Lot 5 Sealark Road, Callala Bay

Integrated Water Cycle Assessment

Project No. 1861
Date: 25 November 2021

Prepared for: The Hare Bay Consortia

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Document and Distribution Status									
Author(s)			Reviewer(s)		Signatures				
Ashley Bond			Ashley Bond						
			Document Distribution						
Revision No.	Status	Release Date	Shoalhaven Council	PRM Architects					
1	DRAFT	02/11/2020	PDF	PDF					
2	FINAL	18/10/2021	PDF	PDF					
3	AMENDED	22/11/2021	PDF	PDF					
4	AMENDED	25/11/2021	PDF	PDF					

Distribution Types: F = Fax, H = Hard Copy, P = PDF, E = Other Electronic Document. Digits indicate number of copies.

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1.0 INTRODUCTION

Footprint (NSW) Pt. Ltd. (*Footprint*) has been engaged by 'The Hare Bay Consortia' as owners of Lot 5 Sealark Road, Callala Bay to prepare an Integrated Water Cycle and Stormwater Management Plan (IWCSMP) to be lodged in support of a planning proposal to re-zone part of the land to enable residential development.

The purpose of the IWCSMP is to:

i. Demonstrate compliance with Chapter G2 of the Shoalhaven Development Control Plan in relation to water quality;
ii. assess any downstream impacts associated with the proposed redevelopment of the subject site;
iii. ensure that water sensitive urban design (WSUD) principles are incorporated into the proposal and protect the downstream environment.

1.1. Scope of Work

The scope of works associated with preparation of the Integrated Water Cycle and Stormwater Management Plan includes;

1) Collect and review any available background information
2) Undertake modelling using MUSIC V.6
3) Model the predicted surface water hydrology and water quality (TSS, TP & TN) from the subject land for;
    a) current condition ('pre-development').
    b) post development, without stormwater treatment.
    c) post development, with stormwater treatment.
4) Prepare a conceptual stormwater management plan that achieves compliance with Chapter G2 of the Shoalhaven DCP 2014 with respect to water quality and protects water quality within the receiving body.
5) Prepare a stormwater management report detailing the methodology undertaken, any assumptions made and presenting the finding of the investigations including associated preliminary drawings detailing the location and extent of any water quality treatment devices.

2.0 SUBJECT SITE

2.1. Site Description

The subject site is described as Lot 5 DP 1225356, Sealark Road, Callala Bay and comprises an area of approximately 6.46 hectares.

The subject site adjoins Sealark Road on its' western boundary, the Jervis Bay National Park on its' northern boundary, Wowly Creek (Gully) on its' eastern boundary and existing residential development in Monarch Place to its southern boundary as shown in Figure 1.

Figure 1: Site Locality Plan (source: Six Maps)

Figure 2: Site Locality Plan with Aerial

The site generally slopes in a north-westly to south-easterly direction towards Wowly Creek. Elevations over the site range from approximately RL6.0m AHD at the north-western corner to approximately RL2.0m AHD along the eastern boundary adjacent to Wowly Creek.

The site is traversed by an open drain which discharges from two stormwater outlets under Sealark Road. This open drain discharges to Wowly Creek near the north-eastern corner of the site.

A Bangalee Forest Ecological Endangered Community (EEC) exists in the eastern portion of the site adjacent to Wowly Creek, otherwise the remainder of the site is relatively free of native vegetation and consists primarily of exotic grasses.

2.2. Flooding

Footprint was also commissioned to prepare a flood study report in support of the planning proposal for the subject site.

> The results of this study are contained in the 'Lot 5 Sealark Road, Callala Bay – Flood Study Report' dated 28 October 2020, by Footprint and the pre and post development 1% AEP flood extents are shown in Figure 3 and Figure 4 respectively below.

It should be noted that the hydraulic model did not include any minor drainage system and therefore flooding within the proposed development footprint and the road as shown in Figure 4 is a result of the rainfall on grid (direct rainfall) modelling and is misrepresented as such flows would be appropriately managed through a network of pits, pipes and overland flow paths.

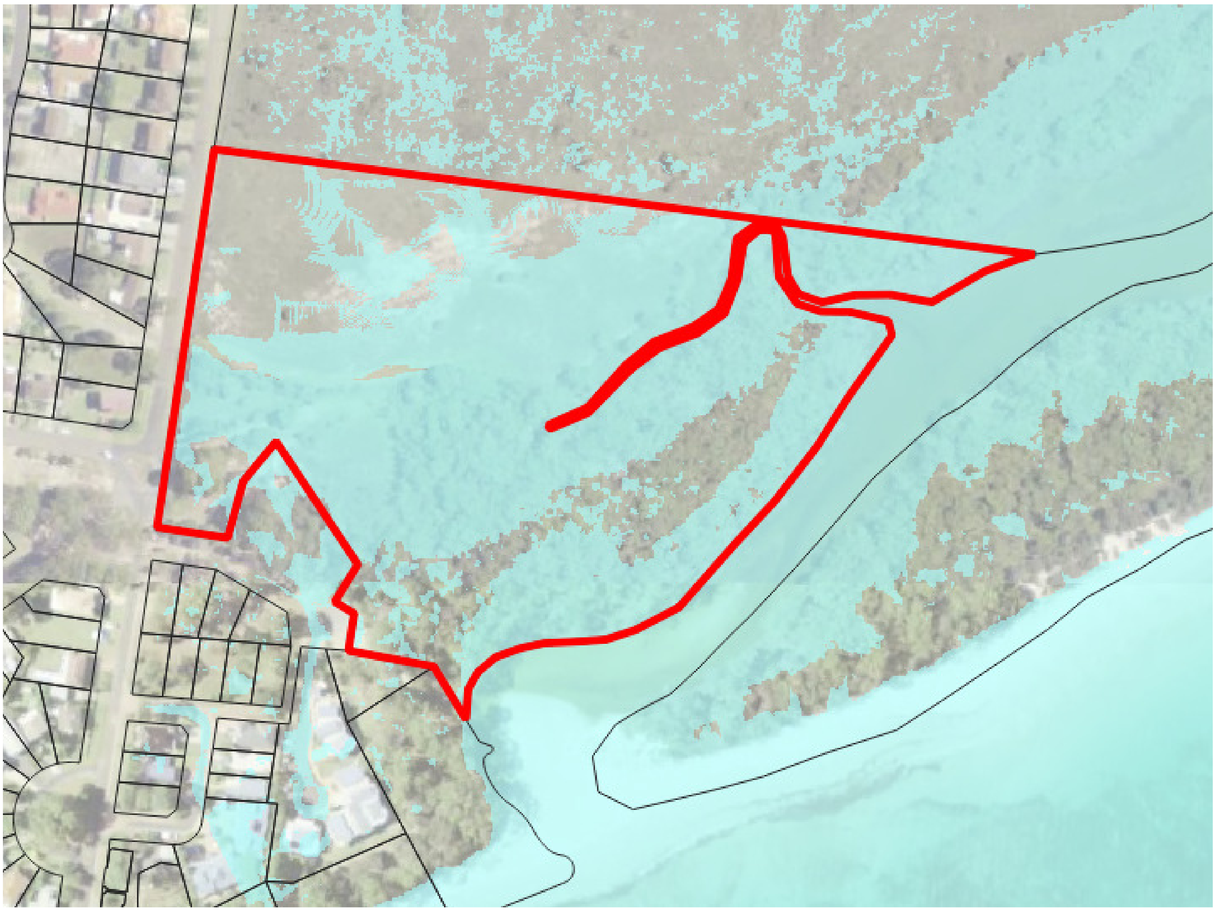


Figure 3 – Pre-Development 1% AEP Flood Extent including RCP8.5 Rainfall Increase and 360mm Seal Level Rise (refer to Flood Study Report by Footprint)

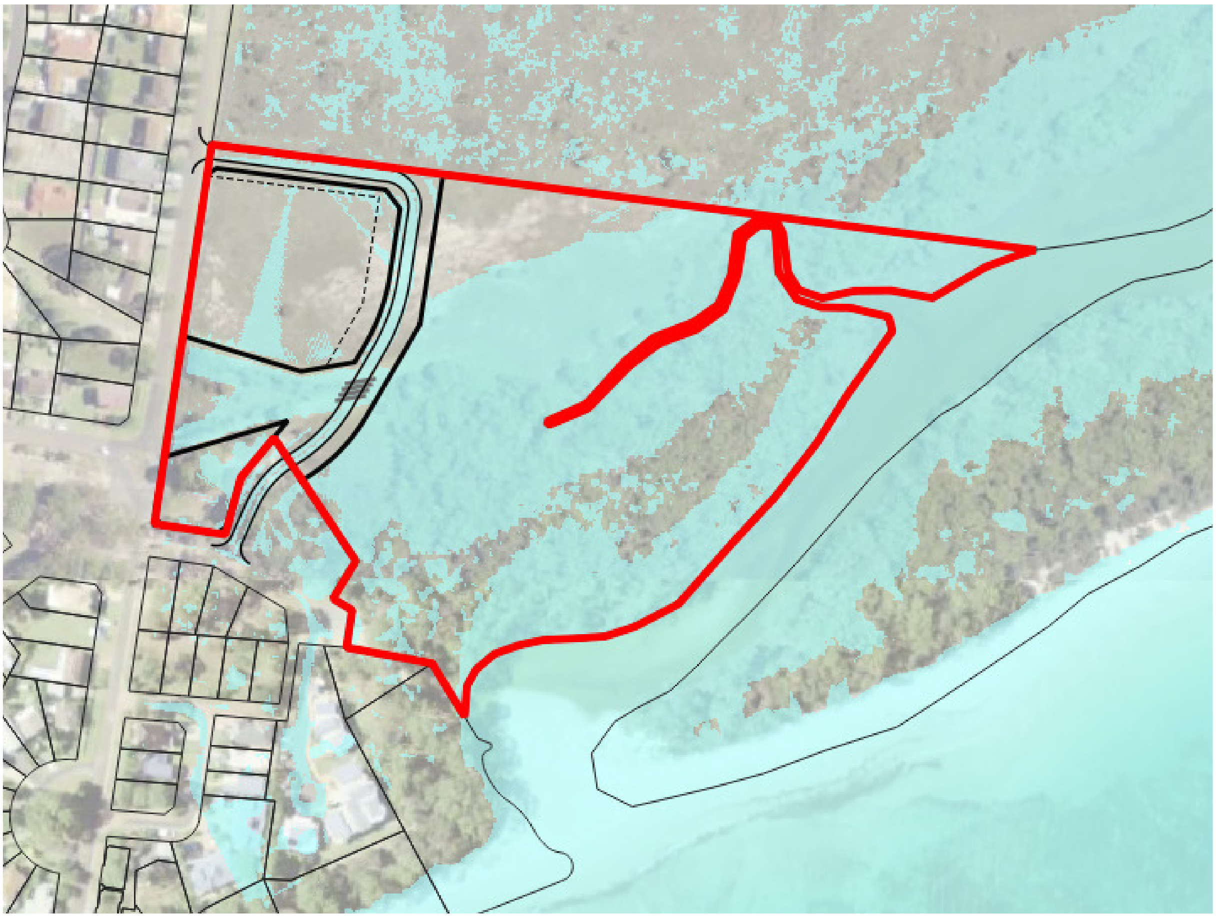


Figure 4 – Post Development 1% AEP Flood Extent including RCP8.5 Rainfall Increase and 360mm Seal Level Rise (refer to Flood Study Report by Footprint)

2.3. Soils and Geology

As per the NSW DPIE eSpade website, the geology of the Site includes several different soil landscapes, including;

- Greenwell Point (Wandrawandian Siltstone) in the north western portion; and
- Seven Mile (Quaternary marine sands and peat; fine to medium marine quartz sands) across the remainder of the site

The proposed developable areas are mostly assumed to be within the Green Point soil landscape. Typically dominant soils include silt loam to loam, fine sands topsoils over sandy clay subsoils trending to medium or heavy clays.

Topsoil limitations include high erodibility, hard setting, sodicity, and shrink-swell characteristics. Subsoil limitation include high permeability, low available water holding capacity, sodicity, and strong acidity.

Generally, fertility is low however there are low limitations for urban development.

Acid Sulphate Soils

As per the NSW DPIE eSpade website there is no potential acid sulphate risk for the proposed developable areas of the site, although the site is within proximity of areas of known acid sulphate soil occurrence (i.e. Wowly Creek Estuary).

2.4. Development Proposal

The current proposal consists of rezoning the north-western portion of the land for residential development due to existing site constraints elsewhere on the site including the presence of an Endangered Ecological Community (EEC) and flooding.

A copy of the concept layout plan is included in Appendix A.

