, yellow is fresh to brackish swamp and blue is brackish lagoon with fringing *Phragmites*.

The areas identified by red and yellow in **Figure 5** are wetlands and were assessed as receiving drainage from the north rather than the west. The drainage from the north to the wetlands reduces the likelihood of impacts from SDRW release.

The area marked blue is the landward section of the lagoon, this is subject to direct marine influences and consequently has the potential to show estuarine characteristics. In the area adjoining the lagoon there were no saltmarsh stands or patches found and there are no mangroves. There are no seagrass beds, patches or any other submerged aquatic plants in the brackish lagoon waters or in the beach lagoon. The lagoon was assessed as degraded habitat.

Upstream of the red area shown in **Figure 5**, the receiving waters flow through forested areas which substantially shades the aquatic habitat. Upstream of the lagoon to the point where 'wet' releases will join the main stream (i.e. at Mixing Point A) there is reasonable quality aquatic habitat.

In the side creek (from the subdivision to Mixing Point A) that will deliver SDRW from wet release there is no significant aquatic habitat. This watercourse has adapted to its previous role as providing drainage from coal reject stockpile areas.

Quoting directly from the aquatic ecology report:

> *The small lagoon is not listed in the Roper et al (2011) condition survey of NSW Estuaries and Coastal Lakes. It is degraded and substantially in-filled by sand brought down from the creeks and brought in by high seas and tides. At the time of inspection in August 2016, there was still substantial indication of storm wave ingress into the lagoon and up to the southern boundary of the property closest to the bridge.*
>
> *The brackish lagoon extends around 80m upstream from the eastern end of the road bridge to the top of the Phragmites bed, the actual open water section upstream of the bridge only extends 40m up and narrows quickly to around 1m at the creek connection.*
>
> *Beyond the bridge there is a beach ponded water lagoon with a width of 10m under the bridge to 15 m width between the old rail bridge revetments (Figure 14). This ponded beach lagoon then meanders across the beach with the meanders varying from due north through east to due south before discharging to the sea.*

Generally, the aquatic ecology assessment found a catchment adapted to a range of disturbances but which still retained some reasonable quality aquatic habitat including a notable absence of the introduced plague minnow (*Gambusia holbrooki*). Several native fish species were found.

As a result of past mining, urban development and marine influences, the ecology was considered adapted to the likely impacts of addition of SDRW via the proposed wet and dry releases to the system.

The findings of the report are quoted directly as follows.

What are the ecological and riparian resources and attributes of the study area aquatic habitats?

- *The study area catchment supports a network of well-forested streams with excellent native riparian vegetation and areas of freshwater swamp all draining to a small estuarine lagoon that is not generally tidal and is choked with marine and catchment sourced sandy sediments. There is an intermittent beach lagoon east of the road bridge.*
- *The small estuary section west of the bridge can be considered a degraded ICOLL by virtue of the infilling with sediments. Even though it is very small and not very complex, it still provides habitat for fish, macroinvertebrates and emergent macrophytes.*

  The lagoon is relatively close to, and connected to freshwater wetlands in the lower main creek around the confluences of the two low elevation northern creek subcatchments (NE and NW) and therefore retains the important function of a transition zone for fish migrating to and from the catchments to the ocean via the intermittent beach lagoon.

Do the creeks provide suitable fish passage?

- *The main creek extending through to the estuary is permanent and is expected to provide more or less permanent fish passage except under severe prolonged drought.*
- *The smaller creeks in Sub-catchments 3, 4 and 5 do not provide permanent fish passage but could provide fish passage during prolonged wet weather and could enable some species to reach the lower parts of the network of small water quality dams remaining from previous coal stockpile water control.*
- *It is unlikely that creeks in the smaller sub-catchments (Sub-catchments 1 and 5) would provide fish passage except under prolonged wet weather events.*

Do the aquatic resources provide suitable and sustained aquatic habitat for fish and other aquatic biota?

- *Aquatic habitat condition for most of the sites located on, or clustered around the main creek and its confluences, was fair to good overall and sufficient to support a reasonably diverse aquatic assemblage. However there are some water quality constraints relating back to catchment attributes (moderate conductivity and TDS, slightly acid pH, elevated nutrients) and land use attributes (uncontrolled access to dirt roads leading to instability and consequent large sediment loads transported to the main creek during wet weather).*
- *As a result there were less pollution-insensitive species of macroinvertebrates and fish found, and lower than expected SIGNAL indices for most sites below WN.*
- *The accumulation of muddy sediments at site WM would indicate that there is not sufficient scouring flow during wet weather events to mobilise these sediments, and this may be due to the network of water quality control ponds in the top section of the catchment.*

Are there or is there a possibility that any protected or threatened aquatic species or communities could be residing within the study area, or could mammals such as platypus and Australian water rat utilise the aquatic resources of the study area?

- *This study has concentrated on investigation of the water quality and ecology of the lower main creek area .... in Sub-catchments 2 and 3 ..... The extent and precise nature of the swampy areas identified adjacent to the main creek ... have not been quantified for this study and there remain further possibilities that there are additional swampy areas in the creek lines of Sub-catchment 2.*
- *In regard to protected or threatened aquatic species, the overall aquatic site condition information for the freshwater creek and the small estuarine section plus the aquatic macroinvertebrate and fish sampling data would indicate that the lower creek section is unlikely to support threatened aquatic species. Nevertheless, there could be suitable aquatic habitat in upstream swampy pockets that could support some threatened species. This would require further investigation.*
- *The study area is unlikely to support platypus, but the lower sections around the lagoon provide suitable habitat for Australian Water Rat.*

The overall conclusion of the aquatic ecology report was:

As indicated from the combined water quality and aquatic ecology sampling results provided in Sections 1.2 and 1.3 above, the creek aquatic ecology in the vicinity of the urban areas is already compromised by elevated nutrients and suspended solids resulting from uncontrolled erosion of forest tracks plus urban derived run-off and septic tank *overflows. Accordingly the assemblage of fish, aquatic plants and macroinvertebrates in the streams below the proposed wetland-treated recycled water discharges (i.e., in the lower creek and the lagoon) is characterised as a relatively pollutant tolerant assemblage. The incremental changes from the approved discharge water quantity and quality to the proposed discharge water quantity and quality is not considered great enough to result in any measurable change in the overall aquatic habitat condition or aquatic assemblages that occur in the lower creek and lagoon.*

The recommendations of the aquatic ecology report were as follows:

- *Ensure that access to motorised vehicles into existing trails from the development is controlled and/or strictly limited.*
- *Work with OEH and the Community to establish controls to limit continuing erosion from track use including measures such as limiting access plus undertaking active track erosion control works.*
- *Work with OEH to explore remediation options for removing excess sediments from the brackish lagoon.*
- *Investigate options for additional sediment control into the creek from the small urban catchments.*
- *Undertake lagoon riparian edge weed eradication works at the Lindsley Street stormwater discharge easement.*
- *Work with the community to minimise sewage overflows by encouraging connection of the existing urban areas to the Beaches TP.*

Whilst the potential for physical harm to aquatic habitats and biota arising from construction activities and increased discharge flows is considered, low residual risk can be minimised by adopting the following management measures during the early stages of the development:

- *Creek WM and the main creek line leading to the lagoon will require visual inspection monitoring to ensure timely remediation works can be instigated if localised bank or bed erosion is noted; and*
- *The proponent should prepare a Discharge Structure and Creek Stabilisation Management Plan that sets out (i) a monitoring regime covering discharge structures and creek/lagoon performance in regard to bank stability and erosion, and (ii) criteria for instigation of stabilisation works and remediation actions that could be implemented.*

The proponent should prepare a Water and Aquatic Ecology Monitoring Program to include:

- *Regular (say monthly initially) sampling of three sites around Mixing Point A – the discharge waters in Creek WM, and sub-catchment 2 waters above Mixing Point A and the combined waters below Mixing Point A (but upstream of urban and track erosion influences).*
- *Discharge event monitoring of the Wet Weather Discharge sites (at least during and after discharge).*
- *Event monitoring of lagoon waters up- and downstream of the Dry Weather Discharge (two sites) prior to, during and after dry weather discharge events.*
- *Bi-annual (spring and autumn) stream health sampling at the above water quality sites using similar methods to those outlined for this present study in Section 1.3.1 above.*

The above program should be undertaken over sufficient events to validate the modelling and provide operational results for the Proponent against which the effectiveness of the WTP and wetland can be measured. Should process remediation actions be required, the monitoring program should include a TARP (Trigger, Action, Response Plan).

3.9 COASTAL PROCESSES ASSESSMENT

The release of SDRW has the potential to cause physical impacts to the beach and lagoon via the proposed additional flows. An assessment of likely impacts has been undertaken by WBM (refer to **Appendix 7**).

WBM assessed potential changes to the creek entrance from increased flow with regard to coastal processes including hazards and climate change.

The beach lagoon was found to be directly connected to the ocean some 73% of the time. The remaining 23% of the time the lagoon was fully shoaled with no surface flow to the ocean. There would still be a hydraulic connection between the lagoon and the ocean via groundwater flows. The rate of flow of the lagoon to the ocean through the beach sands is addressed in the Hydrology Assessment.

The only potential effect of SDRW release was found to be a 1% increase in the likelihood of the fully shoaled lagoon overtopping the dunes and flowing to the sea. This effect was assessed as minor.

No management or mitigation recommendations were made in the coastal process report.

Image 3: The lagoon west of the Flowers Drive culvert following storm wave ingress - June 2016.

4.0 Statutory Considerations

The range of statutory assessment requirements under NSW legislation that apply to the proposed changes to the utility and the proposed release of SDRW are in summary: Part 5 EPA Act, s.228 EPA regulation 2000, POEO Act, FMA Act, TSCA Act, NPW Act, EPBC Act. SEPP Infrastructure 2007, SEPP 71 Coastal Protection, and local environmental planning instruments.

The scope of these legislative requirements includes approvals and permissibility, and assessment and management requirements and considerations.

4.1 PERMISSIBILITY & APPROVAL REQUIREMENTS

The CHB water utility being a recycling plant/STP is already approved and is located on land zoned for STP infrastructure. Changes to the CHB water utility operations and design are thus permissible under the applicable SP2 Infrastructure (Sewage Treatment Plant) zoning and are consistent with the existing approval.

Off the CHB utility site, the changes proposed are addition of the SDRW release points to the sewage reticulation system. Both release points are within the scope of works approved under MP 10_204, the approval for the *Beaches* subdivision. Both proposed release points and any associated works are permissible under ISEPP 2007 as part of a sewage reticulation system.

Consistent with the definition of sewage reticulation system below the Stages 6 and 7 sewage reticulation system is included for approval as part of this REF addendum.

s.106(3) of ISEPP provides for the approval of sewage reticulation systems as follows:

(3) Development for the purpose of sewage reticulation systems may be carried out:
(a) by or on behalf of a public authority or any person licenced under the Water Industry Competition Act 2006 without consent on any land, and
(b) by any other person with consent on any land.

However, such development may be carried out on land reserved under the National Parks and Wildlife Act 1974 only if the development is authorised by or under that Act.

***sewage reticulation system** means a facility for the collection and transfer of sewage to a sewage treatment plant or water recycling facility for treatment, or transfer of the treated water for use or disposal, including associated:*

(a) pipelines and tunnels, and
(b) pumping stations, and
(c) dosing facilities, and
(d) odour control works, and
(e) sewage overflow structures, and
(f) vent stacks.

The definition makes it clear that the transfer of treated water for disposal is part of a sewage reticulation system and thus requires no separate approval.

The proponents CHB Water Utility hold a WICA licence so approval as development without consent (i.e. no development application is required) is the appropriate approval pathway under s106(3) (a) of ISEEP 2007.

Development of either a sewage reticulation system or treatment plant /recycling facility is not proposed on land reserved under the National Parks and Wildlife Act 1974 so the exclusion under s.106 does not apply.

The release of SDRW is ancillary to the subdivision and utility operation and does not of its own require approval. However, the effects of the SDRW release must be assessed because of the potential for environmental impacts and, in particular, for EPL licensing.

Any potential impacts of the disposal of the SDRW must be considered as part of the utility and reticulation system and requires, as development without consent under ISEPP, environmental assessment under Part 5 of the EPA Act.

4.1.1 EPA Act 1979

Development without consent requires assessment in accordance with Part 5 of the EPA Act. An REF in accordance with section 228 of the EPA Regulation must be prepared. An REF has specific heads of consideration under s.228. There is also a requirement under Part 5 to undertake environmental assessment to the fullest possible extent which extends the scope of considerations beyond the scope of s.228.

The specific purpose of an REF is to determine if there will be a significant effect on the environment as result of a proposal. If a significant impact is likely then the assessment process moves to an EIS before a proposal can be approved.

4.1.2 Section 228 EPA Regulation 2000

The specific considerations under section 228 are addressed in the compliance tables in **Appendix 9**. No significant effects were found likely under the s.228 heads of consideration.

4.1.3 POEO Act 1991 Licensing of the SDRW Release

Disposal of water to the environment requires licensing where there is the possibility of causing pollution. Consultation with the EPA about SDRW release has produced a set of specific consultation requirements that include POEO Act matters.

There are statutory requirements under the NSW (POEO Act) that underpins the EPA letter mostly being Section 45 of the POEO Act. These objectives are addressed in detail in the compliance tables (refer to **Appendix 9**).

4.1.4 Objectives of the EPA

The objectives of the EPA as specified in Section 6 of the POEO are required to be addressed under clause 45(b) of the POEO. These objectives are addressed in detail in the compliance tables (refer to **Appendix 9**).

4.1.5 Fisheries Management Act 2004

The purpose of this legislation is to protect NSW aquatic, estuarine and marine habitats and species. Where effects are likely FMA assessment processes apply. If a significant effect is found likely under the assessment process then an SIS is required.

As the proposal to release SDRW will not remove any subject vegetation or riparian habitat, affect fish passage or significantly affect any listed threatened species under the FMA (refer to **Appendix 6** Aquatic Ecology Assessment) the need for a 7 part test is not triggered. Accordingly no SIS is required.

4.1.6 Threatened Species Conservation Act 1999

The purpose of this legislation is to protect INSW terrestrial habitats and species. Where effects are likely the TSCA assessment process applies. If a significant effect is found likely under the assessment process then an SIS is required. Works on land for the reticulation system and SDRW release points will be in areas already converted for urban development. Works on the utility site are over an already cleared area. No natural terrestrial habitat will be affected by works. As such no significant effect on terrestrial threatened species is likely.

A listed key threatening process under the TSCA is Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands. While there will be additional flow as a result of the SDRW, the release process will be managed to protect the natural flow regime by ensuring no flows during naturally dry periods and by keeping flows within the natural range.

Based on the findings of the aquatic ecology report and the absence of any impact on terrestrial ecology and habitat he need for a 7 part test under the TSCA is not triggered and an SIS is not required.

4.1.7 Environment Protection & Biodiversity Conservation Act

This is Commonwealth legislation with the purpose of protecting matters of national environmental significance (NES).

An EPBC protected matters report was obtained for the locality (refer to **Appendix 10**). The search only identified lists of threatened and migratory species. Based on the aquatic ecology assessment and the absence of effects on habitat generally, no NES matters are engaged. No significant effect on any of the EPBC listed species is likely.

No referral to the Commonwealth for approval as a controlled action under the EPBC is necessary.

4.1.8 Land Use Zoning

The proposal is subject to two separate Lake Macquarie LEPs.

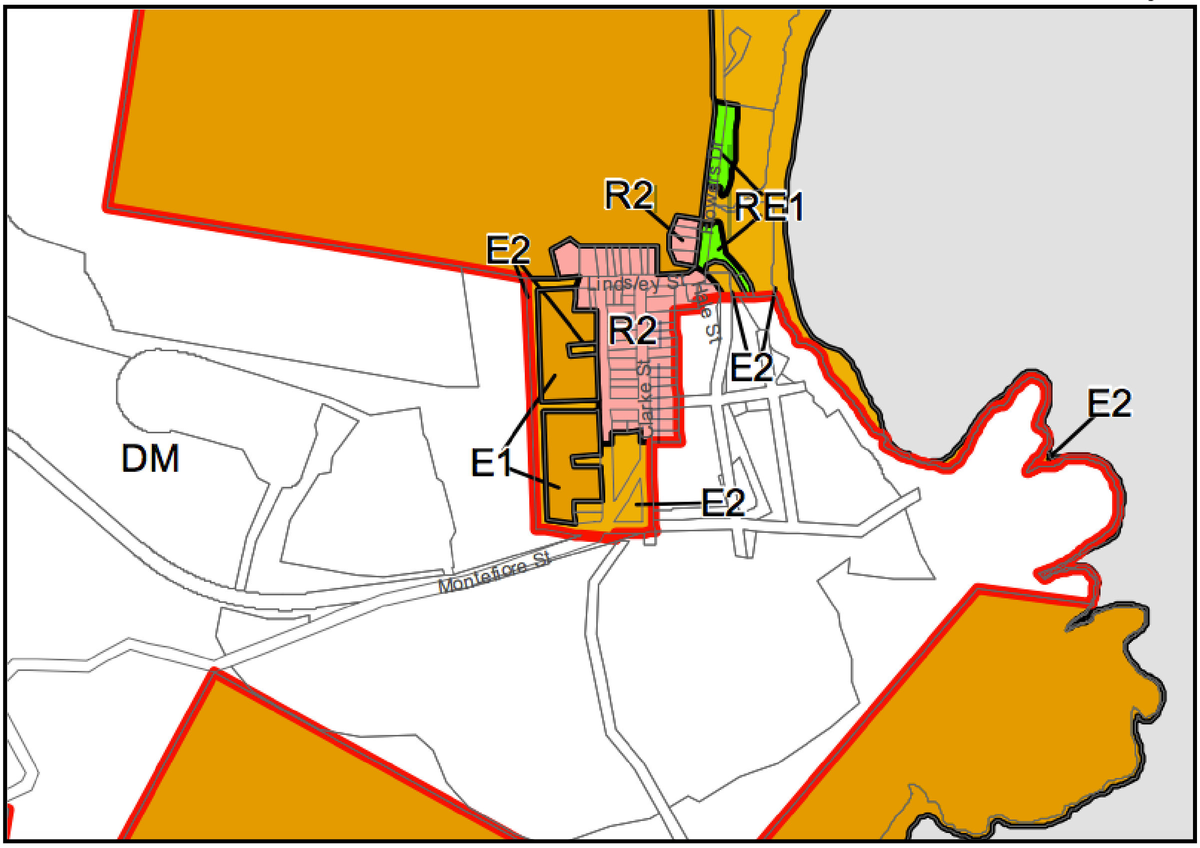


Figure 6: Extract LEP 2014 Catherine Hill Bay zone map.

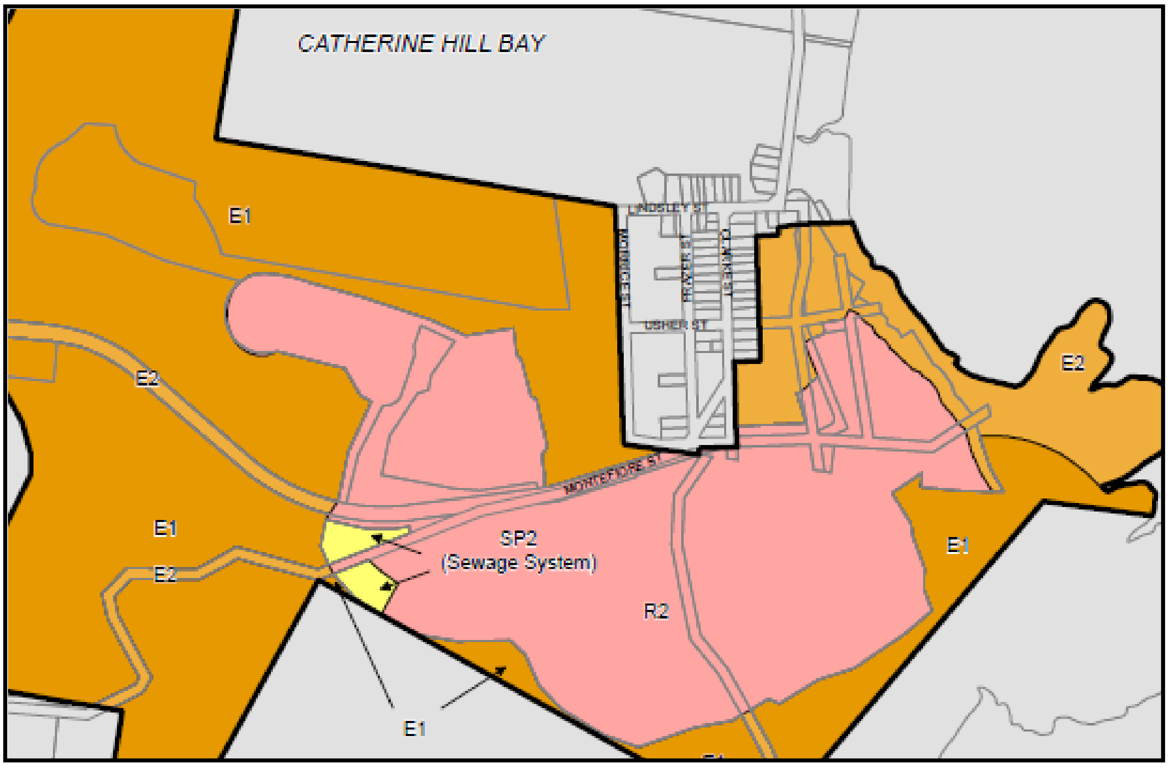


Figure 7: Extract LMCC LEP 2004 Catherine Hill Bay Zone map.

The wetland works and SDRW storage tank will be located within the approved utility and located in an SP2 Infrastructure (Sewage System) zone. All changes to the STP come under the SP2 zone.

The SDRW release points and additional pipe work will be located in the R2 zone (LEP 2004 and 2014) with flow also through E1 zones (LEP 2004 and LEP 2014) and E2 zone (LEP 2014).

4.1.9 Compliance with Zone Objectives

No development or change of use is proposed in the E1 zones but there will be increased flows due to SDRW release.

The location of a wetland and other changes to CHB Utility operations in the SP2 (Sewage System) zone is consistent with a provision of stage and related services.

The location of SDRW release points in the association with stormwater flow paths is unlikely to compromise residential zone amenity.

The relevant zone objectives are addressed in detail in the relevant compliance tables (refer to **Appendix 9**).

There are no significant conflicts with any zone objectives.

4.1.10 National Parks and Wildlife Act 1974

The release of water to land managed under the NPW Act needs to be consistent with the objectives of that Act as detailed in section 2A of that Act. These objectives are addressed in detail in the compliance tables (refer to **Appendix 9**).

4.1.11 Munmorah SCA Plan of Management

The land immediately north of the R2 zone is part of Munmorah State Conservation Area and was dedicated as part of the Catherine Hill Bay subdivision approval process. The land was added after preparation of this Plan of Management but the objectives are still relevant to the proposal. These objectives are addressed in detail in the compliance tables (refer to **Appendix 9**).

There are no significant conflicts with any SCA management objectives.

4.1.12 Non Statutory Assessment Considerations

There is also a range of non-statutory considerations for this project in particular those identified in the EPA requirements as received by ADW Johnson on 6 July 2016 (refer to **Appendix 4**).

There are also matters such as the Australian Wastewater Recycling Guidelines which provide advice on risk assessment and monitoring and the NSW Water Quality Objectives. Risk management tables prepared in accordance with the guideline are provided as **Appendix 11**.

4.1.13 Specific EPA Assessment Requirements

Consultation was undertaken withe the Newcastle office of the NSW EPA. As a result specific assessment requirements were identified for the current proposal, refer to **Appendix 4**.

In summary these requirements are:

- s.45 POEO Act;
- NSW water quality objectives;
- Practical measures to avoid discharge to waters;
- Explanation of the treatment plant process and the benefits and cost of the various options considered;
- Details of reverse osmosis waste disposal;
- De-chlorination details;
- Predicted volumes of surplus water;
- Provision of mixing model results based on a range of hydrological conditions;
- Impacts on the coastal lagoon;
- Ongoing maintenance and management of SDRW; and
- Management and mitigation measures to reduce impacts on hydrology and water quality.

4.1.14 ANZECC Water Quality Guidelines 2000

These guidelines provide a summary of the desirable quality for water for a range of uses including aquatic ecosystem protection.

The guidelines (Chapter1 Box 1.1) provide the following advice:

> *For water whose environmental value is aquatic ecosystem protection, for example, the investigation should aim to develop and adapt these guidelines to suit the local area or region.*
>
> In this case aquatic ecological and hydrological studies have been undertaken to directly assess the capacity of the receiving waters to accommodate the proposed SDRW releases.

4.1.15 Australian Guidelines for Water Recycling: Managing Health & Environmental Risks 2008

The guidelines provide examples of preventative measures for recycled water systems including wetlands and detention to improve water quality. The guidelines also provide a risk assessment process for recycled water use. Risk management tables for SDRW release based on the guidelines are provided as **Appendix 11**.

4.1.16 NSW Water Quality & River Flow Objectives

The SDRW receiving waters are unclassified under the existing mapping (refer to **Figure 8**). This mapping considerably predates the *Beaches* subdivision approval and the dedication of adjoining land for management under the NPW Act 1974.

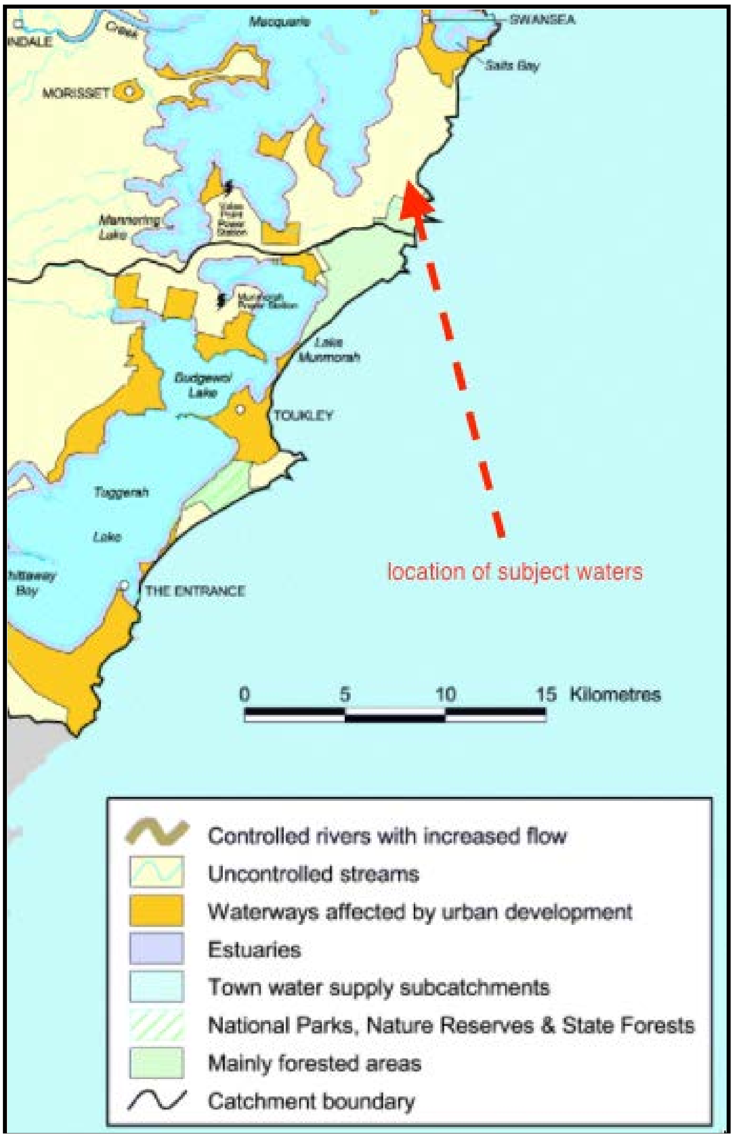


Figure 8: Extract of Lake Macquarie and Tuggerah Lakes Water Quality and River Flow Objectives Map.

Under the river flow and water quality objectives system the receiving water falls under a number of potential categories including land affected by urban development, national parks and nature reserves etc. and mainly forested area even though it is not mapped as any of these.

For the purpose of this assessment, the category of mainly forested lands has been adopted as there are no specified objectives for national parks. The objectives that apply are:

Water Quality Objectives

Protection of:

- Aquatic ecosystems;
- Visual amenity;
- Secondary contact recreation; and
- Primary contact recreation.

River Flow Objectives

- Protect pools in dry times;
- Protect natural low flows;
- Maintain natural flow variability;
- Manage groundwater for ecosystems; and
- Minimise effects of weirs and other structures.

These objectives are addressed in detail in the compliance tables (refer to **Appendix 9**).

4.1.17 Lake Macquarie DCP 1

This DCP applies to land outside the *Beaches* subdivision. Part 7 of DCP covers development in environmental protections zones. As the SDRW release path is through LMCC E1 zones controls covering natural watercourses are relevant. These controls are addressed in detail in the compliance tables (refer to **Appendix 9**).

4.1.18 Catherine Hill Bay (South) DCP

This DCP applies to development within the *Beaches* subdivision. There are no controls that apply directly to the proposed changes to the STP, STP management or reticulation system.

4.2 CONSULTATION

As part of development of the SDRW release consultation has been undertaken with the EPA (refer to **Appendix 4**) and with Hunter New England Health (HNEH). Lake Macquarie City Council has been advised of the proposal.

The HNEH meeting was with the Environmental Health Manager - Population Health on 24 January 2017. The outcome was that there were no concerns with health issues resulting from release of SDRW because the treatment standard was to 'firefighting' quality in accordance with the Recycling Guidelines.

Consultation is required under Clause 13 of ISEPP 2007 with local Council's where there is a chance of significant impacts on Council Infrastructure which is highly unlikely for this particular proposal.

The NSW Office of Environment and Heritage is likely to be a specified authority under Clause 16 of ISEPP 2007 as the proposed works are on land adjoining a SCA.

The statutory requirement is that the works be notified to the relevant authorities before they are carried out. In this case, with the likely referral of the REF to both Council and OEH as part of the WICA licence changes application, direct consultation will not be necessary. Should referral not occur as part of the WICA licence application then the CHB Water Utility will need to undertake any required statutory consultation prior to undertaking works or implementation measures related to the current proposal.

5.0 Environmental Assessment

The relevant assessment matters are:

- Development of the preferred disposal option;
- Likely environmental impacts;
- Mitigation of impacts;
- The EPA requirements;
- Conditions of approval; and
- Completion of statutory duties to assess impacts.

5.1 DEVELOPMENT OF THE PREFERRED OPTION

Initially nine options for disposal of SDRW were identified and referred to the EPA. The EPA agreed to further consideration of the top three ranked options and encouraged the maintaining of an irrigation area within the subdivision. Accordingly, four options were considered, as follows:

- Ocean outfall;
- Retain onsite irrigation area;
- Release to adjoining downstream waters (outflow at south end of Middle Camp Beach); and
- Release to remote waters at Middle Camp Gully (outflow at north end of Middle Camp Beach).

The identified preferred option would then be assessed in detail via various studies and then refined for reduced impacts. The refinement process results in the preferred option being weighed against the other options which were not refined.

It is noted that connection to Hunter Water sewer, as originally proposed in the *Beaches* subdivision approval, relied on other developments to contribute to the substantial infrastructure costs. Doubt over the timing of the other developments lead to the approval of the current utility arrangements. Connection to Hunter Water sewer for disposal of SDRW is neither economic nor sustainable, as such it was rejected as a viable option.

The extensive hydrological studies and detailed climate information highlighted that the irrigation option as proposed and approved was an unrefined approach to SDRW disposal with potentially higher impacts than expected. It is likely that the irrigation area option lacks the capacity to adequately respond to the constraints of local climate variability. As a result, the irrigation option would likely result in runoff and groundwater affecting catchment baseflows, with the potential to unduly affect natural wetting and drying cycles of the affected watercourses in the conservation area.

Assuming protection of environmental values is the primary guiding principle for SDRW disposal. The relative merits of the four options are compared in **Table 15**.

Table 15: SDRW disposal options evaluation

Comparison Criterion	Ocean Outfall	Retain Irrigation Area	Preferred Option of Release to Adjoining Waters	Disposal to Remote Waters of CHB Creek
Economics / establishment cost	**4** Likely very high additional establishment costs.	**3** Poor, lowers subdivision yield and raises relative utility management costs and lowers economies of scale also irrigation pumping costs.	**1** Best despite additional cost of onsite wetland & ongoing release management costs.	**2** Poor additional infrastructure and management costs to pump and pipe SDRW.
Sustainability	**3** Lower as RO retained with RO waste disposal problem.	**4** Lower as RO retained with RO waste disposal problem.	**1** Best eliminates RO energy & waste disposal problems.	**2** Moderate due additional pumping and maintenance costs.
Manageability	**1** Lowest management effort required.	**4** Low as SDRW storage capacity issues during wet periods & potential for effect on downstream baseflows during otherwise dry periods.	**2** Most complex but least likely to result in unintended unforeseen impacts and has greatest potential for adaptive management.	**3** Similar to preferred option.
Environmental impacts	**4** Not directly assessed but likely substantial construction impacts likely	**3** The hydrology assessment indicates that capacity during wetter periods would likely be a problem.	**1** Not significant based on studies outcomes largely due to control of avoidable impacts on wetting and drying cycles.	**2** Much larger and more complex coastal lagoon seen as having higher ecological and conservation values and less direct catchment impacts.
Risk	**1** Risk largely transferred to	**4** RO waste management	**2** Lower due to removal of RO	**3** Similar to preferred option

Comparison Criterion	Ocean Outfall	Retain Irrigation Area	Preferred Option of Release to Adjoining Waters	Disposal to Remote Waters of CHB Creek
	outfall point. No risk to conservation area but any ongoing impacts largely not monitorable. Potentially no RO waste ponds required.	remains an issue no control over potential unmanaged runoff. Little adaptive capacity.	from processing train and increased onsite SDRW storage. Higher adaptive capacity.	but less adaptive capacity and potentially higher impacts in more sensitive aquatic environment.
Score	**13**	**18**	**7**	**12**
Preferred Option Order	**3rd**	**4th**	**1st**	**2nd**

The preferred option has superior economic and management benefits for what is likely to be a similar level of impacts.

5.2 GENERAL OVERVIEW

The proposal is to release high quality (SDRW) in limited and managed volumes to the local environment.

The SDRW to be released is suitable for most forms of domestic use and thus presents near to zero human health risks provided it is not substituted for potable water.

The SDRW has the potential to affect natural systems through both the introduction of additional flows and through increased pollutant loadings.

The approved subdivision provides for the release of urban stormwater. The assessed impacts are those which are expected to result from additional SDRW release over and above the already approved stormwater releases. The potential cumulative impact of stormwater plus SDRW release has been assessed noting that the SDRW is likely to make "no measurable difference". Proposed mitigation is focussed on managing the additional effects of SDRW release.

5.3 REMOVAL OF REVERSE OSMOSIS CAPACITY & WASTE STORAGE PONDS

The removal of the reverse osmosis (RO) capability results in an increased load of total dissolved solids (TDS) in the SDRW compared to what is approved. However with careful management and taking advantage of diluting flows in the catchment salt concentrations can be kept consistent with the existing range of the natural system. The benefits of RO deletion include less energy use, no storage of saline waste on-site and no need to transport saline waste offsite. The potential for seepage of saline RO waste water to adjoining conservation lands, while low, is completely eliminated.

There are no additional impacts subject to adequate management of SDRW release as proposed.

No specific mitigation measures are required.

5.4 INSTALLATION OF SDRW TREATMENT WETLANDS

The sub-surface flow wetlands for SDRW polishing are proposed for the site of the currently approved RO reject ponds. The earthworks required for the wetlands are not significantly different to that which would be required for the RO ponds. The wetlands will need to be planted with salt tolerant species as per the Whitehead and Associates (2017) (see **Appendix 8**) to ensure species are not affected during the initial treatment phase where free chlorine is rapidly off-gassed.

Ongoing management and maintenance of the wetland will be required.

No additional mitigation measures, above those for the construction management of the subdivision, are needed for the earthworks components.

Mitigation

A wetland management plan should be incorporated into a revised Integrated Water Management Plan for the CHB Utility operations.

5.5 ADDITIONAL ONSITE STORAGE FOR SDRW

Additional onsite tanks are to be constructed to provide for an adequate level of flow management of SDRW to the receiving waters. The tanks will be the same height as those already approved, will be under the prescribed 9 m height limit set by LEP 2004, and will not be readily visible from offsite. Any construction impacts can be managed with standard procedures and there are no likely ongoing impacts from the presence of the additional SDRW storage on the site.

There is minimal potential for water quality problems developing within the enclosed SDRW storage tanks. This a low risk and can be addressed as part of ongoing STP Utility management and monitoring.

No mitigation measures are required.

5.6 ADDITION OF SDRW RELEASE POINTS TO THE SEWAGE RETICULATION SYSTEM

The release points are all within the scope of works under major project approval MP10_204. As such the construction can be part of approved infrastructure works, has no significant additional impacts and can be managed as part of subdivision works. Release rates will be capped to ensure design stormwater flow rates are not exceeded and the downstream environment and public safety are not unduly affected. As the release points are directly adjacent to stormwater flow paths, no amenity impacts are anticipated and there is unlikely to be any additional environmental risks created (such as erosional scouring).

Mitigation

No additional mitigation of impacts is required other than compliance with proposed release strategy.

5.7 DELETION OF THE IRRIGATION AREA ADDITION OF RECYCLED WATER RETICULATION

The function of the irrigation area is to be replaced by the system of wet and dry SDRW releases to local waters.

The assessment studies have raised some doubt over the capacity of the irrigation area to cope with the volumes of SDRW and the effects of climate variability even with substantial SDRW storage increases.

Even though the irrigation area is proposed to be deleted the irrigation function is not lost totally. It is estimated that up to 40% of this area, if converted to residential, would remain available for irrigation as landscaped areas around dwellings. Providing for the completion of the approved subdivision over this area improves the economic efficiency of the utility, removes a substantial management requirement for the irrigation area and improves the economies of scale by providing additional customers for utility services.

The addition of the recycled water reticulation system can be managed as part of the subdivision works. As part of the works there will be no construction impacts outside the scope of the environmental management plan required under the subdivision approval. As an essential component of the recycling system the overall environmental impact is likely to be beneficial.

No mitigation measures beyond those proposed for SDRW release are required.

5.8 THE SDRW RECEIVING ENVIRONMENT

The receiving waters are a coastal creek and lagoon system. The proposed SDRW release will increase flows through the system. The receiving water has three separate environments:

- *The water course from the* Beaches *subdivision to Mixing Point A;*
- *The perennial creek from Mixing Point A to the lagoon; and*
- *The lagoon.*

The aquatic ecology report found the receiving waters to be a degraded environment adapted to pollutant loads.

The receiving water course from the edge of the *Beaches* subdivision to Mixing Point A has no aquatic habitat. No significant effects of SDRW release are likely in this area.

There is good quality aquatic habitat from Mixing Point A to the lagoon. This section of the flow path will have short detention times with SDRW an intermittent contributor to flows. The aquatic ecology report has found it likely the main creek is perennial. Perennial flows would provide a post SDRW release flushing effect in the main creek. The perennial baseflow is however likely to be quite low limiting the flushing capacity during dryer periods. The section of the receiving water, above the lagoon, is considered the most sensitive section of the flow path.

Above the lagoon are wetlands that are mostly on side creeks. The side creeks drain from the north. The wetland areas are thus unlikely to rely on, or be overly sensitive to, flows from the main creek which will carry the SDRW. The wetlands may however be sensitive to additional flows in the creek were these to occur during periods of low baseflow.

The inland part of the lagoon is filled with reeds and has no open water. Only a small area of open water exists west of the Flowers Drive culvert. The extent of the lagoon east of the Flowers Drive culvert and over the beach varies considerably depending on prior rainfall and coastal processes. The lagoon has no significant estuarine features but is characterised as brackish. The lagoon is estimated to flow directly to the ocean some 73% of the time.

When the lagoon is shoaled, there is still drainage to the ocean via groundwater flow through the beach sands. In such circumstances, SDRW releases would be expected to pond in the lagoon. The outflow rates of the lagoon when shoaled are still quite substantial. Information provided by WBM (refer to Hydrology report in **Appendix 5**) indicates that outflow accelerates as the water level in the lagoon increases. When the water level in the lagoon reaches 1 m above the Flowers Drive culvert base (invert) the maximum berm height will be exceeded and flow will be direct to the ocean. This provides a natural safety factor for preventing lagoon rises that might otherwise affect adjoining residential properties and the higher quality aquatic and riparian habitats upstream. Adverse effects from flooding of the lagoon due to SDRW release are highly unlikely.

It is known that the lagoon has been artificially opened. Minor to moderate rain events are likely to raise the level of the shoaled lagoon, significant rain events are likely to scour the lagoon entrance and promote flushing of the lagoon. The beach shoal can be overtopped by ocean waves delivering seawater directly into the lagoon (as occurred in June 2016).

A fully shoaled lagoon is where the additional loadings on the system would be expected to have the longest residence time. The lagoon however is likely to have adapted to significant pollutant loadings as the CHB village drains directly to it.

The lagoon and upper creeks are degraded habitat due to a combination of sedimentation, physical alterations and the receipt of drainage from residential and mining development. As a result, the receiving environment has adapted and is assessed as likely to be tolerant of the proposed SDRW release.

SDRW release will likely have very limited effects on the creek system due to short detention times, flushing by baseflow and the likelihood that the majority of natural flow in the catchment will not be affected by intermittent release of SDRW.

The lagoon when shoaled will increase the residence time of SDRW in the system. Significant effects are unlikely due to the adaptation of the lagoon to pollutant loads, occasional inundation by seawater and the high potential rates of water flow through the beach sands.

Mitigation

Operation of the proposed wet and dry release system to protect the more significant aquatic environments.

5.9 WET RELEASE OF SDRW

Wet release will occur when there is sufficient surface water flow to provide minimum levels of dilution to SDRW releases. Wet release will occur at the outlet of the *Beaches* Stages 6 and 7 stormwater system, and be matched in volume against expected flows at Mixing Point A.

Flow rates in the downstream waterways will increase when a wet release occurs, but peak design stormwater flow rates will be unaffected due to the capped discharge rate of approximately 20 L/s. The maximum modelled annual wet release was 39.5 ML, which occurred during both 1976 and 1999. Both years were relatively wet with well above average total flows from the catchment. The greatest potential for impacts is seen to be during periods of lower flow.

When the lagoon is open to the sea there are no significant implications of SDRW release. Larger natural flows provide for regular flushing of the lagoon.

When the lagoon is shoaled (an estimated 27 % of the time), SDRW will be retained in the lagoon and discharged as groundwater through the sand berm. SDRW will be released at a rate which will not lead to rapid water level rise in the lagoon (refer to Figure 5 in **Appendix 5**). Given the volume of a typical SDRW release, it will typically pass through the shoaled lagoon within days.

The lagoon has been found by the aquatic ecology assessment to be degraded habitat and likely to have adjusted to pollutant loadings. The additional salt load (TDS) is unlikely to have a negative impact, as the lagoon is occasionally inundated with sea water so the effects of extremely high salinity are part of the lagoon ecology. While there may be short term cumulative effects from SDRW, the system ecology would effectively be reset by each higher flushing flow and severely disturbed by ingress of seawater.

No human health effects, or effects on recreational amenity are likely due to the quality of the released water.

Overall no significant effects of wet release are likely particularly on the most sensitive aquatic habitats between Mixing Point A and the lagoon. The lagoon ecology experiences, and is adapted to, an extreme range of influences. The aquatic ecology report assessed the likely impact of SDRW release as “unmeasurable” once the impacts of stormwater release from the *Beaches* subdivision are taken into account.

Mitigation

The aquatic ecology report has made a range of recommendations which should be implemented and which will provide for aquatic habitat improvements and monitoring.

The proposed system of wet and dry release must be implemented.

Capping of wet release flow rates at 20 L/s (refer to Section 8.4.1 of **Appendix 5**).

5.10 DRY RELEASE OF SDRW

Dry release will occur when SDRW storage limits are approached and there is insufficient flow in the catchment to provide adequate SDRW dilution. The purpose of dry releases is to protect the more sensitive aquatic and riparian environments in the conservation area during periods of low flow.

The dry release is direct to the lagoon. There are no significant implications of SDRW release if the lagoon is open. There are no implications of dry release for aquatic environments upstream of the lagoon.

Each dry release has been modelled cumulative 1 ML volume. If the lagoon is closed, the dry release SDRW will pond in the lagoon. The rate of dry release should be matched to the expected groundwater flow conditions through the sand berm.

As dry release will occur during the cooler months the potential for impact is reduced as this is the period of least ecological activity. The flow rates of water through the sand of the shoaled lagoon are such that the detention time of dry release in the lagoon will be quite short. Dry release is required so infrequently (12 years out of 35 and a maximum of 3 times in one month during July) that the likelihood of significant effects is low and the chance of cumulative impacts is negligible.

Overall there are no assessed significant effects of dry release likely at the lagoon, with no effect on the more sensitive aquatic habits between Mixing Point A and the lagoon because this section is by-passed.

Mitigation

Adoption of the proposed system of wet and dry release.

Capping of dry release rates for the shoaled lagoon consistent with likely lagoon ground water outflow rates (refer to Figure 5 of **Appendix 5**).

5.11 SCOPE OF MODELLED IMPACTS

The modelling of SDRW release has been conservatively applied and has addressed both means and maxima, where appropriate, to ensure that the full extent of likely impacts has been assessed. Both the quantity and quality impacts of SDRW release are likely to be less than assessed.

Assessed loadings are higher due to conservative modelling assumptions. Mean release volumes used for modelling are likely to be some 20% higher than estimated for the STP operations (refer to Section 10 **Appendix 5**). While concentrations in SDRW are likely to be as modelled, annual loads and volumes are likely to be lower.

The STP process assumes a full and permanent occupancy of 550 ET. This is unlikely in high amenity coastal towns and villages which tend to have more holiday dwellings and lower overall occupancy rates. There likely to be occupancy peaks in summer holidays and on weekends but otherwise a proportion of unoccupied dwellings. This is a factor suggesting further reduced volumes of SDRW and reduced overall pollutant loads. Peak occupancy is likely to be at times of high recycled water demand, occupancy is lowest during cooler and lower recycled water demand periods.

Overall there is likely to be less SDRW release than assessed and potentially lesser impacts. Reduced numbers of dry releases are possible. The predicted pattern of wet release is unlikely to change, being mostly due to climate factors, but both lower frequency and lower volumes of release are possible. An increase in frequency and volumes of SDRW release under operating conditions is highly unlikely due to the use of conservative modelling.

Mitigation

The modelling undertaken is the best indication of likely SDRW release requirements and quantities. To minimise risk, detailed initial monitoring of the STP operations and SDRW releases will be required. Once the actual operating parameters and outcomes are confidently established, monitoring can be reduced. Should outcomes be worse than modelled or assessed, then adaptive management will need to be applied.

The assessment has used much higher loading than likely and has included worst cases. Impacts are thus likely to be less than assessed and proposed mitigation measures effective. This adds to the level of confidence in the assessment findings.

5.12 CLIMATE CHANGE

The only clear climate change trends are increasing temperatures and rising sea levels. Rainfall trends are uncertain but wetter autumns and drier springs are likely.

Increasing temperatures are likely to result in increased demands for recycled water with this potentially leading to reduced SDRW volumes and hence less potential for environmental impacts of SDRW release.

Sea level rise is unlikely to affect SDRW release or recycled water demands.

Increased autumn rain may not have any effect on SDRW release requirements if it comes via more intense rainfall events. Higher catchment flows could assist with wet release management and system flushing.

Drier springs are likely to increase recycled water demand and lead to lower natural catchment flows. It is not clear if an increased climate-based demand for water will offset the likely reduction in wet release opportunities or result in more dry release being required.

Mitigation

None required via for the proposed SDRW release.

5.13 MONITORING REQUIREMENTS

The release of SDRW will not be the only change to the system. There will also be stormwater releases from the approved Stages 3, 6 and 7 of the *Beaches* subdivision which will also pass through then lagoon.

Generally, stormwater discharges are acceptable provided an adequate detention is provided before release to the environment. There are no requirements for the ongoing management and monitoring of stormwater impacts under the *Beaches* subdivision approval.

Based on the studies associated with this assessment, there is unlikely to be a significant stormwater impact. The cumulative impact of stormwater plus SDRW has been assessed by the aquatic ecology report.

For monitoring and management purposes this situation presents a problem as it is unlikely that any adverse changes to the aquatic system will be able to be directly attributable to either the stormwater or the SDRW. The situation is further complicated by untreated drainage runoff to the lagoon from the existing CHB village and roads.

Adaptive management requires monitoring that provides information to guide needed changes. Monitoring of the ecological health of the main creek as recommended may provide general information but is unlikely to able to clearly identify the source of any impacts. Monitoring of the beach lagoon water quality would be unlikely to provide any directly useful management information. Despite the uncertainty the health of the main creek is important and should be monitored until it the scope of any impacts can be established.

The mitigation and monitoring recommendations of the aquatic ecology report should be adopted in full.

A monitoring program is specified in the IWMP for the CHB utility. This will need to be revised and updated to accommodate the proposed changes to STP operations. The Sewage Management Plan and Recycled Water Management Plans required under the WICA Act will need to be updated to include the operational and monitoring requirements of the proposed system.

5.14 ADAPTIVE MANAGEMENT

The proposed process of wet and dry release has been iteratively developed based on engineering, ecological and hydrological considerations. Adaptive management principles have already been used a part of proposal development.

The majority of stormwater from the *Beaches* subdivision (as did stormwater from the former colliery and coal washer on the site) flows to the adjoining Moonee Beach catchment to the south. This option for SDRW disposal was rejected early in the assessment process (but without the benefit of specific ecological assessment) as it was felt that the potential for additional impacts in this very high conservation value area should be avoided. The Moonee Bach catchment may also be a viable future option for SDRW release based on the findings off this assessment.

The system of wet and dry release was developed to minimise ecological impacts, and is based on conservative estimates of flow and loads. The main principle was protection of periods of baseflow. The wet and dry release system may need to be reviewed and adapted should SDRW volumes be significantly different from the modelled situation.

The frequency of dry release as modelled is very low. There is the possibility of increased dry release if necessary.

Despite the conservative modelling, there is capacity for changes to the SDRW release system should this be necessary.

The results of the recommended monitoring program (refer to **Section 5.13**) will provide a platform for adaptive management considerations.

Mitigation

Ongoing review of release impacts and operations with a view to adaptive management as required.

5.15 EPA ASSESSMENT REQUIREMENTS

The EPA requirements as specified for the proposal have been addressed as follows:

s.45 POEO Act

The requirements are addressed in the compliance tables in **Appendix 9**. The proposal is consistent with the requirements of the POEO.

NSW Water Quality Objectives

New South Wales water quality objectives are addressed in the compliance tables provided as part of **Appendix 9**. The proposal is consistent with the water quality and river flow objectives as they apply to the proposal.

Practical Measures to Avoid Discharge to Waters

Avoidance of discharge to waters has been achieved via the water recycling proposed for the *Beaches* subdivision. The recycling is likely to dispose of most of the effluent generated by the CHB utility.

Explanation of the Treatment Plant Process and the Benefits and Cost of the Various Options Considered

A description of the treatment processes is provided in **Section 2** and **Appendix 3** of this report.

The process treats all sewage from the *Beaches* subdivision to a standard suitable for domestic, but not potable, water use.

Details of Reverse Osmosis Waste Disposal

As a part of the proposed changes, reverse osmosis has been deleted from the process.

The issues associated with reverse osmosis, including sustainability, have been assessed in detail. Reverse osmosis presents a range of problems for utility management including storage, transport and disposal of saline waste water. The primary purpose of reverse osmosis is to remove salts from effluent. Modelling has shown that salts can be disposed of safely by the system of wet and dry release to the local environment and within the salinity ranges historically experienced by that environment.

De-chlorination Details

De-chlorination is to be provided by the proposed on-site subsurface flow wetlands system. The wetlands will have a detention time of between four and six days, which will ensure free chlorine is fully removed prior to SDRW storage and release.

Predicted Volumes of Surplus Water

The volumes of SDRW are assessed in detail in the Hydrology report provided as **Appendix 5**. The estimates are conservative being some 20% above the likely SDRW output of the STP.

Provision of Mixing Model Results Based on a Range of Hydrological Conditions

The range of natural flow conditions has been assessed over 35 years of rainfall records. Minimum dilutions achieved at key points in the system are as described in the Hydrology report and at **Table 9** of this report. As the receiving system is mostly open to the ocean, and SDRW wet releases will be timed to maximise post release flushing by natural baseflows, no significant impacts are likely due to the minimal detention time in the sensitive parts of the aquatic environment.

The situation is different for times when the lagoon is shoaled but the impacts are confined to the lagoon which is likely to have adapted to significant pollutant loads due to receiving untreated drainage from the adjoining unsewered CHB village area. The lagoon is occasionally inundated by ocean waves so is subject to extreme salinity ranges and is unlikely to be sensitive to the TDS load of the SDRW releases.

Impacts on the Coastal Lagoon

The impacts on the lagoon were assessed from both ecological and coastal processes perspectives.

The lagoon was assessed as degraded habitat due to the drainage and alteration history. The lagoon is likely to have adapted to ongoing pollution loads and the addition of SDRW has been found to be unlikely to have a measurable effect. The additional flows due to SDRW release are unlikely to be significant under the proposed release management system.

The coastal processes assessment (see **Appendix 7**) determined a likely impact was an increase in the frequency of lagoon waters over-topping the beach shoal. The magnitude of increase was estimated to be 1%, which was assessed as minor. No adverse impacts on coastal processes or recreation are likely.

Ongoing Maintenance and Management of SDRW

Dechlorinated SDRW will be stored on the CHB utility site prior to release. A revised Integrated Water Management Plan will be required. Release protocols will be documented for the STP site to ensure they are controlled in both quantity and quality.

Management and Mitigation Measures to Reduce Impacts on Hydrology and Water Quality

The proposed system of wet and dry release will ensure hydrological change to the natural receiving system is minimal. Wet releases will be within the bounds of natural system hydrology and timed to occur with surface water flows to ensure protection of aquatic ecology and natural processes in areas with higher quality aquatic habitat. Dry releases will be direct to the lagoon to protect more sensitive upstream aquatic environments during low stream flow periods.

The SDRW releases will consist of high quality recycled water. The water will carry nutrient and salt loads but these have been assessed as unlikely to affect the higher aquatic habitat above the lagoon. Mitigating factors are the intermittency of SDRW release, low detention times and availability of perennial and high rainfall event flushing flows.

When the lagoon is directly open to the ocean, extended detention times for SDRW may be experienced. The lagoon already receives untreated runoff from an unsewered urban area of the catchment and is subject to occasional ingress of ocean water. The aquatic ecology report assessment was that the lagoon would have adjusted to these circumstances and could accept SDRW.

The most significant factor affecting water quality was found to be erosion and sediment from unsealed roads in the catchment. The aquatic ecology report recommended that the sediment be addressed as a mitigating factor.

5.16 PRINCIPLES OF ECOLOGICALLY SUSTAINABLE DEVELOPMENT

The principles of Ecologically Sustainable Development and their relevance to the current proposal are as follows.

> *The precautionary principle – namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.*

The potential for serious or irreversible environmental damage is very limited. The proposal is to release high quality treated water to an environment which has been found to have adapted to, and be tolerant to, disturbance. The proposed release strategy has been specifically designed to protect the hydrology and ecology of the receiving system.

> *Inter-generational equity – namely, that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations*

The proposed SDRW release is a far superior means of disposal to the traditional discharges of treated sewerage into the environment and has significantly greater potential for maintenance of the receiving environment. The proposed mitigation measures will provide for enhancement of the aquatic environment.

> *Conservation of biological diversity and ecological integrity – namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration.*

The proposed system of wet and dry release has been designed specifically to protect the integrity of the local hydrology and ecology.

> *Improved valuation and pricing of environmental resources – namely, that environmental factors should be included in the valuation of assets and services, such as polluter pays, full life cycle costing, and utilising incentive structures / maret mechanisms to meet environmental goals.*

The proposal places very high relative values on water as a resource by maximising recycling within the Beaches subdivision and on the receiving environment via the system of wet and dry release, which is designed to protect the aquatic environment.

As indicated above, the proposal is consistent with the four principles of Ecologically Sustainable Development.

5.17 DUTY TO ASSESS ENVIRONMENTAL IMPACT

There is a range of statutory duties to be discharged in considering the potential environmental impacts of the proposed disposal of SDRW. The scope of statutory requirements is addressed in **Section 4** in this report.

Assessment has reached the following statutory conclusions:

- The proposal will not have a significant impact as assessed under s.228 of the EPA Regulation 2000 so an EIS is not required;
- No SIS is required under either of the NSW TSCA or FMA Acts; and
- Referral under the EPBC for approval as controlled action is not required.

The proposed changes are permissible as part of the CHB utility, which is approved as a "sewage treatment plant" and its associated "sewage reticulation system" which can provide for the delivery of SDRW for disposal.

The release of SDRW is ancillary to the plant and reticulation system but still requires assessment as part of these approved land uses due to the potential for adverse environmental impacts.

The assessment includes a substantial range of both statutory and non-statutory policy requirements and specifically assess potential impacts on aquatic ecology, hydrology and coastal processes. As such the scope of the assessment satisfies the requirements under Part 5 of the EPA Act 1979 for assessment of environmental impact.

6.0 Conclusion & Recommendations

Changes are proposed to the CHB Utility STP to improve the sustainability of operations and allow completion of the approved *Beaches* subdivision.

Changes are proposed to both the utility site and utility operations. The major change is disposal of high quality surplus recycled water direct to the local environment rather than to an irrigation area.

Detailed assessments of the impact of SDRW release on hydrology, water quality, aquatic ecology and on coastal processes have been completed. The proposed changes including impacts on the receiving waters have been assessed and found likely have no significant impact.

The result of the studies and progressive, and iterative, development of the proposal is a system for release of SDRW consistent with protection of local environmental values. This has necessitated the inclusion of a subsurface flow wetland and additional SDRW storage on the STP site to provide a quality of SDRW consistent with reduced impacts and timing of SDRW release to avoid impacts during more sensitive phases of the hydrological cycle.

The proposed changes to the STP site are not significant and can be carried out as part of STP construction works. The changes to the reticulation system are also not significant and can be carried out as part of *Beaches* subdivision approval and as part of required stormwater works.

6.1 CONCLUSION

The proposed changes to the STP site and operations can be approved as development without consent under Part 5 of the EPA Act 1979 as they are unlikely to have a significant environmental impact and do not require an EIS.

The broader requirements for environmental assessment under part 5 of the EPA Act have been satisfied.

6.2 RECOMMENDATION

The approval is subject to a range of conditions required to ensure the proposal operates as assessed. Also, recommendations for mitigation measures to improve habitat quality in the receiving environment creeks and lagoon should be adopted.

The recommended conditions of approval are:

- Implementation of the aquatic habitat improvement actions identified in the aquatic ecology report;
- Implementation of the monitoring recommendations of the aquatic ecology report;
- Implementation of the wet and dry release system for SDRW as specified in the hydrology report;
- Implementation of changes to the STP and reticulation system only as detailed in the plans appended to this REF addendum;
- Management of required sewage reticulation works in accordance with construction and environmental requirements of the Beaches subdivision approval under MP 10_204;

- Upgrading of the Integrated Water Management Plan for the STP to include wetland management, SDRW release protocols, SDRW monitoring recommendations and on-going release management review to ensure any impacts are acceptable, and if required adaptive measures which could be applied to any identified unacceptable impacts;
- An application for an EPL licence be made under the NSW POEO Act and approved before any discharge to the environment of SDRW; and
- The requirements of ISEPP 2007 to be reviewed post approval to determine if there are any residual statutory consultation requirements applying to the proposed STP changes.

Appendix 1

PLANS

Appendix 2

WICA LICENCE

Appendix 3

ORIGINAL REF – CATHERINE HILL BAY STP

Appendix 4

EPA CORRESPONDENCE TRANSCRIPT

Appendix 5

HYDROLOGY REPORT

Appendix 6

AQUATIC ECOLOGY REPORT

Appendix 7

COASTAL PROCESSES REPORT

Appendix 8

WETLAND REPORT

Appendix 9

COMPLIANCE TABLES

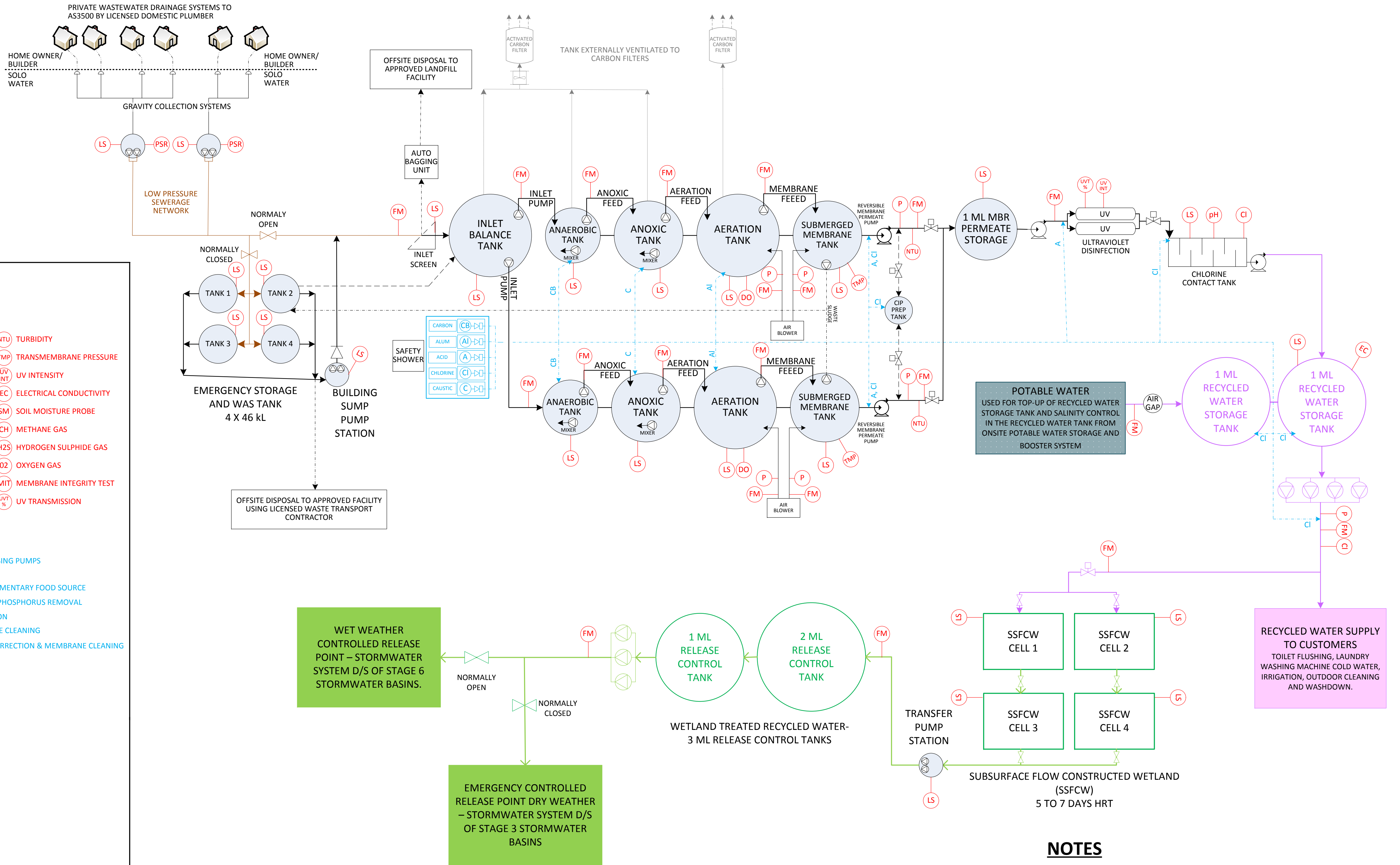
Appendix 10

EPBC PROTECTED MATTERS REPORT

Appendix 11

RISK MANAGEMENT TABLES

PROCESS FLOW DIAGRAM
STAGE 3 RECYCLED WATER RELEASE



LEGEND

PROCESS MONITORING

FM	FLOW METER	NTU	TURBIDITY
P	PRESSURE	TMP	TRANSMEMBRANE PRESSURE
PSR	PUMP STARTS AND RUN HOURS	UV INT	UV INTENSITY
LS	WATER LEVEL	EC	ELECTRICAL CONDUCTIVITY
DO	DISSOLVED OXYGEN	SM	SOIL MOISTURE PROBE
SS	MIXED LIQUOR SUSPENDED SOLIDS	CH	METHANE GAS
pH	pH	H2S	HYDROGEN SULPHIDE GAS
Cl	FREE CHLORINE RESIDUAL	02	OXYGEN GAS
WS	WEATHER STATION	MIT	MEMBRANE INTEGRITY TEST
		UVT %	UV TRANSMISSION

PROCESS CHEMICALS

- BUNDED CHEMICAL STORAGE AREA
- BUNDED CHEMICAL CONTAINERS AND DOSING PUMPS
- CHEMICAL DELIVERY LINES

CB	ACETIC ACID (CARBON) DOSING AS SUPPLEMENTARY FOOD SOURCE
Al	POLYALUMINIUM CHLORIDE DOSING FOR PHOSPHORUS REMOVAL
Cl	SODIUM HYPOCHLORITE FOR CHLORINATION
A	ACID FOR pH CORRECTION AND MEMBRANE CLEANING
C	SODIUM HYDROXIDE (CAUSTIC) FOR pH CORRECTION & MEMBRANE CLEANING

PROCESS EQUIPMENT

- INLET SCREEN
- MEMBRANE BIOREACTOR PROCESS TANKS
- SUBMERSIBLE PUMP
- DRY-MOUNTED PUMP
- MIXING PUMP
- MOTORISED VALVE
- HOUSEHOLD SEWERAGE CONNECTION POINT
- MANUAL VALVE
- VARIABLE SPEED DRIVE PUMP SET

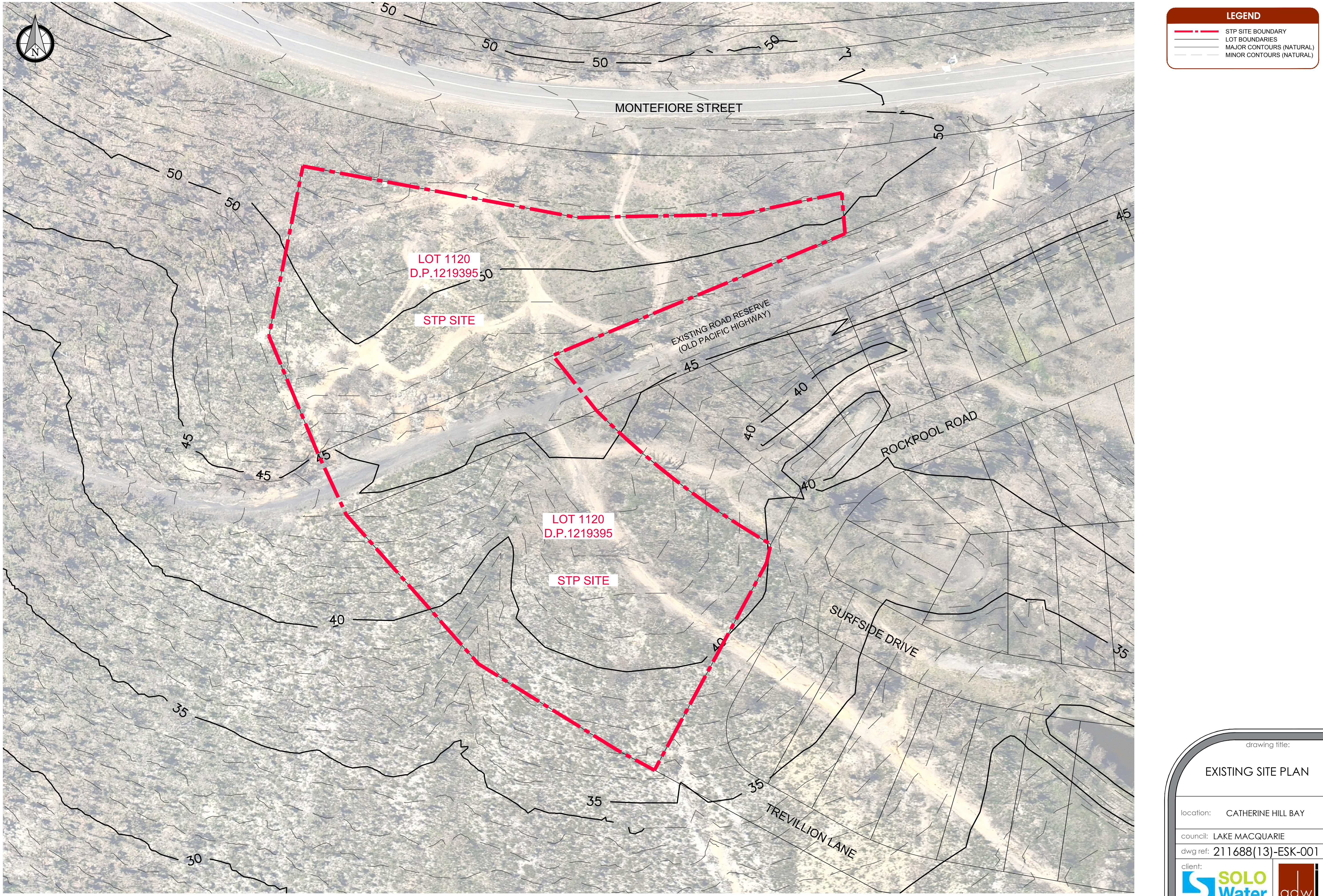
ULTRAVIOLET DISINFECTION SYSTEM
SELF CLEANING SYSTEM WITH UV INTENSITY MONITORING
UV TRANSMISSION OF 60%
USEPA ACCREDITED UV DISINFECTION SYSTEM

CHLORINE CONTACT TANK
CONTACT TANK TO BE DESIGNED TO USEPA GUIDELINES TO ACHIEVE CT VALUES FOR THE REQUIRED LOG REMOVAL TARGETS

NOTES

1. PRELIMINARY PROCESS FLOW DIAGRAM FOR IPART LICENCE VARIATION ONLY. NOT FOR CONSTRUCTION.
2. NOT TO SCALE.
3. SUBJECT TO MINOR CHANGES DURING DETAILED DESIGN.
4. TO BE READ IN CONJUNCTION WITH THE REF PREPARED BY ADW JOHNSON.

CLIENT:	PROJECT:	PHASE:	PRIVATE WATER UTILITY:	DRAWING TITLE:	DRAWING NUMBER:
ROSE PROPERTY GROUP PTY LTD (ROSE)	CATHERINE HILL BAY RESIDENTIAL SUBDIVISION MONTEFIORE STREET, CATHERINE HILL BAY	IPART LICENSE VARIATION – STAGE 3	CATHERINE HILL BAY WATER UTILITY PTY LTD (SOLO Water – Water Utility Solutions)	PROCESS FLOW DIAGRAM STAGE 3 RECYCLED WATER RELEASE	56-RW-PFD-ST3-1A DATE: 10/08/2017



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drawing title:

EXISTING SITE PLAN

location: CATHERINE HILL BAY

council: LAKE MACQUARIE

dwg ref: 211688(13)-ESK-001

client: SOLO Water — Water Utility Solutions

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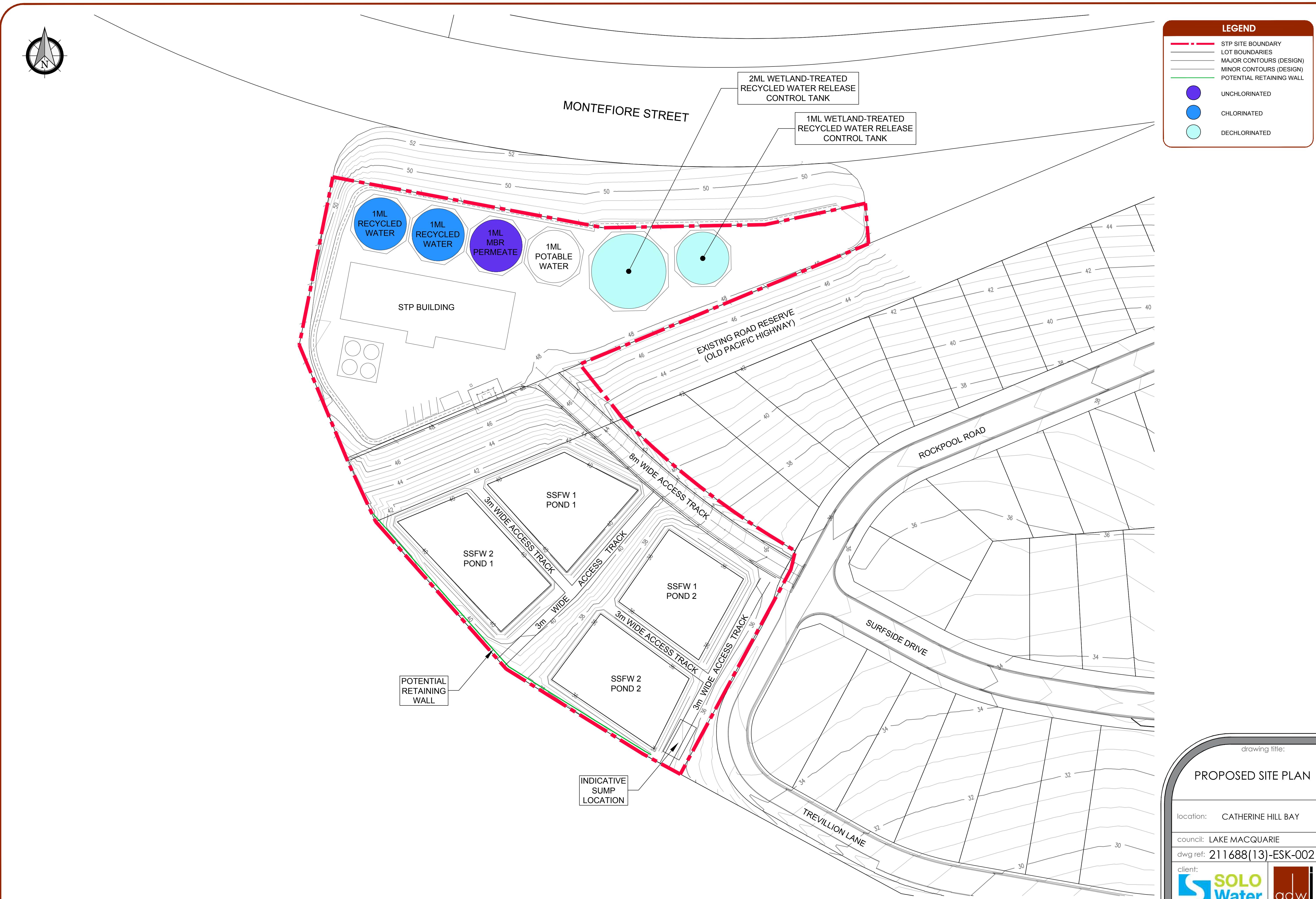

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drawing title:

PROPOSED SITE PLAN

location: CATHERINE HILL BAY

council: LAKE MACQUARIE

dwg ref: 211688(13)-ESK-002

client: SOLO Water — Water Utility Solutions

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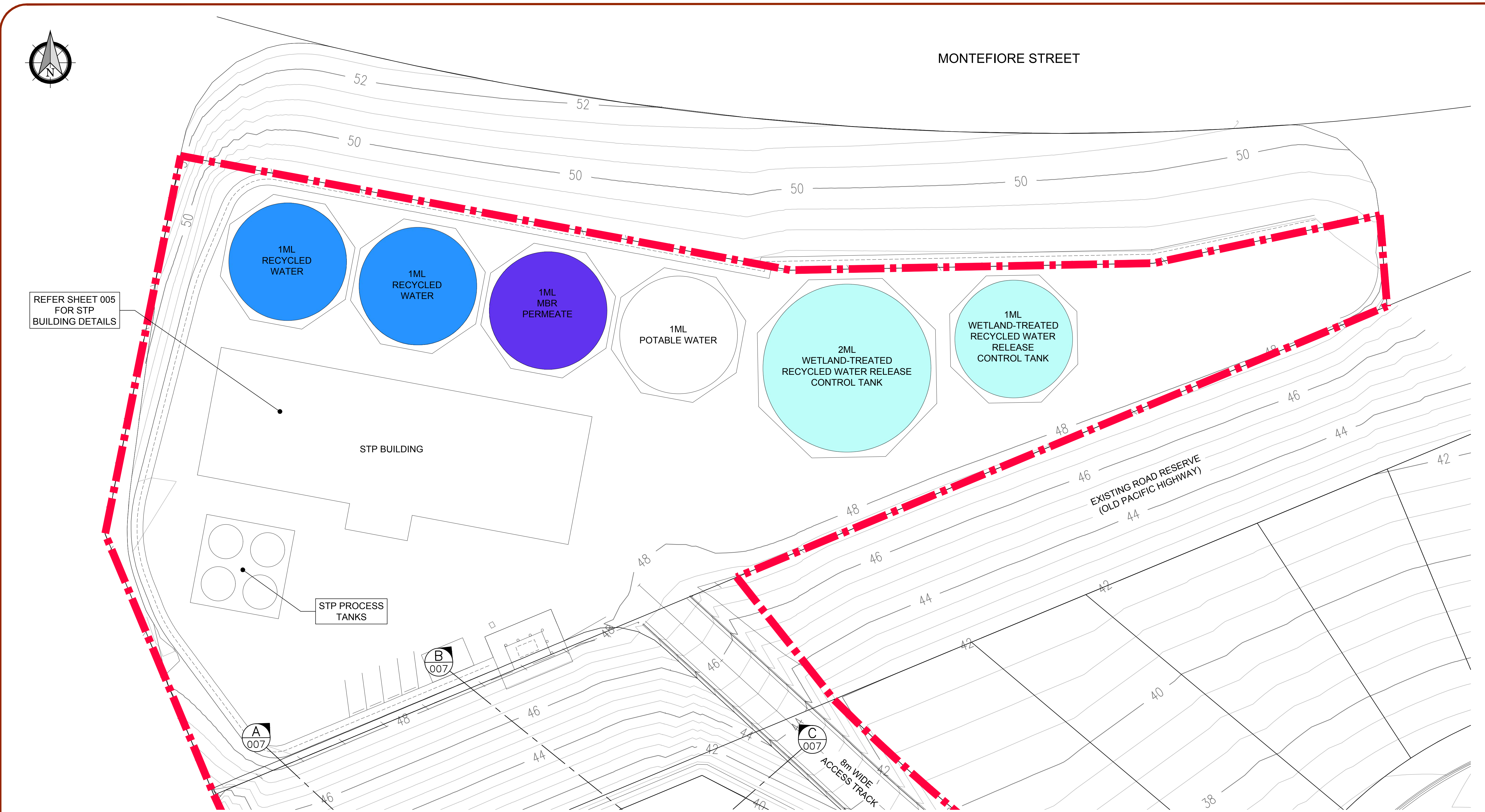

LEGEND

- STP SITE BOUNDARY
- LOT BOUNDARIES
- MAJOR CONTOURS (DESIGN)
- MINOR CONTOURS (DESIGN)
- POTENTIAL RETAINING WALL
- UNCHLORINATED
- CHLORINATED
- DECHLORINATED

ver.	date	comment	drawn	pm	level information	scale (A1 original size)	notes
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drawing title: GENERAL ARRANGEMENT PLAN 1

location: CATHERINE HILL BAY

council: LAKE MACQUARIE

dwg ref: 211688(13)-ESK-003

client: SOLO Water — Water Utility Solutions

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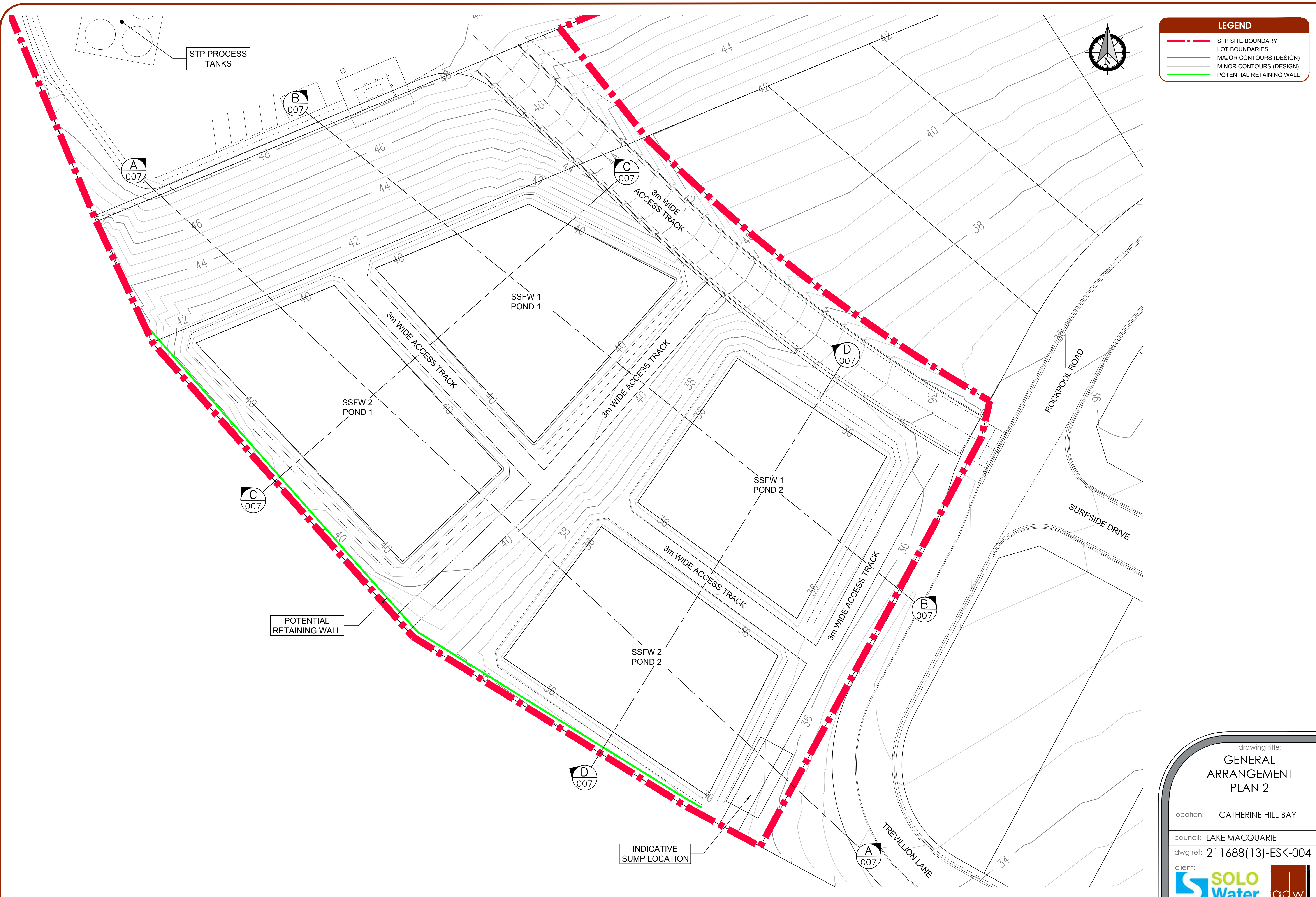

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working beyond expectations

drawing title: GENERAL ARRANGEMENT PLAN 2

location: CATHERINE HILL BAY

council: LAKE MACQUARIE

dwg ref: 211688(13)-ESK-004

client: SOLO Water — Water Utility Solutions

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ver.	date	comment	drawn	pm	level information	scale (A1 original size)	notes
C	26.07.17	REPORT ISSUE.	CB	BM	DATUM: N/A CONTOUR INTERVAL: 0.5m	0 5.0 10.0 12.5m SCALE: 1:250 (FULL)	

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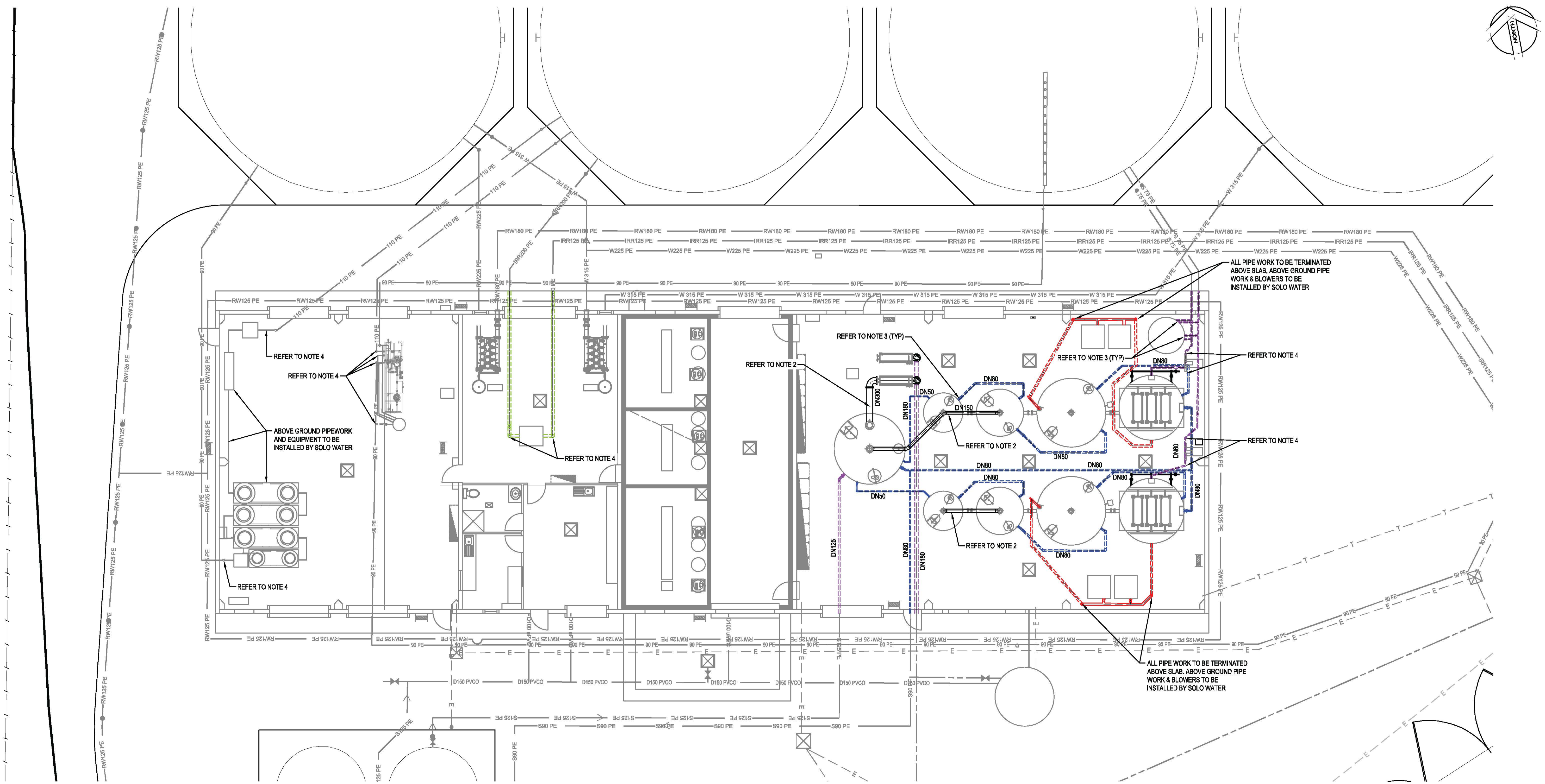

SERVICE LAYOUT PLAN

SCALE 1:100

This plan / specification is to be read in conjunction with the Approval Documentation of:

CERTIFICATE No.: S109R-100957 DATE: 21/06/2017

BUILDCERT CONSULTANTS

NOTE

1. ALL UNDERGROUND uPVC PIPES SHALL BE JOINED WITH RUBBER RING JOINTS. ALTERNATIVELY USE PE PIPES.
2. ABOVE GROUND PIPE WORK TO BE CONSTRUCTED BY SOLO WATER - SHOWN FOR CO-ORDINATION PURPOSES ONLY.
3. BURIED PIPES TO BE INSTALLED, BROUGHT ABOVE GROUND AND CONNECTED TO TANKS BY CIVIL CONTRACTOR.
4. TERMINATION LOCATION FOR BURIED PIPE ABOVE SLAB. EQUIPMENT SHOWN TO BE INSTALLED BY SOLO WATER

0 1 2 4 6 8 10m

SCALE 1:100 @A1

LEGEND

- uPVC PIPE (ABOVE GROUND)
- uPVC PIPE (BELOW GROUND)
- COPPER AIR PIPE - Ø80mm (ABOVE GROUND)
- COPPER AIR PIPE SLEEVED - Ø80mm (BELOW GROUND)
- PE PIPE (BELOW GROUND)
- STAINLESS STEEL PIPE
- IRRIGATION MAIN

Rev.	Date	Description	Des.	Verif.	Appd.
D	7/06/2017	RE-ISSUED FOR APPROVAL	DAC	MBK	BSE
C	17/01/2017	ISSUED FOR APPROVAL	DAC	MBK	BSE
B	22/12/2016	LEGEND UPDATED	FK	MBK	BSE
A	30/11/2016	TENDER ISSUE	FK	MBK	BSE

CATHERINE HILL BAY Water
Water Utility Solutions

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Web: www.cardno.com.au

Drawn	DAC	Date 28/06/2016
Checked	FK	Date 29/11/2016
Designed	FK	Date 28/06/2016
Verified	MBK	Date 30/11/2016
Approved	BSE	30/11/2016

Client: SOLO WATER

Project: CATHERINE HILL BAY
WASTE WATER TREATMENT PLANT
CIVIL ENGINEERING DESIGN

Title: SERVICE LAYOUT PLAN

Status: FOR APPROVAL
FOR CONSTRUCTION PURPOSES WHEN STAMPED

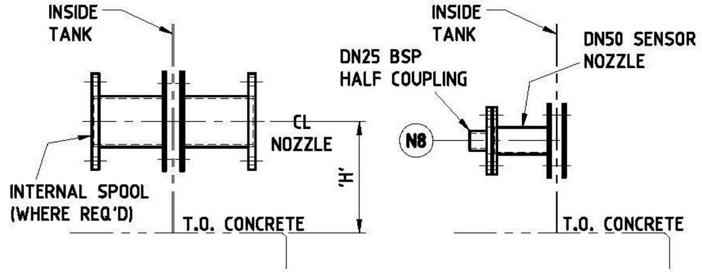
DATUM	Scale	Size
AHD	1:100	A1

Drawing Number: SW-56-WWTP-C-1032 Revision: D

XREFs: X82014058-05 G-Title; X82014058-05 D-WWTP Building; X82014058-05 D-Base; X82014058-05 D-Sub Division; X82014058-05 D-Stormwater Lay; X82014058-05 D-Services
CAD File: U:\FY14\058-05_CHB WWTP Civil & Structural Design\05_WWTP Civil & Struct Design\Drawings\Build\SW-56-WWTP-C-1032.dwg

PENETRATION SCHEDULE

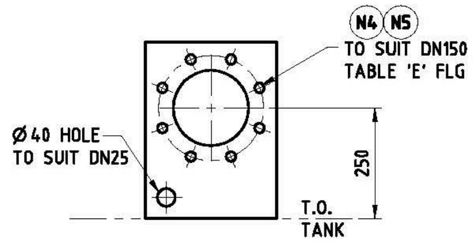
MARK No.	QTY	FITTING SIZE	INTERFACE	SERVICE	MATERIAL	ORIENTATION	FITTING HEIGHT 'H' (mm)
N1	1	DN400	TABLE 'E'	OUTLET (VORTEX)	HDG	166°	825
N2	1	DN150	TABLE 'E'	SLUDGE DRAIN	HDG	325°	305
N3	1	DN200	ROLLED GROOVE	OVERFLOW	HDG	30°	5073
N4	1	DN150	TABLE 'E'	MANUAL INFILL	GALVABOND	135°	6170
N5	1	DN150	TABLE 'E'	PERMEATE INFILL	GALVABOND	W/ PLATFORM	6170
N7	1	DN250	TABLE 'E'	LOW LEVEL BALANCE PIPE	HDG	320°	500
N8	1	DN50	TABLE 'E'	SENSOR NOZZLE W/ DN25 BSP COUPLING	HDG	115°	150
M1	1	800SQ	-	ROOF MANHOLE	GALVABOND	W/ PLATFORM	-
M2	1	600NB	-	SIDE ENTRY MANHOLE	HDG	218.57°	590
L1	1	-	-	LADDER	HDG	45°	-
L2	1	-	-	LEVEL INDICATOR	HDG	SITE LOCATED	-
V1	1	300NB	-	ROOF VENT - WHIRLY BIRD	GALVABOND	SEE PLAN	ROOF



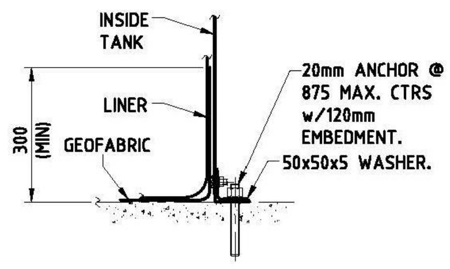
TYPICAL FITTING PENETRATION THROUGH TANK WALL