The proposed development would be serviced by reticulated water and sewer, with the latter minimising the risk to downstream water quality.

3.0 LEGISLATIVE AND POLICY FRAMEWORK

The following plans and policies set the legislative framework for the subject site with regard to the management and disposal of stormwater from development sites.

3.1. Shoalhaven Local Environment Plan 2014 (SLEP 2014)

Clause 7.6 of the Shoalhaven Local Environmental Plan 2014 (SLEP 2014) relate to water quality and riparian land management.

Clause 7.6 – Riparian land and watercourses

The objective of this clause is to protect and maintain the following:

(a) water quality within watercourses,

(b) the stability of the bed and banks of watercourses,

(c) aquatic and riparian habitats,

(d) ecological processes within watercourses and riparian areas.

(2) This clause applies to all of the following:

(a) land identified as "Riparian Land" on the Riparian Lands and Watercourses Map,

(b) land identified as "Watercourse Category 1", "Watercourse Category 2" or "Watercourse Category 3" on that map,

(c) all land that is within 50 metres of the top of the bank of each watercourse on land identified as "Watercourse Category 1", "Watercourse Category 2" or "Watercourse Category 3" on that map.

(3) Before determining a development application for development on land to which this clause applies, the consent authority must consider:

(a) whether or not the development is likely to have any adverse impact on the following:

(i) the water quality and flows within the watercourse,

(ii) aquatic and riparian species, habitats and ecosystems of the watercourse,

(iii) the stability of the bed and banks of the watercourse,

(iv) the free passage of fish and other aquatic organisms within or along the watercourse,

(v) any future rehabilitation of the watercourse and its riparian areas, and

(b) whether or not the development is likely to increase water extraction from the watercourse, and

(c) any appropriate measures proposed to avoid, minimise or mitigate the impacts of the development.

(4) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that:

(a) the development is designed, sited and will be managed to avoid any significant adverse environmental impact, or

(b) if that impact cannot be reasonably avoided—the development is designed, sited and will be managed to minimise that impact, or

(c) if that impact cannot be minimised—the development will be managed to mitigate that impact.

(5) For the purpose of this clause:

bank means the limit of the bed of a watercourse.

bed, of a watercourse, means the whole of the soil of the channel in which the watercourse flows, including the portion that is alternatively covered and left bare with an increase or diminution in the supply of water and that is adequate to contain the watercourse at its average or mean stage without reference to extraordinary freshets in the time of flood or to extreme droughts.

Clause 7.20 of the Shoalhaven Local Environmental Plan 2014 (SLEP 2014) relates to development in the Jervis Bay Region, and covers the subject site.

Clause 7.20 – Development in the Jervis Bay Region

Clause 7.20 (3) is most relevant to water quality and states:

(3) Development consent must not be granted to development in coastal sand dune area, on a rocky headland or on a flat, well-drained area along a major creekline unless the consent authority is satisfied that there will be no significant adverse impact on the natural or cultural values of the area.

3.2. Jervis Bay Settlement Strategy

Section 9.1 of the Jerbis Nay Settlement Strategy (JBSS) addresses water quality and flow. The object of this section is "*to ensure that the water quality and flow of waterways and their aquatic, marine and estuarine ecosystems is not detrimentally affected as a result of new settlement in the region.*"

Actions of Section 9.1 include:

i. All development will meet the statutory requirements of the Jervis Bay Regional Environmental Plan 1996 in respect of clause 11 – Catchment Protection.
ii. New development will be located and designed so as to avoid detrimental impacts on waterbodies and watercourses, including groundwater. Where there are manageable impacts, erosion and sediment control measures and means to mitigate nutrient and other pollutants should be provided on the development site and be excluded from areas set aside for the protection of natural or cultural attributes (eg riparian areas, habitat corridors, Aboriginal places/sites and so on).
iii. New development will be designed so that domestic effluent management does not have a detrimental impact on water quality and flow, meets the Interim Environmental Objectives for the Jervis Bay Catchment (EPA, 1999, and is consistent with the relevant State government guidelines.
iv. New development, including infrastructure (e.g. stormwater controls), will be located, designed and constructed in a manner that does not degrade land based or aquatic ecosystems or processes.
v. Infrastructure works will not have a detrimental impact on the water quality of receiving waters in the region. In order to achieve this outcome, best practice soil and water management will be implemented when constructing various infrastructure, and the number of artificial barriers to flow and impediments to movements of aquatic biota will be minimised.

Section 9.9 of the JBSS addresses urban stormwater management. The objective of this section is "*to ensure the protection of life and property and water quality, by providing best practice stormwater management in new and existing development in the region*"

Actions of Section 9.9 include:

i. A hierarchy of sizes and types of stormwater infrastructure will be provided. This infrastructure should, as far as practicable, be contained within the developable area and excluded from areas set aside for protection of the environmental and cultural attributes (eg. riparian areas, habitat corridors etc).
ii. Stormwater infrastructure associated with new development in the region should be designed and constructed in a manner that does not degrade existing natural land-based or aquatic ecosystems or processes. Wherever possible, stormwater should be treated as close to the source as possible prior to any proposed discharges to natural systems.

iii. Monitoring programs to investigate and assess the effectiveness of stormwater controls will be considered and, where appropriate, implemented in association the new development in the region. A community education campaign targeted at improving attitudes and practices in relation to stormwater will also be developed and implemented as per the Shoalhaven Urban Stormwater Management Plan.
iv. The provisions of the Shoalhaven Urban Stormwater Management Plan will be incorporated into relevant planning instruments, works and development processes.

3.3. Illawarra Shoalhaven Regional Plan (ISRP) 2041

The Illawarra Shoalhaven Regional Plan is a 20 year plan that aims to protect and enhance the region's assets and plan for a sustainable future.

Strategy 17.1 of the ISRP is most relevant to this IWCM and encourages the sustainable use of water resources. It recommends hat strategic planning and local plans should consider opportunities to:

- Locate, design, construct and manage new developments to minimise impacts on water catchments, including downstream impacts and groundwater sources.
- Incorporate water sensitive urban design particularly where development is likely to impact water catchments, water quality and flows.
- Encourage reuse of water in new development, for urban greening and for irrigation purposes
- Improve provision for stormwater management and water sensitive urban design.

3.4. Shoalhaven Development Control Plan 2014

Chapter G2 of the Shoalhaven DCP 2014 relates to sustainable stormwater management and erosion and sediment control.

The objectives of this Chapter are to:

i. Manage stormwater flow paths and systems to ensure the safety of people and property.
ii. Protect and enhance natural watercourses and their associated ecosystems and ecological processes.

iii. Maintain, protect and/or rehabilitate modified watercourses and their associated ecosystems and ecological processes towards a natural state.
iv. Mitigate the impacts of development on water quality and quantity.
v. Encourage the reuse of stormwater.
vi. Integrate water cycle management measures into the landscape and urban design to maximise amenity.
vii. Minimise soil erosion and sedimentation resulting from site disturbing activities.
viii. Minimise the potential impacts of development and other associated activities on the aesthetic, recreational and ecological values of receiving water.
ix. Ensure the principles of ecologically sustainable development are applied in consideration of economic, social and environmental values in water cycle management.
x. Ensure stormwater systems and infrastructure are designed, installed and maintained so as not to increase the risk to life or safety or people.
xi. Provide Green and Golden Bell Frog (GGBF) friendly stormwater detention ponds in areas where GGBF are present.
xii. Ensure stormwater systems and infrastructure are appropriately designed and installed to minimise the ongoing maintenance costs as much as possible.

Stormwater Controls

Major and Minor System Design

Design for the major and minor stormwater systems must address the requirements set out in section 5.1.1 of Chapter G2 of the Shoalhaven DCP and Council's Engineering Design Specification including:

- For residential drainage must be designed to cater for a 5 year Average Recurrence Interval (ARI) event.
- For mixed residential/commercial, commercial and industrial development, the drainage must be designed to cater for a 10 year ARI event.
- Major system drainage will be designed for a 100 year ARI event.
- Flow paths will be designed to ensure a velocity depth product of less than $0.3m^2/s$ for a 100 year ARI storm event.

Shoalhaven City Council Engineering Design Specification D5 (Stormwater Drainage) also specifies:

- Trunk drainage (serving catchments larger than 15 Ha) investigation and design shall:
  - use an appropriate runoff routing model to estimate design flow rates
  - use an appropriate model in the hydraulic analysis design
  - consider the effects of likely blockage

    - provide adequate scour protection at discharge points
- Major Structures shall:
    - Be designed for the 100 year ARI without afflux in urban areas
    - Provide a minimum clearance of 0.3m between the 100 year ARI level and the underside of an major structure to allow passage of debris

Climate Change Controls

- Climate change impacts, such as changes to rainfall intensity, shall be considered in system design as per relevant policies and/or Australian Rainfall and Runoff Guidelines.
- Sea level rise shall be considered in system design as per relevant policies and/or Australian Rainfall and Runoff Guidelines.

Onsite Stormwater Detention

The Shoalhaven DCP, Chapter G2: Sustainable Stormwater Management and Erosion/Sediment Control states that Onsite Stormwater Detention (OSD) may be required.

Detention of stormwater is necessary to maintain the capacity of existing stormwater infrastructure, provide protection of downstream infrastructure and limit flooding impacts.

Any detention at the site discharge point is unlikely to have a significant impact on downstream flood levels (given the proximity to the ocean outlet) and with no downstream infrastructure there is limited benefits of providing OSD in this case. It is acknowledged that Council cannot commit to omitting OSD at the Planning Proposal Stage and it is therefore understood that the need for on-site detention associated with the proposed development will be assessed on merit at the Development Assessment stage.

Stormwater Quality and Waterway Protection Controls

Chapter G2 of the Shoalhaven DCP contains a range of specific stormwater quality and quantity requirements which are summarised below.

Erosion and Sediment control

A conceptual soil and water management plan will be prepared for the development in accordance with the Managing Urban Stormwater: Soils and Construction series.

Stormwater Retention and Reuse

This section applies to all development that is not subject to BASIX.

9-10mm depth of retention is to be provided for the difference in impervious area over the development.

Stormwater quality and stream erosion protection

For areas outside Sydney's drinking water supply catchments, pollutant load reduction must be a minimum percentage reduction of the post development average annual load of pollutants in accordance with the Table 1 and the following:

- For greenfield sites or site draining to a natural stream of third order or lower, the 1.5 year ARI pre-development peak discharge must be maintained; and
- For development discharging to a stream, the post development duration of stream forming flows must be no greater than a stream erosion index of 2; and
- For development discharging to a tidal area or natural watercourse, outlet must be designed to limit erosion and sedimentation at the discharge point; and
- For development discharging to St Georges Basin, Swan Lake, Lake Conjola, Burrill Lake, Lake Tabourie, Willinga Lake and Wollumboola Lake, a higher Total Phosphorus reduction target of 65% must be achieved; and
- For development discharging to an area of significant biodiversity value, the post-development residual pollutant concentrations must not exceed the ecological trigger values listed in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality; and
- Uncoated metal (i.e. copper etc) roofs, facades and/or downpipes will not be supported due to heavy metal concentrations in stormwater runoff from these surfaces being harmful to receiving waterways.

Table 1 - Pollutant Load Reduction

Pollutant	Post Development Average Annual Load Reduction
Gross Pollutants (GP)	End of stormwater network solution is to achieve the following: Litter: Retention of litter greater than 40mm for flows up to the 4 exceedances per year (EY) event (3-month ARI peak flow). Coarse sediment: Retention of sediment coarser than 0.125mm for flows up to the 4EY peak flow.
Total Suspended Solids (TSS)	80%
Total Phosphorous (TP)	45%
Total Nitrogen (TN)	45%

3.5. Summary

The above plans and policies all have similar requirements to ensure that stormwater runoff from development has no net impact on the environment and these requirements can be summarised as follows;

i. maintain or improve water quality
ii. maintain the natural flow regime.

4.0 OVERVIEW OF WSUD AND RECOMMENDED TREATMENT MEASURES

4.1. The Water Sensitive Urban Design (WSUD) Philosophy

WSUD is an holistic approach to the planning and design of urban development that aims to minimise the negative impacts on the natural water cycle and protect the health of aquatic ecosystems. It promotes the integration of stormwater, water supply and sewage management at the development scale. It represents a fundamental change in the way urban development is conceived, planned, designed and built. Rather than using traditional approaches to impose a single form of urban development across all locations, WSUD considers ways in which urban infrastructure and the built form can be integrated with a site's natural features. In addition, WSUD seeks to optimise the use of water as a resource.

One of the major benefits of implementing WSUD is that it enables the management of not only water quality, but of the hydrology of the catchment in which it is applied. Typically, when urban development occurs in an area that was previously dominated by vegetation, increases in both hard surfaces, and the efficiency of the drainage system are usually a result. This leads to not only increased flows, but also for more rapid delivery of those flows and the associated pollutants into the receiving environment. The WSUD approach seeks to sever the connection between the hard surfaces and the drainage system, leading to both a reduction in flow volumes through increased infiltration and/or retention, and also a slowing down of water travelling to the drainage system. This in turn results in a reduction of flow velocities and provides opportunities for settlement and biological removal of pollutants.

The key principles of WSUD are to:

- Protect existing natural hydrological and ecological processes.
- Maintain the natural hydrological behaviour of catchments.
- Protect water quality of surface and ground waters.
- Minimise the demand on the reticulated water supply system.
- Minimise sewerage discharges to the natural environment.
- Integrate water into the landscape to enhance visual, social, cultural and ecological values.

4.2. Overview of Recommended Treatment Measures

The following treatment measures have been recommended for implementation as part of the proposed development.

4.2.1. Gross Pollutant Traps

Gross pollutant traps are treatment devices that use physical processes (i.e. screening, sedimentation, separation) to trap solid waste such as litter and coarse sediment. They are commonly used a primary treatment because they mostly remove large, non-biodegradable pollutants.

Since gross pollutant traps tend not to be effective in removing nutrients, they are most often used as part of the treatment train with other stormwater treatment measure such as wetlands and bioretention systems.

4.2.2. Bioretention Basins

Bioretention Basins are vegetated areas designed to allow water to pool temporarily before percolating through an engineered filter media. As water percolates through the bioretention soil media, sediment and nutrients become trapped within the upper layers.

Water flow rate is controlled by the filter media which also provides a growing media for plants. Ground cover vegetation helps to break up sediment deposited in the top layer of the soil media and prevent erosion during storm events. Vegetation roots within the media act to maintain the porosity of the soil and promote nutrient uptake.

4.2.3. Rainwater Tanks

The core WSUD roles of using rainwater tanks are to conserve water through substituting potable water supply, protect urban streams by reducing stormwater runoff volumes (particularly for small, frequent storms) and reducing the loads of some stormwater pollutants entering the waterways by loss of water through consumption.

The consumption of water from rainwater tanks also reduces the hydraulic loading on downstream stormwater treatment devices, potentially making them more efficient. The maximum benefits of rainwater tanks are realised when the collected water is regularly used.

5.0 STORMWATER QUALITY MODELLING

5.1. Modelling Approach

In order to determine if the development proposal will achieve a neutral or beneficial effect (NORBE) on the receiving waters it is necessary to estimate how the proposed changes in land use together with any treatment measures used to mitigate impacts associated with the development proposal will affect water quality and quantity.

A wide range of stormwater treatment measures are available to improve water quality runoff from new and existing developments. Computer modelling is used to assist in selecting the most effective combination of treatment measures for a given situation.

It then becomes necessary to assess if the proposed land use changes and the beneficial treatment provided by the stormwater treatment measures will lead to a neutral or beneficial effect on water quality. The configuration of a stormwater treatment train and assessment of impacts on hydrology and water quality is complex. The industry has adopted the use of water quality modelling as means of assessing the impact of proposed developments on water quality and quantity and effectiveness of any proposed treatment measures.

The model adopted on this project is MUSIC Version 6 (the Model for Urban Stormwater Improvement Conceptualisation) which has been developed by the Cooperative Research Centre for Catchment Hydrology. MUSIC uses a continuous simulation approach to model water quality and is suitable for simulating catchment areas of up to 100 km^2.

By simulating the performance of stormwater management systems, MUSIC can be used to determine if these proposed systems and changes to land use are appropriate for their catchments and are capable of meeting specified water quality objectives (CRCCH, 2004). The water quality constituents modelled in MUSIC of relevance to this report include Total Suspended Solids, Total Phosphorus and Total Nitrogen (TSS, TP & TN).

MUSIC allows hydrology (hydrographs and cumulative flow) and water quality (TSS, TN and TP loads) to be compared under different land use and stormwater treatment scenarios. It enables decision makers to determine if the proposed development is likely to result in a NORBE.

5.2. Model Inputs

MUSIC simulates catchment processes of rainfall, storage of rainfall in the soil, seepage and evapotranspiration from the soil to emulate the rainfall runoff process. Therefore it is necessary to use appropriate data on rainfall, evapotranspiration and soils before you can simulate the rainfall runoff process with any rigour. Using localised data helps to minimise the assumptions made and maximise rigour and accuracy of the modelling process. The following sections describe the assumptions made and sources of data used to construct the MUSIC models.

5.2.1. Rainfall Data

A total of three pluviograph (rainfall measured every 6 minutes) rainfall data stations exist in the vicinity of the subject site as depicted in Figure 5.

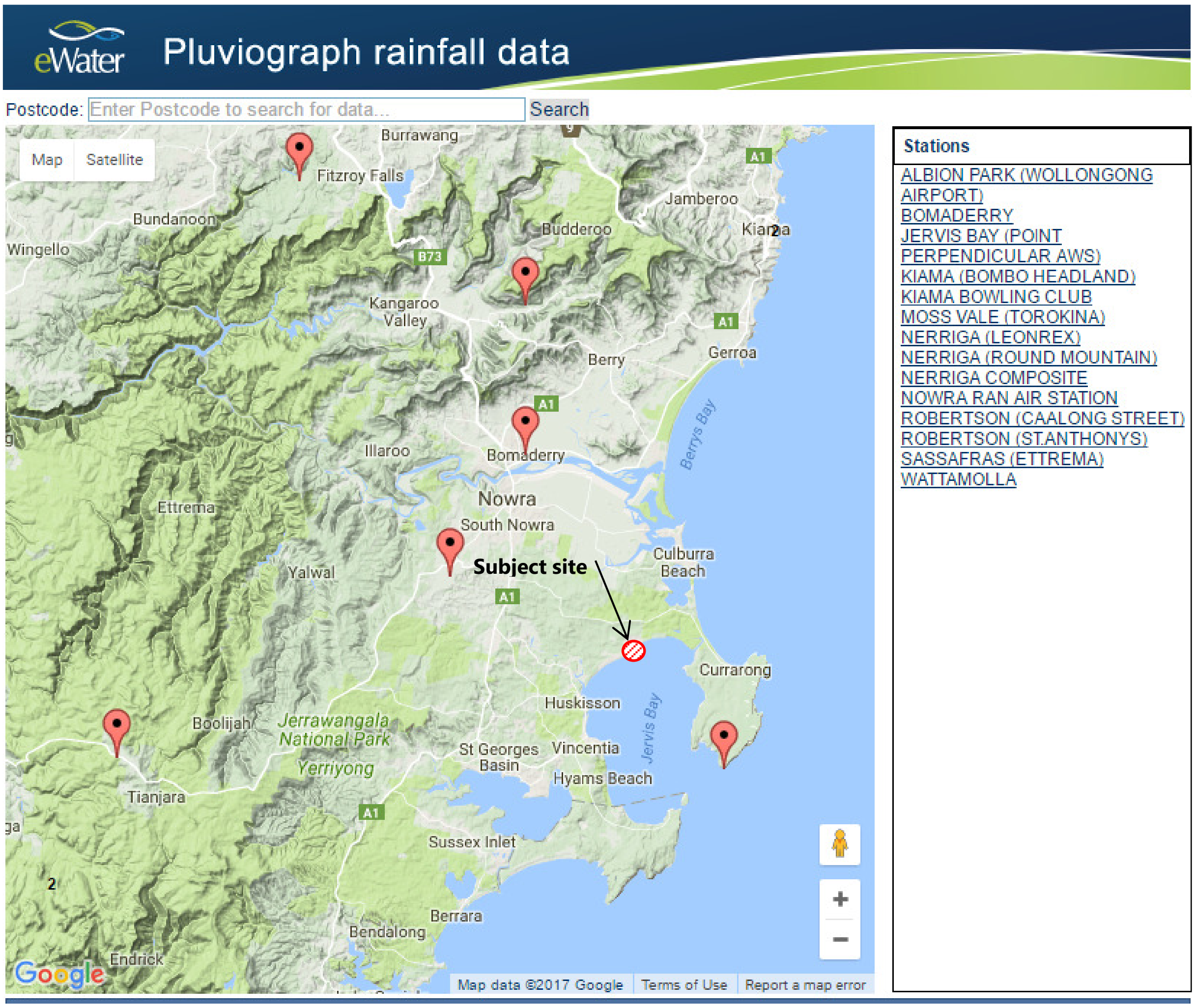


Figure 5 - Pluviograph Rainfall Data Stations

The data available from each station is summarised in Table 2.

Table 2 - Summary of Nearby Pluviograph Rainfall Data Stations

Station No.	Station Name	Distance and Orientation from Subject Site	Period of Data Set
068076	Nowra RAN Air Station	18km WNW	08/1964 – 12/1997
068151	Jervis Bay (Point Perpendicular AWS)	13km SSE	10/2001 – 05/2008
068136	Bomaderry	20km NNW	01/1969 – 10/1972

The Nowra RAN Air Station was adopted as it has the longest period of available data and is situated closest to, and in a similar microclimate to the subject site.

The historical statistics for the Nowra RAN Air Station are provided in Table 3.

Table 3 – Rainfall Statistics

Rainfall Statistic	Annual Rainfall Depth (mm)
Mean	1133.1
5th percentile	549.9
10th percentile	592.8
90th percentile	1750.7
95th percentile	1925.3

The period 1966 – 1975 (10 years) was used for modelling. This period has an average annual rainfall depth of 1128.9mm which compares favourably to the mean rainfall depth for the station. Further the data period contains both a very dry year (1968 – 463mm which is the lowest on record) and a very wet year (1974 – 1928mm which closely approximates a 95th percentile rainfall depth).

This period of data was reviewed for completeness and found to contain a minor period of missing data. The annual average rainfall depth for the 10 year long 6 minute rainfall template used in the MUSIC model for modelling is 1098mm/annum. In comparison to the rainfall statistics shown in Table 3 the MUSIC rainfall template has an average rainfall depth equal to 97% of the mean annual rainfall depth. Given the length of the record to be used and the nature of the "comparative" assessment to be undertaken (i.e. using the same rainfall template to assess both pre and post development scenarios) the data is considered to be of suitable quality and integrity.

5.2.2. Potential Areal Evapotranspiration

Pan evaporation data was obtained from the Bureau of Meteorology (Station 068076 – Nowra RAN Air Station).

Analysis of this data showed an annual total pan evaporation of 1200mm/year. This was compared to the National potential evapotranspiration (PET) atlas available from the Bureau of Meteorology which showed annual Areal PET to be in the order of 1200mm/year. Given that Areal PET is approximately equal to pan evaporation there is no need to convert the pan data and it can be used as Areal PET data for the purposes of modelling in MUSIC.

The Areal PET data adopted is shown in Figure 6.