TANK SPECIFICATION

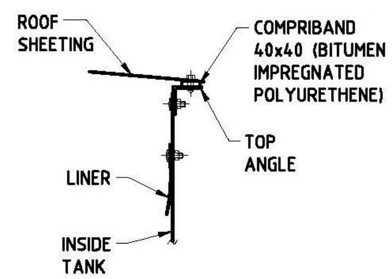
TANK DIAMETER (mm)	15750
TANK HEIGHT (mm)	5920
OPERATING PRESSURE (kPa)	ATMOSPHERIC
DESIGN PRESSURE (kPa)	ATMOSPHERIC
TOTAL VOLUME (kl)	1153
EFFECTIVE CAPACITY (kl)	1000
HYDROSTATIC TEST REQ'D	YES
CONTENTS	RECYCLED WATER
TANK WALLS	G450 Z600 GALVABOND (POWDER COATED)
TANK COLOUR	DUNE
FOUNDATION	CONCRETE SLAB BY OTHERS
ROOF STRUCTURE	GALV. TRUSS, PURLINS, CLEATS TO AS/NZ1170.2
ROOF SHEETING	0.42 MONOCLAD - COLORBOND
ROOF SHEETING COLOUR	DUNE
WIND ANGLES	HOT DIP GALVANISED
LINER	REINF. 0.6mm HEAVY DUTY PVC
LINER PROTECTION	GEOFABRIC MEMBRANE (BIDEM A24)
SEALANT	SIKAFLEX POLYURETHENE FLEXIBLE
FASTENERS	HOT DIP GALVANISED
INTERNAL LADDERS	HOT DIP GALVANISED
EXTERNAL LADDERS	HOT DIP GALVANISED



TYPICAL VIEW AT INLET BOX



TYPICAL BASE CONNECTION DETAIL



TYPICAL TOP ANGLE CONNECTION DETAIL

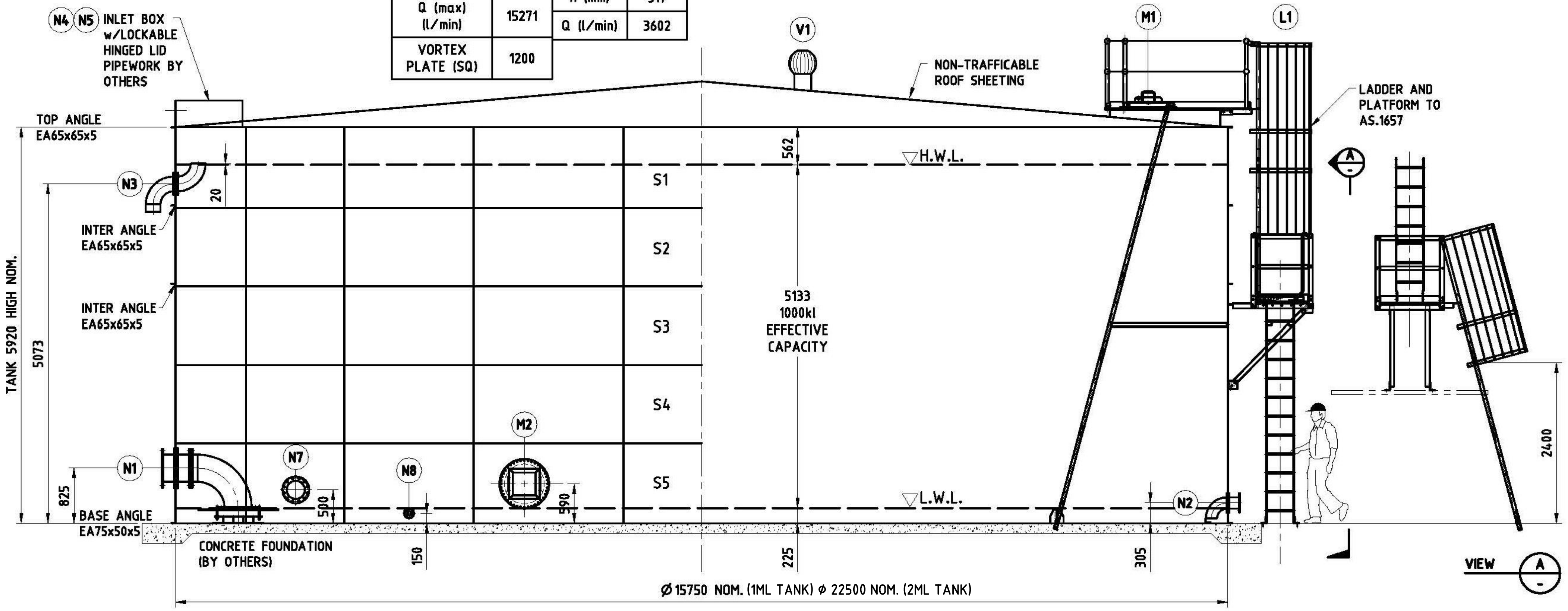
SUCTION TO AS2419.1 SECTION 5.3.2.	
d (mm)	450
ha (mm)	225
Q (max) (l/min)	15271
VORTEX PLATE (SQ)	1200

OVERFLOW TO AS/NZ3500.1 TABLE 8.3	
d (mm)	200
h (mm)	517
Q (l/min)	3602

21 SHEETS AROUND
5 SHEETS HIGH

NOTES:

1. ALL DIMENSIONS IN MILLIMETERS (U.N.O.). DO NOT SCALE.



TANK 1 ELEVATION

drawing title: RECYCLED WATER TANK DETAILS

location: CATHERINE HILL BAY

council: LAKE MACQUARIE

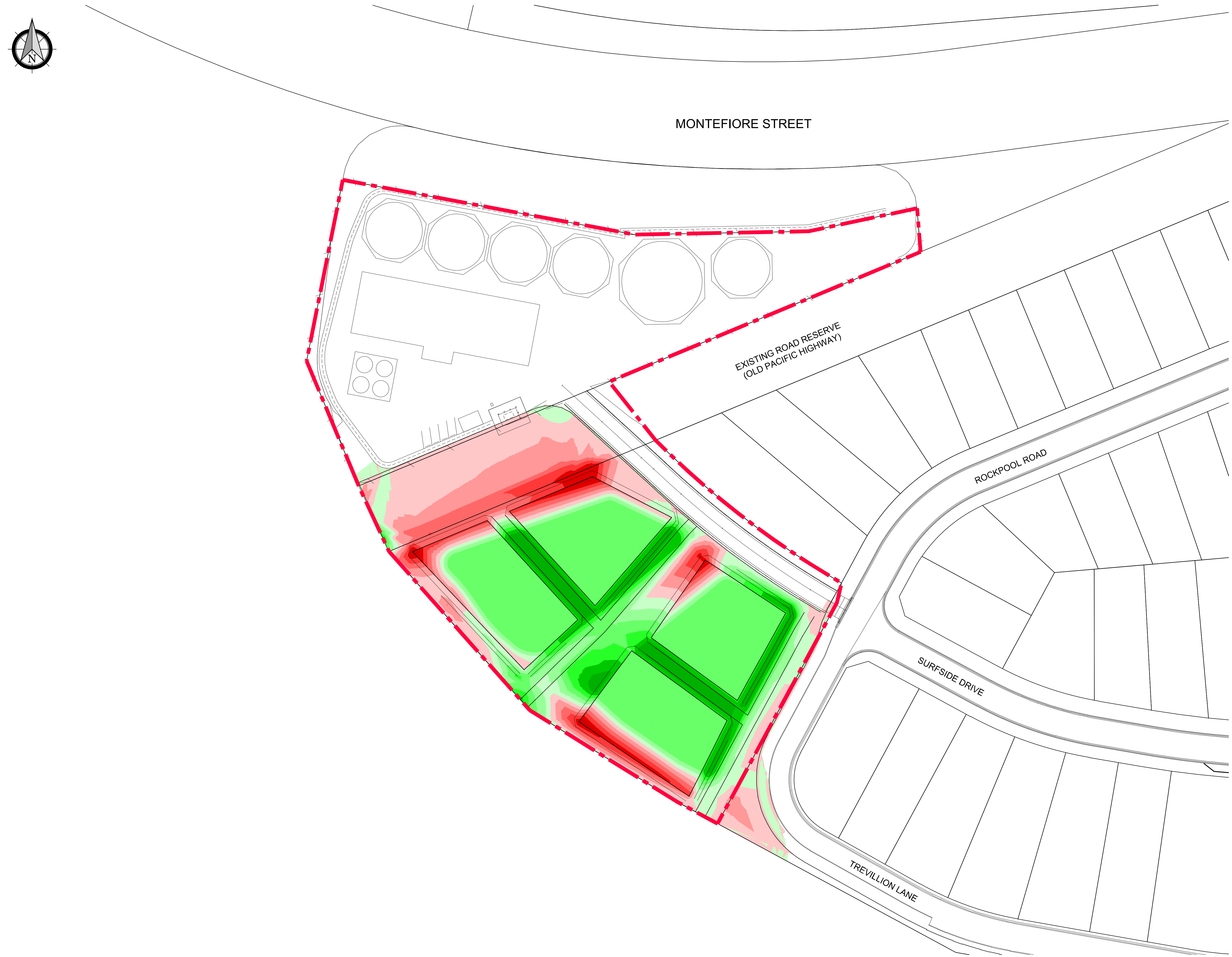
dwg ref: 211688(13)-ESK-006

client: SOLO Water — Water Utility Solutions

adw johnson

ver.	date	comment	drawn	pm	level information	scale (A1 original size)	notes
C	26.07.17	REPORT ISSUE.	CB	BM	DATUM: N/A CONTOUR INTERVAL: 0.5m	NOT TO SCALE	1. TANK DETAILS PROVIDED BY "the TASMAN TANK CO."

central coast office ph: (02) 4305 4300
hunter office ph: (02) 4978 5100
www.adwjohnson.com.au



LEGEND

STP SITE BOUNDARY
LOT BOUNDARIES

CUT FILL LEGEND

Lower value		Upper value		Colour
−3	to	−2.5	m	
−2.5	to	−2	m	
−2	to	−1.5	m	
−1.5	to	−1	m	
−1	to	−0.5	m	
−0.5	to	0	m	
0	to	0.5	m	
0.500	to	1	m	
1	to	1.5	m	
1.5	to	2	m	
2	to	2.5	m	
2.5	to	3	m	

NOTE:
EARTHWORKS EXTENTS HAVE BEEN CALCULATED BASED ON EXISTING APPROVED DESIGN TO NEW DESIGN SURFACE

working beyond expectations

drawing title:

CUT/FILL PLAN

location: CATHERINE HILL BAY

council: LAKE MACQUARIE

dwg ref: 211688(13)-ESK-007

client: SOLO Water — Water Utility Solutions

adw johnson

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C	26.07.17	REPORT ISSUE.	CB	BM	DATUM: N/A CONTOUR INTERVAL: 0.5m	0 12.5 25.0m SCALE: 1:500 (FULL)	

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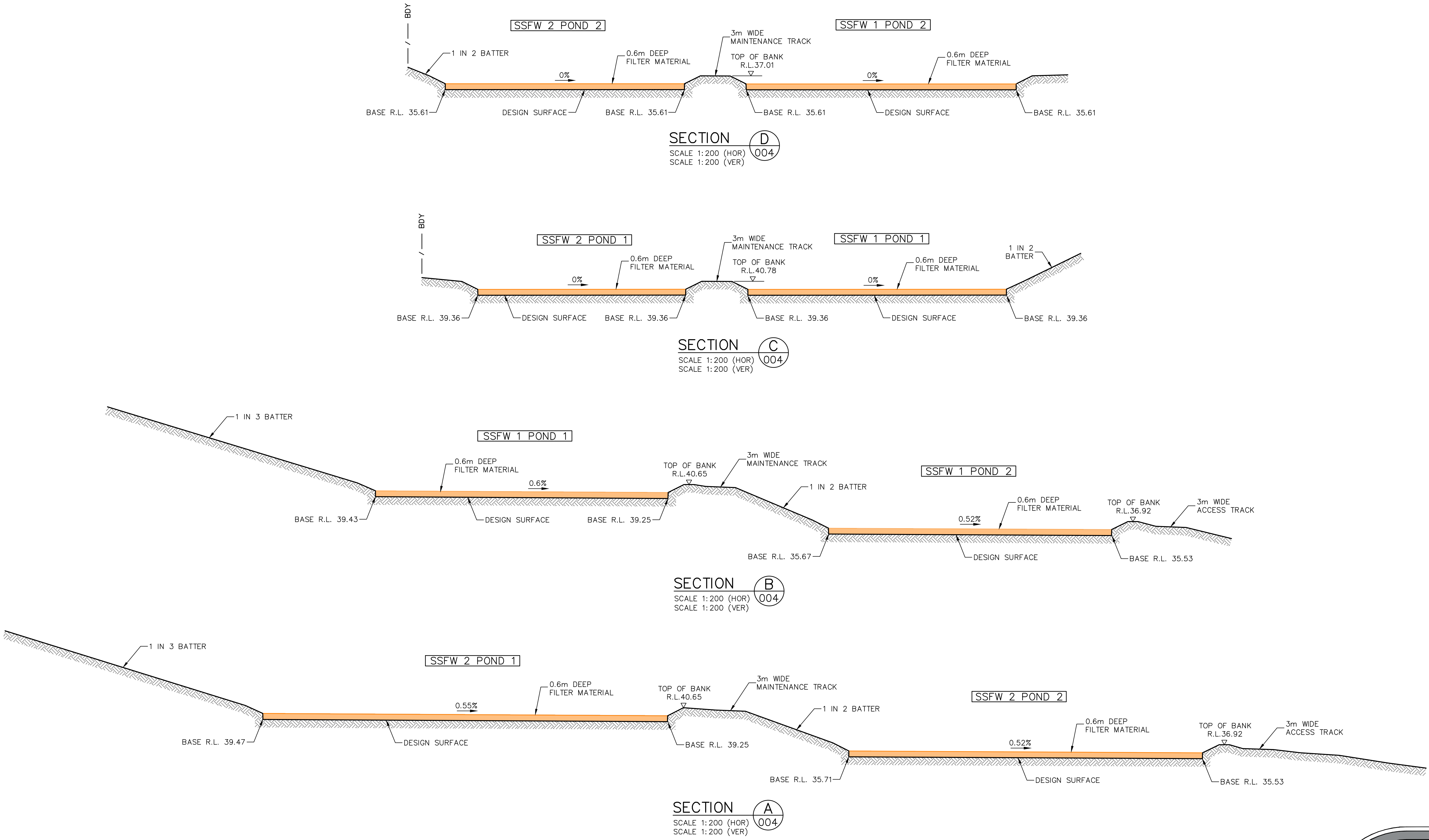
211688(13)-ESK-008-A



working beyond expectations

drawing title:

SITE SECTIONS
A, B, C & D

location: CATHERINE HILL BAY

council: LAKE MACQUARIE

dwg ref: 211688(13)-ESK-008

client: SOLO Water — Water Utility Solutions

adw johnson

central coast office ph: (02) 4305 4300
hunter office ph: (02) 4978 5100

ver.	date	comment	drawn	pm	level information	scale (A1 original size)	notes
C	26.07.17	REPORT ISSUE.	CB	BM	DATUM: N/A CONTOUR INTERVAL: N/A	0 5.0 10.0m SCALE: 1:200 (FULL)	

This plan includes coloured information. If you have a black and white copy you do not have all of the information. This note is coloured RED.

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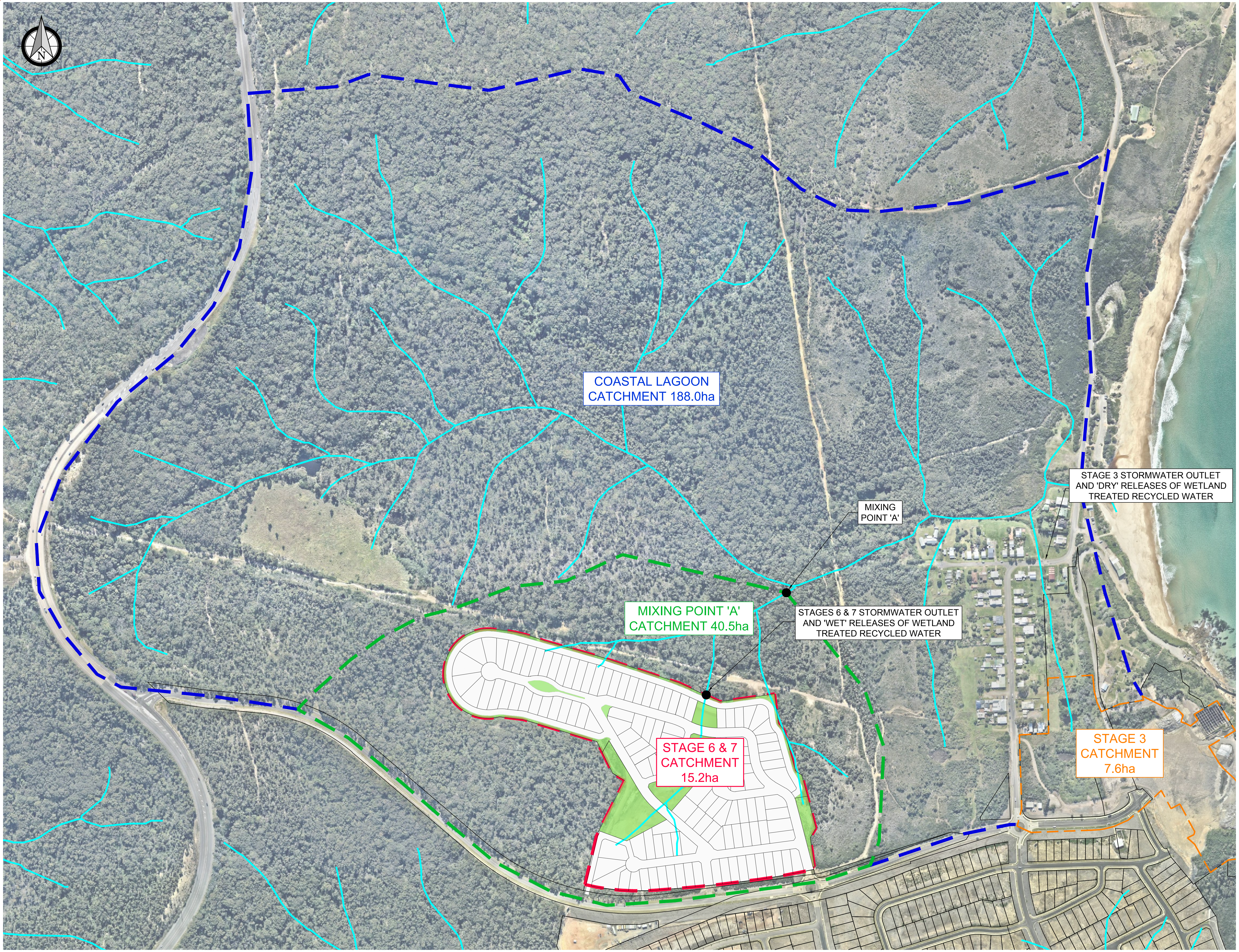
211688(13)-ESK-009-A



LEGEND

- COASTAL CREEK CATCHMENT
- MIXING POINT CATCHMENT
- STAGE 6 & 7 CATCHMENT
- STAGE 3 CATCHMENT
- EXISTING WATERCOURSE (FROM SIXMAPS)
- LOT BOUNDARIES

working beyond expectations

drawing title:

OVERALL CATCHMENT PLAN

location: CATHERINE HILL BAY

council: LAKE MACQUARIE

dwg ref: 211688(13)-ESK-009

client: SOLO Water — Water Utility Solutions

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• project management • civil engineering • infrastructure • superintendency • economic analysis • social impact • town planning • surveying • development feasibility • visualisation • urban design

Plotted By: Chris Brown Plot Date: 15/08/17 9:29:28AM Cad File: S:\211688\211688(13)\DRAWINGS\SKETCHES\211688(13)-ESK-009-A.DWG

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211688(13)-ESK-010-A

LEGEND

- PROPOSED RECYCLED WATER RELEASE LINE
- EXISTING IRRIGATION LINE
- LOT BOUNDARIES

drawing title:

WETLAND - TREATED RECYCLED WATER RELEASE PIPEWORK PLAN

location: CATHERINE HILL BAY

council: LAKE MACQUARIE

dwg ref: 211688(13)-ESK-010

client: SOLO Water Water Utility Solutions

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central coast office ph: (02) 4305 4300
hunter office ph: (02) 4978 5100
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Plotted By: Chris Brown Plot Date: 15/08/17 9:29:38AM Cad File: S:\211688(13)\DRAWINGS\SKETCHES\211688(13)-ESK-010-A.DWG

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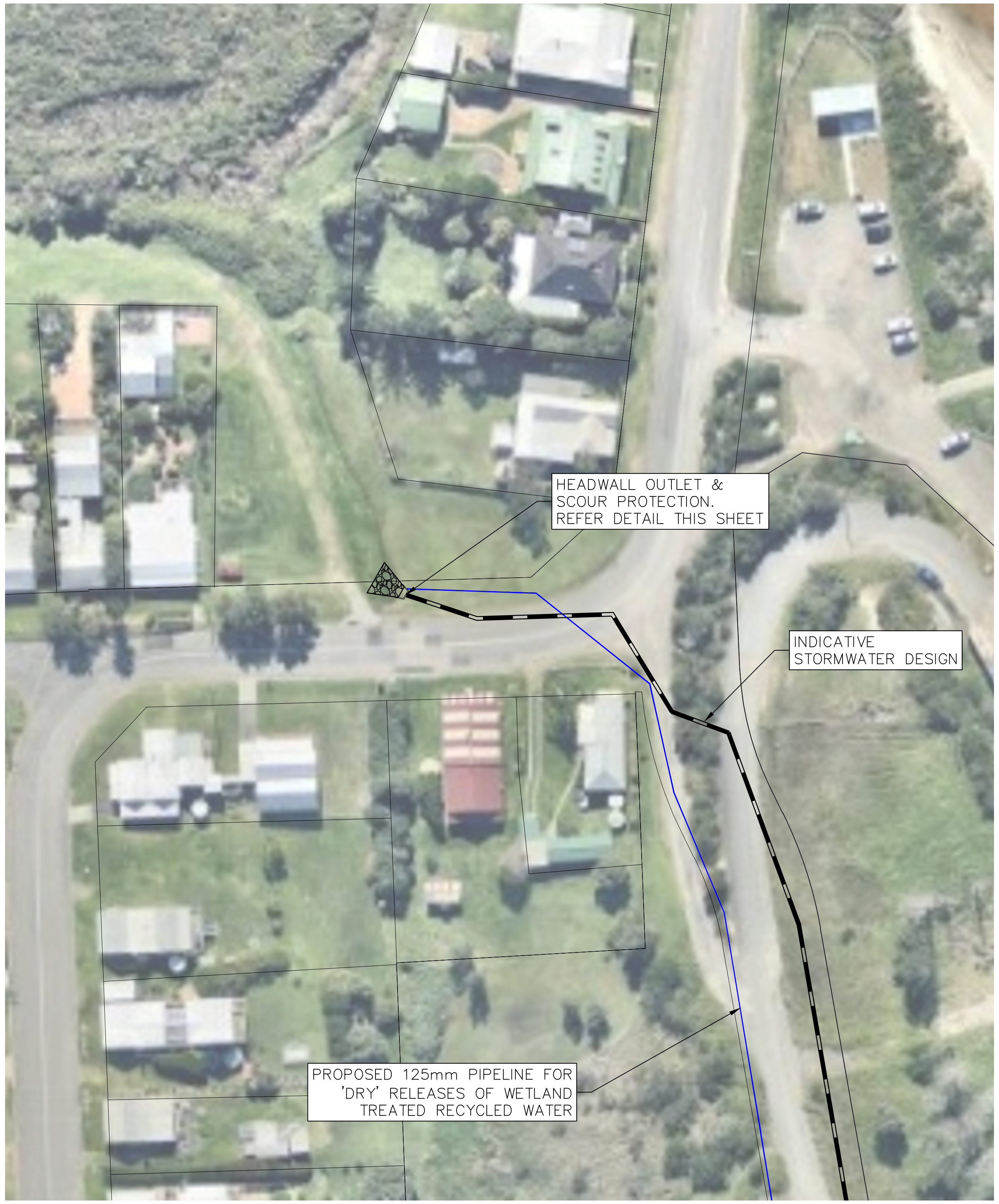
LEGEND

- PROPOSED RECYCLED WATER RELEASE LINE
- EXISTING IRRIGATION LINE
- LOT BOUNDARIES
- INDICATIVE STORMWATER

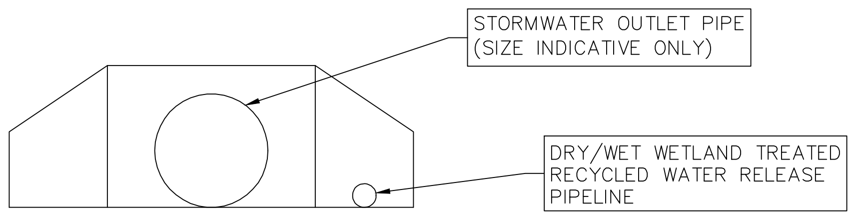
STAGE 6 & 7 – WET RELEASE OUTLET PLAN

SCALE 1:500



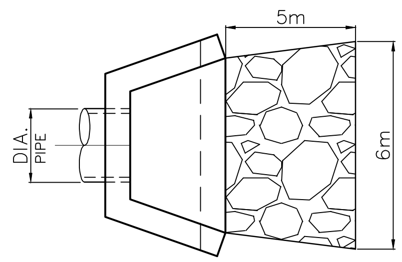
STAGE 3 – DRY RELEASE OUTLET PLAN

SCALE 1:500



INDICATIVE HEADWALL DETAIL

N.T.S



INDICATIVE SCOUR PROTECTION DETAIL

N.T.S

ver.	date	comment	drawn	pm	level information	scale (A1 original size)	notes
C	26.07.17	REPORT ISSUE.	MF	BM	DATUM: N/A CONTOUR INTERVAL: N/A	0 12.5 25.0m SCALE: 1:500 (FULL)	- STORMWATER DESIGN INDICATIVE ONLY. SUBJECT TO DETAILED DESIGN.

drawing title: OUTLET DETAILS

location: CATHERINE HILL BAY

council: LAKE MACQUARIE

dwg ref: 211688(13)-ESK-011

client: SOLO Water — Water Utility Solutions

adw johnson

central coast office ph: (02) 4305 4300
hunter office ph: (02) 4978 5100

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Plotted By: Chris Brown Plot Date: 15/08/17 9:29:47AM Cad File: S:\211688\(13)\DRAWINGS\SKETCHES\211688(13)-ESK-011-A.DWG

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New South Wales

Water Industry Competition Act 2006 (NSW)

Grant of network operator's licence
Licence no. 16_035

I, The Hon. Niall Blair MLC, Minister for Lands and Water, under section 10 of the *Water Industry Competition Act 2006* (NSW), grant a network operator's licence to:

Catherine Hill Bay Water Utility Pty Ltd (ACN 163 381 922)

to construct, maintain and operate water industry infrastructure, subject to:

(i) the conditions imposed by the *Water Industry Competition Act 2006* (NSW);

(ii) the conditions imposed by clause 9 and set out in Parts 1, 2 and 3 of Schedule 1 to the Water Industry Competition (General) Regulation 2008 (NSW);

(iii) the conditions imposed by the Minister in the attached Schedule A, being special Ministerially-imposed licence conditions for Catherine Hill Bay Water Utility Pty Ltd's network operator's licence; and

(iv) the conditions imposed by the Minister in the attached Schedule B, being standard Ministerially-imposed licence conditions for all licensed network operators.

....

Minister for Lands and Water

Dated this 22nd day of March 2016

NEW SOUTH WALES GOVERNMENT

WATER INDUSTRY COMPETITION ACT 2006
(NSW)

NETWORK OPERATOR'S LICENCE

Catherine Hill Bay Water Utility Pty Ltd

(ACN 163 381 922)

LICENCE SCOPE

ACTIVITIES AUTHORISED UNDER THE LICENCE AND AREA OF OPERATIONS

S1 Activities authorised - non-potable water

S1.1 This Licence authorises the Licensee and any authorised persons specified in Table 1.1 to construct, maintain and operate the water industry infrastructure which is specified in Table 1.2, and is substantially consistent with the water industry infrastructure described in the Review of Environmental Factors:

a) for one or more of the authorised purposes specified in Table 1.3; and

b) within the area of operations specified in Table 1.4,

subject to the conditions imposed by or under the Act, the Regulation and this Licence.

Table 1.1 Authorised persons

Solo Water Pty Ltd (ACN 160 013 614)

Table 1.2 Water industry infrastructure

1) A treatment plant for non-potable water and other water infrastructure used, or to be used, in connection with the treatment plant, where components of the treatment plant or the other water infrastructure may also be used for one or more of the following:

   a) production of non-potable water;

   b) treatment of non-potable water;

   c) filtration of non-potable water;

   d) storage of non-potable water; and

   e) conveyance of non-potable water.

2) A reticulation network for non-potable water and other water infrastructure used, or to be used, in connection with the reticulation network, where components of the reticulation network or the other water infrastructure may also be used for one or more of the following:

   a) storage of non-potable water;

   b) conveyance of non-potable water; and

   c) treatment of non-potable water.

Table 1.3 Authorised purposes

Toilet flushing, laundry machine cold water connection, irrigation of private lots and footpaths, outdoor cleaning and washdown (including car and bin washing).

Table 1.4 Area of operations

Lot 100 DP1129872, Lot 101 DP1129872, Lot 106 DP1129872, Lot 1 DP1141989, Lot 1 DP1129299, Lot 103 DP1194707, Lot 101 DP1194707, Lot 102 DP1194707, Lot 213 DP883941, Lot 1 Section I DP163, Lot 1 Section K DP163, Flowers Drive Road Reserve, and Montefiore Street Road Reserve, Catherine Hill Bay.

S2 Activities authorised – drinking water

S2.1 This Licence authorises the Licensee and any authorised persons specified in Table 2.1 to construct, maintain and operate the water industry infrastructure which is specified in Table 2.2, and is substantially consistent with the water industry infrastructure described in the Review of Environmental Factors:

a) for the authorised purposes specified in Table 2.3; and

b) within the area of operations specified in Table 2.4,

subject to the conditions imposed by or under the Act, the Regulation and this Licence.

Table 2.1 Authorised persons

Solo Water Pty Ltd (ACN 160 013 614)

Table 2.2 Water industry infrastructure

A reticulation network for drinking water and other water infrastructure used, or to be used, in connection with the reticulation network, where components of the reticulation network or the other water infrastructure may also be used for one or more of the following:

a) storage of drinking water;
b) conveyance of drinking water; and
c) treatment of drinking water.

Table 2.3 Authorised purposes

Drinking water and fire water

Table 2.4 Area of operations

(a) The area of the transfer pump station on Lot 12 DP598580 and Lot 13 DP598580.

(b) The area of the transfer pipeline on Lot 649 DP1027231, Lot 204 DP1164883, Lot 12 DP1180296, Lot 145 DP755266, Lot 105 DP1129872, Lot 100 DP1129872, Lot 101 DP1129872, Kanangra Drive, Pacific Highway Road Reserve, Montefiore Street Road Reserve, Catherine Hill Bay.

(c) Lot 100 DP1129872, Lot101 DP1129872, Lot 106 DP1129872, Lot 1 DP1141989, Lot 1 DP1129299, Lot 103 DP1194707, Lot 101 DP1194707, Lot 102 DP1194707, Lot 213 DP883941, Lot 1 Section I DP163, Lot 1 Section K DP163, Flowers Drive Road Reserve, and Montefiore Street Road Reserve, Catherine Hill Bay.

S3 Activities authorised – sewerage services

S3.1 This Licence authorises the Licensee and any authorised persons specified in Table 3.1 to construct, maintain and operate the water industry infrastructure which is specified in Table 3.2, and is substantially consistent with the water industry infrastructure described in the Review of Environmental Factors:

a) for one or more of the authorised purposes specified in Table 3.3; and

b) within the area of operations specified in Table 3.4,

subject to the conditions imposed by or under the Act, the Regulation and this Licence.

Table 3.1 Authorised persons

Solo Water Pty Ltd (ACN 160 013 614)

Table 3.2 Water industry infrastructure

1) A treatment plant for sewage and other sewerage infrastructure used, or to be used, in connection with the treatment plant, where components of the treatment plant or the other sewerage infrastructure may also be used for one or more of the following:

    a) production of treated non-potable water from sewage;

    b) treatment of sewage;

    c) filtration of sewage;

    d) storage of sewage; and

    e) conveyance of sewage.

2) A reticulation network for sewage and other sewerage infrastructure used, or to be used, in connection with the reticulation network, where components of the reticulation network or the other sewerage infrastructure may also be used for one or more of the following:

    a) storage of sewage; and

    b) conveyance of sewage.

Table 3.3 Authorised purposes

Sewage collection, transport, treatment, effluent transfer to non-potable water system

Table 3.4 Area of operations

Lot 100 DP1129872, Lot 101 DP1129872, Lot 106 DP1129872, Lot 1 DP1141989, Lot 1 DP1129299, Lot 103 DP1194707, Lot 101 DP1194707, Lot 102 DP1194707, Lot 213 DP883941, Lot 1 Section I DP163, Lot 1 Section K DP 163, Flowers Drive Road Reserve, and Montefiore Street Road Reserve, Catherine Hill Bay.

INTERPRETATION AND DEFINITIONS

Interpretation

In this Licence, unless the context requires otherwise:

- (i) the singular includes the plural and vice versa;
- (ii) headings are used for convenience only and do not affect the interpretation of this Schedule A;
- (iii) a reference to a document includes the document as modified from time to time and any document replacing it;
- (iv) a reference to a person includes a natural person and any body or entity whether incorporated or not;
- (v) a reference to a clause is to a clause in this Schedule A;
- (vi) a reference to a schedule is to a schedule to this Licence;
- (vii) a reference to a law or statute includes regulations, rules, codes and other instruments under it, and consolidations, amendments, re-enactments or replacements of them; and
- (viii) explanatory notes do not form part of this Licence, but in the case of uncertainty may be relied on for interpretation purposes.

Definitions

Expressions used in this Licence that are defined in the Act or the Regulation have the meanings set out in the Act or the Regulation.

In this Licence:

Act	means the *Water Industry Competition Act 2006* (NSW).
Agreement	means any agreement or deed provided to IPART in connection with the Licensee's application for this Licence.
Appropriate Facilities	means a facility or facilities with the capacity to accept excess recycled water or excess sewage from the Water Industry Infrastructure specified in clause S1 and Table 1.2 and clause S3 and Table 3.2, including during wet weather periods.
Construction Environmental Management Plan (**CEMP**)	means a site or project specific plan which, in relation to construction works: (a) complies with the basic structure detailed in the "Guideline for the Preparation of Environmental Management Plans", Department of Infrastructure, Planning and Natural Resources (2004); and (b) identifies the environmental risks associated with the licensed activities and the mitigation measures to be implemented.
IPART	means the Independent Pricing and Regulatory Tribunal of New South Wales established under the *Independent Pricing and Regulatory Tribunal Act 1992* (NSW).
Licence	means this network operator's licence granted under section 10 of the Act.

Licensee	means Catherine Hill Bay Water Utility Pty Ltd (ACN 163 381 922)
Minister	means the Minister responsible for Part 2 of the Act.
Operational Environmental Management Plan (**OEMP**)	means a site or project specific plan which, in relation to the operational phase: (a) complies with the basic structure detailed in the "Guideline for the Preparation of Environmental Management Plans", Department of Infrastructure, Planning and Natural Resources (2004); and (b) identifies the environmental risks associated with the licensed activities and the mitigation measures to be implemented.
Review of Environmental Factors (**REF**)	means the Review of Environmental Factors for the proposed sewage treatment plant and sewage and recycled water reticulation systems (prepared for IPART by Planit Consulting Pty Ltd, August 2015).
Reporting Manual	means the document entitled "Network Operator's Reporting Manual" which is prepared by IPART and is available on IPART's website at www.ipart.nsw.gov.au.
Regulation	means the *Water Industry Competition (General) Regulation 2008* (NSW).

SCHEDULE A - SPECIAL MINISTERIALLY-IMPOSED LICENCE CONDITIONS FOR CATHERINE HILL BAY WATER UTILITY PTY LTD'S NETWORK OPERATOR'S LICENCE

This schedule sets out the conditions which the Minister imposes pursuant to section 13(1)(b) of the Act. In addition to these special Ministerially-imposed conditions, the Licence is subject to conditions imposed by the Act, the Regulation and the standard Ministerially-imposed licence conditions set out in Schedule B. The Minister may vary the conditions in this schedule or impose new conditions, provided there is no inconsistency with the conditions imposed by the Act or the Regulation.

A1 If a party to an Agreement proposes to:

a) terminate the Agreement;
b) novate the Agreement;
c) assign or transfer any of its rights or obligations under the Agreement to any other person; or
d) alter the Agreement in any way that materially reduces the Licensee's technical, financial or organisational capacity to carry out the activities authorised by this Licence,

the Licensee must provide IPART with written notice as soon as practicable, but no later than 3 months, before the time when the proposed action is to occur. The written notice must include details of how the service provided under the Agreement will be provided subsequent to the proposed termination, novation, assignment, transfer or alteration.

A2 The Licensee is to implement environmental mitigation measures substantially consistent with the environmental risk mitigation measures identified in:

a) the Review of Environmental Factors (**REF**) in carrying out any activities authorised under clause S1 and S3 of this Licence.

A3 The Licensee must not commence, or authorise the commencement of, construction of any water industry infrastructure which is:

a) described in Clause S1 and Table 1.2; and
b) described in Clause S3 and Table 3.2.

(**Relevant Recycling Infrastructure**)

until after the Licensee has provided IPART with a Construction Environmental Management Plan (**CEMP**), and IPART has provided written approval of the CEMP to the Licensee.

A4 In addition to any requirements imposed by or under the Act or the Regulation, the Licensee must not commence commercial operation of, or authorise commercial operation of, the Relevant Recycling Infrastructure until the Licensee has provided:

a) a report addressing how the environmental mitigation measures identified in the CEMP have been implemented during the design and construction of the Relevant Recycling Infrastructure (**Report**); and
b) an Operational Environmental Management Plan (**OEMP**),

to IPART, and IPART has provided written approval of the Report and the OEMP to the Licensee.

A5 The Licensee must operate and maintain the Relevant Recycling Infrastructure consistently with the OEMP.

A6 If the Licensee proposes to vary its environmental mitigation measures referred to in clause A2, it must first notify IPART in accordance with the Reporting Manual. The Licensee must not vary its environmental mitigation measures without the prior written approval of IPART.

A7 As at the date of this Licence, the Licensee must have an unconditional bank guarantee executed in its favour which is:

a) for a value of $2.5 million (two million and five hundred thousand dollars); and
b) for a term of at least five years from the day of the grant of this Licence (and such further term as directed in writing by the Minister),

and provide a certified copy of the bank guarantee to the Minister or IPART on request.

A8 The Licensee must not commence, or authorise the commencement of, construction of any water industry infrastructure described in clause S1.1 and Table 1.2 paragraph (1) until:

(a) the Licensee has provided IPART a report prepared by a suitably qualified environmental consultant on the Licensee's proposed strategy of tankering out excess non-potable water as set out in its REF. The report should include:
    i) modelling of truck movements during significant wet weather events or periods in the 10 year period prior to the grant of this Licence at times when irrigation would not have been undertaken;
    ii) an estimation of the costs of trucking during those wet weather events or periods;
    iii) identification of Appropriate Facilities that have the capacity to accept excess recycled water (including during wet weather periods);
    iv) evidence of agreements with the Appropriate Facilities setting out the arrangements for accepting excess non-potable water; and
    v) confirmation that the configuration and size of the non-potable water storage tanks (as described in the REF) is adequate for the activities authorised by the Licence or, if the configuration or size of the non-potable water storage tanks is not considered adequate, advice as to any changes required to the configuration or size of the non-potable water storage tanks; and
(b) IPART has provided written approval of the report.

A9 Before the Licensee brings the Water Industry Infrastructure described in Table 3.2 into commercial operation, the Licensee must provide written evidence of the following to IPART:

a) details of Appropriate Facilities that have the capacity to accept excess sewage; and
b) evidence of agreements with the Appropriate Facilities setting out the arrangements for accepting excess sewage,

and the Licensee must obtain IPART's written approval.

SCHEDULE B - STANDARD MINISTERIALLY-IMPOSED LICENCE CONDITIONS FOR ALL LICENSED NETWORK OPERATORS UNDER THE ACT

This schedule sets out the standard conditions which the Minister imposes on the Licensee and all other licensed network operators pursuant to section 13(1)(b) of the Act. In addition to these standard Ministerially-imposed conditions, the Licensee is subject to obligations imposed by the Act, the Regulation and the special Ministerially-imposed licence conditions set out in Schedule A. The Minister may vary the conditions in this schedule or impose new conditions, provided there is no inconsistency with the conditions imposed on the Licensee by the Act or the Regulation.

B1 Ongoing capacity to operate

B1.1 The Licensee must have the technical, financial and organisational capacity to carry out the activities authorised by this Licence. If the Licensee ceases to have this capacity, it must report this to IPART immediately in accordance with the Reporting Manual.

B2 Obtaining appropriate insurance

B2.1 Before commencing to commercially operate the Specified Water Industry Infrastructure under this Licence, the Licensee must:

a) obtain insurance that is appropriate for the size and nature of the activities authorised under this Licence;

b) provide a copy of each certificate of currency of the insurance obtained to IPART; and

c) demonstrate that the insurance obtained is appropriate for the size and nature of the activities authorised under this Licence by providing a report to IPART from an Insurance Expert that:

   i) certifies that in the Insurance Expert's opinion, the type and level of the insurance obtained by the Licensee is appropriate for the size and nature of the activities authorised under the Licence; and

   ii) is in the form prescribed by the Reporting Manual.

B2.2 [Not applicable]

B3 Maintaining appropriate insurance

B3.1 The Licensee must maintain insurance that is appropriate for the size and nature of the activities authorised under this Licence.

B3.2 The Licensee must provide a copy of each certificate of currency of the insurance maintained by the Licensee to IPART in accordance with the Reporting Manual.

B3.3 If there is to be a change in:

a) the insurer or underwriting panel in respect of an insurance policy held by the Licensee; or

b) the type, scope or limit on the amount of insurance held by the Licensee,

in relation to the activities authorised under this Licence, the Licensee must provide a report to IPART in accordance with the Reporting Manual.

B3.4 From time to time when requested in writing by IPART, the Licensee must provide a report to IPART, in the manner, form and time specified by IPART, from an Insurance Expert certifying that in the Insurance Expert's opinion the type, scope or limit on the amount of the insurance held by the Licensee is appropriate for the size and nature of the activities authorised under this Licence.

[Note: The circumstances in which IPART may request a report under clause B3.4 include (but are not limited to) the following:

- *where IPART has reason to believe that there may be a change in the type, scope or limit on the amount of insurance held by the Licensee in relation to activities authorised under this Licence;*
- *where there is a change in the type or extent of activities authorised under this Licence; or*
- *where IPART or an approved auditor has reason to believe that the type, scope or limit on the amount of insurance held by the Licensee may not be appropriate for the size and nature of the activities authorised under this Licence.]*

B3.5 The Licensee must maintain professional indemnity insurance during the Design Phase and for a minimum period of 6 years from the date of the completion of the Design Phase.

B4 Complying with NSW Health requirements

B4.1 The Licensee must carry out the activities authorised by this Licence in compliance with any requirements of NSW Health that:

a) IPART has agreed to; and

b) are notified from time to time to the Licensee by IPART in writing.

B5 Complying with Audit Guidelines from IPART

B5.1 The Licensee must comply with any Audit Guidelines issued by IPART.

B6 Reporting in accordance with the Reporting Manual

B6.1 The Licensee must prepare and submit reports in accordance with the Reporting Manual.

B7 Reporting information in relation to the Register of Licences

B7.1 Within 14 days of any change in relation to the following, the Licensee must notify IPART, and provide details, of the change in accordance with the Reporting Manual:

a) any source from which the water handled by the Specified Water Industry Infrastructure is derived;

b) the Authorised Purposes of the water handled by the Specified Water Industry Infrastructure;

c) the identity of each licensed retail supplier or public water utility that has access to the infrastructure services provided by the Specified Water Industry Infrastructure for the purpose of supplying water to its customers;

d) any other water infrastructure to which the Specified Water Industry Infrastructure is connected;

e) the identity of each licensed retail supplier or public water utility that has access to infrastructure services provided by the Specified Water Industry Infrastructure for the purpose of providing sewerage services to its customers;

f) any other sewerage infrastructure to which the Specified Water Industry Infrastructure is connected;

g) the arrangements for the disposal of waste from the Specified Water Industry Infrastructure.

B8 Monitoring

B8.1 The Licensee must undertake any monitoring that is required for the purposes of this Licence, any Plan, the Act or the Regulation in accordance with this clause B8.

B8.2 The Licensee must keep the following records of any samples taken for monitoring purposes specified in the Water Quality Plan:

a) the date on which the sample was taken;
b) the time at which the sample was collected;
c) the point or location at which the sample was taken; and
d) the chain of custody of the sample (if applicable).

B8.3 The Licensee must ensure that analyses of all samples taken for the purposes of Verification Monitoring are carried out by a laboratory accredited for the specified tests by an independent body that is acceptable to NSW Health, such as the National Association of Testing Authorities or an equivalent body.

B9 Provision of copy of Plan

B9.1 Whenever the Licensee makes a significant amendment to a Plan, the Licensee must provide a copy of the amended Plan to IPART at the same time that it provides a copy to the approved auditor engaged to prepare a report as to the adequacy of the amended Plan, as required under the Regulation.

B10 Delineating responsibilities – interconnections

B10.1 If a code of conduct has not been established under reg 25 of the Regulation, the Licensee must (by a date specified by IPART) establish a code of conduct (**Licensee's Code of Conduct)** in accordance with this clause B10.

B10.2 The Licensee's Code of Conduct must set out the respective responsibilities of:

a) the Licensee; and
b) each licensed network operator, licensed retail supplier and/or public water utility that:
   (i) supplies water or provides sewerage services by means of, or
   (ii) constructs, maintains or operates any water industry infrastructure that is connected to the Specified Water Industry Infrastructure,

by, at a minimum, providing for:

c) who is responsible for repairing, replacing or maintaining any pipes, pumps, valves, storages or other infrastructure connecting the Specified Water Industry Infrastructure to the other water industry infrastructure;
d) who is responsible for water quality;
e) who is liable in the event of the unavailability of water;
f) who is liable in the event of failure of the Specified Water Industry Infrastructure;
g) the fees and charges payable in respect of the use of the Specified Water Industry Infrastructure; and
h) who is responsible for handling customer complaints.

B10.3 Before the Licensee brings the Specified Water Industry Infrastructure into commercial operation or by a later date specified by IPART (if any), the Licensee's Code of Conduct must be agreed in writing between the Licensee and the other licensed network operators, licensed retail suppliers and/or public water utilities referred to in clause B10.2.

B10.4 [Not applicable]

B10.5 The Licensee must not contravene the Licensee's Code of Conduct to the extent that it makes the Licensee responsible or liable for the matters set out in it.

B11 Notification of changes to end-use

B11.1 If the Licensee proposes to operate the Specified Water Industry Infrastructure to supply water for an end-use which is not set out in the most recent Water Quality Plan provided to IPART, the Licensee must notify IPART in writing at least 3 months before commencing such operation.

B12 Notification of changes to Authorised Person

B12.1 If an Authorised Person ceases, proposes to cease, or receives notification to cease providing any of the services relating to the activities authorised by this Licence, the Licensee must provide IPART with written notice as soon as practicable but no later than 28 days before the date of cessation of the services. The written notice must include details of how the services previously undertaken by the Authorised Person will continue to be undertaken.

B13 Notification of commercial operation

B13.1 This clause B13 applies each time the Licensee has brought any of the Specified Water Industry Infrastructure into commercial operation.

B13.2 The Licensee must:

a) notify IPART in accordance with the Reporting Manual that it has brought the relevant Specified Water Industry Infrastructure into commercial operation; and

b) provide such notification within 10 days after it has brought the relevant Specified Water Industry Infrastructure into commercial operation.

INTERPRETATION AND DEFINITIONS

Interpretation

In this Schedule B, unless the context requires otherwise:

(i) the singular includes the plural and vice versa;
(ii) headings are used for convenience only and do not affect the interpretation of this Schedule B;
(iii) a reference to a document includes the document as modified from time to time and any document replacing it;
(iv) a reference to a "person" includes a natural person and any body or entity whether incorporated or not;
(v) a reference to a clause is to a clause in this Schedule B;
(vi) a reference to a schedule is to a schedule to this Licence;

(vii) a reference to a law or statute includes regulations, rules, codes and other instruments under it, and consolidations, amendments, re-enactments or replacements of them; and

(viii) explanatory notes do not form part of this Licence, but in the case of uncertainty may be relied on for interpretation purposes.

Definitions

Expressions used in this Schedule B that are defined in the Act or the Regulation have the meanings set out in the Act or the Regulation.

In this Schedule B:

Audit Guidelines	means the document entitled "Audit Guideline – Water Industry Competition Act 2006" which is prepared by IPART and is available on IPART's website at www.ipart.nsw.gov.au, and any other guidelines issued by IPART in relation to audits under the Act.
Authorised Person	means the authorised persons specified in, as applicable: (i) Licence Scope, clause S1, Table 1.1; (ii) Licence Scope, clause S2, Table 2.1; and (iii) Licence Scope, clause S3, Table 3.1.
Authorised Purposes	means the authorised purposes specified in, as applicable: (i) Licence Scope, clause S1, Table 1.3; (ii) Licence Scope, clause S2, Table 2.3; and (iii) Licence Scope, clause S3, Table 3.3.
Design Phase	means the period during which any design works are carried out in relation to the water industry infrastructure that the Licensee is authorised to construct, maintain and operate under this Licence.
Insurance Expert	means an insurance broker which holds an Australian financial services licence under Part 7.6 of the *Corporations Act 2001* (Cth) that authorises the broker to provide financial product advice for, and deal in, contracts of insurance within the meaning of Chapter 7 of that Act.
Licensee's Code of Conduct	has the meaning given in clause B10.1.
NSW Health	means the Water Unit of NSW Ministry of Health and any of the local health districts as defined by the NSW Ministry of Health.
Plan	means any infrastructure operating plan, water quality plan or sewage management plan that the Licensee is required to prepare under the Regulation.
Specified Area of Operations	means the area of operations specified in, as applicable: (i) Licence Scope, clause S1, Table 1.4; (ii) Licence Scope, clause S2, Table 2.4; and (iii) Licence Scope, clause S3, Table 3.4.
Specified Water Industry	means the water industry infrastructure specified in, as applicable: (i) Licence Scope, clause S1, Table 1.2;

Infrastructure	(ii) Licence Scope, clause S2, Table 2.2; and (iii) Licence Scope, clause S3, Table 3.2.
Verification Monitoring	means verification monitoring as described in the document entitled "Australian Drinking Water Guidelines" or the document entitled "Australian Guidelines for Water Recycling" as the case may be.
Water Quality Plan	means the water quality plan that the Licensee is required to prepare under the Regulation.

Review of Environmental Factors

Part 5 – EP&A Act, 1979

Sewage Treatment Plant & Sewage Reticulation Network
Catherine Hill Bay Scheme Stages 1 & 2
Lot 100, 101 & 106 DP1129872, Lot 1 DP1141989, Lot 1 DP1129299, Lot 103 DP1194707, Lot 101 & 102 DP1194707, Lot 213 DP883941, Lot 1 Section I DP168, Lot 1 Section K DP163, Flowers Drive Road Reserve, Montefiore Street Road Reserve

No. 85 & 95 Flowers Drive, 6 Keene Street & 12 Montefiore Street
Catherine Hill Bay

PLANIT

CONSULTING

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Review and Amendments Schedule – PLANIT CONSULTING PTY LTD

		Date
Authors	LN	July 2014
Reviewer	AS	July 2014

Revision
Rev A – 22/01/14
Rev B – 02/07/14
Rev C – 15/10/14
Rev D – 11/06/15
Rev E – 29/07/15

Planit Consulting Pty Ltd declares that it does not have, nor expects to have, a beneficial interest in the subject proposal.

Executive Summary

The Proposal

Catherine Hill Bay Water Utility Pty Ltd proposes the construction and operation of a Sewage Treatment Plant and Sewage Reticulation Network to be located on land identified as Lot 100, 101 & 106 DP1129872, Lot 1 DP1141989, Lot 1 DP1129299, Lot 103 DP1194707, Lot 101 & 102 DP1194707, Lot 213 DP883941, Lot 1 Section I DP168, Lot 1 Section K DP163, Flowers Drive Road Reserve, Montefiore Street Road Reserve, Catherine Hill Bay.

The Sewerage Treatment Plant and Sewer Reticulation Network would be located within the Lake Macquarie City Council Local Government Area. The site is boarded by the Munmorah State Conservation Area to the south and west and by the Munmorah State Conservation Area and Pacific Ocean to the east. To the north lies the existing village of Catherine Hill Bay. The location and context of the site are further discussed under Section 2.

The proposal is to service a subdivsion approved by the Planning Assessment Commission under Project Approval MP10_0204 on the 13 May 2011 which includes 550 residential lots, 1 retail lot, 9 reserves and 2 heritage lots. This exsting approval has been subject to modification application identifed as MP10_0204 MOD 2, This modification consolidated a number of approved residential allotments to provide a dedicated allotment for the Sewage Treatment Plant. The Sewage Treatment Plant location, as it relates to the development approved under MP10_0204 MOD 2 is further discussed under Section 2.

The proposed Sewage Treatment Plant would have the peak capacity to service 330kL per day and would be commissioned in three (3) stages. The subdivision the Sewage Treatment Plant is to service will require approximately 556ET treatment capacity. Ultimately the Sewage Treatment Plant would provide class A+ recycled water for domestic reuse on all allotments approved under MP10_0204 as modified. Domestic reuse would be facilitated via ‘third pipe’ (purple pipe) reticulated network.

Stage 1 would provide the full 556ET treatment capacity required by the CHB subdivision using a Membrane Bioreactor and Ultraviolet Disinfection, however only a maximum of 112ET would be connected at stage 1. Stage 1 would include onsite irrigation of treated wastewater. As an interim measure during stage 1 the recycled water network would be charged with potable water.

Stage 2 would see the installation of an Advanced Water Treatment Plant for the supply of class A+ recycled water through the ‘third pipe’ recycled water network for domestic re-use. Stage 2 would include a Reject Reverse Osmosis unit and would include three (3) Reverse Osmosis reject evaporation ponds; Stage 2 would be constructed once one hundred and twelve (112) lots within the subdivision are connected to the system and would service a maximum of 470ET. Stage 2 would include onsite irrigation of treated waste water.

Stage (3) represents an ultimate scenario to service the full 556ET required by the approved subdivision. Stage 3 would require a form of offsite discharge. Stage (3) of the proposal is not included or assessed as part of this Review of Environmental Factors and is mentioned for information purposes only. Stage 3 and the specific issues associated with it including using land which has been subject to recycled water irrigation for residential purposes will be subject to separate assessment and approval.

Need for the Proposal

The proposal is needed to facilitate urban services for the subdivision approved under Project Approval MP10_0204. The proposed Sewage Treatment Plant and Sewer Reticulation Network is a direct response to the need presented by this approved development

Options Considered

Five options have been identified for the proposal, these are:

1 – Do Nothing;
2 – Centralised connection to the Hunter Water Network;
3 – Decentralised system with water recycling and irrigation of Membrane Bioreactor & Ultra Violet treated effluent on private land;
4 – Decentralised system with water recycling and irrigation of Advanced Water Treatment Plant treated effluent on Council parks and verges;

The preferred option is option 3 and is that assessed within this Review of Environmental Factors, this option has been arrived at after considerable investigation into appropriate and economically feasible services provision and alternative measures to deal with wastewater.

A decentralised system licensed under the Water Industry Competition Act 2006 which maximises water recycling and irrigates Membrane Bioreactor treated effluent is the preferred option for the site.

Statutory and Planning Framework

The proposal has been assessed as permissible without consent under the relevant environmental planning instruments. That position is established by reference to Clause 106 of the Infrastructure SEPP.

The proposal is within the definition of an 'activity' set by Section 110 of the Environmental Planning and Assessment Act 1979 and is being proposed by a person licensed under the Water Industry Competition Act 2006 (pending issue of license). Assessment under Part 5 of the Environmental Planning and Assessment Act 1979 is therefore required.

The matters prescribed by Clause 228 of the Environmental Planning and Assessment Regulation 2000, for consideration by assessments under Part 5, are reviewed at Appendix B.

No requirement for a referral under the Environment Protection Biodiversity Conservation Act 1999 has been identified.

The proposal includes irrigation of lands within Stages 6 and 7 of the subdivision approved under MP10_0204. Legal advices have been sought on this issue and the irrigation is ancillary to Project Approval MP10_0204. Refer Legal Advices under Appendix P.

Community and Stakeholder Consultation

Given the nature and scale of the proposal and that no private residences are directly affected, community involvement has been limited.

Consultation has been undertaken with Lake Macquarie City Council and Independent Pricing and Regulatory Tribunal. Ongoing consultation would be held with relevant authorities during implementation of the proposal would be had were required.

Environmental Impacts

Environmental Impact as discussed in detail under Section 7.

Justification and Conclusion

The proposed Sewage Treatment Plant and Sewer Reticulation Network do not require development consent and is subject to assessment under Part 5 of the Environmental Planning and Assessment Act 1979. The Review of Environmental Factors has examined and taken into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the proposal. This has included consideration of critical habitat, impacts on threatened species, populations and ecological communities and their habitats and other protected fauna and native plants.

A number of potential environmental impacts from the proposal have been avoided or reduced during concept design development and options assessment. The proposal as described in the Review of Environmental Factors best meets the proposal objectives. Mitigation measures as detailed in this Review of Environmental Factors would ameliorate or minimise any expected impacts associated with the proposal. On balance the proposal is considered justified.

The environmental impacts of the proposal are not likely to be significant and therefore it is not necessary for an environmental impact statement to be prepared or approval to be sought for the proposal from the Minister for Planning under Part 5.1 of the Environmental Planning and Assessment Act 1979. The proposal is unlikely to affect threatened species, populations or ecological communities or their habitats, within the meaning of the *Threatened Species Conservation Act 1995* or *Fisheries Management Act 1994* and therefore a Species Impact Statement is not required. The proposal is also unlikely to affect Commonwealth land or have an impact on any matters of national environmental significance.

The subject site is considered able to suitably accommodate the proposed Sewage Treatment Plant & Sewer Reticulation Network.

1 – Introduction

1.1 Brief & Purpose of the Report

This Review of Environmental Factors has been prepared by Planit Consulting Pty Ltd on behalf of Coastal Hamlets Pty Ltd. For the purposes of this Review of Environmental Factors, Solo Water Pty Ltd (Catherine Hill Bay Water Utility Pty Ltd) is the proponent and the Minister administering the Independent Pricing and Regulatory Tribunal is the determining authority under Part 5 of the *Environmental Planning and Assessment Act 1979*.

The purpose of the Review of Environmental Factors is to describe the proposal, to document the likely impacts of the proposal on the environment, and to detail protective measures to be implemented.

The description of the proposal and associated environmental impacts have been undertaken in context of Clause 228 of the *Environmental Planning and Assessment Regulation 2000*, the *Threatened Species Conservation Act 1995*, *the Fisheries Management Act 1994*, and the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999*. In doing so, the REF helps to fulfill the requirements of Section 111 of the Environmental Planning & Assessment Act 1979, that the determining authority examine and take into account to the fullest extent possible, all matters affecting or likely to affect the environment by reason of the proposal.

The findings of the REF would be considered when assessing:

- Whether the proposal is likely to have a significant impact on the environment and therefore the necessity for an environmental impact statement to be prepared and approval to be sought from the Minister for Planning and Infrastructure under Part 5.1 of the Environmental Planning and Assessment Act 1979.
- The significance of any impact on threatened species as defined by the Threaten Species Conservation Act 1995 and/or Fisheries Management Act 1994, in Section 5A of the Environmental Planning and Assessment Act 1979 and therefore the requirement for a Species Impact Statement.
- The potential for the proposal to significantly impact a matter of national environmental significance or Commonwealth land and the need to make a referral to the Australian Government Department of Sustainability, Environment, Water, Population and Communities for a decision by the Commonwealth Minister for the Environment on whether assessment and approval is required under the Environment Protection and Biodiversity Conservation Act 1999.

1.2 Proposal Identification

Catherine Hill Bay Water Utility Pty Ltd proposes the construction and operation of a Sewage Treatment Plant and Sewage Reticulation Network to be located on land identified as Lot 100, 101 & 106 DP1129872, Lot 1 DP1141989, Lot 1 DP1129299, Lot 103 DP1194707, Lot 101 & 102 DP1194707, Lot 213 DP883941, Lot 1 Section I DP168, Lot 1 Section K DP163, Flowers Drive Road Reserve, Montefiore Street Road Reserve, Catherine Hill Bay.

The Sewerage Treatment Plant and Sewer Reticulation Network would be located within the Lake Macquarie City Council Local Government Area. The site is boarded by the Munmorah State Conservation Area to the south and west and by the Munmorah State Conservation Area and Pacific Ocean to the east. To the north lies the existing village of Catherine Hill Bay. The location and context of the site are further discussed under Section 2.

The proposal is to service a subdivsion approved by the Planning Assessment Commission under Project Approval MP10_0204 on the 13 May 2011 which includes 550 residential lots, 1 retail lot, 9 reserves and 2 heritage lots. This exsting approval has been subject to modification application identifed as MP10_0204 MOD 2, This modification consolidated a number of approved residential allotments to provide a dedicated allotment for the Sewage Treatment Plant. The Sewage Treatment Plant location, as it relates to the development approved under MP10_0204 MOD 2 is further discussed under Section 2.

The proposed Sewage Treatment Plant would have the peak capacity to service 330kL per day and would be commissioned in three (3) stages. The subdivision the Sewage Treatment Plant is to service will require approximately 556ET treatment capacity. Ultimately the Sewage Treatment Plant would provide class A+ recycled water for domestic reuse on all allotments approved under MP10_0204 as modified. Domestic reuse would be facilitated via 'third pipe' (purple pipe) reticulated network.

Stage 1 would provide the full 556ET treatment capacity required by the CHB subdivision using a Membrane Bioreactor and Ultraviolet Disinfection, however only a maximum of 112ET would be connected at stage 1. Stage 1 would include onsite irrigation of treated wastewater. As an interim measure during stage 1 the recycled water network would be charged with potable water.

Stage 2 would see the installation of an Advanced Water Treatment Plant for the supply of class A+ recycled water through the 'third pipe' recycled water network for domestic re-use. Stage 2 would include a Reject Reverse Osmosis unit and would include three (3) Reverse Osmosis reject evaporation ponds; Stage 2 would be constructed once one hundred and twelve (112) lots within the subdivision are connected to the system and would service a maximum of 470ET. Stage 2 would include onsite irrigation of treated waste water.

Stage (3) represents an ultimate scenario to service the full 556ET required by the approved subdivision. Stage 3 would require a form of offsite discharge. Stage (3) of the proposal is not included or assessed as part of this Review of Environmental Factors and is mentioned for information purposes only. Stage 3 and the specific issues associated with it including using land which has been subject to recycled water irrigation for residential purposes will be subject to separate assessment and approval.

2 - Site & It's Surrounds

2.1 Property Description

The site of the proposal is made up of a number of existing allotments. The legal property description and corresponding property address are identified in table 1. The site is located within the Lake Macquarie Council Local Government Area.

Table 1: Legal Description Summary

Lot & Plan No.	Property Address
Lot 100 DP1129872	95 Flowers Drive, Catherine Hill Bay
Lot 101 DP1129872	95 Flowers Drive, Catherine Hill Bay
Lot 106 DP1129872	95 Flowers Drive, Catherine Hill Bay
Lot 1 DP1141989	95 Flowers Drive, Catherine Hill Bay
Lot 1 DP1129299	95 Flowers Drive, Catherine Hill Bay
Lot 103 DP1194707	95 Flowers Drive, Catherine Hill Bay
Lot 101 DP1194707	95 Flowers Drive, Catherine Hill Bay
Lot 102 DP1194707	95 Flowers Drive, Catherine Hill Bay
Lot 213 DP883941	85 Flowers Drive, Catherine Hill Bay
Lot 1 Section I DP163	6 Keene Street, Catherine Hill Bay
Lot 1 Section K DP163	12 Montefiore Street, Catherine Hill Bay
Flowers Drive Road Reserve	N/A
Montefiore Street Road Reserve	N/A

The site is boarded by the Munmorah State Conservation Area to the south and west and by the Munmorah State Conservation Area and Pacific Ocean to the east. The site is adjoined to the north by the existing village of Catherine Hill Bay. The following further comment is provided on the location of the three key elements of the Proposal:

2.1.1 STP allotment

The Sewage Treatment Plant site would be located within and at the western extent of Lot 101 DP1129872. The proposal is to service a subdivsion approved by the NSW Planning Assessment Commission under Project Approval MP10_0204 on the 13 May 2011 which includes 550 residential lots, 1 retail lot, 9 reserves and 2 heritage lots.

This exsting approval has been modifed to consolidate a number of existing approved residential allotments to provide a dedicated lot for the Sewage Treatment Plant. The Sewage Treatment Plant would be located within this dedicated lot. This modification lodged with and approved by the NSW Department of Planning is identifed as MP10_0204 MOD 2.

The location of the Sewage Treatment Plant in relation to the amended subdivison layout under MP10_0204 MOD 2 is identifed in Figure 2.

2.1.2 Irrigation Area & Location

A total of 8.5 ha of restricted access effluent irrigation area would be provided to service stage 1 and 2 (maximum of 470ET). The irrigation area would be staged in line with the rate of production of surplus recycled water from the subdivision however a total of 4.5ha would be required for stage 1 and a further 4ha for stage 2. The irrigation system will be supplied from its own separate and independent irrigation network with its own irrigation pump.

The irrigation areas would be located on Lot 106 DP1129872 and Lot 100 DP1129872 and would occupy the land identified as subdivision stages 6 and 7 under MP10_0204.

The irrigation areas would be cordoned off from public access via fencing. This fencing would take the form of 0.9m high chain wire fencing and would incorporate warning signs not to enter and to avoid contact with recycled water every 50m around the perimeter of the irrigation area.

An aerial image of the proposed irrigation area location is provided in Figure 1. The Irrigation areas are also identified within the Land Capability Assessment for Effluent Irrigation under Appendix K and the irrigation area and proposed exclusion fencing design is identified on drawing SW-56-C-SK50 under Appendix Q.

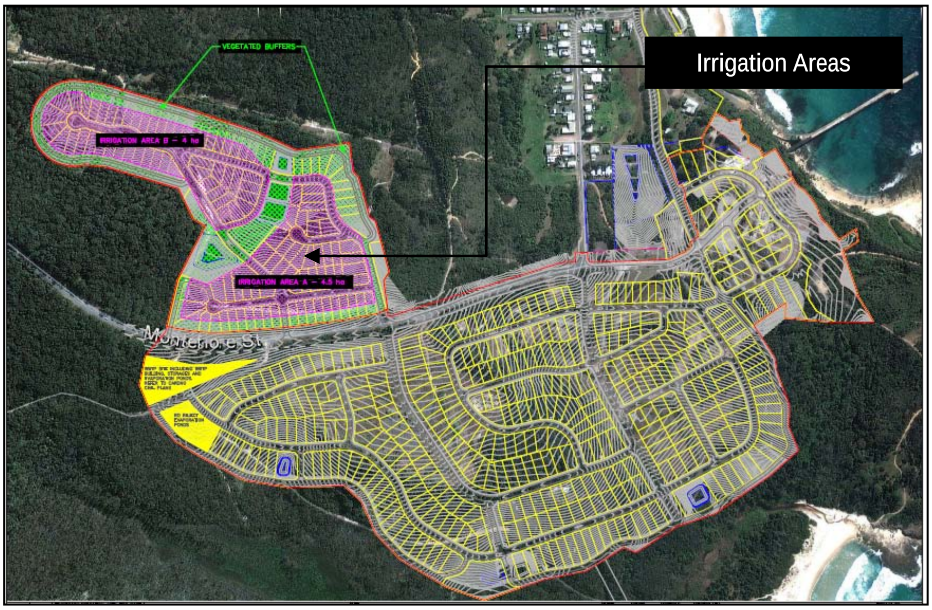


Figure 1 – Irrigation Area Location
Source: Solo Water Integrated Water Management Plan
Illustrative only. Not to scale

The proposed irrigation is ancillary to ancillary to Project Approval MP10_0204. Refer legal advices under Appendix P.

2.1.3 Reticulation Network

2.1.3.1 Pressure Sewer and Recycled Water Network

A sewer reticulation network is approved as part of MP10_0204. The reticulation network detail provided within the Review of Environmental Factors is provided to give a full picture of the overall system and its operation. The only items of the sewer reticulation network associated with the proposal which are not approved by and which will not be installed as part of construction works associated with delivering the approved subdivision under MP10_0204 is the installation of the pressure sewer units and associated gravity sewer components within the bounds of the future residential allotments which will be created as part of MP10_0204.

The reticulation network and the pressure sewer units and gravity sewer items which are separate to the sewer reticulation network approved as part of MP10_0204 would be located within all allotments identified within the Review of Environmental Factors.

Figure 2 – Amended Subdivision Layout Approved Under MP10_0204 MOD 2 & STP Location

Plan of: SUBDIVISION OF LOTS 100, 101, 102, 103, 106 IN D.P.1129872 LOT 1 D.P.1151628 LOT 1 D.P.1141989 LOT 1 D.P.1129299	Location: Catherine Hill Bay Council: Lake Macquarie	Datum: Origin: Projection: MGA Zone 56 Origin: North Direction: Grid Contour Interval:	Date: 17th July 2012 Sheet: 1 of 11 Plan By: KT Project Manager: LB Office: Coast Plan Purpose: Subdivision

Version: AI (14/01/2014)
Client: Coastal Hamlets Pty. Ltd.
Survey:
AutoCAD: 11688-SUB-002-AI-C3D
Our Reference: 11688

LOT COUNT

STAGE	RESIDENTIAL	RESERVE	RETAIL	TOTAL
1	110	1	1	112
2	149	1	-	150
3	40	1	-	41
4	84	-	-	84
5	40	1	-	41
6	79	4	-	83
7	46	-	-	46
HERITAGE	2	2	-	4
TOTAL	550			

CAR SPACES

ROADS 20, 22 & 23	- 81
ROAD 1	- 11
TOTAL	- 92

Ver.	Date	Comment
AI	06/01/2014	Stage 2 lot layout amended
AH	13/12/2013	Consolidate Stage 5 lots
AG	09/12/2013	Lot numbers amended
AF	04/12/2013	Stage 1 lot layout amended

NOTES
1. PROPOSED EASEMENTS FOR SERVICES & DRAINAGE NOT SHOWN & WILL BE SUBJECT TO FINAL DESIGN.
2. BOUNDARIES HAVE BEEN DETERMINED BY PLAN DIMENSIONS ONLY, AND HAVE NOT BEEN SURVEYED. ALL BEARINGS, DIMENSIONS, AREAS AND EASEMENTS ARE SUBJECT TO FINAL SURVEY

adw johnson

Plotted By: jeremyd Plot Date: 14/01/14 - 10:12 Cad File: C:\Users\jeremyd\appdata\local\temp\AcPublish_13161\11688-SUB-002-AI-C3D.dwg

2.2 Location / Context

The proposal would be located on land to the east of the Pacific Highway and the south and south west of the existing Catherine Hill Bay village (which includes approximately 90 dwellings and urban facilities). The proposed development site lies to the north of the Munmorah State Conservation Area.

The Catherine Hill Bay development site is located within the Lake Macquarie Council Local Government Area and is situated approximately 100 kilometers north of Sydney and 26 Kilometers south of Newcastle. The site is identified in Figure 3.

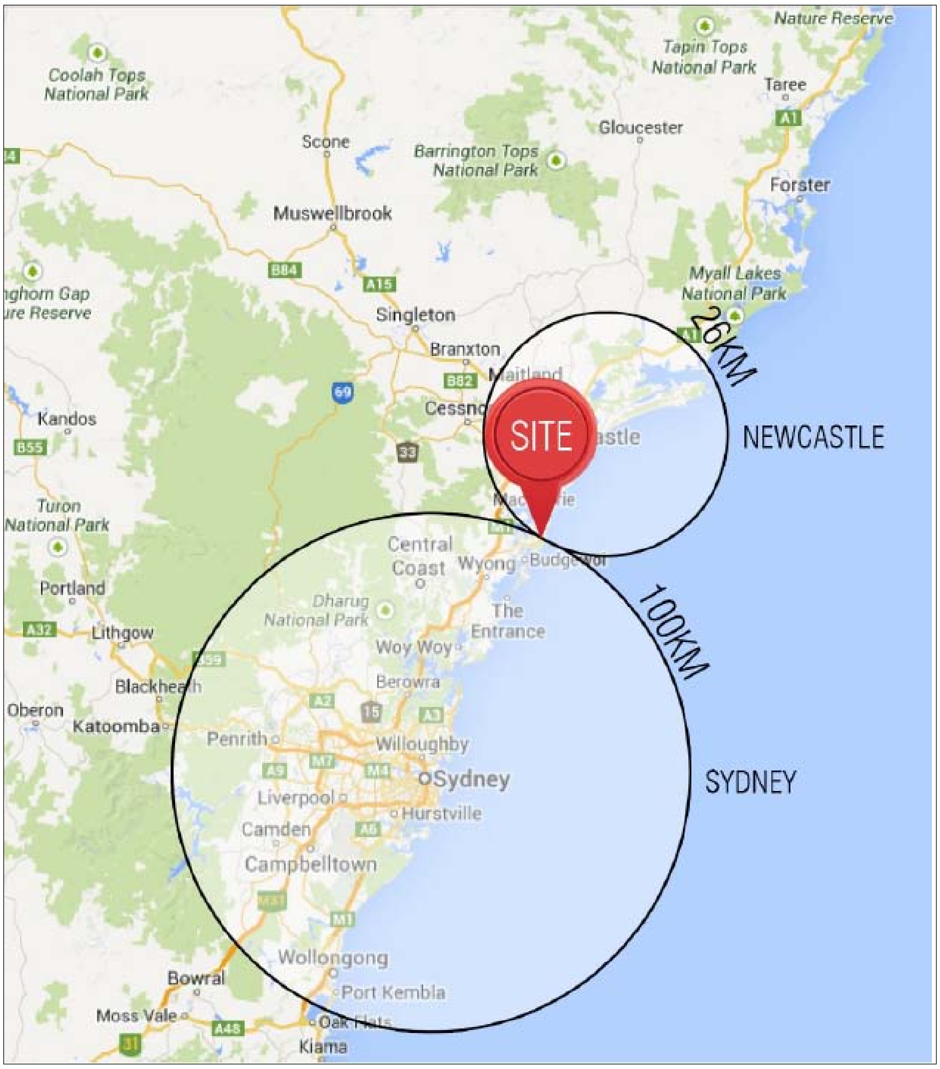


Figure 3 – Site Locality
Source: Landscape & Visual Impact Assessment
Illustrative only. Not to scale

An overview of the Catherine Hill Bay subdivision development site and the approximate location of the Sewage Treatment Plant site are provided below in Figure 4.

Figure 4: Site Location
Source: Landscape & Visual Impact Assessment
Illustrative only. Not to scale

2.3 Existing Approvals

2.3.1 Project Approval MP10_0204

Previous development approval has been granted by the NSW Planning Assessment Commission under Project Approval MP10_0204 on the 13 May 2011 which includes 550 residential lots, 1 retail lot, 9 reserves and 2 heritage lots (as amended 27/05/2013). This exsting approval has been subject to a modification application indentifed as MP10_0204 MOPD 2. MP10_0204 MOD 2 included the consolidation of a number of exsting approved residential allotments to provide a dedicated lot for the Sewage Treatment Plant. The Sewage Treatment Plant would be located within this dedicated lot.

Importantly MP10_0204 was subject to a detailed assessment including but not limited to matters of ecological significance, Aboriginal heritage, land contamination, access, etc. In light of this approval there are a significant number of synergies with regards to items that have already been assessed and approved and that which would potentially need to be assessed as part of this Review of Environmental Factors. There are also a number of items that would normally be associated with such a proposal has already have approval.

To clarify Project Approval MP10_0204 does not cover the following elements of this proposal:

1 – The construction of the Sewage Treatment Plant Building and Facility including the Reverse Osmosis reject Evaporation ponds on the SP2 Zoned Land;
2 – The general operation of the Sewage Treatment Plant (Note the irrigation is ancillary to the subdivision approved under MP10_0204; and
3 – The installation of the sewer pressure units and gravity connections within the bounds of the lots.
4 – Forming of the catch and diversion drains within the irrigation area

Subject to completion of the works approved by MP10_0204, the Sewage Treatment Plant and Irrigation site would be provided as a cleared, remediated site with formed access. Importantly for this assessment where an overlap exists with the requirements of the existing approval it has been recommended that the requirements of the existing consent and other relevant approvals be completed prior to commencement of work on the Sewage Treatment Plant or associated items.

For reference a copy of the MP10_0204 is included under Appendix G.

2.3.2 EPBC Act Approval

As part of the assessment of MP10_0204 an Environmental Protection and Biodiversity Conservation Act (EPBC) Act referral was required due to proposed vegetation clearing. Environment Protection Biodiversity Conservation Act referral 2012/6382 was approved on the 27 February 2009. Importantly MP10_0204 has assessed all issues relating to flora and fauna associated with the clearing required by the subdivision. The Sewage Treatment Plant and Sewer Reticulation Network are located within the approved footprint under MP10_0204 and does not require or result in the need for clearing beyond that already approved.

For reference a copy of the Environment Protection Conservation Act Referral 2012/6382 approval is included under Appendix H.

2.3 Existing Improvements

Subject to completion of that required by MP10_0204, the Sewage Treatment Plant and irrigation site will be presented as a cleared, remediated site with access. As such for the purposes of this Review of Environmental Factors the site is considered to have no existing improvements.

2.4 Roads and Access

The Sewage Treatment Plant site has road access from the Pacific Highway via Montefiore Street, approved road 28 and approved road 3, Refer Figure 2. Approved road 28 & 3 are to be constructed as per consent MP10_0204; while as per the requirements of the voluntary planning agreement applying to MP10_0204 the subdivision developer must enter into a road work agreement with the RTA (now RMS) for the upgrade of the Montefiore Street and Pacific Highway intersection prior to the release of subdivision certificate for the creation of the first urban lot.

The irrigation areas will be accessible from Montefiore Parkway. The location of this access is identified on drawing SW-56-C-SK50 under Appendix Q.

For the purposes of the Review of Environmental Factors it has been assumed that access as required to service the subdivision would be constructed and would be available for the Sewage Treatment Plant and irrigation site.

2.5 Statutory Zoning

The site is subject to the provisions of the Lake Macquarie Local Environmental Plan 2004 and is subject to a number of land use zonings; these zones are identified as follows and are shown in Figure 5:

- SP2 Infrastructure
- R2 Low Density Residential
- E2 Environmental Conservation
- 2(1) Residential
- 7(1) Conservation (Primary); and
- 7(4) Environmental (Coastline)

The surrounding area includes a number of additional land uses and zonings. In the immediate vicinity the following land use zonings are present:

- E1 National Parks and Nature Reserves;
- E2 Environmental Conservation; and
- 8 National Park

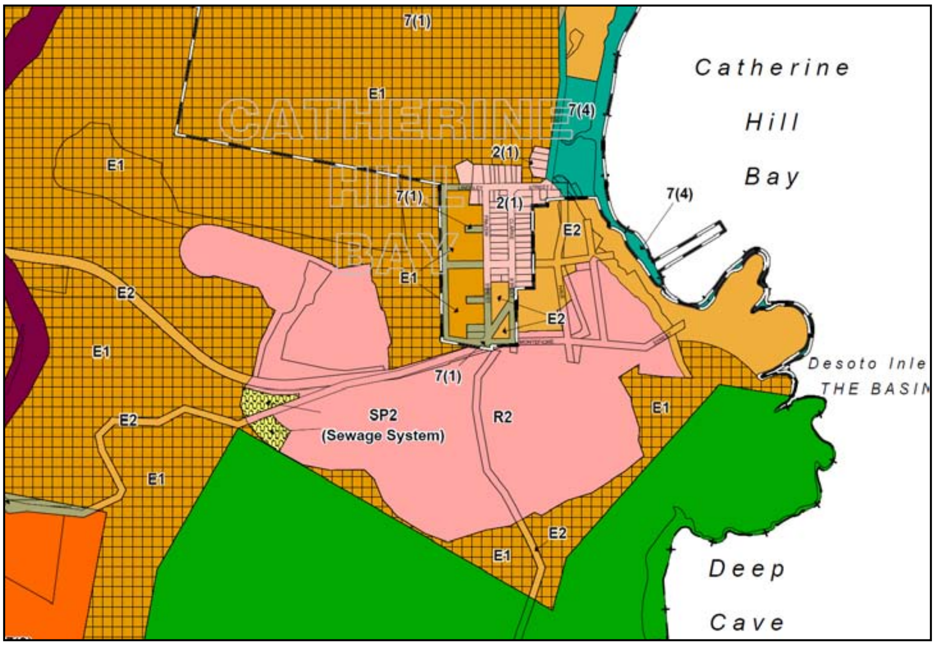


Figure 5: Statutory Zoning
Source: SEPP Major Developments 2005
Illustrative only. Not to scale

2.6 Environmental Considerations

2.6.1 Topography

The topography of the Catherine Hill Bay development area which includes the site is significantly altered terrain. The change to the topography has resulted from the former land use of coal mining access, storage, processing/washery and handling of coal exported from the jetty of Catherine Hill Bay.

Geotechnical testing undertaken in support of the project approval MP10_0204 indicates that the current topography has significant areas of cut to fill with benching of up to 10-15 metres from the existing natural surfaces. This was for the creation of flat pads associated with the coal handling land use. The change to topography commenced in the 1870's.

The Catherine Hill Bay subdivision will require bulk earth works to be undertaken as part of the development. Topography of the Sewage Treatment Plant and Irrigation site would not be a constraint to development.

2.6.2 Bushfire Prone Land

The site is mapped as bushfire prone land.

2.6.3 Flooding

The site is not mapped as flood prone land.

2.6.4 Sensitive Receivers (Noise & Odour)

There is a small number of existing residence located approximately 800m radius from the Sewage Treatment Plant site. Future residence with stage 5 and 6 of the amended subdivision as proposed under MP10_0204 MOD 2 would be located within 500m radius of the Sewage Treatment Plant site. The location of the Sewage Treatment Plant and surrounding noise sensitive receivers is shown in Figure 6. It is noted that the residences with stage 6 would only be constructed pending separate approval of stage 3 of the Sewage Treatment Plant and Sewer Reticulation Network.

Figure 6: Location of Noise Sensitive Receivers
Source: Noise Impact Assessment – Vipac
Illustrative only. Not to scale

2.6.5 Heritage Items

2.6.5.1 Aboriginal Heritage Items

An Aboriginal cultural heritage management plan has been prepared in relation to project approval MP10_0204. A copy of this management plan is included under Appendix M – Aboriginal Cultural Heritage Management Plan for reference. This assessment identified a single isolated stone artefact within the bounds of the Sewage Treatment Plant site, refer figure 7. No other archaeological sites or features where found within the subdivision development footprint approved under MP10_0204.

Figure 7: Location of Isolated Stone Artefact
Source: Aboriginal Cultural Heritage Management Plan for Project Approval, Catherine Hill Bay – Insite Heritage Pty Ltd
Illustrative only. Not to scale

2.6.5.2 Non Aboriginal Heritage Items

A number of the allotments which form part of the site fall within the Catherine Hill Bay Cultural Heritage Precinct. The Catherine Hill Bay Cultural Heritage Precinct is listed on the New South Wales State Heritage Register. The area of the site located within the Catherine Hill Bay Cultural Heritage Precinct is identified in Figure 8.

Figure 8: CHB Cultural Heritage Precinct Mapping
Source: NSW State Heritage Register
Illustrative only. Not to scale

The site also includes lots 101 and 102 DP1194707. Both are identified as heritage lots and are located within the Wallarah House Heritage Precinct under the Catherine Hill Bay (South) Development Control Plan 2012 adopted by the Department of Planning and Infrastructure on 18 July 2012.

Works within the Cultural heritage precinct and within Lots 101 & 102 DP1194707 do not relate to built structures upon these sites. Work would be limited to the installation of pressure sewer units and associated gravity sewer component of the sewer reticulation network.

2.6.6 Biodiversity

In June 2012, the Federal Department of Sustainability, Environment, Water, Populations and Communities (DSEWPC) approved an Environment Protection Biodiversity Conservation Act referral allowing the clearing of all vegetation within the subdivision footprint approved under MP10_0204.

The proposed site of the Sewage Treatment Plant is located within the footprint of the approved subdivision and is to be created in accord with the existing approvals (MP10_0204 as amended) and will be provided by Coastal Hamlets Pty Ltd to Catherine Hill Bay Water Utility Pty Ltd as a vacant clear site for construction of the Sewage Treatment Plant. The proposal would not require any clearing beyond that already approved in association with MP10_0204.

It is also noted that at the time of preparation of this review of environmental factors the clearing permitted under MP10_0204 and the EPBC Act approval has occurred and the site is clear of vegetation.

3 - Description of the Proposal

3.1 General Summary

The proposed Sewage Treatment Plant would have the peak capacity to service 330kL per day and would be commissioned in three (3) stages. The subdivision the Sewage Treatment Plant is to service will require approximately 556ET treatment capacity. Ultimately the Sewage Treatment Plant would provide class A+ recycled water for domestic reuse on all allotments approved under MP10_0204 as modified. Domestic reuse would be facilitated via 'third pipe' (purple pipe) reticulated network.

Stage 1 would provide the full 556ET treatment capacity required by the CHB subdivision using a MeMembrane Bioreactorane Bioreactor and Ultraviolet Disinfection, however only a maximum of 112ET would be connected at stage 1. Stage 1 would include onsite irrigation of treated wastewater. As an interim measure during stage 1 the recycled water network would be charged with potable water.

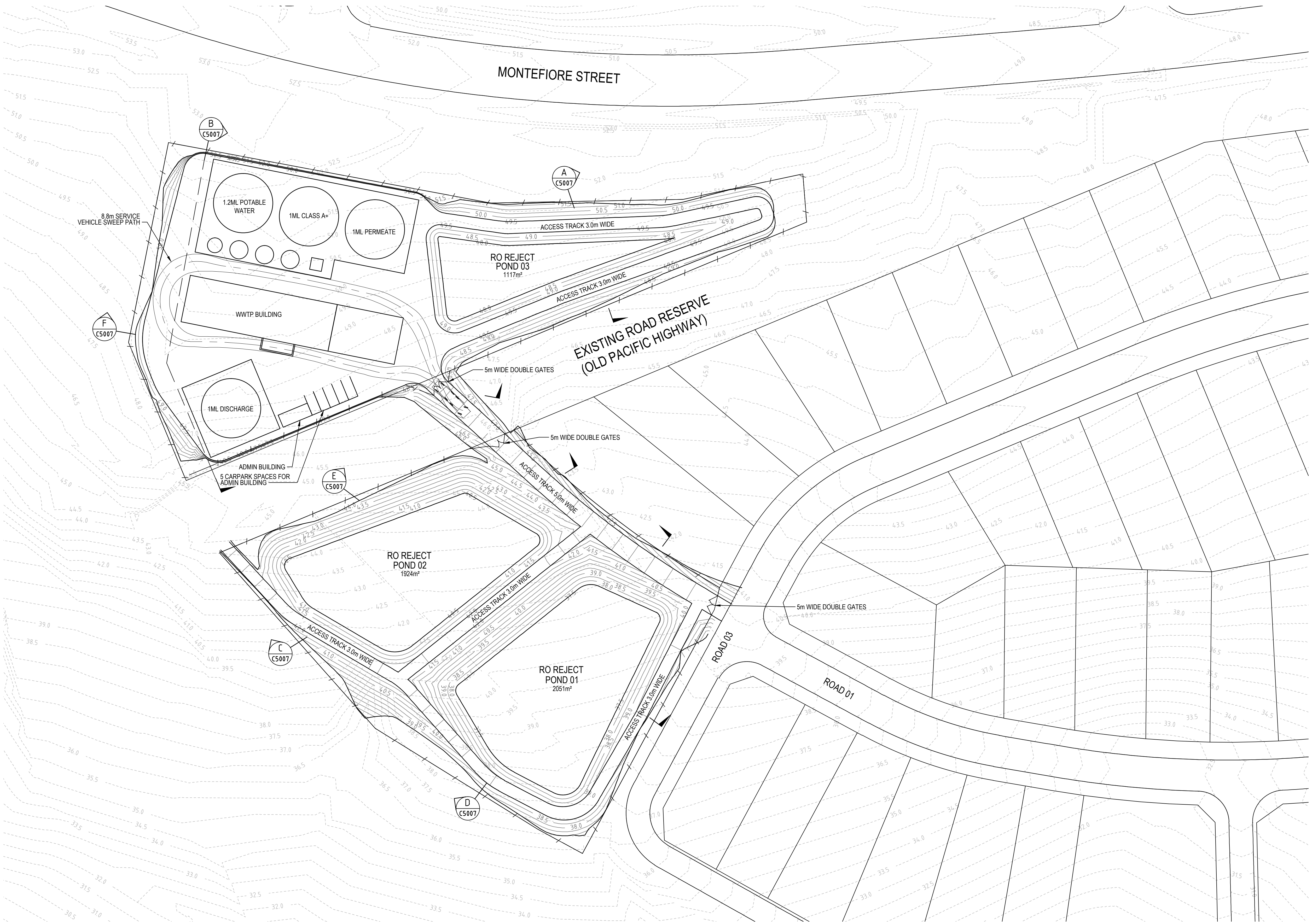
Stage 2 would see the installation of an Advanced Water Treatment Plant for the supply of class A+ recycled water through the 'third pipe' recycled water network for domestic re-use. Stage 2 would include a Reject Reverse Osmosis unit and would include three (3) Reverse Osmosis reject evaporation ponds; Stage 2 would be constructed once one hundred and twelve (112) lots within the subdivision are connected to the system and would service a maximum of 470ET. Stage 2 would include onsite irrigation of treated waste water.

Stage (3) represents an ultimate scenario to service the full 556ET required by the approved subdivision. Stage 3 would require a form of offsite discharge. Stage (3) of the proposal is not included or assessed as part of this Review of Environmental Factors and is mentioned for information purposes only. Stage 3 and the specific issues associated with it including using land which has been subject to recycled water irrigation for residential purposes will be subject to separate assessment and approval.

3.2 Plant Layout

The proposed layout of the plant is identified in Figure 9. This plan graphically depicts the ultimate layout of the Sewage Treatment Plant. It is noted no physical changes occur between stage 2 and 3 of the scheme. This plan is also contained within Appendix A.

Figure 9 – Stage 2 Plant Layout



SITE PLAN

SCALE 1:500

LEGEND

—/—	PROPOSED FENCE
—30.0—	DESIGN CONTOURS (0.5m INTERVAL)
- -30.0- -	EXISTING CONTOURS (0.5m INTERVAL)

0 10 20 30 40 50m

SCALE 1:500 @A1

SCALE 1:1000 @A3

Rev	Date	Description	Des.	Verif.	Appr.
1	13/06/2014	ISSUED FOR REVIEW	LJW	JMK	JMK

SOLO Water

Water Utility Solutions

Cardno

Shaping the Future

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Level 1, 47 Burelli Street, Wollongong, NSW Australia 2500
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		Date
Drawn	LJW	12/06/2014
Checked	JMW	12/06/2014
Designed	JMK	12/06/2014
Verified	JMK	12/06/2014
Approved	JMK	13/06/2014

Client: SOLO WATER - CATHERINE HILL BAY WATER UTILITY

CATHERINE HILL BAY
WASTE WATER TREATMENT PLANT
CIVIL ENGINEERING DESIGN

SITE PLAN

Status: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

Datum	Register	Scale	Size
A.H.D.	****	1:500	A1

Drawing Number: 8201405802-C5002

Revision: 1

DATE PLOTTED: 13 June 2014 4:31 PM BY : LUKE WARD

CAD FILE: U:\FY14058-02_Catherine Hill Bay WWTP\02 - Catherine Hill Bay WWTP\Drawings\Build\8201405802-C5002.dwg

XREF's: X-8201405802-WWTP; X-CO-Contours-Design-500; x-design; X_STAGE_1_BASE; X-CO-Contours-Existing-500

3.2.1 Construction

The proposal will see the construction of the following items independent of that approved as part of the subdivision under Project Approval MP10_0204:

- Sewage Treatment Plant Facility including Reverse Osmosis Reject Evaporation Pond;
- Installation of the irrigation system and forming of the diversion and catch drains within the ancillary irrigation area; and
- Installation of pressure sewer units and gravity connections within the bounds of the lots.

<u>Sewage Treatment Plant</u>

Construction of the Sewage Treatment Plant is to be undertaken in two (2) stages. The following scope of works is identified for each stage of construction. The construction stages align with the two (2) commissioning stages assessed by this REF. Stage two (2) would commence upon connection of 112 lots to the Sewage Treatment Plant.