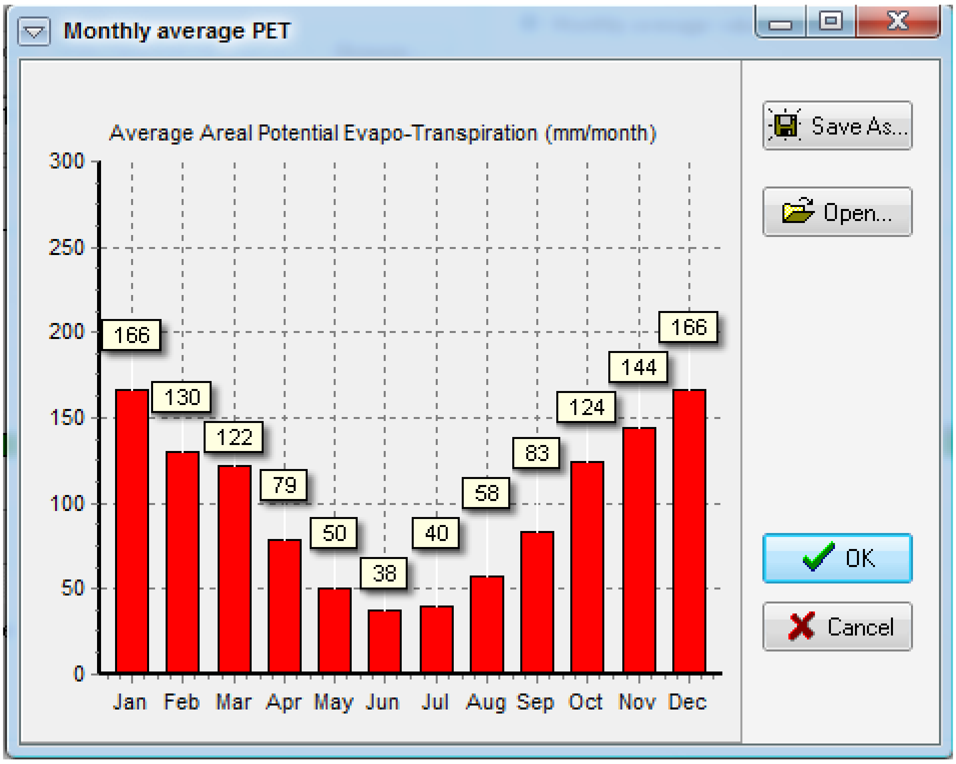


Figure 6 - Graph of Areal PET data adopted

5.2.3. Hydrological Parameters

MUSIC uses a watershed model similar in nature to the tipping bucket type model developed originally by Boughton. The following values were adopted for use in the model:

Table 4 - Values of Hydrological Parameters Adopted in MUSIC

Parameter	Value Adopted	Justification or source of data
Rainfall threshold	0.3mm 1.5mm 1.0mm	Value adopted for roofs based on Table 4.3 – WaterNSW (2019) Value adopted for roads and carparks based on Table 4.3 – WaterNSW (2019) Value adopted for residential based on Table 4.3 – WaterNSW (2019)
Depth of soil	1.0m	Default Value
Soil storage capacity	142mm/m	Based on Sandy Clay soil profile from Soils Landscape (eSpade) and Table 4.4 – WaterNSW (2019)
Field Capacity	94mm/m	Based on Sandy Clay soil profile from Soils Landscape (eSpade) and Table 4.4 – WaterNSW (2019)
Daily baseflow rate	25%	Based on Sandy Clay soil profile from Soils Landscape (eSpade) and Table 4.5 – WaterNSW (2019)
Daily Groundwater recharge rate	25%	Based on Sandy Clay soil profile from Soils Landscape (eSpade) and Table 4.5 – WaterNSW (2019)
Daily deep seepage rate	0%	Based on Sandy Clay soil profile from Soils Landscape (eSpade) and Table 4.5 – WaterNSW (2019)
Infiltration parameter a	180mm/d	Based on Sandy Clay soil profile from Soils Landscape (eSpade) and Table 4.5 – WaterNSW (2019)
Infiltration parameter b	3.0	Based on Sandy Clay soil profile from Soils Landscape (eSpade) and Table 4.5 – WaterNSW (2019)

5.2.4. Pollutant Load Rates

Pollutant concentrations (in the form of event mean concentrations (EMC's) for the range of land uses on the site are based on typical values obtained from the WaterNSW Standard (2019).

The adopted values are shown in Table 5 and Table 6 for base flow and storm flow concentrations respectively.

Table 5 – Adopted Base Flow Concentration Parameters

Landuse/surface type:	Concentration (mg/L-log_{10})					
	TSS		TP		TN	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Residential	1.20	0.17	-0.85	0.19	0.11	0.12
Roofs	N/A	N/A	N/A	N/A	N/A	N/A
Natural	0.78	0.13	-1.52	0.13	-0.52	0.13
Roads	1.20	0.17	-0.85	-0.19	0.11	0.12

Table 6 – Adopted Storm Flow Concentration Parameters

Landuse/surface type:	Concentration (mg/L-log_{10})					
	TSS		TP		TN	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Residential	2.15	0.32	-0.60	0.25	0.30	0.19
Roofs	1.30	0.32	-0.89	0.25	0.30	0.19
Natural	1.60	0.20	-1.10	0.22	-0.05	0.24
Roads	2.43	0.32	-0.30	0.25	0.34	0.19

5.2.5. Effective Impervious Area

Effective Impervious Area (EIA) factors for the different land use/surface types present on the subject site have been adapted from Table 4.2 WaterNSW (2019) and Table 5.2 of Chapter D5 of the Shoalhaven Engineering Guideline and are shown in Table 7.

It should be noted that the definition of an effective impervious area in MUSIC is one that is directly connected to the stormwater system and is a measure of the area of land that is effective in generating runoff that flows directly to the stormwater drainage system.

Table 7 - Surface Type EIA Factors

Surface Type	EIA Factor
Roofs	1.0 x TA
Sealed Road Corridors[1]	0.95 x TA
Residential Land (non-roof component)[2]	0.60 x TA
Natural Land	0 x TA

TA = Total Site/Catchment/Surface Area.

[1] From Table 5.2 of Chapter D5 of the Shoalhaven Engineering Guideline

[2] Provide total impervious area of 80% for residential areas (medium density) in accordance with Table 5.2 of Chapter D5 of the Shoalhaven Engineering Guideline

5.3. Landuse Assumptions

The current state of the site was determined using a combination of an assessment of current aerial photography (Six Maps) and a visual inspection.

For the purposes of determining land use only the areas within the footprint of proposed urban rezoning/development were included as areas outside this footprint will not change (i.e. the Environmental Conservation Area).

Areas of the existing site that are proposed for urban rezoning/development are currently slashed and maintained year-round. The existing drainage lines off Sealark Road are generally infested with Typha and other weeds.

The existing site was typically either classified as 100% pervious 'residential' land use reflecting the proximity of the site to the existing urban fringe and the current maintenance regime undertaken or as 100% pervious 'natural' land use representing the heavily vegetated drainage lines.

Post development land use categories were defined based on the planning proposal zoning. Building envelopes and surrounding APZ areas were classified as 'residential' which is reflective on the more intense use and impacts associated with medium density development. Drainage lines were maintained as natural.

The adopted pre and post development land use is shown on Drawing 1968-C07 in Appendix B.

5.4. Pre-Development Modelling

5.4.1. Model Configuration

The configuration of the pre-development MUSIC model is shown in Figure 7 and consists of two sources nodes representing the two land use types present within the development footprint. The model also includes SEI nodes to assist in determination of Stream Erosion Index (SEI) compliance.

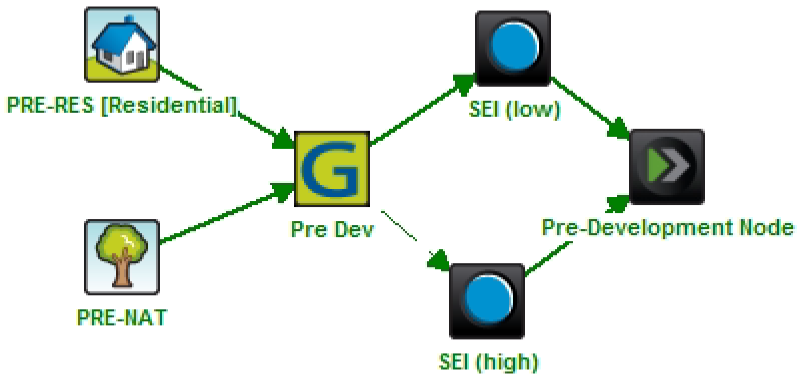


Figure 7 - Pre-Development MUSIC Model Configuration

5.4.2. Results

The results of the pre-development modelling, expressed as mean annual loads, are summarised in Table 8.

Table 8 - Pre-Development Pollutant Loads

Parameter	Total
Flow (ML/yr)	5.89
TSS (kg/yr)	688
TP (kg/yr)	1.40
TN (kg/yr)	10.6
GP (kg/yr)	0.0

5.5. Post Development Modelling

5.5.1. Overview

In addition to future on lot controls (rainwater tanks and reuse), end of line bioretention basin systems are proposed to manage water quality for the residential development areas, including roads. GPT's have been included as primary treatment measures for road runoff to capture gross pollutants and coarse sediment.

5.5.2. Model Configuration

The configuration of the post development MUSIC model is shown in Figure 8. The model consists of residential, road and natural source nodes along with SEI nodes.

Rainwater tanks were applied to roof runoff from new medium density dwellings. For the purposes of modelling 50% of residential areas were assumed to contain roofs with the remainder hardstand and landscaped (note: residential areas modelled as total of 80% impervious).

The MUSIC input values adopted for bioretention basins, GPT's and Rainwater Tanks are shown in Table 9, Table 10 and Table 11 respectively.

In the determination of re-use volumes Lot A was assumed to contain 20 dwellings and Lot B was assumed to contain 6 dwellings which are the yields based on an average lot size of approximately 300m^2 over the developable footprint (i.e. area outside the BAL 29 setback line).

Table 9- Adopted Bioretention Basin Parameters

Parameter	Value Adopted	Justification or source of data
Low Flow Bypass	$0m^3/s$	All flows connected to bioretention basins
High Flow Bypass	Bio A – $0.061m^3/s$ Bio B – $0.016\ m^3/s$	Estimated 4EY flow from contributing area in accordance with Shoalhaven DCP (2014)
Extended Detention Depth	0.2m	Typical value for bioretention basin. Less than the maximum value of 0.3m specified in Shoalhaven DCP (2014).
Surface Area	Bio A – $255m^2$ Bio B – $50m^2$	$\sqrt{2}$ x Filter Area
Filter Area	Bio A – $180m^2$ Bio B – $71m^2$	Refer to Drawing 1861-C06 in Appendix B
Unlined Filter Media Perimeter	0.1m	Water NSW (2019) recommends value as close to zero as possible
Saturated Hydraulic Conductivity	100mm/hr	As per Shoalhaven DCP (2014)
Filter Depth	0.4m	Within the typical range of bioretention devices
TN Content of Filter Media	400mg/kg	Water NSW (2019) recommended value and MUSIC Default
Orthophosphate Content of Filter Media	40	Water NSW (2019) recommended value and MUSIC Default
Exfiltration Rate	0mm/hr	Base to be lined and there will therefore be no exfiltration
Base Lined?	Yes	
Vegetated with Effective Nutrient Removal Plants?	Yes	Bioretention basins to be planted with deep rooted plants which aid in the effective removal of nutrients.
Overflow Weir Width	Bio A – 4.8m Bio B – 3.6m	Indicative of 1200x1200mm and 900X900mm pits respectively
Underdrain Present?	Yes	Bioretention Basin to have subsoil drainage systems
Submerged one with Carbon Present	No	

Table 10- Adopted GPT Parameters

Parameter	Value Adopted	Justification or source of data
Low Flow Bypass	$0m^3/s$	All road flows connected to GPT's
High Flow Bypass	GPT A – $0.012m^3/s$ GPT B – $0.005\ m^3/s$	Estimated 4EY flow from contributing area in accordance with Shoalhaven DCP (2014)
Transfer Function	Varies	As per Water NSW (2019)

Table 11- Adopted Rainwater Parameters

Parameter	Value Adopted	Justification or source of data
Low Flow Bypass	$0m^3/s$	All roof flows connected to rainwater tanks
High Flow Bypass	Lot A – $0.10m^3/s$ Lot B – $0.03\ m^3/s$	$0.005m^3/s$/dwelling as per Water NSW (2019)
Volume below overflow Pipe	Lot A – $62.3m^3$ Lot B – $14.9\ m^3$	Based on 9mm retention storage from Shoalhaven DCP (2014) – assumes medium density
Depth above Overflow	0.1m	MUSIC Default
Surface Area	Lot A – $40m^2$ Lot B – $12m^2$	Based on $2m^2$/tank
Initial Volume	10KL	MUSIC Default
Overflow Pipe Diameter	Lot A – 402mm Lot B – 220mm	Aggregate area of all tanks assuming 90mm overflow on each tank as per WaterNSW (2019)
Annual Reuse Demand	Lot A – 1,100KL/year Lot B – 30KL/year	Based on 55kl/year/dwelling as per WaterNSW (2019)
Daily Reuse Demand	Lot A – 7.2KL/day Lot B – 2.16KL/day	Based on 360/day/dwelling as per WaterNSW (2019) for toilet and laundry uses. Average Occupancy 3 people/dwelling.

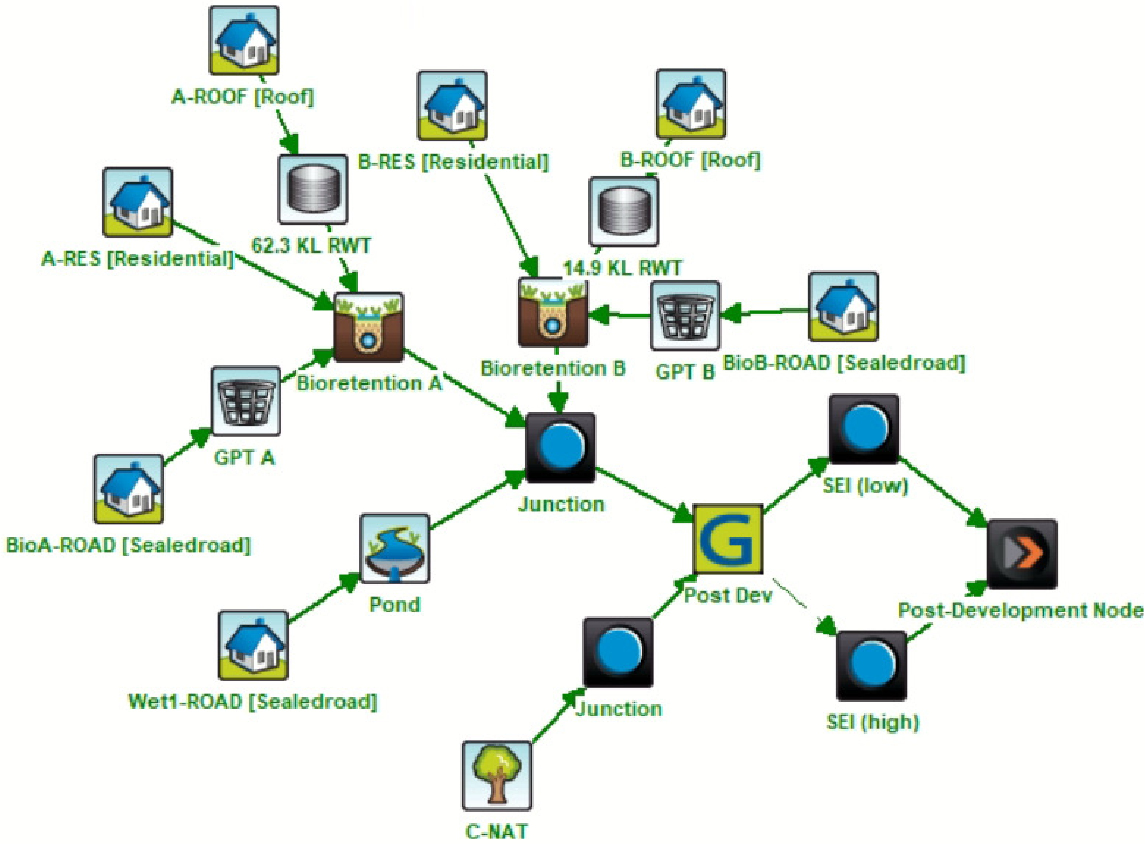


Figure 8 - Post Development Model Configuration

5.5.3. Results

The results of the post development modelling are included in Table 12.

Table 12: Post Development Pollutant Loads

Parameter	Source Load (i.e. before treatment)	Residual Load (i.e. after treatment)
Flow (ML/yr)	12.9	10.4
TSS (kg/yr)	1740	224
TP (kg/yr)	3.44	0.997
TN (kg/yr)	26.5	10.2
GP (kg/yr)	294	2.57

5.5.4. Comparison of Results to DCP Targets

The post development results were compared to the targets specified in the Shoalhaven DCP (refer to Section 3.4) as shown in Table 13. The results demonstrate that the proposed water quality treatment measures achieve compliance with Council's targets, and typically well exceed the targets specified.

Table 13: Comparison of Results to DCP Targets

Parameter	Source Load (i.e. before treatment)	Residual Load (i.e. after treatment)	Post Development Average Annual Load Reduction	DCP Target	Complies
Flow (ML/yr)	12.9	10.4	19.1%	N/A	N/A
TSS (kg/yr)	1740	224	87.1%	80%	Yes
TP (kg/yr)	3.44	0.997	70.9%	45%	Yes
TN (kg/yr)	26.5	10.2	61.4%	45%	Yes
GP (kg/yr)	294	2.57	99.1%		Yes[1]

[1] Essentially 100% of gross pollutants retained for all storm events thereby deemed to satisfy DCP provisions. Note MUSIC cannot differential between different sized gross pollutant particles.

5.5.5. Comparison of Results to NorBE

The pre and post development average annual pollutant loads results were compared to the NorBE criteria and are included in Table 14. The results show that the proposed development will result in a net reduction in pollutants exported from the site thereby satisfying the NorBE criteria.

Table 14: Comparison to NorBE Average Annual Pollutant Load Criteria

Parameter	Pre Dev. Source Load	Post Dev. Residual Load (i.e. after treatment)	Change in Load Pre to Post Dev.	% Change in Load Pre to Post Dev.	NorBE Criteria	Complies
Flow (ML/yr)	5.89	10.4	+4.51	+76%		N/A
TSS (kg/yr)	688	224	-444	-68%	+0%	Yes
TP (kg/yr)	1.40	0.997	-0.403	-29%	+0%	Yes
TN (kg/yr)	10.6	10.2	-0.4	-4%	+0%	Yes
GP (kg/yr)	0.0	2.57	+2.57	0%	+0%	Yes

The pre and post development TP and TN concentrations were also compared for pre and post development scenarios in accordance with the methodology specified in Water NSW (2019) and the results are shown in Figure 9 and Figure 10 respectively.

The results show that for both pollutants the post development concentration (in blue) is less than the pre-development concentration (in red) over the entire frequency range indicating that this aspect of the NorBE criteria is also satisfied.

Figure 9: Comparison of Pre and Post Development TP concentrations

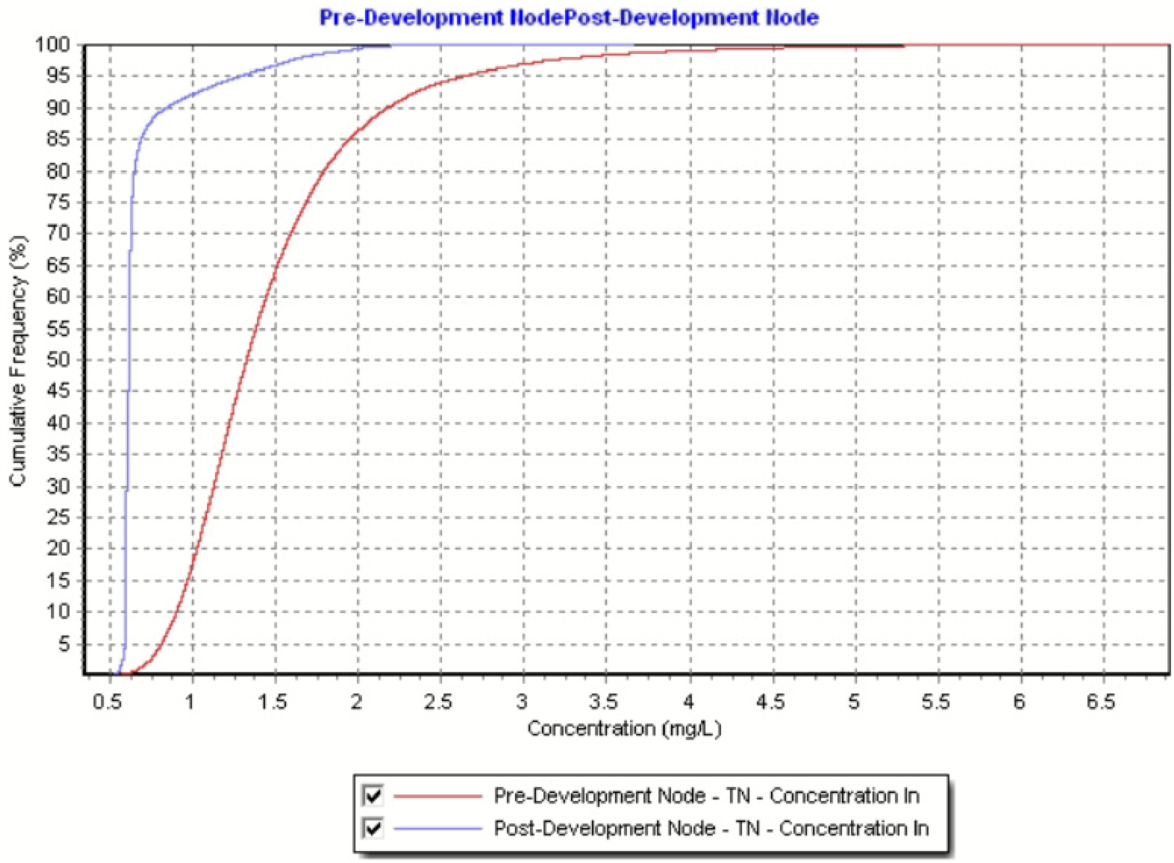


Figure 10: Comparison of Pre and Post Development TN concentrations

5.6. Impact of Development on Surface Hydrology

Section 3.4.1 of Supporting Document 1: Sustainable Stormwater Technical Guidelines states that:

- For development discharging to a natural stream of 3rd order or lower that is not tidal, the post development duration of stream forming flows must be no greater than 2 times the pre-development duration of stream forming flows at this site discharge point (i.e. a stream erosion index of 2)

In the absence of any information in Council's guideline documents stream forming flows are estimated to be 50% of the 2 year ARI peak, in accordance with standard engineering practice. Using the Probabilistic Rational Method the 2-year ARI flow is estimated at 0.226m3/s as per the calculations provided below.

From Equation 1.5 of ARR Volume 1, Book 4 (1987):

$t_c = 0.76A^{0.38} = 0.76 \times (1.478/100)^{0.38} = 0.15hrs = 9\ minutes$

From 2019 IFD data for the site:

$I_2 = I_{0.5EY} = 88mm/hr$

From Equation 1.5 of ARR Volume 1, Book 4 (1987):

$C_2 = C10 \times FF_2 = 0.8 \times 0.78 = 0.624$

and:

$Q_2 = CIA/360 = 0.624 \times 88 \times 1.478/360 = 0.226m^3/s$

50% of the 2-year ARI flow rate (i.e. 0.113m3/s) was input into the generic node in the pre and post development MUSIC model and the average annual flow volumes above this limit were extracted from the model and the results are shown in Table 15.

Table 15: Comparison of Stream Erosion Index

Scenario	Average Annual Volume Above Limit of Stream Forming Flow (ML/year)
Pre-Development	0.391
Post Development	0.404

The results show that the post development volume is only 3% higher than the pre-development volume thereby satisfy the SEI criteria.

6.0 CONCLUSION

This report considered the impact on water quality and quantity associated with the proposed rezoning and subsequent redevelopment of the land for residential purposes.

In order to assess the impact of the development on water quality computer modelling was undertaken using MUSIC in order to estimate how the proposed changes in land use together with any treatment measures used to mitigate impacts associated with the development proposal will affect water quality and quantity.

In addition to a predevelopment model which provided present day baseline results, a post development scenario was modelled including a combination medium density, sealed road and open space reflecting the concept subdivision and development plan prepared as part of the Planning Proposal.

Stormwater treatment measures employed on the site consisted of rainwater tanks and bioretention basins for the treatment of lot and road based runoff (with the addition of GPT's to act as primary treatment for road based runoff).

The results of the pre and post development water quality modelling showed that the development can comply with Council's DCP and NorBE criteria and therefore should achieve a long-term beneficial effect on water quality, water quantity and the receiving environment, subject to implementation of the recommended controls outlined in the report.

Furthermore, the modelling demonstrated that stream forming flows were predicted to be very close to the pre-development state thereby minimising the potential for stream erosion.

7.0 REFERENCES

Fletcher et al (2004) *Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures – A Review and Gap Analysis,* Cooperative Research Centre for Catchment Hydrology.