Stage 1

- Sewage Treatment Plant Building and Office
- Membrane Bioreactor & Associated Process Tanks;
- 2 X 1 ML Wet Weather Storage Tanks;
- 1ML Recycled Water Tank
- 1ML Potable Water Storage tank;
- Permanent fence around perimeter with gate;
- All site hardstand including access and manoeuvring areas;
- Install all service ducting to accommodate final Stage 2 fitout;
- Install stage 1 services;

Stage 2

- Install Advanced Water Treatment Plant and associated process tanks; and
- Reverse Osmosis Reject Evaporation Ponds
- Install stage 2 services;

The above two (2) stages are represented within the plans under Appendix A. For process description associated with each stage refer to the Integrated Water Management Plan under Appendix C.

<u>Irrigation System</u>

The irrigation system will be staged in line with waste water generation with total area for each stage of the sewage treatment plant system to be as follows

Stage 1

- Progressive installation of 4.5ha of irrigation area including vegetated buffers and perimeter fencing

Stage 2

- Progressive installation of 4.0ha of irrigation area including vegetated buffers and perimeter fencing

The above two (2) stages are represented within the plans under Appendix Q.

3.2.2 System Commissioning & Construction Quality

The proposal relies in low infiltration rates to ensure system inflows are not adversely impacted upon. To ensure low infiltration rates the construction of each element of the system is of importance but particularly so for the gravity sewer components of the proposal.

To ensure low infiltration rates the gravity collection will be constructed and tested in line with the Water Services Association of Australia Sewerage Code of Australia WSA02 and provided with a minimum grade of 1 in 60. The gravity component of the proposal uses 150 mm rubber ring PVC on the main line connecting to 100 mm solvent welded PVC house connection. The Standard Drawings of the gravity component and connection are represented within the plans under Appendix Q.

Solo Water has developed Inspection and Test Plans based on the Water Services Association of Australia Code for quality assurance of the gravity and pressure sewer systems. These inspections and tests are undertaken before accepting the sewer reticulation network components installed under Project Approval MP10_0204. A copy of the Inspection and Test Plan is provided under Appendix R.

3.3 Sewage Reticulation Network & 'Third Pipe' recycled water network layout.

As discussed under 2.3.1 Project Approval MP10_0204 has approved a sewer reticulation network and this is to be construction as part of the works associated with MP10_0204. The pressure sewer units and the gravity sewer component of the sewer reticulation system that will be installed as part of the works of this Review of Environmental Factors will located within the bounds of the residential allotments that will be created as part of MP10_0204 will match the subdivision layout approved under MP10_0204 as amended.

The overall sewer reticulation network would be built in seven (7) stages consistent with the staging approved under MP10_0204 as amended. To provide an overview of the whole system the master plan of the network for stage 1 of the subdivision approved under MP10_0204 are contained under Appendix Q.

It is noted stage 6 and 7 of the subdivision approved under MP10_0204 would not proceed until approval is sought and granted for stage 3 of this proposal.

3.4 Irrigation

Recycled water irrigation would occur as part of stage 1 and 2. All waste water for irrigation would be Membrane Bioreactor and Ultra Violet treated. Irrigation is ancillary to the residential use approved under MP10_0204. Legal Advices has been sought on this and are provided under Appendix P.

A total of 8.5 ha of restricted access effluent irrigation area would be provided to service stage 1 and 2 of the proposal (maximum 470ET). The irrigation area would be staged in line with the rate of production of surplus recycled water from the subdivision however a total of 4.5ha would be required for stage 1 and a further 4ha for stage 2. The irrigation system will be supplied from its own separate and independent irrigation network with its own irrigation pump.

The irrigation system and diversion and catch drains would be formed as part of the works under this review of environmental factors.

The irrigation areas would be located on Lot 106 DP1129872 and Lot 100 DP1129872 and would occupy the land identified as subdivision stages 6 and 7 under MP10_0204. An aerial image of the proposed irrigation area location is provided in Figure 1. The irrigation area will also be fully fenced with a 0.9m chain wire fence around the perimeter to prevent access. The fencing will include warning signs not to enter and to avoid contact with recycled water every 50m. The location of the fencing and signage is identified under Appendix Q.

In addition to fencing of the irrigation area and signage, information packs would be provided to all residents of the subdivision approved under MP10_0204 and the residents of the existing Catherine Hill Bay village. As standard these information packs cover homeowner obligations relating to pressure sewer, water usage, waste disposal, incident reporting and appropriate recycled water usage protocols. These information packs will also include information identifying the location of irrigation areas, identifying the risks of coming into contact with effluent, that people should not enter the nominated irrigation areas and provide actions to take should they come into contact with treated effluent (i.e wash, monitor health, seek medical assistance if required).

The onsite irrigation system including daily water and nutrient balance modelling is described within the Land Capability Assessment for Effluent Irrigation. This is included under Appendix K.

The vegetation with the irrigation area would be subject to ongoing monitoring and maintenance to ensure longer term health and function. The monitoring and maintenance measures are outlined within Section 9 of the Land Capability Assessment for Effluent Irrigation. These measures would be incorporated in the operational environmental management plan for the proposal.

3.5 Operational Detail

3.5.1 Plant Operation & Equipment

To demonstrate how the plant will work an Integrated Water Management Plan, Land Capability Assessment for Effluent Irrigation and Preliminary Operating Plan has been prepared. These are included under Appendix C, Appendix K and Appendix N respectively. Table 2 summarises the main components of the system:

Table 2: STP Component Summary

Scheme Component	General Description
Membrane Bioreactor + Ultraviolet disinfection	All wastewater is treated using Membrane Bioreactor + Ultra Violet disinfection to produce high quality effluent. Typical Membrane Bioreactor effluent quality: - BOD < 10 mg/L - SS < 5 mg/L - TN < 10 mg/L - TP < 0.3 mg/L - Faecal Coliform < 10 cfu/100 mL - Turbidity < 1 NTU The Membrane Bioreactor + Ultra Violet treatment plant has a peak design capacity of 330 kL/day and is sized to provide treatment of average wastewater flows plus a 10% contingency allowance. The full capacity of the Membrane Bioreactor is constructed upfront during Stage 1.
Advanced Water Treatment Plant – Constructed during Stage 2	Following construction of the Advanced Water Treatment Plant during Stage 2, Membrane Bioreactor treated effluent undergoes further treatment in the Advanced Water Treatment Plant to produce “Class A+” recycled water suitable for supply to customers in the third pipe non-potable water reticulation network. The Advanced Water Treatment Plant uses a multiple barrier approach to achieve log reduction targets outlined in the Australian Guidelines for Water Recycling (2006) using Ultrafiltration Membrane Bioreactors, Ultraviolet disinfection and Chlorine contact tank and residual chlorination. All treatment processes in the Advanced Water Treatment Plant will be

	designed to appropriate United States Environmental Protection Agency standards using equipment accredited under United States Environmental Protection Agency guidelines. The Advanced Water Treatment Plant is sized with a nominal capacity of 300 kL/day of recycled water. The Advanced Water Treatment Plant will be operational once 112 lots are connected to the scheme.
Third pipe recycled water network	Compliant recycled water supplied through the urban non-potable water reticulation system is reused for the following uses: - Toilet flushing - Laundry washing machine cold water (hard plumbed only) - Outdoor cleaning and washdown (including bin and car washing) - Unrestricted irrigation of private lots The non-potable water reticulation system is supplied from a 1 ML recycled water storage tank using a variable speed drive booster pump set. Pressure in the non-potable water reticulation system is maintained below the pressure in the potable water network. An emergency potable water top-up (with air gap) is used to top-up the recycled water storage tank during consecutive peak day demands for recycled water. During Stage 1 only potable water is used to supply the non-potable water reticulation system until the Advanced Water Treatment Plant is constructed in Stage 2.
8.5ha land irrigation	Surplus Membrane Bioreactor treated effluent is managed by controlled irrigation of the temporary irrigation areas to be constructed on the developer's land inside the footprint of the approved subdivision. A total of 8.5ha of restricted access effluent irrigation area would be provided for the scheme servicing 470ET. Stage 1 will require 4.5ha and stage 2 a further 4ha. All irrigation water is stored in 2 ML wet weather storages prior to supply via a separate independent irrigation supply network. The system is designed to prevent irrigation during or shortly after rainfall through the use of weather station override on the main irrigation supply pump. Automated irrigation controllers are used to schedule effluent irrigation events on the restricted access open space areas in a controlled manner using spray drift controls and vegetated buffers to minimise environmental and public health risks. The effluent irrigation area would provide the following buffers: • Minimum 30m to down gradient property boundary • Minimum 40m to down gradient property boundary in steeper north east corner of the irrigation area • 20m buffer to up gradient property boundary • No irrigation within the 40m wide future waterway corridor approved under MP10_0204 • 70m minimum buffer to nearest residential dwelling

	The irrigation area will also be fully fenced with a 0.9m chain wire fence around the perimeter to prevent access. The fencing will include warning signs not to enter and to avoid contact with recycled water every 50m. The vegetation with the irrigation area would be subject to ongoing monitoring and maintenance to ensure longer term health and function. The monitoring and maintenance measures are outlined within Section 9 of the Land Capability Assessment for Effluent Irrigation. These measures would be incorporated in the operational environmental management plan for the proposal.

3.5.2 Work Force & Operation Times

The proposed sewage treatment plant will operate 365 days a year, 24 hours a day. Once constructed, the plant will be run by two (2) full time employees. Specialist maintenance contractors would be bought into the site as required to provide maintenance.

3.5.3 Waste Management

The proposed sewerage treatment plant would provide five (5) waste streams. In handling the waste the proposal would undertake the following

- A register will be maintained for all waste sampling and classification results for the life of the proposal in accordance with EPA's Classification Guidelines; and
- Detailed procedures for waste handling including storage and disposal procedures are be established and included within the Operation Environmental Management Plan.

The five (5) waste streams are identified as:

<u>Membrane Bioreactor Screenings and Grit</u>

All incoming wastewater passes through a fine screen before entering the membrane bioreactor treatment process. The screen used is a rotating drum screen with automatic bypass and high level monitoring and is located inside the Waste Water Treatment Plant building.

The screen includes an automatic dewatering and bagging unit to minimize Occupational Health & Safety issues associated with handling screenings. As each bag is filled, at approximately monthly intervals, the waste material would be taken off site for disposal at an approved land fill facility.

The amount of screenings produced would be minimized through ongoing customer education designed to increase awareness of appropriate solid waste disposal practices.

<u>Membrane Bioreactor Waste Activated Sludge</u>

The membrane bioreactor is an activated sludge process that produces waste activated sludge at approximately 2% of the inflow rate. At ultimate development approximately 5 kL/day of waste activated sludge at solids content of approximately 10,000 mg/L will be generated from the membrane bioreactor. Waste sludge will be stored in a sealed tank until it is removed from the site at approximately weekly intervals by a licensed liquid waste transport contractor and disposed of to the nearest approved municipal wastewater treatment plant.

<u>Reverse Osmosis Reject</u>

The Sewage Treatment Plant includes a reverse osmosis units for salinity control in the recycled water network. The production of waste concentrate is proportional to flow through the Sewage Treatment Plant and feed water salinity. The Reverse Osmosis process would produce a Reverse Osmosis reject waste stream that requires management.

The Reverse Osmosis system is estimated to produce an average of 6.4kL/day of Reverse Osmosis reject with Total Dissolved Solids concentration of approximately 5000 mg/L. The reject Reverse Osmosis waste stream will be managed by:

- Three (3) High Density Polyethylene lined and level monitored evaporation ponds with total surface area of 4870m^2; and
- Level sensors are used to detect breaks in the liner and to raise alarms before the ponds are full so the operator can take action by either turning off the Reverse Osmosis units or road tanker pump out can be arranged.

The above Reverse Osmosis reject management system has been designed using daily water balance modeling. During prolong and extreme wet weather events when the evaporation ponds may fill, reject Reverse Osmosis would be trucked offsite to ensure there are no uncontrolled overflows to the environment.

Discussion of the Reverse Osmosis reject management system and water balance modeling is provided in Reverse Osmosis Reject Evaporation Pond Water Balance Report under Appendix I. It is noted in these reports the reverse osmosis reject ponds are modeled to overflow in 6% of years. This is a theoretical statistical result from the modeling, the reject ponds will be operated so as to never overflow.

In the 6% of years when the ponds would be full, overflow will be avoided by undertaking the following

- Turning off the reverse osmosis unit; and/or
- Tanking off excess and disposing offsite at the nearest accepting licensed waste facility.

These procedures will occur as outlined within section 3.3 of the Reverse Osmosis Reject Exportation Pond Water Balance Report under Appendix I.

Membrane Bioreactor Chemical Cleaning Wastewater

Chemical laden wastewater used in membrane bioreactor cleaning would contain high concentrations of chlorine, acid/or caustic. The exact constituents would vary depending on the cleaning regime being undertaken. All Membrane Bioreactor cleaning wastewater is temporarily stored in the Clean In Place waste tank and neutralized prior to return to the inlet balance tank for treatment in the membrane bioreactor.

Return of neutralized water is ‘trickled’ back to the inlet balance tank in a controlled manner over a period of several days or weeks to ensure no impact on the biological process of the system. If process impacts are observed during operation this waste stream will be removed from the site and taken to the nearest approved facility by licensed liquid waste transport contractor.

General Waste

The site will generate a small amount of general waste including general waste from staff, landscaping waste from maintenance and general cleaning waste. This waste would be serviced by the local waste contractor.

Irrigation Area Green Waste

Irrigation as part of the proposal will generate a green waste stream. The irrigation areas are to be mowed and maintained to ensure ongoing plant growth and nutrient uptake. Biomass harvesting from the irrigation area will occur to export nutrients from the irrigation area. The green waste stream will be transported to nearest composting facility for disposal.

3.5.4 Air Quality

Odour

An Odour assessment has been undertaken for the facility. A copy of the odour impact assessment is provided under Appendix F. The odour assessment identified the STP and its operations would not result in odour concentrations exceeding the relevant criterion of 2 OU/m^3. The odour modelling did not identify any specific mitigation measures as required.

Dust

All vehicle manoeuvring areas are to be fully sealed. Dust will not be generated onsite as part of operations. Refer plans under Appendix A.

To ensure no dust impacts during construction, measures to control and mitigate dust from the site would be prepared and integrated into the proposed Construction Environmental Management Plan.

3.5.5 Water Quality

Irrigation

The proposal would see 8.5ha of land irrigated during stage 2 of the Sewage Treatment Plant and Sewer Reticulation scheme. The irrigation area would be staged in line with the rate of production of surplus recycled water from the subdivision however a total of 4.5ha would be required for stage 1 and a further 4ha to stage 4. The irrigation system will be supplied from its own separate and independent irrigation network with its own irrigation pump.

The irrigation areas would be located on Lot 106 DP1129872 and Lot 100 DP1129872 and would occupy the land identified as subdivision stages 6 and 7 under MP10_0204. An aerial image of the proposed irrigation area location is provided in Figure 1.

All wastewater to be irrigated would be treated by a Membrane Bioreactor and Ultra Violet disinfection to produce very high quality water that is low in Biochemical Oxygen Demand, nutrients and faecal coliforms. The expected quality of irrigation water is outlined below in Table 3.

Table 3: Typical irrigation water quality following membrane bioreactor + ultra violet treatment.

Parameter	Units	Minimum	Mean	95%ile	Maximum
Biochemical Oxygen Demand	mg/L	-	-	10	20
Suspended Solids	mg/L	-	-	5	10
Total Nitrogen	mg/L as N	-	10	-	20
Total Phosphorus	mg/L as P	-	0.3	-	2
pH	pH	6.5	-	-	8.5
Turbidity	NTU	-	-	1	2
UV Transmission	UVT%	60%			
Faecal Coliforms	cfu/100 mL	-	-	10	100
Total Dissolved Solids	mg/L	-	600	-	-

Detail discussed of the modeling and water and nutrient balance results is included within the Land Capability Assessment for Effluent Irrigation. This is included under K.

Stormwater Management - Sewage Treatment Plant Site

Stormwater would be handled in accord with Councils requirement and relevant Australian Standards. A Stormwater Management Plan would be prepared for the Sewage Treatment Plant site. Is it noted at stormwater management has been approved for the subdivision approved as part of Project Approval MP10_0204. The stormwater management plan to be prepared for the site would detail connection of the Sewage Treatment Plant site to this approved system.

Stormwater Management – Irrigation Area

Stormwater within the irrigation area is to be handled via diversion and catch drains. The diversion and catch drains are shown on drawing SW-56-C-SK50 under Appendix Q.

3.5.6 Noise and Vibrations

A Noise Impact Assessment has been undertaken for the facility for both operation and construction. A copy of the noise impact assessment is provided under Appendix E and Construction Noise Management Plan under Appendix O. The Noise Impact Assessment has identified no specific noise control measures during operation as being required.

The Construction Noise Management Plan has identified standard best practice measures to proactively control construction noise. These requirements would be included within the proposals Construction Noise Environmental Plan.

3.5.7 Traffic and Transport

The site will be accessed via internal roadway network from within the approved subdivision as amended. The proposal can facilitate onsite internal loading/unloading of Articulated Vehicles. As referenced on the currently approved subdivision plan for the Catherine Hill Bay development, access to and from the Pacific Highway would occur via Montefiore Street, Road 28 and Road 3. Refer Figure 2 for amended subdivision layout as sought by MP10_0204 MOD 2 with STP overlay.

It is anticipated only two (2) truck movements per week would occur once the plant is constructed and operational. The proposal would not generate a significant increase in traffic during operation.

In regard to construction, the proposal would not result in a significant increase in construction traffic. As discussed the construction works not covered and being undertaken under MP10_0204 is limited to the Sewage Treatment Plan building and facility located on the SP2 Zoned Lands; and the installation of the pressure sewer units and small runs of gravity sewer which will be located within the future private residential allotments created as part of MP10_0204.

With regards to construction, a traffic management plan would be prepared and implemented as part of a Construction Environmental Management Plan for the proposal.

3.5.8 Chemicals Management

The following water treatment chemicals would be used in the Catherine Hill Bay Water scheme:

- Aluminum Chlorohydrate for enhanced phosphorous removal;
- Acetic Acid as a supplementary carbon source for Mixed Liquor Suspended Solids control and denitrification;
- Hydrochloric acid for pH correction and Membrane Bioreactor cleaning;
- Sodium hydroxide for pH correction and Membrane Bioreactor cleaning;
- Sodium hypochlorite for chlorine dosing and Membrane Bioreactor cleaning;
- Sodium metabisulphite for dechlorination of Reverse Osmosis feed water; and
- RO antiscalant chemicals to prevent fouling of the Reverse Osmosis Membrane Bioreactor.

All chemicals used in the scheme would be managed based on best practice strategy outlined below:

- Online monitoring and control of chemical dosing to minimise chemical consumption;
- All chemicals delivered to the site by licensed chemical transport company in 200 litre or 1000 litre plastic containers to minimise transport risk;
- A dedicated chemical storage area at the Waste Water Treatment Plant site that:
  - Is located inside the Waste Water Treatment Plant building to avoid exposure to direct sunlight, wind etc;

- Is located in an appropriately lined and bunded area with adequate storage volume to contain all spills;
- Provides separation of non-compatible chemicals;
- Lifting gantry to allow safe unloading of chemical containers;

- Material Safety Data Sheets will be maintained onsite for all chemicals;
- Spill response kits will be maintained onsite for all chemicals;
- Procedures to control the acceptance of chemicals to the site to ensure only the correct chemicals are unloaded;
- Emergency response procedures for chemical spills;
- Staff training to ensure competency in chemical management processes and procedures.

3.6 Utilities

3.6.1 Water

No water is used in the treatment process. Water usage would be limited to staff amenities, cleaning and landscaping maintenance. Water usage associated with the proposal will be minimal.

It is noted that in conjunction with the private Sewage Treatment Plant solution, Catherine Hill Bay Water Utility Pty Ltd will also be providing potable water services. The provision of the potable water service is not included within the scope of this Review of Environmental Factors. Emergency potable water backup would be provided for the recycled water reticulation system to ensure the continuity of supply.

3.6.2 Sewerage

Sewage generated by the development would be treated onsite. Sewerage generated onsite would be minimal and would only be associated with staff located on the site at any one time.

3.6.3 Electricity

Electricity supply would be available with appropriate capacity installed as part of works to facilitate the Catherine Hill Bay subdivision approved under MP10_0204.

3.7 Environmental Management Plans

Specific plans to manage the environmental impacts of construction and operation would be prepared as outlined within the Preliminary Infrastructure Operating Plan under Appendix N as part of the proposed Sewage Treatment Plant and Sewer Reticulation Network. The following plans would be prepared (among others):

- Construction Environmental Management Plan;
- Operation Environmental Management Plan;
- Emergency Response Plan;
- Recycled Water Management Plan

The Review of Environmental Factors recommends that certain mitigation measures be implemented as part of the proposal. These mitigative measures are listed in Section 9 and discussed in Section 7 and would be incorporated into these plans as outlined below.

3.7.1 Construction Environmental Management Plan

A Construction Environmental Management Plan would be prepared for the construction and commissioning phase of the proposed Sewage Treatment Plant and Sewer Reticulation Network. The proponent would be responsible for ensuring that the Construction Environmental Management

Plan adequately addresses environmental issues and the conditions of approval. The Construction Environmental Management Plan would include the following information and control plans:

Proposal Objectives and Scope – Once approval of the proposal has been obtained, the Proposal scope and objectives would be reassessed within the terms of any approval conditions.

Permits and Approvals – All permits and approvals required prior to and during the construction of the proposal would be identified in the Construction Environmental Management Plan. This would provide a checklist for construction contractors to ensure all permits and regulations are complied with and relevant approvals are obtained.

Consent Conditions – Consent conditions would be outlined within the Construction Environmental Management Plan with instructions on how to meet the conditions of approval. This would provide a checklist for construction contractors to ensure that consent conditions are met in the most effective manner.

Complaints Procedure – A procedure for managing complaints received during construction would be provided in the Construction Environmental Management Plan. The procedure would provide details on undertaking and monitoring actions following receipt of a complaint.

Construction Methods and Environmental Management Procedures – This section would provide an accurate description of the proposed construction activities. Location plans would be provided. Environmental considerations to be taken into account during all construction activities would be provided. Specific requirements relating noise, dust, traffic, etc would be outlined in other sections of the Construction Environmental Management Plan and would include timing details and who is responsible for their implementation.

Soil and Water Management – An erosion and sediment control plan would be prepared as part of the Construction Environmental Management Plan. The plan would detail the methods of erosion and sediment control, maintenance requirements, location requisites for effective operation of erosion and sediment control measures and related monitoring and reporting requirements.

Waste Management – This section would outline waste management procedures, including waste recycling and reuse measures, waste disposal measures (when reuse is not feasible), and the identification of the closest waste disposal areas. The waste management plan would be developed to minimise the generation of waste during construction and maximise reuse, recovery and recycling of waste products.

The Construction Environmental Management Plan would be reviewed on a regular basis and would incorporate the result of any monitoring undertaken in the previous period.

3.7.2 Operation Environmental Management Plan

An Operation Environmental Management Plan would be prepared for the operational phase of the proposed Sewage Treatment Plant and Sewer Reticulation Network. The proponent would be responsible for ensuring that the Operation Environmental Management Plan adequately addresses environmental issues and the conditions of any relevant approvals. The measures recommended to mitigate predicted environmental impacts during operation are discussed in Section 7.

Key environmental management issues that would be addressed include:

Consent conditions;
Requirements for emissions to air;
Effluent quality requirements;
Overflow prevention procedures;
Requirements for chemical handling;
Odour management;
Noise management;
Waste management;
Irrigation management and scheduling;

Weed management of irrigation areas; and
Environmental Monitoring
Monitoring and Maintenance as outlined in the Preliminary Infrastructure Operating Plan

3.7.3 Emergency Response Plans

Emergency Response Plans will be developed for all critical risks identified for the proposal. Contingency planning and the emergency response plans which would be developed as part of the proposal are identified within the Preliminary Infrastructure Operating Plan under Appendix N. Emergency response plans will be concise documents generally arranged in a flow chart type arrangement with relevant contact details etc. to ensure ease of use by operators.

The preliminary risk analysis undertaken in preparing the Preliminary Infrastructure Operating Plan identifies a broad range of emergency issues including communication and electrical failures, equipment failures, pump station failures and system pump out. Table 4 summarises the scheme component, the infrastructure risk, the contingency provided within the system and the detailed emergency response plan to be developed during detailed design and prior to operations commencing.

Table 4: Contingency Planning and Emergency Response Plans

Scheme Component		Infrastructure Risk	Contingency Planning	Emergency Response Plans (to be developed)^
Potable Water	Bulk water transfer system	Failure of bulk transfer system	24 hours storage in onsite potable water tank Water cartage from Kanangra Drive reservoir Electrical connection point for mobile generator provided on pump station electrical system	Emergency Response Plan for bulk water transfer system failure
	Potable water storage	Contamination or vermin access	Chlorine tablets stored on site	Emergency Response Plan for storage contamination or vermin access
		Tank failure		Emergency Response Plan for tank failure
	Chlorine monitoring and dosing system	Chlorine system failure Inadequate chlorine dose	Duty and standby chlorine dosing pumps Chlorine tablets stored on site	Emergency Response Plan for chlorination system failure or low chlorine alarm
	Potable water supply booster pump station	Pump failure Power outage	Booster pump set designed so one pump can fail while still delivering peak flow and pressure to the reticulation network Emergency standby diesel pump with automatic changeover	Emergency Response Plan for booster pump station failure
	Potable water reticulation	Cross connection	Water pressure control in potable and recycled water networks	Emergency Response plan for cross connections
		Reticulation pipe break	Isolation valves designed into the network as per WSAA Code.	Emergency Response Plan for water main break including sterilisation

Scheme Component		Infrastructure Risk	Contingency Planning	Emergency Response Plans (to be developed)^
Waste water	Pressure sewer pump stations	Pump failure Power failure Control system failure	Standard pumps with spare pumps and parts maintained on site Duty and standby pumps 24 hours storage in each pump station Fail safe for pump to operate during control system failure Road tanker pump-out from each pump station by licensed liquid waste contractor to nearest accepting licensed facility to avoid uncontrolled overflows	Emergency Response Plan for pressure sewer pump station failure or high level alarm Emergency Response Plan for scheme wide power outage
	Pressure sewer pipe lines	Pressure sewer main break	Isolation valves designed into the network as per WSAA Code.	Emergency Response Plan for pressure sewer main break including cleanup & disinfection procedures
	Membrane Bioreactor	Process failure Power outage Tank failure	Standard process pumps with spare pumps and parts maintained on site Electrical connection point for mobile generator provided on MBR electrical system Road tanker pump-out by licensed liquid waste contractor to nearest accepting licensed facility to avoid uncontrolled overflows	Emergency Response Plan for MBR process failure
	Wet weather storage	Algae growth	Potable water backup of recycled water tank if blue green algae outbreak occurs. Allowance to chlorinate effluent prior to entering the wet weather storage. Install aerator into pond if algae events are frequent.	Emergency Response Plan for algae growth in storage
		Structural integrity & leakage	Road tanker pump-out by licensed liquid waste contractor to nearest accepting licensed facility	Emergency Response Plan for pond leakage or wall failure
		High level overflow	Precautionary and emergency irrigation events to avoid uncontrolled storage overflows Road tanker pump-out by licensed liquid waste contractor to nearest accepting licensed facility to avoid uncontrolled overflows	Emergency Response Plan for high level in treated effluent wet weather storage.
Recycled Water	Advanced Water Treatment Plant	Process failure	Potable water back up of recycled water tank	Emergency Response Plan for AWTP failure
	Saline evaporation ponds	Structural integrity & leakage	Road tanker pump-out by licensed liquid waste contractor to nearest accepting licensed facility	Emergency Response Plan for pond leakage or wall failure
		High level overflow	0.5 metre freeboard Road tanker pump-out by licensed liquid waste contractor to nearest accepting licensed facility	Emergency Response Plan for saline evaporation pond high level
Recycled Water cont…	Recycled Water Storages	Contamination or vermin access	Chlorine tablets stored on site	Emergency Response Plan for vermin access to storage
		Tank failure		Emergency Response Plan for tank failure

Scheme Component		Infrastructure Risk	Contingency Planning	Emergency Response Plans (to be developed)^
	Chlorine monitoring and dosing system	Chlorine system failure Inadequate chlorine dose	Duty and standby chlorine dosing pumps Chlorine tablets stored on site	Emergency Response Plan for chlorination system failure or low chlorine alarm
	Recycled water supply booster pump station	Pump failure Power outage	Booster pump set designed so one pump can fail while still delivering peak flow and pressure to the reticulation network Emergency standby diesel pump with automatic changeover	Emergency Response Plan for booster pump station failure
	Recycled water reticulation network	Cross Connection	Water pressure control in potable and recycled water networks	Emergency Response Plan for cross connections
		Reticulation pipe break	Isolation valves designed into the network as per WSAA Code.	Emergency Response Plan for water main break including sterilisation
	Irrigation Systems	Irrigation pipe break	Isolation valves designed into the irrigation system for isolation of each irrigation zone	Emergency Response Plan for irrigation pipe break
Chemical	Chemicals management	Chemical spill	All chemicals storages located in a bunded & covered area	Emergency Response Plan for chemical spillage with cleanup procedures
Monitor-ing & control system	Sensors and probes	Sensor failure	Control system allows manual override of faulty sensor until new sensor installed	Emergency Response Plan for faulty monitoring sensor
	Communication systems	Communication system failure	Multiple path radio system with backup from Telstra Next G mobile phone network Fail safe to ensure pressure sewer units operate during control system failure	Emergency Response Plan for control system failure

As part of all emergency Response Plans, all incidents and "near misses" that occur in the Catherine Hill Bay Water scheme would be logged and reviewed to ensure continuous improvement. An incident reporting procedure would be developed that outlines the requirements of reporting of all incidents. Post incident reviews would be undertaken to identify appropriate preventative measures to be developed and implemented to prevent reoccurrence of similar events.

3.7.3.1 Pump out Locations

The proposal includes a significant level of built in redundancy and ability to manage emergency issues onsite. However, as further redundancy the proposal includes the following pump out locations:

1. Pump out from the inlet tank within the sewerage treatment plant building using a vacuum sucker truck;
2. Pump out from the scour valves in the Pressure Sewer Network; and
3. Pump out from the wet well of each pressure sewer unit using a vacuum sucker truck.

3.7.3.2 Discharge Points

The system is design to ensure that no overflows will occur as part of operations, however If an unmanaged failure was to occur, the system would potentially overflow form the following locations:

1. The Reverse Osmosis Reject Evaporation Ponds;
2. The wells of the sewer pressure units;
3. Wet Weather Storage (wet weather balance tanks)

It is noted that water balance modelling undertaken to demonstrate compliance with the permissible statistical overflow frequencies in the Department of Environment and Conservation Guidelines shows wet weather overflow of irrigation quality effluent would occur in 38% of years from the wet weather balance tanks when irrigation areas were not available due to wet weather. To ensure this does not occur as part of the proposals operations, the proposal has been designed to enable all surplus water to be trucked offsite to another approved facility. Within table 4 above this item is identified as 'high level overflow' and the relevant mitigation measure being truck offsite.

The emergency response plans and procedures outlined in Section 3.7.3 will ensure that no overflow will occur from these discharge points.

3.8 Environmental Monitoring, Reporting and Complaints Control

Environmental monitoring and reporting would be undertaken during construction and operation of the Sewage Treatment Plant and Sewer Reticulation Network. Whilst a detailed monitoring and reporting program would be developed during the preparation of the Construction Environmental Management Plan and Operational Environmental Management Plan in accord with conditions of approval/license, an outline of proposed monitoring, parameters and location is provided in table 5, table 6 and table 7.

Table 5 Membrane Bioreactor Effluent Quality and Operational Monitoring

Parameter	Units	MBR Effluent Quality Monitoring		Location
		Commissioning	Verification	
BOD	mg/L	Frequent monitoring during commissioning period to test the system under a variety of operating conditions.	Monthly	MBR permeate tank/wet weather storage
Suspended Solids	mg/L		Monthly	
Ammonia as N	mg/L as N		Monthly	
TKN as N	mg/L as N		Monthly	
Oxidised Nitrogen as N	mg/L as N		Monthly	
Total Nitrogen as N	mg/L as N		Monthly	
Total Phosphorus as P	mg/L as P		Monthly	
Faecal Coliforms	cfu/100 mL		Weekly	
Metals	Various	N/A	Annual	
Pesticides	Various	N/A	Annual	
Cations/Anions/SAR	Various	N/A	Annual	
All tank water levels	m	Continuous	Continuous	Online
All flows	L/s	Continuous	Continuous	
Dissolved Oxygen (CCP)	mg/L	Continuous	Continuous	
MLSS	mg/L	Continuous	Continuous	
Electrical Conductivity	dS/m	Continuous	Continuous	
pH	pH	Continuous	Continuous	
Transmembrane Pressure (CCP)	ΔkPa	Continuous	Continuous	
Permeate Turbidity (CCP)	NTU	Continuous	Continuous	
UV Intensity (CCP)	mJ/cm^2	Continuous	Continuous	
UVT% (CCP)	%	Continuous	Continuous	

Table 6 Advance Water Treatment Plant Validation and Verification Recycled Water Quality Monitoring

Pollutant	Units	Recycled Water Quality Monitoring		Location
		Validation	Verification	
Biochemical Oxygen Demand	mg/L	Frequent monitoring during commissioning period to test the system under a variety of operating conditions.	Monthly	Recycled Water Storage Tank
Suspended Solids	mg/L		Monthly	
Ammonia as N	mg/L as N		Monthly	
TKN as N	mg/L as N		Monthly	
Oxidised Nitrogen as N	mg/L as N		Monthly	
Total Nitrogen as N	mg/L as N		Monthly	
Total Phosphorus as P	mg/L as P		Monthly	
Faecal Coliforms	cfu/100 mL		Weekly	
Free Residual Chlorine	mg/L		Weekly	
Sodium absorption ratio	ratio		Annual	
Campylobacter (bacteria)	cfu/100 mL		Annual	
Cryptosporidium (protozoa)	cfu/100 mL		Annual	
Adenovirus (virus)	pfu/100 mL		Annual	
Rotavirus (virus)	pfu/100 mL		Annual	
Electrical Conductivity (CCP)	dS/m	Continuous	Continuous	Online
UF Permeate Flow (CCP)	L/s	Continuous	Continuous	
UF Permeate Turbidity (CCP)	NTU	Continuous	Continuous	
UF Transmembrane Pressure (CCP)	ΔkPa	Continuous	Continuous	
UF Direct Integrity Testing (CCP)	ΔkPa/time	Continuous	Continuous	
UV Intensity (CCP)	mJ/cm^2	Continuous	Continuous	
UVT% (CCP)	%	Continuous	Continuous	
pH (CCP)	pH	Continuous	Continuous	
Free Residual Chlorine (CCP)	mg/L	Continuous	Continuous	

Table 7 Environmental Monitoring of Effluent Irrigation Scheme

Type	Parameter	Units	Type	Location	Frequency
Turf and vegetation health	Visual inspection of plant health for signs or stress	General observations	Monitor for change	Irrigation area	Ongoing
	Laboratory biomass analysis of plant nutrients	mg/kg	Identify deficiencies	Irrigation area	If impacts observed
Surface Water monitoring	Faecal Coliform	cfu/100 mL	Monitor for general trends and change	Downstream in Dam 1 and Dam 2 and upstream at SW U/S.	Quarterly
	BOD	mg/L			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus & Plant available phosphours	mg/L as P			
	pH	pH units			
	Electrical Conductivity	dS/m			
Ground water monitoring	pH	pH units	Monitor for general trends and change	Downstream bores BH006 and BH009 and upstream bores BH004 and	Quarterly
	Cations	Mg/L			
	Faecal Coliform	cfu/100 mL			
	Electrical conductivity	dS/m			

Type	Parameter	Units	Type	Location	Frequency
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N		BH008.	
	Total Phosphorus	mg/L as P			
	Plant available phosphorus	mg/L as P			
	Water level	m AHD			
Soil monitoring	Total hydraulic and nutrient load onto each irrigation area	kL/year and kg/year	Monitor for general trends and change.	Select irrigation zones that received the highest hydraulic load. Samples to be taken from top soil and sub soil layers.	Annual
	Electrical conductivity	dS/m			
	Available Phosphorus	mg/kg			
	Available Nitrogen	mg/kg			
	Available Potassium	mg/kg			
	Chloride	meq/100g			
	Exchangeable cations & CEC	meq/100g			
	Exchangeable Sodium %	%			
	Sodium adsorption ratio	Ratio			
	Total Organic Carbon	%			
	pH	pH units			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/kg			
	Total Phosphorus	mg/kg			
	Phosphorus Sorption Capacity	mg/kg			
	Heavy metals	mg/kg			
	Pesticides	mg/kg			

The monitoring methods, locations, frequency, criteria, reporting and responsibilities would be determined during preparation of the Operation Environmental Plan and would be consistent with any relevant licence conditions and with the Integrated Water Management Plan under Appendix C, the Land Capability Assessment for Effluent Irrigation under Appendix K and the prelimary Infrastructure Operating Plan under Appendix N.

3.8.2 External Communications

Operation

All Solo Water schemes, including the Catherine Hill Bay Water scheme, use a centralised customer service call centre for receiving, logging and acting on customer questions, complaints, water outages and faults identified by the general public.

As required under the Independent Pricing and Regulatory Tribunal retail license the Catherine Hill Bay scheme will be supported by a customer call centre. In general the call centre will provide the following functions:

- Receive and log all customer complaints, queries and faults 24-hours a day, 7 days a week;
- Where appropriate call centre staff will escalate issues and provide work orders to Catherine Hill Bay operations staff to attend to complaints and faults etc.;
- Catherine Hill Bay operations staff are required to report back to the call centre when the fault has been acted upon and rectified, or to provide an update on progress. Open work orders are followed up by customer service call centre staff to ensure timely action;

- The customer service database records all complaints, issues, actions, response times etc. To enable extraction of Key Performance Indicators for reporting and continuous improvement;

Construction

A 24 hour contact number would be established and maintained for the duration of the construction period. The responsible person and entity will be identified in the Construction Environmental Management Plan for the proposal.

4 – Need and Options Considered

This section looks at other feasible alternatives to carrying out the development including the do nothing option. These are summarised below. It is concluded that the alternatives are not socially, economically or technically feasible or require further detailed assessment and that the proposal can occur with identified impacts being suitably mitigated and managed.

4.1 Strategic need for the Proposal

The proposal is needed to facilitate urban services for the subdivision approved under Project Approval MP10_0204. The proposed Sewage Treatment Plant and Sewer Reticulation Network is a direct response to the need presented by this approved development

4.2 Objectives of the Proposal

The objectives of the proposal are:

- Provide financially feasibly services to the approved Catherine Hill Bay development;
- To provide best practice sewerage treatment and waste water minimisation for the locality;
- To ensure that activities have minimal environmental impacts upon the locality;
- To ensure noise, odour, visual and traffic impacts on surrounding land uses are at an acceptable level

4.3 Alternatives and Options Considered

4.3.1 Methodology for selection of preferred option

The preferred design option has been selected using a cost / benefit analysis. The preferred design option has been selected based upon the following criteria:

- Cost;
- Service provision;
- Constructability; and
- Potential Impacts
- Sustainability
- Low Energy usage
- Minimizing potable water use

4.3.2 Identified Options

Five options have been identified for the proposal, these are:

1 – Do Nothing;
2 – Centralised connection to the Hunter Water Network;
3 – Decentralised system with water recycling and irrigation of Membrane Bioreactor & Ultra Violet treated effluent on private land;
4 – Decentralised system with water recycling and irrigation of Advanced Water Treatment Plant treated effluent on council parks and verges;

The following assessment is provided for each, for options 2 through 4 the description and evaluation of this option is presented in Table 8.

Do nothing option

The 'do nothing' option is not an alternative if the Catherine Hill Bay subdivision is to be developed. This options was discounted

Options 2 through 4

Table 8: Option 2 through 4 Analysis

	Option	Description	Evaluation Summary
2	Centralised Business As Usual connection to Hunter Water network	The business as usual connection to Hunter Water would involve construction and operation of: • Gravity sewer networks, some of which would be at considerable depth and located below the water table; • A number of smaller sub-catchment scale sewage pump stations; • A number of large sewage transfer pump stations and approximately 10 km sewer rising mains with chemical injection for septicity control to connect to the existing network at Swansea; • Upgrades to the existing network at Swansea; • Treatment of all wastewater at Belmont Waste Water Treatment Plant to secondary treatment standards in a conventional activated sludge process; • Discharge of all treated effluent to the ocean with no wastewater recycling.	The business as usual option is not the preferred option due to: • No water recycling; • 100% of treated effluent discharged to the ocean; • Potential for wet weather overflows from the gravity sewer network and pump stations; • Environmental risk associated with failure of the 10 km sewer rising main; • Issues of septicity due to long detention times in the transfer system, particularly during earlier stages of development; • Belmont Waste Water Treatment Plant and broader catchment is already stressed during peak wet weather flow events; • This option is subject to Hunter Water capital works program and is dependent on contributions from other developers, which is unlikely in the medium term.
3	Onsite treatment with water recycling and irrigation of private land	This option involves the construction and operation of: • Pressure sewer network within continuous online monitoring and alarms; • Onsite Membrane Bioreactor to treat wastewater close to its source; • Advanced Water Treatment Plant sized to treat approximately 60% of wastewater flow for recycling at each house; • The 40% of surplus effluent managed by irrigation of private restricted access irrigation areas; • 8.5 ha irrigation area and 2 ML wet weather storage to manage all surplus water by irrigation with no discharges to waterways.	The original Solo Water proposal had the following advantages: • 60% of all wastewater generated is recycled back to each house; • 40% surplus effluent managed by sustainable irrigation; • No discharges of surplus recycled water to waterways; • No wet weather overflows from the pressure sewer network; • Treat wastewater close to its source and avoid long sewage transfer systems; • Relatively low energy option. • Can deliver 470 ET capacity to allow initial stage of the subdivision approved under MP10_0204 to proceed This is the preferred option for stages 1 and 2 of the Sewage Treatment Plant and Sewer Reticulation Network scheme.
4	Onsite treatment with water	The original Solo Water onsite wastewater proposal involved construction and operation	The original Solo Water proposal had the following advantages:

	Option	Description	Evaluation Summary
	recycling and irrigation of public land	of: • Pressure sewer network within continuous online monitoring and alarms; • Onsite Membrane Bioreactor to treat wastewater close to its source; • Advanced Water Treatment Plant sized to treat approximately 60% of wastewater flow for recycling at each house; • The 40% of surplus effluent managed by irrigation of public open space, parks and landscape buffers; • 10 ha irrigation area and 10 ML wet weather storage to manage all surplus water by irrigation with no discharges to waterways.	• 60% of all wastewater generated is recycled back to each house; • 40% surplus effluent managed by sustainable irrigation; • No discharges of surplus recycled water to waterways; • No wet weather overflows from the pressure sewer network; • Treat wastewater close to its source and avoid long sewage transfer systems; • Relatively low energy option. • Can deliver 556 ET capacity to allow whole subdivision approved under MP10_0204 to proceed This was the preferred option but is not feasible because Lake Macquarie City Council as the ultimate owner of the parks, landscape buffers and public open space will not permit irrigation using recycled water.

Stage 3 of the scheme will require separate assessment of discharge options and will be subject to separate assessment and approval.

4.4 Preferred Option

The preferred option is option 3 and is that assessed within this Review of Environmental Factors, this option has been arrived at after considerable investigation into appropriate and economically feasible services provision and alternative measures to deal with wastewater.

A decentralised system licensed under the Water Industry Competition Act 2006 which maximises water recycling and irrigates membrane bioreactor and ultra violet treated wastewater is the preferred option for stage 1 and 2 of the Sewage Treatment Plant and Sewage Reticulation Network scheme.

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5 - Statutory Framework

5.1 Commonwealth Legislation

5.1.1 Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act 1999)

Under the *Environment Protection and Biodiversity Conservation Act 1999* a referral is required to the Australian Government for proposed 'actions that have the potential to significantly impact on matters of national environmental significance or the environment of Commonwealth land. These are considered in Appendix B and Chapter 7 of the REF. A copy of the Environment Protection Biodiversity Conservation Act Protected Matters Report is included under Appendix L.

The assessment of the proposal's impact on matters of national environmental significance and the environment of Commonwealth land found that there is unlikely to be a significant impact on relevant matters of national environmental significance. Accordingly, the proposal has not been referred to the Australian Government Department of Sustainability, Environment, Water, Population and Communities.

As part of the assessment of MP10_0204 an Environmental Protection and Biodiversity Conservation Act referral was required due to proposed vegetation clearing. Environmental Protection and Biodiversity Conservation Act referral 2012/6382 was approved on the 27 February 2009. Importantly MP10_0204 has assessed all issues relating to flora and fauna associated with the clearing required by the subdivision. The Sewage Treatment Plant, Irrigation Area and Sewer Reticulation Network are located within the approved footprint under MP10_0204 and does not require or result in the need for clearing beyond that already approved.

For reference a copy of the Environmental Protection and Biodiversity Conservation Act Referral 2012/6382 approval is included under Appendix H.

5.2 State Legislation

5.2.1 Environmental Planning and Assessment Act 1979 (EP&A Act 1979)

As provided by Clause 76, an environmental planning instruments being SEPP (Infrastructure) 2007 outlines the proposal is permissible without development consent. The Environmental Planning and Assessment Act 1979 outlines the definition of an activity as it relates to Part 5 of the EP& A Act 1979. The proposal is consistent with this definition and assessment is required in accord with the provisions of Part 5 of the Environmental Planning and Assessment Act 1979.

5.2.2 Environmental Planning & Assessment Regulation 2000 (EPAR 2000)

The matters prescribed by Clause 228 of the Environmental Planning and Assessment Regulation 2000, for consideration by assessments under Part 5, are reviewed at Appendix B.

5.2.3 Protection of the Environment Operations Act 1997

The Protection of Environmental Operations Act 1997, prohibits any person from causing pollution of waters or air, and provides penalties for pollution offences relating to water, air and noise. The Protection of Environments Operation Act 1997 provides a regulatory framework for the licensing of all activities listed in Schedule 1 to the Act that have the potential to impact on the environment.

The proposal falls within the Schedule 1 definition of 'Sewerage Treatment'. Pursuant to Clause 48 of the Protection of Environments Operation Act, an Environmental Protection License is required for all scheduled activities and would be issued to a specific premises or activity. The proposal is not a scheduled activity as the Sewage Treatment Plant capacity does not exceed 2,500 equivalent persons or 750 kL/day. An Environmental Protection License is not required by the development.

Section 120 of the *Protection of the Environment Operations Act 1997* prohibits the pollution of waters. The proposal includes measures to address the risk of water pollution, see section 7.

The proposal will include earthworks to form the proposed storage ponds, If Virgin Excavated Natural Material is to be taken off the site, a Section 143 Notice under the Protection of Environments Operation Act will be required and if the site to receive the spoil requires a development application this will be in place as required by the Section 143 notice prior to the spoil being relocated.

5.2.4 Mines Subsidence Compensation Act 1961

In accord with Clause 15 of the Mines Subsidence Act 1961 the proposed site is located within the Swansea North Entrance Mine subsidence district. As per the requirements of Clause 15 (2A) an approval is required to alter or erect improvements within a mine subsidence district. This approval would have to be obtained prior to commencement of any works.

The issue of mine subsidence has been considered as part of MP10_0204. Condition D7 of MP10_0204 requires that the principle certifying authority for the subdivision works associated with MP10_0204 be provided with evidence from a qualified structural engineer that the land as subdivided under MP10_0204 is able to meet the requirements of the Mine Subsidence Board and that stability, subsidence potential and load bearing capacity has been appropriately addressed.

This requirement applies to the Sewage Treatment Plant Site and this coupled with obtaining a Mine Subsidence Board approval for the proposed works as required by Clause 15 (2A) will full address the requirements of the Mine Subsidence Compensation Act 1961.

5.2.5 National Parks and Wildlife Act, 1974

The harming or desecrating of Aboriginal objects or places is an offence under section 86 of the *National Parks and Wildlife Act 1979*. Under section 90, an Aboriginal heritage impact permit may be issued in relation to a specified Aboriginal object, Aboriginal place, land, activity or person or specified types or classes of Aboriginal objects, Aboriginal places, land, activities or persons. Aboriginal objects or places are not likely to be affected by the proposal, refer Section 7.

All native birds, reptiles, amphibians and mammals, except the dingo, are protected in New South Wales under the National Parks and Wildlife Act. The harming of protected fauna is prohibited under the National Parks and Wildlife Act, but an exemption applies in relation to things that are essential to the carrying out of an activity to which Part 5 of the Environmental Planning and Assessment Act applies and where the determining authority has complied with the provisions of that part.

Potential impacts on flora and fauna are considered in Section 7. The proposal has been assessed as unlikely to impact upon flora or fauna.

5.2.6 Heritage Act, 1977

A number of the allotments which form part of the site fall within the Catherine Hill Bay Cultural Heritage Precinct. The Catherine Hill Bay Cultural Heritage Precinct is listed on the NSW State Heritage Register. Clause 57 Effect of Interim Heritage orders and listing on State Heritage Register of the Heritage Act 1977 requires that:

(1) When an interim heritage order or listing on the State Heritage Register applies to a place, building, work, relic, moveable object, precinct, or land, a person must not do any of the following things except in pursuance of an approval granted by the approval body under Subdivision 1 of Division 3:
(a) demolish the building or work,
(b) damage or despoil the place, precinct or land, or any part of the place, precinct or land,
(c) move, damage or destroy the relic or moveable object,
(d) excavate any land for the purpose of exposing or moving the relic,

(e) carry out any development in relation to the land on which the building, work or relic is situated, the land that comprises the place, or land within the precinct,
(f) alter the building, work, relic or moveable object,
(g) display any notice or advertisement on the place, building, work, relic, moveable object or land, or in the precinct,
(h) damage or destroy any tree or other vegetation on or remove any tree or other vegetation from the place, precinct or land.

As such the proposal would require an approval in respect of doing or carrying out of an act, matter or thing required to in Clause 57(1) of the Heritage Act 1977. In this regard an approval is required prior to installing the pressure sewer unit and associated gravity sewer components.

5.2.7 Roads Act, 1993

The *Roads Act, 1993* sets out rights of members of the public to pass along public roads, establishes procedures for opening and closing a public road, and provides for the classification of roads. It also provides for the requirement for an approval to be issued for any structure or work to be carried out on or over a public road. The Sewerage Treatment Plant site access would include works within existing public road reserve. Approval under Section 138 of the Road act will be required for these items.

5.2.8 Threatened Species Conservation Act, 1995

The Threaten Species Conservation Act 1995 is directed at conserving threatened species, populations and ecological communities of animals and plants. Certain species of animals or plants are identified as endangered species, populations or communities or vulnerable species under the Act. Areas of land comprising the habitats of listed endangered species may also be declared critical habitat under the Act.

By operation of associated Environmental Planning and Assessment Act 1979 provisions, activities that are likely to have a significant impact on listed threatened species, populations, endangered ecological communities or their habitats must be the subject of a species impact statement and require the concurrence of the Director-General of the Office of Environment & Heritage. Likely impacts on threatened species have been considered in Section 7. The assessment identifies the proposal is unlikely to threaten the viability of any local populations.

Section 91 of the Threaten Species Conservation Act 1995 provides for the granting of licenses for, amongst other things, to harm or pick threatened species, populations or ecological communities or damage habitat. The corresponding offence is outlined in section 118A of the National Parks and Wildlife Act. Importantly, several defenses are expressly recognised by the National Parks and Wildlife Act including where the action taken was essential to the carrying out of an activity to which Part 5 of the Environmental Planning and Assessment Act 1979 applies and where the determining authority has complied with the provisions of that part. In this context it can be noted that full compliance with Part 5 of the Environmental Planning and Assessment Act 1979 is being pursued.

The proposed Sewage Treatment Plant and Sewer Reticulation Network do not require any vegetation removal beyond that approved under MP10_0204.

5.2.9 Water Management Act 2000

The Water Management Act 2000 provides for the sustainable and integrated management of the State's water for the benefit of both present and future generations. The Act controls the extraction and use of water, the construction of water bodies such as weirs and dams and any activity that is in or near water sources in New South Wales.

The definition of a 'water source' is a broad term used to describe any or whole parts of a river, lake, estuary, New South Wales coastal waters or a place where water occurs naturally on or below the surface of the ground. The definition of a 'controlled activity' is the carrying out of work or any other activity that affects the quality or flow of water in a water source. The definition of 'waterfront land' is defined as land within 40 metres of a lake, estuary, river or shoreline.

The proposal does not require a controlled activity approval for the operation of the Sewage Treatment Plant and Sewer Reticulation Network as no water extraction would be required as part of the proposal. However any construction that is located within the 40m prescribed distance of a waterway such as installation of the irrigation system and form of the catch and diversion drains will require a controlled activity approval. A controlled activity approval for any such construction would be required prior to commencement of works.

Refer Section 5.6 for comment against the NSW aquifer Interference Policy and the need for an aquifer interference license under the Water Management Act 2000.

5.2.10 Noxious Weeds Act 1993

The Noxious Weeds Act 1993 establishes a system for the identification and control of noxious weeds in New South Wales. Responsibility for the control of noxious weeds lies with the owner and/or occupier of private land and Crown land, local councils and other public authorities on land they occupy. Under the Noxious Weeds Act, the Minister for Primary Industries may declare a plant to be a noxious weed. Control notices can be issued by the Minister and local control authorities to ensure obligations are met.

Weed management measures undertaken as part of the works and operations would comply with the requirements of the Noxious Weeds Act 1993.

5.2.11 Rural Fires Act 1997

The Rural Fires Act 1997 includes the requirement for New South Wales Rural Fire Service approval of certain types of sensitive development, or special fire protection purposes under Section 100B of the Rural Fires Act 1997. The proposal is not listed as a special fire protection purpose and approval under Section 100B of the Rural Fires Act is not required.

The proposed Sewage Treatment Plant and associated structures is classified as a Class 10a structure pursuant to the Building Code of Australia. The Building Codes of Australia does not provide for any bushfire specific performance requirements and as such AS-3959-2009 does not apply as a set of ‘deemed to satisfy’ provisions.

The general fire safety construction provisions are taken as acceptable solutions, but the aims and objectives of Planning for Bushfire Protection 2006 apply in relation to other matters such as access, water and services, emergency planning and landscaping / vegetation management. A review of applicable requirements has been undertaken and is included within the Bushfire Management Plan under Appendix J.

5.3 State Environmental Planning Policies

We note that consideration of the State Environmental Planning policies is not a requirement of assessment under Part 5 of the Environmental Planning and Assessment Act 1979. The State Environmental Planning Policies are to be assessed when consent is required under Part 4 of the Environmental Planning and Assessment Act 1979.

As a matter of good practice the provisions of the State Environmental Planning Policies are commented against where they could have been applied to the proposal had it required consent under Part 4 of the Environmental Planning and Assessment Act 1979

The following State Environmental Planning Policies have been considered as part of the Review of Environmental Factors.

- State Environmental Planning Policy No. 33 – Hazardous and Offensive Development;
- State Environmental Planning Policy No. 44 – Koala Habitat Protection;

- State Environmental Planning Policy No. 55 – Remediation of Land;
- State Environmental Planning Policy No. 71 – Coastal Protection
- State Environmental Planning Policy (Infrastructure) 2007;
- State Environmental Planning Policy (State & Regional Development) 2011

5.3.1 State Environmental Planning Policy No. 33 – Hazardous and Offensive Development (SEPP 33)

State Environmental Planning Policy 33 deals with the definition of and control of hazardous and offensive developments. State Environmental Planning Policy 33 provides definitions for 'hazardous industry', 'hazardous storage establishment', 'offensive industry', 'offensive storage establishment', potentially hazardous industry and potentially offensive industry. The definitions apply to all environmental planning instruments, existing and future.

The policy requires specified matters to be considered for proposals that are 'potentially hazardous' or 'potentially offensive' as defined in the policy. For example, any application to carry out a potentially hazardous or potentially offensive development is to be advertised for public comment, and applications to carry out potentially hazardous development must be supported by a preliminary hazard analysis.

In determining the application of State Environmental Planning Policy 33 to the proposal, consideration of the New South Wales Department of Planning Hazardous and Offensive Development Application Guidelines – Applying SEPP 33 should be considered. Within this guideline it is stated:

> *'Consent authorities should firstly consider whether the proposed use falls within the definition of 'industry' adopted by the planning instrument which applies or whether it is a 'storage establishment'.*

The planning instrument applying to the site is the Lake Macquarie Local Environmental Plan 2004, specifically the provisions of Part 11 South Wallarah Peninsula Site. Clause 133 Interpretation of Part 11 South Wallarah Peninsula Site refers works and expressions within the part as having the same meaning as it has in the standard instrument prescribed by the Standard Instrument (Local Environmental Plans) Order 2006.

Referring to the standard instrument definitions, the proposal would be defined as a sewerage system. It is noted a sewerage system is not defined or considered to be an Industry within the standard instrument definitions. As the proposal does not meet the definition of an Industry the proposal would not be subject to the provisions of State Environmental Planning Policy 33.

It is noted that if State Environmental Planning Policy 33 applied to the proposal and it was considered to be a 'potentially offensive industry' Clause 14 of State Environmental Planning Policy 33 would require the proposal to be notified as per the requirements for designated development. Clause 79 Public participation – designated development of the Environmental Planning and Assessment Act 1979 requires designated development to be publicly exhibited for a period of not less than 30 days.

As part of the Water Industry Competition Act License agreement the proposal including a copy of the Review of Environmental Factors documentation has been put on public exhibition with the public invited to provide comment for a period of 30 days between 18th September 2014 and 18th October 2014. The public exhibition of the proposal which included the Review of Environmental Factors documentation has been undertaken for a period consistent with that required by State Environmental Planning Policy 33.

If State Environmental Planning Policy 33 applied to the proposal the public notification of 30 days required by the policy would be complied with.

The operation of the STP will use minimal chemical storages and is not consistent with any of the definitions contained within State Environmental Planning Policy 33. The proposal does not trigger the need for a preliminary hazard analysis.

5.3.2 State Environmental Planning Policy No. 44 – Koala Habitat Protection (SEPP 44)

As part of this assessment a review against State Environmental Planning Policy 44 has been undertaken, the following extract is provided:

> *This Policy 'aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline.'*
>
> *In association with development applications and in areas where the policy applies a number of criteria are to be addressed to determine levels of assessment and to govern management considerations. The steps are as follows:*
>
> *1. Does the Policy Apply?*
> *Is the land greater than 1ha in size and located within one of the Local Government areas listed within Schedule 1 of SEPP 44?*
>
> *Yes. The land is >1HA in area and located within the Lake Macquarie Local Government area, and the Wyong Local Government Area.*
>
> *2. Is the land potential koala habitat?*
>
> *No the site is cleared of all vegetation*
>
> *3. Is the land core koala habitat?*
>
> *No the site is clear of all vegetation*
>
> *4. Is there a requirement to prepare a Plan of Management for land containing core koala habitat?*
>
> *No. It is considered that the site does not contain core Koala habitat as described*.

As the site does not contain core koala habitat a koala management plan is not required. Again it is noted that all clearing of the site and surrounding subdivision footprint has been approved under MP10_0204 and Environment Protection Biodiversity Conservation Act referral 2012/6382. At the time of preparing the review of environmental factors the site is clear of all vegetation.

5.3.3 State Environmental Planning Policy No. 55 – Remediation of Land (SEPP 55)

State Environmental Planning Policy 55 deals with the remediation of land, with the consent authority required to consider the items listed under Clause 7. As stated by Clause 7:

(1) A consent authority must not consent to the carrying out of any development on land unless:

  (a) It has considered whether the land is contaminated, and
  (b) If the land is contaminated, it is satisfied that the land is suitable in its contaminated state (or will be suitable, after remediation) for the purpose for which the development is proposed to be carried out, and
  (c) If the land requires remediation to be made suitable for the purpose for which the development is proposed to be carried out, it is satisfied that the land will be remediated before the land is used for that purpose.

(2) Before determining an application for consent to carry out development that would involve a change of use on any of the land specified in subclause (4), the consent authority must consider a report specifying the findings of a preliminary investigation of the land concerned carried out in accordance with the contaminated land planning guidelines.

(3) The applicant for development consent must carry out the investigation required by subclause (2) and must provide a report on it to the consent authority. The consent authority may require the applicant to carry out, and provide a report on, a detailed investigation (as referred to in the contaminated land planning guidelines) if it considers that the findings of the preliminary investigation warrant such an investigation.

(4) The land concerned is:

(a) Land that is within an investigation area,
(b) Land on which development for a purpose referred to in Table 1 to the contaminated land planning guidelines is being, or is known to have been, carried out,
(c) To the extent to which it is proposed to carry out development on it for residential, educational, recreational or child care purposes, or for the purposes of a hospital—land:
(i) in relation to which there is no knowledge (or incomplete knowledge) as to whether development for a purpose referred to in Table 1 to the contaminated land planning guidelines has been carried out, and
(ii) On which it would have been lawful to carry out such development during any period in respect of which there is no knowledge (or incomplete knowledge).

The Sewage Treatment Plant and Sewer Reticulation Network will be located within the approved footprint of the Catherine Hill Bay subdivision under MP10_0204. As part of the assessment of MP10_0204 the issue of site contamination was given significant consideration. As required by the conditions of approval for MP10_0204 a Remediation Action Plan is to be prepared for the entire Catherine Hill Bay development.

Approval MP10_0204 requires that an accredited Environmental Protection Agency auditor certify that the Remediation Action Plan has been implemented and that the whole site is suitable for the proposed residential development prior to the issue of a subdivision certificate. As the Sewage Treatment Plant site is within the bounds of the approved Catherine Hill Bay subdivision the site will be subject to the works required by the Remediation Action Plan for the subdivision and upon completion will be suitable for the construction of the Sewage Treatment Plant.

5.3.4 State Environmental Planning Policy No. 71 – Coastal Protection

The site falls within the bounds of the New South Wales Coastal Zone and as such the provisions of State Environmental Planning Policy 71 would typically apply to the site. In this regard however we note the provisions of Clause 135(2) of the Lake Macquarie Local Environmental Plan which states as follows:

(2) The following State environmental planning policies (or provisions) do not apply to the South Wallarah Peninsula site:

State Environmental Planning Policy No 1—Development Standards
State Environmental Planning Policy No 4—Development Without Consent and Miscellaneous Exempt and Complying Development (clause 6 and Parts 3 and 4)
State Environmental Planning Policy No 60—Exempt and Complying Development
State Environmental Planning Policy No 71—Coastal Protection

By virtue of Clause 135(2) of the Lake Macquarie Local Environmental Plan 2004 State Environmental Planning Policy 71 does not apply to the site. We note the Lake Macquarie Local Environmental Plan 2004 has specific provisions relating to development within the Coastal Zone and these are addressed under Section 5.4.

5.3.5 State Environmental Planning Policy (Infrastructure) 2007

State Environmental Planning Policy (Infrastructure) 2007 aims to facilitate the effective delivery of infrastructure across the State.

Clause 106(1) of State Environmental Planning Policy (Infrastructure) permits development for the purposes of sewage treatment plants to be carried out by or on behalf of a public authority or any person licensed under the *Water Industry Competition Act 2006* without consent on land in a prescribed zone; while Clause 106(3) permits development for the purposes of sewerage reticulation system by or on behalf of a public authority or any person licensed under the *Water Industry Competition Act 2006* without consent on any land.

As the proposal is for a sewerage treatment plant and sewerage reticulation system and is to be carried out by Solo Water Pty Ltd (Catherine Hill Bay Water Utility Pty Ltd) which will be licensed under the WIC Act 2006, it can be assessed under Part 5 of the *Environmental Planning and Assessmen*t *Act 1979*. Development consent under Part 4 of the EP&A Act 1979 is not required.

It is noted the Sewage Treatment Plant will be located on land zoned SP2 Infrastructure a prescribed zone for the purposes of Clause 106(1) of ISEPP.

The proposal is not located on land reserved under the *National Parks and Wildlife Act 1974* and does not affect land or development regulated by *State Environmental Planning Policy No. 14 - Coastal Wetlands, State Environmental Planning Policy No. 26 - Littoral Rainforests* or *State Environmental Planning Policy (Major Projects) 2005.*

Part 2 of the State Environmental Planning Policy (Infrastructure) contains provisions for public authorities to consult with local councils and other public authorities prior to the commencement of certain types of development. Consultation, including consultation as required by State Environmental Planning Policy (Infrastructure) (where applicable), is discussed in chapter 6 of this REF.

With regards to the irrigation, Irrigation is an approved ancillary component of MP10_0204. Legal advices have been obtained on this issue and these are presented under Appendix P.

5.3.6 State Environmental Planning Policy (State & Regional Development) 2011

The provisions of State Environmental Planning Policy (State & Regional Development) 2011 provide for the nomination of development that is state significant development pursuant to Section 89C of the Environmental Planning & Assessment Act 1979. Specifically clause 8 Declaration of State Significant development: section 89 states:

8 Declaration of State significant development: section 89C

(1) Development is declared to be State significant development for the purposes of the Act if:
- *(a) the development on the land concerned is, by the operation of an environmental planning instrument, not permissible without development consent under Part 4 of the Act, and*
- *(b) the development is specified in Schedule 1 or 2.*

As part of the site is located on land on the State Heritage Register the proposal is listed within the Schedule of State Environmental Planning Policy (State & Regional Development) 2011. However by virtue of Clause 106 of State Environmental Planning Policy (Infrastructure) 2007 the proposal is permissible without development consent. Clause 106 of State Environmental Planning Policy (Infrastructure) 2007 does not include any exclusion for land located on the State Heritage Register.

As such the proposal does not meet the requirement of Clause 8(1)(a) and as such is not state significant development.

5.4 Lake Macquarie Local Environmental Plan 2004

Permissibility is established by State Environmental Planning Policy (Infrastructure) 2007 and is discussed under Section 5.3.5. The Lake Macquarie Local Environmental Plan 2004 also applies to the site, specifically Part 11 South Wallarah Peninsula Site. The proposal does not compromise the provisions contained within the LMLEP 2004. The following comment is provided against the relevant clauses:

Clause 144 – Height of Building

The site of the Sewage Treatment Plant is identified with a statutory height limit of 9m. The tallest structure associated with the Sewage Treatment Plant is the storage tanks. The tanks provide a height of 6m to top of tank (roof) and 6.9m to the top of open access platform which is required in accord with AS1657. The proposal is complaint with Clause 144. Refer Appendix A.

Clause 147 – Development within the coastal zone

The site is located within the NSW Coastal Zone. Clause 147 of the Lake Macquarie Local Environmental Plan 2004 provides the following for development within the coastal zone.

(2) Development consent must not be granted to development on land within the South Wallarah Peninsula site that is wholly or partly within the coastal zone unless the consent authority has considered:

(a) existing public access to and along the coastal foreshore for pedestrians (including persons with a disability) with a view to:
(i) maintaining existing public access and, where possible, improving that access, and
(ii) identifying opportunities for new public access, and

The proposed Sewage Treatment Plant and Sewer Reticulation network do not impact upon existing public foreshore access, new foreshore improvements and public open space to be provided as part of Project Approval MP10_0204, nor does it due to its location provide further opportunity of new public foreshore access.

(b) the suitability of the proposed development, its relationship with the surrounding area and its impact on the natural scenic quality, taking into account:
(i) the type of the proposed development and any associated land uses or activities (including compatibility of any land-based and water-based coastal activities), and
(ii) the location, and
(iii) the bulk, scale, size and overall built form design of any building or work involved, and

The proposed Sewage Treatment Plant is located such that it will not be visible from foreshore areas and as such will not have an impact upon the scenic quality of the foreshore area. A Visual Impact Assessment has been prepared as part of this Review of Environmental Factors and mitigations measures proposed to ensure the proposal blends and is appropriately screened to prevent a visual impact in the wider locality. It is noted the structures proposed as part of the Sewage Treatment Plant comply with the statutory height limit of 9m prescribed for the site.

(c) the impact of the proposed development on the amenity of the coastal foreshore, including:
(i) any significant overshadowing of the coastal foreshore, and
(ii) any loss of views from a public place to the coastal foreshore, and

The Sewage Treatment Plant has significant separation from the coastal foreshore area and will not overshadow the foreshore area. In terms of views the Sewage Treatment Plant is located such that it will not impede views from a public place to the coastal foreshore.

> *(d) how the visual amenity and scenic qualities of the coast, including coastal headlands, can be protected, and*

The proposed Sewage Treatment Plant is located such that it will not be visible from foreshore areas and as such will not have an impact upon the scenic quality of the foreshore area. A Visual Impact Assessment has been prepared as part of this Review of Environmental Factors and mitigations measures proposed to ensure the proposal blends and is appropriately screened to prevent a visual impact in the wider locality. It is noted the structures proposed as part of the Sewage Treatment Plant comply with the statutory height limit of 9m prescribed for the site.

> *(e) how biodiversity and ecosystems, including:*
> *(i) native coastal vegetation and existing wildlife corridors, and*
> *(ii) rock platforms, and*
> *(iii) water quality of coastal waterbodies, and*
> *(iv) native fauna and native flora, and their habitats, can be conserved, and*

As discussed within this review of environmental factors the proposed sewage treatment plant and sewer reticulation network is located within the approved footprint of the Catherine Hill Bay subdivision approved under MP10_0204. No further clearing is required to facilitate the proposal. Implementing the proposal has no direct impact upon native coastal vegetation, rock platforms, native fauna and flora and their habitats.

With regards to water quality assessment of the proposal, through the application of the proposed mitigations measures for the proposal it will not have a negative impact upon the surface or ground water quality of the locality.

We note this preferred option for the proposal was selected as it reduced the impact on surrounding biodiversity and ecosystems. Particularly Option 2 which was originally approved as part of MP10_0204 would have required significant construction works and ongoing maintenance within lands dedicated as National Parks. The proposal as assessed in this review of environmental factors removes this impact.

> *(f) the effect of coastal processes and coastal hazards and potential impacts, including sea level rise:*
> *(i) on the proposed development, and*
> *(ii) arising from the proposed development, and*

The site is not affected by coastal process.

> *(g) the cumulative impacts of the proposed development and other development on the coastal catchment.*

Cumulative impacts have the potential to arise from the interaction of individual elements within the proposal and the additive effects of the proposal with other external projects. Clause 228 (2) of the Environmental Planning and Assessment Act 1979 requires that potential cumulative impacts as a result of the proposal be taken into account.

The Sewage Treatment Plant will be located within the bounds of an approved residential subdivision and as such cumulative impact associated with vegetation removal does not result as part of the proposal. The proposed works may produce greenhouse gas. Due to the small scope of the proposal, these impacts do not have the potential to have a significant cumulative environmental effect on existing or likely future activities. The potential impacts on the environment would be minimised with the implementation of the safeguards given in this Review of Environmental Factors.

With regard to traffic impacts the proposal will not generate significant traffic during either construction or operation.

The proposed works would not significantly increase demands on resources, which are, or are likely to become, in short supply. Relatively small amounts of materials would be required for the proposed works. The safeguards listed in this Review of Environmental Factors would be implemented to minimise any impacts.

It is also noted the proposal makes provisions for future connection of existing Catherine Hill Bay allotments into the system. This would allow the removal of existing and aging individual effluent disposal systems and allow this effluent to be treated to an appropriate standard within the proposed system. This would allow the future removal of an existing impact in the locality.

(3) Development consent must not be granted to development on land within the South Wallarah Peninsula site that is wholly or partly within the coastal zone unless the consent authority is satisfied that:

(a) the proposed development will not impede or diminish, where practicable, the physical, land-based right of access of the public to or along the coastal foreshore, and

The proposed Sewage Treatment Plant and Sewer Reticulation network do not impact upon existing public foreshore access, new foreshore improvements and public open space to be provided as part of Project Approval MP10_0204, nor does it due to its location provide further opportunity of new public foreshore access.

(b) if effluent from the development is disposed of by a non-reticulated system, it will not have a negative effect on the water quality of the sea, or any beach, estuary, coastal lake, coastal creek or other similar body of water, or a rock platform, and

The proposal is not a non-reticulated system; it is a private reticulation system which would be licensed under the Water Industry Competition Act. With regards to water quality assessment of the proposal, through the application of the proposed mitigations measures for the proposal it will not have a negative impact upon the surface or ground water quality of the locality.

(c) the proposed development will not discharge untreated stormwater into the sea, or any beach, estuary, coastal lake, coastal creek or other similar body of water, or a rock platform.

The proposal will not discharge untreated stormwater. The Sewage Treatment Plant site will be connected into the stormwater system of the approved Catherine Hill Bay subdivision approved under MP10_0204. Stormwater management for the Sewage Treatment Plant would be prepared and would be in accord with Lake Macquarie Councils DCP No.1 Volume 2 Engineering Guidelines. No drainage is to be directed to the adjacent conservation lands.

Clause 150 – Heritage Conservation

The proposal does not include any of the items listed as requiring consent in relation to a heritage item. The proposal will require an approval under Clause 57(1) of the Heritage Act 1977 prior to installation of the pressure unit and gravity sewer components of the sewer reticulation network within the area of the site listed on the State Heritage Register.

5.5 Catherine Hill Bay (South) Development Control Plan

The STP site will be located within the South Montefiore Street precinct. The intent of the precinct is for structures to correspond to the surrounding bushland with structures to be constructed of natural materials and neutral colours. Structures are to be low in scale to allow surrounding bush to be dominate feature of the locality.

The proposed STP structures would meet this intent with the tallest structure associated with the Sewage Treatment Plant being the storage tanks. The tanks provide a height of 6m to top of tank (roof) and 6.5m to the top of open access platform which is required in accord with AS1657, native screen planting to be provided and were possible colours will be natural. The STP building would be clad with a natural colorbond colour such as Pale Eucalypt or similar. Refer Landscape and Visual Impact Assessment under Appendix D for assessment of the Sewage Treatment Plant visual impact upon the locality.

Stormwater management for the Sewage Treatment Plant would be prepared and would be in accord with Lake Macquarie Councils DCP No.1 Volume 2 Engineering Guidelines. No drainage is to be directed to the adjacent conservation lands.

5.6 NSW Aquifer Interference Policy

The purpose of the NSW Aquifer Interference Policy is stated as:

> *'The purpose of this Aquifer Interference Policy ("this Policy") is to explain the role and requirements of the Minister administering the Water Management Act 2000 ("the Minister") in the water licensing and assessment processes for aquifer interference activities under the Water Management Act 2000 and other relevant legislative frameworks.*

The proposal does not meet the definition of an aquifer interference activity as defined under the Water Management Act 2000. An aquifer interference activity is defined as:

> ***Aquifer interference activity*** *means an activity involving any of the following:*
>
> *(a) the penetration of an aquifer,*
> *(b) the interference with water in an aquifer,*
> *(c) the obstruction of the flow of water in an aquifer,*
> *(d) the taking of water from an aquifer in the course of carrying out mining, or any other activity prescribed by the regulations,*
> *(e) the disposal of water taken from an aquifer as referred to in paragraph (d).*

As outlined within this Review of Environmental Factors, the proposal does not undertaken an activity listed in points (a) through (e) of the definition of an aquifer interference activity and as such the proposal does not meet the definition of an aquifer interference activity and an aquifer interference license under the Water Management Act 2000 is not required. As an aquifer interference license is not required the NSW Aquifer Interference Policy is technically not applicable to the proposal.

It is also noted the NSW Aquifer Interference Policy States:

> *'an assessment of aquifer interference activities seeking approval under the Environmental Planning and Assessment Act 1979 will be made on a case by case basis for each particular project in accordance with this policy'*

The proposal is subject to environmental assessment under Part 5 of the Environmental Planning and Assessment Act 1979. The proposal is not seeking consent under Part 4 or Part 5.1 of the Environmental Planning and Assessment Act 1979.

Although not applicable to the proposal a review of the NSW Aquifer Interference Policy has been undertaken and the proposal would be defined as a low impact activity, namely the 'construction and ongoing use of waste liquid/effluent storage and irrigation reuse schemes providing these are carried out in accordance with their planning and other approvals' as outlined within Section 3.3 of the policy

In addition to this the REF demonstrates there is negligible potential for surface or groundwater contamination or water level/flow increases as a result of the scheme which meet the Minimal Impact Considerations within the Policy. These issues are discussed within Section 7.5 and 7.6 of this Review of Environmental Factors. The irrigation area is also located approximately 400m from nearest mapped ground water bore. This distance exceed the minimum setback required under the NSW EPA Effluent Irrigation Guidelines and the NSW Onsite Silver Book, this is discussed under Section 5.7.

Finally it is noted the NSW Office of Water have reviewed this review of environmental factors during its assessment and provided comments to the Independent Pricing and Regulatory Tribunal. The NSW Office of Water has raised no issues regarding the proposal either being an aquifer interference activity or requiring an aquifer interference license under the Water Management Act 2000.

5.7 Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009

The proposal is located in the area defined in the Water Sharing Plan Hunter Unregulated and Alluvial Water Sources 2009, in the Lake Macquarie Management Unit. The objectives of the plan are identified as:

(a) protect, preserve, maintain or enhance the important river flow dependent and high priority groundwater dependent ecosystems of these water sources,
(b) protect, preserve, maintain or enhance the Aboriginal, cultural and heritage values of these water sources,
(c) protect basic landholder rights,
(d) manage these water sources to ensure equitable sharing between users,
(e) provide opportunities for market based trading of access licences and water allocations within sustainability and system constraints,
(f) provide recognition of the connectivity between surface water and groundwater,
(g) provide sufficient flexibility in water account management to encourage responsible use of available water, and
(h) adaptively manage these water sources.

A search of the NSW Groundwater Bores online system identifies fourteen (14) bores within the boundary of the subdivision approved under MP10_0204 and one (1) within the existing Catherine Hill Bay Village. Figure 10 below is an extract of this mapped data.

Figure 10: Groundwater Works Location (Bores)
Source: NSW Office of Water: Map of NSW Groundwater Bores
Illustrative only. Not to scale

The fourteen (14) bores within the approved subdivision footprint of MP10_0204 if not already decommissioned will be as part of going subdivision works approved under MP10_0204.

The single bore within the existing Catherine Hill Bay village is located approximately 400m from the near point of the proposal irrigation areas. This exceeds the NSW EPA Effluent Irrigation Guidelines and the NSW Onsite Silver Book setback from of a minimum of 250m for domestic ground water bores.

Further this Review of Environmental Factors demonstrates negligible potential for surface or groundwater contamination or water level/flow increases as a result of the proposal. Given this the potential for impacts on river flows, groundwater levels, existing water users and dependant ecosystems is negligible. The single bore identified within the existing Catherine Hill Bay Village will not be impacted upon by this proposal.

It is noted the existing bore within the existing Catherine Hill Bay Village is adjacent to existing properties which currently rely upon onsite effluent disposal the use of this bore is unlikely to be for potable purposes.

5.8 Confirmation of statutory position

The proposal has been assessed as permissible without consent under the relevant environmental planning instruments. That position is established by reference to Clause 106 of State Environmental Planning Policy (Infrastructure) 2007.

The proposal is within the definition of an activity set by Section 110 of the Environmental Planning and Assessment Act 1979 and is being proposed by a person licensed under the Water Industry Competition Act 2006 (pending issue of license). Assessment under Part 5 of the Environmental Planning and Assessment Act is therefore required.

The matters prescribed by Clause 228 of the Environmental Planning and Assessment Regulation 2000, for consideration by assessments under Part 5, are reviewed at Appendix B.

No requirement for a referral under the Environment Protection Biodiversity Conservation Act has been identified.

With regards to the irrigation, Irrigation is an approved ancillary component of MP10_0204. Legal advices have been obtained on this issue and these are presented under Appendix P.

6 – Stakeholder and community consultation

6.1 Community involvement

Community involvement of consultation has been limited on the proposed Sewage Treatment Plant and Sewage Reticulation Network. The proposal plant will not impact upon the existing Catherine Hill Bay village. The proposal is such that it will not have undue adverse impact on the residential allotments it will adjoin within the approved subdivision.

6.2 Aboriginal community involvement

Further consultation with the local Aboriginal community has not been undertaken as part of this Review of Environmental Factors. The proposed Sewage Treatment Plant & Sewage Reticulation Network is located within the existing approved footprint of the Catherine Hill Bay subdivision under MP10_0204. In accord with the requirements of MP10_0204 an Aboriginal Heritage Management Plan was prepared. This report included detail consultation with the Aboriginal Community and includes recommendation to address any Aboriginal heritage items onsite. The proposed Sewage Treatment Plant & Sewer Reticulation Network does not alter or expand the approved subdivision footprint and further consultation is not required in this instance.

6.3 State Environmental Planning Policy (Infrastructure) consultation

Part 2 of the State Environmental Planning Policy (Infrastructure) contains provisions for public authorities or persons acting on behalf of a public authority to consult with local councils and other public authorities prior to the commencement of certain types of development. In this regard the proponents are not a public authority nor are they acting on behalf of a public authority. As such the provisions of the clause are such that consultation is NOT strictly required.

In light of this the consultation requirements at clauses 13-16 of the Infrastructure SEPP have been reviewed and considered against the consultation undertaken as part of the project as a whole and the following is provided:

<u>Lake Macquarie City Council</u>

In this regard to potential direct impact to public authority's assets, formal consultation with Lake Macquarie Council has occurred. Specifically, it is noted that excavation of council managed roads (or parts thereof) may be such that the work cannot reasonably be characterized as minor or inconsequential (see clause 13 of the State Environmental Planning Policy (Infrastructure)).

The consultation that has occurred with LMCC has taken the form of two (2) site meetings held with relevant Council officers on the 17/01/2013 and 07/03/2013. Given the proposal has minimal impact upon Council infrastructure it is considered to be sufficient for the purposes of proposal. The main feedback received centered around the location and use of irrigation.

As discussed within Section 4 options consideration, it was this consultation that ultimately determined that irrigation of private owned restricted access open space was the preferred option and that option 4 was ruled out.

Ongoing consultation will be required with Lake Macquarie City Council and where required S138 approval will have to be issued by LMCC.

<u>Office of Environment and Heritage (OEH) – National Parks & Wildlife</u>

The office of Environment and Heritage were consulted during the assessment of MP10_0204 MOD 2 which rezoned the site of the Sewerage Treatment Plant to SP2. The comments from the Office and Environment and Heritage were received in writing on the 18th Oct 2013. These comments centered on the potential for direct and indirect impacts upon the adjoining Munmorah State Conservation Area, including noise, odour, lighting, groundwater seepage and wet weather discharge. These issues have specifically been addressed within this Review of Environmental Factors and no impact is expected upon the Munmorah State Conservation Area.

Rural Fire Service

The Rural Fires Act 1997 includes the requirement for New South Wales Rural Fire Service approval of certain types of sensitive development, or special fire protection purposes under Section 100B of the Rural Fires Act 1997. The proposal is not listed as a special fire protection purpose and approval under Section 100B of the Rural Fires Act is not required as such specific consultation with the NSW Rural Fire Service is not required by the proposal.

6.4 Government agency and stakeholder involvement

Independent Pricing and Regulatory Tribunal

Consolation with the Independent Pricing and Regulatory Tribunal has been ongoing, with the Independent Pricing and Regulatory Tribunal currently in receipt of a Network Operator and Retail Suppliers License Application under the Water Industry Competition Act 2006 for the proposal. The Independent Pricing and Regulatory Tribunal will be familiar with discussion had to date with regards to the proposal.

NSW Health

Ongoing consultation with NSW Health regarding the regulation, management and prevent of public health issues must occur following WIC Act License being granted. This proposal includes specific commitments to ongoing consultation with NSW Health as part of preparing a Recycled Water Management Plan and Drinking Water Quality Management Plan.

7 – Environmental Considerations & Impacts

This section of the Review of Environmental Factors provides a detailed description of the potential environmental impacts associated with the construction and operation of the proposal. All aspects of the environment potentially impacted upon by the proposal are considered. This includes consideration of the factors specified in the guidelines *Is an EIS required?* (DUAP 1999) as required under clause 228(1)(b) of the *Environmental Planning and Assessment Regulation 2000*. The factors specified in clause 228(2) of the *Environmental Planning and Assessment Regulation 2000* are also considered in Appendix B. Site-specific safeguards are provided to ameliorate the identified potential impacts.

7.1 Soils

7.1.1 Existing Environment

Geotechnical investigation of the site undertaken by Geotech Solutions Pty Ltd (2010) indicates the natural soils across the site consist of:

- Clean Aeolian quartz sand overlying silty and clayey quartz sand
- A mixture of sand, gravel, clay and silt overlying extremely to highly weathered rock
- Higher plasticity clays at depth near the interface of bedrock
- Triassic and late Permian age bedrock

Given the sites former use as a coal mine, topsoil conditions vary across the site based on the specific mining activities that have previously occurred, e.g. stockpiles, tailings dams, earthworks etc. Post development soil conditions will vary from what is currently on site due to the remediation works being undertaken by the coal mine and the bulk earth works that will occur as part of the residential subdivision approved under MP10_0204.

As part of the assessment of MP10_0204 the issue of site contamination was given significant consideration. As required by the conditions of approval for MP10_0204 a Remediation Action Plan is to be prepared for the entire Catherine Hill Bay development.

Approval MP10_0204 requires that an accredited Environmental Protection Agency auditor certify that the Remediation Action Plan has been implemented and that the whole site is suitable for the proposed residential development prior to the issue of subdivision certificate. As the Sewage Treatment Plant site is within the bounds of the approved Catherine Hill Bay subdivision the site will be subject to the works required by the Remediation Action Plan for the subdivision and upon completion will be suitable for the construction of the Sewage Treatment Plant.

With regards to irrigation detailed evaluation of soil physical and chemical properties will be undertaken during each phase of the subdivision build out and reassessed following bulk earthworks. Appropriate management measures will be incorporated in to the Irrigation Management Plans.

Given the high sand content of the top soil layers where recycled water will be applied, issues associated with poor drainage, Sodicity, soil pH and soil salinity are not expected to be a significant constraint to effluent irrigation.

During establishment of the restricted access open space areas, a minimum of 100 mm of high quality sandy loam topsoil sourced from the site and other areas will be used to develop suitable soil conditions for plant growth in the irrigation areas.

7.1.2 Potential Impacts

Importantly, to address the potential impacts associated with the sites previous use and the potential to expose contaminated materials any work identified by the remediation action plan required for the CHB subdivision under MP10_0204 must be completed prior to commencement of works for the Sewage Treatment Plant and Sewer Reticulation Network on the subject site.

Upon completion of any works required to facilitate the subdivision under MP10_0204. Impacts associated with the proposal would relate to construction activities and potential for increased erosion and sediment runoff.

7.1.3 Mitigation Measures

- The preparation of the Remediation Action Plan as required under MP10_0204 and any works required by this plan must be completed prior to works on the Sewage Treatment Plant & Sewer Reticulation Network commencing.
- A Sediment and Erosion Control plan is to be prepared.
- Irrigation controls and measures are to be in accord with that described within the Land Capability Assessment for Effluent Irrigation under Appendix K and as summarized in the table below. These are to be incorporated into an Operation Environmental Management Plan for plant operations.

Issue	Measures to be Incorporated into detailed Irrigation Management Plan
Preparation of irrigation areas	During development of each stage of the residential subdivision, a minimum of 100 mm of good quality sandy loam topsoil cover is to be provided in all new irrigation areas. Detailed soil testing will be undertaken following the bulk earthworks and land clearing activities. Soil testing will include assessment of top soil and sub soil physical and chemical properties as well as field permeability testing. If required soil amendments, e.g. organics, gypsum, lime etc will be incorporated into the soil profile prior to commencement of irrigation. Detailed landscape design, vegetation species selection and irrigation system design plans are to be prepared for each stage of the development prior to construction.
Pathogen exposure controls	Restricted access irrigation area with minimum of 70 metre distance to the nearest dwelling. Spray drift controls through the use of large droplet sprinklers and weather station assisted irrigation scheduling, i.e. avoid irrigation during high wind or rain. Warning/advisory signage around all irrigation areas. The irrigation area will be fenced with lockable access gates. Fencing will be 0.9 m open mesh fence with warning signage.
Cross connection	Separate pipe network and irrigation pump supplies water to irrigation areas. Lilac pipe with identification tape and signage.
Irrigation scheduling controls	Irrigation scheduling to be controlled by the central control system with adjustable settings to control the time of day, frequency and duration of irrigation events. Weather station sensor override on the irrigation supply pump to ensure irrigation does not occur during or shortly after rain or during high wind conditions. Soil moisture probes and an irrigation control system will be used to ensure over irrigation does not occur. When the storage is 100% full an emergency irrigation event will be scheduled automatically.
Overflow Management	During prolonged wet weather when the wet weather storage approaches full, water will be trucked to the nearest accepting licensed facility to ensure there is no potential for any offsite or downstream impacts.
Non-Irrigated Buffers	Minimum 30 metre buffer from irrigation area to down gradient property boundary. Minimum 40 metres buffer from irrigation areas to down gradient property boundary in the steeper NE corner of the irrigation area. 20 metre buffer from irrigation area to up gradient property boundary. No irrigation within the 40 metre wide future waterway corridor. Minimum buffer to the nearest future residential dwelling is 70 metres.

Issue	Measures to be Incorporated into detailed Irrigation Management Plan
Monitoring	Continuous online monitoring, control and alarms on effluent turbidity, UVT%, UV intensity and other critical process parameters at the WWTP. Monthly effluent quality compliance monitoring from the wet weather storage. Detailed annual effluent quality monitoring for trace contaminants. Annual soil monitoring. Event based stormwater monitoring. Quarterly groundwater monitoring. Flow monitoring to each irrigation zone. A detailed monitoring plan will be developed prior to commencement of operation.
Maintenance of irrigation areas	Frequent mowing of irrigation area to keep grass in high growth state. Harvesting lawn clippings to remove nutrients and other pollutants from the irrigation area. Collected lawn clippings are to composted onsite and/or disposed of via green waste recycling contractor. Weekly inspection of the irrigation system for leaks, breakages of broken sprinkler heads. Weekly inspection for evidence of runoff or surface ponding of water or boggy areas. Weekly inspection of vegetation for signs of plant stress. If stress identified a specialist will be engaged and biomass analysis undertaken to identify the route cause. Weekly inspection of fencing and signage to ensure access restrictions are maintained. Weeding of the irrigation area and buffer zones and ensure crop does not spread offsite.

- Environmental monitoring is to be undertaken in accord with the Integrated Water Management Plan under Appendix C and the table below.

Type	Parameter	Units	Type	Location	Frequency
Turf and vegetation health	Visual inspection of plant health for signs or stress	General observations	Monitor for change	Irrigation area	Ongoing
	Laboratory biomass analysis of plant nutrients	mg/kg	Identify deficiencies	Irrigation area	If impacts observed
Surface Water monitoring	Faecal Coliform	cfu/100 mL	Monitor for general trends and change	Downstream in Dam 1 and Dam 2 and upstream at SW U/S.	Quarterly
	BOD	mg/L			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus & Plant available phosphours	mg/L as P			
	pH	pH units			
	Electrical Conductivity	dS/m			
Ground water monitoring	pH	pH units	Monitor for general trends and change	Downstream bores BH006 and BH009 and upstream bores BH004 and BH008.	Quarterly
	Cations	Mg/L			
	Faecal Coliform	cfu/100 mL			
	Electrical conductivity	dS/m			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus	mg/L as P			
	Plant available phosphorus	mg/L as P			
	Water level	m AHD			
Soil monitoring	Total hydraulic and nutrient load onto each irrigation area	kL/year and kg/year	Monitor for general trends	Select irrigation zones that	Annual

Type	Parameter	Units	Type	Location	Frequency
	Electrical conductivity	dS/m	and change.	received the highest hydraulic load. Samples to be taken from top soil and sub soil layers.	
	Available Phosphorus	mg/kg			
	Available Nitrogen	mg/kg			
	Available Potassium	mg/kg			
	Chloride	meq/100g			
	Exchangeable cations & CEC	meq/100g			
	Exchangeable Sodium %	%			
	Sodium adsorption ratio	Ratio			
	Total Organic Carbon	%			
	pH	pH units			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/kg			
	Total Phosphorus	mg/kg			
	Phosphorus Sorption Capacity	mg/kg			
	Heavy metals	mg/kg			
	Pesticides	mg/kg			

- Irrigation areas and irrigation implementation are to incorporate the following:
  - Diversion drains as shown on drawing SW-56-C-SK50 along uphill slope to divert upslope stormwater around the irrigation areas;
  - Catch drain/swale as shown on drawing SW-56-C-SK50 along the downhill boundary of irrigation areas;
  - Exclusion fencing and signage as shown on drawing SW-56-C-SK50
  - Dense deep rooted grass vegetation will be established, e.g. kikuyu pasture;
  - Low application rate sprinklers are to be used;
  - No irrigation during rainfall when there is increased potential for run off;
  - Contour mounds to be constructed at intervals of approximately 30-50 metres;
  - 30 metre down gradient buffer to the property boundary.
  - Minimum 40m to down gradient property boundary in steeper north east corner of the irrigation area
  - 20m buffer to up gradient property boundary
  - No irrigation within the 40m wide future waterway corridor approved under MP10_0204
  - 70m minimum buffer to nearest residential dwelling
  - System and vegetation monitoring in accord with Section 9 of the Land Capability for Effluent Irrigation Report.

  These measures are to be incorporated in the Operational Environmental Management Plan for plant operation
- If the irrigation area is proven to be not suitable, a portion or all of the surplus recycled water would be removed by road tanker to the nearest licensed facility and stage 3 of the proposal would be implemented.

7.2 Odour

7.2.1 Existing Environment

There is a small number of existing residence located approximately 800m radius from the Sewage Treatment Plant site. Future residence with stage 5 and 6 of the amended subdivision as proposed under MP10_0204 MOD 2 would be located within 500m radius of the Sewage Treatment Plant site. It is noted stage 6 of the approved subdivision would not proceed until such time as the separate approvals for stage 3 of the Sewage Treatment Plant and Sewer Reticulation Network scheme are sought and received.

7.2.2 Assessment Criteria

The sense of smell is a subjective human response to the presence of a chemical compound or “odour” in air. The sensitivity to a particular odour can vary from one individual to another by up to two (2) orders of magnitude. Differences in sensitivity to an odour are due to a variety of factors, including age, health, prior exposure to the odour and natural variation within the population.

The factors that are commonly recognised as influencing whether an odour will result in a complaint or not depend on a number of factors referred to as the FIDOL factors.

- Frequency – how often the odour is detected,
- Intensity – how strong the odour is,
- Duration – how long the odour persists for,
- Offensiveness – how the odour smells, and
- Location – where the odour occurs

Dynamic olfactometry involves taking samples of air that contain an odourant and presenting the odour to a panel. The odour is diluted with “clean” air until 50% of the panel can detect the presence of the odour. This concentration is the threshold concentration and is deemed to be 1 odour unit (OU). The number of dilutions required to achieve this level determines the odour concentration of the original sample.

This science in conjunction with dispersion modelling has been shown to be the best available method of predicting odour nuisance on a community over long periods. It is the accepted approach in most developed countries.

The current New South Wales odour policy presented in the *Approved Methods and Guidance – For the Modelling and Assessment of Air Pollutants in New South Wales, August 2001* is not a regulatory document. In this document a method is provided for determining an odour impact criterion based upon the number of people likely to be impacted by an operation, ranging from 2 OU/m^3 to 7 OU/m^3

As per the *Approved Methods and Guidance – For the Modelling and Assessment of Air Pollutants in New South Wales, August 2005* the nose response time average (i.e. on a 1 second average) which is the 99th percentile should be 2 OU/m^3 for a community with a population of 2000 or more people. This 1 second average criterion has been used within the Odour Assessment under Appendix F.

The maximum one second contour plots for the Sewage Treatment Plant are identified within the Odour Assessment under Appendix F.

The results show that the criterion of 2OU/m^3 will not be exceeded at any location and the highest concentration at the boundary of the proposed residential properties is significantly below the criterion, therefore odour nuisance from the Sewage Treatment Plant is not expected.

7.2.3 Potential Impacts

Potential impacts associated with the proposal include loss of amenity for nearby sensitive receivers due to odour emissions.

7.2.4 Mitigation Measures

It is noted the odour assessment under Appendix F did not include the modeling of any additional mitigation measures. The measures to ensure odour is not an impact are inherent in the design of the Sewage Treatment Plant. However the proposal includes the following mitigations measures

- Ventilation stacks provided on all house connections to ensure gravity sewers are well ventilated;
- All gravity sewers designed to achieve self cleansing velocity to avoid accumulation and breakdown of solids in the network;
- Passively ventilated Mcberns activated carbon filters will be used on all air valves in the pressure sewer network;
- Actively ventilated Mcberns activated carbon filter on the Sewage Treatment Plant inlet balance tank;
- All Membrane Bioreactor biological tanks are fully enclosed and passively ventilated through McBerns activated carbon filters located on the roof of the Sewage Treatment Plant building;
- The Membrane Bioreactor room in the Sewage Treatment Plant building has automatic indoor air quality monitoring for temperature, oxygen, hydrogen sulphide and methane, with automatic operation of an evaporative air conditioning unit to maintain ventilation and air quality;
- Deodorizing sprays are included in the design of the Sewage Treatment Plant building to enable release of deodorizing sprays if required;
- Catherine Hill Bay has a 24 hour customer service call centre for fielding all odour and other complaints. All complaints are recorded, reviewed and acted upon as outlined in the Integrated Wastewater Management Plan under Appendix C.

7.3 Traffic

The proposal is to be located within a residential area and will be access from the Pacific Highway via Montefiore Street, approved road 28 and approved road 3. The existing road and to be constructed road network has sufficient capacity to cater for the traffic generated by the development. The proposal can facilitate internal unloading/loading and onsite manoeuvring of vehicles up to and including articulated vehicles.

It is anticipated only two (2) truck movements per week will occur once the plant is constructed and operational.

In regard to construction the proposal would not result in a significant increase in construction traffic. As discussed the construction works not covered and being undertaken under MP10_0204 is limited to the Sewage Treatment Plan building and facility located on the SP2 Zoned Lands; and the installation of the irrigation system and forming the catch and diversion drains within the irrigation area.

With regards to construction, a traffic management plan would be prepared and implemented as part of a Construction Environmental Management Plan for the proposal.

7.4 Noise

The site is located within proximity to a number of sensitive receivers and the potential for disruption due to excessive noise exists.

7.4.1 Existing Environment

The proposals acoustic consultants installed noise logging equipment in two locations to measure baseline environmental noise levels at a representative location in the vicinity of the proposed Sewage Treatment Plant. The location of the monitoring points is identified in the Noise Impact Assessment under Appendix E. Table 9 identifies current ambient noise levels as measured onsite.

Table 9 – Onsite Ambient Noise Levels

Monitoring Location	Period	L_{Aeq}	L_{A90}	RBL
N1	Day	66	49	45
	Evening	65	43	41
	Night	60	40	38
N2	Day	63	49	47
	Evening	58	50	49
	Night	62	52	49

7.4.2 Assessment Criteria

Operational

The EPA Industrial Noise Policy sets limits on the noise that may be generated by the Sewage Treatment Plant during the operational stage. These limits are dependent upon the existing noise levels at the site and are designed to ensure changes to the existing noise environment are minimised and deal with the intrusiveness of the noise and amenity environment. The most stringent of the limits is taken as the limiting criterion for the noise source.

The intrusiveness noise criterion requires that the $L_{Aeq,\ 15\ minute}$ for the noise source, measured at the most sensitive receiver under the worst-case conditions, should not exceed the rated background level (RBL) by more than 5dB, represented as follows:

- $L_{Aeq,\ 15minute}$ < RBL + 5dB.

The noise levels at nearby noise sensitive receptors associated with the operation phase of the Sewage Treatment Plant should not exceed the noise levels identified in Table 10 below. The locations in Table 6 and 7 below are identified in the Noise Impact Assessment under Appendix E.

Table 10 – Proposal Specific Noise Levels at Noise Sensitive Receptors

Location	Period	L_{Aeq}	RBL	Recommended Acceptable L_{Aeq}	Intrusiveness Criteria Level	Proposal Specific Noise Level
F1 & F2	Day	63	47	55	52	52
	Evening	58	49	45	54	45
	Night	62	49	40	54	40
F3	Day	66	45	55	50	50
	Evening	65	41	45	46	45
	Night	60	38	40	43	40

Noise Prediction modelling has been carried out to assess the potential impact associated with the proposed Sewage Treatment Plant on the noise environment at the nearest noise sensitive receptors located in proximity to the site. The predicted noise levels of the operational phase of each stage is representative of the ultimate stage of the proposal for both neutral conditions and worst-case conditions during day and night time, these are presented in Table 11 below

Table 11 – Proposed STP Operations (Stage 1) – Predicted Noise Impact

Location	Predicted Noise Levels dB(A)			
	Day time		Night time	
	Neutral	Worst	Neutral	Worst
F1	29	30	29	30
F2	38	39	38	39
F3	21	21	21	21

The predicted noise impact from the proposed sewage treatment plant on the noise sensitive receivers ranged between 21 to 39dB(A), falling below the applicable criteria during day, evening and night time.

Construction

The New South Wales interim Construction Noise Guideline was developed by the New South Wales – Office of Environment and Heritage and contains detailed procedures for the assessment and management of construction noise impacts. The proposed subdivision is to be constructed in stages with the houses in close proximity to the Sewage Treatment Plant being constructed in stage 5 and 6. Construction Noise impacts are not expected to present a significant impact. A construction noise management plan is include under Appendix O.

7.4.3 Potential Impacts

Potential impacts associated with the proposal include loss of amenity for nearby sensitive receivers due to elevated noise levels.

7.4.4 Mitigation Measures

<u>Operational</u>

It is noted the Noise Impact Assessment under Appendix E did not include the modeling of any additional mitigation measures. The measures to ensure noise is not an impact are inherent in the design of the Sewage Treatment Plant. However the proposal includes the following mitigations measures:

- All sewage pumps in the pressure sewer networks are submersible pumps located below ground level in an enclosed chamber;
- The Membrane Bioreactor and Advanced Water Treatment Plant are fully enclosed within the Sewage Treatment Plant building;
- Specific “noisy” equipment items like aeration blowers etc will be housed inside custom noise enclosures. Equipment specifications and design of custom noise enclosures will be undertaken to ensure compliance with the New South Wales Industrial Noise Policy of background noise plus 5 dBA at nearest residential dwelling;
- All planned construction and routine maintenance works will be undertaken during standard permissible hours;
- All emergency works will be undertaken to minimise noise impacts on residents;
- Catherine Hill Bay has a 24 hour customer service call centre for fielding all noise and other complaints. All complaints are recorded, reviewed and acted upon as outlined in the Integrated Wastewater Management Plan under Appendix C.

<u>Construction</u>

- The measures recommended within the construction noise management plan prepared by Vipac Engineers and Scientists included under Appendix O are to be included within the Construction Environmental Management Plan to be prepared for the proposal.

7.5 Ground Water

7.5.1 Existing Environment

A preliminary site & soil evaluation has been undertaken to identify any significant constraints to irrigation, refer land capability assessment for effluent irrigation under Appendix C. As identified in this report a Geotechnical investigation undertaken by Geotech Solutions Pty Ltd (2010) indicated minimal groundwater was encountered in the upper soil profile or within 3 meters of effluent irrigation areas.

Some localised areas of the site were noted to be susceptible to water logging during extensive rain periods, particularly in areas of the site impacted by mining activities, e.g. where dams and ponds had been filled. No irrigation is proposed in low lying areas of the site or in the drainage reserves.

The land capability assessment for effluent irrigation also indicates a more detailed geotechnical and groundwater baseline investigation have been undertaken at the site during 2014/2015. These investigations have installed two (2) ground water monitoring bores located on the northern side (down slope side) of the irrigation areas. These bores are identified as BH006 and BH009. The location of these boreholes is identified on drawing No. SW-56-C-SK50 included under Appendix Q.

7.5.1.1 Ground Water Depth

Irrigation of treated water will occur within the area of stage 6 and 7 of the approved subdivision under MP10_0204. This land is located on the north facing side of a ridge with heights ranging from RL21m AHD up to RL44m AHD. Based on the data from boreholes BH006 and BH009 the depth between the irrigation area and groundwater varies from 3.3m to 33.4m. The groundwater depth, irrigation land heights and depths to ground water are outlined in Table 12

Table 12: Ground Water and Depth to Groundwater

Irrigation Area	Ground water bore	Standing Water Levels Feb-15 (m AHD)	Irrigation Area Levels (m AHD)	Depth to Groundwater (m)
East	BH006	10.6	21 to 44	10 to 33.4
West	BH009	21.7	25 to 35	3.3 to 13.3

Under the Department of Environment and Conservation *Environmental Guidelines: Use of Effluent by Irrigation 2004* a depth to groundwater of greater than 3m is not a constraint to effluent irrigation.

Irrigation of restricted access privately owned open space will be with Membrane Bioreactor & Ultra Violet treated waste water. The proposal will utilise a low average irrigation rate of 1mm/day to ensure there is minimal potential for deep percolation of recycled water irrigation. Further this irrigation will be scheduled using soil moisture probes, weather station and irrigation control system to ensure over irrigation or irrigation during high soil moisture conditions cannot occur.

The proposed irrigation scheme also includes a 2 ML wet weather storage to enable effluent to be stored during and following periods of heavy rainfall when localised saturated soil conditions may occur.

7.5.1.2 Ground Water Quality

Background groundwater quality monitoring was also undertaken from boreholes BH006 and BH009, a summary of the results is presented in Table 13:

Table 13: Ground Quality

Groundwater Monitoring Bore	TDS (mg/L)	pH	Turbidity (NTU)	Nitrates (mg/L)	Nitrites (mg/L	Ammonia (mg/L)	Phosphorus (mg/L)
BH006	890	4.5	16	0.015	<0.005	0.017	<0.05
BH009	590	6.7	49	0.67	0.027	0.15	<0.05

It can be seen from the above table that the water in the aquifer is slightly brackish with Total Dissolved Solids ranging from 590 mg/L to 890mg/L. The potential to contaminate the aquifer with salts due to irrigation activities is therefore negligible given the irrigated effluent will have a similar Total Dissolved Solids to the background groundwater conditions.

Some background nitrogen was also detected, particularly at BH009 that recorded total oxidised nitrogen of approximately 0.7 mg/L and an ammonia concentration of 0.15 mg/L. Irrigation activities are not expected to impact on nutrient concentrations in groundwater given the average irrigation rate of 1mm/day and plant uptake accounts for all nutrients applied. For reference the expected quality of irrigation wastewater is outlined below in table 14

Table 14: Typical irrigation water quality following Membrane Bioreactor + Ultra Violet treatment.

Parameter	Units	Minimum	Mean	95%ile	Maximum
Biochemical Oxygen Demand	mg/L	-	-	10	20
Suspended Solids	mg/L	-	-	5	10
Total Nitrogen	mg/L as N	-	10	-	20
Total Phosphorus	mg/L as P	-	0.3	-	2
pH	pH	6.5	-	-	8.5
Turbidity	NTU	-	-	1	2
UV Transmission	UVT%	60%			
Faecal Coliforms	cfu/100 mL	-	-	10	100
Total Dissolved Solids	mg/L	-	600	-	

MEDLI modelling undertaken as part of the Land Capability Assessment for Effluent Irrigation under Appendix K indicates all nutrients applied in irrigation are managed inside the boundary of the irrigation area by plant uptake and soil absorption, hence the potential for export of nutrients groundwater is considered low, provided irrigation scheduling controls are implemented.

7.5.2 Potential Impacts

Construction

Construction of the Sewage Treatment Plant is not expected to have any significant impact on groundwater in the vicinity of the site. There is a minor risk of groundwater contamination from chemical and fuel spills if appropriate control measures are not in place. Hazardous substances will be stored in accordance with their material safety data sheet and appropriate environmental controls will be established.

Operation

As with any such proposal, the storage of water has the potential for the deep percolation of reject RO storage to groundwater. Further, irrigation if undertaken in the absence of the proposed water quality treatment, irrigation rates and scheduling has the potential for the deep percolation of irrigated wastewater to groundwater.

To ensure no long term impacts a detail scheme of environmental monitoring including background monitoring of surface water, ground water and plant growth will occur on an ongoing basis as part of operations. This monitoring is to occur as described in Section 9.0 of the Integrated Water Management Plan under Appendix C.

7.5.3 Mitigation Measures

The proposal is designed with the following mitigation measures to ensure ground water quality is maintained:

- Where perched water (evaporation ponds) is to be stored on the site High Density Polyethylene or other suitable liners will be required to prevent loss of water into the underlying strata that could cause a watertable rise.
- Level sensors are used on the Reverse Osmosis Reject Evaporation ponds to enable detection of breaks in the liner and to raise alarms before the ponds are full so the operator can take action by either turning off the Reverse Osmosis units or road tanker pump out can be arranged.
- All site earthworks and construction is to be carried out in accord with a sediment and erosion control plan.
- A Stormwater Management Plan for the Sewage Treatment Plant site is to be prepared in accord with Lake Macquarie Councils DCP No.1 Volume 2 Engineering Guidelines. No drainage from the Sewage Treatment Plant site is to be directed to the adjacent conservation

lands. This plan is to document the site connection to the stormwater management system approved under MP10_0204.

- The treatment and irrigation of water is to be undertaken in accord with the Integrated Water Management Plan under Appendix C.
- Environmental monitoring is to be undertaken in accord with the Integrated Water Management Plan under Appendix C and the table below.

Type	Parameter	Units	Type	Location	Frequency
Turf and vegetation health	Visual inspection of plant health for signs or stress	General observations	Monitor for change	Irrigation area	Ongoing
	Laboratory biomass analysis of plant nutrients	mg/kg	Identify deficiencies	Irrigation area	If impacts observed
Surface Water monitoring	Faecal Coliform	cfu/100 mL	Monitor for general trends and change	Downstream in Dam 1 and Dam 2 and upstream at SW U/S.	Quarterly
	BOD	mg/L			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus & Plant available phosphours	mg/L as P			
	pH	pH units			
	Electrical Conductivity	dS/m			
Ground water monitoring	pH	pH units	Monitor for general trends and change	Downstream bores BH006 and BH009 and upstream bores BH004 and BH008.	Quarterly
	Cations	Mg/L			
	Faecal Coliform	cfu/100 mL			
	Electrical conductivity	dS/m			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus	mg/L as P			
	Plant available phosphorus	mg/L as P			
	Water level	m AHD			
Soil monitoring	Total hydraulic and nutrient load onto each irrigation area	kL/year and kg/year	Monitor for general trends and change.	Select irrigation zones that received the highest hydraulic load. Samples to be taken from top soil and sub soil layers.	Annual
	Electrical conductivity	dS/m			
	Available Phosphorus	mg/kg			
	Available Nitrogen	mg/kg			
	Available Potassium	mg/kg			
	Chloride	meq/100g			
	Exchangeable cations & CEC	meq/100g			
	Exchangeable Sodium %	%			
	Sodium adsorption ratio	Ratio			
	Total Organic Carbon	%			
	pH	pH units			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/kg			
	Total Phosphorus	mg/kg			
	Phosphorus Sorption Capacity	mg/kg			

Type	Parameter	Units	Type	Location	Frequency
	Heavy metals	mg/kg			
	Pesticides	mg/kg			

- Irrigation areas and irrigation implementation are to incorporate the following:
  - Diversion drains as shown on drawing SW-56-C-SK50 along uphill slope to divert upslope stormwater around the irrigation areas;
  - Catch drain/swale as shown on drawing SW-56-C-SK50 along the downhill boundary of irrigation areas;
  - Exclusion fencing and signage as shown on drawing SW-56-C-SK50
  - Dense deep rooted grass vegetation will be established, e.g. kikuyu pasture;
  - Low application rate sprinklers are to be used;
  - No irrigation during rainfall when there is increased potential for run off;
  - Contour mounds to be constructed at intervals of approximately 30-50 metres;
  - 30 metre down gradient buffer to the property boundary.
  - Minimum 40m to down gradient property boundary in steeper north east corner of the irrigation area
  - 20m buffer to up gradient property boundary
  - No irrigation within the 40m wide future waterway corridor approved under MP10_0204
  - 70m minimum buffer to nearest residential dwelling
  - System and vegetation monitoring in accord with Section 9 of the Land Capability for Effluent Irrigation Report.

  These measures are to be incorporated in the Operational Environmental Management Plan for plant operation

7.6 Surface Water

7.6.1 Existing Environment

Surface water

The Sewage Treatment Plant site has a southerly fall from Montefiore Street with a defined ephemeral drainage line bisecting the lower portion of the site. This drainage ultimately drains to Munmorah State Conservation Area and discharges at Moonee Beach, south of the existing Township. Ultimately drainage will be provided in accord with that approved under project approval MP10_0204 via detention basins and bio-retention basins.

Irrigation of treated water will occur within the area of stage 6 and 7 of the approved subdivision under MP10_0204. This land is located on the north facing side of a ridge with heights ranging from RL21m AHD up to RL44m AHD and which provides average slopes across the irrigation area of approximately 10%. The levels and location of the irrigation area and associated stormwater controls relative to stages 6 and 7 of MP10_0204 is identified on Plan SW-56-C-SK50 under Appendix Q.

The proposal will also include the perched storage of Reverse Osmosis Reject for evaporation that will not overflow.

7.6.2 Potential Impacts

General Operation

Potential impact as part of the proposal relate to increased sediment and erosion control and nutrient runoff into the stormwater catchments in and surrounding the site or the overtopping of the reverse osmosis reject ponds

As part of the proposal a detailed stormwater management plan for the Sewage Treatment Plant building site will be prepared to direct all drainage to the stormwater management system approved under MP10_0204, while for the irrigation areas a combination of diversion and catch drains, varying width buffers up to 50m and a low average irrigation rate of 1mm/day are provided to ensure that treated water irrigated onsite infiltrates and does not run off to the down slope lands.

To ensure the reverse osmosis ponds do not overtop, level sensors are used on the Reverse Osmosis Reject Evaporation ponds to enable detection of breaks in the liner and to raise alarms before the ponds are full so the operator can take action by either turning off the Reverse Osmosis units or road tanker pump out can be arranged.

To ensure no long term impacts a detailed scheme of environmental monitoring including background monitoring of surface water, ground water and plant growth will occur on an ongoing basis as part of operations. This monitoring is to occur as described in Section 9.0 of the Integrated Water Management Plan under Appendix C.

7.6.3 Mitigation Measures

The proposal is designed with the following mitigation measures to ensure surface water quality is maintained:

- A Stormwater Management Plan for the Sewage Treatment Plant site is to be prepared in accord with Lake Macquarie Councils DCP No.1 Volume 2 Engineering Guidelines. No drainage from the Sewage Treatment Plant site is to be directed to the adjacent conservation lands. This plan is to document the sites connection to the stormwater management system approved under MP10_0204.
- No drainage from the Sewage Treatment Plant site is to be directed to the adjacent conservation lands as per project approval MP10_0204.
- A Sediment and Erosion Control plan is to be prepared.
- Wastewater reuse and recycling is maximised in the scheme through the supply of Class A+ recycled water to customers for toilet flushing, laundry and outdoor recycled water uses;
- Irrigation areas and irrigation implementation are to incorporate the following:
  - Diversion drains as shown on drawing SW-56-C-SK50 along uphill slope to divert upslope stormwater around the irrigation areas;
  - Catch drain/swale as shown on drawing SW-56-C-SK50 along the downhill boundary of irrigation areas;
  - Exclusion fencing and signage as shown on drawing SW-56-C-SK50
  - Dense deep rooted grass vegetation will be established, e.g. kikuyu pasture;
  - Low application rate sprinklers are to be used;
  - No irrigation during rainfall when there is increased potential for run off;
  - Contour mounds to be constructed at intervals of approximately 30-50 metres;
  - 30 metre down gradient buffer to the property boundary.
  - Minimum 40m to down gradient property boundary in steeper north east corner of the irrigation area
  - 20m buffer to up gradient property boundary
  - No irrigation within the 40m wide future waterway corridor approved under MP10_0204
  - 70m minimum buffer to nearest residential dwelling

- System and vegetation monitoring in accord with Section 9 of the Land Capability for Effluent Irrigation Report.

These measures are to be incorporated in the Operational Environmental Management Plan for plant operation

- Environmental monitoring is to be undertaken in accord with the Integrated Water Management Plan under Appendix C and the table below.

Type	Parameter	Units	Type	Location	Frequency
Turf and vegetation health	Visual inspection of plant health for signs or stress	General observations	Monitor for change	Irrigation area	Ongoing
	Laboratory biomass analysis of plant nutrients	mg/kg	Identify deficiencies	Irrigation area	If impacts observed
Surface Water monitoring	Faecal Coliform	cfu/100 mL	Monitor for general trends and change	Downstream in Dam 1 and Dam 2 and upstream at SW U/S.	Quarterly
	BOD	mg/L			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus & Plant available phosphours	mg/L as P			
	pH	pH units			
	Electrical Conductivity	dS/m			
Ground water monitoring	pH	pH units	Monitor for general trends and change	Downstream bores BH006 and BH009 and upstream bores BH004 and BH008.	Quarterly
	Cations	Mg/L			
	Faecal Coliform	cfu/100 mL			
	Electrical conductivity	dS/m			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus	mg/L as P			
	Plant available phosphorus	mg/L as P			
	Water level	m AHD			
Soil monitoring	Total hydraulic and nutrient load onto each irrigation area	kL/year and kg/year	Monitor for general trends and change.	Select irrigation zones that received the highest hydraulic load. Samples to be taken from top soil and sub soil layers.	Annual
	Electrical conductivity	dS/m			
	Available Phosphorus	mg/kg			
	Available Nitrogen	mg/kg			
	Available Potassium	mg/kg			
	Chloride	meq/100g			
	Exchangeable cations & CEC	meq/100g			
	Exchangeable Sodium %	%			
	Sodium adsorption ratio	Ratio			
	Total Organic Carbon	%			
	pH	pH units			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/kg			
	Total Phosphorus	mg/kg			
	Phosphorus Sorption Capacity	mg/kg			

Type	Parameter	Units	Type	Location	Frequency
	Heavy metals	mg/kg			
	Pesticides	mg/kg			

- Free board and Level sensors are used on the Reverse Osmosis Reject Evaporation ponds to enable detection of breaks in the liner and to raise alarms before the ponds are full so the operator can take action by either turning off the Reverse Osmosis units or road tanker pump out can be arranged.

7.7 Flora & Fauna

7.7.1 Existing Environment

In June 2012, the Federal Department of Sustainability, Environment, Water, Populations and Communities (DSEWPC) approved an Environment Protection Biodiversity Conservation Act referral allowing the clearing of all vegetation within the subdivision footprint approved under MP10_0204.

The proposed site of the Sewage Treatment Plant is located within the footprint of the approved subdivision and is to be created in accord with the existing approvals (MP10_0204 as amended) and will be provided by Coastal Hamlets Pty Ltd to Catherine Hill Bay Water Utility Pty Ltd as a vacant clear site for construction of the Sewage Treatment Plant. The proposal would not require any clearing beyond that already approved in association with MP10_0204.

It is also noted that at the time of preparation of this review of environmental factors the clearing permitted under MP10_0204 and the EPBC Act approval has occurred and the site is clear of vegetation.

7.7.2 Potential Impacts

As all clearing works are approved and have been undertaken as part of the works associated with MP10_0204, The potential impacts to flora and fauna associated with the proposal relate to construction activities onsite and the Sewage Treatment Plant and irrigation areas ongoing interaction with retained vegetation adjoining the site.

Potential exists for negative weed edge effects to occur on adjoining national parks land.

7.7.3 Mitigation Measures

- A Stormwater Management Plan for the Sewage Treatment Plant site is to be prepared in accord with Lake Macquarie Councils DCP No.1 Volume 2 Engineering Guidelines. No drainage from the Sewage Treatment Plant site is to be directed to the adjacent conservation lands. This plan is to document the sites connection to the stormwater management system approved under MP10_0204.
- No drainage from the Sewage Treatment Plant site is to be directed to the adjacent conservation lands as per project approval MP10_0204.
- All site earthworks and construction is to be carried out in accord with a sediment and erosion control plan.
- All clearing works approved under MP10_0204 must be completed in accord with the relevant approvals prior to works associated with the Sewage Treatment Plant commencing.
- The designated construction zone and boundary between the site and National Parks and Wildlife land is to be clearly marked via high visibility fencing, sediment fencing and/or signage identifying that no construction activities (including temporary storage, stockpiling, vehicle movement etc) are permitted beyond prior to commencement of any work.
- A Weed Management Plan is to be prepared for both the Sewage Treatment Plant site and Irrigation areas and included within the operational environmental management plan to ensure negative edge effects do not occur to adjoining national park lands.

- A detailed landscaping plan of the proposed irrigation area vegetation buffers including appropriate species selection is to be prepared.

7.8 Aboriginal Heritage

7.8.1 Existing Environment

An Aboriginal cultural heritage management plan has been prepared in relation to project approval MP10_0204. This assessment identified a single isolated stone artefact within the bounds of the Sewage Treatment Plant site, refer section 2.6.5. No other archaeological sites or features where found within the subdivision development footprint approved under MP10_0204 as part of the Archaeological assessment of the site.

7.8.2 Potential Impacts

Although identified as clear of Aboriginal Heritage with exception of one (1) isolated item during investigations for the subdivision approved under MP10_0204, unexpected finds can occur.

7.8.3 Mitigation Measures

- Should any unexpected Aboriginal heritage items be found during works all works would cease immediately and the National Parks & Wildlife Service and the relevant Local Aboriginal Land Council would be notified. Procedures to address this issue are to be included within the Construction Environmental Management Plan for the proposal.
- The procedures outlined within the Aboriginal Heritage Management Plan approved under MP10_0204 must be implemented to relocate the isolated artifact found onsite prior to commencement of any works.

7.9 Visual Amenity

7.9.1 Existing Environment

A Landscape and Visual Impact Statement has been prepared as part of this Review of Environmental Factors. The Visual Catchments for Catherine Hill Bay are made up of two distinct primary regions, VCA1 Catherine Hill Bay Visual Catchment Area and VCA2 Moonee Visual Catchment Area. These regions are defined largely through topography with the main site ridgelines acting as the perimeters of these.

The general site topographic features reduce the potential visual impact of the Sewage Treatment Plant to a single Visual Catchment Area referred to in this report as Visual Catchment Area 2. Visual Catchment Area 2 correlates to Stage 5 of the Catherine Hill Bay development approved under MP10_0204. Refer Landscape and Visual Impact Statement under Appendix D for detailed discussion of these Visual Catchments.

7.9.2 Potential Impacts

The subject site will be vacant cleared land and as such potential impacts are limited to the introduction of structures within the locality. The potential for significant impact is associated with the three (3) main key vantage points identified within the Landscape and Visual Impact Statement.

7.9.3 Mitigation Measures

To mitigate the potential impact to visual amenity the following mitigations measures are proposed

- Buffer planting as outlined within Landscape and Visual Impact Statement under Appendix D is to be implemented as part of Sewage Treatment Plant construction.
- The Sewage Treatment Plant building is to be clad in natural colours such as colorbond Pale

Eucalypt or similar.

7.10 Bushfire Hazard

The proposed STP is classified as a Class 10a structure pursuant to the Building Code of Australia (BCA). The Building Code of Australia does not provide for any bushfire specific performance requirements and as such AS-3959-2009 does not apply as a set of 'deemed to satisfy' provisions. The general fire safety construction provisions are taken as acceptable solutions, but the aims and objectives of Planning for Bushfire Protection 2006 apply in relation to other matters such as access, water and services, emergency planning and landscaping / vegetation management.

Development such as the proposed requires on site car parking and loading space. As demonstrated on the Bushfire Management Plan under Appendix J, these areas have been located so at to allow for perimeter vehicle access over the site. This ensures that should emergency services require access during a bushfire event, all vehicles and personnel will be able to circumnavigate the Sewage Treatment Plant buildings and structures.

The Sewage Treatment Plant will have access to reticulated water supply and is also provided with sufficient storage tanks. A fire hydrant is to be located at site entrance into the Sewage Treatment Plant to allow for connection to the reticulated water supply and a sprinkler system is to be installed between the built structures and bushfire hazard. It is considered that the large storage tanks on site provide for a secondary water supply for firefighting purposes.

A Bushfire Evacuation Plan is to be created and a copy of the plan is to be kept within the site office. Once the road network of the adjoining subdivision has been completed, the most efficient evacuation route away from the western bushfire threat is to be identified on a plan and erected near the exit of the site office.

7.11 Non Aboriginal Heritage

7.11.1 Existing Environment

A number of the allotments which form part of the site fall within the Catherine Hill Bay Cultural Heritage Precinct. The Catherine Hill Bay Cultural Heritage Precinct is listed on the NSW State Heritage Register. As such the proposal would require an approval in respect of doing or carrying out of an act, matter of thing under Clause 57(1) of the Heritage Act 1977

7.11.2 Potential Impacts

All works located within the Catherine Hill Bay Cultural Heritage Precinct would be limited to excavation and installation of the pressure sewer units and gravity sewer connections which are located below ground. As no works are proposed in direct relation to any built structures within the Cultural Heritage Precinct impacts upon the precinct are unlikely.

7.11.3 Mitigation Measures

- The relevant approval under the Heritage Act 1977 for the works within the Cultural Heritage Precinct is to be obtained prior to any work commencing within the Cultural Heritage Precinct. Works within the Cultural Heritage Precinct is to be undertaken in accord with any conditions of this approval.

7.12 Waste

The proposed sewerage treatment plant would provide five (5) waste streams. In handling the waste the proposal would undertake the following mitigation measures:

- A register will be maintained for all waste sampling and classification results for the life of the proposal in accordance with Environmental Protection Agency's Classification Guidelines; and
- Detailed procedures for waste handling including storage and disposal procedures are be established and included within the Operation Environmental Management Plan.

7.13 Cumulative Impacts

Cumulative impacts have the potential to arise from the interaction of individual elements within the proposal and the additive effects of the proposal with other external projects. Clause 228 (2) of the Environmental Planning and Assessment Act 1979 requires that potential cumulative impacts as a result of the proposal be taken into account.

The Sewage Treatment Plant will be located within the bounds of an approved residential subdivision and as such cumulative impact associated with vegetation removal does not result as part of the proposal. The proposed works may produce greenhouse gas. Due to the small scope of the proposal, these impacts do not have the potential to have a significant cumulative environmental effect on existing or likely future activities. The potential impacts on the environment would be minimised with the implementation of the safeguards given in this Review of Environmental Factors.

With regard to traffic impacts the proposal will not generate significant traffic during either construction or operation.

The proposed works would not significantly increase demands on resources, which are, or are likely to become, in short supply. Relatively small amounts of materials would be required for the proposed works. The safeguards listed in this Review of Environmental Factors would be implemented to minimise any impacts.

It is also noted the proposal makes provisions for future connection of existing Catherine Hill Bay allotments into the system. This would allow the removal of existing and aging individual effluent disposal systems and allow this effluent to be treated to an appropriate standard within the proposed system. This would allow the future removal of an existing impact in the locality.

In comparison to the previously approved business as usual model the proposal has significantly less impacts in its construction and operation. The proposal provides benefits through reduced energy consumption, reduced potable water demand, increased use of recycled water and no overflows.

8 – Proposal Justification

This chapter provides a justification for the proposed Sewage Treatment Plant & Sewer Reticulation Network within the following contexts:

- Biophysical effects
- Social / community effects
- Economic effects
- The principles of ecologically sustainable development (ESD).

The main beneficial effects are listed, together with the proposed development's main adverse effects.

8.1 Biophysical Context

8.1.1 Beneficial Effects

The proposed development is expected to have the following beneficial effects on the biophysical environment:

- No expected impacts on any threatened species, population or ecological community, or their habitat. This option removes the impact of the previously approved servicing option which is identified as option 2 in the options discussion.
- The provision of essential infrastructure for the Catherine Hill Bay subdivision approved under MP10_0204 which will help facilitate a significant reduction in potable water demand.

8.1.2 Adverse Effects

The proposed development, if conducted in the absence of any mitigation measures, could be expected to have the following adverse effects on the biophysical environment:

- Potential for water pollution and subsequent downstream degradation from wastewater irrigation;
- Potential for noise;
- Potential for odour;

Of the above, it is considered that the potential for water quality impacts, noise and odour are the most significant potential risks upon the biophysical environment. Construction of the plant in accord with the supporting noise and odour assessment will negate the risk of adverse noise and odour. Operation of the plant in accord with the commitments contained within the Integrated Water Management Plan (and summarised in this report) and Land Capability Assessment for Effluent Irrigation (and summarised in this report) will negated any water quality impacts.

8.2 Social / Community Effects

8.2.1 Beneficial Effects

The proposed development is expected to have the following beneficial effects on the social environment:

- The proposed development would not impact upon existing community facilities or services
- There would be no significant visual impact from the proposed development

- The proposed plant will enable the ongoing development of Catherine Hill Bay subdivision approved under MP10_0204 and will help facilitate the new community.
- The plant will provide employment during the construction and operational phase.

8.2.2 Adverse Effects

The proposed development, if conducted in the absence of any mitigation measures, could be expected to have the following adverse effects on the social / community environment:

- Potential for increase in ambient noise levels;
- Potential for odours spread;
- Potential water quality impacts

Construction of the plant in accord with the supporting noise and odour assessment will negate the risk of adverse noise and odour. Operation of the plant in accord with the commitments contained within the Integrated Water Management Plan (and summarised in this report) and Land Capability Assessment for Effluent Irrigation (and summarised in this report) will negated any water quality impacts.

8.3 Economic Context

8.3.1 Beneficial Effects

The proposed development is expected to have the following beneficial economic effects:

- Direct and indirect income benefits to the local and wider community
- Creation of employment opportunities.
- Provide essential infrastructure to facilitate the ongoing development of the adjoining residential estate.

8.3.2 Adverse Effects

The proposed development could have the following adverse effects on the economic environment if the site is not effectively managed.

- Additional expenses for Council and the general public should waste not be effectively managed on site with spin off environmental costs

8.4 Ecologically Sustainable Development

Ecologically Sustainable Development is a concept firmly entrenched in NSW environmental legislation and government policy. The four guiding principles of Ecologically Sustainable Development (as contained in the Environmental Planning and Assessment Regulation 2000) and their relation to the proposed development are outlined below:

a) *The precautionary principle – namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.*

The nature of the proposed development is such that the potential for serious or irreversible environmental damage is extremely limited. The proposal is a modern, high tech sewerage treatment plant that provides whole system management and provides an alternative water source.

Scientific modelling and parameters are well established for the control of the main potential impacts (water quality, noise & odour) associated with the proposal.

Mitigation strategies have been developed as part of the proposal system design to prevent water quality issues and prevent downstream environmental degradation. These mitigation measures have been developed in accordance with current best management practices and with a view to achieving a sustainable long term sewerage treatment option.

b) Inter-generational equity – *namely, that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.*

The proposed development responds in the positive to inter-generational equity providing a modern alternative to traditional sewerage treatment systems, an alternative source of water and does not require typical discharges of sewerage into the environment.

The potential impacts of the proposal are such that long term degradation is unlikely and the mitigation measures which form a fundamental part of the proposal ensure no serious or irreversible environmental effects.

c) *Conservation of biological diversity and ecological integrity – namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration.*

The proposed development is able to be conducted without any significant impact on the biological diversity and ecological integrity of the locality. The proposed sewerage treatment plant would be located on a cleared site provided as part of the Catherine Hill Bay subdivision approved under MP10_0204. No Flora or Fauna is impacted as part of the proposal.

d) Improved valuation and pricing of environmental resources – *namely, that environmental factors should be included in the valuation of assets and services, such as polluter pays, full life cycle costing, and utilising incentive structures / market mechanisms to meet environmental goals.*

Waste is a resource. The proposed STP provides an alternative water source for reuse in the adjoining residential development.

As demonstrated above, the proposal can be undertaken in a manner which accords with the principles of Ecologically Sustainable Development. As demonstrated throughout this Review of Environmental Factors the proposed development is justifiable, as it would have minimal impact on the biophysical, social and economic environment.

9 – Mitigation Measures

9.1 Summary of Commitments and Mitigation Measures

The following sections summarise the commitments by the proponent regarding mitigations and control measures to be implemented for the proposal:

9.1.1 Soils

- The preparation of the Remediation Action Plan as required under MP10_0204 and any works required by this plan must be completed prior to works on the Sewage Treatment Plant & Sewer Reticulation Network commencing.
- A Sediment and Erosion Control plan is to be prepared.
- Irrigation controls and measures are to be in accord with that described within the Land Capability Assessment for Effluent Irrigation under Appendix K and as summarized in the table below. These are to be incorporated into an Operation Environmental Management Plan for plant operations.

Issue	Measures to be Incorporated into detailed Irrigation Management Plan
Preparation of irrigation areas	During development of each stage of the residential subdivision, a minimum of 100 mm of good quality sandy loam topsoil cover is to be provided in all new irrigation areas. Detailed soil testing will be undertaken following the bulk earthworks and land clearing activities. Soil testing will include assessment of top soil and sub soil physical and chemical properties as well as field permeability testing. If required soil amendments, e.g. organics, gypsum, lime etc will be incorporated into the soil profile prior to commencement of irrigation. Detailed landscape design, vegetation species selection and irrigation system design plans are to be prepared for each stage of the development prior to construction.
Pathogen exposure controls	Restricted access irrigation area with minimum of 70 metre distance to the nearest dwelling. Spray drift controls through the use of large droplet sprinklers and weather station assisted irrigation scheduling, i.e. avoid irrigation during high wind or rain. Warning/advisory signage around all irrigation areas. The irrigation area will be fenced with lockable access gates. Fencing will be 0.9 m open mesh fence with warning signage.
Cross connection	Separate pipe network and irrigation pump supplies water to irrigation areas. Lilac pipe with identification tape and signage.
Irrigation scheduling controls	Irrigation scheduling to be controlled by the central control system with adjustable settings to control the time of day, frequency and duration of irrigation events. Weather station sensor override on the irrigation supply pump to ensure irrigation does not occur during or shortly after rain or during high wind conditions. Soil moisture probes and an irrigation control system will be used to ensure over irrigation does not occur. When the storage is 100% full an emergency irrigation event will be scheduled automatically.
Overflow Management	During prolonged wet weather when the wet weather storage approaches full, water will be trucked to the nearest accepting licensed facility to ensure there is no potential for any offsite or downstream impacts.

Issue	Measures to be Incorporated into detailed Irrigation Management Plan
Non-Irrigated Buffers	Minimum 30 metre buffer from irrigation area to down gradient property boundary. Minimum 40 metres buffer from irrigation areas to down gradient property boundary in the steeper NE corner of the irrigation area. 20 metre buffer from irrigation area to up gradient property boundary. No irrigation within the 40 metre wide future waterway corridor. Minimum buffer to the nearest future residential dwelling is 70 metres.
Monitoring	Continuous online monitoring, control and alarms on effluent turbidity, UVT%, UV intensity and other critical process parameters at the WWTP. Monthly effluent quality compliance monitoring from the wet weather storage. Detailed annual effluent quality monitoring for trace contaminants. Annual soil monitoring. Event based stormwater monitoring. Quarterly groundwater monitoring. Flow monitoring to each irrigation zone. A detailed monitoring plan will be developed prior to commencement of operation.
Maintenance of irrigation areas	Frequent mowing of irrigation area to keep grass in high growth state. Harvesting lawn clippings to remove nutrients and other pollutants from the irrigation area. Collected lawn clippings are to composted onsite and/or disposed of via green waste recycling contractor. Weekly inspection of the irrigation system for leaks, breakages of broken sprinkler heads. Weekly inspection for evidence of runoff or surface ponding of water or boggy areas. Weekly inspection of vegetation for signs of plant stress. If stress identified a specialist will be engaged and biomass analysis undertaken to identify the route cause. Weekly inspection of fencing and signage to ensure access restrictions are maintained. Weeding of the irrigation area and buffer zones and ensure crop does not spread offsite.

- Environmental monitoring is to be undertaken in accord with the Integrated Water Management Plan under Appendix C and the table below.

Type	Parameter	Units	Type	Location	Frequency
Turf and vegetation health	Visual inspection of plant health for signs or stress	General observations	Monitor for change	Irrigation area	Ongoing
	Laboratory biomass analysis of plant nutrients	mg/kg	Identify deficiencies	Irrigation area	If impacts observed
Surface Water monitoring	Faecal Coliform	cfu/100 mL	Monitor for general trends and change	Downstream in Dam 1 and Dam 2 and upstream at SW U/S.	Quarterly
	BOD	mg/L			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus & Plant available phosphours	mg/L as P			
	pH	pH units			
	Electrical Conductivity	dS/m			
Ground water monitoring	pH	pH units	Monitor for general trends and change	Downstream bores BH006 and BH009 and upstream bores BH004 and BH008.	Quarterly
	Cations	Mg/L			
	Faecal Coliform	cfu/100 mL			
	Electrical conductivity	dS/m			
	Total Nitrogen, nitrate, nitrite,	mg/L as N			

Type	Parameter	Units	Type	Location	Frequency
	TKN, Ammonia				
	Total Phosphorus	mg/L as P			
	Plant available phosphorus	mg/L as P			
	Water level	m AHD			
Soil monitoring	Total hydraulic and nutrient load onto each irrigation area	kL/year and kg/year	Monitor for general trends and change.	Select irrigation zones that received the highest hydraulic load. Samples to be taken from top soil and sub soil layers.	Annual
	Electrical conductivity	dS/m			
	Available Phosphorus	mg/kg			
	Available Nitrogen	mg/kg			
	Available Potassium	mg/kg			
	Chloride	meq/100g			
	Exchangeable cations & CEC	meq/100g			
	Exchangeable Sodium %	%			
	Sodium adsorption ratio	Ratio			
	Total Organic Carbon	%			
	pH	pH units			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/kg			
	Total Phosphorus	mg/kg			
	Phosphorus Sorption Capacity	mg/kg			
	Heavy metals	mg/kg			
	Pesticides	mg/kg			

- Irrigation areas and irrigation implementation are to incorporate the following:
  - Diversion drains as shown on drawing SW-56-C-SK50 along uphill slope to divert upslope stormwater around the irrigation areas;
  - Catch drain/swale as shown on drawing SW-56-C-SK50 along the downhill boundary of irrigation areas;
  - Exclusion fencing and signage as shown on drawing SW-56-C-SK50
  - Dense deep rooted grass vegetation will be established, e.g. kikuyu pasture;
  - Low application rate sprinklers are to be used;
  - No irrigation during rainfall when there is increased potential for run off;
  - Contour mounds to be constructed at intervals of approximately 30-50 metres;
  - 30 metre down gradient buffer to the property boundary.
  - Minimum 40m to down gradient property boundary in steeper north east corner of the irrigation area
  - 20m buffer to up gradient property boundary
  - No irrigation within the 40m wide future waterway corridor approved under MP10_0204
  - 70m minimum buffer to nearest residential dwelling
  - System and vegetation monitoring in accord with Section 9 of the Land Capability for Effluent Irrigation Report.

  These measures are to be incorporated in the Operational Environmental Management Plan for plant operation

- If the irrigation area is proven to be not suitable, a portion or all of the surplus recycled water would be removed by road tanker to the nearest licensed facility and stage 3 of the proposal would be implemented.

9.1.2 Odour

- Ventilation stacks provided on all house connections to ensure gravity sewers are well ventilated;
- All gravity sewers designed to achieve self cleansing velocity to avoid accumulation and breakdown of solids in the network;
- Passively ventilated Mcberns activated carbon filters will be used on all air valves in the pressure sewer network;
- Actively ventilated Mcberns activated carbon filter on the Sewage Treatment Plant inlet balance tank;
- All Membrane Bioreactor biological tanks are fully enclosed and passively ventilated through McBerns activated carbon filters located on the roof of the Sewage Treatment Plant building;
- The Membrane Bioreactor room in the Sewage Treatment Plant building has automatic indoor air quality monitoring for temperature, oxygen, hydrogen sulphide and methane, with automatic operation of an evaporative air conditioning unit to maintain ventilation and air quality;
- Deodorizing sprays are included in the design of the Sewage Treatment Plant building to enable release of deodorizing sprays if required;
- Catherine Hill Bay has a 24 hour customer service call centre for fielding all odour and other complaints. All complaints are recorded, reviewed and acted upon as outlined in the Integrated Wastewater Management Plan under Appendix C.

9.1.3 Traffic

- A Construction traffic management plan is to be prepared and implemented as part of the Construction Environmental Management Plan for the proposal.

9.1.4 Noise

- All sewage pumps in the pressure sewer networks are submersible pumps located below ground level in an enclosed chamber;
- The Membrane Bioreactor and Advanced Water Treatment Plant are fully enclosed within the Sewage Treatment Plant building;
- Specific “noisy” equipment items like aeration blowers etc will be housed inside custom noise enclosures. Equipment specifications and design of custom noise enclosures will be undertaken to ensure compliance with the New South Wales Industrial Noise Policy of background noise plus 5 dBA at nearest residential dwelling;
- All planned construction and routine maintenance works will be undertaken during standard permissible hours;
- All emergency works will be undertaken to minimise noise impacts on residents;
- Catherine Hill Bay has a 24 hour customer service call centre for fielding all noise and other complaints. All complaints are recorded, reviewed and acted upon as outlined in the Integrated Wastewater Management Plan under Appendix C.
- The measures recommended within the construction noise management plan prepared by Vipac Engineers and Scientists included under Appendix O are to be included within the Construction Environmental Management Plan to be prepared for the proposal.

9.1.5 Ground Water

- Where perched water (evaporation ponds) is to be stored on the site High Density Polyethylene or other suitable liners will be required to prevent loss of water into the underlying strata that could cause a watertable rise.
- Level sensors are used on the Reverse Osmosis Reject Evaporation ponds to enable detection of breaks in the liner and to raise alarms before the ponds are full so the operator can take

action by either turning off the Reverse Osmosis units or road tanker pump out can be arranged.

- All site earthworks and construction is to be carried out in accord with a sediment and erosion control plan.
- A Stormwater Management Plan for the Sewage Treatment Plant site is to be prepared in accord with Lake Macquarie Councils DCP No.1 Volume 2 Engineering Guidelines. No drainage from the Sewage Treatment Plant site is to be directed to the adjacent conservation lands. This plan is to document the site connection to the stormwater management system approved under MP10_0204.
- The treatment and irrigation of water is to be undertaken in accord with the Integrated Water Management Plan under Appendix C.
- Environmental monitoring is to be undertaken in accord with the Integrated Water Management Plan under Appendix C and the table below.

Type	Parameter	Units	Type	Location	Frequency
Turf and vegetation health	Visual inspection of plant health for signs or stress	General observations	Monitor for change	Irrigation area	Ongoing
	Laboratory biomass analysis of plant nutrients	mg/kg	Identify deficiencies	Irrigation area	If impacts observed
Surface Water monitoring	Faecal Coliform	cfu/100 mL	Monitor for general trends and change	Downstream in Dam 1 and Dam 2 and upstream at SW U/S.	Quarterly
	BOD	mg/L			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus & Plant available phosphours	mg/L as P			
	pH	pH units			
	Electrical Conductivity	dS/m			
Ground water monitoring	pH	pH units	Monitor for general trends and change	Downstream bores BH006 and BH009 and upstream bores BH004 and BH008.	Quarterly
	Cations	Mg/L			
	Faecal Coliform	cfu/100 mL			
	Electrical conductivity	dS/m			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus	mg/L as P			
	Plant available phosphorus	mg/L as P			
	Water level	m AHD			
Soil monitoring	Total hydraulic and nutrient load onto each irrigation area	kL/year and kg/year	Monitor for general trends and change.	Select irrigation zones that received the highest hydraulic load. Samples to be taken from top soil and sub soil layers.	Annual
	Electrical conductivity	dS/m			
	Available Phosphorus	mg/kg			
	Available Nitrogen	mg/kg			
	Available Potassium	mg/kg			
	Chloride	meq/100g			
	Exchangeable cations & CEC	meq/100g			
	Exchangeable Sodium %	%			
	Sodium adsorption ratio	Ratio			
	Total Organic Carbon	%			
	pH	pH units			

Type	Parameter	Units	Type	Location	Frequency
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/kg			
	Total Phosphorus	mg/kg			
	Phosphorus Sorption Capacity	mg/kg			
	Heavy metals	mg/kg			
	Pesticides	mg/kg			

- Irrigation areas and irrigation implementation are to incorporate the following:
  - Diversion drains as shown on drawing SW-56-C-SK50 along uphill slope to divert upslope stormwater around the irrigation areas;
  - Catch drain/swale as shown on drawing SW-56-C-SK50 along the downhill boundary of irrigation areas;
  - Exclusion fencing and signage as shown on drawing SW-56-C-SK50
  - Dense deep rooted grass vegetation will be established, e.g. kikuyu pasture;
  - Low application rate sprinklers are to be used;
  - No irrigation during rainfall when there is increased potential for run off;
  - Contour mounds to be constructed at intervals of approximately 30-50 metres;
  - 30 metre down gradient buffer to the property boundary.
  - Minimum 40m to down gradient property boundary in steeper north east corner of the irrigation area
  - 20m buffer to up gradient property boundary
  - No irrigation within the 40m wide future waterway corridor approved under MP10_0204
  - 70m minimum buffer to nearest residential dwelling
  - System and vegetation monitoring in accord with Section 9 of the Land Capability for Effluent Irrigation Report.

  These measures are to be incorporated in the Operational Environmental Management Plan for plant operation

9.1.6 Surface Water

- A Stormwater Management Plan for the Sewage Treatment Plant site is to be prepared in accord with Lake Macquarie Councils DCP No.1 Volume 2 Engineering Guidelines. No drainage from the Sewage Treatment Plant site is to be directed to the adjacent conservation lands. This plan is to document the sites connection to the stormwater management system approved under MP10_0204.
- No drainage from the Sewage Treatment Plant site is to be directed to the adjacent conservation lands as per project approval MP10_0204.
- A Sediment and Erosion Control plan is to be prepared.
- Wastewater reuse and recycling is maximised in the scheme through the supply of Class A+ recycled water to customers for toilet flushing, laundry and outdoor recycled water uses;
- Irrigation areas and irrigation implementation are to incorporate the following:
  - Diversion drains as shown on drawing SW-56-C-SK50 along uphill slope to divert upslope stormwater around the irrigation areas;
  - Catch drain/swale as shown on drawing SW-56-C-SK50 along the downhill boundary of irrigation areas;
  - Exclusion fencing and signage as shown on drawing SW-56-C-SK50
  - Dense deep rooted grass vegetation will be established, e.g. kikuyu pasture;
  - Low application rate sprinklers are to be used;

- No irrigation during rainfall when there is increased potential for run off;
- Contour mounds to be constructed at intervals of approximately 30-50 metres;
- 30 metre down gradient buffer to the property boundary.
- Minimum 40m to down gradient property boundary in steeper north east corner of the irrigation area
- 20m buffer to up gradient property boundary
- No irrigation within the 40m wide future waterway corridor approved under MP10_0204
- 70m minimum buffer to nearest residential dwelling
- System and vegetation monitoring in accord with Section 9 of the Land Capability for Effluent Irrigation Report.

These measures are to be incorporated in the Operational Environmental Management Plan for plant operation

- Environmental monitoring is to be undertaken in accord with the Integrated Water Management Plan under Appendix C and the table below.

Type	Parameter	Units	Type	Location	Frequency
Turf and vegetation health	Visual inspection of plant health for signs or stress	General observations	Monitor for change	Irrigation area	Ongoing
	Laboratory biomass analysis of plant nutrients	mg/kg	Identify deficiencies	Irrigation area	If impacts observed
Surface Water monitoring	Faecal Coliform	cfu/100 mL	Monitor for general trends and change	Downstream in Dam 1 and Dam 2 and upstream at SW U/S.	Quarterly
	BOD	mg/L			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus & Plant available phosphours	mg/L as P			
	pH	pH units			
	Electrical Conductivity	dS/m			
Ground water monitoring	pH	pH units	Monitor for general trends and change	Downstream bores BH006 and BH009 and upstream bores BH004 and BH008.	Quarterly
	Cations	Mg/L			
	Faecal Coliform	cfu/100 mL			
	Electrical conductivity	dS/m			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus	mg/L as P			
	Plant available phosphorus	mg/L as P			
	Water level	m AHD			
Soil monitoring	Total hydraulic and nutrient load onto each irrigation area	kL/year and kg/year	Monitor for general trends and change.	Select irrigation zones that received the highest hydraulic load. Samples to be taken from top soil and sub soil layers.	Annual
	Electrical conductivity	dS/m			
	Available Phosphorus	mg/kg			
	Available Nitrogen	mg/kg			
	Available Potassium	mg/kg			
	Chloride	meq/100g			
	Exchangeable cations & CEC	meq/100g			
	Exchangeable Sodium %	%			
	Sodium adsorption ratio	Ratio			

Type	Parameter	Units	Type	Location	Frequency
	Total Organic Carbon	%			
	pH	pH units			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/kg			
	Total Phosphorus	mg/kg			
	Phosphorus Sorption Capacity	mg/kg			
	Heavy metals	mg/kg			
	Pesticides	mg/kg			

- Free board and Level sensors are used on the Reverse Osmosis Reject Evaporation ponds to enable detection of breaks in the liner and to raise alarms before the ponds are full so the operator can take action by either turning off the Reverse Osmosis units or road tanker pump out can be arranged.

9.1.7 Flora & Fauna

- A Stormwater Management Plan for the Sewage Treatment Plant site is to be prepared in accord with Lake Macquarie Councils DCP No.1 Volume 2 Engineering Guidelines. No drainage from the Sewage Treatment Plant site is to be directed to the adjacent conservation lands. This plan is to document the sites connection to the stormwater management system approved under MP10_0204.
- No drainage from the Sewage Treatment Plant site is to be directed to the adjacent conservation lands as per project approval MP10_0204.
- All site earthworks and construction is to be carried out in accord with a sediment and erosion control plan.
- All clearing works approved under MP10_0204 must be completed in accord with the relevant approvals prior to works associated with the Sewage Treatment Plant commencing.
- The designated construction zone and boundary between the site and National Parks and Wildlife land is to be clearly marked via high visibility fencing, sediment fencing and/or signage identifying that no construction activities (including temporary storage, stockpiling, vehicle movement etc) are permitted beyond prior to commencement of any work.
- A Weed Management Plan is to be prepared for both the Sewage Treatment Plant site and Irrigation areas and included within the operational environmental management plan to ensure negative edge effects do not occur to adjoining national park lands.
- A detailed landscaping plan of the proposed irrigation area vegetation buffers including appropriate species selection is to be prepared.

9.1.8 Aboriginal Heritage

- Should any unexpected Aboriginal heritage items be found during works all works would cease immediately and the National Parks & Wildlife Service and the relevant Local Aboriginal Land Council would be notified. Procedures to address this issue are to be included within the Construction Environmental Management Plan for the proposal.
- The procedures outlined within the Aboriginal Heritage Management Plan approved under MP10_0204 must be implemented to relocate the isolated artifact found onsite prior to commencement of any works.

9.1.9 Visual Amenity

- Buffer planting as outlined within Landscape and Visual Impact Statement under Appendix D is to be implemented as part of Sewage Treatment Plant construction.
- The Sewage Treatment Plant building is to be clad in natural colours such as colorbond Pale

Eucalypt or similar.

9.1.10 Bushfire

- A fire hydrant is to be located at site entrance into the Sewage Treatment Plant to allow for connection to the reticulated water supply and sprinkler system is to be installed between the built structures and bushfire threat.
- A Bushfire Evacuation Plan is to be created and a copy of the plan is to be kept within the site office. This plan is to identify the most efficient evacuation route away from the western bushfire threat. This evacuation route is to be identified on a plan and erected near the exit of the site office. The plan must include procedures to inform employees and visitors to the site of the bushfire evacuation plan and its content.

9.1.11 Non Aboriginal Heritage

- The relevant approval under the Heritage Act 1977 for the works within the Cultural Heritage Precinct is to be obtained prior to any work commencing within the Cultural Heritage Precinct. Works within the Cultural Heritage Precinct is to be undertaken in accord with any conditions of this approval.

9.1.12 Waste

- A register will be maintained for all waste sampling and classification results for the life of the proposal in accordance with Environmental Protection Agency's Classification Guidelines; and
- Detailed procedures for waste handling including storage and disposal procedures are be established and included within the Operation Environmental Management Plan.

9.1.13 Environmental Management Plans

- Specific plans to manage the environmental impacts of construction and operation would be prepared as outlined within the Preliminary Infrastructure Operating Plan under Appendix N as part of the proposed Sewage Treatment Plant and Sewer Reticulation Network. The following plans would be prepared:

  - Construction Environmental Management Plan;
  - Operation Environmental Management Plan;
  - Emergency Response Plan;
  - Recycled Water Management Plan

9.1.14 Public Health

- A Recycled Water Management Plan and Drinking Water Quality Management Plan are to be prepared.
- Consultation is to be undertaken with NSW Health regarding the regulation, management and prevention of public health issues as part of the preparation of the Recycled Water Management Plan and Drinking Water Quality Management Plan.
- An information package is to be developed and provided to all residents of the subdivision and existing Catherine Hill Bay village identifying the following:

  - Home owner obligations relating to pressure sewer, water use, waste disposal, incident reporting and appropriate recycled water usage protocols
  - The location of effluent irrigation areas and instruction that people should not enter these areas
  - The risk associated with coming into contact with effluent; and
  - Measure to take should contact be made with effluent.

9.2 Environmental Monitoring and Reporting

- Operational and water quality will be monitored is to be in accord with the following tables and that required under Section 5.3 of the EPA Effluent Irrigation Guidelines.

Table - Membrane Bioreactor Effluent Quality and Operational Monitoring

Parameter	Units	MBR Effluent Quality Monitoring		Location
		Commissioning	Verification	
BOD	mg/L	Frequent monitoring during commissioning period to test the system under a variety of operating conditions.	Monthly	MBR permeate tank/wet weather storage
Suspended Solids	mg/L		Monthly	
Ammonia as N	mg/L as N		Monthly	
TKN as N	mg/L as N		Monthly	
Oxidised Nitrogen as N	mg/L as N		Monthly	
Total Nitrogen as N	mg/L as N		Monthly	
Total Phosphorus as P	mg/L as P		Monthly	
Faecal Coliforms	cfu/100 mL		Weekly	
Metals	Various	N/A	Annual	
Pesticides	Various	N/A	Annual	
Cations/Anions/SAR	Various	N/A	Annual	
All tank water levels	m	Continuous	Continuous	Online
All flows	L/s	Continuous	Continuous	
Dissolved Oxygen (CCP)	mg/L	Continuous	Continuous	
MLSS	mg/L	Continuous	Continuous	
Electrical Conductivity	dS/m	Continuous	Continuous	
pH	pH	Continuous	Continuous	
Transmembrane Pressure (CCP)	ΔkPa	Continuous	Continuous	
Permeate Turbidity (CCP)	NTU	Continuous	Continuous	
UV Intensity (CCP)	mJ/cm^2	Continuous	Continuous	
UVT% (CCP)	%	Continuous	Continuous	

Table - Advance Water Treatment Plant Validation and Verification Recycled Water Quality Monitoring

Pollutant	Units	Recycled Water Quality Monitoring		Location
		Validation	Verification	
Biochemical Oxygen Demand	mg/L	Frequent monitoring during commissioning period to test the system under a variety of operating conditions.	Monthly	Recycled Water Storage Tank
Suspended Solids	mg/L		Monthly	
Ammonia as N	mg/L as N		Monthly	
TKN as N	mg/L as N		Monthly	
Oxidised Nitrogen as N	mg/L as N		Monthly	
Total Nitrogen as N	mg/L as N		Monthly	
Total Phosphorus as P	mg/L as P		Monthly	
Faecal Coliforms	cfu/100 mL		Weekly	
Free Residual Chlorine	mg/L		Weekly	
Sodium absorption ratio	ratio		Annual	
Campylobacter (bacteria)	cfu/100 mL		Annual	

Pollutant	Units	Recycled Water Quality Monitoring		Location
		Validation	Verification	
Cryptosporidium (protozoa)	cfu/100 mL		Annual	
Adenovirus (virus)	pfu/100 mL		Annual	
Rotavirus (virus)	pfu/100 mL		Annual	
Electrical Conductivity (CCP)	dS/m	Continuous	Continuous	Online
UF Permeate Flow (CCP)	L/s	Continuous	Continuous	
UF Permeate Turbidity (CCP)	NTU	Continuous	Continuous	
UF Transmembrane Pressure (CCP)	∆kPa	Continuous	Continuous	
UF Direct Integrity Testing (CCP)	∆kPa/time	Continuous	Continuous	
UV Intensity (CCP)	mJ/cm^2	Continuous	Continuous	
UVT% (CCP)	%	Continuous	Continuous	
pH (CCP)	pH	Continuous	Continuous	
Free Residual Chlorine (CCP)	mg/L	Continuous	Continuous	

Table - Environmental Monitoring of Effluent Irrigation Scheme

Type	Parameter	Units	Type	Location	Frequency
Turf and vegetation health	Visual inspection of plant health for signs or stress	General observations	Monitor for change	Irrigation area	Ongoing
	Laboratory biomass analysis of plant nutrients	mg/kg	Identify deficiencies	Irrigation area	If impacts observed
Surface Water monitoring	Faecal Coliform	cfu/100 mL	Monitor for general trends and change	Downstream in Dam 1 and Dam 2 and upstream at SW U/S.	Quarterly
	BOD	mg/L			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus & Plant available phosphours	mg/L as P			
	pH	pH units			
	Electrical Conductivity	dS/m			
Ground water monitoring	pH	pH units	Monitor for general trends and change	Downstream bores BH006 and BH009 and upstream bores BH004 and BH008.	Quarterly
	Cations	Mg/L			
	Faecal Coliform	cfu/100 mL			
	Electrical conductivity	dS/m			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/L as N			
	Total Phosphorus	mg/L as P			
	Plant available phosphorus	mg/L as P			
	Water level	m AHD			
Soil monitoring	Total hydraulic and nutrient load onto each irrigation area	kL/year and kg/year	Monitor for general trends and change.	Select irrigation zones that received the highest hydraulic load. Samples to be taken from top soil and sub soil layers.	Annual
	Electrical conductivity	dS/m			
	Available Phosphorus	mg/kg			
	Available Nitrogen	mg/kg			
	Available Potassium	mg/kg			
	Chloride	meq/100g			

Type	Parameter	Units	Type	Location	Frequency
	Exchangeable cations & CEC	meq/100g			
	Exchangeable Sodium %	%			
	Sodium adsorption ratio	Ratio			
	Total Organic Carbon	%			
	pH	pH units			
	Total Nitrogen, nitrate, nitrite, TKN, Ammonia	mg/kg			
	Total Phosphorus	mg/kg			
	Phosphorus Sorption Capacity	mg/kg			
	Heavy metals	mg/kg			
	Pesticides	mg/kg			

- The monitoring methods, locations, frequency, criteria, reporting and responsibilities are to be determined during preparation of the Operation Environmental Plan and are to be consistent with any relevant licence conditions and with the Integrated Water Management Plan under Appendix C, the Land Capability Assessment for Effluent Irrigation under Appendix K and the preliminary Infrastructure Operating Plan under Appendix N.
- The NSW Office of water (now DPI Water) is to be consulted during preparation of the Operational Environmental Plan.
- Impact Trigger Levels for surface water, groundwater and soil chemistry and salinity, and groundwater levels are to be developed based on results of baseline monitoring program and procedures for responding to and reporting exceedances of these triggers values is to be specified in the Operational Management Plan or Recycled Water Management Plan.
- Consultation is to be undertaken with NSW Health regarding the regulation, management and prevention of public health issues as part of the preparation of the Recycled Water Management Plan and Drinking Water Quality Management Plan.

9.3 Licensing and approvals

Table 15 provides a summary of licensing and approval required prior to construction.

Table 15: Licensing and approvals required

Requirement	Timing
Road Occupancy License	A minimum of 10 days prior to the commencement of works (only required if public road will be occupied during construction)
Section 143 Notice under the Protection of the Environment Operations Act 1997	Prior to relocation spoil if spoil is created by earth works to form the Reverse Osmosis Reject Evaporation Ponds
Approval to alter or erect improvements within a mine subsidence district under Clause 15(2) of the Mines Subsidence Act 1961	Prior to any works onsite
Construction Certificate (or equivalent)	Prior to any works onsite
S138 Approval for works located within an existing road reserve	Prior to any works within the road reserve
Approval under Clause 57(1) of the Heritage Act 1977	Prior to the installation of any pressure sewer units and gravity connections on land within the Catherine Hill Bay Cultural Heritage Precinct.
Controlled Activity Approval under Water	Prior to installation of any component of the

Management Act 2000	irrigation system if it is located within 40m of a water way
WICA License	Concurrent with determination of review of environmental factors

10 – Conclusion

The proposed Sewage Treatment Plant and Sewer Reticulation Network do not require development consent and is subject to assessment under Part 5 of the Environmental Planning and Assessment Act 1979. The Review of Environmental Factors has examined and taken into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the proposal. This has included consideration of critical habitat, impacts on threatened species, populations and ecological communities and their habitats and other protected fauna and native plants.

A number of potential environmental impacts from the proposal have been avoided or reduced during the concept design development and options assessment. The proposal as described in the Review of Environmental Factors best meets the proposal objectives. Mitigation measures as detailed in this Review of Environmental Factors would ameliorate or minimise any expected impacts associated with the proposal. On balance the proposal is considered justified.

The environmental impacts of the proposal are not likely to be significant and therefore it is not necessary for an environmental impact statement to be prepared or approval to be sought for the proposal from the Minister for Planning under Part 5.1 of the Environmental Planning and Assessment Act. The proposal is unlikely to affect threatened species, populations or ecological communities or their habitats, within the meaning of the *Threatened Species Conservation Act 1995* or *Fisheries Management Act 1994* and therefore a Species Impact Statement is not required. The proposal is also unlikely to affect Commonwealth land or have an impact on any matters of national environmental significance.

The subject site is considered able to suitably accommodate the proposed Sewage Treatment Plant & Sewer Reticulation Network.

As such it is respectfully requested that the application be considered favourably and approved subject to reasonable and relevant conditions.

11 – Certification

This review of environmental factors provides a true and fair review of the proposal in relation to its potential effects on the environment. It addresses to the fullest extent possible all matters affecting or likely to affect the environment as a result of the proposal.

Lance Newley
Town Planner
Planit Consulting Pty Ltd
Date: 18/06/2015

I have examined this review of environmental factors and the certification by Lance Newley from Planit Consulting Pty Ltd and accept the review of environmental factors on behalf of Independent Pricing and Regulatory Tribunal.

Insert name
Position title, eg Project Manager
Date:

A – Sewage Treatment Plant Plans

B – Consideration of Clause 228(2) factors and matters of national environmental significance

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F – Odour Assessment

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G – Project Approval MP10_0204

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H – EPBC Act Referral Approval

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I – Reverse Osmosis Water Balance Report

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J – Bushfire Management Plan

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K – Land Capability Assessment for Effluent Irrigation

L – EPBC Act Protected Matters Report

M – Aboriginal Cultural Heritage Management Plan MP10_0204

N – Preliminary Infrastructure Operating Plan

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O – Construction Noise Management Plan

P – Legal Advices

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Q – Reticulation & Irrigation Area Plans

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R – Inspection and Test Plan

NSW EPA

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- 7 JUL 2016
BY: ....

DOC16/318114, File No. SF16/24842

ADW Johnson Pty Limited
7/335 Hillsborough Road
WARNERS BAY NSW 2282

Attention: Mr Ian McNicol

Dear Mr McNicol

COASTAL HAMLETS PTY LTD
SURPLUS RECYCLING WATER DISPOSAL OPTIONS

I refer to discussions with ADW Johnson and the Environment Protection Authority (EPA) on 9 June 2016 regarding potential surplus effluent disposal options identified in the document titled *"Surplus Recycling Water Disposal Options Catherine Hill Bay"*, dated June 2016, prepared by ADW Johnson ("scoping report").

The EPA understands the sewage treatment system serving the Catherine Hill Bay Subdivision is to be constructed, maintained and operated by Solo Water Pty Ltd. I also note that final effluent quality achieved at the Catherine Hill Bay Subdivision will meet domestic reuse quality standards and it is expected that surplus treated effluent generated will be disposed of off-site.

Nine options for disposal of surplus treated effluent have been identified. The preferred option identified in the scoping report is Option 6, being discharge to stormwater, via a series of bio-retention basins. The bioretention basins discharge to the intermittently closed and open lagoon which flows to ocean via an open drainage channel on the southern end of Catherine Hill Bay Beach. Option 8, discharge to Catherine Hill Bay Creek, and Option 4, discharge via ocean outfall, were the second and third ranked options respectively.

The EPA supports further consideration of the top three ranked options but encourages ADW Johnson to consider maintaining an area of irrigation in community title, integrated into the scheme, or, providing a range of contingencies for on-site storage of surplus water. The EPA's preference is nil discharge to the environment, however the EPA will consider offsite disposal, provided it is demonstrated that all other feasible and reasonable options have been considered.

For the EPA to consider discharge to waters, the following must be included within the environmental assessment, but may not be limited to:

- Consideration of factors listed in section 45 of the *Protection of the Environment Operations Act 1997*.
- Consideration of the NSW Water Quality Objectives and environmental values of the area;
- Documentation of the expected surplus treated effluent quality to be discharged to the environment;
- An assessment of the practical measures that will be taken to avoid discharge to waters;
- An explanation of the wastewater treatment process, wastewater recycling reticulation network and options for disposal of surplus treated water, including the benefits and costs of each;

- Details of how the reverse osmosis waste is to be disposed of lawfully, including the likely volumes generated;
- If surplus treated effluent has been chlorinated following reverse osmosis for reticulation within the subdivision, detail how the water will be de-chlorinated before it is discharged to waters;
- The predicted volumes of surplus water to be discharged must be modelled in the range of hydrological conditions including worst case scenarios;
- Provision of mixing model results based on a range of volumes of recycled water, mixing with stormwater and/or receiving waters during a range of hydrological conditions to demonstrate mixing and identify the distance from discharge point at which ambient conditions are met;
- Assessment of the impact of hydrological changes on the intermittently closed and open lagoon and beach including potential impacts of coastal erosion, coastal recession and entrance instability and migration;
- Detail the ongoing maintenance arrangements and management of the discharge of surplus treated effluent; and
- Provide management and mitigation measures to reduce or prevent environmental impacts, particularly in relation to changes in hydrology and water quality.

If you require any further information regarding this matter please contact myself on (02) 4908 6830.

Yours sincerely

REBECCA SCRIVENER
A/Head Regional Operations Unit - Hunter
Environment Protection Authority

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Planning

Working Beyond Expectations

Hydrology and Pollutant Assessment of Offsite Disposal of Wetland-Treated Recycled Water

Beaches Subdivision

Property:
Lot 100, 101 & 106 DP 1129872, Lot 1 DP 141989, Lot 1 DP 1129299,
Lot 103 DP 1194707, Lot 101 and 102 DP 1194707, Lot 213 DP 883941,
Lot 1 Section 1 DP 168, Lot 1 Section K DP 163,
Flowers Drive road reserve, Montefiore Street road reserve
85 & 95 Flowers Drive, 6 Keene Street & 12 Montefiore Street,
Catherine Hill Bay

Applicant:
Solo Water Pty. Limited

Date:
August 2017

Document Control Sheet

Issue No.	Amendment	Date	Prepared By	Checked By
A	Draft	3.07.2017	AK	IM
B	Final	15.08.2017	AK	IM

Executive Summary

The *Beaches* subdivision at Catherine Hill Bay is approved for 550 residential lots across seven stages. The Catherine Hill Bay Water Utility Pty. Limited (CHBWU) will own all water, wastewater and recycled water infrastructure. CHBWU and Solo Water Pty. Limited will hold the IPART Network Operators Licences and all design, construction, operation and maintenance activities will be subcontracted to Solo Water. Solo Water will also be the IPART Retail Licence holder.

Under the current WICA licence, Stages 6 and 7 of the *Beaches* subdivision is to provide an onsite irrigation area for disposal of excess recycled water. The current WICA licence was granted on the provision that the irrigation area could be removed if direct disposal of excess recycled water to the environment could be justified. Assessment of the modification is required because local hydrology will be affected. Specifically, the impact of recycled water releases on surface flows from the subdivision requires assessment. Under the current *Beaches* subdivision planning approval, household rain water tanks are employed as part of the stormwater management concept. Under the proposed WICA licence requirements, rain water tanks will no longer be permitted as they would reduce household demand for recycled water. Removal of rainwater tanks will alter stormwater flows, and therefore also requires assessment.

This report details changes to downstream hydrology and pollutant loading expected because of the non-permissibility of household rain water tanks, and the proposed recycled water release strategy. The focus area is the 188 ha Study Area catchment and the assessment period spans the consecutive 35 years from 1974 to 2008. Appropriate historical climate data for modelling purposes are available during this period, and a suitable range of annual rainfall totals are represented.

The CHBWU Sewage Treatment Plant (STP) will treat a mean household wastewater generation rate of 272.25 kL/day from an estimated 3 persons per household, or 1,650 persons in total. The plant will produce recycled water to *Fire Fighting* standard – the most stringent recycled water quality standard as per *National guidelines for water recycling: managing health and environmental risks*.

Household recycled water demand was estimated in accordance with the Sydney Water edition of the Water Services Association of Australia Code. A daily timestep model was used to determine a household demand time series (1974-2008) based on climate data and pasture crop factors. The adopted baseline, mean, and peak household recycled water demands were 110.0 kL/day, 192.5 kL/day, and 605.0 kL/day, respectively. Annual mean demand will not be sufficient to reuse all recycled water, and quantities of *surplus-to-demand recycled water* will be produced during periods of low household irrigation demand. This study adopted a mean *surplus-to-demand recycled water* production rate of 100 kL/day, and a peak of 162.3 kL/day. The mean production rate is considered conservative and likely to be overestimated by >20%.

A four-cell subsurface flow wetland system with basal area of 3,300 m^2 is proposed to polish *surplus-to-demand recycled water* to produce *wetland-treated recycled water*. The wetland cells will be located at the footprint of the previously approved reverse osmosis reject ponds, and construction will incorporate an underlying impervious liner. A daily wetland water balance model was developed to generate an outflow time series of *wetland-treated recycled water* for 1974 to 2008. The mean outflow was estimated to be 93.0 kL/day (34.0 ML/yr), which represents a 7% decrease compared to wetland inflow (i.e. evapotranspiration losses exceed incident rainfall inputs). Intra-annual wetland outflow oscillates in response to seasonal climatic influences, with the minimum mean outflow of 34.6 kL/day occurring during January, and the maximum of 147.8 kL/day occurring during June.

The MUSIC model (Model for Urban Stormwater Improvement Conceptualisation) was used to determine stormwater changes caused by exclusion of household rain water tanks at Stages 6 and 7. The modelling period was 1974 to 2008. The removal of rainwater tanks has a predicted impact of increasing mean daily stormwater flow by 18% from 202 to 238 kL/day (or 73.7 to 86.8 ML/yr). At downstream Mixing Point A, surface water flow is increased an estimated 11% from 326 to 362 kL/day (or 119.2 to 132.2 ML/yr). At the Study Area lagoon outlet, surface water flow is increased an estimated 3% from 1,270 to 1,310 kL/day (or 465 to 478 ML/yr).

'Wet' releases of *wetland-treated recycled water* will be discharged in conjunction with surface water flow via an underground pipeline to the outlet of Stages 6 and 7. A release model was developed to pair 'wet' releases with MUSIC-estimated surface water flow rates. Based on the ecological assessment finding of Marine Pollution Research (2017), which determined the waterway immediately downstream of Stages 6 and 7 does not provide aquatic habitat, a 1:1 'wet' release to surface water flow ratio was applied at the location of downstream Mixing Point A. When a 'wet' release is not possible, and onsite storage of *wetland-treated recycled water* is near capacity (98%), a 'dry' release (nominal 1 ML 'pulse' volume) will be enacted via an underground pipeline to the Lindsley Street road culvert.

To minimise impacts to the downstream surface water flow regime, a recycled water management strategy preference is to minimise 'dry' releases, such that discharges occur primarily in conjunction with surface water flows. The primary control mechanism is onsite *wetland-treated recycled water* storage capacity. Using an iterative procedure, tank capacity was increased in the release model from 2 ML up to 5 ML to achieve what is considered a satisfactory scenario, whereby mean annual 'dry' releases are 0.7 ML/yr, and account for only 2% of the 33.5 ML/yr of *wetland-treated recycled water* releases (note a mean 0.5 ML/yr of *wetland-treated recycled water* releases are discounted due to missing data in the MUSIC pluviograph record). A total of 23 of the 35 years experienced zero 'dry' releases, the peak 'wet' release of 39.5 ML/yr occurred during both 1976 and 1999, and the peak 'dry' release of 4 ML/yr occurred during 2004.

Proposed changes to surface water flow at Mixing Point A and the Study Area lagoon outlet are the result of *wetland-treated recycled water* releases and rain water tank exclusion at Stage 6 and 7. Using MUSIC surface water flow estimates and the *wetland-treated recycled water* release model, mean annual surface water flow at Mixing Point A is estimated to increase 38% to 165.0 ML/yr. At the Study Area outlet lagoon, the increase is 10% to 511.5 ML/yr, of which 7% consists of 'wet' releases, 3% is due to rain water tank removal, and the remaining ~0.1%. consists of 'dry' releases.

Pollutants in *wetland-treated recycled water* considered to be of concern include:

- Total nitrogen (TN);
- Total phosphorus (TP);
- Total suspended solids (TSS);
- Faecal coliforms (FC);
- Total dissolved solids (TDS);
- Biochemical oxygen demand (BOD); and
- Free chlorine (Cl).

Solo Water have advised that free Cl will vary between 0.2-2.0 mg/L [Brad Irwin, pers. comm. 6 July 2016]. Free Cl will be off-gassed and utilised in the oxidation of organic material in the front end of the subsurface flow wetland (Whitehead and Associates 2017), and therefore poses no threat to downstream aquatic invertebrates.

The Advanced Water Treatment Plant within the STP will reduce concentrations of faecal coliforms to two-orders-magnitude below the primary contact Water Quality Objective for the Lake Macquarie and Tuggerah Lakes catchment.

The estimated BOD concentration in wetland outflow is a factor-of-three lower than the freshwater stressor guideline value for the protection of aquaculture species in *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

Offsite pollutant discharge estimates associated with 'wet' and 'dry' release volumes of *wetland-treated recycled water* were derived from 50th-percentile MBR permeate pollutant concentrations of TN and TP, 95th-percentile MBR permeate pollutant concentration of TSS, and a subsurface flow wetland inflow rate equivalent to the monthly peak inflow (June). Surface water pollutant concentrations emanating from Study Area land surfaces were derived by MUSIC, with loads calculated using MUSIC flow rate estimates. A conservative TDS concentration of 200 mg/L was adopted for stormwater and baseflow based on monitoring by Marine Pollution Research (2017), which showed TDS ranged between 100-300 mg/L in upland creeks with the Study Area. Baseline and *proposed* development pollutant load estimates at the Study Area outlet are tabulated below, in conjunction with pollutant load change estimates caused by the *proposed* development.

Parameter	Units	Development Scenario		% Change
		Approved	*Proposed*	
Flow	ML/day	1.27	1.40	10
	ML/yr	465.0	511.5	
TN	mg/L	1.22	1.38	13
	kg/yr	566	704	24
TP	mg/L	0.13	0.132	2
	kg/yr	61.0	67.6	12
TSS	mg/L	51.3	47.9	-7
	kg/yr	23,900	24,500	3
TDS	mg/L	200	252	26
	kg/yr	93,000	129,000	39

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Figure 13 – Monthly time series of stormwater discharge at Stages 6 and 7 outlet for approved and proposed development scenarios during (A) 1974 to 1991 and (B) 1992 to 2008. Data are presented as columns. MUSIC stormwater estimates for the approved development scenario (with rainwater tanks) are the top of the green columns, MUSIC stormwater estimates for the proposed development scenario (no rainwater tanks) are the top of the red column sections, and stormwater generated by the proposed development scenario with including 'wet' releases of wetland-treated recycled water are the top of the yellow column sections.

Figure 14 – Monthly time series of stormwater discharge at Mixing Point A for approved and proposed development scenarios during (A) 1974 to 1991 and (B) 1992 to 2008. Data are presented as columns. MUSIC stormwater estimates for the approved development scenario (with rainwater tanks) are the top of the green columns, MUSIC stormwater estimates for the proposed development scenario (no rainwater tanks) are the top of the red column sections, and stormwater generated by the proposed development scenario with including 'wet' releases of wetland-treated recycled water are the top of the yellow column sections. (For data plotting purposes the x-axis is capped at 120,000 kL/month - the February 1990 discharge exceeds 184,000 kL/month)

Figure 15 – Monthly time series of stormwater discharge at Flowers Drive culvert crossing of the unnamed creek lagoon for approved and proposed development scenarios during (A) 1974 to 1991 and (B) 1992 to 2008. Data are presented as columns. MUSIC stormwater estimates for the approved development scenario (with rainwater tanks) are the top of the green columns, MUSIC stormwater estimates for the proposed development scenario (no rainwater tanks) are the top of the red column sections, and stormwater generated by the proposed development scenario with including 'wet' and 'dry' releases of wetland-treated recycled water are the top of the yellow column sections. (For data plotting purposes, the x-axis is capped at 500,000 kL/month - the February 1990 total exceeds 820,000 kL/month).

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Table 15 – Subsurface flow wetland pollutant inlet concentrations adopted for assessment
Table 16 – Subsurface flow wetland pollutant outlet concentrations based on inlet flow rates (Whitehead and Associates 2017)
Table 17 – Mean surface water flow pollutant concentrations and loads at Stages 6 and 7 outlet prior to mixing with 'wet' releases of wetland-treated recycled water.
Table 18 – Mean surface water flow pollutant concentrations and loads at Stages 6 and 7 outlet after mixing with 'wet' releases of wetland-treated recycled water.
Table 19 – Mean surface water flow pollutant concentrations and loads at Mixing Point A.
Table 20 – Mean surface water flow pollutant concentrations and loads at the Flowers Drive culvert crossing of the unnamed creek lagoon.

1.0 Introduction

Rose Property Group Pty. Limited is constructing the *Beaches* residential subdivision at Catherine Hill Bay. The current approval is for construction of 550 residential lots, roads and associated parks and open space.

All water, wastewater and recycled water infrastructure under the scheme will be owned by the newly created entity Catherine Hill Bay Water Utility Pty. Limited (CHBWU). CHBWU and Solo Water Pty. Limited (Solo Water) will hold the IPART Network Operators Licences and all design, construction, operation and maintenance activities will be subcontracted to Solo Water. Solo Water will also be the IPART Retail Licence holder.

A Sewage Treatment Plant (STP) will be constructed to treat sewage and produce recycled water for reuse by all households at the development. The development's Integrated Water Management Plan (Solo Water, July 2015) identified *surplus-to-demand recycled water* during periods of low household irrigation demand. The existing licence for the development requires that this excess quantity of recycled water be disposed of via on-site irrigation at Stages 6 and 7. Rose Property Group instead wishes to develop Stages 6 and 7 of the residential subdivision. Accordingly, ADW Johnson (ADWJ) is preparing a submission to IPART on behalf of Solo Water for treatment of *excess recycled water* in a subsurface flow wetland, and for discharge of *wetland-treated recycled water* to the downstream environment. It is proposed to enact 'wet' releases in conjunction with surface water flows emanating from an area consisting of Stages 6 and 7 of the urban subdivision and a portion of natural downstream catchment. Due to the intermittent nature of surface water flow, limited 'dry' release volumes are also proposed directly into the coastal creek lagoon.

It is understood that IPART will seek a review of the submission by the NSW Environment Protection Authority (NSW EPA), which has indicated the requirement for assessments of water quantity and quality impacts at the downstream receiving environment (see correspondence in **Appendix A**).

This report details modelling undertaken to estimate the changes to water quantity and quality expected to result from releases of *wetland-treated recycled water* to the downstream environment.

2.0 Background

2.1 STUDY AREA

Catherine Hill Bay comprises two beaches split by a rock platform near a disused jetty (**Figure 1**). The beach north of the jetty is Middle Camp Beach. It is backed by two coastal valleys which drain to respective coastal lagoons. The 'Study Area' catchment is the 188 ha southern-most valley. The *Beaches* development straddles the southern ridgeline, with approved Stages 3, 6 and 7 draining to Middle Camp Beach. The catchment also contains the Catherine Hill Bay village.

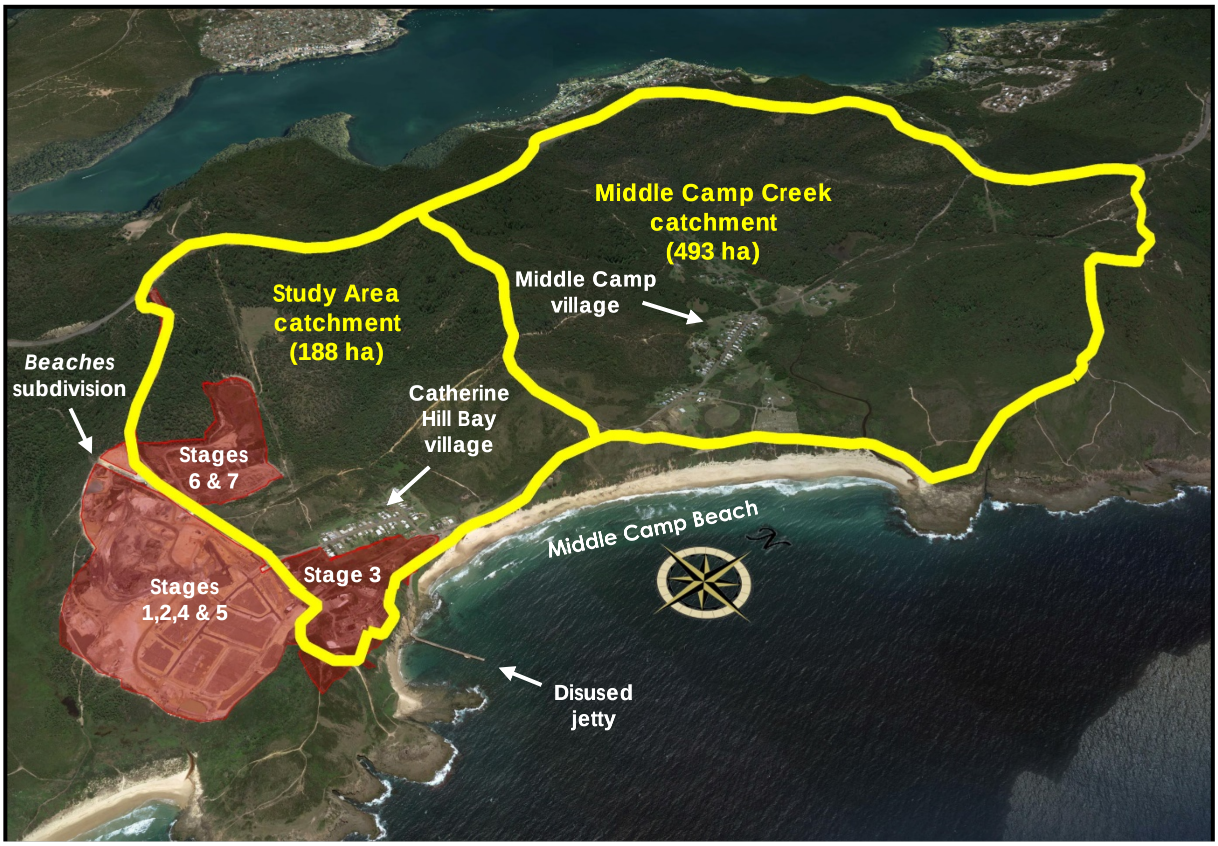

Figure 1 – Catchments draining to Middle Camp Beach and location of *Beaches* subdivision development stages.

Study Area vegetation is described in detail by Marine Pollution Research (2017). Most of the area consists of undeveloped forest. Swampy woodland dominates the lower catchment area. Stages 3, 6 and 7 are approved on cleared and rehabilitated Moonee Colliery lands. These areas have experienced substantial landform modification by earthworks, and are currently mostly grassed.

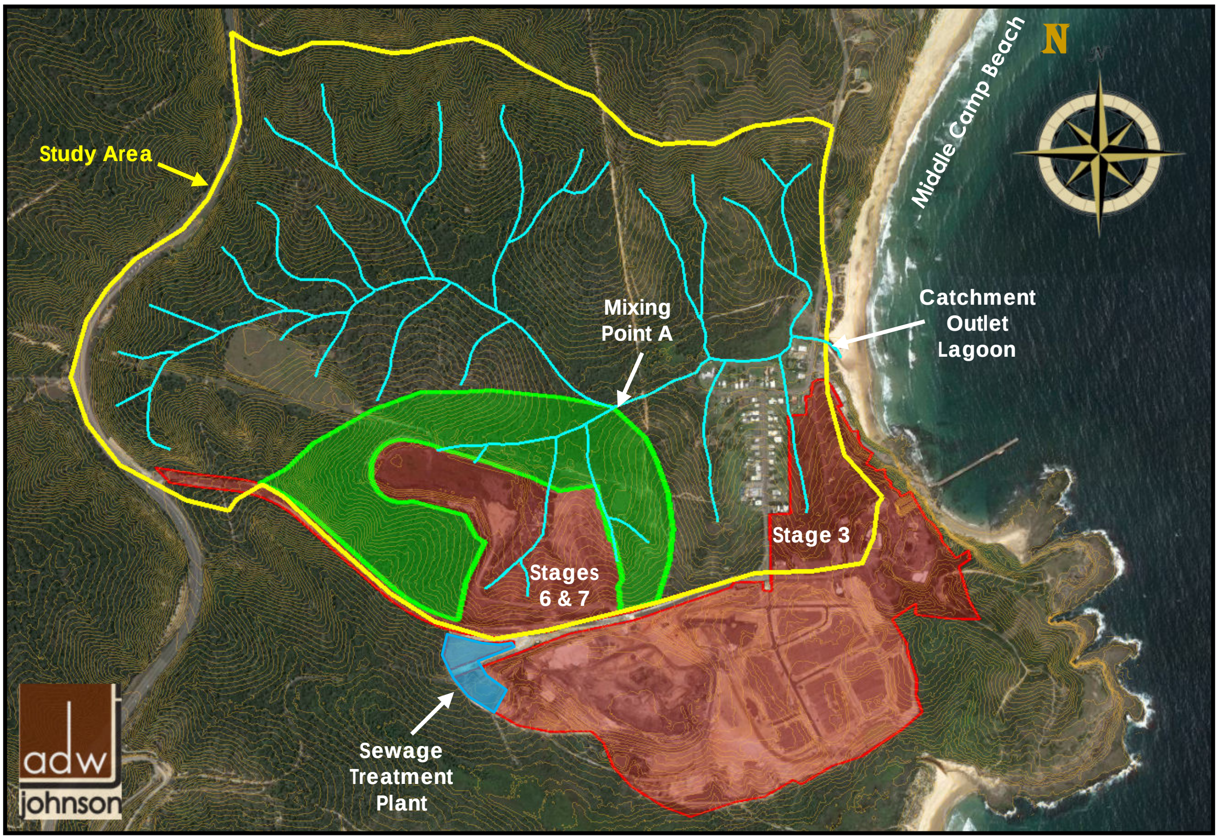

Figure 2 – Study Area catchment waterways, sub-catchment to Mixing Point A and location of lagoon at outlet.