Landcom (2004) *Managing Urban Stormwater; Soils and Construction – Volume 1 (4th Edition)*

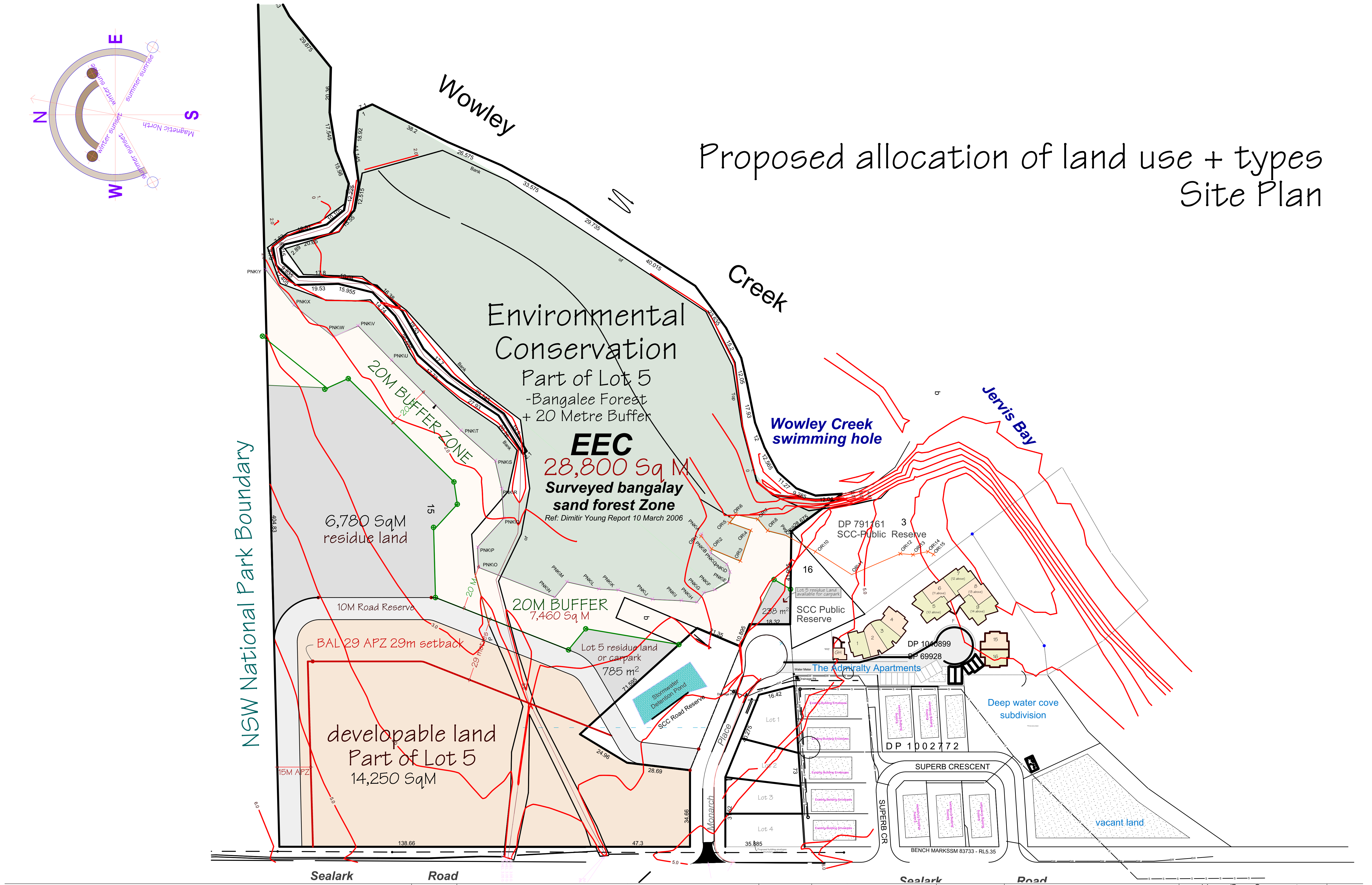
SCA (2011) *Neutral of Beneficial Effect on Water Quality Guideline*, Sydney Catchment Authority

WaterNSW (2019) *Using MUSIC in Sydney Drinking Water* Catchment, WaterNSW

APPENDIX A

Concept Layout Plan

Proposed allocation of land use + types Site Plan



Dwg Issue:	Revision Notes:	Date Issued:
PRM 303A	Release for consultative Final Reports	16th July 2020

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Hare Bay Consortia
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Sealark Road, Callala Bay

Drawing: Proposed Land allocation + ring road layout PLAN

Sheet: 303 A
Issue: PP
Drawn: cad | Check: prm | Issue Date: 16July2020 | Scale: 1:1,500
Job No

APPENDIX B

Preliminary Civil Design Drawings

LOT 5 SEALARK ROAD, CALLALA BAY
PLANNING PROPOSAL

PRELIMINARY CIVIL DESIGN DRAWINGS

LOCALITY PLAN
NOT TO SCALE

SHEET INDEX

DRAWING No.	DESCRIPTION
1861–C01	TITLE SHEET
1861–C02	GENERAL ARRANGEMENT PLAN
1861–C03	PRELIMINARY EARTHWORKS PLAN
1861–C04	ROAD LONGITUDINAL SECTION & CROSS SECTIONS – SHEET 1 OF 2
1861–C05	ROAD CROSS SECTIONS SHEET 2 OF 2
1861–C06	PRELIMINARY STORMWATER MANAGEMENT PLAN
1861–C07	WATER QUALITY PRE AND POST DEVELOPMENT LAND USE PLAN

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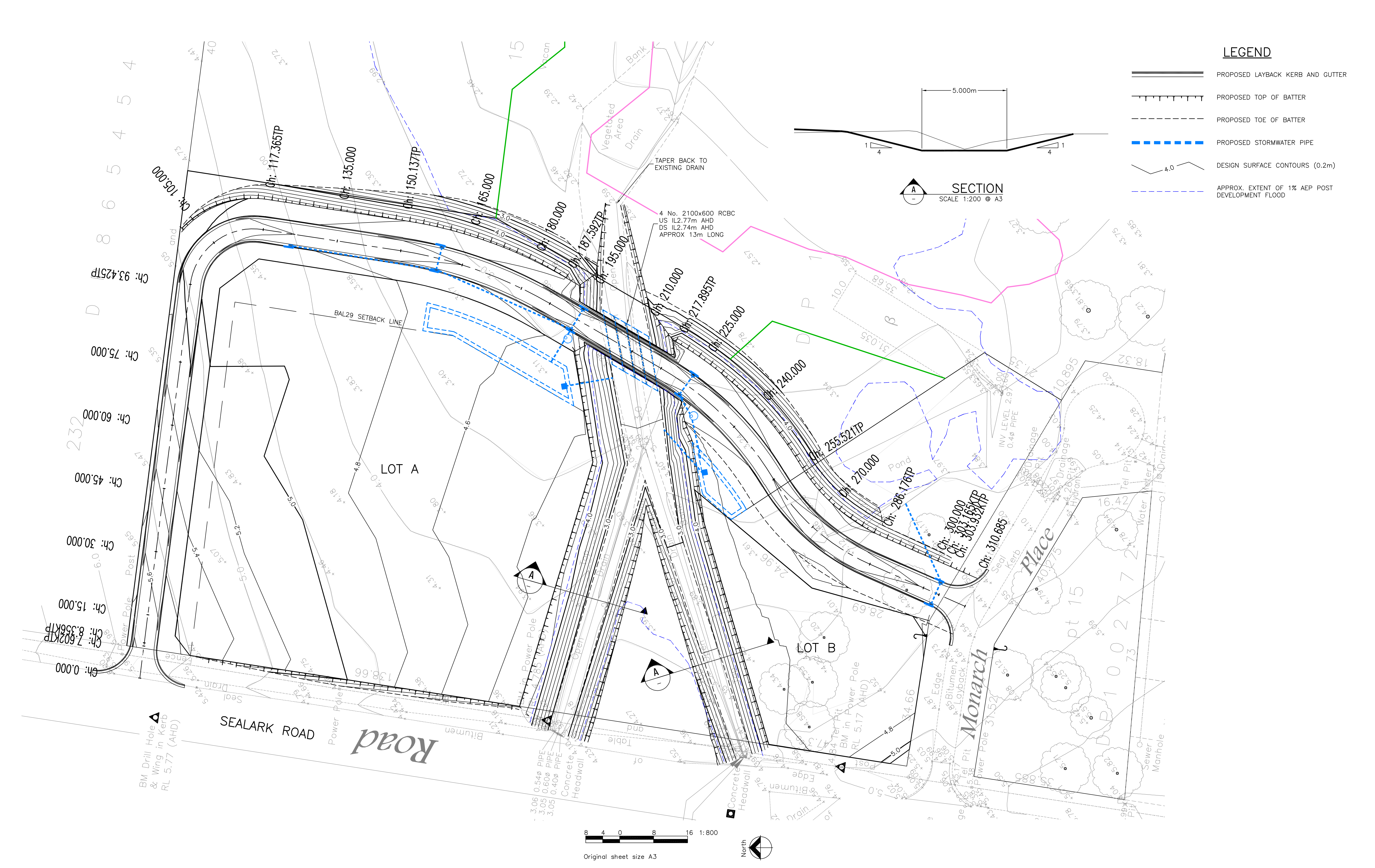

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STORMWATER MANAGEMENT PLAN

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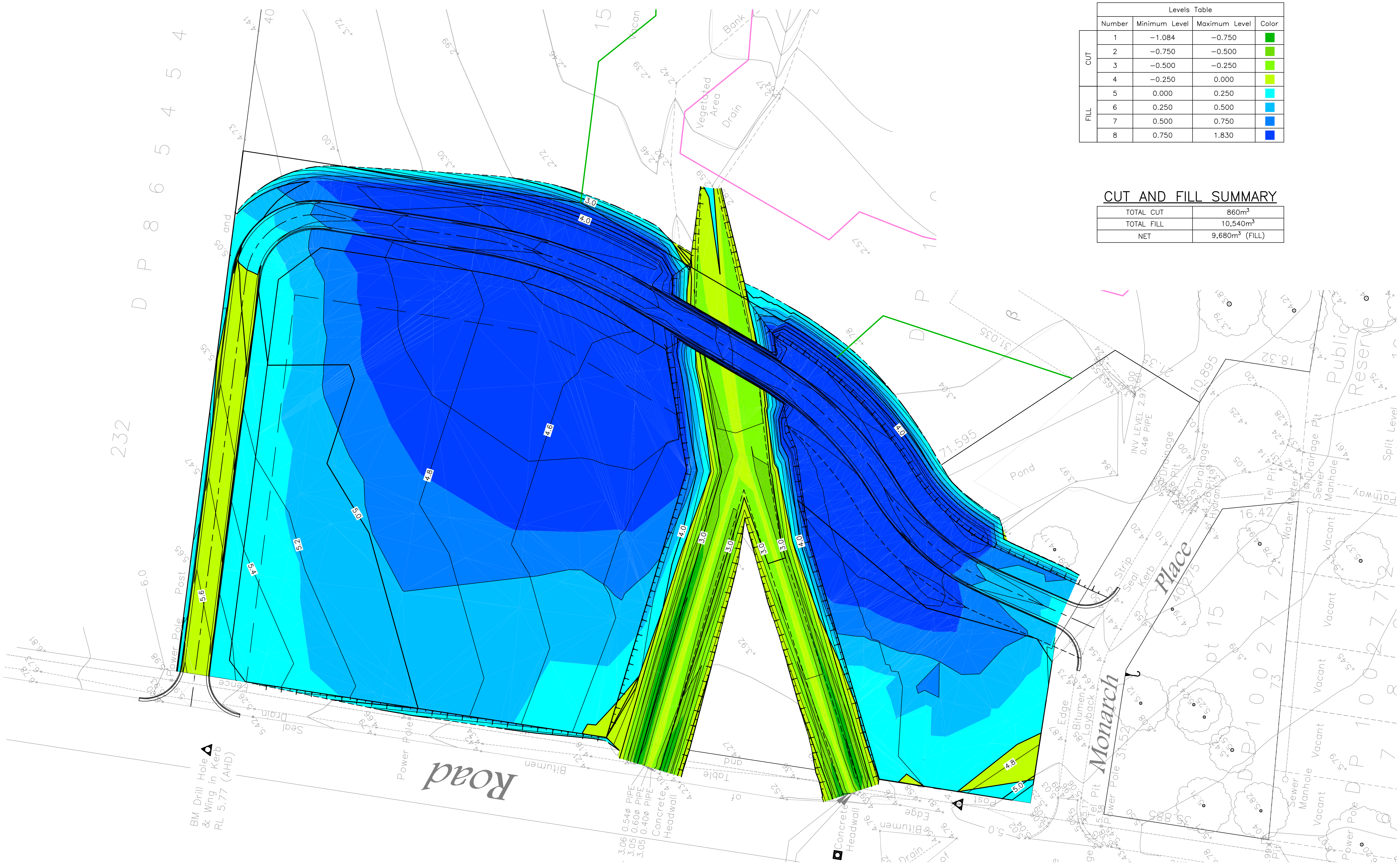
SHEET 6 OF

Levels Table				
	Number	Minimum Level	Maximum Level	Color
CUT	1	−1.084	−0.750	
	2	−0.750	−0.500	
	3	−0.500	−0.250	
	4	−0.250	0.000	
FILL	5	0.000	0.250	
	6	0.250	0.500	
	7	0.500	0.750	
	8	0.750	1.830	

CUT AND FILL SUMMARY

TOTAL CUT	860m³
TOTAL FILL	10,540m³
NET	9,680m³ (FILL)