2.2 CLIMATE

The Study Area experiences a temperate climate, characterised by a defined summer-autumn-winter-spring pattern. Key climate statistics are shown in **Figure 3** for Williamtown RAAF AWS (BoM Station 061078). Annually, mean rainfall depth is 1,127 mm (1942-2017) and mean evaporation depth is 1,753 mm (Class A evaporation pan; 1974-2017). During January to June, mean monthly rainfall is 113 mm and remains relatively consistent. A pronounced decline in mean monthly rainfall to 74 mm occurs during July to December, and again mean rainfall is relatively consistent through this period. Temperatures peak in summer, and are lowest in winter. As would be expected, mean monthly evaporation rates follow the intra-annual temperature variation.

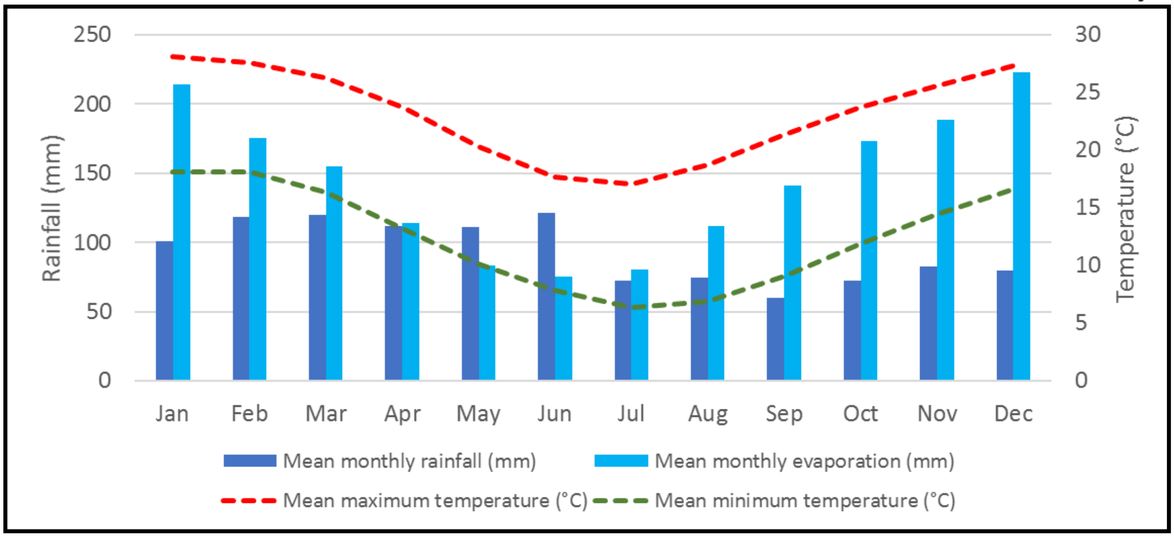

Figure 3 – Monthly rainfall, evaporation and temperature means for Williamtown RAAF AWS (Bureau of Meteorology 2017).

2.3 LOCAL HYDROLOGY

A literature search was undertaken to establish existing hydrological understanding of coastal catchments within the locality. In a comprehensive study of NSW coastal catchments, Littleboy *et al.* (2009) used measurements from 78 stream gauging stations within 37 coastal catchments to infer hydrological response at 163 ungauged coastal catchments. The ungauged Middle Camp Gully catchment (**Figure 1**) was included in this study, and flow data estimates were obtained from the NSW Office of Environment and Heritage (OEH 2016) as monthly runoff and baseflow totals for the period 1975 to 2007. Mean annual surface flow was estimated to be 657 ML/yr, which exceeded by a factor of 3.4 the mean annual baseflow of 192 ML/yr. On an areal basis, the combined surface runoff and baseflow entering the coastal creek (i.e. streamflow) was estimated to be 1.72ML/ha/yr.

The spatial distribution of land surface slope within the coastal catchments is shown in **Figure 4**. Slope analysis determined the Study Area to have an average slope of 17.3% compared to 16.9% for the adjacent Middle Camp Gully catchment. Ignoring the Moonee Colliery lands which have been levelled by earthworks, the Study Area average slope would be closer to 18%. The maximum overland flow path length for the narrower Study Area is less than half that of the larger and broader Middle Camp Gully catchment.

The two catchments have similar sized residential areas (~8 ha). The Middle Camp village is sited on low slopes (0-5%) and is more than 1.0 km from the catchment outlet. The Catherine Hill Bay village is primarily sited within the Study Area on steep slopes (up to 20%), and in close proximity to the catchment outlet.

Based on physical differences between the adjacent catchments, the following hydrological observations are made:

- The shallower land surface slopes and longer flow paths of the Middle Camp Gully catchment would be expected to result in higher infiltration rates of incident rainfall, leading to a potentially higher baseflow fraction, and greater potential for deep drainage losses to regional groundwater. The net result would be a lowering of per unit area rates of streamflow generation; and

- Based on proximity to catchment outlet and the higher land surface slope, the residential land use in the Study Area would be expected to deliver a larger fraction of runoff to the catchment outlet.

Compared to the Middle Camp Gully catchment, the Study Area would be expected to exhibit a higher surface runoff to baseflow ratio, and to produce higher streamflow per unit area.

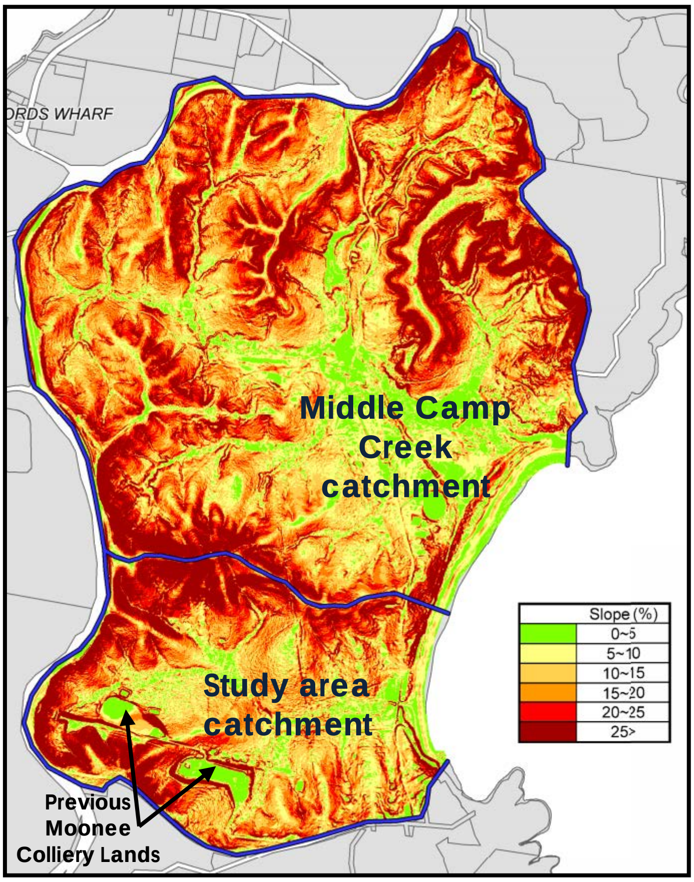

Figure 4 – Land surface slope of the adjacent catchments draining to Middle Camp Beach.

2.3.1 Study Area Waterways & Lagoon Outlet

Drainage from the Study Area is directed to an unnamed coastal creek and small brackish lagoon which discharges flow via a culvert under Flowers Drive at a location near the south end of Middle Camp Beach. The elevation of the culvert invert is 1.25 mAHD. BMT-WBM (2017) determined the sand berm at the lagoon outlet developed and eroded in an intermittent manner through time. When the sand berm is lower than 1.25 mAHD, the entrance is open and stormwater flows directly to the ocean. When the entrance is partly shoaled, a small beach-side lagoon is formed upstream of the low berm, and stormwater flows directly to the ocean whenever the lagoon water level exceeds the height of the low berm. When the entrance is heavily shoaled, or completely closed by beach sand (dune formation), the creek water body acts as a reservoir with water levels responding to stormwater, direct rainfall, evaporation, baseflow and groundwater flow through the sand dune.

The key factors controlling groundwater flow through the sand berm are (i) width of lagoon at the berm, and (ii) head difference between the respective water levels of the lagoon and ocean. Based on a berm consisting of 'medium' sand, relationships between the key factors have been developed using Darcy's Law[1] to estimate groundwater flow from lagoon to ocean (**Figure 5**) [L. Kidd, BMT-WBM, personal communication, August 2016]. Head difference is indicative of the expected range of berm height versus the mean ocean tide water level of 0.0 mAHD. The maximum berm height is estimated to be 2.25 mAHD. If the lagoon water level was at maximum berm height, the culvert invert would be submerged to a depth of 1.0 m. During a prolonged dry period, the lagoon water level has been anecdotally known to fall below the culvert invert, disconnecting the upper lagoon from the beach lagoon. Depending on the scoured depth of sand at the beach lagoon, the retained water level may fall as low 0.5 mAHD.

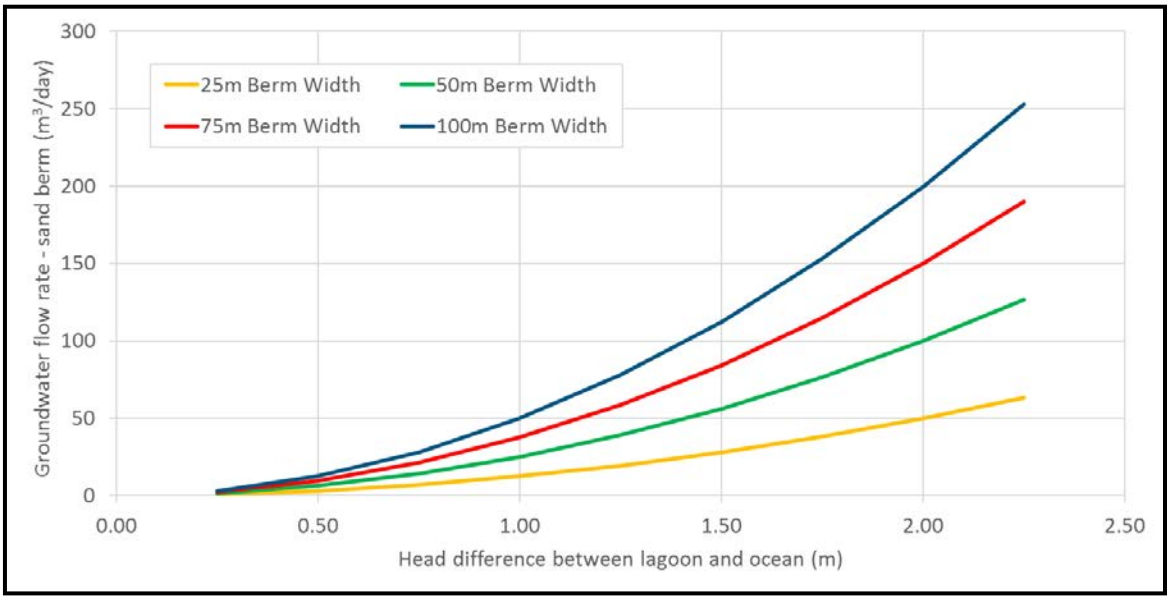

Figure 5 – Estimated relationships between lagoon conditions (water level and beach berm width) and groundwater flow rate to ocean for varying berm widths.

[1] Q = KiA,

where: Q = flow rate (m^3/s)
K = hydraulic conductivity (m/s)
i = hydraulic gradient (m/m)
A = flow cross sectional area (m^2)

Assumptions: Beach berm sediments comprise medium grained well-sorted sands (You *et al.* 2014)
K of well sorted sand is between 10^{-3} cm/s and 10^{-1} cm/s (Fetter 2001)

3.0 Site Water Management Strategy

The approved STP will be managed by CHBWU. The Advance Water Treatment Plant (AWTP) process component will treat all wastewater generated by the *Beaches* subdivision to recycled water of *Fire Fighting* standard – the most stringent recycled water quality standard as per *National guidelines for water recycling: managing health and environmental risks* (Biotext 2006). This class of recycled water is suitable for "ingestion water and sprays", and is proposed for all non-potable household uses (see **Section 6.5**). It will be mandatory for all households in Stages 1 to 7 to connect to the recycled water reticulation system.

When household demand for recycled water falls below the production rate, *surplus-to-demand recycled water* will be generated. This water will be prepared for offsite release by treatment via a constructed subsurface flow wetland at the STP site. The subsurface flow wetland will produce *wetland-treated recycled water*, which will be temporarily stored onsite prior to offsite discharge.

Concept plans of the STP infrastructure, *wetland-treated recycled water* discharge pipelines and discharge outlets are provided in ADW Johnson (2017). Extracts of these plans are shown in this report for reference.

The concept layout of the STP site, access road and subsurface flow wetland arrangement are provided in **Figure 6**.

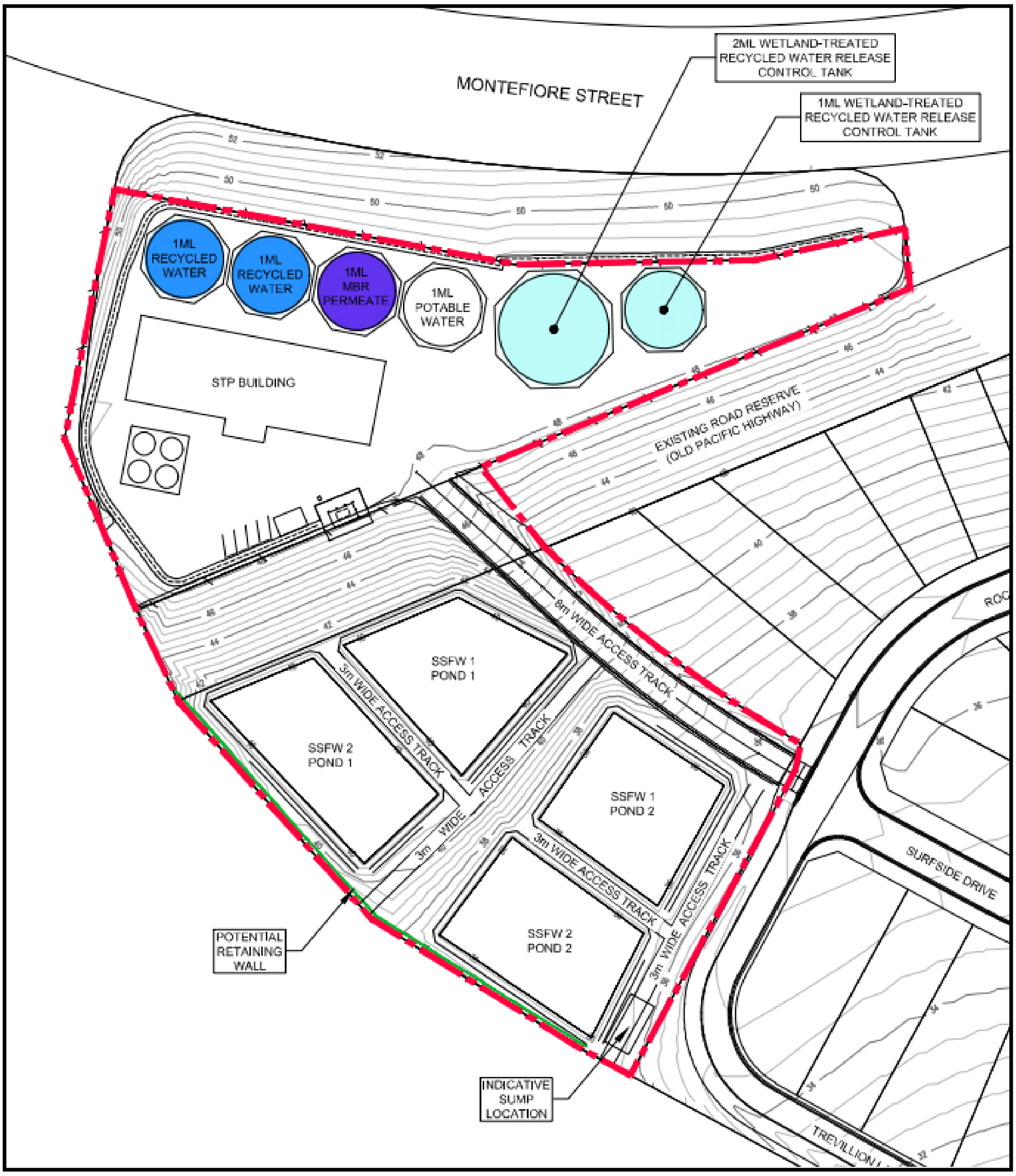

Figure 6 – CHBWU STP and subsurface flow wetland pond arrangement.

Two licensed discharge points are proposed:

- 'Wet' releases via a proposed underground pipeline to an outlet location adjacent to the stormwater outlet for Stages 6 and 7; and
- 'Dry' releases via a proposed underground pipeline to an outlet location at the Lindsley Street culvert crossing of an unnamed waterway, which drains to the coastal creek lagoon at the south end of Middle Camp Beach.

A 'wet' release of *wetland-treated recycled water* will occur simultaneously with surface water flow generated by rainfall and baseflow. A 'dry' release of *wetland-treated recycled water* will be required when 'wet' releases are insufficient to maintain on-site tank storage drawdown under a nominal critical threshold level. In this study, the adopted level is 98%, or conversely 2% remaining capacity.

The proposed pipeline routes to the 'wet' and 'dry' release locations are shown in **Figure 7**. Both discharge points will be designed with suitable flow energy dissipators. Concept head wall designs are shown in **Figure 8.**

Figure 7 – Proposed pipeline routes to the *wetland-treated recycled water* 'wet' release location adjacent to the stormwater outlet of Stages 6 and 7, and the *wetland-treated recycled water* 'dry' release location at Lindsley Street.

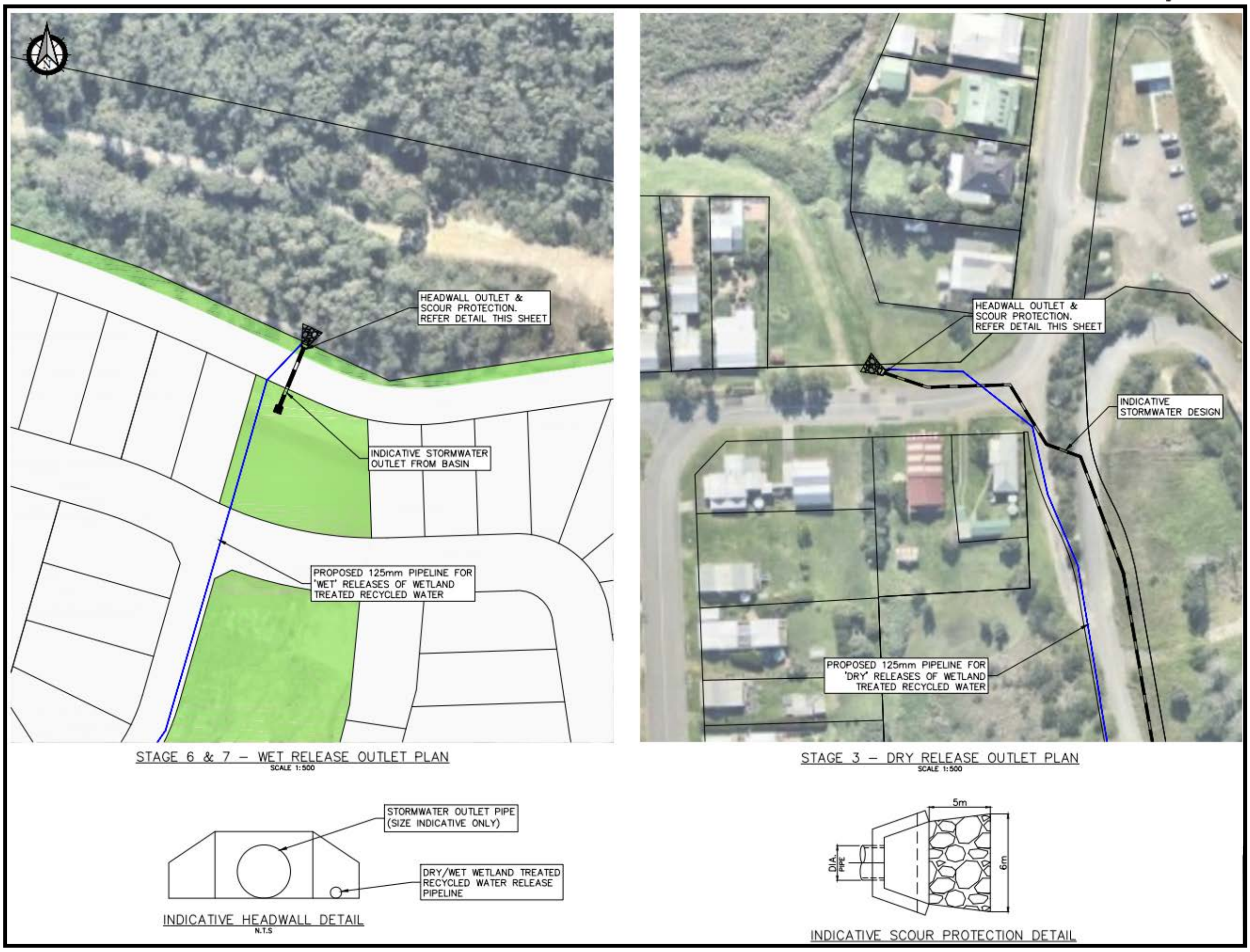

Figure 8 – Concept headwall designs for the *wetland-treated recycled water* 'wet' release location adjacent to the stormwater outlet of Stages 6 and 7, and the *wetland-treated recycled water* 'dry' release location at Lindsley Street.

4.0 Catchment Development Overview

The *baseline* Study Area development scenario includes:

- The existing 8.0 ha Catherine Hill Bay village;
- Previously *approved* 22.8 ha urban development of Stages 3, 6 and 7; and
- The 157.2 ha undeveloped and primarily vegetated catchment.

The Stage 3 development (7.6 ha) is approved without household rainwater tanks (to generate household demand for recycled water), and Stages 6 and 7 (15.2 ha) are currently approved with rainwater tanks.

The *proposed* development differs in that rainwater tanks are no longer permitted in Stages 6 and 7. The amendment will impact stormwater generation rates which will increase in direct response to the proposed removal of household rainwater tanks. The release of *wetland-treated recycled water* will also directly increase streamflow rates to the downstream environment.

Rainwater tank removal will alter the pollutant load of stormwater emanating from Stages 6 and 7. The introduction of *wetland-treated recycled water* releases will also create an additional pollutant load.

5.0 Climate Data Availability & Period of Assessment

The period of assessment used in this study was governed by (i) the availability of climate data and (ii) the requirement to assess development impacts across a range of historical climate extremes.

The development's impacts on water quantity and quality are determined through water resource simulation models which target the following:

- Stormwater generation;
- Wetland water balance;
- Recycled water demand; and
- Site water discharge (both stormwater and recycled water).

Climate variables are key inputs to each of the water models. The most important climate variable is rainfall. Importantly, the required temporal scale of rainfall detail varies depending upon the modelled hydrological process.

Due to the mechanics of infiltration and its influence on stormwater generation from incident rainfall, a sub-daily temporal scale of rainfall intensity is required for generation of an accurate stormwater generation time series. In this study, the process of recycled water release is directly related to stormwater generation and subsequently also requires equivalent temporal rainfall detail.

Processes which are key to wetland water balance and recycled water demand models remain well-defined at temporal scales exceeding that of a daily period. Daily rainfall data are therefore more than adequate for parameterisation of such models.

5.1 PLUVIOGRAPH RAINFALL DATA

Sub-daily rainfall intensity data are captured at 6-minute intervals by an automatic recording pluviograph at contemporary Australian meteorological stations. The length of record and quality of data vary between pluviograph stations. Missing pluviograph data are typically the result of equipment failure and human error. Data omissions reduce the amount of recorded rainfall, and subsequently reduce apparent mean annual rainfall depth.

A series of missing pluviograph data records can alternatively be in-filled with a mean rainfall rate when a separate manual record exists. This is performed by dividing the known rainfall depth evenly across the missing data period. This approach suffers from the loss of temporal rainfall intensity, but conserves rainfall depth for the period.

The Bureau of Meteorology (BoM) Williamtown RAAF AWS (station no. 061078) is located 44 km NNE of the study area and less than 5 km from the coast. The data record is likely to incorporate similar coastal influences experienced at Catherine Hill Bay, and was subsequently selected for use in this current study. Data at this site are available from the eWater Toolkit database (eWater 2016). Data were accessed November 2016, and at that time the period of data availability was 31/12/1952 to 31/5/2010. Following a data quality assessment, it was established this period includes 4.9% missing data and an additional 4.7% 'averaged' data (generated by in-filling based on average rain gauge totals).

It is noted that Lake Macquarie City Council's MUSIC-link utilises Cooranbong pluviograph data for the period 1999 to 2008 for stormwater assessments within the local government area. This period is considered insufficient in length to capture a comprehensive range of wet and dry climatic conditions. An attempt was made to source a longer period of data for the Cooranbong site, but the location has not been included in the eWater Toolkit database.

Based on the availability of data at the Williamtown RAAF AWS, the 35 consecutive years from 1/1/1974 to 31/12/2008 were adopted for use in this current study. It would have been preferable to extend the period to 2010, but an apparent error at the Williamtown RAAF AWS recording station resulted in significant data loss during the 2009 calendar year. As a result, the continuous study period was terminated at the end 2008. The selected period is considered to contain a suitably wide range of annual rainfall depth totals as shown in **Figure 9.**

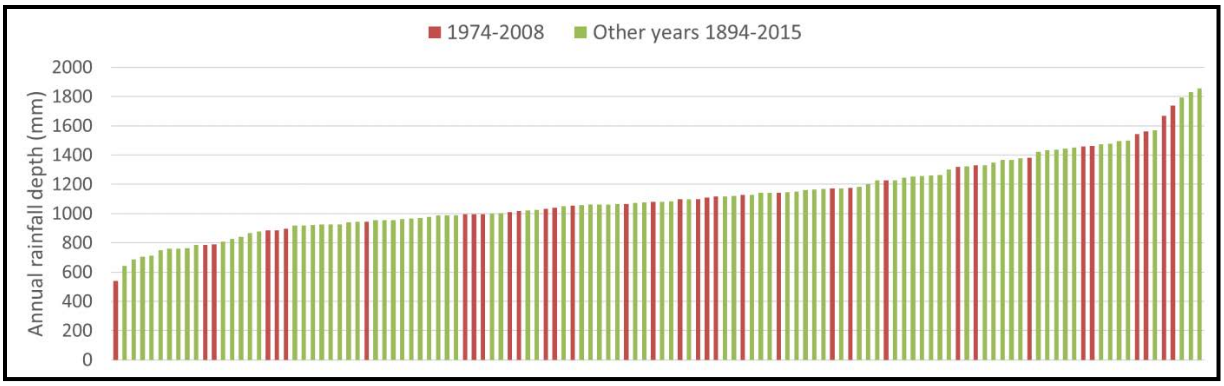

Figure 9 – Ranked annual rainfall depths for years within the 1974-2008 period of assessment and other years within the 1894-2015 Williamtown RAAF AWS SILO database climate record.

Missing 6-minute pluviograph data observations total 1.5% during 1974 to 2008, which compares favourably to the 4.9% missing data across the full 1952-2010 record. Calendar days missing all 240 observations total 1.3%, days missing at least 50% of observations (>120) total 1.5%, and days missing at least one observation total 1.7%. All findings of this study are provided with acknowledgment that the pluviograph record does not include rainfall which may have fallen during timesteps with missing data. An impact of the missing data is a lower mean annual pluviograph-based rainfall depth of 1,107 mm/yr for 1974 to 2008. This represents a 2.5% reduction compared to the BoM Williamtown RAAF AWS mean annual rainfall depth of 1,135 mm/yr[2] for the same period.

Pluviograph data consisting of in-filled average values (by substitution of manual rainfall observations) total 6.0% of the record. This is marginally above the 4.7% frequency which exists for the full 1952-2010 data record. Rainfall depth is conserved for these data, but the temporal distribution is not.

[2] The Williamtown RAAF AWS mean annual rainfall depth has been determined from SILO patched point techniques as discussed in Section 5.2.

5.2 DAILY RAINFALL DATA

BoM daily rainfall data at the Williamtown RAAF AWS is also affected by the missing pluviograph data records. To gain a continuous daily record for wetland water balance and recycled water demand models, patched point SILO climate data (QLD DSITI 2017) were obtained for Williamtown RAAF AWS. SILO is an enhanced climate database which constructs a temporally complete climate dataset from raw observations provided by BoM.

6.0 Wastewater Generation & Recycled Water Supply

6.1 EQUIVALENT POPULATION

The CHBWU scheme is designed to service the approved *Beaches* subdivision at Catherine Hill Bay. The subdivision approval is for 550 equivalent tenements (ET). Solo Water advised a suitable long-term occupancy of 3 equivalent population (EP) per ET, which equates to 1,650 EP.

6.2 WASTEWATER MINIMISATION

Wastewater generation in the CHBWU Scheme will be minimised through implementation of wastewater minimisation measures (Solo Water 2015). The wastewater minimisation measures will be mandatory for all lots in the scheme and will be controlled through agreements/contracts with each resident. The wastewater minimisation strategy for the CHBWU Scheme will include:

- Water efficient fixtures and appliances as per the NSW Building Sustainability Index (BASIX) (NSW Government, 2014);
- New customer contracts and access agreements that outline the responsibilities of the resident with regard to appropriate water usage and waste management practices;
- Connection to the recycled water network is a requirement for all connections to the sewerage network;
- Ongoing awareness and communication with existing customers through additional information provided at each billing cycle and the CHBWU website;
- Welded polyethylene pressure sewer system to minimise infiltration; and
- Continuous monitoring of pressure sewer pump starts and hours run to detect infiltration, high water use and/or inappropriate waste disposal practices, i.e. swimming pools backwash etc.

The water efficiency and demand management requirements will be audited during plumbing inspection.

6.3 WASTEWATER & RECYCLED WATER GENERATION

Wastewater generation for the proposed development was estimated to be 150 L/EP/day in accordance with WSAA (2002). A nominal volumetric allowance of 10% has been made for inflow and infiltration to the pressure sewerage system. This is a conservative allowance given the scheme uses a water tight welded polyethylene sewerage system. The 1,650 EP for the fully developed subdivision generates 272.25 kL/day (**Table 1**).

Solo Water has advised that approximately 2% of wastewater would be lost to waste sludge during treatment. This loss is not captured in this assessment as a further conservative measure. Hence the fully developed subdivision wastewater generation rate of 272.25 kL/day is assumed to also be the recycled water generation rate.

Table 1 – Recycled water volumes for proposed 550 ET development with a 272.25 kL/day wastewater generation rate

Parameter	Units	'Wet Day'	Mean	'Dry Day'
Baseline Recycled Water Demand	kL/day	110.0	110.0	110.0
Weather-based Recycled Water Demand		0	82.5	495.0
Total Recycled Water Demand		110.0	192.5	605.0
Surplus-to-demand Recycled Water		162.3	90.2	0 (-326.7*)
Conservative Surplus-to-demand Recycled Water		162.3	100.0	0

*Negative indicates a shortfall in recycled water availability which will be met by potable supply

It is noted the treatment of recycled water will be to *Fire Fighting* standard in accordance with Biotext (2006). This standard requires the most stringent log reduction of viruses, bacteria and protozoa for priority uses of recycled water from treated wastewater, and is suitable for human ingestion of up to 20 mL on 50 occasions per year.

6.4 MODELLED SURPLUS-TO-DEMAND RECYCLED WATER QUALITY

Stage 1 of the STP process includes a membrane bioreactor (MBR) with a capacity to treat all incoming wastewater. The MBR is a modified activated sludge process which has been designed by Solo Water as described in ADW Johnson (2017). Stage 2 of the STP process is an AWTP that produces recycled water for supply to household customers.

To facilitate the assessment of potential offsite water quality change impacts, the predicted 50th/95th-percentiles and maxima of environmental water quality pollutants of concern in MBR permeate (Solo Water 2015) have been adopted for investigation. The pollutants of concern include:

- Total nitrogen (TN);
- Total phosphorus (TP);
- Total suspended solids (TSS);
- Faecal coliforms (FC);
- Total dissolved solids (TDS); and
- Biochemical oxygen demand (BOD).

The data shown in **Table 2** have been provided to Whitehead and Associates (2017) (**Appendix B**) to assess the performance of the subsurface flow wetland.

Table 2 – Recycled water quality based on expected MBR effluent pollutant concentrations (Solo Water 2015)

Parameter	TN	TP	TSS	FC	TDS	BOD
Units	mg/L	mg/L	mg/L	cfu/100 mL	mg/L	mg/L
50th-Percentile	10	0.3	--	--	600	--
95th-Percentile	--	--	5	10*	--	10
Maximum	20	2	10	100*	1,000	20

-- no data available
* MBR effluent FC concentrations are used as wetland input to demonstrate the wetland's effectiveness at FC removal. In practice, the STP's AWTP process will reduce FC to <1 cfu/100ml, and the wetland will instead receive recycled water of this quality.

6.5 RECYCLED WATER DEMAND

Recycled water will be utilised by households for all appropriate non-potable uses including:

- Toilet flushing;
- Laundry washing machine cold water (hard plumbed);
- Outdoor cleaning & wash down, including bin and car washing; and
- Irrigation of household lots and footpaths.

The Sydney Water Version of the WSAA Code (WSAA 2012) recommends an estimated household recycled water demand of 350 L/ET/day per property (assumes all laundry washing by recycled cold water). This equates to an estimated mean recycled water demand of 192.5 kL/day for the proposed 550 ET development (**Table 1**).

A breakdown of the *baseline recycled water demand* estimate of 110 kL/day (**Table 1**) is provided in **Table 3**. A nominal baseline irrigation rate of 6.7 L/EP/day is assumed to account for human and automatic sprinkler irrigation undertaken without regard of actual climate-driven lawn and garden water requirements. The *baseline recycled water demand* represents a rainfall day scenario, whereby rainfall depth is sufficient to *not* warrant any additional *climate-based irrigation demand* by households for use on lots and footpaths.

Table 3 – Baseline recycled water demand estimate

End use	Toilet flushing	Laundry	Outdoor uses	Irrigation	Total
L/EP/day	25	25	10	6.7	**66.7**
EP/ET	3				-
ET	550				-
kL/day	41.25	41.25	16.5	11.0	**110**

A maximum demand (or 'dry' day) scenario is assumed to occur when evapotranspiration is high and local rainfall is absent. WSAA (2012) estimate that *climate-based irrigation demand* increases by a multiple of 6.5 times under such circumstances. As a conservative approach, a multiple of 6.0 is adopted here, resulting in a peak *climate-based irrigation demand* of 495 kL/day (**Table 1**). Accounting for the *baseline recycled water demand*, the combined peak recycled water demand is estimated at 605 kL/day.

6.5.1 Daily Recycled Water Demand Model

Referencing the minimum and maximum recycled water demand estimates in **Table 1**, a conceptual model was developed to generate a daily time series of household recycled water demand. A continuous climate record consisting of BoM daily rainfall totals was employed, along with daily SILO daily pan evaporation.

The model assumes a fixed *baseline recycled water demand* of 110 kL/day, and allows *climate-based irrigation demand* to vary up to a maximum of 495 kL/day. In acknowledgment of the role of significant rainfall events on household irrigation habits, *climate-based irrigation demand* was set to zero when the 2-day rainfall depth total exceeded ~10 mm.

On climate-based irrigation days, irrigation demand was estimated as the daily evapotranspiration rate experienced by a typical grass species. Evapotranspiration rates were estimated by the product of daily pan evaporation and a monthly crop factor (shown in **Table 4** for pasture). The crop factors were sourced from *Environmental guidelines: use of effluent by irrigation* (NSW DEC 2004 – Table 4.1). Evapotranspiration rates range from 2.2 to 13.4 mm/day. Days with peak evapotranspiration were assigned the estimated peak irrigation demand rate of 495 kL/day. All other non-zero irrigation demand days were assigned an irrigation demand rate on a pro rata basis using the daily evapotranspiration rate.

Table 4 – Pasture crop factors by month

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Crop Factor#	0.70	0.70	0.70	0.60	0.50	0.45	0.40	0.45	0.55	0.65	0.70	0.70

Source: NSW DEC 2004 – Table 4.1
#Crop factors are expressed as the ratio of crop evapotranspiration to pan evaporation.

The modelled mean daily household recycled water demand is 82.5 kL/day and the peak is 192.5 kL/day. These key model statistics match the WSAA (2012) referenced estimates provided in **Table 1**. A time series of model estimates of daily recycled water demand is shown in **Figure 10**, and monthly means and percent of days with zero *climate-based irrigation demand* are provided in **Table 5**. The cyclical nature of recycled water demand is evident. Summer months are associated with high recycled water demands as the model varies climate-based irrigation in response to higher evapotranspiration rates during hotter periods. In contrast, during June, recycled water demand is approximately 50% lower than the summer peak in December. A contributing factor to the demand differential is the higher fraction of days with zero *weather-based irrigation demand* (defined by the model as two consecutive days with more than ~10 mm rainfall).

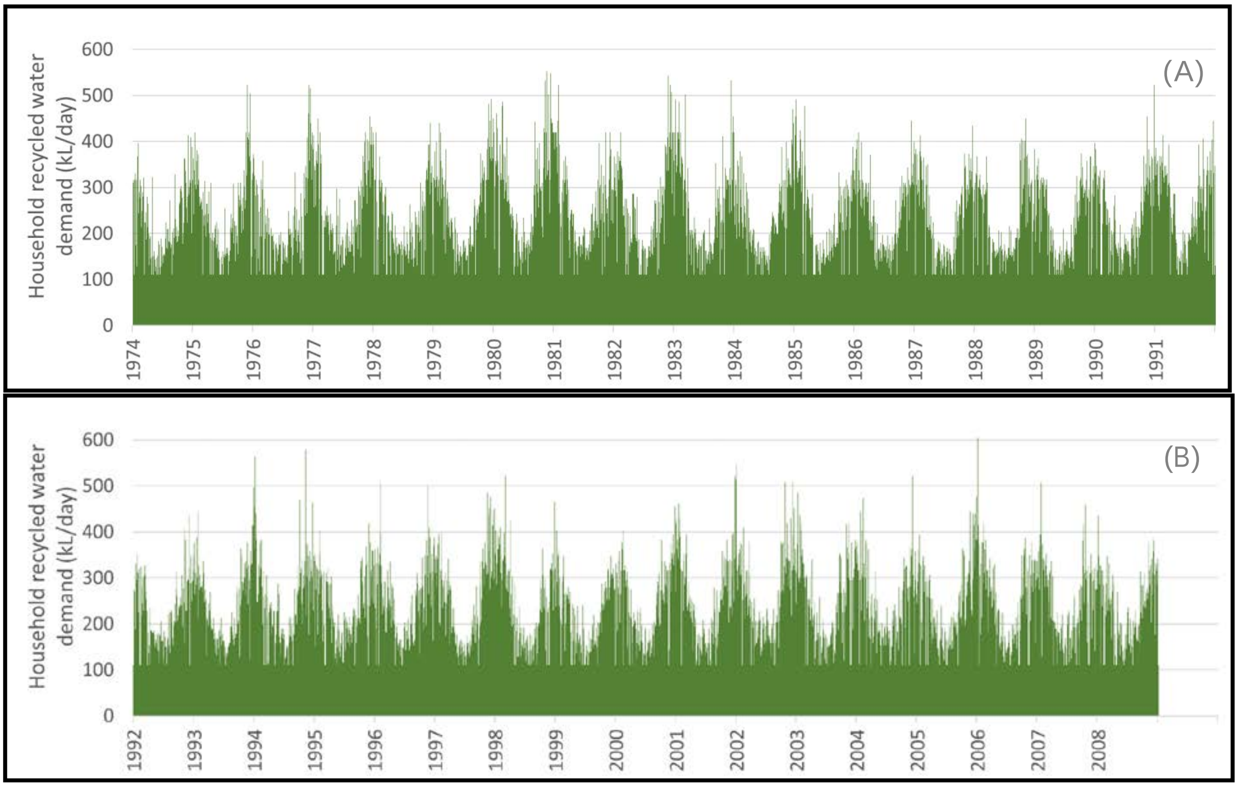

Figure 10 – Household daily recycled water demand time series for (A) 1974 to 1991 and (B) 1992 to 2008.

Table 5 – Mean monthly household recycled water demand and percent of days with zero weather-based irrigation demand for the period 1974 to 2008

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean recycled water demand (ML/month)	7.7	6.5	6.1	5.1	4.4	4.1	4.3	4.9	5.5	6.6	7.0	8.1
% days zero weather-based irrigation demand	22	27	29	30	35	34	29	22	23	22	26	21

6.5.2 Model of daily surplus-to-demand recycled water

In practice, the STP will have 2.0 ML of tank storage to manage recycled water reticulation to households. The storage capacity will act to balance demand for recycled water against its production, allowing for water use optimisation. When recycled water demand exceeds the production rate, stored recycled water will be drawn from tank storage. When demand falls below the production rate, tank storage increases until capacity is reached, after which *surplus-to-demand recycled water* is released to the subsurface flow wetland.

As a conservative measure, it was decided to ignore the beneficial recycled water reticulation option offered by the 2.0 ML of tank storage. Instead, the model directs all recycled water from the STP to the subsurface flow wetland. This approach will lead to overestimation of the onsite recycled water storage requirement.

Using a daily timestep model, *surplus-to-demand recycled water* was determined for the period 1974 to 2008. The daily mean was calculated to be 90.2 kL/day, and the maximum of 162.3 kL/day occurs on rainfall days when only *baseline recycled water demand* exists (see **Table 1**). Monthly *surplus-to-demand recycled water* estimates are shown in **Figure 11.** Annual fluctuations are evident in response to seasonal climatic influences. During periods of relatively low rainfall, higher levels of household irrigation reduce the generation of *surplus-to-demand recycled water*.

To add a further level of conservatism, the mean daily *surplus-to-demand recycled water* generation rate was increased by ~10% to 100 kL/day. This approach accounts for uncertainty in actual recycled water usage rates by households. To affect this change within the model, a nominal minimum demand of 25 kL/day was introduced, and daily demands >25 kL/day were increased on a weighted-scale. In keeping with the wastewater production rate of 272.3 kL/day and the baseline recycled water demand of 110 kL/day, scaled *surplus-to-demand recycled water* generation rates were capped at the daily maximum of 162.3 kL/day. Monthly scaled *surplus-to-demand recycled water* estimates are shown in **Figure 11**, and daily means by month are shown in **Table 6**.

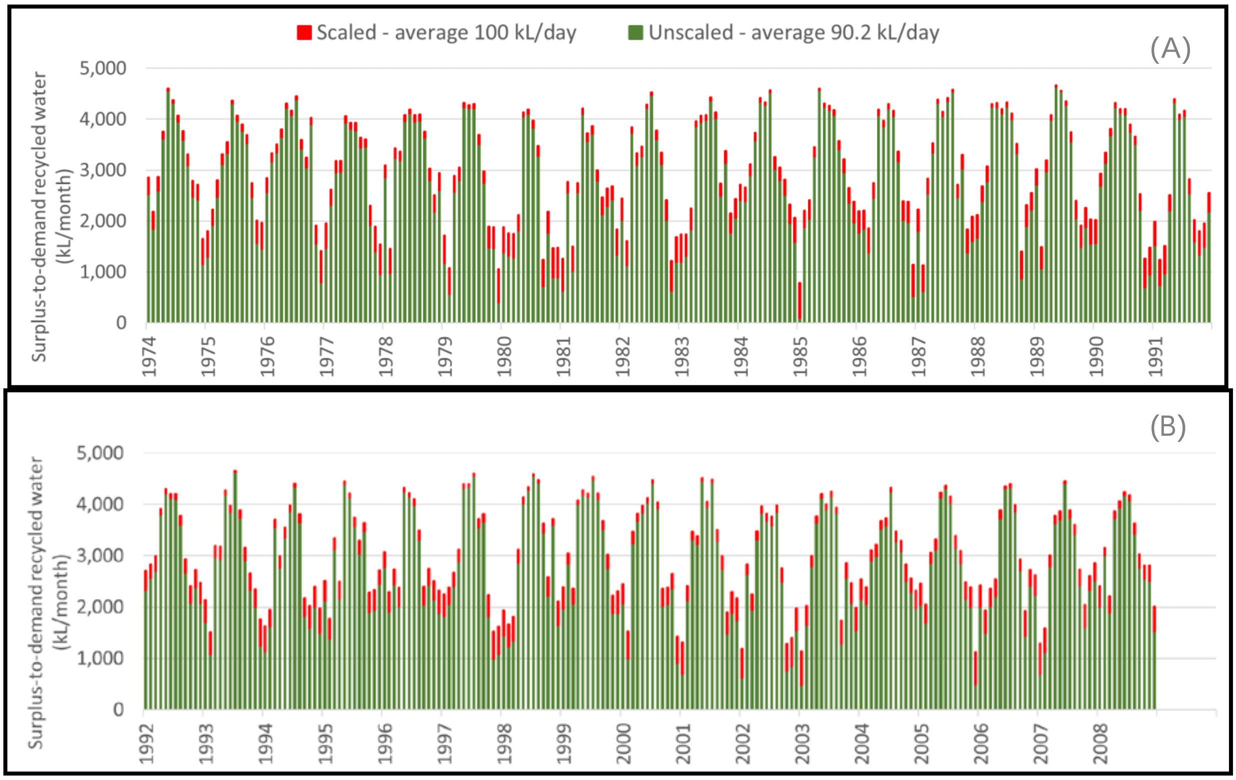

Figure 11 – Column chart of monthly time series of *surplus-to-demand recycled water* for (A) 1974 to 1991 and (B) 1992 to 2008. A 26% crop factor reduction was used to scale demand up 23% from 81.6 to 100 kL/day.

Table 6 – Monthly distribution of daily mean *surplus-to-demand recycled water* generation rate estimates.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Unscaled (90.2 kL/day mean)	53.0	61.7	80.1	104.0	130.3	135.3	133.3	115.4	90.5	68.0	61.3	48.4
Scaled (100 kL/day mean)	68.6	75.4	90.3	111.6	134.7	139.1	137.3	121.6	100.0	80.3	75.3	64.5

7.0 Water Balance for Subsurface Flow Wetland

7.1 WATER BALANCE MODEL

A subsurface flow wetland water balance by Whitehead and Associates (2017) has been adapted to a daily time step to generate a time series of wetland outflows, which will ultimately govern the management of offsite discharges.

The water balance model has been applied to a constructed subsurface flow wetland design (see **Figure 6**) which has a footprint wholly within the southern portion of Lot 1120 DP 1219395. This is the location of Reverse Osmosis Reject Ponds 01 and 02 under the currently approved STP concept design. The combined basal area of the four proposed subsurface flow wetland ponds is 3,300 m^2, which at a depth of 0.6 m equates to a volumetric capacity of 1,980 m^3. With a void fraction is 0.35 (conversely, gravel and plant fraction is 0.65), the working capacity is 693 m^3.

The water balance inputs are *surplus-to-demand recycled water* and rainfall incident on the subsurface flow wetland surface and adjacent batter slopes (a batter area of 510 m^2 was adopted in the model). Outputs are evapotranspiration and *wetland-treated recycled water* overflows from the downstream end of the subsurface flow wetland. The wetland will be constructed with an impermeable liner. No losses by seepage are considered by the model.

Wetland vegetation species will require a period of establishment using potable water supply. It is assumed at model commencement that wetland storage volume is 50% of capacity.

Normal subsurface flow wetland operation will also require supplementary potable water inflows during extended 'dry' periods to prevent wetland vegetation stress. It is assumed additional input flows would be directly offset by evapotranspiration losses, and hence they are not considered by the model.

Climate data (rainfall and evaporation) were sourced from the SILO patch point module for the location of the Williamtown RAAF AWS recording station (QLD DSITI 2016).

Crop factors of wetland vegetation species are shown in **Table 7** and have been estimated or referenced from literature (see Whitehead and Associates 2017 in **Appendix B**).

Table 7 – Monthly crop factors of wetland vegetation species (see Whitehead and Associates 2017)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2.1	1.6	1.1	0.7	0.8	0.7	0.7	0.7	0.7	0.7	1.1	1.5

7.2 OVERFLOW OF WETLAND-TREATED RECYCLED WATER

The mean *wetland-treated recycled water* overflow for the modelling period was estimated be 93.0 kL/day (34.0 ML/yr). In comparison to the 100.0 kL/day mean inflow of *surplus-to-demand recycled water*, the model predicts an average 7.0% reduction in flow through the wetland environment (ie. evapotranspiration losses exceed rainfall inputs).

A time series of *wetland-treated recycled water* overflows is shown in **Figure 12**. Discharge spikes are common during autumn through to spring in response to high daily rainfall totals. The combination of high evapotranspiration rates and low *surplus-to-demand recycled water* inflows in warmer months are evidenced by the annual cycle of no-overflow periods, which occur when subsurface flow wetland storage capacity is below the maximum.

The mean monthly *wetland-treated recycled water* overflow rates are shown in **Table 8**. Mean monthly inflow (**Table 6**) exceeds outflow for the period August to March as evapotranspiration rates surpass rainfall input. The converse occurs during the colder months of April to July, when evapotranspiration rates decline but rainfall means remain at >100 mm/month (see **Figure 3**).

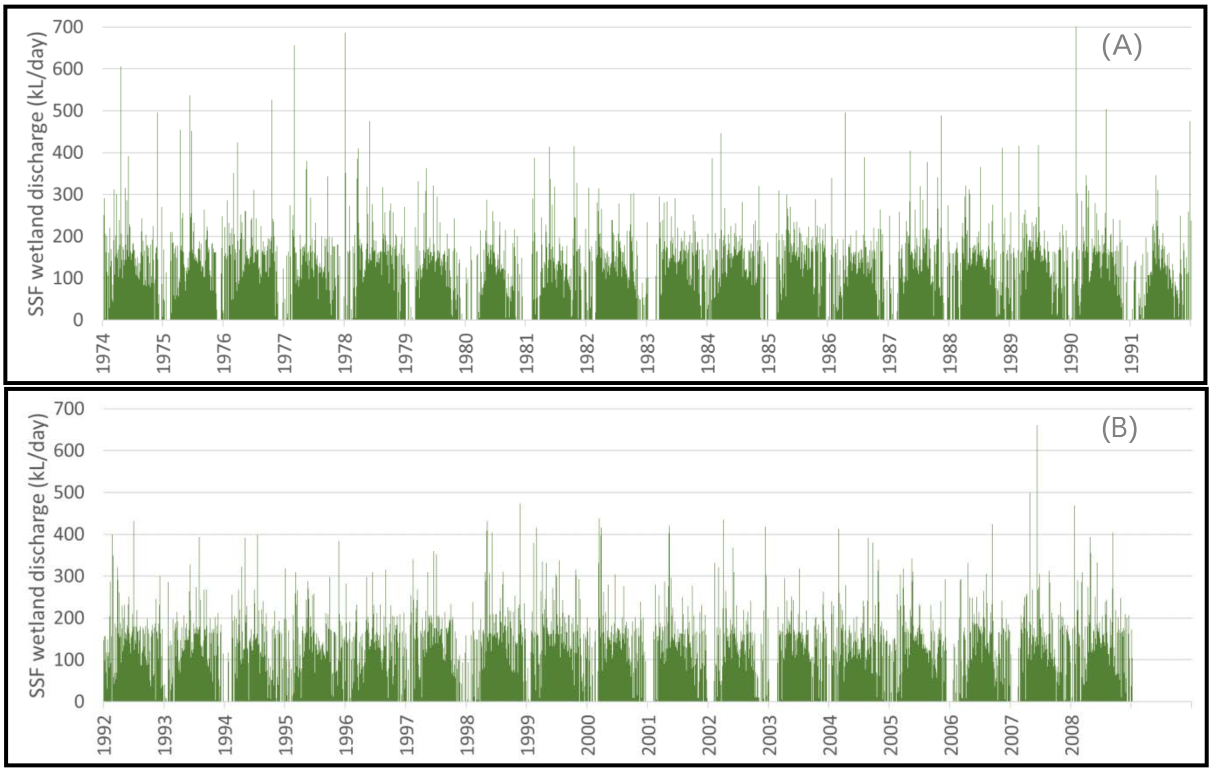

Figure 12 – Subsurface flow wetland discharges for (A) 1974 to 1991 and (B) 1992 to 2008. The mean discharge rate is 93.0 kL/day. (For data plotting purposes, the x-axis is capped at 700 kL/day. The maximum daily discharge is 1,088 kL/day.)

Table 8 – Mean daily discharge rates by month of *wetland-treated recycled water* from the subsurface flow wetland

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean daily discharge (kL/day)	34.6	52.9	86.7	116.3	141.3	147.8	139.9	120.8	96.6	75.4	62.7	38.7

8.0 Stormwater Discharge & Recycled Water Release Estimates

8.1 ASSESSMENT OVERVIEW OF ONSITE WATER MANAGEMENT STRATEGY

To enable assessment of changes to surface water flows resulting from the *proposed* development, the catchments draining to the following three key locations were selected for estimation of discharge rates:

- Outlet of Stages 6 and 7 – 15.2 ha;
- Mixing Point A (see **Figure 2**) – 40.5 ha; and
- Flowers Drive culvert crossing of the unnamed creek lagoon – 188 ha (entire Study Area).

This assessment considers baseline flows as those generated by the *approved* development scenario, which consists of Stages 6 and 7 urban development, at which households are permitted rainwater tanks. The comparative scenario is the *proposed* development, which does not permit household rainwater tanks, and also introduces disposal of *wetland-treated recycled water* to the downstream environment.

Wetland-treated recycled water will be transferred to tank storage at the STP site prior to release to the downstream environment. It is the intention of the *proposed* development to store *wetland-treated recycled water* for preferential 'wet' release in conjunction with surface water flows. *Wetland-treated recycled water* will be piped to the 'wet' release location shown in **Figure 7**.

There will be periods of insufficient 'wet' releases to maintain onsite tank storage of *wetland-treated recycled water* below the critical 98% storage level. Discharge of *wetland-treated recycled water* will be accommodated by 'dry' releases at such times. These discharges will be piped to the release point shown in **Figure 8**, which is located adjacent to Lindsley Street. The downstream grassed drainage channel delivers flow to the unnamed creek lagoon at the south end of Middle Camp Beach. This lagoon is also the outlet of the 188 ha Study Area catchment.

8.2 MUSIC STORMWATER-POLLUTANT MODEL

Version 6 of MUSIC (Model for Urban Stormwater Improvement Conceptualisation) was adopted for use in this study. The MUSIC modelling software was developed by researchers and practitioners of the former CRC for Catchment Hydrology and the current eWater CRC and represents an accumulation of the best available knowledge and research into urban stormwater management in Australia. The model can also be applied to natural vegetated catchments. MUSIC estimates stormwater flow and pollution generation and simulates the performance of any proposed stormwater treatment devices. It is typically applied in a stormwater quality improvement sense, whereby a proposed system is conceptually assessed by fractional pollutant removal targets. MUSIC does, however, also generate pollutant load concentration time series data. This option permits load based assessment of impacts on downstream waters.

For the *approved* development scenario, flows comprise the following:

- Stages 6 and 7 outlet:
  - Stormwater from the urban land use (household rainwater tanks permitted).
- Mixing Point A:
  - Stormwater from Stages 6 and 7 (household rainwater tanks permitted); and
  - Stormwater and baseflow from the natural catchment area.
- 188 ha Study Area (to Flowers Drive culvert crossing of lagoon):
  - Stormwater from Stages 3, 6 and 7 (household rainwater tanks permitted); and
  - Stormwater and baseflow from the natural catchment area, and the existing Catherine Hill Bay village.

For the *proposed* development scenario, flows comprise the following:

- Stages 6 and 7 outlet:
  - Stormwater from the urban land use (household rainwater tanks not permitted).
- Mixing Point A:
  - Stormwater from Stages 6 and 7 (household rainwater tanks not permitted); and
  - Stormwater and baseflow from the natural catchment area; and
  - 'Wet' releases of wetland-treated recycled water.
- 188 ha Study Area (to Flowers Drive culvert crossing of lagoon):
  - Stormwater from Stages 3, 6 and 7 (household rainwater tanks not permitted);
  - Stormwater and baseflow from the natural catchment area, and the existing Catherine Hill Bay village; and
  - 'Wet' and 'dry' releases of wetland-treated recycled water.

MUSIC was applied in accordance with WBM BMT (2010) to generate stormwater and baseflow from all land use types within the study area. 'Wet' and 'dry' releases of *wetland-treated recycled water* are discussed later in **Section 8.3**. The configurations of the Study Area catchment MUSIC models for *approved* and *proposed* development scenarios are shown **Appendix C**.

8.2.1 MUSIC parameters

8.2.1.1 Time Step

Catchment time of concentration dictates the computation time step used by MUSIC. As the Study Area contains multiple urban land use subcatchments, the recommended time step is a 6-minute increment. This equates to some 3.1 million individual time steps, which provides for high level definition of temporal stormflow behaviour. For facilitation of output analysis using spreadsheet software, stormflow was aggregated to a 30-minute time step commencing at midnight 1/1/1974.

8.2.1.2 Rainfall

Pluviograph data from the Williamtown RAAF AWS were sourced via the eWater Toolkit database (eWater 2016) for the period 1/1/1974 to 31/12/2008. Reasoning behind selection of this particular 35-year assessment period is presented in **Section 5**. It is noted MUSIC considers the 1.5% of time steps with missing pluviograph data as periods of no rainfall. This is likely to lead to an underestimation of MUSIC-generated surface water flow estimates.

8.2.1.3 Potential Evapotranspiration

Monthly mean areal potential evapotranspiration (PET) data were adopted from the Lake Macquarie City Council (LMCC) MUSIC-link. The PET values are shown in **Table 9**.

Table 9 – Monthly mean areal PET rates used in MUSIC (source: LMCC MUSIC-link)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Potential evapotranspiration (mm/day)	4.6	4.1	3.5	2.7	1.9	1.5	1.7	2.3	3.1	3.9	4.4	4.8

8.2.1.4 Surface Flow & Baseflow Apportions

To reliably determine MUSIC parameter values which govern partitioning of runoff and baseflow, calibration is required against known hydrological catchment responses to a rainfall time series. This is not possible within the 188 ha Study Area catchment due to the lack of streamflow gauging.

As discussed in **Section 2.3**, Littleboy *et al.* (2009) developed a model to infer hydrological response for the Middle Camp Gully catchment located immediately north of the Study Area. Based on the results of that assessment, and also the differences in hydrology-related physical characteristics of the Study Area catchment (i.e. higher fraction of impervious surfaces due to a higher fraction of urban area; shorter overall flow paths reducing the opportunity for surface water losses to deep drainage), the *approved* development MUSIC model for the entire 188 ha catchment was parameterised to achieve a surface runoff to baseflow ratio of 3.9, and a streamflow rate (stormwater + baseflow) of 2.47 ML/ha/yr. To affect this baseflow ratio outcome, deep drainage was calibrated to 15% for all land use types other than the *Beaches* urban areas of Stages 3, 6 and 7. Deep drainage, and hence baseflow, for these urban areas remained at zero in accordance with industry-best stormwater design practice.

8.2.1.5 Impervious Land Use Fractions

Aerial imagery and subdivision plans were used to determine the impervious fractions shown in **Table 10** for each land surface type modelled with MUSIC.

Table 10 – Impervious areas by land use used in MUSIC

Land Use	Land Surface	Area (ha)	% Impervious
Natural Catchment	Forest	157.2	0
Catherine Hill Bay village	Roads	3.5	70
	Roofs	2.7	100
	Lots	1.8	20
Stage 3	Roads	1.9	75
	Lots	1.3	61
	Roofs	1.3	100
	Open Space	3.1	5
Stages 6 & 7	Roads	5.0	60
	Lots	3.5	Varies
	Roofs	4.6	100
	Open Space	2.1	5
TOTAL		188.0	

8.2.2 Surface Water Generation Estimates

MUSIC surface water generation estimates are provided in **Section 8.2.2.1** to **Section 8.2.2.3** for the assessed catchments. A summary of mean annual surface water flow estimates is provided later in **Table 14** for all *approved* and *proposed* development scenarios.

8.2.2.1 Stages 6 and 7 (15.2 ha catchment)

MUSIC stormwater estimates for Stages 6 and 7 have been generated at a 6-minute time step for both the *approved* development (rainwater tanks permitted) and the *proposed* development (no rainwater tanks) for the period 1974 to 2008. The removal of rainwater tanks has a predicted impact of increasing mean daily stormwater flow by 18% from 202 to 238 kL/day (or 73.7 to 86.8 ML/yr). To assist interpretation of results, these 6-minute data have been aggregated into monthly totals in **Figure 13**. The monthly flow time series for *approved* and *proposed* development types is highly variable in direct response to rainfall variability. The monthly stormwater rate increases due to rainwater tank removal (red column sections) are shown to be relatively consistent throughout the modelling period. This indicates that during high rainfall periods the removal of rainwater tanks has less relative contribution to stormwater generation than during low flow periods, when nearly all monthly flow can be attributed to the removal of the storage capacity offered by rainwater tanks. The impact of 'wet' releases of *wetland-treated recycled water* at the Stages 6 and 7 outlet (yellow column sections) is discussed later in **Section 8.4**.

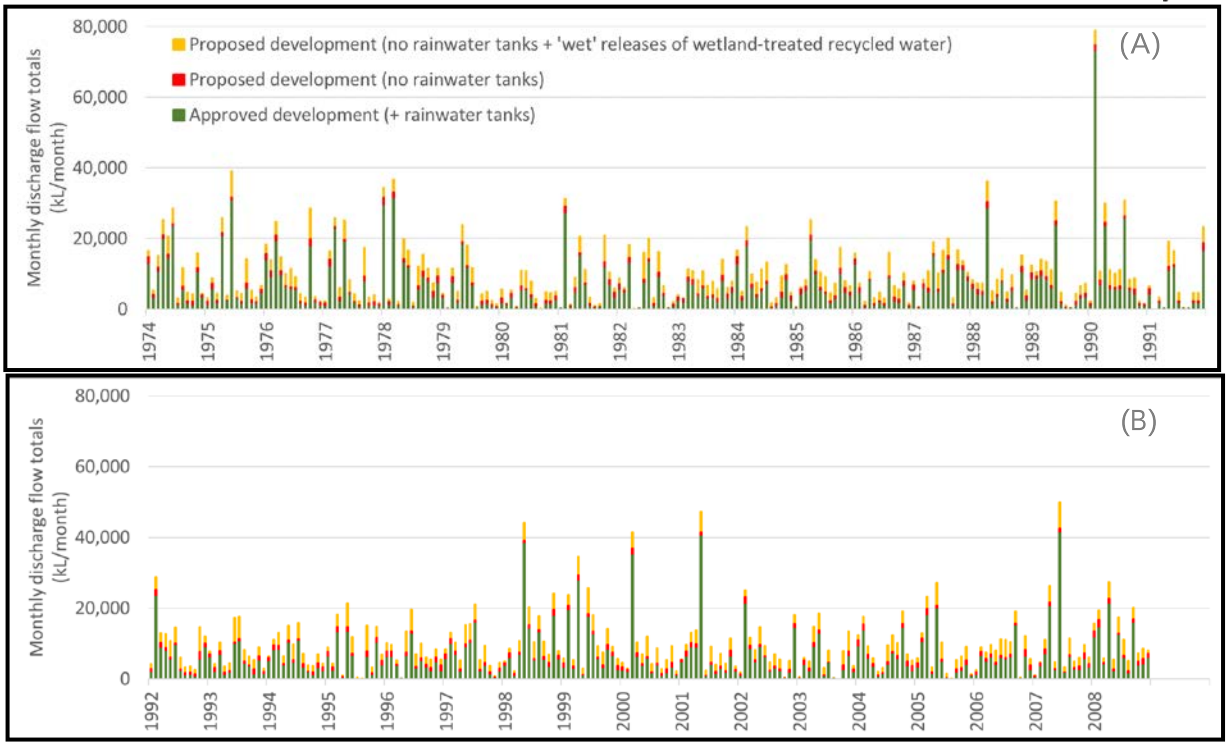

Figure 13 – Monthly time series of stormwater discharge at Stages 6 and 7 outlet for approved and proposed development scenarios during (A) 1974 to 1991 and (B) 1992 to 2008. Data are presented as columns. MUSIC stormwater estimates for the approved development scenario (with rainwater tanks) are the top of the green columns, MUSIC stormwater estimates for the proposed development scenario (no rainwater tanks) are the top of the red column sections, and stormwater generated by the proposed development scenario with including 'wet' releases of wetland-treated recycled water are the top of the yellow column sections.

8.2.2.2 Downstream Mixing Point A (40.5 ha catchment)

Marine Pollution Research (2017) assessed the physical morphology and aquatic environment of 'Creek WMup' – the waterway which stormwater enters directly from Stages 6 and 7. It was found,

> *"the creek-line has been modified by previous mine discharge flows to a uniform U-shaped drainage line with no permanent pools and little ability to store runoff water post-storms. Accordingly, it does not provide aquatic habitat for the support of aquatic macroinvertebrates, fish or other aquatic fauna such as amphibians."*

Based on the poor habitat quality of this waterway, it was decided to position a mid-catchment assessment reference point at a location downstream of where the waterway has its confluence with a larger sub-catchment entering from the west. The reference point is known as Mixing Point A (see **Figure 2**). The contributing catchment area is 40.5 ha, which comprises 25.3 ha of undeveloped natural catchment and 15.2 ha for urban development of Stages 6 and 7. The benefit of a mid-catchment reference point is higher surface water flow, into which the 'wet' releases of *wetland-treated recycled water* can be added.

MUSIC stormwater estimates have been generated at Mixing Point A on a 6-minute time step for both the *approved* development (rainwater tanks permitted) and the *proposed* development (no rainwater tanks) for the period 1974 to 2008. The removal of rainwater tanks has a predicted impact of increasing mean daily surface water flow by 11% from 326 to 362 kL/day (or 119.2 to 132.2 ML/yr). To assist interpretation of results, these 6-minute data have been aggregated into monthly totals in **Figure 14**. As would be expected, the temporal pattern of monthly totals replicates that shown in **Figure 13**. Again, the magnitudes of monthly stormwater increase due to rainwater tank removal (red column sections) are shown to be relatively consistent throughout the modelling period, although the larger contributing catchment area diminishes the relative increase to overall flow. The magnitude of 'wet' releases at Mixing Point A (yellow column sections) is discussed later in **Section 8.4**.

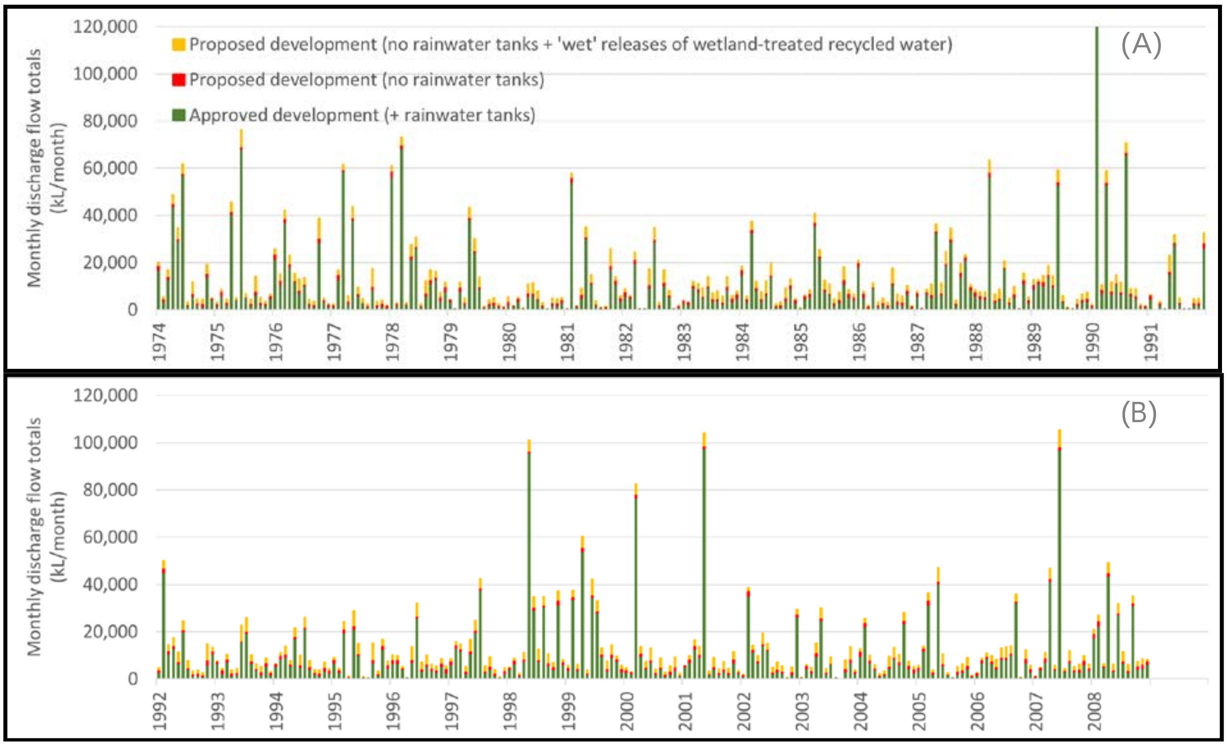

Figure 14 – Monthly time series of stormwater discharge at Mixing Point A for approved and proposed development scenarios during (A) 1974 to 1991 and (B) 1992 to 2008. Data are presented as columns. MUSIC stormwater estimates for the approved development scenario (with rainwater tanks) are the top of the green columns, MUSIC stormwater estimates for the proposed development scenario (no rainwater tanks) are the top of the red column sections, and stormwater generated by the proposed development scenario with including 'wet' releases of wetland-treated recycled water are the top of the yellow column sections. (For data plotting purposes the x-axis is capped at 120,000 kL/month - the February 1990 discharge exceeds 184,000 kL/month)

8.2.2.3 Creek Lagoon (188 ha catchment)

MUSIC stormwater estimates at the Flowers Drive culvert crossing of the unnamed creek lagoon have been generated on a 6-minute time step for both the *approved* development (rainwater tanks permitted) and the *proposed* development (no rainwater tanks) for the period 1974 to 2008. The removal of rainwater tanks has a predicted impact of increasing mean daily surface water flow by 3% from 1,270 to 1,310 kL/day (or 465 to 478 ML/yr). Annual surface water flow ranges from 106 ML during 1980, which was the driest year with 541 mm of rainfall, to 1,534 ML during 1990, which was the wettest year with 1,738 mm of rainfall.

To assist interpretation of results, these 6-minute data have been aggregated into monthly totals in **Figure 15**. As expected, the temporal pattern of monthly totals replicates that shown in **Figure 13** and **Figure 14**. Once again, the magnitudes of monthly stormwater increase due to rainwater tank removal (red column sections) are shown to be relatively consistent throughout the modelling period, but the much larger contributing catchment area further diminishes the relative increase to overall flow. The magnitudes of 'wet' and 'dry' releases at the lagoon (yellow column sections) are discussed later in **Section 8.4.**

8.3 WETLAND-TREATED RECYCLED WATER DISCHARGE ESTIMATION MODEL

Overflow of *wetland-treated recycled water* from the subsurface flow wetland is returned to the STP site for temporary storage in onsite control tanks prior to offsite release.

The preferred pathway for disposal to the downstream environment is via a 'wet' release. At any timestep when the storage capacity of *wetland-treated recycled water* is below the critical 98% level and MUSIC predicts surface water flow, the discharge model permits a simultaneous 'wet' release from the storage tanks.

In practice, the maximum rate of 'wet' release flow will be governed by the hydraulics of the main (HDPE, 125 mm diameter, PN16) from the STP to Stages 6 and 7 stormwater outlet, and by the requirement to not exceed pre-development design storm event flows. Discussion of these operational issues is provided in **Section 8.4.1**.

There will be periods of insufficient 'wet' releases to maintain onsite tank storage of *wetland-treated recycled water* under the critical 98% storage level. Discharge of *wetland-treated recycled water* will be accommodated by 'dry' releases during such times. For modelling purposes, tank storage of *wetland-treated recycled water* is reduced instantaneously by a nominal 1.0 ML 'pulse'. In practice, the actual release rate to the lagoon will be determined by the capacity of the sand berm to transmit groundwater flow from the lagoon to the ocean[3]. Discussion of this operational issue is provided in **Section 8.4.2**.

8.3.1 Pluviograph Exclusion Periods

The potential for 'wet' releases to occur is governed by MUSIC simulation of surface water flows. Because surface water generation via stormwater flow dominates surface water generation by baseflow, pluviograph rainfall depth is the primary driver for 'wet' releases. As discussed in Section 5.1, the BoM Williamtown RAAF AWS pluviograph record contains 1.5% missing data for the 1974 to 2008 period. No opportunity exists for the model to enact a 'wet' release during a period of missing data, and *wetland-treated recycled water* would otherwise accumulate in tank storage because no drawdown of stored capacity is possible. This would ultimately lead to an oversized tank storage requirement outcome. To prevent this, it was decided to 'switch off' the model during days when missing pluviograph data exceeds an arbitrary 50% of the 6-minute observations (ie. more than

[3] The discharge period will be release-rate dependent, and governed by shoaling conditions present at the lagoon's beach outlet. The wider the shoal length, the larger the cross-sectional area available to convey lagoon water to the ocean via groundwater flow through the sand berm. Any time a 'dry' release is required, an estimate of current groundwater flow rate will be determined from a shoal length observation and lagoon depth measurement. Release rate will be matched to groundwater flow rate to ensure the lagoon water level is sustained but not raised. Refer to Section 2.3.1 for discussion regarding groundwater flow rates through the sand berm.

120 of the 240 observations on a given day). The BoM Williamtown RAAF AWS pluviograph record for the 1974 to 2008 period contains 1.5% or 187 days with >50% missing data.

To investigate whether the pluviograph data loss is a systematic seasonal issue, and therefore might affect model results, the days affected by >50% missing data were totalled for each calendar month (see **Table 11**). There does not appear to be a systematic intra-annual cause for the pluviograph data losses, and it is subsequently assumed that model results would not be unduly skewed by the missing data.

Table 11 – Monthly distribution of total days with >50% missing 6-minute observations for the BoM Williamtown RAAF AWS pluviograph rainfall record during 1974 to 2008.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total days with >50% missing pluviograph data	34	3	25	33	15	8	20	18	7	8	8	8

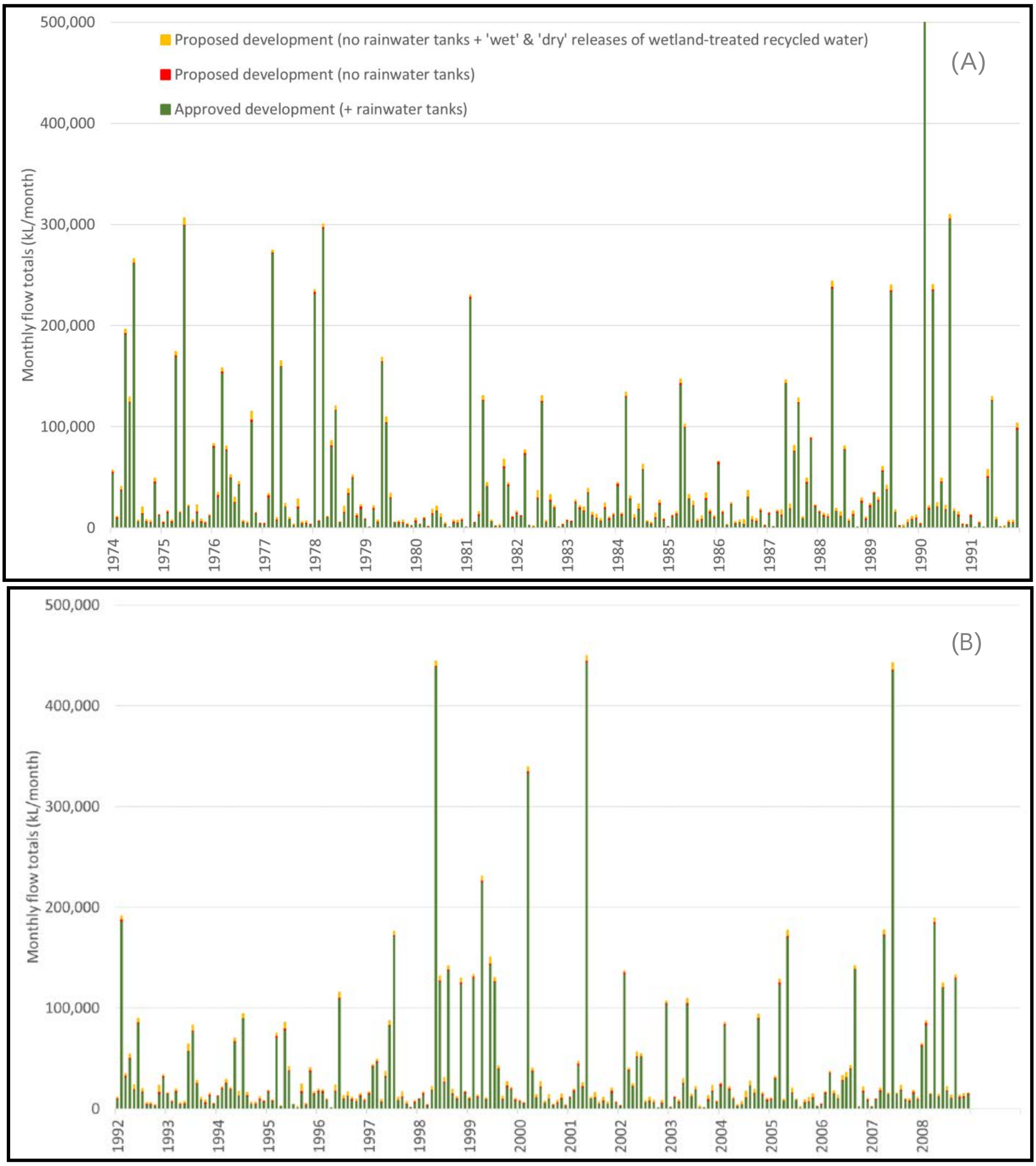

Figure 15 – Monthly time series of stormwater discharge at Flowers Drive culvert crossing of the unnamed creek lagoon for approved and proposed development scenarios during (A) 1974 to 1991 and (B) 1992 to 2008. Data are presented as columns. MUSIC stormwater estimates for the approved development scenario (with rainwater tanks) are the top of the green columns, MUSIC stormwater estimates for the proposed development scenario (no rainwater tanks) are the top of the red column sections, and stormwater generated by the proposed development scenario with including 'wet' and 'dry' releases of wetland-treated recycled water are the top of the yellow column sections. (For data plotting purposes, the x-axis is capped at 500,000 kL/month - the February 1990 total exceeds 820,000 kL/month).

8.4 WETLAND-TREATED RECYCLED WATER DISCHARGE ESTIMATES

An estimated annual mean of 34.0 ML/yr of *wetland-treated recycled water* is required for discharge from the site (see **Section 7.2**). Due to the pluviograph exclusion periods (see **Section 8.3.1**), a mean of 0.5 ML/yr of *wetland-treated recycled water* is disregarded annually as no opportunity exists to make 'wet' releases in conjunction with stormwater runoff. Subsequently, 33.5 ML/yr is the mean annual *wetland-treated recycled water* release volume considered by this assessment.

Annual mean discharge via 'wet' releases is dependent on the overall capacity of the onsite control tanks. That is, the larger the onsite tanks, the greater the opportunity to delay releases and wait for favourable (higher rate) surface water flow conditions. The other controlling factor is the ratio of 'wet' release flow rate to surface water flow rate. That is, when wet conditions prevail, the larger the 'wet' releases, the higher the re-establishment rate of spare tank capacity, and the lower the likelihood of a future 'dry' release.

In an iterative procedure, the controlling factors were varied to assess the influence on respective 'wet' and 'dry' annual mean release volumes. Following initial trial model runs, and findings on downstream impacts determined by Marine Pollution Research (2017), the ratio of 'wet' release to MUSIC estimated surface water flow was set to 1:1. Due to the finding that the waterway immediately downstream of Stages 6 and 7 does not provide aquatic habitat, the ratio is applied at Mixing Point A.

Tank storage capacity was then considered as the sole variable parameter. Results in **Table 12** show that by increasing tank capacity to 5 ML, 'dry' releases are reduced to 0.7 ML/yr and occur during approximately one third of calendar years from 1974 to 2008 (12 of 35 years). This outcome was considered an acceptable minimisation of 'dry' releases, and 5 ML[4] of onsite tank storage was subsequently adopted.

It is noted 5 ML of tank storage offers 100 kL of spare capacity at the 'dry' release trigger capacity level of 98%. This equates to ~24 hrs remaining storage at the mean daily generation rate of *wetland-treated recycled water*.

Table 12 – Impact of tank storage capacity at the STP on 'dry' and 'wet' releases of *wetland-treated recycled water* during the 35-years modelling period from 1974 to 2008.

Tank capacity (ML)	Mean annual 'dry' releases (ML/yr)	Mean annual 'wet' releases (ML/yr)	Number of years with a 'dry' release
2	4.1	29.4	34
3	2.3	31.2	26
4	1.3	32.2	20
5	0.7	32.8	12

[4] The total 5 ML of recycled water storage comprises 2 ML of storage in the balancing tanks located after the AWTP, and a further 3 ML of tanks used exclusively for storage of *wetland-treated recycled water* prior to offsite release. The advantage of the 2 ML balancing storage is that recycled water can be preferentially sent to households for reuse, or if demand is insufficient, it becomes *surplus-to-demand recycled water* and is directed to the subsurface flow wetland. For modelling undertaken in this current study, the combined 5 ML of tank storage is considered a single storage.

'Time series' of monthly discharge totals of *wetland-treated recycled water* are shown in **Figure 16** for both 'wet' and 'dry' release conditions, and the breakdown of monthly and annual discharges are tabulated in **Table 13**. The mean annual 'wet' and 'dry' release volumes for 1974 to 2008 are 32.8 ML/yr (98%) and 0.7 ML/yr (2%), respectively. The peak 'wet' release of 39.5 ML/yr occurred during both 1976 and 1999. The peak 'dry' release of 4 ML/yr occurred during 2004.

There are estimated to be zero 'dry' releases during 23 of the 35 years modelled, which equates to 67% of years during 1974 to 2008. During such years, sufficient surface water flow had been estimated at Mixing Point A to permit the timing of all discharges at a 1:1 ratio.

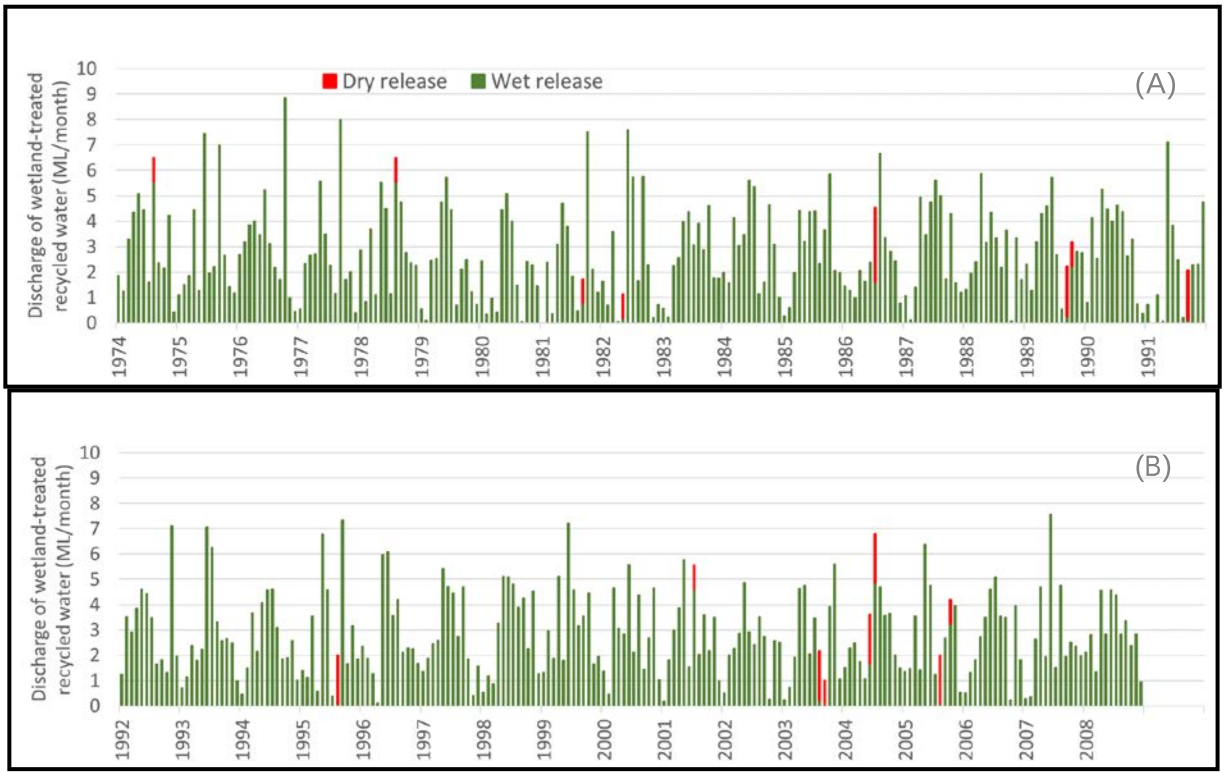

Figure 16 – Monthly offsite discharge totals of *wetland-treated recycled water* for (A) 1974 to 1991 and (B) 1992 to 2008. Data are presented as stacked columns, where 'dry' releases (red) are added to 'wet' releases (green) to provide a combined total for each month.

The contribution of 'wet' releases to catchment flow is shown at the Stages 6 and 7 outlet in **Figure 13**, and at Mixing Point A in **Figure 14**. The contribution of combined 'wet' and 'dry' releases to catchment flow is shown at the Study Area lagoon outlet in **Figure 15**.

The relative contribution of mean annual *wetland-treated recycled water* releases to the *proposed* development scenario flow (no rainwater tanks at Stages 6 and 7 plus 'wet'/'dry' releases) decreases as the focus catchment area increases along with volumetric stormwater generation potential. At the Stages 6 and 7 outlet (15.2 ha catchment), mean annual 'wet' releases account for 34% of the mean annual flow of 119.5 ML/yr. At Mixing Point A (40.5 ha catchment area), the mean annual contribution reduces to 27% of the mean annual flow of 165.0 ML/yr. At the lagoon (188 ha catchment area) the estimated mean annual flow rate is 511.5 ML/yr, of which 7% consists of 'wet' releases. The contribution of 'dry' releases to annual mean lagoon catchment flow is minimal at <0.13%.

Table 13 – Estimated monthly ‘dry’ releases and estimated annual totals of ‘dry’ and ‘wet’ releases for the 1974 to 2008 model period.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual ‘dry’ releases	Annual ‘wet’ releases
	ML													
1974								1					1	36.3
1975														33.9
1976														39.5
1977														32.7
1978								1					1	37.1
1979														27.6
1980														25.2
1981									1				1	28.0
1982					1								1	29.9
1983														31.8
1984														36.5
1985														35.0
1986							3						3	27.2
1987														35.0
1988														33.2
1989									2	1			3	32.4
1990														37.1
1991									2				2	24.9
1992														37.7
1993														33.4
1994														31.4
1995								2					2	32.3
1996														33.6
1997														34.0
1998														36.9
1999														39.5
2000														34.1
2001							1						1	32.9
2002														29.3
2003								2	1				3	28.4
2004						2	2						4	30.8
2005								2		1			3	30.4
2006														32.5
2007														32.4
2008														34.8
Mean	**0**	**0**	**0**	**0**	**0.03**	**0.05**	**0.15**	**0.21**	**0.15**	**0.05**	**0**	**0**	**0.7**	**32.8**
Total	**0**	**0**	**0**	**0**	**1**	**2**	**6**	**8**	**6**	**2**	**0**	**0**	**25**	**1,147**

8.4.1 Operational Controls on 'Wet' Release Flow Rates

In accordance with *Lake Macquarie Development Control Plan 2014*, stormwater runoff resulting from any development must not adversely affect downstream properties, infrastructure, or the environment for all storm events up to and including the 1 in 100yr ARI design storm event. It is proposed to modify the currently approved stormwater detention system at Stages 6 and 7. This will be subject to an assessment by others of pre-development and post-development design storm flows. Because the proposed 'wet' releases will increase stormwater flow at the outlet of Stages 6 and 7, consideration of the increase to post-development flow rates is required.

It is proposed to cap 'wet' release flow rates. Releases will be delivered to the outlet via a DN125 polyethylene main (90 mm ID), which was previously installed for approved irrigation at Stages 6 and 7. Based on preliminary calculations, 20 L/s (or 0.02 m^3/s) is an achievable main flow rate. Compared to design storm event flows from Stages 6 and 7, this flow rate is expected to be relatively minor, as evidenced by the 1 in 100 year pre-development design storm flow rate estimate which is more than two orders-of-magnitude larger at 4.78 m^3/s (ADW Johnson 2010). Accommodating the peak 'wet' release flow rate into post-development stormwater design, whilst not exceeding pre-development design storm conditions, will be a readily achievable outcome.

Capping the peak 'wet' release flow will reduce the quantity of *wetland-treated recycled water* which can be released simultaneously with stormwater from Stages 6 and 7. The 30 minute timestep 'wet' release dataset for 1974 to 2008 was analysed to determine the frequency of flows exceeding an average of 20 L/s, which equates to 36 m^3 per 30 minutes. It was established <1% of timesteps met the criteria. In practice, 'wet' releases performed in conjunction with these infrequent high intensity rainfall events would need to continue for a period after stormwater runoff had fallen below 20 L/s to ensure the 1:1 ratio of 'wet' release to stormwater was achieved.

8.4.2 Operational Controls on 'Dry' Release Flow Rates

'Dry' releases of *wetland-treated recycled water* are associated with extended dry periods, during which limited opportunity has existed to drawdown onsite storage via 'wet' releases in conjunction with surface water flow at Mixing Point A. The model used in this study assumes 'dry' releases are 1 ML in volume and discharge is enacted instantaneously. In practice, the discharge rate of 'dry' releases will be controlled to avoid sudden lagoon water level increases.

Estimated groundwater flow rates through the sand berm will be used to advise CHBWU operators of suitable 'dry' release flow rates. Groundwater flow is controlled by entrance conditions (berm width) and the head differential between the lagoon water level and tidal ocean fluctuations (see **Figure 5**). Because 'dry' releases are associated with extended dry periods, it is expected at such times the rate of generation of *surplus-to-demand recycled water*, and hence *wetland-treated recycled water*, would be less than the 93.0 kL/day mean (see **Section 7.2**). To drawdown tank storage of *wetland-treated recycled water*, the 'dry' release rate would need to exceed the daily inflow rate.

8.5 SUMMARY OF APPROVED & PROPOSED DISCHARGE ESTIMATES

A summary of all discharge estimates presented throughout **Section 8** is provided in **Table 14**. The contribution of rain water tank removal reduces from 18% at the Stages 6 and 7 outlet, to 11% at Mixing Point A, and down to 3% at the Study Area outlet. 'Wet' releases contribute a more significant increase to mean annual surface water flow, with a further 44% increase (to 62%) estimated at Stages 6 and 7 outlet, a further 27% increase (to 38%) at Mixing Point A, and a further 7% increase (to 10%) estimated at the Study Area outlet.

Table 14 – Summary of baseline surface water flow estimates for the *approved* development scenario and estimated changes caused by the *proposed* development scenario (+% changes versus *approved*).

Development Scenario		Mean Annual Surface Water Flow (ML/yr)		
		Stages 6 and 7 Outlet	Mixing Point A	Study Area Lagoon Outlet
Catchment Area (ha)		15.2	40.5	188
Approved	Stages 6 and 7 + rain water tanks	73.7	119.2	465.0
Proposed	Stages 6 and 7 no rain water tanks	86.8 (+18%)	132.2 (+11%)	478.1 (+3%)
	+'wet' releases	119.5 (+62%)	165.0 (+38%)	510.8 (+10%)
	+'dry' releases	-	-	511.5 (+10%)

9.0 Pollutant Discharges

9.1 POLLUTANT ASSESSMENT OVERVIEW

The *approved* development provides the *baseline* condition against which *proposed* development pollutant changes are assessed. The key development changes include the removal of rainwater tanks from the Stages 6 and 7 urban development, and the introduction of 'wet' and 'dry' releases of *wetland-treated recycled water* to the downstream environment.

The water balance assessment in **Section 7** provides a time series of overflow of *wetland-treated recycled water* from the onsite subsurface flow wetland. The discharge assessment in **Section 8** determined catchment hydrologic responses to incident rainfall using the MUSIC model, and managed the 'wet' and 'dry' release pattern of *wetland-treated recycled water* with a discharge model. The accounting of surface water flows was performed at the following three key locations:

- Outlet of Stages 6 and 7;
- Mixing Point A; and
- Flowers Drive culvert crossing of the unnamed creek lagoon (Study Area catchment).

This pollutant assessment combines surface water flow data and pollutant concentration estimates to determine pollutant loads expected for *approved* and *proposed* development scenarios.

9.2 POLLUTANT ESTIMATION MODELS

9.2.1 MUSIC Stormwater-Pollutant Model

MUSIC is the Australian industry standard for estimation of pollutant changes caused by urban development. The foundations of its pollutant change estimation capability are the statistical analyses of land use-specific nutrient generation (Duncan 1999), which includes data for both urban and naturally vegetated surfaces. Importantly for this current study, MUSIC has the capability to generate a pollutant concentration time series at a nominated catchment location. When combined with flow rate time series data, pollutant loads estimates are achieved for the assessment of impacts on downstream waters. In this current study, MUSIC was applied to assess TN, TP and TSS as pollutants of concern.

MUSIC was run for the period 1/1/1974 to 31/12/2008. As discussed in **Section 8.2.1**, the recommended MUSIC time step is a 6-minute increment.

9.2.2 Subsurface Flow Wetland Model

A constructed subsurface flow wetland is proposed to polish *surplus-to-demand recycled water* prior to offsite release. MUSIC has a constructed wetland module for open water wetlands which have up to 50% vegetation cover (WBM BMT 2010). Vegetation cover is capped at 50% because deeper waters towards the middle of a wetland cannot support growth, and vegetation is restricted to shallower edge zones. It is proposed to maintain near 100% vegetation at the proposed onsite subsurface wetland. As such, MUSIC is not considered a suitable tool for assessing the complexity of pollutant transport through a fully vegetated subsurface wetland system. Instead, Whitehead and Associates (2017) developed a conceptual wetland system model (see **Section 7.0**) based on best industry practice (Kadlec & Knight, 1996; NSW DLWC, 1998), and this model was applied to assess treatment of pollutants of concern (TN, TP, TSS, FC and BOD).

TDS is another pollutant of concern. The mean and maximum concentrations of TDS in MBR permeate are 600 mg/L and 1,000 mg/L, respectively (Solo Water 2015). Because no removal of TDS is afforded by the subsurface wetland, *wetland-treated recycled water* is assumed to contain the maximum influent TDS concentration of 1,000 mg/L.

Chlorination of MBR permeate is a key AWTP disinfection process required to ensure recycled water is to *Fire Fighting* standard in accordance with Biotext (2006). Residual free chlorine can be harmful to aquatic invertebrates, and is also considered a pollutant of concern by the current study. As a gas, free chlorine is rapidly removed by off-gassing when chlorinated water is open to the atmosphere, and is utilised in the oxidation of organic materials in a subsurface wetland scenario (Whitehead and Associates 2017). A salt tolerant mix of subsurface flow wetland vegetation species has been identified by Whitehead and Associates (2017), and they have advised the predicted free chlorine levels of 0.2-2.0 mg/L will not unduly affect growth of the salt-tolerant plants. As a result, *wetland-treated recycled water* will be dechlorinated, and chlorine is not considered further.

As described in **Section 7.1,** the wetland water balance was adapted to a daily time step model informed by daily climate parameters. Hydraulic models are suitable for this type of adaptation because accounting for inputs and outputs is well understood and readily achievable. Understanding of wetland controls on pollutant uptake has been historically formed by observation at time scales exceeding that of a single day. The conceptual wetland pollutant model used in this study is instead employed to estimate outflow effluent pollutant concentrations based on wetland influent pollutant characteristics and a single nominated rate of flow. This approach limits model application to assessment of wetland pollutant uptake for a single nominated flow rate condition.

9.3 WETLAND POLLUTANT & FLOW INPUT

Subsurface flow wetland pollutant inlet concentrations adopted for assessment are shown in **Table 15**. These are based on Solo Water (2015) 50th-percentile, 95th-percentile and maximum concentrations in MBR permeate. The proposed AWTP treats MBR permeate to *Fire Fighting* standard recycled water. BOD and FC are reduced by the AWTP process, however as a conservative measure, maximum MBR permeate concentrations have been adopted in this assessment.

The 50th-percentile TN and TP concentrations, and the 95th-percentile TSS concentration are each assumed to be the mean value for this assessment. It is acknowledged the 50th-percentile values for TN and TP will provide only an approximation of the respective means, and the 95th-percentile value for TSS will likely overestimate the mean.

Table 15 – Subsurface flow wetland pollutant inlet concentrations adopted for assessment

Parameter	Units	50th-percentile adopted as mean	95th-percentile adopted as mean	Maximum concentration
TN	mg/L	10	-	20
TP	mg/L	0.3	-	2.0
TSS	mg/L	-	5	10
BOD	mg/L	-	-	20
FC	cfu/100 ml	-	-	100*

*The proposed AWTP will produce recycled water with a maximum FC concentration <1 cfu/100 ml.
An influent concentration of 100 cfu/100 ml is adopted in this assessment solely to demonstrate the effectiveness of the subsurface flow wetland at reducing this pollutant of concern.

Piped inflow to the subsurface flow wetland consists of *surplus-to-demand recycled water*. A conservative mean daily flow rate of 100 kL/day has been adopted in this assessment (see **Section 6.6**). The maximum daily flow rate of 162.3 kL/day occurs on rainfall days when only *baseline recycled water demand* exists at households. The peak *seasonal* mean daily flow rate of 139.1 kL/day (**Table 6**) was estimated for June.

9.4 WETLAND POLLUTANT GENERATION ESTIMATES

Between the percentiles and maximum pairings of pollutant concentrations (**Table 15**), and the three input flow rates (**Section 6.6**), there exist six wetland flow and pollutant scenario combinations. Whitehead and Associates (2017) modelled each scenario to determine the estimated range of *wetland-treated recycled water* pollutant concentrations shown in **Table 16**. It is evident the higher inlet pollutant concentrations and inflow rate, the higher the wetland outlet concentrations of the key pollutants TN and TP.

The estimated BOD concentration in wetland outflow is a factor-of-three lower than the 15 mg/L freshwater stressor guideline value for the protection of aquaculture species in *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000). BOD does not represent a potential threat to the downstream aquatic environment and it is no longer considered by this assessment.

The inlet concentration of FC was artificially set at 100 cfu/100 ml to test the effectiveness of the subsurface wetland at the removal of thermotolerant pathogens (the AWTP will produce recycled water with <1 cfu/100ml). The estimated outlet concentrations are at least 28 times lower than the 150 cfu/100 ml primary contact Water Quality Objective for the Lake Macquarie and Tuggerah Lakes catchment. This demonstrates a large factor of safety exists regarding the removal of FC from wastewater at the STP and in the subsurface flow wetland. FC does not represent a potential threat to the downstream aquatic environment and it is no longer considered by this assessment.

Table 16 – Subsurface flow wetland pollutant outlet concentrations based on inlet flow rates (Whitehead and Associates 2017)

Parameter		Annual Mean Daily Flow		Seasonal Peak Daily Flow		Short-term Wet Period Peak Daily Flow	
Surplus-to-demand Recycled Water Production Rate (kL/day)		100.0		139.1		162.3	
MBR Permeate Concentrations at Wetland Inlet		Assumed mean	Max	Assumed mean	Max	Assumed mean	Max
TN	mg/L	2.47	3.60	3.31	5.42	3.67	6.22
TP	mg/L	0.13	0.77	0.16	1.01	0.17	1.10
TSS	mg/L	8.12	8.43	8.12	8.43	8.12	8.43
BOD	mg/L	4.56	4.56	4.56	4.56	4.56	4.56
FC	cfu/100 ml	4.55	4.55	4.91	4.91	5.28	5.28

9.5 OFFSITE POLLUTANT LOAD DISCHARGES

9.5.1 Representative Pollutant Concentrations and Flow Rates

Determination of offsite pollutant discharges requires consideration of recycled water management at the STP and the rate of *surplus-to-demand recycled water* generation.

A total of 5 ML of recycled water storage is proposed (**Figure 6**). 2 ML capacity of recycled water tanks will be used to optimise household supply ahead of diversion to the subsurface flow wetland. Based on the *surplus-to-demand recycled water* estimates in **Table 6**, a minimum of 14 days of storage (June peak flow) is afforded by the 2 ML tank capacity.

The additional 3 ML capacity of *wetland-treated recycled water* tanks will be used to maximise 'wet' releases ahead of 'dry' releases to the downstream environment. Based on the *wetland-treated recycled water* generation estimates in **Table 8**, a minimum of an additional 20 days of storage (June peak flow) is afforded by the 3 ML tank capacity.

The combined 5 ML capacity of all recycled water tanks allows for 34 days of onsite storage at seasonal peak flow conditions. It is expected that MBR permeate quality will fluctuate through time, with pollutant concentrations estimated by 50th/95th-percentiles and maxima in SOLO Water (2015) (which are adopted as subsurface flow wetland inlet concentrations as per **Table 15**). The minimum 34 days of storage is expected to extend across MBR permeate quality fluctuations, and tend towards the 50th-percentile concentrations for TN and TP, which have been adopted as mean concentrations for pollutant discharge estimation.

The 34 days of tank storage of recycled water types best matches the temporal scale of the seasonal (monthly) peak flows expected for *surplus-to-demand recycled water* generation rates of 139.1 kL/day. This flow rate is adopted as the representative subsurface flow wetland inlet flow rate from which pollutant discharge estimates are derived.

9.5.2 Pollutant Discharge Estimates

Offsite pollutant discharge estimates associated with 'wet' and 'dry' release volumes of *wetland-treated recycled water* (see **Section 8.4**) have been derived from adopted 50th/ 90th-percentile MBR permeate pollutant concentrations (**Table 15**) and a subsurface flow wetland inflow rate of 139.1 kL/day. Surface water pollutant concentrations emanating from Study Area land surfaces have been derived by MUSIC, with loads calculated using MUSIC flow rate estimates. A conservative TDS concentration of 200 mg/L was adopted for stormwater and baseflow based on monitoring by Marine Pollution Research (2017) which showed TDS ranged between 100-300 mg/L in upland creeks with the Study Area.

Surface water flow pollutant concentration means and load estimates are provided in **Table 17** at the Stages 6 and 7 outlet (prior to mixing with 'wet' releases of *wetland-treated recycled water*), in **Table 18** at the Stages 6 and 7 outlet (after mixing with 'wet' releases of *wetland-treated recycled water*) in **Table 19** at Mixing Point A, and in **Table 20** at the Flowers Drive culvert crossing of the unnamed creek lagoon.

Table 17 – Mean surface water flow pollutant concentrations and loads at Stages 6 and 7 outlet prior to mixing with 'wet' releases of wetland-treated recycled water.

Parameter	Units	Development Scenario		% Change
		Approved	*Proposed*	
Flow	ML/day	0.202	0.238	18
	ML/yr	73.7	86.8	
TN	mg/L	1.98	2.01	2
	kg/yr	146	174	19
TP	mg/L	0.143	0.144	1
	kg/yr	10.5	12.4	18
TSS	mg/L	24.8	24.6	-1
	kg/yr	1,830	2,130	16
TDS	mg/L	200	200	0
	kg/yr	14,800	17,300	17

Table 18 – Mean surface water flow pollutant concentrations and loads at Stages 6 and 7 outlet after mixing with 'wet' releases of wetland-treated recycled water.

Parameter	Units	Development Scenario		% Change
		Approved	*Proposed*	
Flow	ML/day	0.202	0.327	62
	ML/yr	73.7	119.5	
TN	mg/L	1.98	2.36	19
	kg/yr	146	282	93
TP	mg/L	0.143	0.147	3
	kg/yr	10.5	17.6	68
TSS	mg/L	24.8	20.1	-19
	kg/yr	1,830	2,400	31
TDS	mg/L	200	419	110
	kg/yr	14,800	50,100	239

Table 19 – Mean surface water flow pollutant concentrations and loads at Mixing Point A.

Parameter	Units	Development Scenario		% Change
		Approved	*Proposed*	
Flow	ML/day	0.327	0.452	38
	ML/yr	119.2	165.0	
TN	mg/L	1.57	1.96	25
	kg/yr	202	323	60
TP	mg/L	0.118	0.128	8
	kg/yr	15.1	21.1	40
TSS	mg/L	29.3	24.6	-16
	kg/yr	3,790	4,060	7
TDS	mg/L	200	359	80
	kg/yr	25,800	47,500	84

Table 20 – Mean surface water flow pollutant concentrations and loads at the Flowers Drive culvert crossing of the unnamed creek lagoon.

Parameter	Units	Development Scenario		% Change
		Approved	*Proposed*	
Flow	ML/day	1.27	1.40	10
	ML/yr	465.0	511.5	
TN	mg/L	1.22	1.38	13
	kg/yr	566	704	24
TP	mg/L	0.13	0.132	2
	kg/yr	61.0	67.6	12
TSS	mg/L	51.3	47.9	-7
	kg/yr	23,900	24,500	3
TDS	mg/L	200	252	26
	kg/yr	93,000	129,000	39

10.0Pollutant Generation Conservatism

A range of conservative options have been adopted in the overall modelling process to estimate *wetland-treated recycled water* release volumes to the downstream environment. These options have increased the annual mean volume of releases, and have likely lead to overestimation of the pollutant loads generated by the *proposed* development. In summary, the conservative measures are:

- Daily household generation of wastewater was increased by 10% to account for external inflows (stormwater and groundwater) to the pressure sewerage system. The recently constructed sewerage system was pressure tested during commissioning and is known to be 100% sealed. The 10% wastewater increase is therefore considered to be a highly conservative measure.
- The waste sludge removal process also removes 2% of wastewater from the STP process. This extraction has not been accounted by the modelling process.
- The mean daily *surplus-to-demand recycled water* generation rate was increased by ~10% from 90.2 to 100 kL/day to account for uncertainty in actual household recycled water use. To affect this change within the model, a nominal minimum demand of 25 kL/day was introduced, and daily demands >25 kL/day were increased on a weighted-scale, with the daily maximum conserved at 162.3 kL/day.
- The modelling process assumes all 5 ML of recycled water storage at the STP is located after wetland treatment. This does not allow the opportunity to preferentially hold *surplus-to-demand recycled water* at the STP until household demand increases. Instead, the model directs *surplus-to-demand recycled water* instantaneously to the wetland for treatment. The proposed STP process will have 2 ML of tank storage after the AWTP to manage the distribution of recycled water. This will optimise household reuse of recycled water and reduce the volume of *wetland-treated recycled water* as predicted by this modelling assessment.

The conservative pollutant generation measures adopted in this assessment are estimated to result in a >20% increase in flow releases and pollutants to the downstream environment as a result of the proposed development. Impacts to the aquatic environment should be viewed in consideration of the overall conservative approach adhered to by this assessment.

11.0 Conclusions

This study has estimated the impacts of the *approved* and *proposed* developments on water quantity and quality through water resource simulation models which target:

- Stormwater generation;
- Wetland water balance;
- Recycled water demand; and
- Site water discharge (both stormwater and recycled water).

The modelling was performed for a 35-year simulation period from 1974 to 2008. During this period, historical climate records show that rainfall conditions were highly variable, which enabled the models to be tested under worst case climate conditions.

The predicted water quantity and quality estimates of releases to the downstream aquatic environment are considered robust, and therefore suitable for the purpose of environmental impact assessment of the *proposed Beaches* subdivision development.

12.0 References

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Appendix A

NSW EPA CORRESPONDENCE

Appendix B

CONCEPTUAL WETLAND MODEL (WHITEHEAD & ASSOCIATES 2017)

Appendix C

MUSIC MODELS FOR APPROVED & PROPOSED DEVELOPMENT SCENARIOS

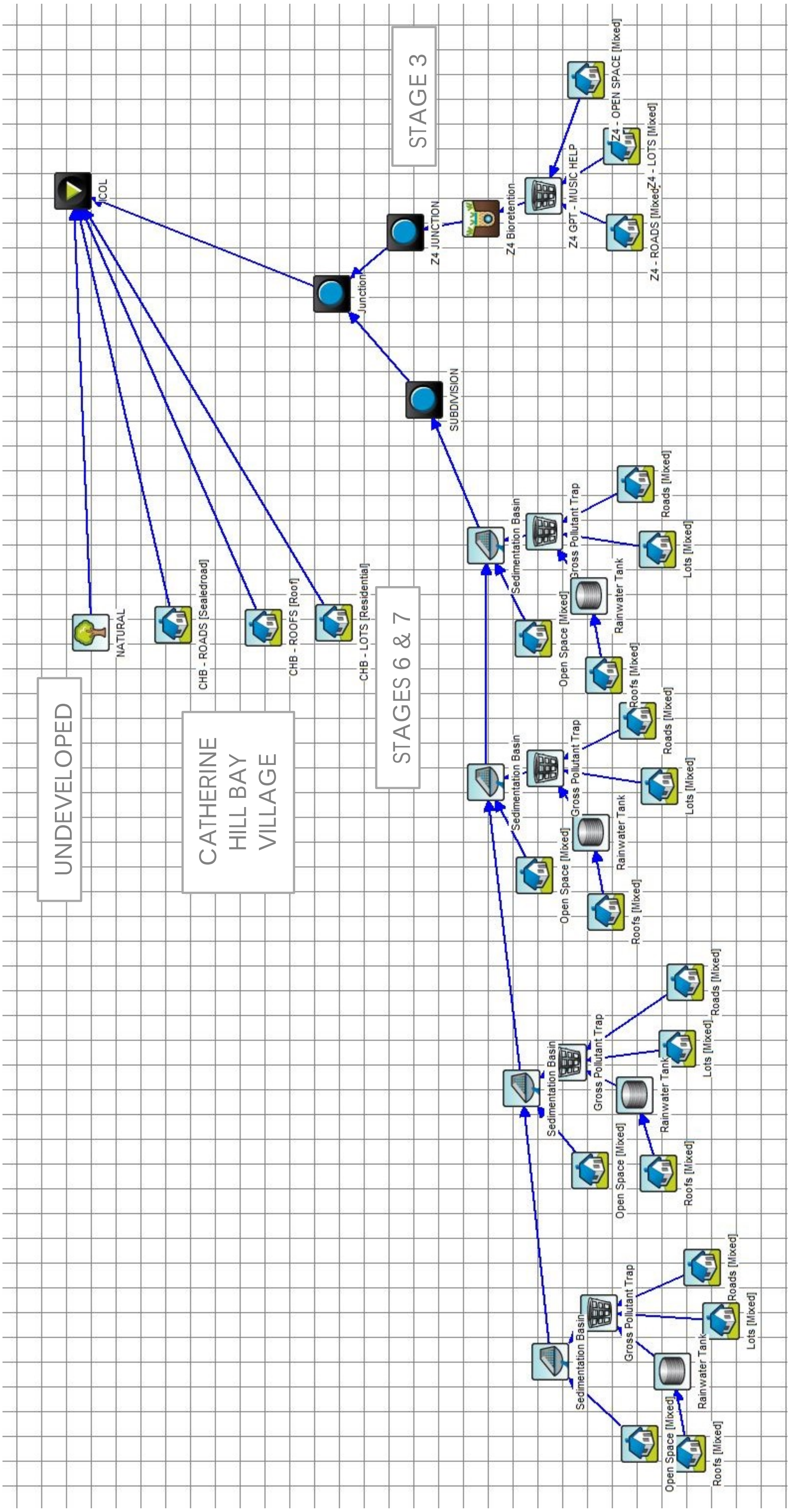

Figure C-1 MUSIC model for the *Approved* development scenario.

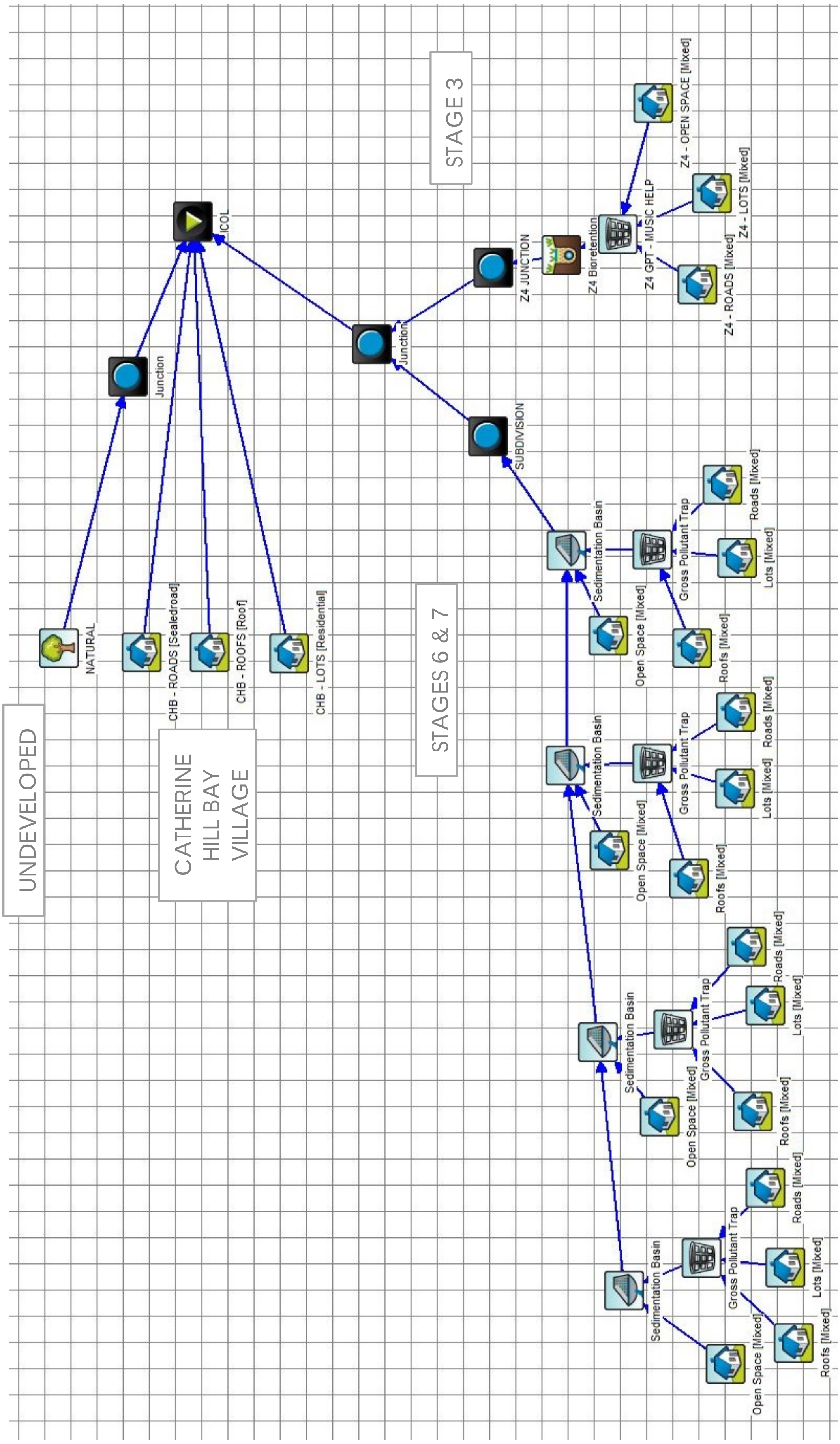

Figure C-2 MUSIC model for the *Proposed* development scenario.

COASTAL HAMLETS PTY LTD CATHERINE HILL BAY SUB-DIVISON – RECYCLED WATER DISPOSAL OPTIONS ASSESSMENT:

AQUATIC ECOLOGY ASSESSMENT 2016

Looking Southeast over Catherine Hill Bay.

Final Report for inclusion with *ADW Johnson Pty Ltd* Submission on behalf of Rose Property Group (Coastal Hamlets Pty Ltd)

MARINE POLLUTION RESEARCH PTY LTD
JUNE 2017

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APPENDIX A
WATER & AQUATIC ECOLOGY FIELD NOTES & SAMPLING DATA

Table A-1 Daily Rainfall – Swansea Jan 2016 to Feb 2017
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September 2016 and February 2017 Laboratory Water Quality Analysis Reports

1 INTRODUCTION

Rose Property Group is constructing the *Beaches* residential subdivision at Catherine Hill Bay. The current approval is for construction of 540 residential lots, roads and associated parks and open space. All water, wastewater and recycled water infrastructure under the scheme will be owned by the newly created entity Catherine Hill Bay Water Utility Pty Ltd (CHBWU). CHBWU will hold the IPART Network Operator Licence and subcontract all design, construction, operation and maintenance activities to Solo Water. Solo Water will be the IPART Retail Licence holder for all Solo Water schemes.

A Water Treatment Plant (WTP) will be constructed to produce recycled water for reuse by all households at the development. The development's Integrated Water Management Plan (Solo Water, July 2015) identified surplus-to-demand recycled water during periods of low household irrigation demand. The existing licence for the development requires that this excess recycled water be disposed of via on-site irrigation at Stages 6 and 7. Rose Property Group instead wishes to develop the land for Stages 6 and 7 of the residential subdivision. Accordingly, ADW Johnson (ADWJ) is preparing a submission to IPART for treatment of excess recycled water in a sub-surface flow wetland, and for discharge of wetland-treated recycled water to the downstream environment. It is proposed, where possible, to time 'wet' discharges in conjunction with stormwater flows emanating from the Stages 6 and 7 subdivision. Due to the intermittent nature of runoff, limited 'dry' discharge volumes are also proposed for the lower coastal lagoon at the approved Lindsley Street stormwater outlet (Figure 1).

It is understood that IPART will seek a review of the submission by the NSW Environment Protection Authority (NSW EPA), which has indicated the requirement for assessments of water quality impacts in the downstream receiving environment, and ADWJ has commissioned Marine Pollution Research Pty Ltd (MPR) to provide an assessment of the aquatic environment into which the wetland-treated recycled water is to be discharged, assess possible impacts and provide suggestions for avoiding, mitigating and/or offsetting impacts to the aquatic environment.

1.1 Receiving Environment

The hamlet of Catherine Hill Bay is located between Lake Macquarie and the Tasman Sea. There are two catchments draining the locality to the coast at Middle Camp Beach; a 501 ha northern catchment draining to Middle Camp Gully at the north corner of Middle Camp Beach, and a smaller 188 ha southern catchment draining to a coastal creek at the south end of Middle Camp Beach (Figure 1). The southern catchment is the focus of the current project. The approved subdivision straddles the Montefiore Street ridge between the project focus catchment and the Moonee Beach catchment further south. Conservation lands are located both north and south of the subdivision (Figure 1).

Figure 2 shows an aerial view of the 188 ha southern catchment, with its sub-catchment boundaries based on 'blue drainage lines' and elevation contours obtained from the NSW Government Six Maps application[1]. The Beaches Stages 6 and 7 will be developed on cleared and rehabilitated Moonee Colliery lands located in Sub-catchments 3 and 4.

Figure 3 provides a catchment slope analysis, with low slope areas (0-5%) shown in green. As indicated, there are old constructed mining areas and car parking areas with this slope characteristic, and there are also several broad low slope areas around the main Sub-catchment 2 stream line that most probably support some sort of swampy woodland. Given the extent of low slope areas throughout the sub-catchments, it is inferred that the hydrographic tail and subsequent base-flow runoff curve for a storm event would be relatively long when compared to runoff expected from areas of sparsely wooded catchment on steep slopes.

The grouped sub-catchments shown in Figure 2 are described as follows:

Sub-catchment 1:

- There are two small creeks (NE and NW) that drain an area that supports some *Coastal Headland Complex* plus some *Coastal Plains Smooth-Barked Apple Woodland* along the drainage lines.
- The drainage line between NE and the confluence with the main creek was inspected on 10 August 2016 and there was water ponded around the confluence but there was no flow from the creek itself.
- The confluence of creek NW with the main creek could not be found as it drained into a large *Coastal Sand Mahogany-Paperbark Swamp Forest* (an EEC) located to the north of the main creek between sites CKuw and CKdn (labelled FWsm in Figure 2). The location and probable extent of this freshwater swamp area can also be inferred by the area of low slope lands around and to the north of the lower main creek in Sub-catchment 1, as indicated on the project *Catchment Slope Analysis Plan* ((Figure 3). It is noted a portion of the low slope area alongside Flowers Drive is dry grassland and cleared lands for car parks.
- The creek sites NE and NW were inspected on 30 September 2016. NE was dry and there was sufficient trickle flow at NW for water quality analysis.

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[1] 'Blue drainage lines' have been overlaid onto a Google Earth aerial image. Due to the Google Earth aerial image not being ortho-rectified, the fit is approximate, but is considered sufficient for the purposes of describing the receiving aquatic environment of the proposed WTP discharge.

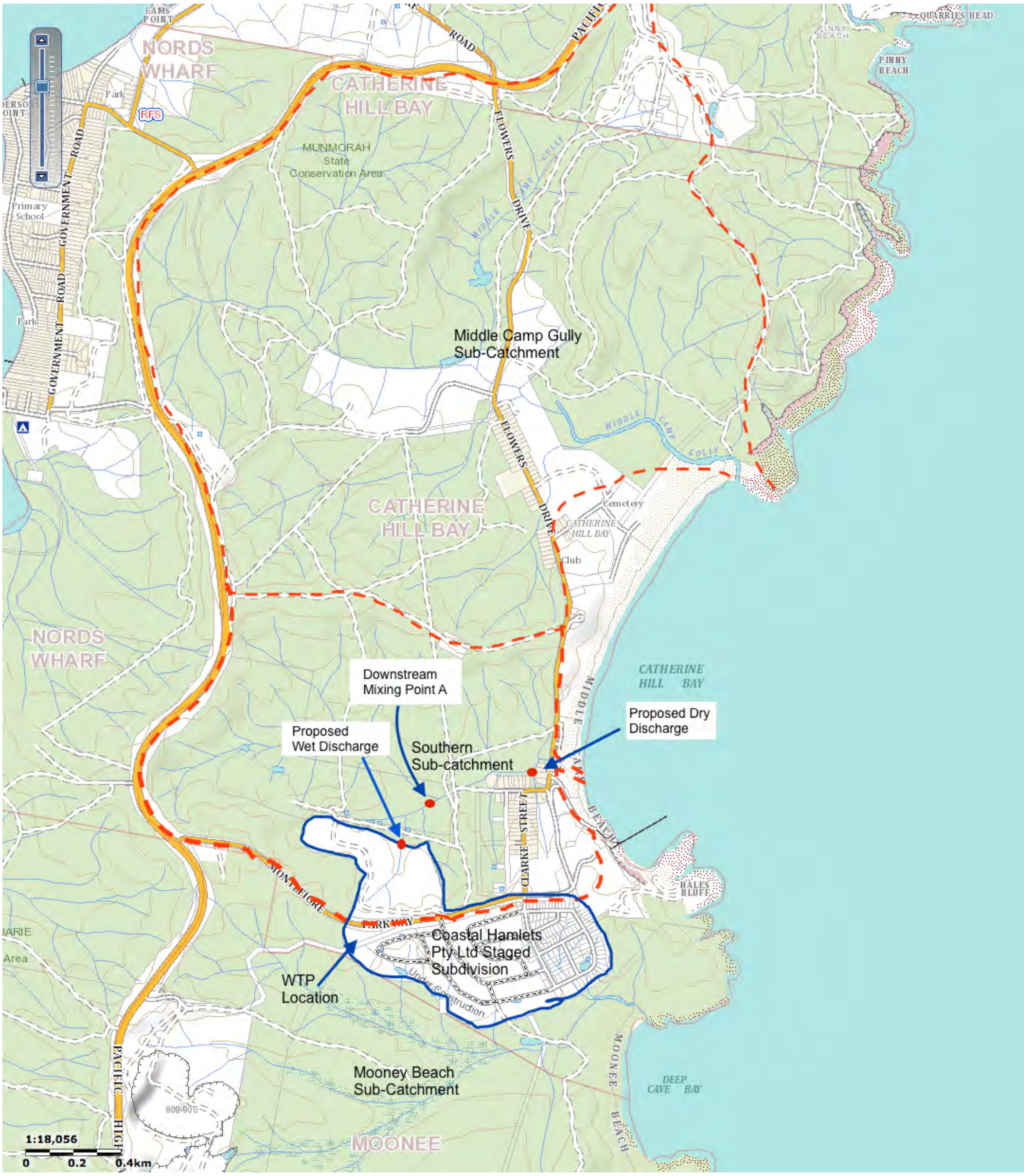

Figure 1 Topographic Map of Catherine Hill Bay sub-catchments showing location of the Beaches sub-division in relation to the proposed wet and dry weather discharge outlets into the Southern sub-catchment. *Mixing Point A* is at the confluence of the Stage 6 & 7 stormwater discharge creek lines (sub-catchments 3 and 4) and just upstream of the native-forested sub-catchment 2 creek shown in Figure 2 below. See Section 2.1 for definition of *Mixing Point A*.

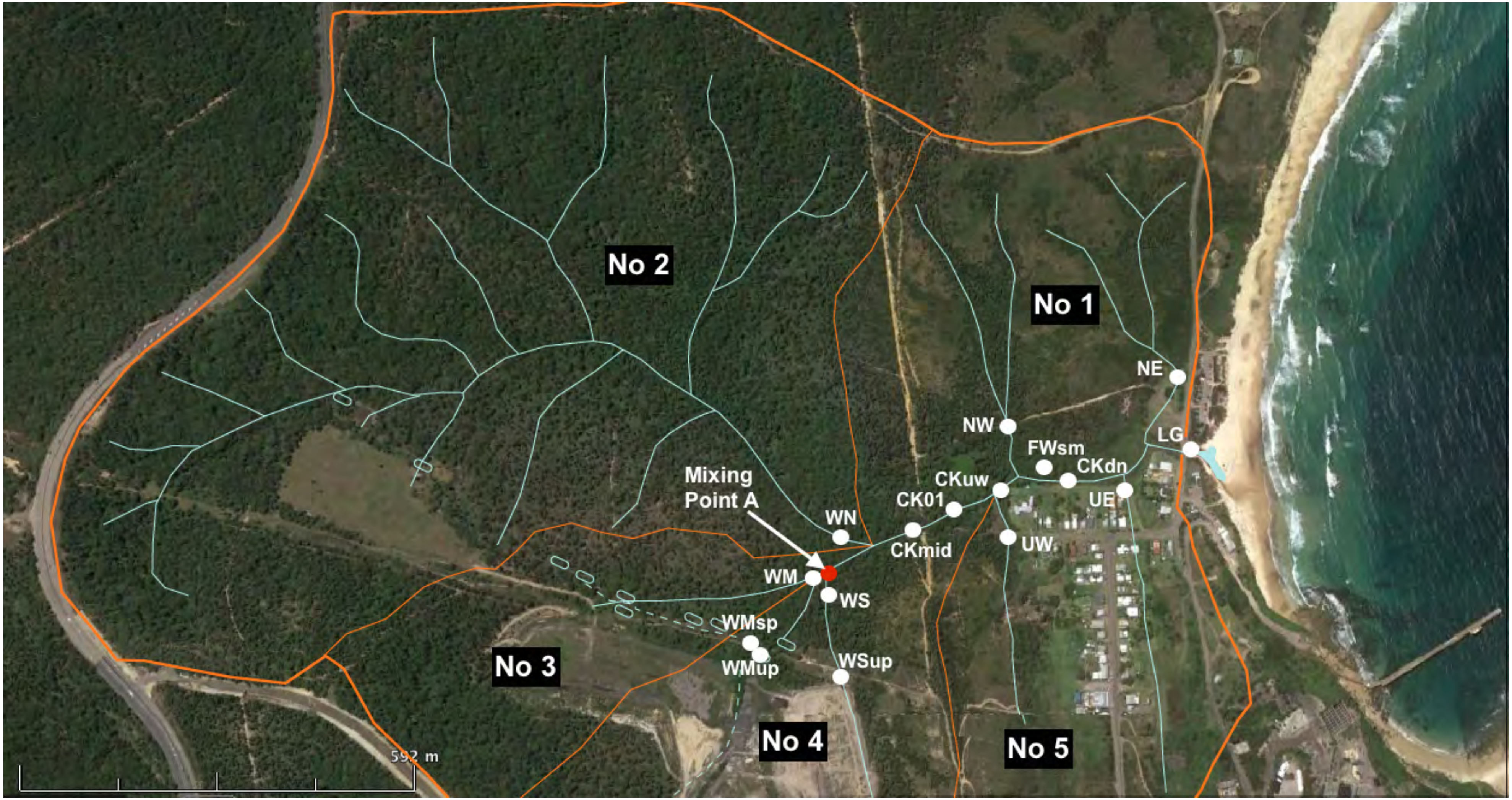

Figure 2 Smaller sub-catchments draining to an unnamed creek that discharges via the southern beach lagoon at the southern end of Flowers Drive, showing survey sites inspected and/or sampled for this aquatic ecology study. Sub-catchments have been numbered arbitrarily anti-clockwise.

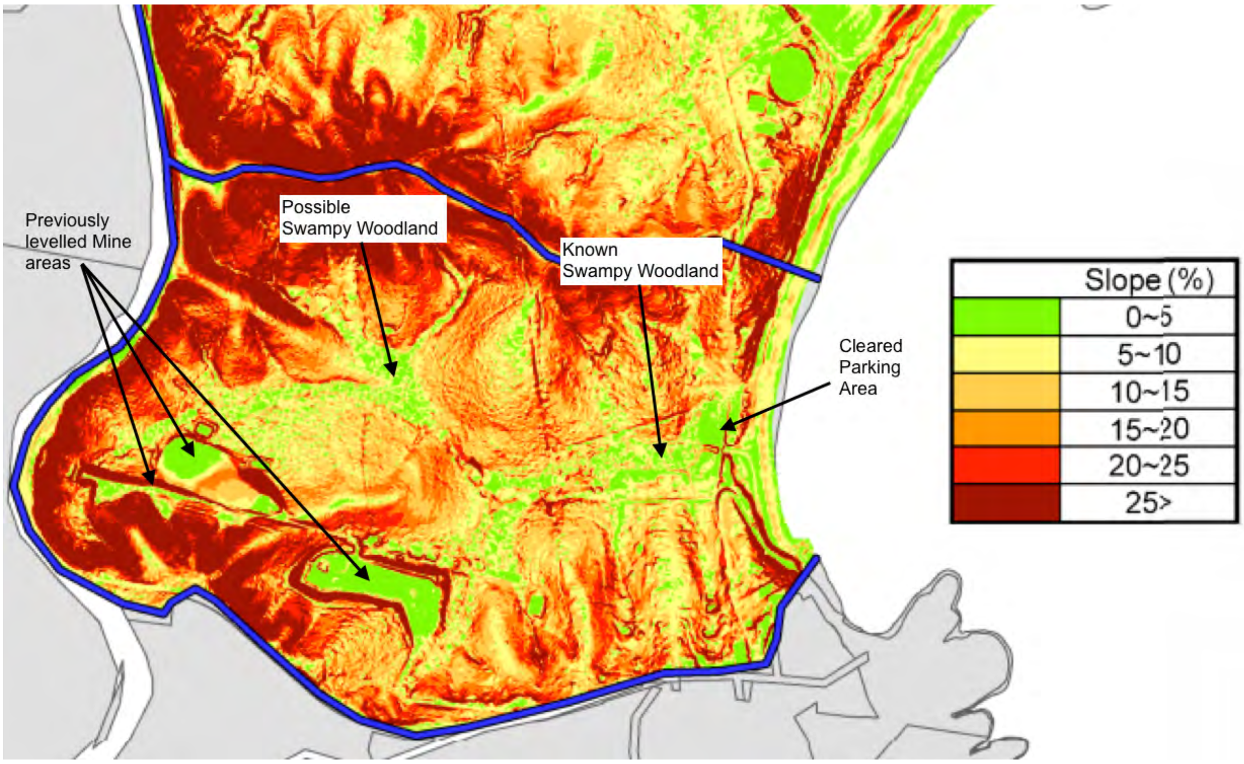

Figure 3 Portion of Slope Analysis Plan for the Southern Catherine Hill Bay sub-catchment indicating relatively wide low slope flood channels for the main sub-catchment creeks.

Sub-catchment 2:

- This sub-catchment includes all the smaller north-western drainages to the main creek from the substantially undeveloped forested lands bounded by the main northern ridge and the Pacific Highway to the west. It supports an overall greater density of woodland and tree cover when compared to Sub-catchment 1.
- On the basis of partial mapping provided in RPS (2010), the main vegetation community is *Narrabeen Wallarah Sheltered Grassy Forest* with the upper reaches of the main and feeder creeks classified as *Mummorah Palm-Apple Dry Drainage Line Forest,* and the lower main and lower feeder creeks supporting areas of *Coastal Sand Mahogany-Paperbark Swamp Forest EEC*.
- Inspection of the catchment slope analysis map (see Figure 3) indicates that there are two relatively large low-slope areas in Sub-catchment 2 around the main upper creek that could support swampy woodlands.
- Site WN was inspected in August and again in September with water quality, macroinvertebrate and fish sampling undertaken on 30 September 2016.
- There are several small feeder creeks draining the western extension of the rehabilitated coal stockpile lands that take the overflow from two small dams associated with runoff from the rehabilitated area.

Sub-catchments 3 and 4:

- These sub-catchments include drainage from the proposed Stages 6 and 7 subdivision where the rehabilitated coal stockpile lands are currently being used for construction related stormwater management.
- Drainage from the former stockpile areas is collected into stormwater drains and ponds located along the southern side of the east-west elevated unpaved roadway. The ponded waters are then piped under the roadway into another series of small dams also strung along the north side of the roadway.
- At least three of the small dams located in Sub-catchment 3 (and currently draining the Stage 7 development area) are connected in-series down-slope from west to east, prior to final discharge to the Sub-catchment 3 drainage line.
- The WMup dam is piped under the road to a single dam below (north of) the road and this latter dam appears to drain directly down to the Sub-catchment 3 drainage line. There is probably a break in the pipe that has resulted in a spring flow located in the roadway (site WMsp).
- Drainage line WS was inspected in August 2016 and currently takes drainage from the partly disturbed vegetated lands immediately east of the Stage 6 lands. The Stage 6 lands are isolated from the creek via bunding that directs flow west and north to the construction stormwater dam. The stormwater dam has a high-level overflow structure that drains to Creek WS.
- The WTP 'wet' discharge is to be made to the small feeder creek labelled WMup in Figure 2. This creek-line has been modified by previous mine discharge flows to a uniform U shaped drainage line with no permanent pools and little ability to store runoff water post-storms. Accordingly it does not provide aquatic habitat for the support of aquatic macroinvertebrates, fish or other aquatic fauna such as amphibians.

Sub-catchment 5:

- There are two drainage lines in this sub-catchment running south to north from the development on the ridge. The western drainage line (UW) directs flow emanating from the houses along the west side of Clarke Street and the eastern drainage line (UE) receives flow emanating from the houses along the east side of Clarke Street.
- The UW drainage line has been diverted and piped under the western end of Lindsley Street and there is an area of swampland in the creek above the Lindsley Street drain. There was at least one property pumping water for irrigation out of the upper part of this swamp during both spring sampling days.
- The UE drainage has been substantially modified as it traverses close to property boundaries south of Lindsley Street and becomes an open grassy drain from Lindsley Street to the main creek confluence.

Main Creek from CKmid to LG:

- The main creek below the confluence of Sub-catchments 2, 3 and 4 is around 6-10 m wide and up to 0.5 m deep (average 0.25 m deep). It would appear to be perennial, seldom drying out (see Figures 4 to 6).
- It is not clear whether there are swampy areas in the upper catchments but if they exist they are likely to be short and narrow rather than wide and circular. Notwithstanding, there would appear to be sufficient well-forested catchment area to sustain long-tail surface flows after rainfall with extended subsurface flows during extended droughts.
- It would appear that the check drain and pond system used for the former coal-stockpile runoff control are working to the extent of limiting sediment movement into the lower creek at least down to CKmid.
- At and beyond CKmid the creek is substantially in-filled with sand mainly derived from erosion from the north-south dirt road that traverses the creek at CKmid. This road is used and substantially destabilised by off-road motorbikes (see Figures 7 to 9).
- There is an area of freshwater Paperbark and *Gahnia* swamp located off the main creek line with an approximate boundary indicated in red in Figure 10. It is likely the swamp receives runoff from the NW creek sub-catchment and the swamp includes portions of *Coastal Sand Mahogany-Paperbark Swamp Forest EEC*.
- There is further *Gahnia*, small leafed paperback and *Phragmites* fresh to brackish water swamp further downstream beside the creek and connected upstream to the NE drainage. The approximate boundary is shown in yellow in Figure 10.
- The creek drains to a small brackish lagoon above the Flowers Road Crossing that is bounded by *Phrgamites* as indicated in blue in Figure 10. This small lagoon is not listed in the Roper et al (2011) condition survey of NSW Estuaries and Coastal Lakes. It is degraded and substantially in-filled by sand brought down from the creeks and brought in by high seas and tides. At the time of inspection in August 2016, there was still substantial indication of storm wave ingress into the lagoon and up to the southern boundary of the property closest to the bridge. (see Figures 11 to 13).
- Whilst the brackish lagoon extends around 80m upstream from the eastern end of the road bridge to the top of the *Phragmites* bed, the actual open water section upstream of the bridge only extends 40m up and narrows quickly to around 1m at the creek connection (see Figure 11).
- Beyond the bridge there is a beach ponded water lagoon with a width of 10m under the bridge to 15 m width between the old rail bridge revetments (Figure 14). This ponded beach lagoon then meanders across the beach with the meanders varying from due north through east to due south before discharging to the sea.

At the August 2016 sampling, the beach lagoon was cut off from the sea and had formed to the north, with a high tide and wave overtopping back-flow channel located at the north end (Figures 15 and 16). In contrast, and from inspection of the 16 available Google Earth images between April 2005 and February 2016, the beach lagoon was generally orientated to ESE or SE with several of the earlier images showing a direct E channel. From inspection of the Google Images it was also noted that the beach lagoon was:

- Isolated at low tide for seven images with two full, four dry and one opened lagoon.
- The lagoon was connected to the sea eight times, with four of these indicative of high tide wave filling, two drained, one assisted opening and one filled from the catchment but not spilling.

It is clear the creek and lower lagoon discharges out over the beach and the waters are stored in a beach lagoon formed behind a beachfront wave berm. This breaks out when the catchment flow overtops the berm and drains either partially or fully depending on the flow event and prevailing tides/waves. The lagoon can also be refilled by overtopping waves that then flow back through the original discharge channel keeping it open. These conclusions are in line with the assessment undertaken by BMT WBM Pty Ltd (BMT WBM 20167 who concluded that the beach lagoon is open around 20% of the time, partially shoaled around 24% of the time, heavily shoaled for 29% and closed for 27% of the remaining time.

Figure 4 Creek WM just upstream of main creek confluence.

Figure 5 Main Creek WN just upstream of WM confluence.

Figure 6 Main Creek just upstream of CKmid.

Figure 7 Off-road motor bike erosion scars leading down to main creek at CKmid.

Figure 8 Large sand deltas accumulated in main creek. Note sampling net handle pushed 1m into sand delta.

Figure 9 Main creek at site CK01. The creek is broad but very shallow with accumulated soft sand.

Figure 10 Approximate boundaries of lower creek swamp lands. A freshwater swamp that includes segments of *Coastal Sand Mahogany-Paperbark Swamp Forest EEC* (red), a fresh to brackish water swamp around the lower portion of creek NE (yellow) and fringing *Phragmites* around the brackish lagoon (blue). There were no saltmarsh stands or patches found around the perimeter of the inner lagoon and there are no mangroves. There are also no seagrass beds, patches or any other submerged aquatic plants in the brackish lagoon waters or in the beach lagoon.

Figure 11 The brackish lagoon upstream of the bridge. Note deposits of pumice from the June 2016 storm on the southern bank, up to the property lawn. View is upstream to bend.

Figure 12 The upstream part of the lagoon chocked with *Phragmites* that was flattened by the heavy seas during the June 2016 east coast low storm. (View downstream to bend).

Figure 13 View of upstream section of lagoon this time looking upstream to indicate extent of wave penetration during the June 2016 storm.

Figure 14 Beach lagoon on 10 August 2016 – Bridge Section.

Figure 15 Beach lagoon on 10 August 2016. Note that waves are able to splash over into the lagoon at high tide.

Figure 16 Northern extent of beach lagoon on 10th August 2016 showing high tide wave return channel at north end of photo.

1.2 Catchment Water Quality

Water quality sampling data from within the local coastal area have been sourced to aid understanding of study area water quality within the downstream receiving environment.

1.2.1 Previous Water Quality Data

A Moonee Colliery water quality sampling dataset at the Flowers Drive bridge culvert site (W1) consists of 45 sampling events during the period 18 May to 1 December 2010. Sampling targeted licensed mine dam water discharges to the creek system in accordance with the now surrendered Environment Protection Licence 1558. Table 1 provides a statistical summary of the data.

Table 1 Mine Discharge Water Quality at Mine Site W1
Flowers Road Bridge May to December 2010

Statistic	Conductivity µS/cm	pH units	TSS mg/L	Turbidity NTU
Count	45	45	45	45
Min	132	5.8	0.5	6
Median	1040	6.2	4	20
Mean	2416	6.3	8.0	23.7
SE of Mean	586	0.0	1.9	2.3
95%ile	8620	6.68	18.2	51.4
Max	22300	7.1	81	73

Conductivity ranged from 132 to 22,300 µS/cm, and it is not clear from the data what influence, if any, there was from marine water ingress into the brackish lagoon. In order to check on this possibility, the full data set was expanded to include rainfall for the accumulated rain volume during the previous five days of each sampling event. The data were then sorted from high to low conductivity, and the dataset was then split at the median value with conductivity statistics calculated for each set. The low rainfall dataset has a mean rainfall of 8.1 mm (std dev = 1.6 mm) and a mean conductivity of 4,177 µS/cm (std dev = 1,087 µS/cm). The high rainfall dataset has a mean rainfall of 25.1 mm (std dev = 3.2 mm) and a mean conductivity of 746 µS/cm (std dev = 49 µS/cm). Because substantially higher conductivity levels were observed during low rainfall periods, there is likely to be some marine water ingress influence on the lower coastal creek.

Douglas and Partners (2010) conducted dry and wet weather water quality sampling (Table 2) at five sites shown in Figure 17. Sites W1, W2 and W3 are located at the Middle Camp Gully catchment, which is north of the study catchment. As the landscape is similar in elevation, geology and plant assemblages to the study catchment these data can provide a guide as to what would be expected from the study Sub-catchments 1 and 2. Sites W4 and W5 are located in the current study catchment, with site W4 equivalent to site NE (refer Figure 2), and site W5 is located at the dogleg in the lagoon upstream of site LG (refer Figure 2).
The Douglas and Partners (2010) results are summarised as follows:

- Conductivity is elevated in the catchment drainage lines at sites W2 to W4, where observations range from 390 to 930 μS/cm during dry weather and from 300 to 490 μS/cm during wet weather.
- Dry weather catchment drainage waters are generally more acid (4.9 to 5.9 pH units) than wet weather waters (6.8 to 6.9 pH units).
- Turbidity and TSS values were quite variable between sites and times.
- Dry weather catchment drainage water dissolved oxygen concentrations are generally lower (5.8 to 6.2 mg/L) than wet weather waters (7.8 to 9.2 mg/L).
- Catchment drainage water Total Nitrogen concentrations are all elevated and dry weather values are higher (1.4 to 2.5 mg/L) than wet weather waters (0.8 to 1.1 mg/L).
- Total Phosphorus concentrations were only available for the wet weather sampling and were uniformly elevated over both sub-catchments ranging from 50 to 80μg/L.
- Catchment drainage bacterial (*E.coli)* counts are generally low during dry weather and higher plus more variable during wet weather.

Table 2 Douglas & Partners (2010) Catherine Hill Bay Water Quality Sampling Results May and June 2007*

Site	Weather Condition	pH pH units	EC μS/cm	Eh mV	Temp °C	Turb NTU
W1	dry	6.2	2000	185	17.6	11
W2	dry	5.5	390	209	17.1	29
W3	dry	5.9	450	241	16.3	38
W4	dry	4.9	930	210	22.1	9.7
W5	dry	6	1710	102	18.2	13
W1	wet	6.9	6650	136	14.7	4
W2	wet	6.8	400	162	14	19
W3	wet	6.8	300	185	13.6	38
W4	wet	6.9	490	176	15.2	6.7
W5	wet	7	560	158	14.8	28
Site	**Weather Condition**	**TSS mg/L**	**DO mg/L**	**TN mg/L**	**TP mg/L**	**E.coli mpn100mL**
W1	dry	6	3.5	1.7		64
W2	dry	21	5.8	1.4		30
W3	dry	13	6.2	1.7		38
W4	dry	11	5.9	2.5	<0.5	137
W5	dry	8	4	0.8	<0.5	36
W1	wet	9	9.2	0.66	0.06	3450
W2	wet	6	8	0.8	0.05	614
W3	wet	30	7.8	1.1	0.08	91
W4	wet	9	8.4	0.8	0.05	2582
W5	wet	13	8	0.7	0.08	3744

Note * Site W4 is equivalent to This study Site NE and Site W5 is upstream of Site Lg

Figure 17 Douglas & Partners 2007 water-quality sampling sites

1.2.2 Water quality sampling for present project

Four water quality sampling events were undertaken for the present study. Creek waters were metered during the initial scoping study in August 2016 and additional sites were sampled and metered for water quality during the follow-up aquatic ecology survey in September 2016. Further metered water quality sampling was undertaken after a prolonged dry spell on 6 December 2016 and a final survey (metered and sampled water) was undertaken on 20 February 2017 following sporadic rainfall in the general area during the preceding week.

The combined results, including daily rainfall observations at Swansea, are shown in Appendix Tables A-1 to A-4 and water quality range results combining all the relevant available water quality data are summarised in Table 3 below.

Table 3 Southern Catchment Dry Weather Water Quality Summary

Catchments	Conductivity µS/cm	TDS mg/L	TN µg/L	TP µg/L	E.coli cfu/100ml
Catchment No 2 (site WN)	715	400	300	<10	16
Catchments No 3 and 4 (sites WM/WS)	246-609	100-300	500-1000	20	24-300
All Catchments 2,3 & 4, (CKmid, CK01)	532-808	400-510	350 - 550	<50 - 70	43 -1300
Urban Catchments sites (UW/UE)	245-416	100 - 300	700-800	10	35-910
Lower N Catchments (sites NW/NE/W4)	241-490	100	400-2500	<10 - <50	137
Upper Lagoon (sites LgUp & W5)	494-1710	420 - 500	800-1550	50	36- -922
Lagoon (Site Lg)	786-1243				230

1.3 Aquatic Ecology Sampling

The combined aquatic ecology monitoring investigation for the study area catchment endeavoured to answer the following questions:

- What are the ecological and riparian resources and attributes of the study area aquatic habitats?
- Do the creeks provide suitable fish passage?
- Do the aquatic resources provide suitable and sustained aquatic habitat for fish and other aquatic biota?
- Are there or is there a possibility that any protected or threatened aquatic species or communities could be residing within the study area, or could mammals such as platypus and Australian water rat utilise the aquatic resources of the study area?

1.3.1 Sampling Methods

Aquatic site condition is described using a standardised ranking of site habitat attributes that are then used to compile a stream site condition index. The method is based on the River-Creek-Environment (RCE) method developed by Petersen (1992), as modified by Chessman *et al* (1997) for the greater Hunter River catchment.

Aquatic macroinvertebrate assemblages were collected and sorted using the standardised National River Process and Management Program River Bio-assessment Manual methods (NRPMP 1994) as adapted for the National River Health Program (referred to as the AusRivAS method (Turak *et al* 2004, Chessman 2003b). The AusRivAS protocol provides a number of definitions of sites and habitats within sites for selection of sampling locations and recommends that, wherever possible, two habitats (riffles and edges) be sampled at each site. Given the location of a number of the study sites in reaches of creeks where there are no or at the most limited riffle sections available for sampling, it was decided that only pool 'edge' samples would be sampled, as riffle samples could not be guaranteed for all (or possibly even for most) sites at all sample times. Organisms are identified (as a minimum) to the appropriate taxa level as per AusRivAS protocols.

The results of the aquatic macroinvertebrate sampling are used to calculate site taxa diversity (number of individual AusRivAS taxa) and a site SIGNAL score, where SIGNAL (Stream Invertebrate Grade Number Average Level) is a pollution tolerance index for stream macroinvertebrates (Chessman 1995). The water chemistry attributes used for determining SIGNAL scores are temperature, turbidity, conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorus (Chessman 2003a). Site SIGNAL Indices are graded into the following general categories (Chessman *et al*. 1997):

- SIGNAL Index > 6 = Healthy Unimpaired
- SIGNAL Index 5-6 = Mildly Impaired
- SIGNAL Index 4-5 = Moderately Impaired
- SIGNAL Index < 4 = Severely Impaired.

At each macroinvertebrate sampling site fish bait traps (dimensions 250 mm by 250 mm by 400 mm, 4 - 5 mm mesh size and 50 mm diameter entrance) were deployed for the duration of the sampling event or for a minimum of two hours whichever is the greatest. Captured fish are identified in situ and released. Any fish caught or observed as part of the macroinvertebrate dip net sampling are also identified, noted and released.

1.3.2 Catherine Hill Bay Aquatic Ecology Survey Results Spring 2016

Sampling for the Spring Catherine Hill Bay aquatic ecological monitoring survey was undertaken on the 10^{th} of August (fish sampling only) with aquatic macroinvertebrate and additional fish sampling undertaken on 30^{th} September 2016. Field notes, site locations and descriptions for all study sites are presented in Appendix Table A-5. Appendix A also includes site photographs showing site conditions during the September 2016 survey.

Full site habitat condition (RCE) data sheets are presented in Appendix Table A-6, and site aquatic habitat conditions are summarised in Table 4 below:

- The overall aquatic habitat condition of the lower Catchment 2 site WN was good at 72% (from a possible 100%).
- Catchment 3 Discharge-site WM had a similar RCE score of 69.2%, with the lower score resulting from the accumulated sediments in the stream bed.

- The CKmid site had a lower (fair) score of 62.5% resulting from both lower riparian vegetation condition and the existence of deep sandy bed sediments, as this site is located close to the eroding north-south traverse road.
- The lower CKdn site is in marginally fair condition (50%). It scored low on riparian vegetation as it is located adjacent to cleared and weed infested urban lands on the south bank and has a very shallow muddy sediment bottom.

Table 4 Summary of RCE Results Spring 2016

	WM	WN	CKmid	CKdn
Land-use pattern beyond immediate riparian zone	3	3	3	1.5
Width of riparian strip-of woody vegetation	4	4	3	2
Completeness of riparian strip of woody vegetation	3.5	3.5	2	1
Vegetation of riparian zone within 10 m of channel	3	3	3	2.5
Stream bank structure	3	3	3	3
Bank undercutting	2.5	2.5	2.5	2.5
Channel form	4	4	4	4
Riffle/pool sequence	2.5	2.5	2	2
Retention devices in stream	2	2	1	1
Channel sediment accumulations	0	2	1.5	0
Stream bottom	2	1	1	0
Stream detritus	2.5	3	3	3
Aquatic vegetation	4	4	3.5	3.5
RCE Score	36	37.5	32.5	26
RCE %age	69.23	72.12	62.5	50

Table 5 Summary of Fish & Macroinvertebrate Sampling 30 September 2016

Site	WM	WN	CKmd	CKdn
Striped Gudgeon	x	√	√	√
Macroinvertebrate Diversity	7	9	13	13
Site SIGNAL Index	3.57	5.22	3.75	4.62

Full aquatic aquatic macroinvertebrate sampling results are shown in Appendix Table A-7 and Table 5 provides a summary of fish and macroinvertebrate sampling results.

Results are summarised as follows:

- There were 24 taxa identified for the aquatic macroinvertebrate sampling program, 19 insect taxa, two crustaceans, two molluscs and an oligochaete worm.
- In terms of individual taxa pollution sensitivity 23 of the 24 had SIOGNAL scores assigned. There were three sensitive taxa (SIGNAL indices 7 or 8 out of 10), six relatively sensitive (SIGNAL indices 5 to 6) and 14 relative insensitive taxa (SIGNAL indices of 1 to 4).

- Whilst individual site diversities were relatively low (ranging from seven taxa at site WM to 13 taxa at CKdn), the site WN SIGNAL score of 5.22 was in the 'mildly impared' range, site CKdn at 4.62 was in the moderately impared range whilst the two remaining site SIGNAL scores of 3.75 at site CKmd and 3.57 at site WM were in the severely impacted range. This is consistent with the site RCE scores assessed above that identified excessive sedimentation by muddy sediments at site WM, and by sand at site CKmid.

Four fish bait-traps were deployed on 10 August - two in the lagoon above the bridge, and one each at sites CKsm and CK01. Four fish bait-traps were deployed on 30 September, where traps were set at the four aquatic macroinvertebrate sampling sites. All fish captured were identified and released. There were fish captured at all sites except site WM, and three native fish were identified:

- Striped Gudgeons *Gobiomorphus australis* were found at all freshwater sites on both sampling occasions, but were not found at the lower estuarine site at the Lagoon Bridge.
- Flathead Gudgeons *Philypnodon grandiceps* and Common Jollytail *Galaxias maculatus* were caught in both lagoon traps set on 10 August 2016.
- There were no introduced fish caught or seen, and the catchment is exceptional in that the listed pest species Plague minnow *Gambusia holbrookii*, which is almost endemic throughout the waterways of NSW, was not found.
- Frogs were heard at most of the creek sites above (and including) site CKdn on both occasions. Analysis of recordings indicated only one species *Crina signifera*, the common eastern froglet. No tadpoles were noted or caught.

1.3.3 Aquatic Ecology Summary

In terms of the original study questions:

What are the ecological and riparian resources and attributes of the study area aquatic habitats?

- The study area catchment supports a network of well-forested streams with excellent native riparian vegetation and areas of freshwater swamp all draining to a small estuarine lagoon that is not generally tidal and is choked with marine and catchment sourced sandy sediments. There is an intermittent beach lagoon east of the road bridge.
- The small estuary section west of the bridge can be considered a degraded ICOLL by virtue of the infilling with sediments. Even though it is very small and not very complex, it still provides habitat for fish, macroinvertebrates and emergent macrophytes.

- The lagoon is relatively close to, and connected to freshwater wetlands in the lower main creek around the confluences of the two low elevation northern creek sub-catchments (NE and NW) and therefore retains the important function of a transition zone for fish migrating to and from the catchments to the ocean via the intermittent beach lagoon.

Do the creeks provide suitable fish passage?

- The main creek draining Sub-catchment 2 and extending through to the estuary is permanent and is expected to provide more or less permanent fish passage except under severe prolonged drought.
- The smaller creeks in Sub-catchments 3, 4 and 5 do not provide permanent fish passage but could provide fish passage during prolonged wet weather and could enable some species to reach the lower parts of the network of small water quality dams remaining from previous coal stockpile water control.
- It is unlikely that creeks in the smaller sub-catchments (Sub-catchments 1 and 5) would provide fish passage except under prolonged wet weather events. Notwithstanding, there are additional freshwater swamp areas around the lower sections of Creeks NW and NE (in Sub-catchment 1) and around the lower section of UW that provide suitable fish habitat and there is adequate fish passage from the main creek to the NE and NW swamps as well. Fish passage to the UW creek would be very infrequent.

Do the aquatic resources provide suitable and sustained aquatic habitat for fish and other aquatic biota?

- Aquatic habitat condition for most of the sites located on, or clustered around the main creek and its confluences, was fair to good overall and sufficient to support a reasonably diverse aquatic assemblage. However there are some water quality constraints relating back to catchment attributes (moderate conductivity and TDS, slightly acid pH, elevated nutrients) and land use attributes (uncontrolled access to dirt roads leading to instability and consequent large sediment loads transported to the main creek during wet weather).
- As a result there were less pollution-insensitive species of macroinvertebrates and fish found, and lower than expected SIGNAL indices for most sites below WN.
- The accumulation of muddy sediments at site WM would indicate that there is not sufficient scouring flow during wet weather events to mobilise these sediments, and this may be due to the network of water quality control ponds in the top section of Creek WM below the old stockpile east-west dirt road, that contain and prevent runoff to the creek during rainfall.

Are there or is there a possibility that any protected or threatened aquatic species or communities could be residing within the study area, or could mammals such as platypus and Australian water rat utilise the aquatic resources of the study area?

- This study has concentrated on investigation of the water quality and ecology of the lower main creek area below sites WN and WM in Sub-catchments 2 and 3 in Figure 2. The extent and precise nature of the swampy areas identified adjacent to the main creek below site CK01 in Figure 2 have not been quantified for this study and there remain further possibilities that there are additional swampy areas in the creek lines of Sub-catchment 2.
- In regard to protected or threatened aquatic species, the overall aquatic site condition information for the freshwater creek and the small estuarine section plus the aquatic macroinvertebrate and fish sampling data would indicate that the lower creek section is unlikely to support threatened aquatic species. Nevertheless, there could be suitable aquatic habitat in upstream swampy pockets that could support some threatened species. This would require further investigation.
- The study area is unlikely to support platypus, but the lower sections around the lagoon provide suitable habitat for Australian Water Rat.

2 IMPACT ASSESSMENT & MANAGEMENT

2.1 Project Description in Relation to Potential Aquatic Ecology Impact

The proposal under consideration is described in ADWJ (2017) and is summarised as follows:

- The WTP produces recycled water to the most stringent 'fire fighting' standard in accordance with Table 3.7 of the *National Guidelines for Water Recycling* - see reference to Biotext *et.al* 2006 in ADWJ (2017). Recycled water is used by households for toilet flushing, hard plumbed laundry washing machine use, outdoor cleaning and wash down, plus irrigation of household lots and footpaths.
- When demand for recycled-water falls below supply, *surplus-to-demand recycled water* is generated. This is to be directed to a sub-surface flow wetland, as described in Whitehead & Associates (2017).
- Outflow from the sub-surface flow wetland is termed *wetland-treated recycled water*. This water is stored on-site in tanks (total 3 ML storage capacity post-wetland, with a further 2 ML pre-wetland to aid control of wetland inflows) until it can be released with stormwater at the outlet of Stages 6-7. This is termed *'wet' discharge*. The ratio of released *wetland-treated recycled water* to stormwater is based on catchment stormwater flows measured at the *downstream mixing point A,* which is defined as the point in the catchment where the *wet discharge* channel discharges to and mixes with additional sub-catchment waters. This point is located in Sub-catchment 3/4, and immediately upstream of the confluence with Sub-catchment 2 (see Figures 1 and 2). The catchment area at the *downstream mixing point A* is 40.5 ha, comprising 15.2 ha of Stage 6-7 plus 25.3 ha external forested area.
- The ratio of *wetland-treated recycled water* release to stormwater is 1:1 at *downstream mixing point A, in accordance with the model presented in ADWJ (2017).*
- During the 35 years model simulation period (1974 to 1988), an average of 33.5 ML/yr of *wetland-treated recycled water* is produced, of which an average of 32.8 ML/yr is able to be released under *'wet' discharge* conditions.
- The release of *'wet' discharge*s will occur at the approved stormwater outlet structure located at the north facing edge of Stage 6 and will enter directly into WM creek in Sub-catchment 4 (see Figure 2).
- *'Wet' discharge* of *wetland-treated recycled water* is predicted to occur during all months of the year, with largest average releases occurring during periods of low evaporation and low water re-use by irrigation, which is more likely to occur during the colder months between May and August each year.
- During prolonged dry periods when storage tank capacity is reached and no opportunity exists for '*wet' discharge* in conjunction with stormwater, '*dry*' *discharge* of *wetland-treated recycled water* occurs. The *wetland-treated recycled water* would then be piped directly from the storage tanks and discharged via the approved stormwater outlet at

Lindsley Street easement into the lower lagoon. Based on the ADWJ (2017) assessment, average *'dry' discharg*e is estimated to be 0.7 ML/yr.

2.2 Management of Construction Related Impacts

Potential impacts relating to construction of discharge infrastructure include:

- loss of upper creek discharge line (creek WM) habitat due to construction of a suitable discharge structure/energy dissipater for '*wet' discharge*;
- potential impacts arising from the construction of the '*dry' discharge* pipeline between the WTP and lagoon discharge outlet.

It is understood that '*wet' discharge* will occur adjacent to the location of Stages 6 and 7 stormwater releases. The current subdivision approval includes construction of a suitable stormwater structure/energy dissipater to facilitate flow discharge to creek WM. It is assumed there are no additional risks of habitat loss for the addition of a '*wet' discharge* outlet at the same location.

Construction related impacts on aquatic habitats and biota from construction of the '*dry' discharge* pipeline has been *avoided* by ensuring the pipeline and discharge are incorporated into existing road drainage easements and stormwater outlets. Discharge impacts to the lagoon can be *mitigated* by incorporating suitable erosion controls, particularly within the riparian zone of the Lindsley Street easement below the stormwater discharge structure.

2.3 Model Estimates of Flow and Pollutant Change

To enable assessment of the potential impacts of altered discharge flows and water quality on the main creek downstream of Stages 6 and 7, ADWJ (2017) has undertaken modelling of flows and nutrient loads through to the lower lagoon at the south end of Catherine Hill Bay beach using MUSIC. In addition, a separate constructed sub-surface flow wetland nutrient and flow model was developed based on the wetland model of Whitehead & Associates (2017). Modelling was performed for a 35-year period (1974 to 2008) for the following development scenarios:

- The present *approved development* that comprises the entire 188 ha catchment to the un-named creek system with Stages 6 and 7 of the *Beaches* development in its current approved form (which includes household rainwater tanks).
- The *proposed development* is based on the above, with the following changes:
    - Increased flow volumes from modification to approved Stages 6 and 7, whereby household rainwater tanks are not permitted (to encourage re-use of recycled water by households); and

- Increased flow volumes through discharge of *wetland-treated recycled water* including:
  - *'Wet' discharge* piped directly to the stormwater outlet of Stages 6 and 7 and released in conjunction with stormwater flows.
  - *'Dry' discharge* piped directly to the lagoon during no stormwater flow conditions.

The ratio of *wetland-treated recycled water* release to stormwater is 1:1 at downstream *Mixing Point A:*

- During the 35 years model simulation period (1974 to 1988), an average of 33.5 ML/yr of *wetland-treated recycled water* is produced, of which an average of 32.8 ML/yr is able to be released under *'wet' discharge* conditions, and an average of 0.7 ML/yr released under *'dry' discharge* conditions.
- *'Wet' discharge* of *wetland-treated recycled water* is predicted to occur during all months of the year, with largest average releases occurring during periods of low evaporation and low water re-use by irrigation, which is more likely to occur during the colder months between May and August.
- *'Dry' discharge* of *wetland-treated recycled water* is predicted to occur only during May to October when recycled water usage by households is lowest, and the opportunity to reduce on-site storage is not always possible via a 'wet' discharge.

ADWJ (2017) predicted mean concentrations and annual loads of nutrients, TSS and TDS are shown in Table 6 for the 40.5 ha catchment draining to downstream *Mixing Point A*. Equivalent data are shown in Table 7 for the 188 ha lagoon catchment. Whitehead & Associates (2017) estimates of pollutant concentrations in wetland outflows are incorporated into the *proposed* development scenario. The wetland inlet concentrations adopted by ADWJ (2017) for the assessment are based on average outlet concentrations from the membrane bioreactor at the WTP, coupled with an average flow rate of 139.1 kL/day, which represents the highest monthly flow period (determined to be the winter month of June).

2.3.1 Assessment of Potential Impacts of Increased Discharge Flows

The potential for destabilisation of creek/lagoon beds and riparian banks arising from the intermittent 'wet' discharge of wetland-treated recycled water into creek WM or 'dry' discharge directly to the lower lagoon are assessed as follows:

- Creek WM has historically functioned as a carrier drain for Moonee Colliery coal stockpile stormwater discharge. The physical character of this drainage line is likely to have already adapted to carry stormwater flows similar to those predicted for the proposed development.

- This finding is in line with observations of the channel dimensions at the confluence with the main creek, which found the channel to be wide and box like, relatively deep and filled with fine sediment.
- These characteristics are consistent with historical high flow volumes from active coal stockpile operations, followed by lower flow volumes since mining cessation and stockpile area rehabilitation. As such, the potential risk is considered low for physical destabilisation of creek WM arising from the proposed development.
- In terms of physical scouring impacts further downstream of creek WM extending to the lagoon, it is considered that the changes to overall flow characteristics as described above would not alter the *approved* stormwater flow characteristics to an extent that would cause discernible change to creek bank and bed form at these locations, and there would not be exacerbated scouring. This finding is in line with that of BMT WBM (2017) who assessed potential hydraulic change impacts arising from the proposal and concluded that whilst the proposal resulted in greater flows, there was minimal change to the actual catchment flow duration characteristics.

Table 6 Predicted Water Quantity & Quality for Currently Approved Development vs Proposed Development at Downstream *Mixing Point A*

Parameter	Units	Approved	Proposed	% increase
Flow	ML/day	0.327	0.452	38
Flow	ML/yr	119.2	165.0	38
TN mean	mg/L	1.57	1.96	25
TN Annual Load	kg/yr	202	323	60
TP mean	mg/L	0.118	0.128	8
TP Annual Load	kg/yr	15.1	21.1	40
TSS mean	mg/L	29.3	24.6	-16
TSS Annual Load	kg/yr	3,790	4,060	7
TDS mean	mg/L	200	359	80
TDS Annual Load	kg/yr	25,800	47,500	84

- In terms of impacts on beach lagoon opening and closing, BMT WBM (2017) concluded that the *proposed* development would only have an impact on entrance conditions when moderate to high additional discharges occur during periods of low rainfall and catchment runoff. The impact under those conditions would be greatest when the entrance is closed or heavily shoaled, as the increased creek level may cause a closed entrance to overtop and open, or shoaled channel to scour. If realised, it is considered that such conditions would occur infrequently (about 1% of the time on average) and their overall consequence to beach morphology and coastal processes would be minor.

Table 7 Predicted Water Quantity & Quality for Currently Approved Development vs Proposed Development at the Lagoon

Parameter	Units	Approved	Proposed	% increase
Flow	ML/day	1.27	1.40	10
Flow	ML/yr	465.0	511.5	10
TN mean	mg/L	1.22	1.38	13
TN Annual Load	kg/yr	566	704	24
TP mean	mg/L	0.130	0.132	2
TP Annual Load	kg/yr	61	67.6	12
TSS mean	mg/L	51.3	47.9	-7
TSS Annual Load	kg/yr	23,900	24,500	3
TDS mean	mg/L	200	252	26
TDS Annual Load	kg/yr	93,000	129,000	39

- In terms of impacts on beach lagoon opening and closing, the BTM WBM (2017) report concluded that the *proposed* development would only have some impact on entrance conditions where moderate to high additional discharges occur during periods of low rainfall and catchment runoff. The impact under those conditions would be greatest when the entrance is closed or heavily shoaled, as the increased creek level may cause a closed entrance to overtop and open, or shoaled channel to scour. If realised, it is considered that such conditions would occur infrequently (about 1% of the time on average), their overall consequence to beach morphology and coastal processes would be minor, would not result in any adverse impact on the aquatic ecology of the lower creek or on the lagoon located above the road-bridge box culvert, and may have a beneficial impact by allowing fish passage to and from the lagoon during times when the beach lagoon would otherwise remain closed for an extended period.

2.3.2 Assessment of Magnitude of Water Quality Changes

As would be expected with the addition of *wetland-treated recycled water* to stormwater discharges from the development and surrounding forested areas, pollutants levels are expected to increase at downstream *Mixing Point A* (Table 6). However, based on the predicted water quality changes, there will be only a relatively modest increase in mean TN concentration, minor change to mean TP concentration and a decrease in TSS mean concentration. Whilst modelled mean TDS concentrations would increase by 80%, the modelled resultant mean TDS concentration of 360 mg/L remains lower than the measured receiving creek TDS of 400 mg/L (refer Table 3).

Pollutants levels are also expected to increase at the brackish lagoon (Table 7). The changes are more modest than those at the downstream *Mixing Point A* due to increased dilution by the increased catchment area. As such, the increases are all considered minor.

2.4 Potential Impacts on Aquatic Ecology

As described in Section 2.1 and discussed in Section 2.3, the proposed *'wet discharges'* will occur in conjunction with stormwater flows and will not result in any significant change to flow duration characteristics of the catchment. Mean daily flow (as modelled for the lagoon – Table 7) increases from 1.27 to 1.40 ML/day, which equates to a 10% increase relative to the *approved* development. Whilst this will result in more frequent flow events down the discharge creek WM, likely resulting in longer duration ponding in that creek than at present, once the discharge waters reach the main creek and combine with the main flow from Sub-catchment 2 there is not likely to be any discernible change to pool widths and depth downstream to the brackish lagoon. Based on these estimated flow volume changes, it is concluded that increased creek and lagoon flows would have a neutral impact on aquatic habitats and ecology, and is instead more likely to have a beneficial impact by providing additional makeup water to sustain creek ponds and the upper lagoon during longer dry spells between rainfall events.

As indicated from the combined water quality and aquatic ecology sampling results provided in Sections 1.2 and 1.3, the creek aquatic ecology downstream of Mixing Point A and in the vicinity of the urban areas is already compromised by elevated nutrients and suspended solids resulting from uncontrolled erosion of forest tracks plus urban derived run-off and septic tank overflows. Accordingly, the assemblages of fish, aquatic plants and macroinvertebrates in the lower creek and the lagoon are characterised as relatively pollutant tolerant. The incremental changes from the *approved* discharge water quantity and quality to the *proposed* discharge water quantity and quality are not considered of sufficient magnitude to cause any measurable change in the overall aquatic habitat condition or aquatic assemblages.

As indicated from the combined water quality and aquatic ecology sampling results provided in Sections 1.2 and 1.3 above, the creek aquatic ecology in the vicinity of the urban areas is already compromised by elevated nutrients and suspended solids resulting from uncontrolled erosion of forest tracks plus urban derived run-off and septic tank overflows. Accordingly the assemblage of fish, aquatic plants and macroinvertebrates in the streams below the proposed *wetland-treated recycled water* discharges (i.e., in the lower creek and the lagoon) is characterised as a relatively pollutant tolerant assemblage. The incremental changes from the *approved* discharge water quantity and quality to the *proposed* discharge water quantity and quality is not considered great enough to result in any measurable change in the overall aquatic habitat condition or aquatic assemblages that occur in the lower creek and lagoon.

2.5 Additional Mitigation Measures

As noted in Section 2.4, the lower creek ecology is already compromised by (i) existing catchment activities including excessive track erosion from uncontrolled trail riding resulting in large sediment deposits in both the lower creek and the brackish lagoon and (ii) from additional nutrient inputs arising from sewage overflows from the existing Catherine Hill Bay urban area. The proponent should be able to assist in mitigating or remediating some of these impacts and it is recommended that the proponent:

- Ensure that access to motorised vehicles into existing trails from the development is controlled and/or strictly limited.
- Work with OEH and the Community to establish controls to limit continuing erosion from track use including measures such as limiting access plus undertaking active track erosion control works.
- Work with OEH to explore remediation options for removing excess sediments from the brackish lagoon.
- Investigate options for additional sediment control into the creek from the small urban catchments.
- Undertake lagoon riparian edge weed eradication works at the Lindsley Street stormwater discharge easement.
- Work with the community to minimise sewage overflows by encouraging connection of the existing urban areas to the *Beaches* TP.

2.6 Management and Monitoring Requirements

As discussed in Sections 2.2 and 2.3, whilst the potential for physical harm to aquatic habitats and biota arising from construction activities and increased discharge flows is considered low residual risk can be minimised by adopting the following management measures during the early stages of the development:

- Creek WM and the main creek line leading to the lagoon will require visual inspection monitoring to ensure timely remediation works can be instigated if localised bank or bed erosion is noted; and
- The proponent should prepare a Discharge Structure and Creek Stabilisation Management Plan that sets out (i) a monitoring regime covering discharge structures and creek/lagoon performance in regard to bank stability and erosion, and (ii) criteria for instigation of stabilisation works and remediation actions that could be implemented.

Based on assessment of the modelled water quality and quantity results (Sections 2.4 and 2.5) it is concluded the *proposed* development would not have a measurable impact on the aquatic ecology of the lower creek and lagoon over that of the *approved* development scenario. It is recommended that these predictions be tested against a water-quality monitoring program (to validate the modelled water quality and quantity results). It is also recommended a stream health (aquatic ecology) monitoring program be enacted to ensure unexpected impacts to aquatic ecology do not arise. The proponent should prepare a Water and Aquatic Ecology Monitoring Program to include:

- Regular (say monthly initially) sampling of three sites around *Mixing Point A* - the discharge waters in Creek WM, and sub-catchment 2 waters above *Mixing Point A* and the combined waters below *Mixing Point A* (but upstream of urban and track erosion influences).
- Discharge event monitoring of the Wet Weather Discharge sites (at least during and after discharge).
- Event monitoring of lagoon waters up- and downstream of the *Dry Weather Discharge* (two sites) prior to, during and after dry weather discharge events.
- Bi-annual (spring and autumn) stream health sampling at the above water quality sites using similar methods to those outlined for this present study in Section 1.3.1 above.

The above program should be undertaken over sufficient events to validate the modelling and provide operational results for the Proponent against which the effectiveness of the WTP and wetland can be measured. Should process remediation actions be required, the monitoring program should include a TARP (Trigger, Action, Response Plan).

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CATHERINE HILL BAY AQUATIC ECOLOGY

APPENDIX A

FIELD NOTES, SITE PHOTOGRAPHS AND SAMPLING DATA – SPRING 2016

Table A-1 Swansea Daily Rainfall Jan to Dec 2016

Table A-2 Metered Dry Weather Water Quality August to December 2016

Table A-3 Field Notes – Spring 2016 Survey

Table A-4 Site Sampling Schedule Spring 2016

Table A-5 Site RCE Inventory

Table A-6 Macroinvertebrate & Fish Survey Results

September 2016 Aquatic Ecology Site Field Photographs.

September 2016 and February 2017 Laboratory Water Quality Analysis Reports

Appendix Table A-1 Daily Rainfall (mm to 9am) at Swansea BoM Gauge located 6.4km north of Catherine Hill Bay (Jan 2016 to Feb 2017)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
1	0	0	1	0	1.6	59.2	0	0	0	0	0	1	0.8	12
2	0	0	0.2	0	10.6	0.2	0	0	7.8	0	0	2.6	5.2	3.8
3	0	0	0	0	0	0	0	16.8	7.6	0	0	0	0	0
4	50.4	13.2	0	0	0	12.2	0	14.4	0	0	0	0	0.8	11.2
5	55.4	6.6	0	0	0	100.4	1.8	8.2	0	0	0	0	3.4	0
6	141.8	1.2	0	0	0	0	0	3	0	0	0	2.2	0.8	0
7	44.2	0.2	0	0	0	0	4.8	3	0	0	0	21.6	0	0
8	0	0	0	1.4	0	0	16.2	6.6	0	0	0	0	0	3.4
9	0	0	0	2.4	0.6	0	12.8	0.2	0	0	1.4	3.2	0	0
10	0	0	0	0	0	0	0.4	0	1.2	0	4.6	0	0	0
11	0	0	0	0	0	0	0	0	0	5	0	0	0	0
12	1.8	0	0	0	0	0	0	0	0	0	26.4	0	0	0
13	0	0	0	0	0	0	0	0	0	6	0.6	0	0	0
14	0	0	0	1	0	3	0	0	10.4	20.4	0	0	0	0
15	33.4	0	2	0	0	0	0	0	0	0	4.6	0	0	18.2
16	20.6	0	5.2	0	0	0	0	0	1	0	0	0	0	0
17	5	1	36	0	0	0	5	0	0	0	1.4	0	0	0
18	0.4	0	1	13.8	0	2.6	0.8	0	0	4.2	1.2	0	0	0
19	0	2.4	1	0.2	0	2	0	0	20.2	0	0	0	0	1.4
20	0	1.8	0	0	0	53	14.8	0	0	0	0	0	0.2	0.2
21	0	1	22.6	0.2	0	0.4	14	0	0	0	0	0	8	0
22	8.2	0	9.8	0	0	0	0	1.8	3	28.6	4.2	0	0	0
23	33.2	0	1.8	10.4	0	0	2.2	0	0	10.2	0	0	0	0
24	0.4	0	0	5.2	0	0	0	6	0	0	0	0	0	0
25	0	0	0	0	0	0	0	7.6	3.6	0	0	0	41.8	0
26	0	0	0	0.4	2	0	0	3	2.6	0	0	0	1	11.2
27	0	0	0	0	2	0	0	21.4	0	0	0	0	6	3
28		0	0	0	0	0	0	0	0	6	0	0	0	36.8
29	3.4	0	0.2	0	0.2	0	0	0	0	1	0	0	0	
30	0		2.6	0	0	0	0	0	3	0	0	0	0	
31	0		0		0		0	0		2		0	0	
Total	398.2	27.4	83.4	35	17	233	72.8	92	60.4	83.4	44.4	30.6	68	101.2

Table A-2 Metered Dry Weather Water Quality Results - August to Decemnber 2016

Site	Date	Time	Depth (m)	Temp °C	Conduct μg/L	TDS mg/L	DO %sat	DO mg/L	pH units	ORP mV	Turb NTU
WMup	10/08/16	16:45	0.1	15.6	609		32.6	3.2	6.16	590	84.7
WMsp	10/08/16	16:41	0.1	13.02	612		14.8	1.6	6.28	586	16.4
WM	30/09/16	11:30	0.2	14.92	484	300	67.2	6.8	5.96	310	4.7
WSup	10/08/16	16:28	0.1	13.95	501		50.1	5.2	5.72	577	19.3
WS	30/09/16	10:56	0.1	16.04	246	100	57.8	5.7	5.68	439	6.9
WN	30/09/16	1:13	0.1	15.00	715	400	88.4	8.9	6.51	353	62.8
CKmid	10/08/16	14:33	0.1	13.27	532		97.2	10.2	6.84	561	9.1
CKmd	30/09/16	12:40	0.2	14.98	666	400	90.0	9.1	6.46	343	93.4
CKmd	06/12/16	18:00	0.1	21.31	806	510	32.8	2.9	6.51	341	3.4
CKmd	06/12/16	18:00	0.2	21.17	799	500	32.6	2.89	6.46	345	3.6
CKmd	20/02/17	8:25	0.1	19.14	808	500	21.6	1.99	6.43	312	4.4
CK01	10/08/16	14:00	0.1	13.33	527		96.8	10.1	6.74	543	43.8
CK01	06/12/16	18:06	0.1	21.99	787	490	35.7	3.12	6.48	362	8.4
CK01	06/12/16	18:06	0.2	21.95	783	500	35.5	3.1	6.47	364	8.7
CK01	20/02/17	8:26	0.1	19.3	781	490	35.6	3.28	6.46	330	109.1
UW	10/08/16	13:47	0.1	13.26	346		74.6	7.8	6.47	562	29.2
UW	30/09/16	2:09	0.1	14.65	416	300	60.0	6.1	5.87	426	28.1
CKuw	10/08/16	13:35	0.1	12.37	380		53.9	5.8	6.77	544	13.0
NW	30/09/16	3:41	0.1	14.29	241	100	41.2	4.2	5.23	465	33.2
FWsw	10/08/16	13:16	0.1	10.82	663		16.6	1.8	6.01	519	33.5
CKdn	10/08/16	13:11	0.1	12.45	490		81.5	8.7	6.85	489	35.9
CKdn	30/09/16	2:21	0.1	14.78	606	400	65.0	6.6	6.21	367	51.7
CKdn	06/12/16	18:16	0.1	20.98	667	420	13	1.16	6.28	365	7.5
CKdn	20/02/17	8:27	0.1	18.65	695	430	29.2	2.73	6.18	301	13.6
CKdn	20/02/17	8:27	0.2	21.45	766	470	59.1	5.21	6.87	326	19.7
UE	10/08/16	12:27	0.1	16.63	256		110.1	10.7	7.23	496	60.2
UE	30/09/16	2:58	0.1	17.16	245	100	80.1	7.7	6.74	432	34.2
LgUp	10/08/16	12:40	0.2	11.95	494		77.9	8.4	6.92	494	42.2
LgUp	06/12/16	18:40	0.1	20.29	668	420	3.4	0.31	6.57	349	11.7
LgUp	06/12/16	18:43	0.1	22.2	792	500	4.1	0.36	6.51	338	43.8
LgUp	20/02/17	8:27	0.1	21.52	766	470	58	5.11	6.84	326	16.7
LG	10/08/16	11:43	0.1	13.02	1243		68.0	7.1	6.74	408	22.9
LG	10/08/16	11:45	0.2	14.56	6898		99.2	9.9	6.67	441	43.6
LG	30/09/16	3:55	0.1	17.52	786	500	105.5	10.1	7.29	395	40.0
Input Creek Stats											
	Min			10.82	241	100	14.8	1.6	5.23	310	4.7
	Median			14.79	450	200	58.9	5.9	6.09	481	31.2
	Mean			14.96	425	217	61.5	6.2	6.17	476	34.5
	StDev of Mean			1.73	178	133	28.7	2.8	0.54	92	23.9
	80%ile			15.95	611	300	79.0	7.8	6.50	574	55.0
	Max			17.52	6898	500	110.1	10.7	7.29	590	84.7
Lower Main Creek Stats											
	Min			11.95	380	400	3.4	0.3	6.18	301	3.4
	Median			19.30	695	480	35.7	3.3	6.51	349	13.6
	Mean			18.06	674	464	48.6	4.8	6.57	389	28.4
	StDev of Mean			3.91	133	41	30.0	3.2	0.23	87	30.2
	80%ile			21.48	789	500	79.3	8.5	6.84	491	43.8
	Max			22.20	808	510	97.2	10.2	6.92	561	109.1

Appendix Table A-3 Field Comments –Spring 2016 Survey

Site	Date	Comments
WM	30/9/16	Water turbid and flowing through entire site length. Maximum depth was 0.7m with an average depth of 0.4m. Evidence of high flows with scouring on channel edges. No instream macrophytes. Orange precipitate present. Few log jams observed. Sediments were mostly comprised of silt with some sands and gravels found in the upstream section of site. No filamentous green algae present.
WN	30/9/16	Water clear and flowing throughout site. Canopy cover was high in most sections. Maximum depth was 0.5m with an average depth of 0.3m. no instream macrophytes were observed. Sediments were mostly made up of sands and gravels. No filamentous green algae present.
CKmd	30/9/16	Water was turbid with low flow. Channel dimensions: Maximum depth 0.9m with an average depth of 0.4m. Maximum width was 3.2m and average width was 2.2m. No instream macrophytes were observed apart from *Triglochin microtuberosa* (Water Ribbons). Channel basin had plenty of detritus along with some submerged sticks and logs. Sediments consisted of soft sand (unconsolidated) with lesser amounts of gravel. Habitats sampled were mostly leaf detritus, some trailing bank vegetation and undercut banks. No filamentous green algae was observed.
CKdn	30/9/16	Water turbid with no observable surface flow. Channel dimensions: Maximum depth 0.9m with an average depth of 0.5m. Maximum width was 2.5m and average width was 2.0m. Macrophytes observed: *Triglochin microtuberosa* (Water Ribbons), *Schoenoplectus validus* (River Club Rush), *Phragmites australis* (Common Reed). Sediments consisted mainly of silt, sands and gravel. Habitats sampled included leaf detritus, some trailing bank vegetation and undercut banks. Brown silt and algal matrix found throughout site. No filamentous green algae observed.

Table A-4 Catherine Hill Bay Site Sample Schedule Spring 2016					
Site	SDL	Chemical Water Quality	Macro & fish	Easting	Northing
WN	x	x	x	371523	6330374
WM	x	x	x	371519	6330344
WS	x	x		371566	6330319
CKmd	x		x	371670	6330375
UW	x	x		371818	6330379
CKdn	x		x	371910	6330488
UE	x	x		372016	6330429
NW	x	x		371796	6330541
NE	x			372076	6330610
LG	x	x		372120	6330504

Appendix Table A-2

Modified Riparian, Channel and Environment (RCE) Inventory (after Chessman et al 1997).