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PRELIMINARY EARTHWORKS PLAN

GENERAL ARRANGEMENT PLAN

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ISSUE. 3

ROAD LONGITUDINAL SECTION

SCALES H 1:1000
V 1:100

Chainage	Design Levels	Existing Levels
0.000	5.820	5.820
7.602	5.744	5.806
8.356	5.737	5.797
15.000	5.670	5.720
30.000	5.520	5.545
45.000	5.370	5.394
60.000	5.220	5.274
71.554	5.105	5.218
75.000	5.072	5.200
79.054	5.039	5.158
86.554	4.992	5.060
90.000	4.975	5.014
93.425	4.958	4.969
105.000	4.900	4.678
117.365	4.838	4.240
120.000	4.825	4.154
135.000	4.750	3.674
150.000	4.675	3.342
150.137	4.674	3.339
165.000	4.600	3.059
180.000	4.525	2.957
187.592	4.487	2.909
195.000	4.450	3.019
209.225	4.521	2.824
210.000	4.525	2.890
213.743	4.506	3.134
225.000	4.450	3.011
240.000	4.525	3.161
255.000	4.600	3.377
255.521	4.603	3.386
270.000	4.675	3.523
276.952	4.710	3.725
285.000	4.670	4.163
286.176	4.664	4.180
300.000	4.595	4.344
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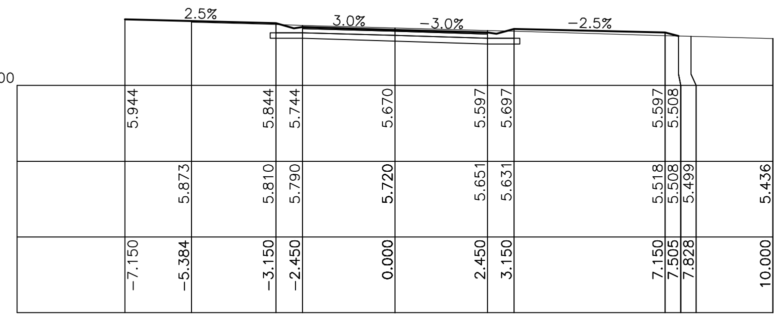
303.932	4.575	4.391
310.685	4.541	4.541



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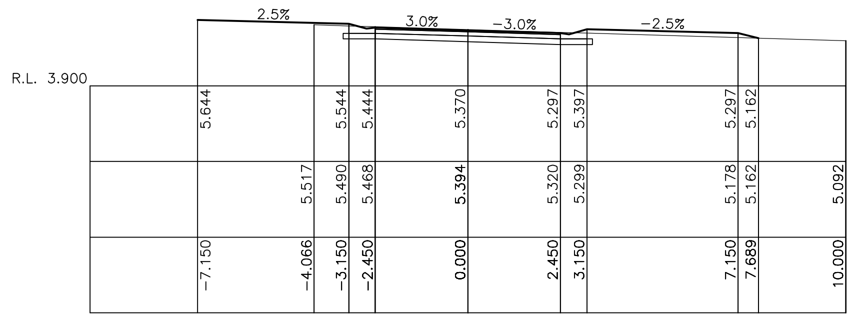

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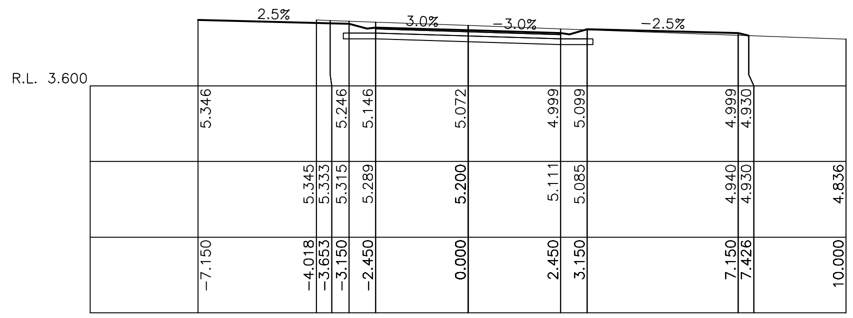

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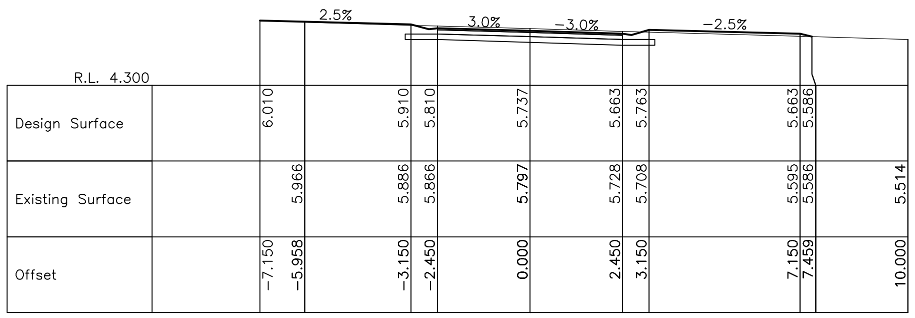

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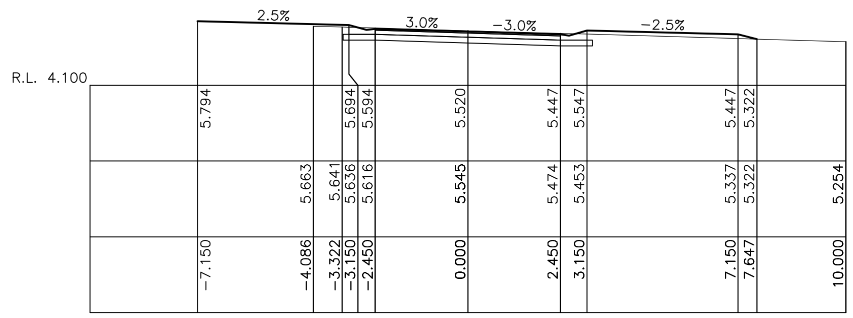

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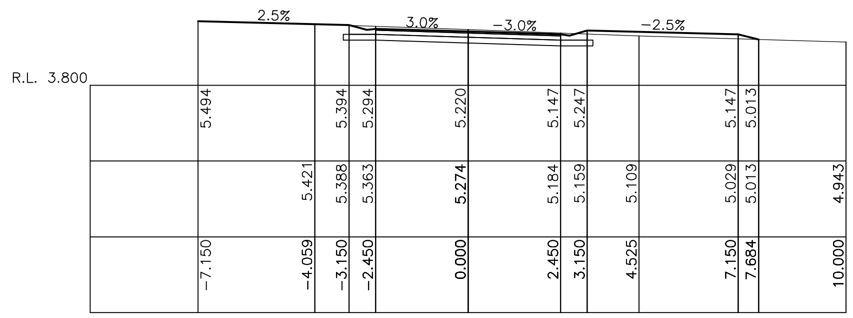

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LOT 5 SEALARK ROAD, CALLALA BAY

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ROAD LONGITUDINAL SECTION & CROSS SECTIONS - SHEET 1 OF 2

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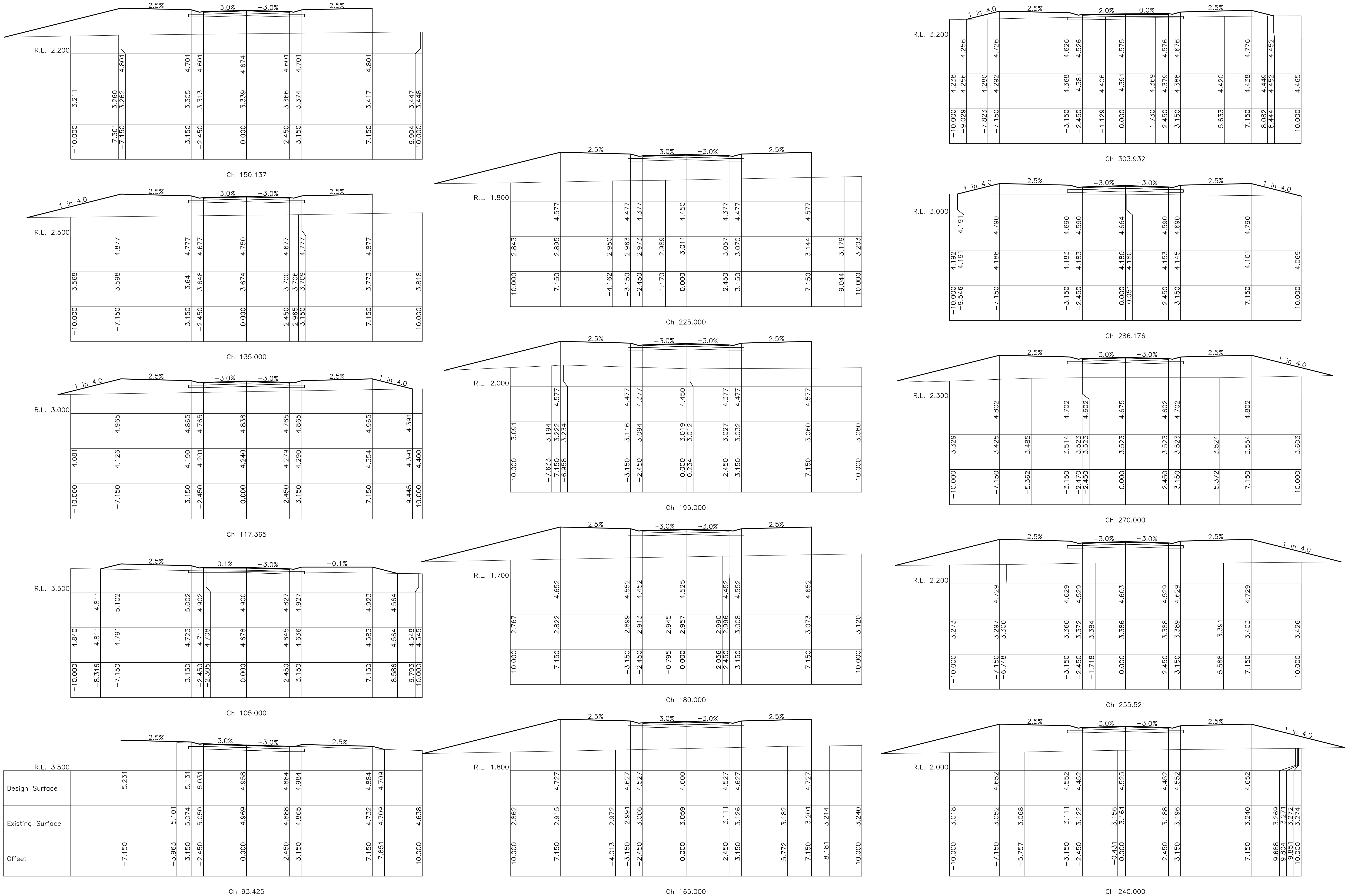

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LOT 5 SEALARK ROAD, CALLALA BAY

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PRELIMINARY CIVIL DESIGN

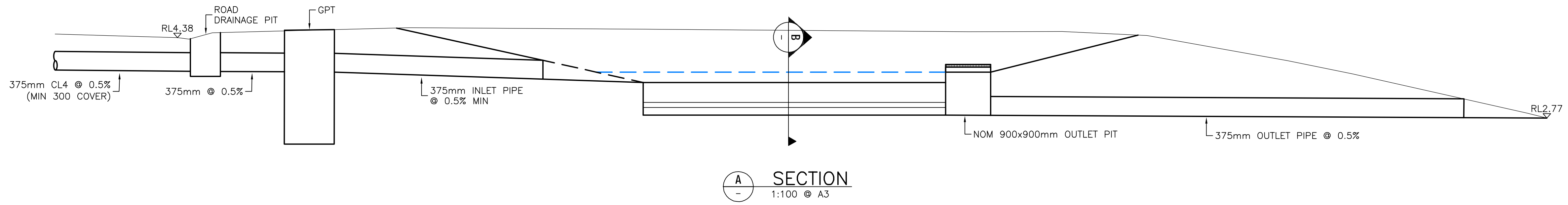
ROAD CROSS SECTIONS - SHEET 2 OF 2

DRAWING NO. 1861-C05

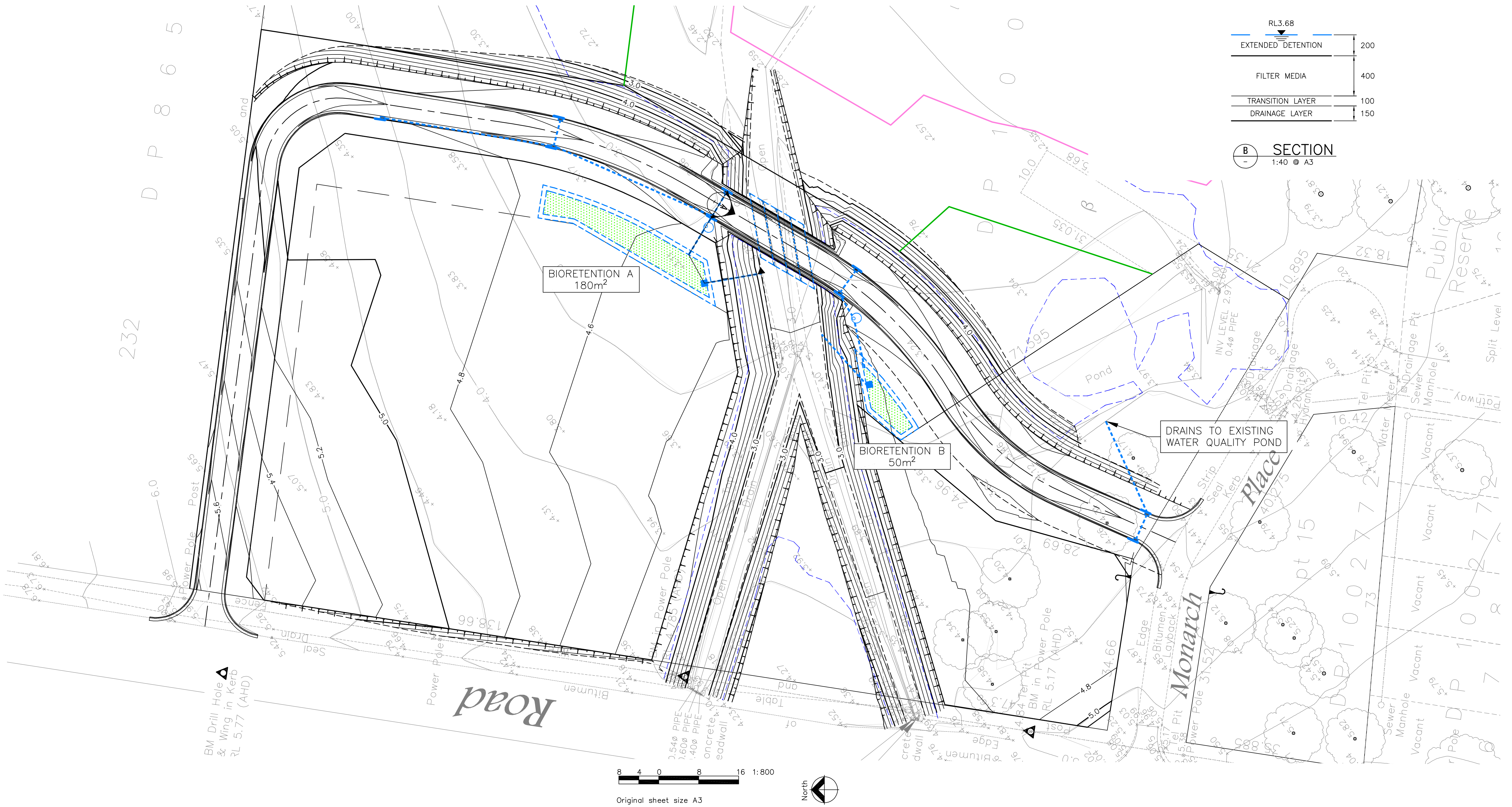
ISSUE. 3

LEGEND

- PROPOSED BIORETENTION BASIN
- PROPOSED TOP OF BATTER
- PROPOSED TOE OF BATTER
- PROPOSED STORMWATER PIPE
- DESIGN SURFACE CONTOURS (0.2m)
- APPROX. EXTENT OF 1% AEP POST DEVELOPMENT FLOOD



A SECTION 1:100 @ A3



3	RE-ISSUED FOR PLANNING PROPOSAL	22/11/21
2	RE-ISSUED FOR PLANNING PROPOSAL	22/11/21
1	FOR PLANNING PROPOSAL	30/10/20
ISSUE	DESCRIPTION	DATE

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SCALES	ORIGINAL
1:800	A3

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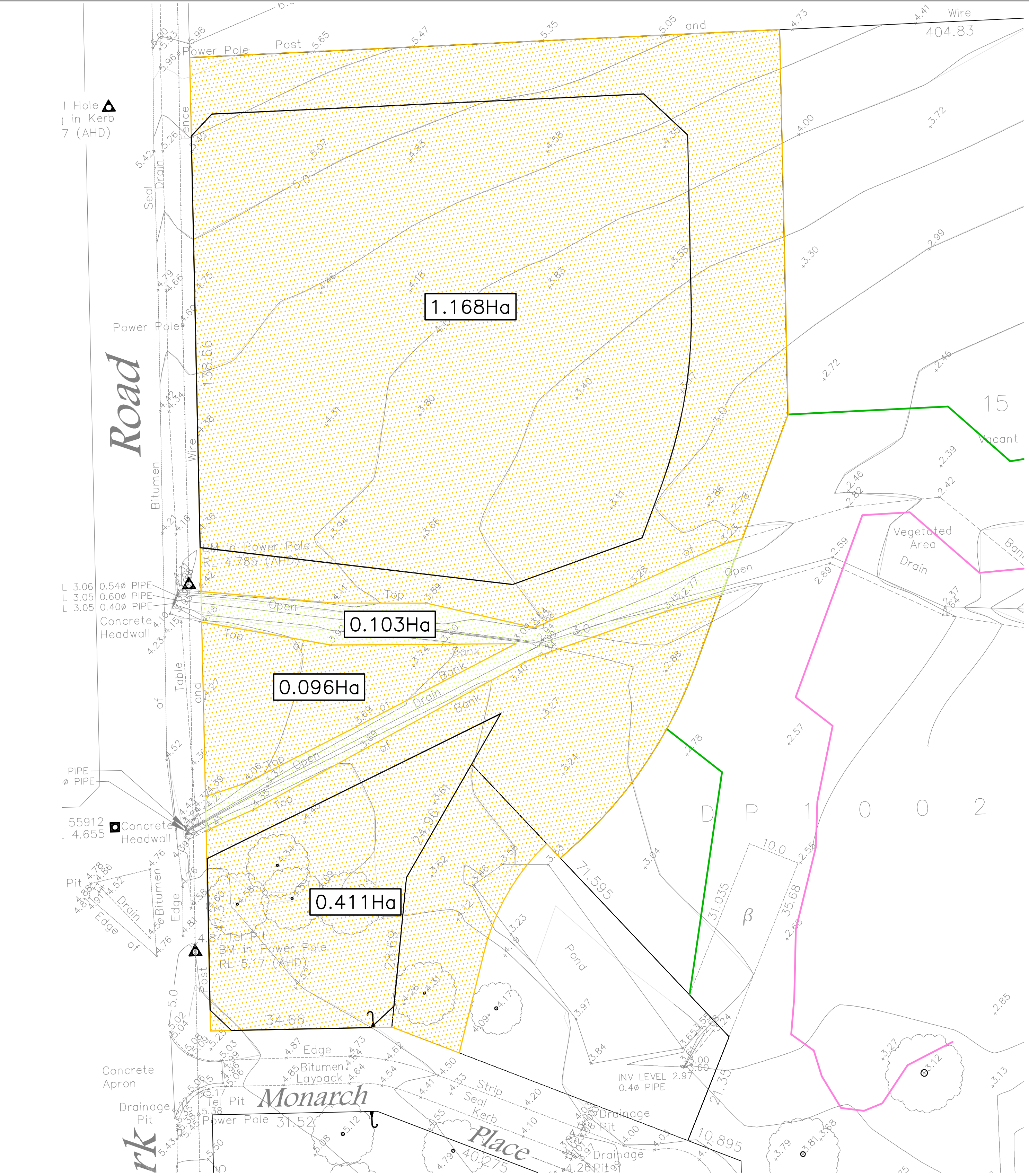
LOT 5 SEALARK ROAD, CALLALA BAY

PLANNING PROPOSAL
PRELIMINARY CIVIL DESIGN
PRELIMINARY STORMWATER MANAGEMENT PLAN

DRAWING NO. 1861-C06
ISSUE. 3
SHEET 6 OF 7

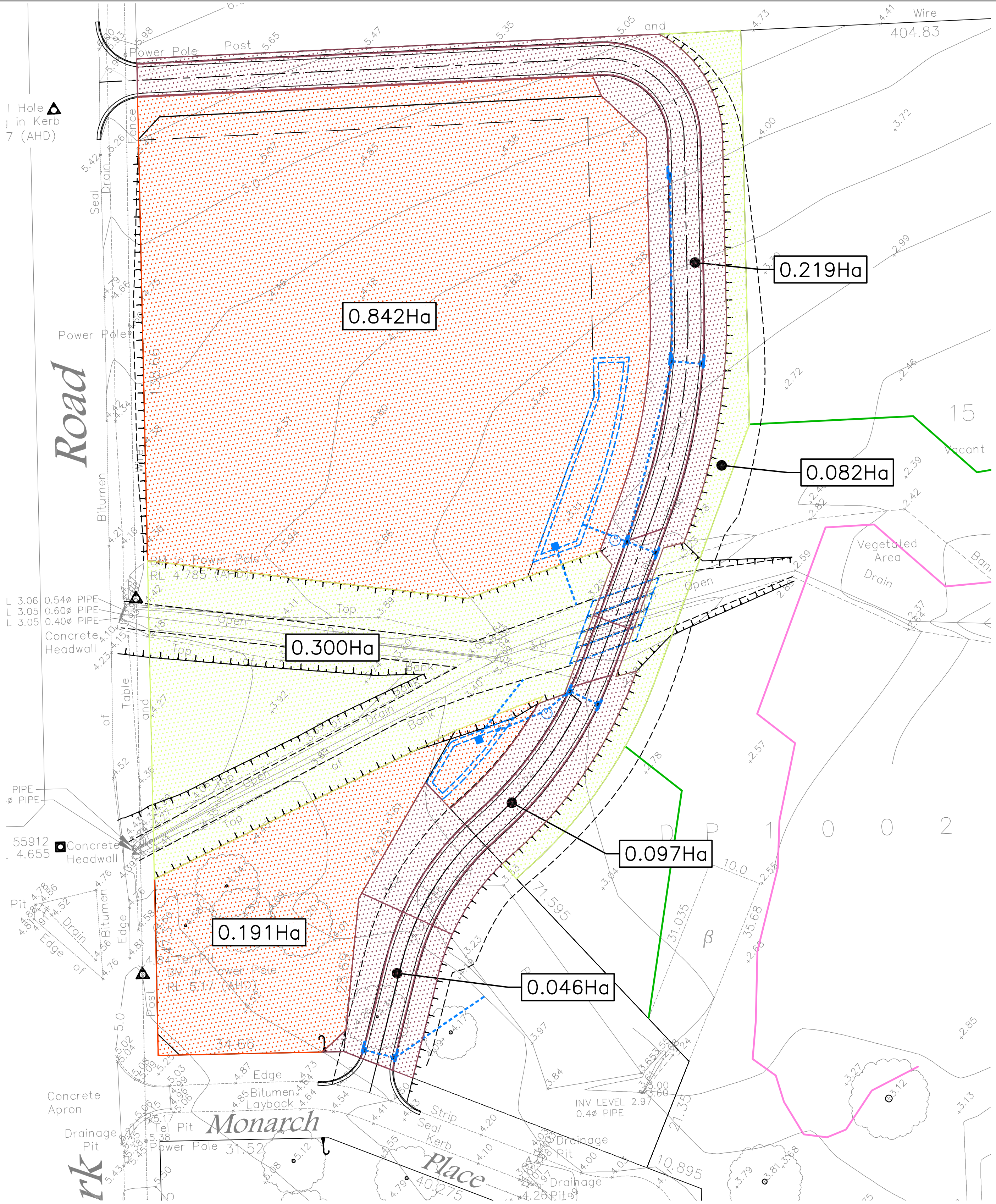


PRE-DEVELOPMENT – SUB-CATCHMENTS

LEGEND

NATURAL AREAS

DISTURBED LAND USE



POST-DEVELOPMENT – SUB-CATCHMENTS

LEGEND

NATURAL AREAS

PROPOSED MEDIUM DENSITY LAND USE

PROPOSED ROAD RESERVE

8 4 0 8 16 1:800

Original sheet size A3

North

ISSUE	DESCRIPTION	DATE
3	RE-ISSUED FOR PLANNING PROPOSAL	22/11/21
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LOT 5 SEALARK ROAD, CALLALA BAY

PLANNING PROPOSAL

PRELIMINARY CIVIL DESIGN

WATER QUALITY PRE AND POST DEVELOPMENT LAND USE PLAN

DRAWING NO. 1861-C07

ISSUE. 3