Descriptor						
	Category		SP16	SP16	SP16	SP16
		Value	WM	WN	Ckmd	Ckdn
1	Land-use pattern beyond immediate riparian zone					
	Undisturbed native vegetation	4				
	Mixed native vegetation and pasture/exotics	3	3	3	3	
	Mainly pasture, crops or pine plantation	2				
	Urban, some vegetation	1				1.5
	Industrial, little vegetation	0				
2	Width of riparian strip-of woody vegetation					
	More than 30 m	4	4	4		
	Between 5 and 30 m	3			3	
	Less than 5 m	2				2
	No woody vegetation	1				
	No Vegetation	0				
3	Completeness of riparian strip of woody vegetation					
	Riparian strip without breaks in vegetation	4				
	Breaks at intervals of more than 50 m	3	3.5	3.5		
	Breaks at intervals of 10-50 m	2			2	
	Breaks at intervals of less than 10 m	1				1
	No riparian strip at all	0				
4	Vegetation of riparian zone within 10 m of channel					
	Native tree and shrub species	4				
	Mixed native and exotic trees and shrubs	3	3	3	3	
	Exotic trees and shrubs	2				2.5
	Exotic grasses/weeds	1				
	No vegetation at all	0				
5	Stream bank structure					
	Banks fully stabilized by trees, shrubs, concrete	4				
	Banks firm but held mainly by grass and herbs	3	3	3	3	3
	Banks loose, partly held by sparse grass, rubble	2				
	Banks unstable, mainly loose sand or soil	1				
	Banks actively eroding	0				
6	Bank undercutting					
	None, or restricted by tree roots or man-made	4				
	Only on curves and at constrictions	3				
	Frequent along all parts of stream	2	2.5	2.5	2.5	2.5
	Severe; bank collapses common	1				
	Total bank collapse	0				
7	Channel form					
	Deep; width:depth ratio less than 8:1	4	4	4	4	4
	Medium; width:depth ratio 8:1 to 15:1	3				
	Shallow; width:depth ratio greater than 15:1	2				
	Artificial; concrete or excavated channel< 8:1	1				
	Artificial; concrete or excavated channel > 8:1	0				
8	Riffle/pool sequence					
	Frequent alternation of riffles and pools	4				
	Long pools with infrequent short riffles	3				
	Natural channel without riffle/pool sequence	2	2.5	2.5	2	2
	Artificial channel; some riffle/pool sequence	1				
	Artificial channel; no riffle/pool sequence	0				
9	Retention devices in stream					
	Many large boulders and/or debris dams	4				
	Rocks/logs present; limited damming effect	3				
	Rocks/logs present but unstable; no damming	2	2	2		
	Stream or channel with few or no rocks/logs	1			1	1
	Artificial channel; no retention devices	0				

10	Channel sediment accumulations						
		Little or no accumulation of loose sediments	4				
		Some gravel bars but little sand or silt	3				
		Bars of sand and silt common	2		2		
		Braiding by loose sediment	1			1.5	
		Complete in-filled muddy channel	0	0			0
11	Stream bottom						
		Mainly clean stones with obvious interstices	4				
		Mainly stones with some cover of algae/silt	3				
		Bottom heavily silted but stable	2	2			
		Bottom mainly loose and mobile sandy sedimen	1		1	1	
		Bottom mainly loose and mobile muddy sedimer	0				0
12	Stream detritus						
		Mainly unsilted wood, bark, leaves	4				
		Some wood, leaves, etc. with much fine detritus	3		3	3	3
		Mainly fine detritus mixed with sediment	2	2.5			
		Little or no organic detritus, mainly sandy	1				
		No organic detritus, mainly mud	0				
13	Aquatic vegetation						
		Little or no macrophyte or algal growth	4	4	4		
		Substantial algal growth; few macrophytes	3			3.5	3.5
		Substantial macrophyte growth; little algal grow	2				
		Substantial macrophyte and algal growth	1				
		Total cover of macrophytes plus algae	0				
		RCE Score		36	38	33	26
		RCE %age		69	72	63	50

Table A-4 Macroinvertebrate and Fish Survey Results Spring 2016																	
									Life Stage			30/09/2016	30/09/2016	30/09/2016	30/09/2016		
Phylum	Class	Sub-Class	Order	Sub-Order	Family	Sub-Fam	Genus/spp	Common name	L	N	A	WM	WN	CKmd	CKdn	Occurrence	SIG-2
Arthropoda	Insecta		Coleoptera		Dytiscidae			Diving Beetles	x		x				1	1	2
Arthropoda	Insecta		Coleoptera		Hydrophilidae			Scavenger Water Beetles			x			1		1	2
Arthropoda	Insecta		Coleoptera		Psephenidae			Water Pennies					1			1	6
Arthropoda	Insecta		Coleoptera		Scirtidae			Marsh Beetles							1	1	6
Arthropoda	Insecta		Diptera		Athericidae			Water Snipe Flies	x						1	1	8
Arthropoda	Insecta		Diptera		Ceratopogonidae			Biting Midges	x			1	1	1	1	4	4
Arthropoda	Insecta		Diptera		Chironomidae	Chironominae		Bloodworms	x			1	1	1	1	4	3
Arthropoda	Insecta		Diptera		Chironomidae	Orthocladiinae		Bloodworms	x				1			1	4
Arthropoda	Insecta		Diptera		Chironomidae	Tanypodinae		Bloodworms	x			1	1	1	1	4	4
Arthropoda	Insecta		Ephemoptera		Leptophlebiidae			Mayflies		x			1	1	1	3	8
Arthropoda	Insecta		Hemiptera		Gerridae			Water Striders				1		1	1	3	4
Arthropoda	Insecta		Hemiptera		Notonectidae			Backswimmers						1		1	1
Arthropoda	Insecta		Hemiptera		Pleidae			Pygmy Backswimmers						1		1	2
Arthropoda	Insecta		Hemiptera		Veliidae			Samll Water Striders				1				1	3
Arthropoda	Insecta		Megaloptera		Corydalidae			Dobsonflies	x				1			1	7
Arthropoda	Insecta		Odonata	Epiproctophor	Corduliidae			Dragonflies	x						1	1	5
Arthropoda	Insecta		Odonata	Epiproctophor	Cordulephyidae			Dragonflies	x				1	1		2	5
Arthropoda	Insecta		Odonata	Zygoptera	Megapodagrionidae			Damselflies	x			1			1	2	5
Arthropoda	Insecta		Trichoptera		Helicopsychidae			Caddis Flies					1	1	1	3	6
Arthropoda	Crustacea	Copepoda	Cyclopoida		Cyclopidae			Copepods						1		1	*
Arthropoda	Crustacea		Decapoda		Atyidae			Freshwater Shrimp							1	1	3
Annelida	Oligochaeta							Freshwater Worms				1				1	2
Mollusca	Gastropoda				Ancylidae			Freshwater Limpets						1		1	4
Mollusca	Gastropoda				Planorbidae			Freshwater Snails						1	1	2	2
Chordata	Osteichthyes				Eleotridae		*Gobiomorphus australis*	Striped Gudgeon					1	1	1	3	*
								Total number of invertebrate taxa per site:				7	9	13	13	24	23
Notes:	* Represents those taxa for which SIGNAL-2 scores are not available, or do not apply.							Site SIGNAL2 Scores:				3.57	5.22	3.75	4.62		4

Plate 1: Looking upstream at WS.

Plate 2: Looking downstream at WM.


Plate 3: Looking upstream at WM.


Plate 4: Looking downstream through Ckmd


Plate 5: Looking upstream at Ckmd


Plate 6: Looking upstream through WN.


Plate 7: Looking downstream through WN.


Plate 8: Small man made pool above site UW.


Plate 9: Small pool of water at site UW.


Plate 10: Looking upstream through Ckdn.


Plate 11: Looking downstream though site Ckdn.


Plate 12: Looking up stream at Ckmd.


Plate 13: Looking downstream through storm water pipe at UE.


Plate 14: Looking upstream at site NW.


Plate 15: Looking upstream through NE.

ALS Environmental

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ADELAIDE 21 Burma Road Pooraka SA 5095 Ph: 08 8359 0890 E: adelaide@alsglobal.com
☐BRISBANE 32 Shand Street Stafford QLD 4053 Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com
☐GLADSTONE 46 Callemondah Drive Clinton QLD 4680 Ph: 07 7471 5600 E: gladstone@alsglobal.com
☐MACKAY 78 Harbour Road Mackay QLD 4740 Ph: 07 4944 0177 E: mackay@alsglobal.com
☐MELBOURNE 2-4 Westall Road Springvale VIC 3171 Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com
☐MUDGEE 27 Sydney Road Mudgee NSW 2850 Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com
☐NEWCASTLE 5 Rose Gum Road Warabrook NSW 2304 Ph: 02 4968 9433 E: samples.newcastle@alsglobal.com
☐NOWRA 4/13 Geary Place North Nowra NSW 2541 Ph: 024423 2063 E: nowra@alsglobal.com
☐PERTH 10 Hod Way Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsglobal.com
☐SYDNEY 277-289 Woodpark Road Smithfield NSW 2164 Ph: 02 8784 8555 E: samples.sydney@alsglobal.com
☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818 Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com
☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500 Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: MPR
OFFICE:
PROJECT:
ORDER NUMBER:
PROJECT MANAGER: Paul Anink
CONTACT PH: 0405 482 811
SAMPLER: Jacob Broom
SAMPLER MOBILE: "
COC emailed to ALS? (YES / NO)
EDD FORMAT (or default):
Email Reports to (will default to PM if no other addresses are listed): JacobCbroom@hotmail.com
Email Invoice to (will default to PM if no other addresses are listed): Panink@iimetro.com.au

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☐ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):
ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: 0.6 °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
[signature]	SOY 30/9/16 HS		
DATE/TIME: 30/9/16	DATE/TIME: 30/9/16 1910	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

LAB ID (ALS USE)	SAMPLE ID (SAMPLE DETAILS MATRIX: SOLID (S) WATER (W))	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below) (CONTAINER INFORMATION)	TOTAL CONTAINERS	TN, TP NH4+	NOx	TSS	TOC*	Alkalinity	Bacto (E-coli)			Additional Information: Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	W-Ck-D	30/9/16	W		3	/	/	/	/	/	/			* is it possible to decant water from tss bottles for TOC??
2	W-Ck-S	↓	↓		3	/	/	/	/	/	/			
3	W-Ck-N				3	/	/	/	/	/	/			
4	DWS				3	/	/	/	/	/	/			
5	UW				3	/	/	/	/	/	/			
6	NW				2	/	/	/	/	/				
7	L9				1						/			
					TOTAL 18									

ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).

Environmental Division
Sydney
Work Order Reference
ES1622101

Telephone : + 61-2-8784 8555

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ... reserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **ES1622101**

Client	: **MARINE POLLUTION RESEARCH PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR PAUL ANINK	Contact	:
Address	: PO BOX 279 CHURCH POINT SYDNEY NSW 2105	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: panink@iimetro.com.au	E-mail	:
Telephone	: 02 9997 6541	Telephone	: +61-2-8784 8555
Facsimile	: ----	Facsimile	: +61-2-8784 8500
Project	: ----	Page	: 1 of 2
Order number	: ----	Quote number	: ES2016MARPOL0001 (SYBQ/360/15)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: JACOB BROOM (hotmail)		

Dates

Date Samples Received	: 30-Sep-2016 7:10 PM	Issue Date	: 30-Sep-2016
Client Requested Due Date	: 10-Oct-2016	Scheduled Reporting Date	: **10-Oct-2016**

Delivery Details

Mode of Delivery	: Undefined	Security Seal	: Intact.
No. of coolers/boxes	: 1	Temperature	: 0.6'C - Ice present
Receipt Detail	:	No. of samples received / analysed	: 7 / 7

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**
- Please direct any queries you have regarding this work order to the above ALS laboratory contact.
- Analytical work for this work order will be conducted at ALS Sydney.
- Sample Disposal - Aqueous (14 days), Solid (60 days) from date of completion of work order.

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

Method *Client sample ID*	Sample Container Received	Preferred Sample Container for Analysis
Total Organic Carbon : EP005		
W-CK-D	- Clear Plastic Bottle - Natural	- Amber TOC Vial - Sulfuric Acid
W-CK-S	- Clear Plastic Bottle - Natural	- Amber TOC Vial - Sulfuric Acid
W-CK-N	- Clear Plastic Bottle - Natural	- Amber TOC Vial - Sulfuric Acid
DWS	- Clear Plastic Bottle - Natural	- Amber TOC Vial - Sulfuric Acid
UW	- Clear Plastic Bottle - Natural	- Amber TOC Vial - Sulfuric Acid
NW	- Clear Plastic Bottle - Natural	- Amber TOC Vial - Sulfuric Acid

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default to 15:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory for processing purposes and will be shown bracketed without a time component.

Matrix: **WATER**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	WATER - EA025H Suspended Solids (High Level)	WATER - ED037-P Alkalinity as CaCO3 (PCT)	WATER - EK055G Ammonia as N By Discrete Analyser	WATER - EP005 Total Organic Carbon (TOC)	WATER - MW006 (Ec) E.coli by Membrane Filtration	WATER - NT-11 Total Nitrogen and Total Phosphorus
ES1622101-001	[30-Sep-2016]	W-CK-D	✓	✓	✓	✓	✓	✓
ES1622101-002	[30-Sep-2016]	W-CK-S	✓	✓	✓	✓	✓	✓
ES1622101-003	[30-Sep-2016]	W-CK-N	✓	✓	✓	✓	✓	✓
ES1622101-004	[30-Sep-2016]	DWS	✓	✓	✓	✓	✓	✓
ES1622101-005	[30-Sep-2016]	UW	✓	✓	✓	✓	✓	✓
ES1622101-006	[30-Sep-2016]	NW	✓	✓	✓	✓		✓
ES1622101-007	[30-Sep-2016]	LG					✓	

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

JACOB BROOM (gmail)		
- *AU Certificate of Analysis - NATA (COA)	Email	jacobcbroom@gmail.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	jacobcbroom@gmail.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	jacobcbroom@gmail.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	jacobcbroom@gmail.com
- A4 - AU Tax Invoice (INV)	Email	jacobcbroom@gmail.com
- Chain of Custody (CoC) (COC)	Email	jacobcbroom@gmail.com
- EDI Format - ENMRG (ENMRG)	Email	jacobcbroom@gmail.com
- EDI Format - ESDAT (ESDAT)	Email	jacobcbroom@gmail.com
PAUL ANINK		
- *AU Certificate of Analysis - NATA (COA)	Email	panink@iimetro.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	panink@iimetro.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	panink@iimetro.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	panink@iimetro.com.au
- A4 - AU Tax Invoice (INV)	Email	panink@iimetro.com.au
- Chain of Custody (CoC) (COC)	Email	panink@iimetro.com.au
- EDI Format - ENMRG (ENMRG)	Email	panink@iimetro.com.au
- EDI Format - ESDAT (ESDAT)	Email	panink@iimetro.com.au

CERTIFICATE OF ANALYSIS

Work Order	: **ES1622101**	Page	: 1 of 4
Client	: **MARINE POLLUTION RESEARCH PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR PAUL ANINK	Contact	:
Address	: PO BOX 279 CHURCH POINT SYDNEY NSW 2105	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 02 9997 6541	Telephone	: +61-2-8784 8555
Project	: ----	Date Samples Received	: 30-Sep-2016 19:10
Order number	: ----	Date Analysis Commenced	: 01-Oct-2016
C-O-C number	: ----	Issue Date	: 07-Oct-2016 15:45
Sampler	: JACOB BROOM (hotmail)		
Site	: ----		
Quote number	: ----		
No. of samples received	: 7		
No. of samples analysed	: 7		

NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Tony DeSouza	Senior Microbiologist	Sydney Microbiology, Smithfield, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- MF = membrane filtration
- CFU = colony forming unit
- MW006 is ALS's internal code and is equivalent to AS4276.7.

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

Compound	CAS Number	LOR	Unit	W-CK-D	W-CK-S	W-CK-N	DWS	UW
			Client sampling date / time	[30-Sep-2016]	[30-Sep-2016]	[30-Sep-2016]	[30-Sep-2016]	[30-Sep-2016]
				ES1622101-001	ES1622101-002	ES1622101-003	ES1622101-004	ES1622101-005
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	**16**	**7**	<5	<5	**9**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**10**	**38**	**24**	**17**	**37**
Total Alkalinity as CaCO3	----	1	mg/L	**10**	**38**	**24**	**17**	**37**
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.05**	**0.03**	**0.06**	<0.01	<0.01
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.9**	**0.5**	**0.2**	**0.8**	**0.7**
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**1.0**	**0.5**	**0.3**	**0.8**	**0.7**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.02**	**0.02**	<0.01	**0.06**	**0.01**
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**21**	**12**	**8**	**13**	**11**
MW006: Faecal Coliforms & E.coli by MF								
Escherichia coli	----	1	CFU/100mL	**300**	**24**	**16**	**910**	**35**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Client sample ID	**NW**	**LG**	**----**	**----**	**----**
			Client sampling date / time	[30-Sep-2016]	[30-Sep-2016]	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**ES1622101-006**	**ES1622101-007**	**--------**	**--------**	**--------**
				Result	Result	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**8**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**8**	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.02**	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.4**	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ **Total Nitrogen as N**	----	0.1	mg/L	**0.4**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.01	----	----	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**13**	----	----	----	----
MW006: Faecal Coliforms & E.coli by MF								
Escherichia coli	----	1	CFU/100mL	----	**230**	----	----	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **ES1622101**	Page	: 1 of 5
Client	: **MARINE POLLUTION RESEARCH PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR PAUL ANINK	Contact	:
Address	: PO BOX 279 CHURCH POINT SYDNEY NSW 2105	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 02 9997 6541	Telephone	: +61-2-8784 8555
Project	: ----	Date Samples Received	: 30-Sep-2016
Order number	: ----	Date Analysis Commenced	: 01-Oct-2016
C-O-C number	: ----	Issue Date	: 07-Oct-2016
Sampler	: JACOB BROOM (hotmail)		
Site	: ----		
Quote number	: ----		
No. of samples received	: 7		
No. of samples analysed	: 7		

Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Tony DeSouza	Senior Microbiologist	Sydney Microbiology, Smithfield, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
\# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 607584)									
ES1621991-001	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	20	19	0.00	No Limit
ES1622082-001	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	212	212	0.472	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 608138)									
ES1622064-010	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.00	No Limit
ES1622064-006	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.00	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 608141)									
ES1622101-004	DWS	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	17	17	0.00	0% - 50%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	17	17	0.00	0% - 50%
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 604066)									
ES1622052-001	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	82.2	82.7	0.667	0% - 20%
ES1622067-006	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.09	0.10	0.00	No Limit
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 604069)									
ES1622101-006	NW	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 604068)									
ES1622085-006	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.09	0.09	0.00	No Limit
ES1622101-005	UW	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.00	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 604056)									
ES1622101-004	DWS	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.8	0.7	0.00	No Limit
ES1622085-005	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.3	0.3	0.00	No Limit
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 604055)									
ES1622101-004	DWS	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.06	0.05	0.00	No Limit
ES1622085-005	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.06	0.09	32.3	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 605168)									
ES1622027-007	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	911	907	0.418	0% - 20%
ES1622119-003	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	23	25	8.45	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 607584)								
EA025H: Suspended Solids (SS)	----	5	mg/L	<5	150 mg/L	104	83	129
				<5	1000 mg/L	98.4	82	110
ED037P: Alkalinity by PC Titrator (QCLot: 608138)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	89.7	81	111
ED037P: Alkalinity by PC Titrator (QCLot: 608141)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	92.1	81	111
EK055G: Ammonia as N by Discrete Analyser (QCLot: 604066)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	1 mg/L	100	90	114
EK055G: Ammonia as N by Discrete Analyser (QCLot: 604069)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	1 mg/L	101	90	114
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 604068)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	102	91	113
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 604056)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	10 mg/L	89.1	69	101
				<0.1	1 mg/L	93.4	70	118
				<0.1	5 mg/L	94.9	74	118
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 604055)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	4.42 mg/L	87.0	71	101
				<0.01	0.442 mg/L	97.4	72	108
				<0.01	1 mg/L	105	78	118
EP005: Total Organic Carbon (TOC) (QCLot: 605168)								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	91.7	72	120

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EK055G: Ammonia as N by Discrete Analyser (QCLot: 604066)							
ES1622052-001	Anonymous	EK055G: Ammonia as N	7664-41-7	1 mg/L	# Not Determined	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	Recovery Limits (%) High
EK055G: Ammonia as N by Discrete Analyser (QCLot: 604069)							
ES1622101-006	NW	EK055G: Ammonia as N	7664-41-7	1 mg/L	88.6	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 604068)							
ES1622085-006	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	96.2	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 604056)							
ES1622085-006	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	93.5	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 604055)							
ES1622085-006	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	98.0	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 605168)							
ES1622027-008	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	100	70	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **ES1622101**	Page	: 1 of 5
Client	: **MARINE POLLUTION RESEARCH PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR PAUL ANINK	Telephone	: +61-2-8784 8555
Project	: ----	Date Samples Received	: 30-Sep-2016
Site	: ----	Issue Date	: 07-Oct-2016
Sampler	: JACOB BROOM (hotmail)	No. of samples received	: 7
Order number	: ----	No. of samples analysed	: 7

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EK055G: Ammonia as N by Discrete Analyser	ES1622052--001	Anonymous	**Ammonia as N**	7664-41-7	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EP005: Total Organic Carbon (TOC)						
Clear Plastic Bottle - Natural W-CK-D, W-CK-S, W-CK-N, DWS, UW, NW	----	----	----	04-Oct-2016	01-Oct-2016	**3**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
Alkalinity by PC Titrator	3	34	8.82	10.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA025: Total Suspended Solids dried at 104 ± 2°C							
Clear Plastic Bottle - Natural (EA025H) W-CK-D, W-CK-S, W-CK-N, DWS, UW, NW	**30-Sep-2016**	**----**	----	----	**06-Oct-2016**	07-Oct-2016	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED037P: Alkalinity by PC Titrator								
Clear Plastic Bottle - Natural (ED037-P)								
W-CK-D,	W-CK-S,	**30-Sep-2016**	**----**	----	----	**06-Oct-2016**	14-Oct-2016	✓
W-CK-N,	DWS,							
UW,	NW							
EK055G: Ammonia as N by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK055G)								
W-CK-D,	W-CK-S,	**30-Sep-2016**	**----**	----	----	**04-Oct-2016**	28-Oct-2016	✓
W-CK-N,	DWS,							
UW,	NW							
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK059G)								
W-CK-D,	W-CK-S,	**30-Sep-2016**	**----**	----	----	**04-Oct-2016**	28-Oct-2016	✓
W-CK-N,	DWS,							
UW,	NW							
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK061G)								
W-CK-D,	W-CK-S,	**30-Sep-2016**	**04-Oct-2016**	28-Oct-2016	✓	**04-Oct-2016**	28-Oct-2016	✓
W-CK-N,	DWS,							
UW,	NW							
EK067G: Total Phosphorus as P by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK067G)								
W-CK-D,	W-CK-S,	**30-Sep-2016**	**04-Oct-2016**	28-Oct-2016	✓	**04-Oct-2016**	28-Oct-2016	✓
W-CK-N,	DWS,							
UW,	NW							
EP005: Total Organic Carbon (TOC)								
Clear Plastic Bottle - Natural (EP005)								
W-CK-D,	W-CK-S,	**30-Sep-2016**	**----**	----	----	**04-Oct-2016**	01-Oct-2016	×
W-CK-N,	DWS,							
UW,	NW							
MW006: Faecal Coliforms & E.coli by MF								
Sterile Plastic Bottle - Sodium Thiosulfate (MW006)								
W-CK-D,	W-CK-S,	**30-Sep-2016**	**----**	----	----	**01-Oct-2016**	01-Oct-2016	✓
W-CK-N,	DWS,							
UW,	LG							

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	3	34	**8.82**	**10.00**	×	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	3	25	**12.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	16	**12.50**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	2	16	**12.50**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	2	34	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	2	25	**8.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	16	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	3	17	**17.65**	**15.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	16	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	3	18	**16.67**	**15.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	2	25	**8.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	16	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	16	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N by Discrete analyser	EK055G	2	25	**8.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	16	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	16	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Suspended Solids (High Level)	EA025H	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of `non-filterable` residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C . This method is compliant with NEPM (2013) Schedule B(3)
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	In house: Referenced to APHA 4500-Norg D (In house). An aliquot of sample is digested using a high temperature Kjeldahl digestion to convert nitrogenous compounds to ammonia. Ammonia is determined colorimetrically by discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	In house: Referenced to APHA 4500-Norg / 4500-NO3-. This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al (1976), Zhang et al (2006). This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Organic Carbon	EP005	WATER	In house: Referenced to APHA 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (2013) Schedule B(3)
Thermotolerant Coliforms & E.coli by Membrane Filtration	MW006	WATER	In house: Referenced to AS 4276.7 2007

Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)

CHAIN OF CUSTODY

ALS Laboratory: **please tick →**

☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2164 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ Brisbane: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com

CLIENT: Marine Pollution Research
OFFICE: PO BOX 279 CHURCH POINT NSW 2105
PROJECT:
ORDER NUMBER:
PROJECT MANAGER: PAUL ANINK **CONTACT PH:** 0412 562 081
SAMPLER: JACOB BROOM **SAMPLER MOBILE:** 0405 482 811
COC emailed to ALS? (YES / NO) **EDD FORMAT (or default):**
Email Reports to (will default to PM if no other addresses are listed): jacobcbroom@gmail.com
Email Invoice to (will default to PM if no other addresses are listed): panink@iimetro.com.au

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☐ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: 3.6 °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
J Broom	Mark S		
DATE/TIME: 20/2/17 1030	DATE/TIME: 20/2/17 10:30	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Troy! w 80

PLEASE ADDRESS INVOICE AS INDICATED IN CLIENT BOX ABOVE

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	TSS	TOC	Ammonia	NO2, NO3	TKN, OP, TP	E. coli			Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	CK mid	20/2/17	W		3	✓	✓	✓	✓	✓	✓			
2	CK ol	↓	↓		3	✓	✓	✓	✓	✓	✓			
3	CK dn	↓	↓		3	✓	✓	✓	✓	✓	✓			
4	La up.	↓	↓		3	✓	✓	✓	✓	✓	✓			
				TOTAL	12									

Environmental Division
Newcastle - Water
Work Order Reference
WN1700658

Telephone : +61 2 4014 2500

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag

CERTIFICATE OF ANALYSIS

Work Order	: **WN1700658**	Page	: 1 of 2
Client	: **MARINE POLLUTION RESEARCH PTY LTD**	Laboratory	: ALS Water - Newcastle
Contact	: MR PAUL ANINK	Contact	: Andrea Swan
Address	: PO BOX 279 CHURCH POINT SYDNEY NSW 2105	Address	: 5/585 Maitland Road Newcastle West NSW Australia 2304
Telephone	: 02 9997 6541	Telephone	: +61 2 4014 2500
Project	: ----	Date Samples Received	: 20-Feb-2017 10:30
Order number	: ----	Date Analysis Commenced	: 20-Feb-2017
C-O-C number	: ----	Issue Date	: 28-Feb-2017 15:24
Sampler	: JACOB BROOM (gmail)		
Site	: ----		
Quote number	: SYBQ/360/15		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrea Swan	Manager	Chemistry, Newcastle West, NSW
Jaclyn Lindstrom	Senior Technical Officer	Microbiology, Newcastle West, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	CK mid	CK 01	CK dn	LG up	----
			Client sampling date / time	20-Feb-2017 00:00	20-Feb-2017 00:00	20-Feb-2017 00:00	20-Feb-2017 00:00	----
Compound	CAS Number	LOR	Unit	WN1700658-001	WN1700658-002	WN1700658-003	WN1700658-004	--------
				Result	Result	Result	Result	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	<1	**34**	**6**	**130**	----
EK055A: Ammonia as N								
Ammonia as N	7664-41-7	0.05	mg/L	**0.06**	<0.05	<0.05	<0.05	----
EK057A: Nitrite as N								
Nitrite as N	14797-65-0	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	----
EK058A: Nitrate as N								
Nitrate as N	14797-55-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	----
EK061A: Total Kjeldahl Nitrogen as N								
Total Kjeldahl Nitrogen as N	----	0.2	mg/L	**0.3**	**0.3**	**0.5**	**1.5**	----
EK067A: Total Phosphorus as P								
Total Phosphorus as P	----	0.05	mg/L	**0.05**	<0.05	**0.07**	**0.05**	----
EK071A: Reactive Phosphorus as P								
Reactive Phosphorus as P	14265-44-2	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	----
EP005-NPOC.WN: Total Organic Carbon as Non Puregable Organic Carbon								
Nonpurgeable Organic Carbon	----	0.2	mg/L	**6.4**	**7.2**	**6.0**	**12.0**	----
MW004.WN: Coliforms and Escherichia coli (Defined Substrate Technology)								
Escherichia coli (Colilert)	----	1	MPN/100mL	**43**	**1300**	**137**	**922**	----

QUALITY CONTROL REPORT

Work Order	: **WN1700658**	Page	: 1 of 4
Client	: **MARINE POLLUTION RESEARCH PTY LTD**	Laboratory	: ALS Water - Newcastle
Contact	: MR PAUL ANINK	Contact	: Andrea Swan
Address	: PO BOX 279 CHURCH POINT SYDNEY NSW 2105	Address	: 5/585 Maitland Road Newcastle West NSW Australia 2304
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Project	: ----	Date Samples Received	: 20-Feb-2017
Order number	: ----	Date Analysis Commenced	: 20-Feb-2017
C-O-C number	: ----	Issue Date	: 28-Feb-2017
Sampler	: JACOB BROOM (gmail)		
Site	: ----		
Quote number	: SYBQ/360/15		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrea Swan	Manager	Chemistry, Newcastle West, NSW
Jaclyn Lindstrom	Senior Technical Officer	Microbiology, Newcastle West, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 760825)									
WN1700640-001	Anonymous	EA025: Suspended Solids (SS)	----	1	mg/L	<1	<1	0.00	No Limit
WN1700676-001	Anonymous	EA025: Suspended Solids (SS)	----	1	mg/L	39	41	5.00	0% - 20%
EK055A: Ammonia as N (QC Lot: 762439)									
WN1700658-001	CK mid	EK055A: Ammonia as N	7664-41-7	0.05	mg/L	0.06	0.05	18.2	No Limit
EK057A: Nitrite as N (QC Lot: 762440)									
WN1700658-001	CK mid	EK057A: Nitrite as N	14797-65-0	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EK067A: Total Phosphorus as P (QC Lot: 764391)									
WN1700635-002	Anonymous	EK067A: Total Phosphorus as P	----	0.05	mg/L	3.40	3.50	2.90	0% - 20%
WN1700676-002	Anonymous	EK067A: Total Phosphorus as P	----	0.05	mg/L	7.60	7.40	2.67	0% - 20%
EK071A: Reactive Phosphorus as P (QC Lot: 767712)									
WN1700658-001	CK mid	EK071A: Reactive Phosphorus as P	14265-44-2	0.05	mg/L	<0.05	<0.05	0.00	No Limit
WN1700689-007	Anonymous	EK071A: Reactive Phosphorus as P	14265-44-2	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EP005-NPOC.WN: Total Organic Carbon as Non Puregable Organic Carbon (QC Lot: 764111)									
WN1700658-001	CK mid	EP005-NPOC.WN: Nonpurgeable Organic Carbon	----	0.2	mg/L	6.4	6.3	1.57	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 760825)								
EA025: Suspended Solids (SS)	----	1	mg/L	<1	1000 mg/L	99.0	90	110
EK055A: Ammonia as N (QCLot: 762439)								
EK055A: Ammonia as N	7664-41-7	0.05	mg/L	<0.05	2 mg/L	98.4	90	110
EK057A: Nitrite as N (QCLot: 762440)								
EK057A: Nitrite as N	14797-65-0	0.05	mg/L	<0.05	1 mg/L	98.0	90	110
EK067A: Total Phosphorus as P (QCLot: 764391)								
EK067A: Total Phosphorus as P	----	0.05	mg/L	<0.05	5 mg/L	99.1	90	110
EK071A: Reactive Phosphorus as P (QCLot: 767712)								
EK071A: Reactive Phosphorus as P	14265-44-2	0.05	mg/L	<0.05	5 mg/L	101	90	110
EP005-NPOC.WN: Total Organic Carbon as Non Puregable Organic Carbon (QCLot: 764111)								
EP005-NPOC.WN: Nonpurgeable Organic Carbon	----	0.2	mg/L	<0.2	10 mg/L	101	90	110

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 760825)							
WN1700640-002	Anonymous	EA025: Suspended Solids (SS)	----	100 mg/L	92.0	80	120
EK055A: Ammonia as N (QCLot: 762439)							
WN1700658-002	CK 01	EK055A: Ammonia as N	7664-41-7	2 mg/L	98.0	80	120
EK057A: Nitrite as N (QCLot: 762440)							
WN1700658-002	CK 01	EK057A: Nitrite as N	14797-65-0	1 mg/L	98.7	80	120
EK067A: Total Phosphorus as P (QCLot: 764391)							
WN1700648-001	Anonymous	EK067A: Total Phosphorus as P	----	5 mg/L	# 68.0	80	120
EK071A: Reactive Phosphorus as P (QCLot: 767712)							
WN1700658-002	CK 01	EK071A: Reactive Phosphorus as P	14265-44-2	2 mg/L	99.1	80	120
EP005-NPOC.WN: Total Organic Carbon as Non Puregable Organic Carbon (QCLot: 764111)							
WN1700658-002	CK 01	EP005-NPOC.WN: Nonpurgeable Organic Carbon	----	20 mg/L	99.5	80	120

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **WN1700658**	Page	: 1 of 6
Client	: **MARINE POLLUTION RESEARCH PTY LTD**	Laboratory	: ALS Water - Newcastle
Contact	: MR PAUL ANINK	Telephone	: +61 2 4014 2500
Project	: ----	Date Samples Received	: 20-Feb-2017
Site	: ----	Issue Date	: 28-Feb-2017
Sampler	: JACOB BROOM (gmail)	No. of samples received	: 4
Order number	: ----	No. of samples analysed	: 4

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EK067A: Total Phosphorus as P	WN1700648--001	Anonymous	**Total Phosphorus as P**	----	68.0 %	80-120%	**Recovery less than lower data quality objective**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EK071A: Reactive Phosphorus as P						
Clear Plastic Bottle - Natural						
CK mid, CK 01, CK dn, LG up	----	----	----	24-Feb-2017	22-Feb-2017	**2**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA025: Total Suspended Solids dried at 104 ± 2°C							
Clear Plastic Bottle - Natural (EA025)							
CK mid, CK 01, CK dn, LG up	**20-Feb-2017**	**----**	----	----	**20-Feb-2017**	27-Feb-2017	✓
EK055A: Ammonia as N							
Clear Plastic Bottle - Sulfuric Acid (EK055A)							
CK mid, CK 01, CK dn, LG up	**20-Feb-2017**	**----**	----	----	**21-Feb-2017**	20-Mar-2017	✓
EK057A: Nitrite as N							
Clear Plastic Bottle - Natural (EK057A)							
CK mid, CK 01, CK dn, LG up	**20-Feb-2017**	**----**	----	----	**21-Feb-2017**	22-Feb-2017	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK067A: Total Phosphorus as P								
Clear Plastic Bottle - Sulfuric Acid (EK067A)								
CK mid,	CK 01,	**20-Feb-2017**	**23-Feb-2017**	20-Mar-2017	✓	**24-Feb-2017**	20-Mar-2017	✓
CK dn,	LG up							
EK071A: Reactive Phosphorus as P								
Clear Plastic Bottle - Natural (EK071A)								
CK mid,	CK 01,	**20-Feb-2017**	**----**	----	----	**24-Feb-2017**	22-Feb-2017	×
CK dn,	LG up							
EP005-NPOC.WN: Total Organic Carbon as Non Puregable Organic Carbon								
Clear Plastic Bottle - Sulfuric Acid (EP005-NPOC.WN)								
CK mid,	CK 01,	**20-Feb-2017**	**----**	----	----	**22-Feb-2017**	20-Mar-2017	✓
CK dn,	LG up							
MW004.WN: Coliforms and Escherichia coli (Defined Substrate Technology)								
Sterile Plastic Bottle - Sodium Thiosulfate (MW004.WN)								
CK mid,	CK 01,	**20-Feb-2017**	**----**	----	----	**20-Feb-2017**	21-Feb-2017	✓
CK dn,	LG up							

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Ammonia as N	EK055A	1	10	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N	EK057A	1	8	**12.50**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P	EK071A	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids	EA025	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon as Non Puregable Organic Carbon (NPOC)	EP005-NPOC.WN	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P	EK067A	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Ammonia as N	EK055A	1	10	**10.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N	EK057A	1	8	**12.50**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P	EK071A	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids	EA025	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon as Non Puregable Organic Carbon (NPOC)	EP005-NPOC.WN	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P	EK067A	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N	EK055A	1	10	**10.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N	EK057A	1	8	**12.50**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P	EK071A	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids	EA025	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon as Non Puregable Organic Carbon (NPOC)	EP005-NPOC.WN	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P	EK067A	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N	EK055A	1	10	**10.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N	EK057A	1	8	**12.50**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P	EK071A	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids	EA025	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon as Non Puregable Organic Carbon (NPOC)	EP005-NPOC.WN	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P	EK067A	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Suspended Solids	EA025	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of \`non-filterable\` residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C . This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N	EK055A	WATER	In house: referenced to APHA (2012) 4500 - NH3 H. This method is based on the Berthelot react. Ammonia reacts in alkaline solution with hypochlorite to form monochlormine which, in the presence of phenol, catalytic amounts of nitroprusside and excess hypochlorite, gives indophenol blue. This colour formation requires a pH between 8.0 - 11.5 and is measured @ 630nm.
Nitrite as N	EK057A	WATER	In house: referenced to APHA (2012) 4500 - NO3 I (no reduction). Nitrite (NO2-) is determined through the formation of a reddish purple azo dye produced at pH 2.0 to 2.5 by coupling diazotised acid with N-(1-naphthyl) -ethylenediamine dihydrochloride which is measured at 520 nm.
Nitrate as N	EK058A	WATER	In house: referenced to APHA (2012) 4500 - NO3 I. This automated procedure for the determination of TON (NO2- + NO3-) utilises the procedure whereby (NO3-) is reduced to nitrite (NO2-) at a pH 7.5 in a copper-cadmium reductor cell. The NO2- reduced from NO3- plus any free NO2- present reacts under acidic conditions with sulfanilamide to form a diazo compound that then couples with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a reddish purple azo dye which is measured at 520 nm.
Total Kjeldahl Nitrogen as N	EK061A	WATER	In house 6. TKN is calculated by difference from Total Nitrogen and NOx. Contributing method parameters are determined by FIA
Total Phosphorus as P	EK067A	WATER	In house: referenced to APHA (2012) 4500 - P G. The Total Phosphorus content of a sample includes all the orthophosphates and condensed phosphates, both soluble insoluble and the organic and inorganic species of Phosphorus in the sample. The more complex forms of phosphorus must be converted to the simple orthophosphate species before analysis is possible and this is achieved by digesting the sample with ammonium persulphate and sulphuric acid.
Reactive Phosphorus as P	EK071A	WATER	In house: referenced to APHA (2012) 4500 - P G. This automated procedure for the determination of Ortho Phosphorus is based on the colorimetric method in which a blue colour is formed by the reaction of ortho phosphorus and molybdate ion followed by reduction with ascorbic acid at an acidic pH. The reduced blue phosphomolybdenum complex is read at 660 nm.
Total Organic Carbon as Non Puregable Organic Carbon (NPOC)	EP005-NPOC.WN	WATER	In house: Referenced to APHA 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. Nonpurgeable Organic Carbon (NPOC) ¿ the fraction of TOC that remains after acidification and sparging.
Coliforms & Escherichia coli (MPN by DST - Colilert/Quanti-	MW004.WN	WATER	In house: referenced to AS4276.21:2005.

Preparation Methods	Method	Matrix	Method Descriptions
Basic Persulfate Digestion for TN with FIA finish.	EK062-PA	WATER	In house: Referenced to APHA 24500 P - J.

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Acid Persulfate Digestion for TP with FIA finish.	EK067-PA	WATER	#

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Our Ref: LJK: L.N20719.004.docx

17 May 2017

Andrew Krause
ADW Johnson
EMAILED

Attention: Andrew Krause

Dear Andrew

RE: COASTAL HYDROLOGY IMPACT ASSESSMENT – CATHERINE HILL BAY COASTAL CREEK

As part of the planned residential development associated with Stage 6 and Stage 7 of the 'Beaches' Development, excess wetland-treated recycled water is proposed to be discharged to the receiving environment. At this stage, the proposed increase of annual average flows from site is approximately 46 ML/yr. As a result, an increase to the flow volume entering the coastal creek at the southern end of Catherine Hill Bay is expected.

The following letter provides a summary of the existing environment, coastal processes and entrance conditions experienced at the study site. An assessment of potential coastal erosion, coastal recession, and entrance instability and migration for the coastal creek study area as a result of the proposed excess recycled water discharge and increased stormwater runoff is also provided.

I trust the following information provides sufficient detail for your purposes, however, should you wish to discuss this further please do not hesitate to contact the undersigned.

Yours Faithfully
BMT WBM

Luke Kidd

Luke Kidd
Senior Environmental Engineer
Team Leader Coast & Environment

1 Introduction

1.1 Background

Rose Group are developing a beach front estate at Catherine Hill Bay named the ‘Beaches’. The future plan for Stages 6 and 7 of the ‘Beaches’ development proposes to exclude residential rainwater tanks and allow discharge of additional wetland-treated recycled water within the small coastal catchment at the southern end of Catherine Hill Bay. This catchment drains to a small unnamed coastal creek that connects to the ocean (when the coastal entrance is open) at the southern end of Middle Camp Beach (see Figure 1-1).

At this stage, the planned increase in stormwater runoff and excess treated recycled water volumes draining to the small coastal creek catchment are estimated at 46 ML/year on average. The NSW Environmental Protection Authority (EPA) requires the potential hydrological and coastal impacts of the proposed excess treated recycled water to be assessed, which are presented in this report. Estimated pre and post-development runoff volumes provided by ADW Johnson were used to assist with the assessment outlined below.

Figure 1-1 Unnamed Coastal Creek Entrance at Middle Camp Beach, south end of Catherine Hill Bay, looking east

1.2 Scope of Investigations

The scope of the investigations and assessment presented in the following sections is largely qualitative (desktop-based) and includes the following:

- Description of the coastal setting, coastal processes and morphological characteristics of the coastal creek based on historical aerial photography (i.e. aerial imagery available form Google Earth between 2004 and 2016) and observations during a recent site inspection; and
- Assessment of the likely on-beach impacts caused by changes in pre and post-development flows. For this task a comparison and review of the changes to modelled inflow volumes entering the coastal creek are provided including an assessment of the relative contribution of excess treated recycled water to creek flows.

2 Existing Environment

2.1 Study Area

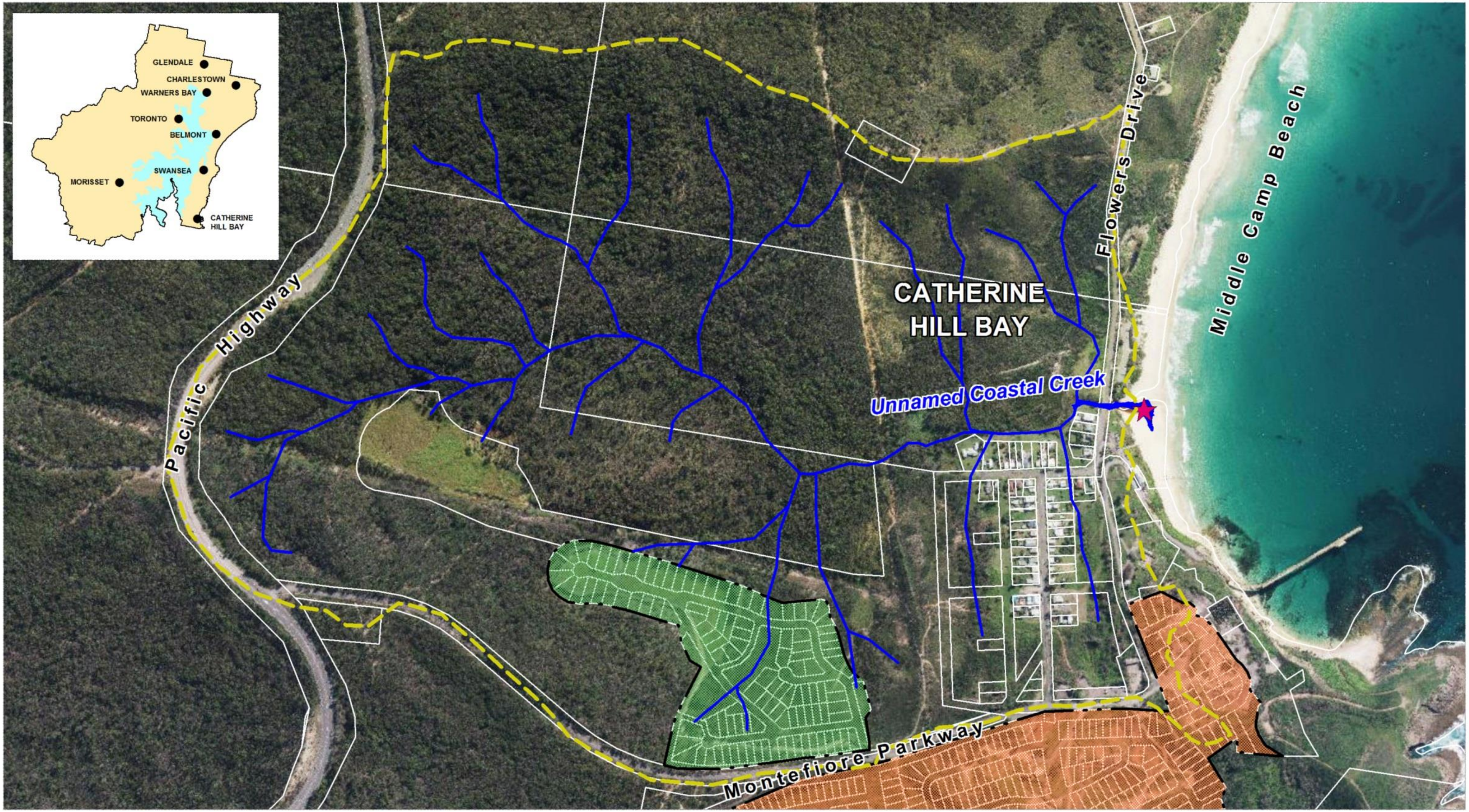
Catherine Hill Bay is a 1.5 km long east facing sandy embayment located towards the southern limit of Lake Macquarie Council Local Government Area approximately 1 km north of Moonee Beach. Catherine Hill Bay comprises two sandy beaches bounded by rocky platforms and prominent headlands at both ends (Short, 2007). A section of rocky shore and headland upon which the jetty is attached separates these two beaches. The main sandy beach, named Middle Camp Beach, stretches between the jetty and northern headland and is backed by two small valleys. The northern creek, known as Middle Camp Gully flows out at the northern end of this beach, while the smaller unnamed coastal creek flows across the beach towards the southern end immediately north of the Catherine Hill Bay Surf Life Saving Club (SLSC).

The entrance to the small coastal creek in the south is intermittently closed and open to the ocean. The catchment of the southern coastal creek is mostly vegetated and contained within a reserve, with the exception of the small mining village located within the lower slopes of the catchment. Stages 3, 6 and 7 of the 'Beaches' development are located on the southern boundary of the catchment (see Figure 2-1). The study site area for this coastal hydrology assessment is focussed on the small unnamed coastal creek at the southern end of Middle Camp Beach at Catherine Hill Bay as described above, and its associated catchment and beach area that adjoins the creek entrance.

2.2 Field Investigation

A field inspection was undertaken on the 23 August 2016 to investigate the geomorphology and hydrology of the small unnamed coastal creek system at Catherine Hill Bay. The objective of the site visit was to provide site context for the assessment, in particular the condition and likely behaviour of the creek entrance, its coastal water body and more generally the catchment environment. The following observations were made during the site visit:

- The creek entrance was partially shoaled at the time of the inspection. It is likely that the June 2016 east coast storm complety opened the creek mouth and a wide beach berm has since been deposted over the intervening period of about 2 months. A small meandering channel and flow from the creek was observed (see Figure 2-2);
- The coastal creek water body joins the beach (and ocean when open) via the Flowers Drive culvert. This culvert system comprises a three cell box culvert, each appoximately 3m wide and 2.7m high (see Figure 2-3);
- The main water body of the coastal creek is realatively small, located within a narrow creek channel that extends approximatley 100 metres landward of the Flowers Drive culvert (see Figure 2-4). Upstream of here, the creek channel becomes less well defined and heavily vegetated.
- The main creek channel is bordered by a small coastal floodplain area that joins with the coastal village area to the south. A small volume of flow was observed in the the upstream creek channel approximatly 300 metres upstream of the Flowers Drive culvert (see Figure 2-5). The riparian vegtetation was dense and comprised a mix of native coastal wetland species and some exotic weed species.



LEGEND

- Catchment boundary (approx)
- Watercourse
- Coasal creek entrance

The Beaches Development Footprint

- Stages 1 - 5
- Stages 6 & 7

Title:

Unnamed Coastal Creek Catchment Map
Catherine Hill Bay

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 200 400m
Approx. Scale

Figure: **2-1**

Rev: **A**

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Figure 2-2 Heavily Shoaled Coastal Creek Entrance, August 2016

Figure 2-3 Unnamed Creek Culvert (downstream of Flowers Drive)

Figure 2-4 Narrow Lower Creek Channel, Upstream of Flowers Drive Culvert

Figure 2-5 Narrow Creek Channel and Dense Wetland Vegetation characterises the Coastal Floodplain (photo taken 300 metres upstream of Flowers Drive Culvert)

2.3 Catchment Hydrology

The unnamed coastal creek occurs within a narrow gully positioned behind the southern half of Catherine Hill Bay. The creek drains a catchment area of approximately 190 ha that reaches heights of up to 95 m AHD at the headwaters adjacent to the Pacific Highway. The catchment is mostly comprised of bedrock slopes that are largely forested with bushland, and include a small mining village. A small narrow coastal floodplain approximately 300 metres long and between 30 to 70 metres wide is positioned at the base of the primarily forested bedrock catchment, which is impounded behind coastal dunes and the Flowers Drive. The creek drains to a small (degraded) brackish lagoon above the Flowers Road crossing (see Figure 2-6).

The hydrology of this coastal creek is dominated by local runoff from the catchment foothills positioned between Montefiore Street to the south, Pacific Highway to the west, and a ridgeline to the north. The upper and middle reaches of the small catchment occur within the Lake Macquarie State Conservation Area that primarily comprises bushland dominated by coastal heath. The lower reaches of the catchment include the southern half of the historical Catherine Hill Bay mining village in addition to a small coastal floodplain area with densely vegetated wetland and riparian vegetation in some areas.

The coastal waterbody size is small and typically extends some 100 metres or so landward of the Flowers Drive bridge, where it connects with a small (approximately 3 ha) coastal wetland positioned within the floodplain at the base of the bedrock gully system. The volume of water stored within this lower creek channel is approximated to range between 0.5 and 2 ML, based on the surface area of the creek waterbody and an assumed water depth of between 0.5 metres and 2 metres.

The creek mouth is intermittently closed and open to the ocean and experiences some tidal fluctuations under open conditions.

The hydrology of the coastal creek wetland is controlled by three interactive processes:

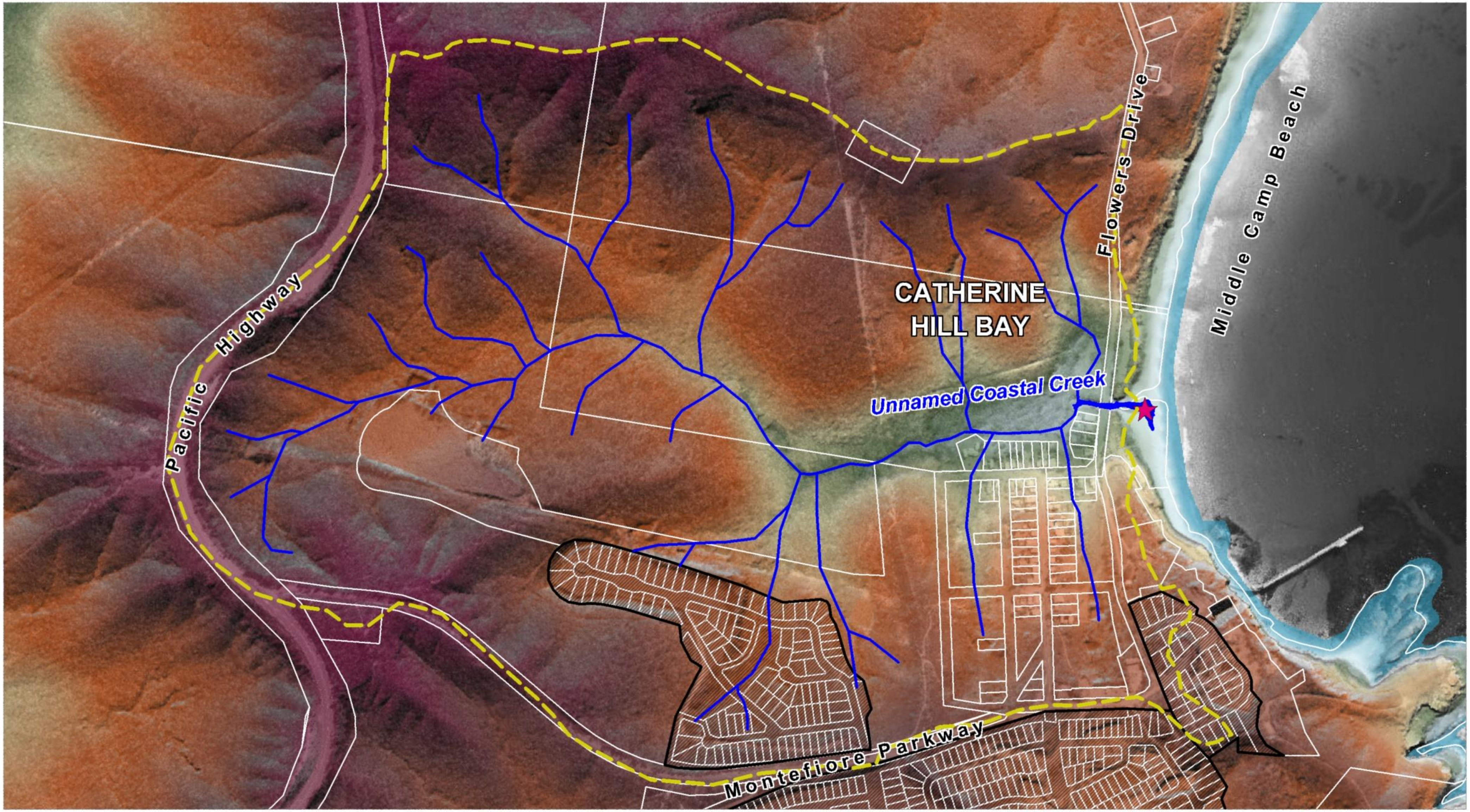
- Catchment rainfall and evapotranspiration;
- Tidal processes, when open to the ocean; and
- Groundwater processes.

The majority of the catchment is bushland, with some development near to the coast. The area of impervious surfaces within the catchment is small. Increased runoff and pollutant loads (e.g. heavy metals, nutrients and suspended solids) would be expected from the developed areas, in addition to that potentially sourced from the Pacific Highway and historic coal mining operations positioned on the western and southern catchment boundary.

2.4 Coastal Processes

Catherine Hill Bay is located on the NSW open coast within the Lake Macquarie region that generally faces southeast and is highly exposed to the dominant southeast wave climate. The southern end of Middle Camp Beach, which includes the entrance to the unnamed southern creek, faces due east and receives slight protection from the prevailing southerly swell by the protruding rock platform and adjoining the southern headland.

A summary of key coastal processes including swell waves, ocean water levels, and sediment transport is provided in the following sections.



LEGEND

- Catchment boundary (approx)
- Watercourse
- Coasal creek entrance

The Beaches Development Footprint

- All stages

Elevation (m AHD): 0, 2, 5, 10, 20, 50, 100

Title:
Unnamed Coastal Creek Catchment Topography Catherine Hill Bay

Figure: **2-6**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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0 200 400m
Approx. Scale

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2.4.1 Wave Climate

The regional wave climate is the dominant coastal process acting on Middle Camp Beach at Catherine Hill Bay. The Central Coast of NSW comprises a moderate to high energy wave climate. The NSW coast experiences a variety of wave generation sources, with the dominant southeast swells mostly derived from east coast cyclones and mid-latitude cyclones (BMT WBM, 2015).

Offshore wave data from Sydney indicate that the average offshore significant wave height is 1.6 metres (Hs), with the highest waves experienced from March to July and the highest recorded Hs wave height of 8.4 m in May 1997 (BMT WBM, 2015).

Waves arriving in the nearshore zone have been transformed from offshore through refraction and diffraction processes, and dissipated though friction with the seabed. Wave modelling undertaken by BMT WBM (2015) shows that for extreme storm events (100-year ARI 6 hour duration storm wave of 8.7 m from SSE), the nearshore Hs at -10 m AHD is approximately 55% of the offshore significant wave height at Catherine Hill Bay (compared with 60-65% at Caves Beach and >70% at Redhead, for example). The entrance to the unnamed creek at the southern end of Middle Camp Beach therefore receives some protection from the storm wave activity, relative to other open coast beaches in the region.

2.4.2 Ocean Water Levels

Elevated ocean water from coastal storms occurs on open coastal beaches, like Middle Camp Beach at Catherine Hill Bay, from a variety of processes. The components which contribute to elevated water levels include:

- Astronomical tide;
- Storm surge processes (inverted barometric effect, plus wind setup);
- Wave set up; and
- Wave run-up.

Projected sea level rise will also contribute to elevated ocean water levels at the study site in the future.

Extreme elevated water levels for the Sydney region, considered to be representative of conditions experienced along Lake Macquarie’s open coast, are shown in Table 2-1 below. These design levels are driven by storm surge processes, combined with high astronomical tides and do not incorporate the influence of waves (wave setup and wave runup).

Table 2-1 Design Elevated Water Levels (DECCW, 2010)

ARI (years)	2010 conditions (m AHD)	2050 conditions (m AHD), with 0.4 m Sea Level Rise	2100 conditions (m AHD), with 0.9 m Sea Level Rise
1	1.24	1.58	2.08
20	1.38	1.72	2.22
50	1.41	1.75	2.25
100	1.44	1.78	2.28

As waves approach the beach they cause changes in water level, with broken waves raising the water level. This process is referred to a wave set up. As a general rule, wave set up is taken to be about 15 to 20% of the offshore significant wave height (Masselink and Hughes, 2003).

Wave run-up occurs from the uprush of water from waves across a beach of coastal structure, and is dependent on a number of factors (beach slope, roughness, permeability, whether the wave is broken or unbroken). Where wave run-up levels exceed the crest levels of coastal structures (e.g. dune or berms) overtopping occurs.

When the unnamed creek entrance is shoaled or closed, overtopping of the entrance berm will deposit sediment into the creek channel. The process is referred to a cross-shore sediment transport.

2.4.3 Sediment Transport

Open coast beaches, like Middle Camp Beach at Catherine Hill Bay, experience sediment transport processes in response to the complex interaction of waves, currents and water levels. Beach sediments can either be moved along the coast, in response to waves approaching the shore from an oblique angle (longshore sediment transport), or across the shore (cross-shore sediment transport) due to prevailing wave conditions arriving perpendicular to the beach.

On NSW beaches, net longshore sediment transport is directed north due to the predominant southeast wave climate relative to the general north to south oriented shoreline, and occurs within the surf zone. Catherine Hill Bay forms a bedrock embayed beach compartment that is mostly contained, but may experience some leakage of sediment into and out of the beach embayment through longshore transport processes. For the Lake Macquarie region, a regional net longshore transport rate of up to 21,000 m^3/year has been estimated (BMT WBM, 2015).

During storms, increased wave heights and elevated water levels cause sediments to be eroded from the upper beach and dunes, which become transported offshore to form a sand bar in the nearshore zone. During calmer weather, this sand is moved slowly back onshore to rebuild the beach. The severity of wave attack at the dune depends on wave height, water levels and the preceding beach condition.

At Middle Camp Beach, the southern end of the beach experiences some protection from the protruding headland, and therefore experiences less severe erosion than the northern beach section from south-easterly storm swells. The southern end Middle Camp Beach is also constrained by bedrock bluffs in areas adjacent to the unnamed creek entrance. These bedrock slopes which are mostly covered with dune sands will limit potential landward extent of storm erosion.

2.5 Entrance Conditions and Dynamics

The small unnamed coastal creek at the southern end of Catherine Hill Bay flows out to the ocean via an entrance that is intermittently closed and open. Coastal lake, lagoon and creek systems of this type demonstrate two distinctly different hydrodynamic regimes, depending on the entrance conditions. When open, they will exhibit tidal behaviour and when closed the water body will behave as a reservoir with water levels responding to catchment runoff, direct rainfall, evaporation and groundwater percolation through dunes (Haines, 2007).

The condition of intermittently closed and open coastal entrances is a function of the following natural processes:

- Wave climate;
- Incoming tides;
- Ebb tide currents; and
- Discharge of floodwaters (Haines, 2007).

For small coastal creeks, such as that being assessed, the influence flood and ebb tides on entrance conditions is less when compared to large coastal lake and lagoons.

Entrance breakouts generally occur when water levels within the coastal waterbody overtop, and then scour out the entrance berm. Hence, breakouts mostly occur in response to heavy rainfall raising the water level above the berm height. Closed entrances can also artificially breakout through assistance of a mechanically excavated channel across the beach berm.

Entrance closures often involve recovery of the entrance berm, which occurs naturally through cross-shore transport of sediment (i.e. offshore bar being worked back onshore) and/or longshore sand transport (oblique waves progressively reworking sediment downcoast). The majority of coastal waterways that exhibit intermittently closed and intermittently open entrance conditions are closed most of the time, but this is not always the case.

While no water level records are available for the small coastal creek at Catherine Hill Bay, recent satellite imagery and aerial photography shows the creek maintains some hydrological connection to the ocean more often than not, since 2005, however lengthy periods of closure have likely occurred. It is also apparent that the creek entrance has been mechanically opened on occasions, which likely takes place for amenity purposes. An entrance condition assessment of the southern coastal creek at Catherine Hill Bay is detailed in Section 3.

2.6 Coastal Hazards

Coastal hazards have been assessed for Catherine Hill Bay by BMT WBM (2015) as part of a wider coastal assessment completed for the Lake Macquarie region. Beach erosion, shoreline recession and coastal inundation were assessed in detail for this study. Coastal entrance instability is also discussed by BMT WBM (2015) however a site-specific assessment for the unnamed coastal creek at Catherine Hill Bay was not undertaken. The following sections summarise relevant information from BMT WBM (2015), in addition to providing some site-specific analysis on coastal entrance instability and impacts of sea level rise.

2.6.1 Beach Erosion and Shoreline Recession

Beach Erosion

Severe beach erosion occurs from large storms, or a series of storms in succession. Erosion of the beach face and dunes pose a hazard to back beach land and assets, where the beach is backed by erodible sediments (e.g. sand dunes). At Catherine Hill Bay, the southern end of Middle Camp Beach is backed by bedrock substrate in places that will limit the potential extent of erosion. The land adjoining the unnamed coastal creek channel is however formed of erodible sediments and therefore susceptible to erosion.

Photogrammetry data of historic changes to coastal profiles (i.e. beach and dune topography, +/- bedrock slopes) provides information on past changes to beach volume and dune position. Photogrammetry data from Catherine Hill Bay was analysed by BMT WBM (2015), which found that the average volume of beach change is 55 m^3/m with a maximum change of 150 m^3/m (excluding profiles backed by bedrock).

Beach erosion hazard setback distances determined for Catherine Hill Bay by BMT WBM (2015), based on photogrammetry data are provided in Table 2-2. Setback distances have been provided for three different scenarios. The 40 metre 'unlikely' erosion set back distance should be adopted for most planning purposes. Under this scenario, mapped in yellow in Figure 2-7, the Flowers Drive box culverts and section of roadway could become damaged by erosion.

Table 2-2 Immediate Beach Erosion Extents for Catherine Hill Bay (BMT WBM, 2015)

	Almost Certain	Unlikely	Rare
Erosion Setback Distance	25 m, or limit to bedrock	40 m, or limit to bedrock	65 m, or limit to bedrock

Shoreline Recession

The long-term average shoreline position of a sandy beach can move landward, or seaward, in response to coastal processes and sediment supply. Under stable sea level conditions, a negative sediment budget (a net loss in sand volume from a beach system) would result in shoreline retreat.

Under rising sea level conditions, like that projected to occur over the coming century and beyond, sandy beaches are generally expected to experience recession in response to rising water levels and increased wave action attacking the back of a beach. Lake Macquarie City Council has adopted sea level rise benchmarks of 0.4 and 0.9 metres rise by 2050 and 2100, above 1990 levels.

An assessment of photogrammetry beach profile data from Catherine Hill Bay suggests that this beach is relatively stable at present. That is, there is no discernible long term trend in the shoreline position at Catherine Hill Bay, and therefore the beach has a neutral sediment budget at present (BMT WBM, 2015).

Modelling undertaken by BMT WBM (2015) found that the entire embayment of Catherine Hill Bay will be affected by recession due to sea level rise. Therefore, it is expected that sections of sandy shoreline will move progressively landward over time, where not constrained by bedrock substrate.

Recession due to sea level rise is expected to be greatest at the southern end of the beach. Erosion and recession setback distances for the modelled 2050 and 2100 'unlikely' scenario at the south end of Catherine Hill Bay are shown in Table 2-3. The creek channel length and volume will be reduced in the future, should the future shoreline recession estimations be realised.

Table 2-3 Erosion and Recession Setback Distances

Timeframe	Hazard Type	Sea Level Rise	Predicted Setback Distance
Immediate	Beach Erosion	Nil	40 m, or limit to bedrock
2050	Shoreline Recession	0.4 m	60 m, or limit to bedrock
2100	Shoreline Recession	0.9 m	80 m, or limit to bedrock

Beach Erosion and Recession Impacts

Erosion and recession mapping provided in BMT WBM (2015) is reproduced in Figure 2-7. This shows that the coastal creek entrance to be susceptible to erosion impacts at present, and that shoreline recession may see the creek entrance migrate landward in the future. Built assets surrounding the creek entrance are also at risk of erosion impacts. A summary of assets at risk of erosion is provided below:

Immediate timeframe

- Foreshore carparks (x2) and adjoining reserve land, located either side of the creek entrance;
- Flowers Drive and culvert system; and
- Residential property (x1).

Future timeframes

- Flowers Drive, increasing length of roadway through time; and
- Residential properties, increasing numbers through time (+2 by 2050, +1 by 2100).

2.6.2 Coastal Entrance Instability

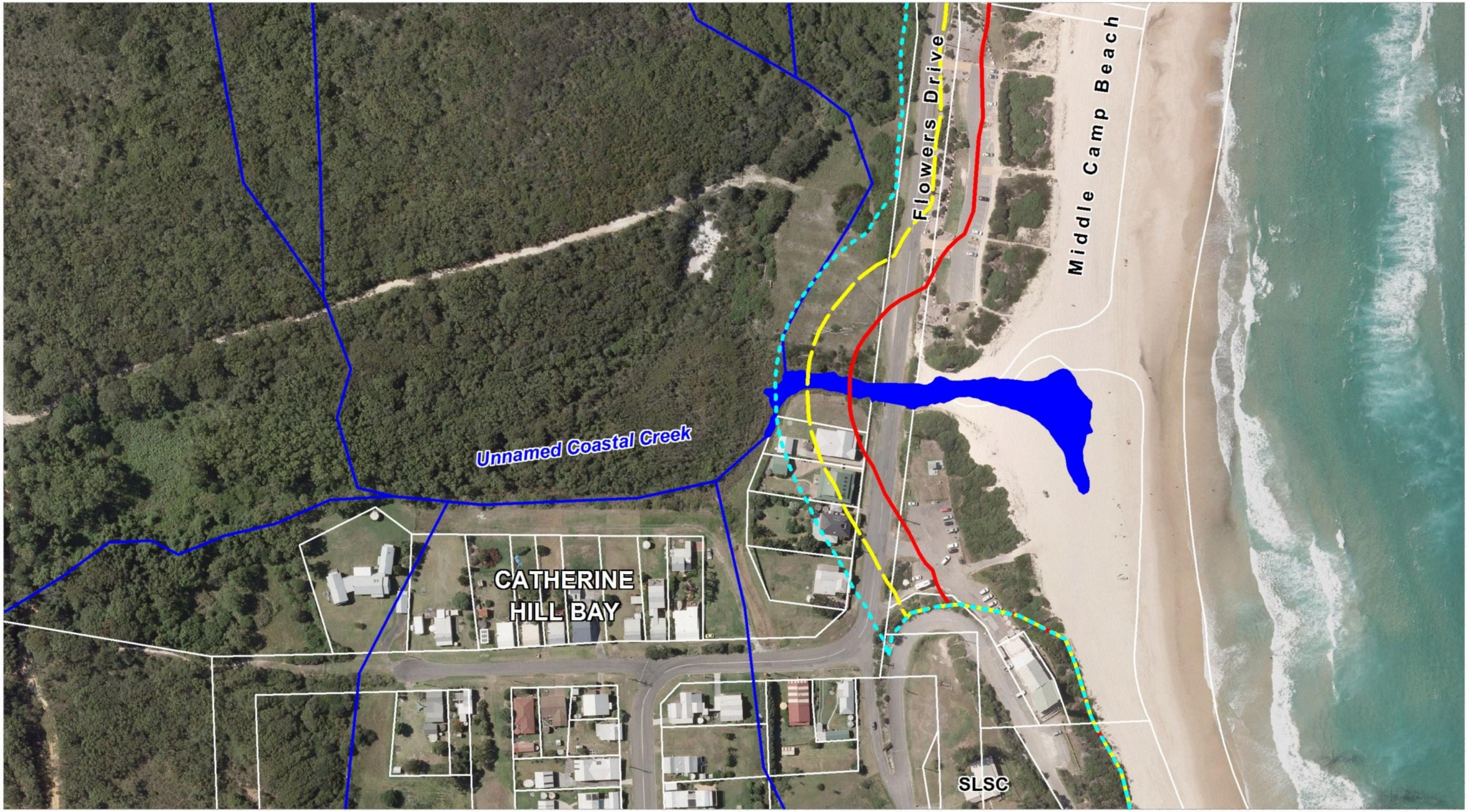
With the exception of Swansea Channel, coastal entrances contained within the Lake Macquarie LGA, including the unnamed creek at the southern end of Catherine Hill Bay, are considered to be predominately closed (BMT WBM, 2015). This is due to the wave and tide driven sediment transport being the dominant processes influencing the entrance conditions relative to catchment (rainfall) inputs. That is, for the most part catchment inputs are relatively small and therefore unable to keep the entrances open regularly.

Contrary to this general view, the current study found the southern unnamed coastal creek at Catherine Hill Bay to maintain a hydrological connection with the ocean more often than not. Further details regarding the entrance morphology and behaviour of the unnamed Catherine Hill Bay coastal creek is provided in Section 3.

2.6.3 Effects of Sea Level Rise on Entrance Conditions

It is expected that an increase in mean sea level will lead to increased beach erosion and recession, as described in Section 2.6.1. With regards to coastal waterways that experience intermittently closed and open entrance conditions, beach recession is expected to be accompanied by landward and upward translation of the entrance berm (Hanslow et al., 2000; Haines and Thom, 2007). This will enable higher creek levels to occur under closed entrance conditions, and increased runoff requirements for natural entrance breakouts to occur. Also, the creek entrance when open will progressively scour to shallower elevations as sea level rise continues into the future.

In addition, it is expected that the entrance channels to coastal waterways, especially those positioned in the southern corner of beach embayment's (such as the study site), will experience a shortening of the entrance channel in response to shoreline recession and minor (clockwise) rotation of beach embayment's.



LEGEND

Beach Erosion and Recession Hazard

- Immediate Timeframe
- 2050 Timeframe (with 0.4m SLR)
- 2100 Timeframe (with 0.9m SLR)

Title:

Beach Erosion and Shoreline Recession Hazards
Catherine Hill Bay

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 50 100m
Approx. Scale

Figure: **2-7**

Rev: **A**

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3 Entrance Condition Assessment

A desktop assessment of the entrance condition to the unnamed creek at the southern end of Catherine Hill Bay was undertaken. The aim of the assessment was to:

- Describe morphological characteristics and dynamics of the creek entrance;
- Identify areas susceptible to entrance instability; and
- Assess impacts of increased catchment flows on the entrance instability, migration and functioning.

The following tasks were undertaken as part of this assessment:

- Site inspection to assess morphology, condition and characteristics of the entrance; and
- Review of readily available aerial imagery and topographic data, including satellite imagery accessed from Google Earth between 2005 and 2016 and aerial photographs obtained from NearMap between 2010 and 2016, in addition to high resolution LiDAR topography available from 2007.

Note: that no historical imagery predating 2005, or water level records from the unnamed creek was available for this assessment.

3.1 Entrance Morphology

The small unnamed coastal creek is located in a narrow gully behind the southern end of Middle Camp Beach. The entrance to the small coastal creek is intermittently closed and open to the ocean, as demonstrated in the assessment of aerial imagery presented below. The small coastal waterbody of this coastal creek extends a short distance upstream of Flowers Drive, and often extends seaward of the road culvert when the entrance condition allows (see Figure 3-1 for example).

Under open entrance conditions, the creek flows out to the ocean via the Flowers Drive box culvert system. This culvert forms a hydraulic control on the position of the lower creek channel and mouth. Under closed conditions, a beach berm (with crest elevations that likely builds up to 2.5 m AHD) blocks the surface connection between the creek and ocean. The berm typically forms in the swash zone, up to 100 metres seaward of the culvert. Once the entrance berm has formed, subsequent infilling of the entrance compartment (i.e. the impounded creek waterbody seaward of the culvert) can then take place, through constructional waves overtopping the berm and depositing sediment into the creek channel.

Entrance breakouts occur when creek water levels are raised above the entrance berm which causes the berm become overtopped and scoured, resulting in the formation of an entrance channel. Once scoured, the entrance channel can become shoaled through sediment deposition by wave, tide and current activity. These oceanic processes progressively restrict the flow of water into and out of the creek channel. As described in Section 2.5, the entrance condition is a function of many factors including waves, tides, current and catchment rainfall. An assessment of the varying entrance conditions captured by satellite imagery and aerial photography over the past 11 years is presented below.

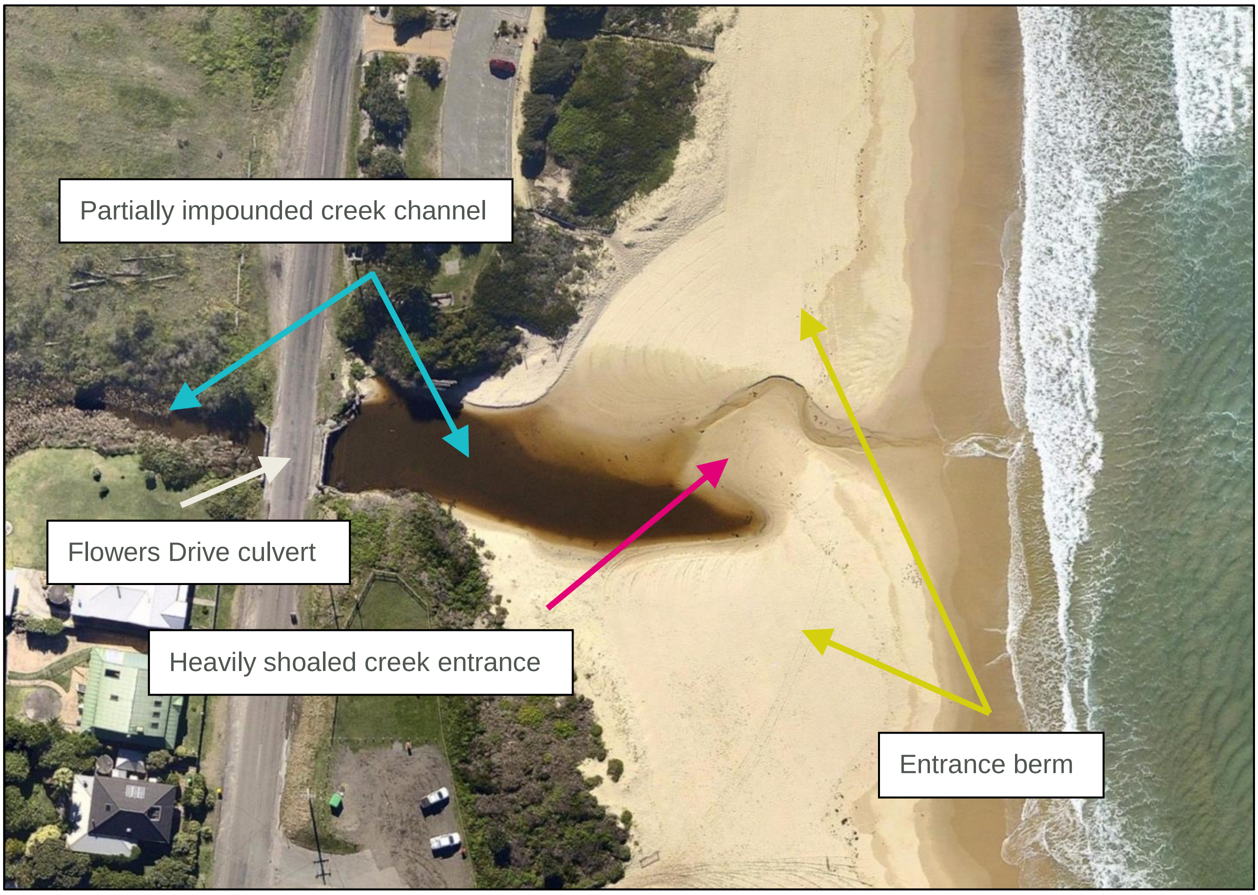


Figure 3-1 Coastal Creek Entrance Conditions, June 2014, showing some morphological features and controls

3.2 Assessment of Aerial Images

3.2.1 Information Sources

Readily available aerial imagery dating back to 2005 was accessed for this study, from the following sources:

- Google Earth satellite imagery (20 images, from 2005 to 2016);
- Near Map aerial photographs (20 images, from 2010 to 2016); and
- NSW Government (Six Map) aerial photography (1 image from 2014).

An assessment of this imagery was undertaken primarily to characterise the range of entrance conditions and typical behaviour, in addition to mapping the footprint of entrance breakouts. This information is subsequently used to assess the impact of increased catchment flows from proposed Stage 6 and Stage 7 development of the 'Beaches'.

3.2.2 Entrance Classification

The entrance conditions captured in each of the 41 available images were categorised as follows:

- Closed;
- Heavily shoaled;
- Partially shoaled; or
- Scoured (open).

Closed entrance conditions maintain no hydrological connection with the ocean, whereas scoured entrance conditions comprise an open entrance channel which drains the creek to the ocean. Partially shoaled and heavily shoaled entrance conditions maintain some hydrological connection between the creek and ocean, with the berm experiencing varying degrees of recovery (see Figure 3-2 for example).

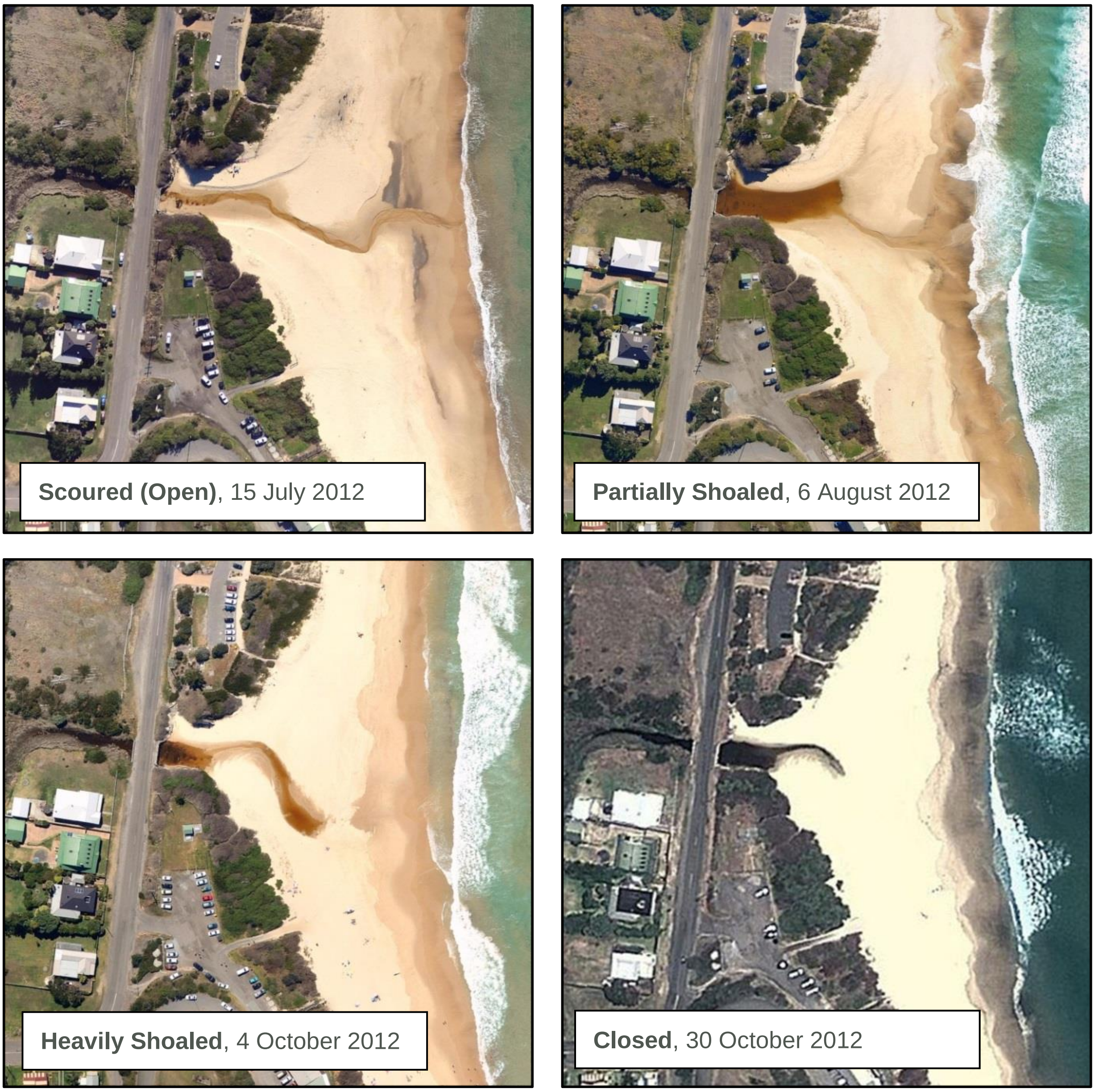


Figure 3-2 Stages in Entrance Condition (July to October, 2012)

3.2.3 Entrance Assessment Results

The results of the aerial assessment are shown in Figure 3-3 and summarised in Table 3-1. While the results show the entrance is closed or heavily shoaled in more than 50% of the aerial images, some creek connection in surface hydrology (i.e. creek discharge) is observed around 70% of the images (i.e. the entrance is heavily shoaled, partially shoaled or open). The entrance is scoured and open to the ocean in 20% of the images.

It is noted however that decadal to longer term cycles in coastal processes (e.g. wave climate, sediment transport) are not captured in the results below, and therefore it should be expected that some prolonged periods of entrance closure (e.g. several months, or more) may occur.

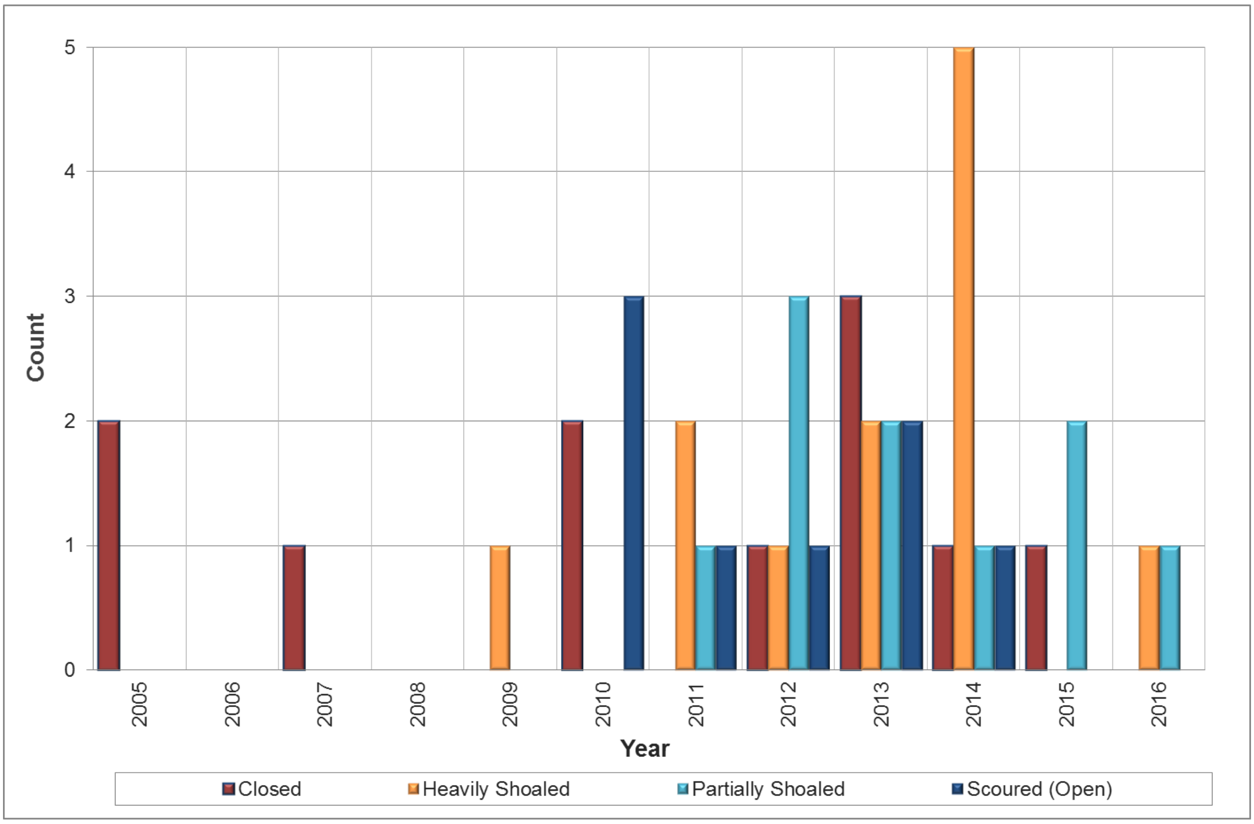


Figure 3-3 Entrance Conditions from 2005 to 2016

Table 3-1 Summary of Entrance Conditions (2005 – 2016)

	Closed	Heavily Shoaled	Partially Shoaled	Scoured (Open)
Entrance Condition	27%	29%	24%	20%

In addition to the above, BMT WBM has identified the following characteristics of the coastal catchment, creek entrance morphology and it's functioning, based on the review of aerial imagery and site observations:

- While some entrance breakouts form a relatively large (wide and deep) channel through the entrance berm, other breakout events do not appear to significantly scour out the beach (see Figure 3-4). Prevailing coastal processes would be a key determinant in what type of entrance breakout event occurs.
- The period of entrance recovery following a breakout event can take months or longer (i.e. from scour to complete closure).
- The Flowers Drive culvert forms a hydraulic control on the location of the creek channel and adjoining entrance mouth. The entrance channel migration footprint mapped from the available aerial imagery is shown in Figure 3-3.
- Prior to settlement of the area and subsequent construction of the hydraulic controls on the creek (culvert, road and historical railway), the creek entrance likely migrated further north and south of the areas mapped in Figure 3-3.

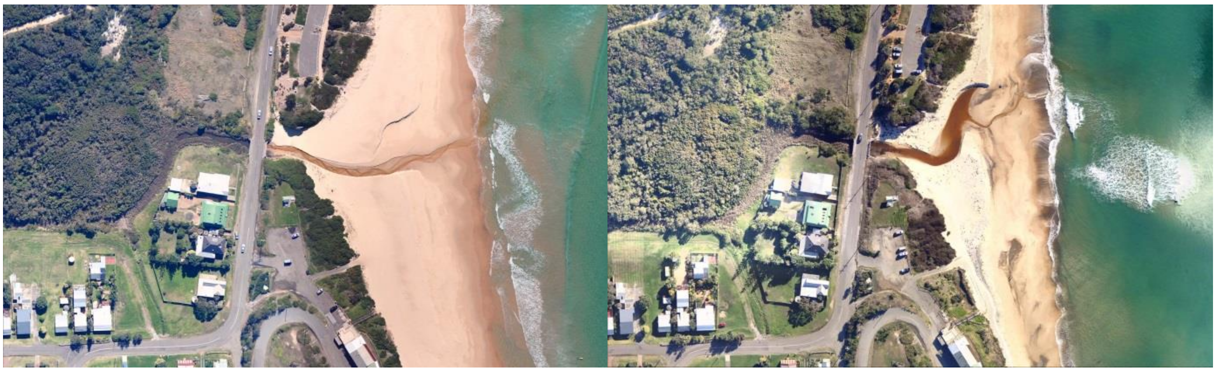
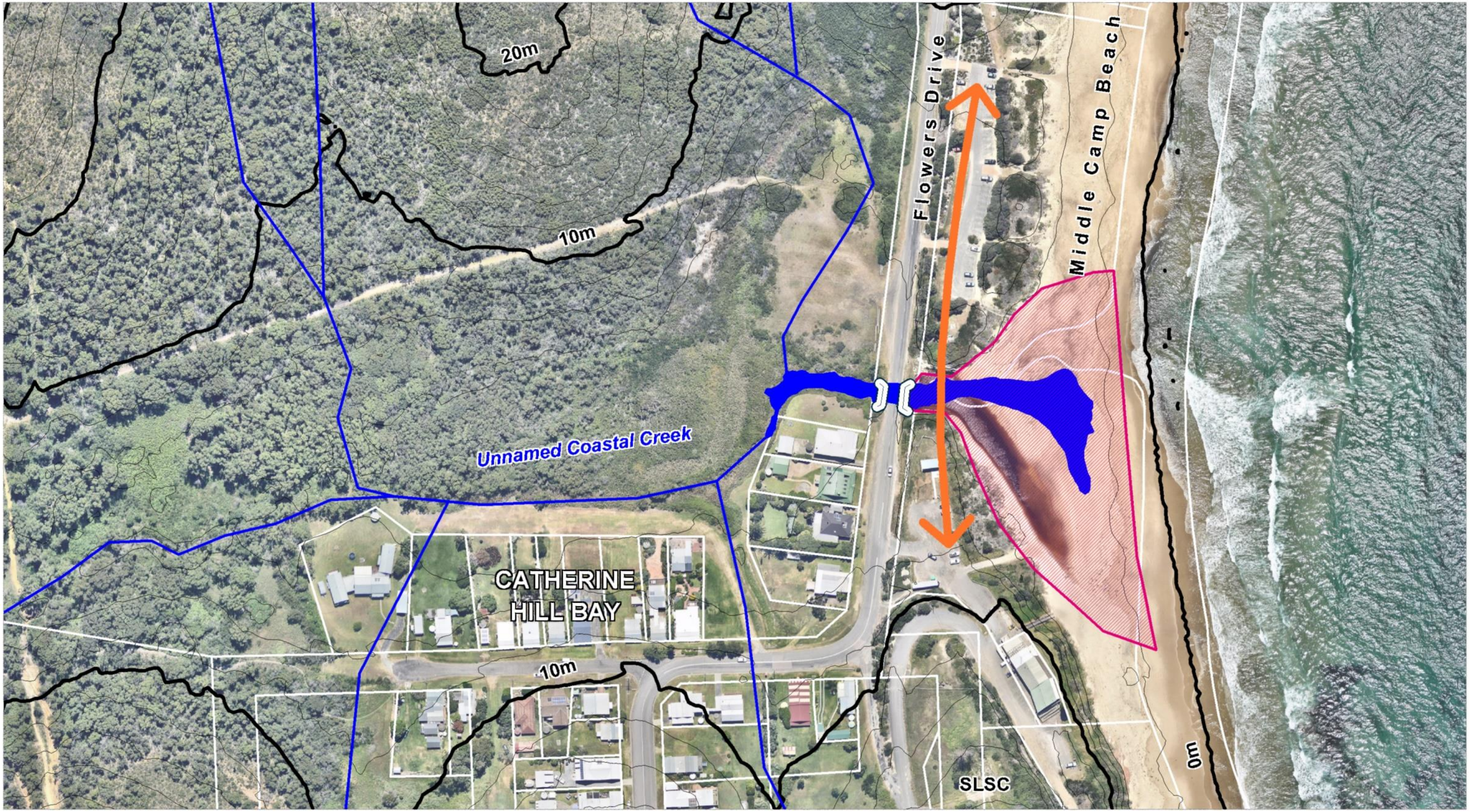


Figure 3-4 Entrance breakout types, showing a narrow and shallow breakout channel (left) in comparison to a wider deeper channel (right)



LEGEND

Entrance Instability Hazard

- Entrance Instability Hazard
- Box Culvert (control on entrance position)
- Entrance Migration Potential (minus contolling feautres)

Title:

Entrance Instability and Migration Hazard, Unnamed Coastal Creek at the south end of Catherine Hill Bay

Figure: 3-5

Rev: A

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Approx. Scale

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Filepath : K:\N20719_CatherineHillBayBeachCoastalHydrologyAssessment\MI\Workspaces\DRG004_EntranceInstabilityMap_R90_Fig3-5.wor

4 Creek Entrance Impact Assessment

A qualitative assessment of potential beach and creek entrance impacts arising from changes to the catchment hydrology associated with proposed changes to Stages 6 and 7 of the ‘Beaches’ development is provided below. This assessment is based on the work undertaken above characterising the morphology, condition and behaviour of the creek entrance and adjoining beach, and has given consideration to the modelled estimates of catchment flows under two development scenarios.

4.1 Development Model Scenarios

For the current impact assessment, modelled runoff was obtained using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) to assess the relative impact of proposed recycled water discharges on the catchment hydrology. ADW Johnson also developed a separate model to characterise the flow rate of treated-recycled water from an external subsurface flow wetland (located to the south within Moonee Beach catchment). Two development scenarios were simulated by ADW Johnson to inform this assessment, namely:

- **‘Approved’ development scenario** that comprises entire 188 ha coastal creek catchment and includes Stages 6 and 7 of the ‘Beaches’ development in their current approved form (which includes households and rainwater tanks); and
- **‘Proposed’ development scenario** based on the above scenario, but incorporates the following:
  - Increased flow volumes from modification to the approved Stages 6 and 7, whereby household rainwater tanks are not permitted; and
  - Increased flow volumes from excess wetland-treated recycled water discharges.

Pluviograph rainfall data from Williamston RAAF AWS (BoM station no. 061078) was adopted by the MUSIC model. Williamtown is similarly located in close proximity to the coast, and the data record is likely to incorporate similar coastal influences expected at the Catherine Hill Bay site. This dataset was the most complete record available from the potentially suitable gauges within the study region, as only 1.5% of the 35-year record was missing. No attempt was made to in-fill missing rainfall observations.

The Catherine Hill Bay coastal creek catchment is ungauged and no flow monitoring record exists against which the MUSIC model could be calibrated. The MUSIC model was parameterised to achieve a surface runoff to baseflow ratio of 3.9 and an overall streamflow rate of 2.47 ML/ha/yr, which represents a 44% per unit area increase over that estimated by Littleboy et al. (2009) for the Middle Camp Creek catchment. This is considered to be a liberal estimate which is suitable for assessing the impact of flow changes on the coastal creek's opening and closing regime to the ocean.

4.2 Model Results

The following section presents an analysis of results obtained from MUSIC modelling of the ‘approved’ development scenario and MUSIC and wetland flow modelling of the ‘proposed’ development scenario. These were provided to BMT WBM as simulated catchment flows at 30 minute intervals between 1974 and 2008. These data were aggregated to daily runoff volumes (ML/day) over that same period.

The purpose of the analysis is to compare the simulated changes to catchment hydrology from the ‘proposed’ scenario relative to the ‘approved’ scenario, and comment on the potential impacts to the coastal creek entrance condition and dynamics. The analysis of results is presented below as:

- Time series of estimated runoff volumes;
- Descriptive statistics; and
- Flow curve durations.

4.3 Flow Comparison

4.3.1 Catchment flows and descriptive statistics

Modelled runoff volumes for the unnamed coastal creek catchment over the period of 1974 to 2008 are presented in Figure 4-1. The time series shows the modelled runoff for the ‘approved development’ and ‘proposed development’ scenarios, as well as the difference between the two modelled scenarios which essentially represents the excess treated recycled water and increased stormwater due to the removal of rainwater tanks. Note this graph is presented on a log scale to enhance the small variation in flow magnitude.

Descriptive statistics for the modelled runoff flows from 35-year modelled period are presented in Table 4-1 to Table 4-3. Figure 4-2 plots the relationship between the modelled ‘approved ‘catchment flows and ‘proposed’ flows due to no rainwater tanks and excess wetland-treated treated recycled water.

Table 4-1 Modelled Average Daily Flow Statistics (ML/day)

Statistic	Approved Development	Proposed Development	Difference (approved minus proposed development)
Minimum	0.00	0.00	0.00
Maximum	358.70	360.0	1.30
Mean	1.27	1.40	0.13
Median	0.04	0.05	0.01
25th Percentile	0.00	0.00	0.00
75th Percentile	0.52	0.69	0.17

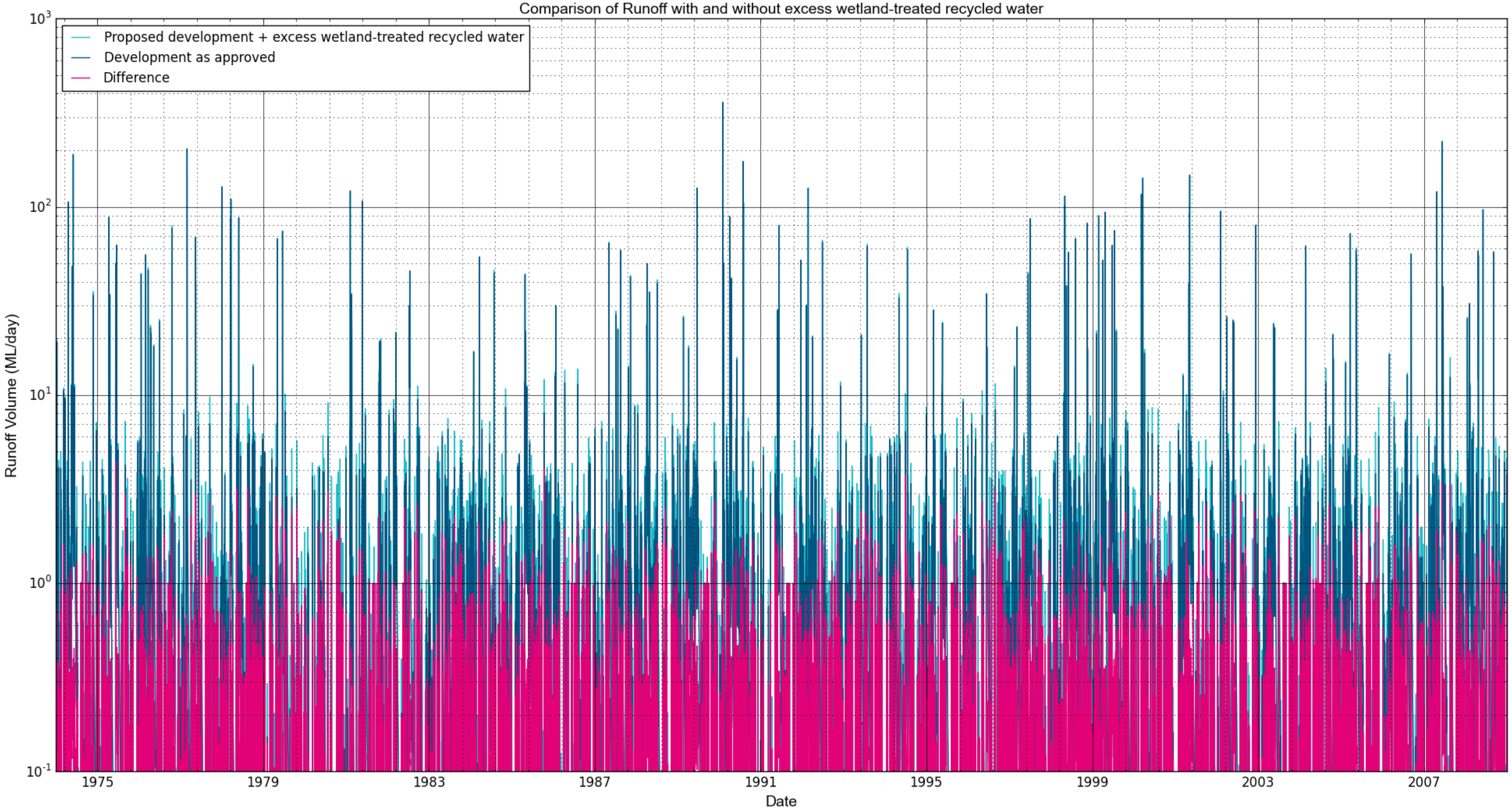

Figure 4-1 Modelled Catchment Runoff Volume from 1974 to 2008, for 'Approved Development' Scenario (dark blue), 'Proposed Development' Scenario (light blue) and the Difference (excess treated recycled water plus rainwater tank influence) between the two scenarios (pink)

Table 4-2 Modelled Average Monthly Flow Statistics (ML/month)

Statistic	Approved Development	Proposed Development	Difference (approved minus proposed development)
Minimum	0.01	0.01	0.00
Maximum	814.6	820.9	6.2
Mean	38.8	42.6	3.9
Median	12.0	15.9	3.9
25th Percentile	5.2	8.3	3.1
75th Percentile	31.0	36.4	5.4

Table 4-3 Modelled Average Yearly Flow Statistics (ML/year)

Statistic	Approved Development	Proposed Development	Difference (approved minus proposed development)
Minimum	70.6	103.4	32.8
Maximum	1483.9	1534.9	51.0
Mean	465.0	511.5	46.5
Median	418.6	461.3	42.7
25th Percentile	294.3	336.7	42.4
75th Percentile	569.3	619.3	50.0

Table 4-1 to Table 4-3 show relatively minor increase in daily flow volumes from modelled 'proposed scenario', relative to the modelled 'approved scenario', with the maximum daily difference of 1.3 ML/day modelled between the two scenarios. The minimum difference of 0 ML/day is representative of days where no excess treated recycled water or stormwater flows are discharged into the catchment. Figure 4-1 illustrates that zero discharges are not uncommon (see also Section 4.3.2).

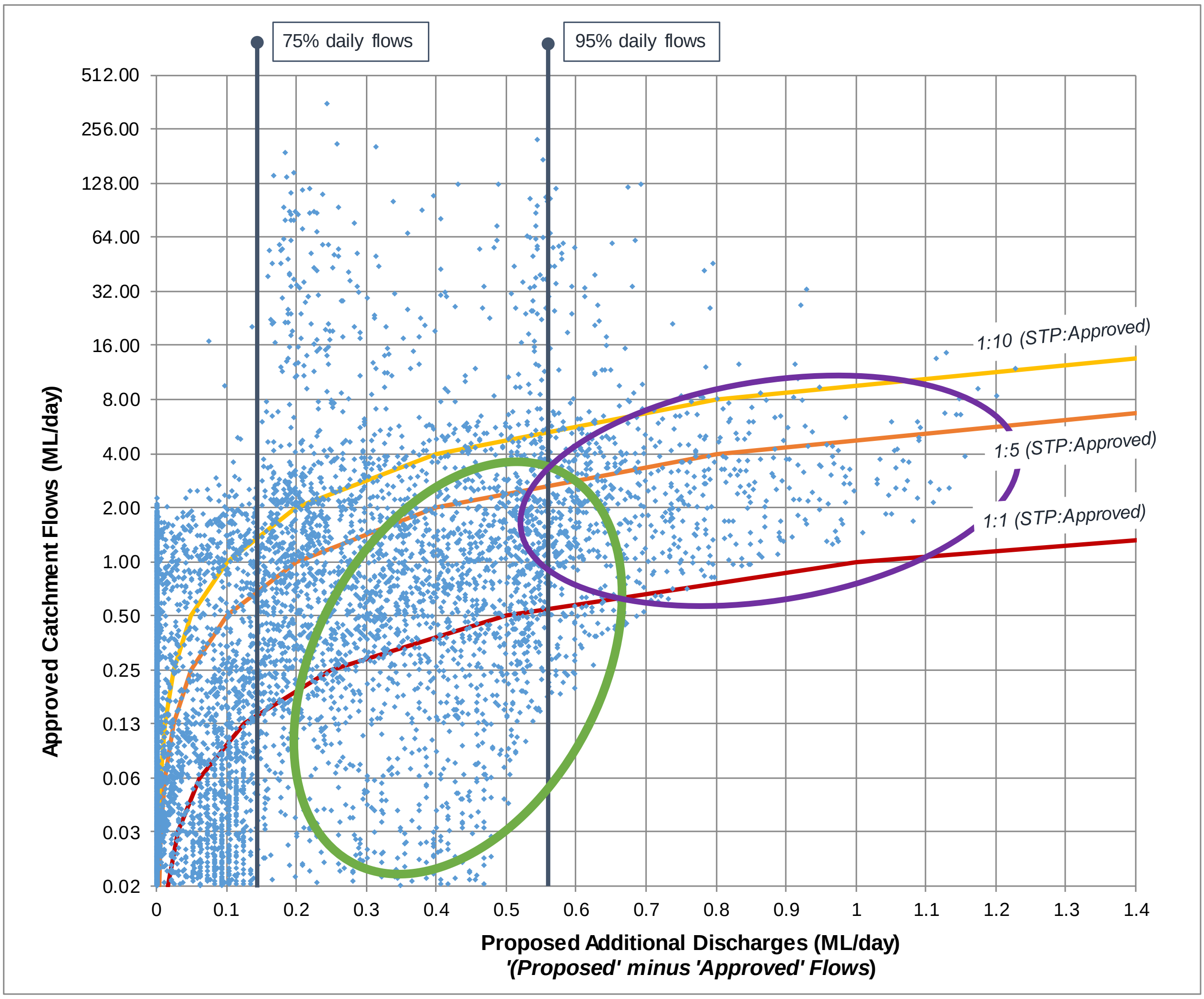

Figure 4-2 Scatter Plot of Modelled 'Approved' Catchment Flows and 'Proposed' Additional Discharges

Figure 4-2 further demonstrates that the coincidence of modelled difference between 'proposed' and 'approved' flows (i.e. additional flows) with the 'approved' catchment flows. The MUSIC model results indicate that, for up to 75% of the time, additional flows up to 0.14 ML/day coincide with small catchment flows (i.e. 'approved' scenario flows) primarily 2 ML/day or less. Additional proposed daily flows (see red line in Figure 4-3) ranging between 0.14 (75%ile) and 0.56 ML (95%ile) coincide with a range of daily catchment flows, including no catchment flows to very high catchment flows (up to 360 ML/day). In some instances, the modelling indicates that 0.5 ML of additional proposed flows could be released on days when only a small volume of catchment runoff is predicted. The top 5% of additional daily discharges typically coincide with 'medium sized' catchment flows ranging between 1 to 8 ML/day.

The green zone shown on Figure 4-2 highlight the concurrence of medium sized additional daily flows that coincide with relatively small catchment runoff events. The purple zone highlights the larger additional daily flows that coincide with medium catchment runoff events.

The potential impact of the above changes to catchment runoff volume on the entrance condition is described in Section 4.4.

4.3.2 Flow duration

Flow duration curves were prepared to summarise the timeseries of modelled flow data for the 'approved' and 'proposed' development scenarios. The flow duration curves (refer to Table 4-2) show the percentage of time a given flow is exceeded for both modelled scenarios. The graph is presented in log scale to highlight small changes in flow.

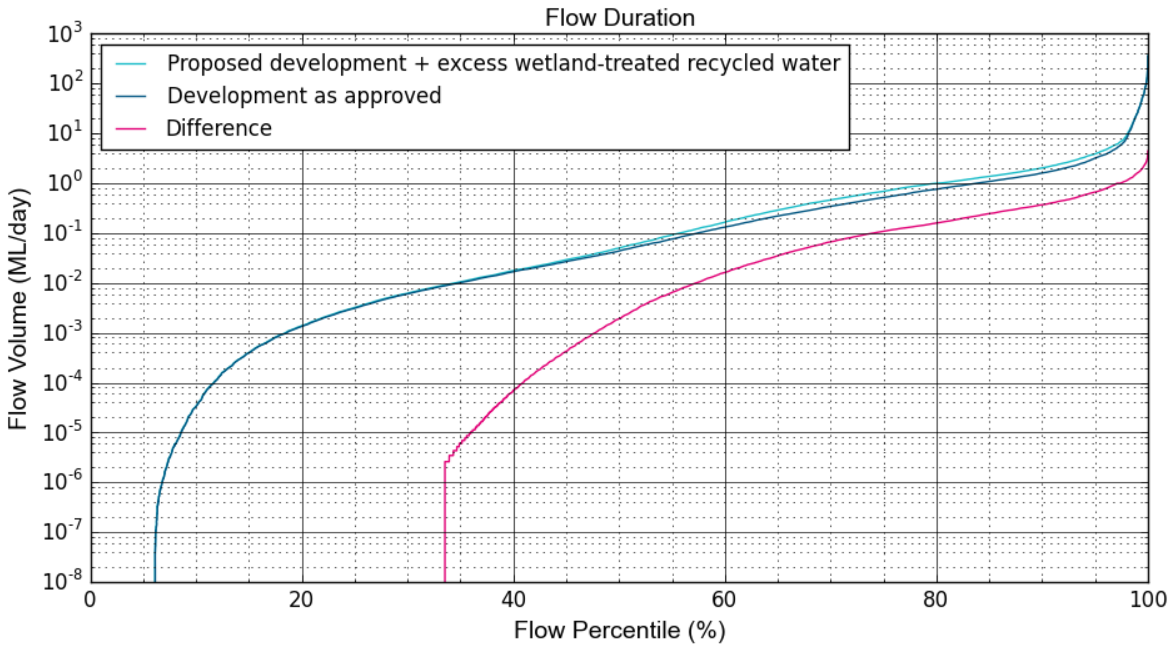

Figure 4-3 Flow Duration Curves, for 'Approved Development' Scenario (dark blue), 'Proposed Development' Scenario (light blue) and Difference between the two scenarios (pink)

There are a number of important points revealed in the above flow duration figure:

- The steep section at the bottom end of the 'approved' (dark blue line) and 'proposed' (light blue line) represent very small (<0.0005 ML/day) and infrequent catchment flows. Conversely the seep section at the top end of the 'approved' and 'developed' line represent infrequent medium to high catchment flows (>3 ML/day).
- The 'approved' (dark blue line) and 'proposed' (light blue line) development flow duration curves are similar, with the majority of flow difference occurring around the middle of the curve (between the 60%ile and 90%ile).
- The pink line which shows the difference between the 'approved' and 'proposed' development, and represents the excess treated recycled water plus the influence of no rainwater tanks. The additional ('difference') flows are modelled to occur for around 40% of the time, ranging mostly between 0.01 and 4.4 ML/day. As shown in Figure 4-3, the model results indicate that additional daily discharges of greater than 0.1 ML occur about 25% of the time, while additional daily discharges greater than 0.5 ML occur much less frequently i.e. around 7% of the time, and greater than 1 ML per day for less than 3% of the time.

4.4 Discussion

4.4.1 Proposed Impacts on Creek Entrance Conditions

As discussed, coastal creek entrance conditions are controlled primarily by catchment flows and oceanic processes, including waves, tide, currents. Periods of high catchment flows lead to coastal entrances breaking out and previously impounded creek waters draining to the ocean. Conversely, periods of low flow coupled with constructional wave conditions cause the entrance berm to build up over time and eventually close the creek mouth, in the absence of high catchment flows.

The assessment of creek entrance condition presented here indicates that the unnamed coastal creek entrance may be fully closed around 30% of the time, and shoaled to varying degrees around 50% of the time noting that shoaled entrance conditions still allow the creek waters to drain to the ocean. No stream flow data are available for this creek and therefore the relationship between catchment flows, creek levels and entrance conditions cannot be quantified. As such, the potential impact of increased catchment flows from the proposed development must therefore be assessed based on relative (modelled) changes to the catchment hydrology.

MUSIC modelling of the two development scenarios shows that median flows from the ‘proposed development’ could increase to 460 ML/year, compared with 420 ML/year from the ‘approved development’. The proposed additional discharge (i.e. excess treated recycled water and stormwater) therefore equates to an approximate increase in catchment flows of around 10% on average, relative to the ‘approved’ conditions. Additional discharges (above cease to flow conditions of 0.01 ML/day) were modelled to occur around 40% of the time, with additional daily flows exceeding 0.14 ML/day for 25% of the time and 0.56 ML/day for 5% of the time.

On this basis, the proposed development is considered to have minor impact on the creek entrance morphology and functioning under the flowing conditions:

- Periods of no additional discharge from the Stage 6 and Stage 7 development areas.
- Where additional discharges occur during periods of high catchment flow that would have raised the creek levels to a height sufficient to force an entrance breakout; and
- Where small to moderate additional discharges occur at times when the entrance conditions would allow the creek waters to drain freely to the ocean (i.e. under open or partially shoaled entrance conditions, which occur around 40 to 50% of the time).

Changes to the catchment hydrology from the proposed development may have an impact on the entrance conditions when additional discharges of a moderate to high volume occur during periods of low catchment rainfall. The impact of such events would be greatest when the creek entrance condition is closed or heavily shoaled. Larger additional discharges in the absence of background catchment flows may cause a closed entrance to artificially breakout, where the creek level becomes raised above the crest of the entrance berm. Likewise, the larger additional discharges in the absence of natural catchment runoff and flows may cause a heavily shoaled entrance to become scoured more often. The proposed additional discharges that may be related to the above impacts are highlighted in Figure 4-2, which have a low frequency of occurrence. Increases of open entrance conditions may have a minor impact on beach amenity, with respect to beach users accessing areas of beach located on either side of the entrance channel. For example, access to the SLSC flagged area along the beach from the carpark to the north of the Flowers Drive may be reduced.

4.4.2 Proposed Impacts on Beach Erosion Hazards

Severe beach erosion can impact the southern end of Middle Camp Beach from large storms, or a series of storms in succession. When this occurs, sand contained within the entrance berm can be moved offshore. While beach erosion does not typically cause the creek entrances to open, eroded beach conditions can promote channel scour when an entrance breakout occurs.

The severity of a beach erosion event will be determined by the complex interaction of wave heights and direction, storm duration, ocean water levels and preceding beach condition. The marginal increase to total catchment runoff arising from the proposed additional discharges is not expected to significantly impact the beach erosion hazard at Catherine Hill Bay.

With respect to sea level rise, the shoreline is expected to move landward and upward in response to rising ocean water levels. The proposed additional flows are not expected to influence the shoreline response to projected sea level rise. However, the sea level rise and shoreline recession may influence the behaviour and condition of the creek entrance by shortening the lower creek channel, and subsequently reducing the total volume of water that can be held under closed entrance conditions prior to the berm becoming overtopped. Conversely, sea level rise would see the berm crest level move upward in line with mean sea level. This in term may increase the volume behind the beach that can hold creek waters.

As noted in Section 3.2.3, Flowers Drive culvert controls the location of the creek entrance channel. Should the roadway and culvert be relocated in response to sea level rise impacts at some stage in the future, the entrance may migrate further along the beach than currently occurs (see Figure 3-5).

5 Conclusions

This investigation provides information to support a Review of Environmental Factors (REF) for the proposed changes to Stages 6 and 7 of the 'Beaches' development at Catherine Hill Bay. The aim of the study was to assess potential impacts from increased catchment flows associated with the proposed additional discharges (relative to the approved development condition) on the coastal entrance to the unnamed creek at Catherine Hill Bay. Central to this assessment was (i) a synthesis of available coastal hazard information; (ii) an assessment of entrance creek morphology and behaviour from available aerial images; and (iii) an analysis of modelled catchment flows from the 'approved; and 'proposed' development scenarios. The assessment of entrance morphology and behaviour was limited to available aerial imagery from 2005 onwards. The impact assessment of proposed additional flows on the entrance condition was based on analysis of 35 years of catchment flow data modelled by ADW Johnson for the two development scenarios.

Coastal hazards found to threaten Middle Camp Beach (including unnamed coastal creek entrance) at Catherine Hill Bay includes beach erosion, shoreline recession, entrance instability and coastal inundation. Beach erosion and shoreline recession will be limited by bedrock in some areas, however the beach and entrance to the unnamed creek will move landward in response to these two hazards. Coastal creek entrance conditions vary as a function wave climate, tides, currents and catchment discharges. An assessment of entrance conditions between 2005 and 2016 shows that the entrance of the coastal creek varied between fully closed and scoured (open) conditions, with two intervening stages that experience shoaling to varying degrees. The entrance was found to be closed 27% of the time, heavily shoaled 29% of the time, partially shoaled 24% of the time and scoured open 20% of the time. The creek entrance location is largely controlled by the presence of Flowers Drive and the associated box culverts. In recent times, the entrance channel has migrated north and south along a 150 m length of beach centred on the culvert location. The entrance may have also migrated further north in the past and as such exhibits a range of open entrance conditions are possible at the site. It is considered the proposed additional discharges and associated increase in combined catchment runoff would not significantly exacerbate the potential impact of beach erosion related hazards.

Catchment flows from the 'approved development' scenario and 'proposed development' scenario which includes excess treated recycled water and stormwater were modelled from a continuous 35-year period. The assessment of the modelled daily runoff volumes found the overall change to catchment hydrology from the 'proposed' development, relative to the 'approved' development is small, with a 10% increase in average annual flow volume, and with additional discharges occurring only about 40% of the time.

With respect to entrance conditions impacts, it is considered the proposed development will have a negligible impact on creek entrance conditions during periods of no additional discharge from excess recycled water or stormwater; during high rainfall events that would drive the entrance to breakout naturally in the absence of any additional flow contributions; and when small to moderate excess treated recycled water and stormwater discharges occur during an entrance condition that is open or partially shoaled (as the increased creek flows can discharge for the ocean under these conditions). It is expected that these conditions would prevail for the majority of time.

The proposed development may have some impact on entrance conditions where moderate to high additional discharges occur during periods of low rainfall and catchment runoff. The impact under those conditions would be greatest when the entrance is closed or heavily shoaled, as the increased creek level may cause a closed entrance to overtop and open, or shoaled channel to scour. If realised, it is considered that such conditions would occur infrequently (about 1% of the time on average) and their overall consequence to beach morphology and coastal processes would be minor.

6 References

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Appendix A - Satellite Images from Google Earth

22 April 2005

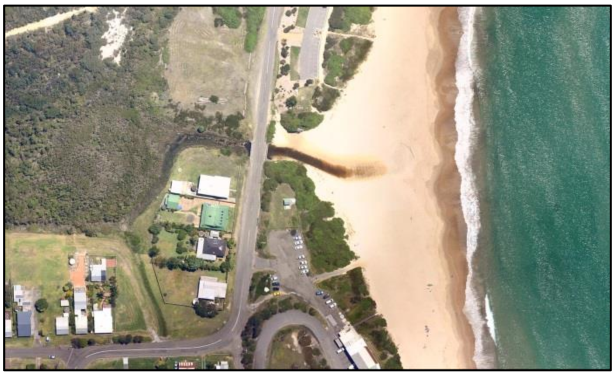
20 June 2005

01 November 2007

02 September 2009

20 March 2010

05 August 2010



26 October 2010

19 November 2010

07 December 2010

31 January 2011

11 February 2011

18 June 2011

17 September 2011

31 March 2012

15 July 2012

06 August 2012


23 September 2012


04 October 2012


30 October 2012


04 January 2013


19 March 2013


28 March 2013


10 April 2013


26 April 2013


05 July 2013


15 October 2013


07November 2013


13 November 2013


30 January 2014


04 March 2014


24 April 2014


03 June 2014


29 July 2014


19 October 2014


31 October 2014


17 January 2015


31 March 2015


24 November 2015


10 January 2016


23 February 2016

Whitehead & Associates
Environmental Consultants

Andrew Krause – Senior Engineer
ADW Johnson
7/335 Hillsborough Road,
Warners Bay, NSW, 2282
(via email)

Our ref: 1759_Letter Report_008.docx

14th August 2017

Dear Andrew,

Design Support for Surplus Recycled Water System at Catherine Hill Bay Subdivision

Prologue

Preliminary design and advice regarding implementation of a recycled water polishing facility was undertaken for surplus-to-demand recycled water as part of the 'Beaches' subdivision at Catherine Hill Bay ("the Site") to be operated by Solo Water ("network operator").

We understand that the subdivision will be serviced by a Recycled Water Scheme with provision of third-pipe supply to individual properties. During portions of the year, 'surplus-to-demand' recycled water has been identified and it was intended that this water would be sustainably irrigated on a dedicated area within the subdivision. However, the network operator no longer wishes to utilise the irrigation application option and has requested investigation of alternative solutions.

We understand that the network operator has expressed preference for a horizontal subsurface flow constructed wetland system (SSF wetland) combined with tank storage to manage surplus-to-demand recycled water volumes, and subsequent environmental releases. We understand that NSW EPA has given qualified support to the option if it can be demonstrated that it can achieve environmental protection objectives.

Preliminary Design

A conceptual design for the wetland system was undertaken using the Kadlec & Knight sizing method (DLWC, 1998; Kadlec & Knight, 1996) for managing both the seasonably-variable hydraulic loads and target contamination concentrations.

The Kadlec & Knight (K&K) method is based on a first-order decay (k-C*) areal model and is extensively detailed within Chapter 21 of Kadlec & Knight (1996) for SSF wetlands. The K&K method considers the wetland as an attached growth biological reactor and uses first-order plug flow kinetics to model fluid movement through the bed.

The proposed basal area of the wetland is 3,300m^2 and is subdivided as follows:

- SSFW 1: 1,684m^2
- SSFW 2: 1,616m^2

Surplus-to-demand Recycled Water Volumes

ADW Johnson provided W&A with the predicted average monthly surplus-to-demand recycled water volumes (refer to Table 1), which were calculated from a daily time-step model over the period of 1/1/1974 to 31/12/2008. The values reflect anticipated surplus volumes for 550 equivalent tenements (ET) and an equivalent population (EP) of 1,650 or 3 EP/ET.

Table 1: Predicted Daily Surplus-to-demand Recycled Water Volumes by Month (kL/day)

Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
68.6	75.4	90.3	111.6	134.7	139.1	137.3	121.6	100.0	80.3	75.3	64.5	36523.1

Conceptual designs were undertaken for three wetland inlet flow rate scenarios which represent the following key flow conditions for surplus-to-demand recycled water:

- Annual average daily flow of 100kL/day based on the entire 35 year modelling period;
- Monthly period with highest average daily flow, 139.1kL/day for June, representing the seasonal period of highest flows; and
- Short-term daily peak flow of 162.3kL/day which occurs during extended wet periods when household irrigation is assumed to be zero.

Wetland Climatic Balance

A climate balance was undertaken for the wetland to determine the inputs, outputs and storage requirements into the system. The wetland will be lined with compacted clay or bentonite to ensure that there is no seepage. The bunds around the wetland ponds will direct stormwater away from the wetland, ensuring only incident rainfall over the wetland surface. Williamtown RAAF Bureau of Meteorology (BoM) data was used for rainfall and evaporation as supplied by ADW Johnson. Table 2 below details the wetland climatic balance.

Figure 1 below details the hydraulic balance for the entire wetland. The results show that wetland outflows are predicted for all months under average climatic conditions. The largest average outflows are predicted in June (4.4ML/month).

Table 2: Wetland Climatic Balance

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Days	31	28	31	30	31	30	31	31	30	31	30	31	365
Surplus-to-demand Recycled Water (kL)	68.6	75.4	90.3	111.6	134.7	139.1	137.3	121.6	100.0	80.3	75.3	64.5	36507.5
Rainfall (mm)	99.4	122.9	126.6	113.2	119.4	119.0	68.4	57.2	62.2	72.8	87.2	76.3	1124.6
Rainfall Gain (m3/month)	325.0	402.0	413.9	370.3	390.5	389.2	223.8	187.1	203.3	237.9	285.1	249.4	3677.5
Evaporation (mm)	213.5	173.8	151.8	114.5	83.7	72.0	81.0	109.3	139.2	171.1	187.4	219.7	1717.0
Crop Factor (Fraction)	2.1	1.6	1.1	0.7	0.8	0.7	0.7	0.7	0.7	0.7	1.1	1.5	
ET (mm)	448.4	278.1	167.0	80.1	67.0	50.4	52.6	71.0	97.4	119.8	206.1	329.5	1967.6
ET Volume Loss (m3/month)	1466.3	909.4	546.1	262.1	218.9	164.9	172.1	232.3	318.6	391.8	674.1	1077.5	6434.0
Wetland Water Inputs (m3/month)	2451.6	2513.2	3213.2	3718.3	4566.2	4562.2	4480.1	3956.7	3203.3	2727.2	2544.1	2248.9	40185.0
Wetland Water Inputs (m3/day)	79.1	89.8	103.7	123.9	147.3	152.1	144.5	127.6	106.8	88.0	84.8	72.5	
Wetland Water Discharge (m3/month)	985.3	1603.7	2667.1	3456.2	4347.3	4397.4	4307.9	3724.5	2884.7	2335.5	1870.0	1171.4	33751.0
Wetland Water Discharge (m3/day)	31.8	57.3	86.0	115.2	140.2	146.6	139.0	120.1	96.2	75.3	62.3	37.8	
Cumulative Storage (m3/month)	985.3	2589.0	5256.1	8712.4	13059.6	17457.0	21764.9	25489.4	28374.1	30709.6	32579.6	33751.0	

Notes:
STP discharge calculations based on Williamtown RAAF climate data
Daily rainfall – Williamtown RAAF (BoM daily and SILO patch point data are the same)
SILO patch point evaporation – Williamtown RAAF
From Galvao *et al.*
Estimated

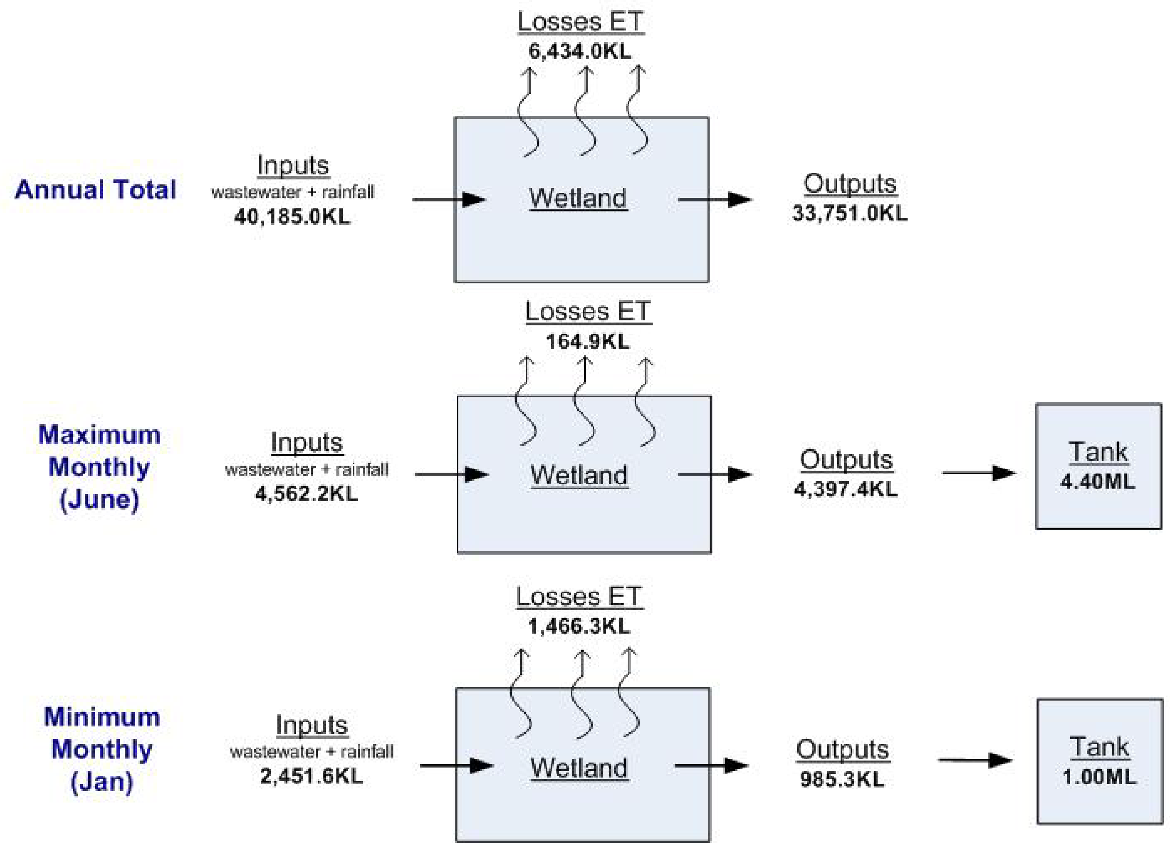


Figure 1: Wetland Hydraulic Balance for the Constructed SSF Wetland System

1759 – Catherine Hill Bay Recycled Water SSF Wetland

Whitehead & Associates
Environmental Consultants

Revision	A
Drawn	JK
Approved	MS

Pollutant and Hydraulic Balance

Pollutant and hydraulic balances were undertaken for each scenario for the entire wetland. The wetland physical parameters used in the pollutant and hydraulic balances remained relatively constant as detailed in Table 3.

Table 3: Pollutant and Hydraulic Balance Inputs

Parameters	Values	References
Porosity of Media (%)	0.35	Table 5 (gravelly sand) EPA US (1993). Variably iterated to address bed hydraulic considerations.
Depth of Media (m)	0.6	
Depth of Media at Outlet Invert (m)	0.54	
Nominal Hydraulic Conductivity of Selected Bed Media (m/day)	5,000	Table 5 (gravelly sand) EPA US (1993).
Nominal diameter of particle size (cm)	0.8	Table 5 (gravelly sand) EPA US (1993).

Table 4 details the wetland pollutant inlet concentrations for the wetland. The initial wetland inlet concentrations were provided by SOLO Water as per the maximum and 50th percentile Membrane Bioreactor (MBR) water quality concentrations. The 50th-percentiles of TSS, TP and TN are assumed to be representative of the respective average concentrations of these pollutants. As a conservative measure, average BOD and FC concentrations are assumed to be equivalent to the maxima of these pollutants.

Table 4: Wetland Pollutant Inlet Concentrations

Parameters		Values		References
		Maximum	Assumed Average	
Wetland Inlet Concentrations (mg/L)	TSS	10	5	As per the maximum and assumed average MBR water quality concentrations shown in Solo Water (2015), as provided by ADW Johnson.
	BOD	20	20	
	TP	2.0	0.3	
	TN	20	10	
	FC (cfu/100ml)	100	100	

The daily surplus-to-demand recycled water load is split in half to feed into each of the two wetlands (SSFW1 and SSFW2) that will run in parallel.

Table 5 details the pollutant analysis/requirements for each wetland. Table 6 details the hydraulic balance for each wetland under each loading scenario.

The formulas and information that guide the pollutant and hydraulic balances detailed in this section is attached in Appendix A.

Table 5: Wetland Pollutant Balance

Parameters		**Annual Average Daily Flow 100kL/day**		**Seasonal Peak Daily Flow 139.1kL/day**		**Short-term Wet Period Peak Daily Flow 162.3kL/day**	
Surplus-to-demand Recycled Water Rate (kL/day)		50.0		70.0		81.2	
MBR Outlet Concentrations		Max	Ave	Max	Ave	Max	Ave
Wetland Effluent Concentrations (mg/L)	TSS	8.43	8.12	8.43	8.12	8.43	8.12
	BOD	4.56	4.56	4.56	4.56	4.56	4.56
	TP	0.77	0.13	1.01	0.16	1.10	0.17
	TN	3.60	2.47	5.42	3.31	6.22	3.67
	FC (cfu/100ml)	4.55	4.55	4.91	4.91	5.28	5.28
Required Area based on most limiting pollutant (m^2)		~1,470					
Hydraulic Loading Rate (cm/day)		3.4		4.8		5.4	
Hydraulic Residence Time (days)		6.2		4.4		3.9	

Due to the high quality of the surplus-to-demand recycled water, post-wetland recycled water quality is expected to be consistent with environmental concentrations.

Table 6: Wetland Hydraulic Balance

Parameters	**Annual Average Daily Flow 100kL/day**	**Seasonal Peak Daily Flow 139.1kL/day**	**Short-term Wet Period Peak Daily Flow 162.3kL/day**
Surplus-to-demand Recycled Water rate (kL/day)	50.0	70.0	81.2
Minimum required Wetland Surface Area for Hydraulics (m^2)	1,634	1,633	1,634
Wetland Surface Area (m^2)	1,635		
Hydraulic Loading Rate (cm/day)	3.1	4.3	4.9
Dimensions and Aspect Ratio	27m L x 60m W Short circuiting		
Wetland Velocity (m/day)	1.5	2.2	2.5
Slope of Bed Base (cm drop)	5.4		
Flooding Constraint (m/day)	1,375		
Particle Size of Media (mm)	1.0		
Hydraulic Residence Time (days)	6.9	4.9	4.3

The results tabulated above highlight that under all scenarios both wetlands are hydraulically limited, if constructed as a single-cell, with a reduction in effluent quality expected during times of higher (short-term wet period peak daily flow) surplus-to-demand recycled water volumes.

The length to width ratio (aspect) is critically important in design as it has an effect on the flow distribution and hydraulic short-circuiting of a wetland. Table 6 estimates that both wetlands are expected to short-circuit based on the available dimensions. In order to prevent short-circuiting, each wetland will be further divided into two cells linked in series to achieve the required aspect ratio, as shown in Table 7.

The specific dimensions for each wetland cell are shown on Figure 2 and are all deemed suitable except for SSFW2 pond 2 which is marginally undersized. If the additional area required cannot be achieved, it is recommended that the surplus-to-demand recycled water volumes are accordingly proportioned as discussed below.

With respect to wetland media, the proposed gravelly sand meets the flooding constraints and is considered suitable for the wetland based on the following specified geometry.

Table 7: Wetland Cell geometry

Parameters	Cells
Area (m^2)	818
Length (m)	30
Width (m)	27

Proposed Wetland Layout

Figure 2 below outlines the recommended SSF wetland layout. SSFW1 and SSFW2 will run in parallel, with each wetland split into two parallel cells by a central berm. The wetland cell configuration is subject to change and there is an option to install manifolds to split the flows proportionally to ensure that an appropriate length to width ratio is maintained.

SSFW2 has slightly less area than modelled based on an equally split surplus-to-demand recycled water flow. The surplus-to-demand recycled water volume could be split 51.5% and 49.5% between SSFW1 and SSFW2, respectively, at the wetland inlet manifolds.

Disinfection

SOLO Water has advised that the free chlorine concentration within the surplus-to-demand recycled water will range between 0.2 and 2mg/L (Brad Irwin, pers. comm. 6th July 2016). This free chlorine concentration is considered to be within manageable range. It is expected that the majority of the free chlorine will be utilised in the oxidation of organic materials within the front end of each wetland. While this may have a marginal impact on plant health within the entry zone of each wetland, mitigation is provided with a recommendation for salt-tolerant plants to be established as discussed below.

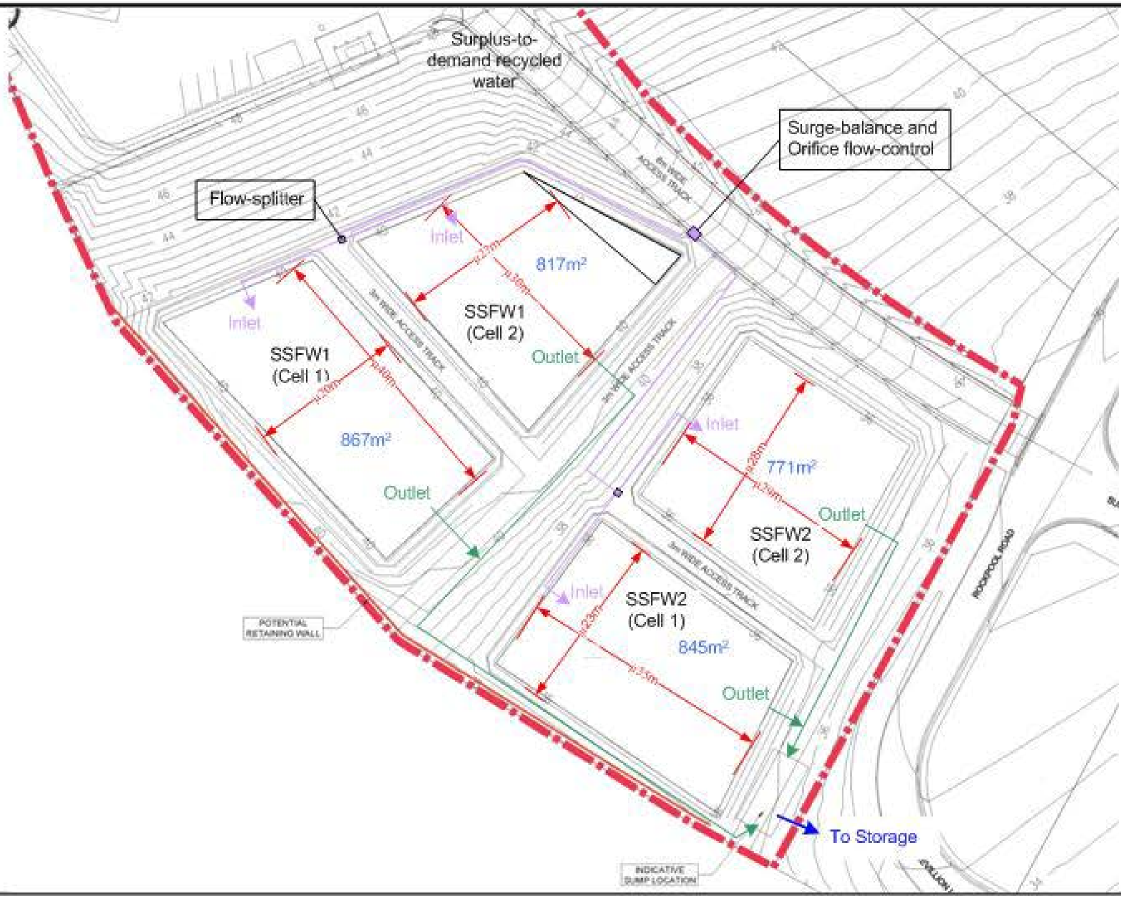


Figure 2: Preliminary Constructed SSF Wetlands (SSFW1 and SSFW2)	Scale as shown
1759 – Catherine Hill Bay Recycled Water SSF Wetland	

Whitehead & Associates Environmental Consultants	SSFW 1 - 1,684m² and 1010m³ at 0.6m depth SSFW 2 - 1,616m² and 970m³ at 0.6m depth	Revision	B
		Drawn	JK
		Approved	MS

Preliminary Vegetation Requirements

SOLO water has advised the expected average and maximum total dissolved solids (TDS) concentrations of the surplus-to-demand recycled water from the MBR are 600mg/L and 1,000mg/L, respectively.

Given the salinity concentration of the surplus recycled water, the wetland system will need to be vegetated with saline tolerant species. It is best to choose native species that grow in the catchment. It is preferred that the wetland is vegetated by polycultures (multiple species). Examples of appropriate wetland vegetation that have high salt tolerances and their associated rooting depths include:

- Common reed (*Phragmites australis*) – 0-600mm
- Salt couch (*Paspalum vaginatum*) – 0-100mm
- Water couch (*Paspalum distichum*) – 0-500mm
- Sea clubrush (*Bolboschoenus caldwellii*) – 0-300mm
- Marsh clubrush (*Bolboschoenus fluviatilis*) – 0-300mm

A detailed planting plan for the wetland should be developed by a qualified wetland plant specialist.

Wetland Discharge

Wetland-treated recycled water will be stored in a closed tank prior to (approved) offsite discharge. The suitability of recycled water quality for discharge and the optimal sizing of the storage tank are being considered by others.

Based on average climatic conditions, surplus-to-demand recycled water volumes are estimated as follows:

- Annual total – 33.75ML
- Minimum monthly – 0.99ML
- Maximum monthly – 4.40ML

Yours sincerely,

Jasmin Kable
Environmental Consultant
02 4954 4996

References

EPA US. 1993. *Subsurface flow constructed wetlands for wastewater treatment: A technology assessment* (Table 5).

Kadlec R. & Knight R. 1996. *Treatment Wetlands*. Lewis Publishers. New York.

Reed et al and Kadlec & Knight. 1998. *Constructed Wetland Manual.* New South Wales Department of Land and Water Conservation.

Solo Water. 2015. *Catherine Hill Bay Water Utility Integrated Water Management Plan, Montefiore Street, Catherine Hill Bay*, Revision D, July 2015.

Appendix A
Calculation Information Guide

INFORMATION GUIDE
Preliminary Annual Average Subsurface Flow Wetland System Pollutant Calculation Sheet

SSF and SF wetland system preliminary sizing undertaken using Kadlec & Knight method
K-C* areal annual average uptake model

$$\text{In}\left(\frac{\text{Ce}-\text{C}^*}{\text{Ci}-\text{C}^*}\right) = -\left(\frac{\text{k}}{\text{q}}\right)$$

Where:

Ce	mg/L	outlet target concentration
Ci	mg/L	inlet concentration
C*	mg/L	background concentration
k	m/yr	first-order areal rate constant
q	m/yr	hydraulic loading rate (HLR)

Notes:

Note No.	Symbol		Description
1	C*		The background concentration/limit is provided within Table 21-1 'SSF Model Parameter Values- Preliminary' pp. 642 of Kadlec & Knight, which is based on compiled studies for plug-flow systems. This is the background concentrations that a wetland system will generate through internal processes.
2	k		First-order areal rate constant (m/yr). K values are provided in Table 21-1 and Table 21-3 (pp.642 and 644), respectively, of Kadlec & Knight.
3	A	$A = \left(\frac{0.0365\text{Q}}{\text{k}}\right) \text{x In} \left(\frac{\text{Ci}-\text{C}^*}{\text{Ce}-\text{C}^*}\right)$	Required wetland area (ha) for an individual parameter to achieve target outlet condition. Where: A= required wetland area and Q= water flow rate/volume (m^3/day). Equation for calculating the area required for a particular parameter. Table 20-2 Kadlec & Knight. The required wetland area is the largest of the individual required areas for pollutant reduction. Each regulated parameter gives rise to a wetland area necessary for the reduction of that pollutant to the required level. Area does not include required areas for dikes, buffers and other peripherals.
4	C_o	$C_o = C^* + (C_i - C^*)\exp(-\frac{kA}{0.0365Q})$	Expected outlet effluent concentrations (mg/L) from the wetland system via k-C* Model. Note: use the maximum area required for the most limiting parameter
5	C_e		Target outlet concentration (mg/L) refers to the required targets that may be prescribed by a governing body (i.e. EPA for discharge or NSW Health for further land application).
6	C_i		Inlet concentration (mg/) refers to the previously treated or untreated water (wastewater) that enters the wetland system.
7	HLR		Hydraulic loading rate (HLR) (cm/day) - load (Q) divided by area (A)
8	HRT		Hydraulic residence time (HRT) (days) - depth of wetland (d) divided by the HLR, mulitplied by the porosity (E) of the media used in the SSF wetland construction.
9	d		Depth of SSF wetland media. Bed depth is typically 0.5m (pp.648 Kadlec & Knight). Plant root depth penetration typically 30-60cm.
10	E		Porosity of media.
11	LW	$T = \left(\frac{LWh_oE}{Q}\right)$	Required wetland surface area (m^2) based on hydraulics. Where: T= detention time (days), L=wetland bed length (m), W= wetland bed width (m), ho = depth of media at outlet invert (m) - typically 5cm below the total bed depth, E= porosity of media (% fraction), Q= water flow rate/volume (m^3/day).
12	q	$q = Q/LW$	Hydraulic loading (cm/day) based on hydraulics. Where: Q= water flow rate/volume (m^3/day), LW= wetland surface area (m^2)[11].
13	L:W	$G_3 = \left(\frac{\frac{q}{nk}}{\left(\frac{h_o}{L}\right)^2}\right) < 0.1$	Length to width ratio design constraint. The L:W ratio and media conductivity must meet the hydraulic constraint. The aspect ratio (L/W) must be greater than or equal to 1, otherwise the bed would be conducive to short circuting and should be corrected using several cells in parallel. Where: q= hydraulic loading rate (cm/day)[12], nk= hydraulic conductivity of the bed media (m/day) - A tenfold reduction in the conductivity of the media is presumed due to clogging, ho= depth of outlet invert (m)[14], L= bed length- rearrange equation to find 'L' (m) = $\frac{L^2}{k} <?$
14	h_o		Depth of media at outlet invert. The invert is presumed to be controlled at 90% of the total media bed depth. i.e. for the 0.5m average bed depth the invert will be at 0.45m.
15	u	$u = \frac{Q}{WH}$	Velocity of water flow in wetland (m/day). Where: Q= water flow rate/volume (m3/day), W= width of calculated bed (m), H= 90% of total media bed depth. The resultant velocity must be within the laminar range as per Reynolds number (<10).
16	S_b	$G_1 = \left(\frac{S_b}{\frac{h_o}{L}}\right) < 0.1$	Maximum slope of bed base (cm) for the designed L:W dimensions. The drainability condition sets the bottom slope of the bed to avoid dryout at reduced loadings. Where: h_o= depth of outlet invert (m), L= length of bed (m).
17	FC k	$FC = k > L^2/ho$	Flooding constraint bed media hydraulic conductivity requirements. Where L= length of bed (m) and h_o= depth of outlet invert (m).
18	D	$D = \sqrt{\frac{nD^2 * (FCk\ * 5)}{nk}}$	Allows for 5x reduction in conductivity due to clogging.
19	A	$A = h_oW = \frac{Q}{nKS_b}$	Darcy's Law, where: A = recommended cross-sectional area of inlet zone, perpendicular to flow path (m^2); h_o = depth of liquid in bed (m); bed width (m); Q = design flow (m^3/d); nK = hydraulic conductivity of bed media + 10% FOS; and Sb = slope of bed base (as decimal). From Eq (9-23), Crites & Tchobanaglous, 1998.

Appendix B
Wetland Balances

Inputs	
Calculated Values	

Scenario: Max load

Wetland Physical Characteristics	
Surface Area (m2)	3270
Depth (m)	0.6
Wetlands Volume (m3)	1,962
Void Ratio (Gravel + Plant)	0.3
Working Volume	1,373

01/01/1974-31/12/2008

Climate Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Daily Ave
Days	31	28	31	30	31	30	31	31	30	31	30	31	365	
Surplus-to-demand Recycled Water (kL)	68.6	75.4	90.3	111.6	134.7	139.1	137.3	121.6	100.0	80.3	75.3	64.5	36507.5	100
Rainfall (mm)	99.4	122.9	126.6	113.2	119.4	119.0	68.4	57.2	62.2	72.8	87.2	76.3	1124.6	
Rainfall Gain (m3/month)	325.0	402.0	413.9	370.3	390.5	389.2	223.8	187.1	203.3	237.9	285.1	249.4	3677.5	
Evaporation (mm)	213.5	173.8	151.8	114.5	83.7	72.0	81.0	109.3	139.2	171.1	187.4	219.7	1717.0	
Crop Factor (Fraction)	2.1	1.6	1.1	0.7	0.8	0.7	0.7	0.7	0.7	0.7	1.1	1.5		
ET (mm)	448.4	278.1	167.0	80.1	67.0	50.4	52.6	71.0	97.4	119.8	206.1	329.5	1967.6	
ET Volume Loss (m3/month)	1466.3	909.4	546.1	262.1	218.9	164.9	172.1	232.3	318.6	391.8	674.1	1077.5	6434.0	
Wetland Water Inputs (m3/month)	2451.6	2513.2	3213.2	3718.3	4566.2	4562.2	4480.1	3956.7	3203.3	2727.2	2544.1	2248.9	40185.0	
Wetland Water Inputs (m3/day)	79.1	89.8	103.7	123.9	147.3	152.1	144.5	127.6	106.8	88.0	84.8	72.5		
Wetland Water Discharge (m3/month)	985.3	1603.7	2667.1	3456.2	4347.3	4397.4	4307.9	3724.5	2884.7	2335.5	1870.0	1171.4	33751.0	
Wetland Water Discharge (m3/day)	31.8	57.3	86.0	115.2	140.2	146.6	139.0	120.1	96.2	75.3	62.3	37.8		
Cumulative Storage (m3/month)	985.3	2589.0	5256.1	8712.4	13059.6	17457.0	21764.9	25489.4	28374.1	30709.6	32579.6	33751.0		

Wetland Catchment Characteristics	
Catchment Area (m2)	510
Annual Mean Rainfall (mm)	1124.6
Impervious Fraction	0.05
Run-off Fraction (Fletcher)	0.30
Q	169.3

Storage Requirements (ML)	total wetland system
Annual	33.75
Minimum Monthly	0.99
Maximum Monthly	4.40

Wetland Inputs		
Daily Wastewater Volume (m3/day)	139.1	*maximum used*
Annual Wastewater Volume (m3/year)	50,772	
Incident Rainfall (m3/year)	3677.5	
Catchment Rainfall (m3/year)	169.3	
Total	54,618	

References

- STP discharge calcs - based on Williamtown RAAF Rain and Evap (SILO patch point daily record 19700101 - 20100531).xlsx
- Daily rainfall - Williamtown RAAF (BoM daily and SILO patch point data are same)
- SILO patch point evaporation - Williamtown RAAF
- From Galvão *et al*
- Estimated

Wetland Outputs	
Outflow to tank (m3/day)	
Outflow to tank (m3/year)	0
Evapotranspiration (m3/year)	6434.0
Total	6434.0

Balance

Inputs-Outputs (m3/year)	48,184.3

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Planning

Working Beyond Expectations

Review of Environmental Factors Catherine Hill Bay Water Utility – Proposed Changes

Statutory Compliance Tables

Property:
Catherine Hill Bay

Applicant:
Solo Water Pty. Limited

Date:
August 2017

adw johnson

Document Control Sheet

Issue No.	Amendment	Date	Prepared By	Checked By
A	Draft	14.08.2017	Ian McNicol	Craig Marler

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1.0 Section 45 POEO Act

45 Matters to be taken into consideration in licencing functions

In exercising its functions under this Chapter, the appropriate regulatory authority is required to take into consideration such of the following matters as are of relevance:

Section 45 POEO Act 1991	Comments
a) any protection of the environment policies,	There are no relevant PEPs.
b) the objectives of the EPA as referred to in section 6 of the Protection of the Environment Administration Act 1991,	See separate table.
c) the pollution caused or likely to be caused by the carrying out of the activity or work concerned and the likely impact of that pollution on the environment,	See aquatic ecology, hydrology, wetland and coastal processes reports.
d) the practical measures that could be taken:	
i. to prevent, control, abate or mitigate that pollution, and	Additional SDRW storage, wetland treatment and carefully managed release proposed.
ii. to protect the environment from harm as a result of that pollution,	Carefully managed release, ongoing monitoring and adaptive management proposed.
e) any relevant green offset scheme, green offset works or tradeable emission scheme or other scheme involving economic measures, as referred to in Part 9.3,	While not a scheme under part 9.3 an environmental offset of some 200 ha of land was dedicated for management under the NPW Act as part of the Beaches subdivision approval.
f) whether the person concerned is a fit and proper person (as referred to in section 83),	The CHB Utility Pty Ltd is not known to have had any environmental licences revoked or breached.
(f1) in relation to an activity or work that causes, is likely to cause or has caused water pollution:	
i. the environmental values of water affected by the activity or work, and	The conservation and recreational values of the receiving water and Middle Camp Beach have been considered in forming the current proposal.
ii. the practical measures that could be taken to restore or maintain those environmental values,	The proposed water treatment and release management has been assessed as unlikely to produce measurable effects on aquatic ecology and minor at most effects on the beach.
g) in connection with a licence application relating to the control of the carrying out of non-scheduled activities for the	The licence application will be by the CHB Water Utility Pty Ltd who will control operations and SDRW releases.

purpose of regulating water pollution—whether the applicant is the appropriate person to hold the licence having regard to the role of the applicant in connection with the carrying out of those activities	
h) in connection with a licence application—any documents accompanying the application,	For the EPA to address.
i) in connection with a licence application—any relevant environmental impact statement, or other statement of environmental effects, prepared or obtained by the applicant under the Environmental Planning and Assessment Act 1979,	This table is part of an environmental assessment under part 5 of the EPA Act 1979.

2.0 Objectives of the EPA

6 Objectives of the Authority	Comment
(a) To protect, restore and enhance the quality of the environment in New South Wales, having regard to the need to maintain ecologically sustainable development, and	The proposal addresses the principles of ESD by protecting the environment, encouraging water recycling, and reducing energy use of the treatment process.
(b) To reduce the risks to human health and prevent the degradation of the environment, by means such as the following: • promoting pollution prevention,	The SDRW will be to the highest recycled water quality and thus is unlikely to affect human health via recreational contact. The utility will be operated to remove potential pollutants to the maximum practical level consistent with sustainable operation of the utility and protection of receiving waters.
Adopting the principle of reducing to harmless levels the discharge into the air, water or land of substances likely to cause harm to the environment,	The proposed levels of potential pollutants in the SDRW releases have been assessed as unlikely to have significant effects in the receiving system.
Minimising the creation of waste by the use of appropriate technology,	The utility will use combination of modern technology and a wetland system to minimise pollutant levels in SDRW.
Regulating the transportation, collection, treatment, storage and disposal of waste,	The proposal removes the previous necessity to store and transport saline RO waste.
Encouraging the reduction of the use of materials, encouraging the re-use and recycling of materials and encouraging material recovery,	The proposal to eliminate the onsite irrigation area provides for overall increased community reuse /recycling of water. While the dedicated irrigation area is removed a significant proportion of the area (approximately 40%) will still be subject to irrigation but by land owners rather than the CHB utility.
Adopting minimum environmental standards prescribed by complementary Commonwealth and State legislation and advising the Government to prescribe more stringent standards where appropriate,	For the EPA to apply.
Setting mandatory targets for environmental improvement,	For the EPA to apply.
Promoting community involvement in decisions about environmental matters,	For the EPA to apply. There are also public consultation requirements for environmental assessment that apply.

Ensuring the community has access to relevant information about hazaredous substances arising from, or stored, used or sold by, any industry or public authority,	For the EPA to apply. While there will be limited hazardous materials involved in utility operations this assessment will be made public.
Conducting public education and awareness programs about environmental matters.	The CHB utility will undertake its own awareness programs as a part of ongoing management.

3.0 LMCC LEP 2004 & LMCC LEP 2014 Zone Objectives

The receiving waters for the SDRW are zoned under two separate EPIs and some four zones. The R2 and E1 zones apply under both relevant EPI's.

The wet release flows will only occur on land under LEP 2014, being flow through the zones R2 to E1 to E2 then to the ocean.

The dry release flows will cross R2 and E1 zones under LEP 2004 before entering the E1 zone under LEP 2014.

New as, in as yet unapproved works under the EPA Act, will only occur in the SP2 zone under LEP 2004 and involve changes to the CHB utility. Works in the R2 zone will be under the MP10_204 approval for the Beaches subdivision.

Zone R2 Low Density Residential

1 Objectives of zone

- *To provide for the housing needs of the community within a low density residential environment.*
- *To enable other land uses that provide facilities or services to meet the day to day needs of residents.*
- *To encourage development that is sympathetic to the scenic, aesthetic and cultural heritage qualities of the built and natural environment.*

Comment

The SDRW release point will be part of the stormwater infrastructure constructed for the Hale Street / Lindsley Street / Flowers drive intersection regrade. These works were approved as part of MP 10_204.

This proposed release point will be in Lindsley Street adjoining an existing stormwater flow path. This point will only be used for the proposed "dry" releases as it will deliver SDRW direct to the rear of the beach lagoon below the more sensitive creek and wetland systems.

The proposed release point will be part of stormwater works consistent with providing facilities to meet the day to day needs of residents.

71 Zone E1 National Parks and Nature Reserves LMCC LEP 2014

(1) The objectives of Zone E1 National Parks and Nature Reserves are as follows:
(a) to enable the management and appropriate use of land that is reserved under the National Parks and Wildlife Act 1974,
(b) to enable uses authorised under the National Parks and Wildlife Act 1974,
(c) to identify land that is to be reserved under the National Parks and Wildlife Act 1974 and to protect the environmental significance of that land.

Comment

The objectives are only relevant (as no works are proposed in the zone) to the extent of ensuring the proposed SDRW releases are consistent with the management and appropriate use of land under the NPW Act 1974.

The specific management objectives for the land are contained in the Munmorah State SCA PoM. These objectives are addressed in the separate compliance tables for the SCA.

Zone E2 Environmental Conservation LMCC LEP 2014

1 Objectives of zone

- *• To protect, manage and restore areas of high ecological, scientific, cultural or aesthetic values.*
- *• To prevent development that could destroy, damage or otherwise have an adverse effect on those values.*
- *• To conserve, enhance and manage corridors to facilitate species movement, dispersal and interchange of genetic material.*
- *• To encourage activities that meet conservation objectives.*
- *• To enhance and manage areas affected by coastal processes*

Comment

SDRW will flow across the coastal creek/beach lagoon which is zoned E2 east of Flowers Drive.

The SDRW release may facilitate fish passage, was assessed as likely to have no measurable difference on the ecology of the system but may have a minor effect by increasing the likelihood of overtopping of the lagoon when shoaled.

The proposed releases are generally consistent with the zone objectives as it is unlikely the flows will detract from the values sought to be protected by the zoning

138 Zone R2 Low Density Residential LMCC LEP 2004

(1) The objectives of Zone R2 Low Density Residential are as follows:
(a) to provide for the housing needs of the community within a low density residential environment,
(b) to enable other land uses that provide facilities or services to meet the day to day needs of residents,
(c) to encourage development that does not impact on the scenic, aesthetic and cultural heritage qualities of the built and natural environment of the Wallarah Peninsula,
(d) to encourage development that responds and is sympathetic to the surrounding built and natural environmental setting,
(e) to ensure that the nuisance generated by non-residential development, such as that related to operating hours, noise, loss of privacy, vehicular and pedestrian traffic or other factors, is controlled to preserve the quality of life for residents in the area.

Comment

The proposed release point and release are ancillary to the residential use of the R2 zone. As such they are consistent with the R2 zone objectives.

140 Zone E1 National Parks and Nature Reserves LMCC LEP 2004

(1) The objectives of Zone E1 National Parks and Nature Reserves are as follows:
(a) to enable the management and appropriate use of land that is reserved under the National Parks and Wildlife Act 1974 *or that is acquired under Part 11 of that Act,*
(b) to enable uses authorised under the National Parks and Wildlife Act 1974*,*
(c) to identify land that is to be reserved under the National Parks and Wildlife Act 1974 *and to protect the environmental significance of that land.*

Comment

The objectives are only relevant to the extent of ensuring the proposed SDRW releases are consistent with the management and appropriate use of land under the NPW Act 1974.

The specific management objectives for the land are contained in the Munmorah State conservation Area PoM. These objectives are addressed in a later table.

139 Zone SP2 Infrastructure

(1) The objectives of Zone SP2 Infrastructure are as follows:
(a) to provide for infrastructure and related uses,
(b) to prevent development that is not compatible with, or that may detract from, the provision of infrastructure.

Comment

The CHB water utility site has been specifically zoned for a sewage treatment plant. As the proposed works are part of the treatment and recycling disposal the addition of the wetland and recycling water storage on the site is consistent with the zone objectives.

4.0 Specific Objectives for the Munmorah State Conservation Area

The management objectives are provided in Section 3.1 of the PoM for the conservation area.

Specific Objectives for Munmorah State Conservation Area	Compliance
The specific objectives for the management of Munmorah State Conservation Area are to:	
• Conserve the park's biodiversity, with emphasis on protection and restoration of the habitat of threatened species, populations and ecological communities;	For most part the receiving waters are within areas for conservation. The managed SDRW flows have been assessed as likely to have an unmeasurable level of effect on ecology.
• Protect visual and aesthetic values;	No significant change is likely to affect the receiving waters which are not considered to be of particular visual or aesthetic significance.
• Provide low impact recreational opportunities in a natural setting;	The proposed SDRW release is unlikely to have an effect on recreational opportunities.
• Promote the importance of the park's natural and cultural values to visitors and neighbours, and promotion of the purpose of management programs; and	For NP& W to address.
• Increase environmental education opportunities for visitors.	For NP& W to address.

5.0 Objects of NP&W Act

The release of SDRW to lands managed under the NP&W Act 1974 requires consideration of the objects of this act.

2A Objects of NP&W Act	Compliance
1. The objects of this Act are as follows:	
a. The conservation of nature, including, but not limited to, the conservation of:	Environment protection and conservation principles have informed the proposed release strategy for SDRW.
i. Habitat, ecosystems and ecosystem processes, and	No change to habitat, ecosystems or processes are likely with the proposed SDRW release management.
ii. Biological diversity at the community, species and genetic levels, and	No effects likely as release is to a change adapted local system.
iii. Landforms of significance, including geological features and processes, and	There will be no significant effect on land forms or geological processes.
iv. Landscapes and natural features of significance including wilderness and wild rivers,	There will be no significant landscape effects.
b. The conservation of objects, places or features (including biological diversity) of cultural value within the landscape, including, but not limited to:	No effect on cultural values is likely.
i. Places, objects and features of significance to Aboriginal people, and	No effect as works will be within developed urban areas and release will not significantly affect the landscape.
ii. Places of social value to the people of New South Wales, and	Only minor effects possible to beach morphology, the potential increase in flows from the beach lagoon is very unlikely to affect beach use for recreation.
iii. (Places of historic, architectural or scientific significance,	No effect on local heritage significance.
c. Fostering public appreciation, understanding and enjoyment of nature and cultural heritage and their conservation,	For OEH to foster. The CHB water utility will provide public information regarding reuse of water and local conservation values.
d. Providing for the management of land reserved under this Act in accordance with the management principles applicable for each type of reservation.	See separately addressed SCA management principles.
2. The objects of this Act are to be achieved by applying the principles of	The SDRW release strategy has been designed for to promote the sustainability of

ecologically sustainable development.	the local environment and has resulted in revised utility processes that reduce energy use and remove some waste transport requirements.

6.0 NSW Water Quality & Flow Objectives for Lake Macquarie & Tuggerah Lakes

Water Quality and Flow Objectives	Comment
Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term	The proposal has been designed so as to maintain current ecological conditions.
Aesthetic qualities of waters	The local circumstances are such that aesthetic qualities are unlikely to be affected by SDRW release.
Maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed	Wading may occur in the beach lagoon and is unlikely to be affected by the SDRW as it is suitable for most domestic uses other than drinking and bathing.
Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed	Swimming is unlikely due to the shallow and narrow waters. The beach lagoon is generally too shallow for swimming and there are superior swimming opportunities available in the adjoining ocean.
Protect natural water levels in pools of creeks and rivers and wetlands during periods of no flows	Release of SDRW is to be carefully managed avoid providing flows to the creek in periods of low flow. Additional storage has been provided so release can be limited to periods of flow in the catchment. “Dry” period releases will be below the natural creek system and be direct be to the permanent water of the beach lagoon if shoaled or across the beach if not shoaled.
Protect natural low flows	SDRW “wet” releases will only be made during periods of natural flow in the catchment.
Protect or restore a proportion of moderate flows ('freshes') and high flows	NA the catchment has largely natural flow patterns.
Maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain	Flows in the catchment will increase by some 10% because of SDRW release.

Water Quality and Flow Objectives	Comment
ecosystems	Only during natural flow periods will wet releases of SDRW be made and then within the flow characteristics of the natural catchment. The releases may extend the duration and volume of flow events but will not create new events for the creeks or wetlands.
Mimic the natural frequency, duration and seasonal nature of drying periods in naturally temporary waterways	The proposed system of dry release to the lagoon will ensure that those upper sections of the receiving waters not receive additional wetting.
Maintain or mimic natural flow variability in all streams	The natural flow pattern of streams will be maintained by releasing SDRW with stormwater.
Maintain rates of rise and fall of river heights within natural bounds	SDRW releases will be managed to reflect flows in the catchment.
Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems	The proposed management of releases is unlikely to affect groundwater levels or base flows in the creek system or adjoining wetlands.

7.0 Section 228 EPA Regulation

228 What Factors Must be Taken into Account Concerning the Impact of an Activity on the Environment?	Comment
1. For the purposes of Part 5 of the Act, the factors to be taken into account when consideration is being given to the likely impact of an activity on the environment include:	
a. For activities of a kind for which specific guidelines are in force under this clause, the factors referred to in those guidelines, or	There are no relevant guidelines.
b. For any other kind of activity:	See below.
i. The factors referred to in the general guidelines in force under this clause, or	NA
ii. If no such guidelines are in force, the factors referred to subclause (2).	See below.
2. The factors referred to in subclause (1) (b) (ii) are as follows:	
a. Any environmental impact on a community,	Overall positive impact as it assists in the provision of water utility services to the local community.
b. Any transformation of a locality,	No - the locality will remain largely as is without significant effects on the existing environment or land uses.
c. Any environmental impact on the ecosystems of the locality,	Assessed as below measurable levels - there will be no free chlorine in released waters having been removed by wetland treatment and detention in storage tanks.
d. Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality,	No significant impacts.
e. Any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or	No effect on local heritage or other values likely.

228 What Factors Must be Taken into Account Concerning the Impact of an Activity on the Environment?	Comment
other special value for present or future generations,	
f. Any impact on the habitat of protected fauna (within the meaning of the National Parks and Wildlife Act 1974),	No - the affected habitat was not found to support protected fauna.
g. Any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air,	No there will be no habitat alteration other than increased flows during wet periods - natural drying cycles will be maintained.
h. Any long-term effects on the environment,	No - the local receiving waters are relatively well flushed there being surface flow to the sea some 73% of the time with permanent groundwater connections - there is thus little likelihood of a build of nutrients in the system. The dilutions provided by the already approved stormwater releases and natural flows through what is a system adapted to disturbance are consistent with maintaining existing environmental values.
i. Any degradation of the quality of the environment,	No - the existing quality of the environment should be maintained by the proposed system of wet and dry releases which avoid impacts and the reasonably high quality of the released SDRW.
j. Any risk to the safety of the environment,	No - significant increase is likely under the proposed management of releases.
k. Any reduction in the range of beneficial uses of the environment,	No - all currently beneficial uses will be maintained.
l. Any pollution of the environment,	Unlikely - however, the release of recycling water will increase the loading of potential pollutants to the receiving waters. The increased loadings have been assessed as likely to have no measurable effects due to the current condition of the waters (which have adapted to catchment changes of mining and urban development), the proposed wet and dry release strategy and the salinity of the

228 What Factors Must be Taken into Account Concerning the Impact of an Activity on the Environment?	Comment
	beach lagoon waters due to marine influences.
m. Any environmental problems associated with the disposal of waste,	No - the proposal includes changes to the utility operations that removes problems of storage and transport of high salinity reverse osmosis waste. The primary waste is the SDRW which has the potential to disrupt natural wetting and drying cycles in the receiving waters. The cycles are to be protected through a combination of storage and "wet " and "dry" SDRW releases that keep additional flows outside of sensitive areas and periods.
n. Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply,	No - the proposed changes will increase water recycling, reduce utility plant energy use and decrease waste transport requirements.
o. Any cumulative environmental effect with other existing or likely future activities,	No significant effects likely, - any proposed future increases would require additional assessment and there are other local opportunities for similar releases.
p. Any impact on coastal processes and coastal hazards, including those under projected climate change conditions.	No significant effect - the effect on coastal processes of SDRW release has been assessed as part of this REF with only minor effects likely. There may be increased periods of beach lagoon flow to the sea but without significant effect on beach morphology. The beach lagoon and local shoreline is likely to undergo significant change under sea level rise but the proposed SDRW release will not increase the local level of risk or hazard due to changes in beach morphology.
3. For the purposes of this clause, the Secretary may establish guidelines for the factors to be taken into account when consideration is being given to the likely impact of an activity on the	NA

228 What Factors Must be Taken into Account Concerning the Impact of an Activity on the Environment?	Comment
environment, in relation to activities generally or in relation to any particular kind of activity.	
4. The Secretary may vary or revoke any guidelines in force under this clause.	NA

8.0 SEPP 71 Coastal Protection

2 Aims of Policy	Comment
(1) This Policy aims:	
(a) To protect and manage the natural, cultural, recreational and economic attributes of the New South Wales coast, and	The proposal is generally consistent with protection of all coastal attributes.
(b) To protect and improve existing public access to and along coastal foreshores to the extent that this is compatible with the natural attributes of the coastal foreshore, and	No change.
(c) To ensure that new opportunities for public access to and along coastal foreshores are identified and realised to the extent that this is compatible with the natural attributes of the coastal foreshore, and	Addressed by the MP10_204 approval for the Beaches subdivision.
(d) To protect and preserve Aboriginal cultural heritage, and Aboriginal places, values, customs, beliefs and traditional knowledge, and	Addressed by the MP10_204 approval for the Beaches subdivision.
(e) To ensure that the visual amenity of the coast is protected, and	Addressed by the MP10_204 approval for the Beaches subdivision.
(f) To protect and preserve beach environments and beach amenity, and	No significant issues based on coastal processes study.
(g) To protect and preserve native coastal vegetation, and	No direct changes with indirect effects unlikely.
(h) To protect and preserve the marine environment of New South Wales, and	No significant effect likely from the flow of SDRW to the ocean.
(i) To protect and preserve rock platforms, and	No effect likely.
(j) To manage the coastal zone in accordance with the principles of ecologically sustainable development (within the meaning of section 6 (2) of the Protection of the Environment Administration Act 1991), and	The proposal provides for a more sustainable and higher capacity water utility that should provide ongoing services to the community with minimal environmental impact.

2 Aims of Policy	Comment
(k) To ensure that the type, bulk, scale and size of development is appropriate for the location and protects and improves the natural scenic quality of the surrounding area, and	No additional effects as a result of the proposed utility changes and SDRW release.
(l) To encourage a strategic approach to coastal management.	NA for individual developments on appropriately zoned land.

Clause 8 Matters for Consideration	Comment
The matters for consideration are the following:	
(a) The aims of this Policy set out in clause 2,	See above.
(b) Existing public access to and along the coastal foreshore for pedestrians or persons with a disability should be retained and, where possible, public access to and along the coastal foreshore for pedestrians or persons with a disability should be improved,	No change.
(c) Opportunities to provide new public access to and along the coastal foreshore for pedestrians or persons with a disability,	NA
(d) The suitability of development given its type, location and design and its relationship with the surrounding area,	No issues.
(e) Any detrimental impact that development may have on the amenity of the coastal foreshore, including any significant overshadowing of the coastal foreshore and any significant loss of views from a public place to the coastal foreshore,	Nothing is proposed that will affect foreshore amenity or views.
(f) The scenic qualities of the New South Wales coast, and means to protect and improve these qualities,	No change to scenic qualities likely.
(g) Measures to conserve animals (within the meaning of the Threatened Species Conservation Act 1995) and plants (within the meaning of that Act), and their habitats,	No effects on threatened species or habitat under the TSCA or FMA or EPBC acts likely.

Clause 8 Matters for Consideration	Comment
(h) Measures to conserve fish (within the meaning of Part 7A of the Fisheries Management Act 1994) and marine vegetation (within the meaning of that Part), and their habitats	No effect on marine or aquatic vegetation likely - the SDRW release strategy has been designed to protect natural hydrological cycles.
(i) Existing wildlife corridors and the impact of development on these corridors,	No adverse effect - fish passage may be enhanced.
(j) The likely impact of coastal processes and coastal hazards on development and any likely impacts of development on coastal processes and coastal hazards,	Assessed in detail with only temporary and minor impacts on lagoon and beach morphology likely.
(k) Measures to reduce the potential for conflict between land-based and water-based coastal activities,	None required.
(l) Measures to protect the cultural places, values, customs, beliefs and traditional knowledge of Aboriginals,	None required.
(m) Likely impacts of development on the water quality of coastal waterbodies,	Assessed as likely to be below measurable levels.
(n) The conservation and preservation of items of heritage, archaeological or historic significance,	No effect on heritage items likely.
(o) Only in cases in which a council prepares a draft local environmental plan that applies to land to which this Policy applies, the means to encourage compact towns and cities,	NA
(p) Only in cases in which a development application in relation to proposed development is determined:	
(i) The cumulative impacts of the proposed development on the environment, and	None likely.
(ii) Measures to ensure that water and energy usage by the proposed development is efficient.	A high energy use process has been deleted from the utility plant as has the need to transport saline waste for disposal.

9.0 LMCC DCP 1 - Part 7 – Development in Environment Protection Zones

Objective	Comment
The aims of LM DCP 2014 for development in environment protection zones are:	
1. To ensure that the amenity of natural landscapes is maintained.	No change to natural land scape proposed.
2. To ensure that lifestyle development in environmental areas is effectively integrated with environmental and conservation uses.	NA
3. To ensure that development occurs in an ecologically sustainable manner, and is energy efficient in terms of design and layout, consumption and materials.	NA no actual development proposed in the environmental areas subject to the DCP.
4. To maintain the amenity and integrity of conservation and other environmentally valuable areas, and to maintain the natural character of the landscape.	Proposal management has been developed for purpose of protecting aquatic ecology of local waters.

2.10 NATURAL WATER SYSTEMS	
Objectives	**Comment**
a) To protect and maintain the water regime of natural water systems.	Proposed through SDRW wet and dry release management.
b) To ensure that development does not adversely affect aquatic fauna.	See aquatic ecology study -no measurable effect likely.
c) To ensure that development does not adversely affect water quality or availability, including ground water	No significant quality affects likely, no effect on water availability.
d) To ensure that watercourses and associated riparian vegetation are maintained to contribute to water quality, and to mitigate sedimentation of the Lake Macquarie waterway.	No direct effects on vegetation likely - see aquatic ecology report recommendations for proposed mitigatory/improvement actions.
e) To ensure that natural water systems and associated vegetation and landforms are protected to improve the ecological processes and ensure that land is adequately buffered from development.	Achieved by proposal.
f) To ensure that the pre-development water quality of receiving waters is maintained or improved.	Not achieved but assessment shows no significant effects likely.

Controls	
1. Natural water systems must be maintained in a natural state, including the maintenance of riparian vegetation and habitat such as fallen debris.	No changes proposed.
2. Where a development is associated with, or will affect a natural water system, rehabilitation must occur to return that natural water system – as much as possible – to a natural state.	Aquatic ecology report improvement recommendations to be adopted.
3. Rehabilitation should occur where a development site includes a degraded watercourse, water body, or wetland.	As proposed in aquatic ecology report.
4. Stormwater must be managed to minimise nutrient and sediment run-off entering constructed drainage lines, natural watercourses, or waterways.	To be managed under MP10-204 the Beaches subdivision approval.
5. Development within a Vegetated Riparian Zone (VRZ), as shown in Figure 1 – Vegetated Riparian Zones, should be avoided where possible to retain its ecological processes. Where development is unavoidable within the VRZ, it must be demonstrated that potential impacts on water quality, aquatic habitat, and riparian vegetation will be negligible.	No development proposed in the VRP proposed.
6. A Plan of Management must be submitted in accordance with State Government guidelines for development proposed within a VRZ.	NA
7. Asset Protection Zones must not be located within the Vegetated Riparian Zone.	NA

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

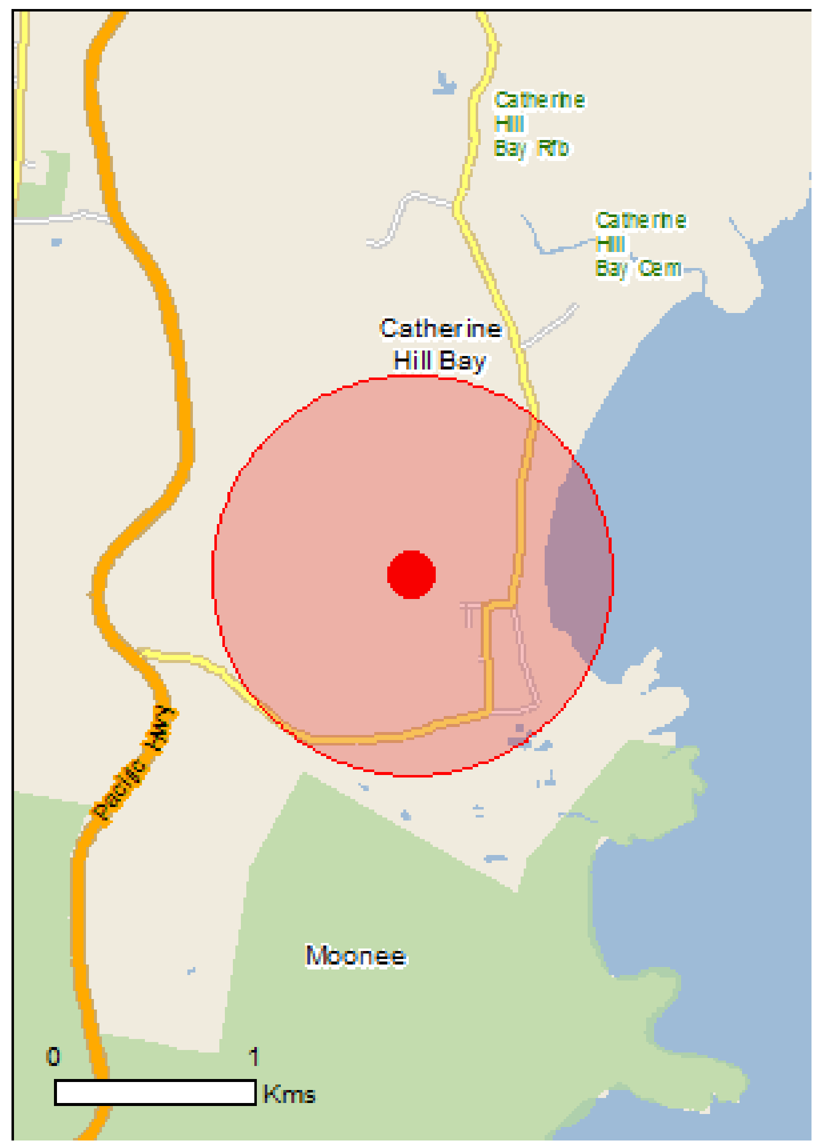
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

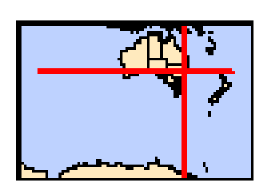
Report created: 19/06/17 15:26:56

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



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	64
Listed Migratory Species:	51

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	79
Whales and Other Cetaceans:	14
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

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

State and Territory Reserves:	1
Regional Forest Agreements:	1
Invasive Species:	42
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Dasyornis brachypterus Eastern Bristlebird [533]	Endangered	Species or species habitat likely to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat likely to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pterodroma leucoptera leucoptera Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Pterodroma neglecta neglecta Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri platei Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely

Name	Status	Type of Presence
		to occur within area
Fish		
Epinephelus daemelii		
Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat likely to occur within area
Frogs		
Heleioporus australiacus		
Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat may occur within area
Litoria aurea		
Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat likely to occur within area
Litoria littlejohni		
Littlejohn's Tree Frog, Heath Frog [64733]	Vulnerable	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat may occur within area
Chalinolobus dwyeri		
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus maculatus maculatus (SE mainland population)		
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat likely to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Petauroides volans		
Greater Glider [254]	Vulnerable	Species or species habitat may occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus		
Long-nosed Potoroo (SE mainland) [66645]	Vulnerable	Species or species habitat may occur within area
Pseudomys novaehollandiae		
New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat known to occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Plants		
Caladenia tessellata		
Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat likely to occur within area
Corunastylis insignis		
Wyong Midge Orchid 1, Variable Midge Orchid 1 [84692]	Critically Endangered	Species or species habitat likely to occur within area
Cryptostylis hunteriana		
Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat known to occur within area

Name	Status	Type of Presence
Diuris praecox Newcastle Doubletail [55086]	Vulnerable	Species or species habitat likely to occur within area
Eucalyptus camfieldii Camfield's Stringybark [15460]	Vulnerable	Species or species habitat likely to occur within area
Eucalyptus parramattensis subsp. decadens Earp's Gum, Earp's Dirty Gum [56148]	Vulnerable	Species or species habitat known to occur within area
Melaleuca biconvexa Biconvex Paperbark [5583]	Vulnerable	Species or species habitat may occur within area
Rutidosis heterogama Heath Wrinklewort [13132]	Vulnerable	Species or species habitat likely to occur within area
Syzygium paniculatum Magenta Lilly Pilly, Magenta Cherry, Daguba, Scrub Cherry, Creek Lilly Pilly, Brush Cherry [20307]	Vulnerable	Species or species habitat likely to occur within area
Tetratheca juncea Black-eyed Susan [21407]	Vulnerable	Species or species habitat known to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Sharks		
Carcharias taurus (east coast population) Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		

Name	Threatened	Type of Presence
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Sternula albifrons Little Tern [82849]		Breeding likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Migratory Marine Species		
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat likely to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat likely to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Cuculus saturatus Oriental Cuckoo, Himalayan Cuckoo [710]		Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely

Name	Threatened	Type of Presence
		to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat likely to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Puffinus carneipes		
Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Foraging, feeding or related behaviour likely to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna albifrons		
Little Tern [813]		Breeding likely to occur within area
Thalassarche bulleri		
Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta		
Tasmanian Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita		
Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini		
Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche sp. nov.		
Pacific Albatross [66511]	Vulnerable*	Species or species habitat may occur within area
Thalassarche steadi		
White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area
Fish		
Acentronura tentaculata		
Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Festucalex cinctus		
Girdled Pipefish [66214]		Species or species habitat may occur within area
Filicampus tigris		
Tiger Pipefish [66217]		Species or species habitat may occur within area
Heraldia nocturna		
Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippichthys penicillus		
Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hippocampus abdominalis Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse [66233]		Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]		Species or species habitat may occur within area
Histiogamphelus briggsii Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish [66242]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Notiocampus ruber Red Pipefish [66265]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paegnius Rough-snout Ghost Pipefish [68425]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Stigmatopora olivacea a pipefish [74966]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		

Name	Threatened	Type of Presence
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal [21]		Species or species habitat may occur within area
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area

Name	Status	Type of Presence
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Munmorah	NSW

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
North East NSW RFA	New South Wales

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Pycnonotus jocosus Red-whiskered Bulbul [631]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax,		Species or species

Name	Status	Type of Presence
Florist's Smilax, Smilax Asparagus [22473]		habitat likely to occur within area
Asparagus plumosus		
Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Asparagus scandens		
Asparagus Fern, Climbing Asparagus Fern [23255]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera		
Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera		
Boneseed [16905]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera subsp. rotundata		
Bitou Bush [16332]		Species or species habitat likely to occur within area
Cytisus scoparius		
Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Eichhornia crassipes		
Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana		
Broom [67538]		Species or species habitat may occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum		
African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Opuntia spp.		
Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata		
Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Protasparagus densiflorus		
Asparagus Fern, Plume Asparagus [5015]		Species or species habitat likely to occur within area
Protasparagus plumosus		
Climbing Asparagus-fern, Ferny Asparagus [11747]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate		
Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla		
Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii		
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss,		Species or species

Name	Status	Type of Presence
Kariba Weed [13665]		habitat likely to occur within area
Senecio madagascariensis		
Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

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

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

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

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

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

Coordinates

-33.15668 151.6237

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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SDRW Release Risk Assessment

Project: Catherine Hill Bay Water Utility

Client: Solo Water Pty. Limited

Author: Ian McNicol

Date: August

Risk Criteria: As per Tables 2.5, 2.6 & 2.7: Australian Guidelines for Water Recycling: Managing Health and Environmental Risks phase 1 (2006)

Exposure/ Use	Hazard	Hazardous Event	Effect	Unmitigated Risk			Control Strategy	Mitigated Risk		
				Likelihood	Consequence	Risk		Likelihood	Consequence	Risk
Chlorine residue to surface water	Free chlorine	Release to surface water	Toxicity/loss of biodiversity	Possible	Major	Very High	3 to 4 day wetland treatment to remove chlorine.	Unlikely	Minor	Low
Hydraulic loading to surface water	Affect on natural hydrology	Release to surface water	Interrupt ecology related to wetting & drying cycles	Possible	Minor	Minor	System of wet & dry release to protect natural hydrological cycles & receiving system ecology.	Unlikely	Insignificant	Low
Nitrogen discharge to surface water	Pollution	Release to surface water	Eutrophication	Possible	Minor	Minor	Nutrient removal via STP processes wet release for dilution of flows, release rates consistent with low detention times in the system. Dry release direct to lagoon to protect more sensitive environments upstream.	Unlikely	Minor	Low
Phosphorus discharge to surface water	Pollution	Release to surface water	Eutrophication	Possible	Minor	Minor	Nutrient removal via STP processes wet release for dilution of flows, release rates consistent with low detention times in the system. Dry release direct to lagoon to protect more sensitive environments upstream.	Unlikely	Minor	Low
Pathogens to surface water	Pollution	Release to surface water	Public illness	Possible	Minor	Insignificant	Pathogen removal via STP processes wet release for dilution of flows, release rates consistent with low detention times in the system. Dry release direct to lagoon to protect more sensitive environments upstream.	Unlikely	Minor	Low
Salinity (TDS) to creeks	Pollution	Release to surface water	Loss of biodiversity	Possible	Minor	Minor	Wet release for dilution of flows, release rates consistent with low detention times in the system. Dry release direct to lagoon to protect more sensitive environments upstream.	Unlikely	Minor	Low
Salinity (TDS) to lagoon	Pollution	Release to surface water	Loss of biodiversity	Unlikely	Minor	Insignificant	Wet release for dilution of flows, release rates consistent with low detention times in the system. Dry release direct to lagoon to protect more sensitive environments upstream.	Unlikely	Minor	Low
Delete SDRW irrigation area	Nil - alternative proposed			Unlikely			Replace irrigation area with managed surface water disposal and additional pathogen and nutrient removal longer term effect unlikely due to flushing capacity of natural system.			Low
Install wetland SDRW treatment	Wetland failure			Possible	Minor	Low/minor	Ongoing wetland management and monitoring.	Unlikely	Minor	Low
Install 5 ML of SDRW storage tanks	Positive management benefits					Nil	Positive effect on management generally.			Nil
Delete utility reverse osmosis capacity	Positive management benefits					Nil	Replaced by managed release of SDRW to local environment.			Nil
Remove reverse osmosis waste ponds	Positive management benefits					Nil	Converted for wetland treatment of SDRW.			Nil
Install release points for SDRW	Positive management benefits					Nil	The risk of the release points is in the effects of release of SDRW.			Nil
Revised utility water management	Poor performance	Release to environment	Pollution	Unlikely	Minor	Minor	Ongoing process and environmental monitoring adaptive management of SDRW release.	Unlikely	Minor	Low
Install stages 6 & 7 recycled water reticulation	Construction/leakage	Offsite effects/release to surface water	down stream pollution/flow increase	Unlikely		Insignificant	Construction works undertaken in accordance with subdivision EMP/ regular maintenance and timely repairs	Unlikely	Minor	Low