Water Cycle Management Report

PROPOSED SUBDIVISION OF LOT 4 DP 553816

16 MACPHERSON STREET, WARRIEWOOD

Prepared for: Warrimac Pty Ltd

Date: May 2023

Our Reference: 048-22-SWMR-DA-REV **E**

CRAIG & RHODES

02 9869 1855

Suite 7.01 Level 7, 3 Rider Boulevard

Rhodes NSW 2138

PO Box 3220, Rhodes NSW 2138

ABN 77 050 209 991

www.craigandrhodes.com.au

Contents

DOCUMENT CONTROL					
Date	Revision	Issue	Author	Reviewed	Approved
14.04.2023	A	Issued for DA	SY		
14.04.2023	B	Issued for DA	SY		
17.04.2023	C	Issued for DA	SY		
04.05.2023	D	Issued for DA	TF		
16.05.2023	E	Issued for DA	TF		

C&R Location Z:\048-22P Macpherson St\Engineering\Stormwater_Major\Reports\048-21P-DA-SWMR-E

1 Background

Craig & Rhodes has been engaged by Warrimac Pty Ltd to prepare for the civil design, stormwater drainage, stormwater detention and Water Sensitive Urban Design (WSUD) treatment to support the development application of the proposed residential development of LOT 4 DP 553816, being 16 Macpherson Street, Warriewood NSW 2102 (the subject site).

A full set of concept engineering drawings prepared by Craig & Rhodes accompanies this report and DA submission. Council's Water Management Specification Form has been appended to this report. Refer to Appendix A.

The proposed development is located within the Warriewood Valley Land Release. This site is located within the Northern Beaches Local Government Area.

1.1 Site Description

The site is adjoined by Macpherson Street, Brands Lane, residential properties to the north-west and Narrabeen Creek to northeast.

The subject site is current part residential and part commercial with the existing dwelling and nursery on site. Refer to figures 1 & 2 below and on the next page.

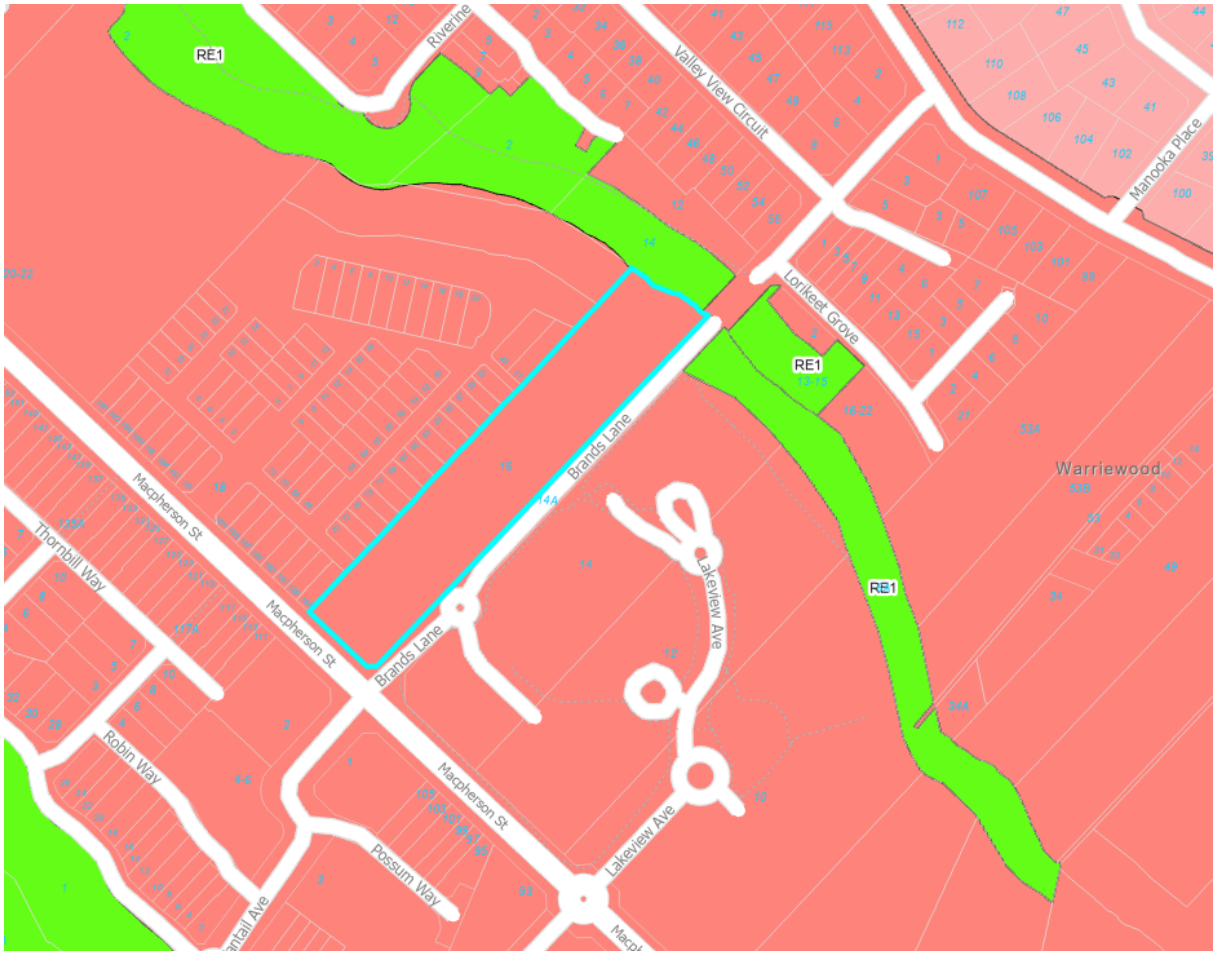

Figure 1 - Northern Beaches Planning Map

The subject site is currently zoned as medium density residential (R3). The site area is approximately 1.012 hectares.

Figure 2 - Site Location Ariel Map (Near Maps 2023)

The subject site is irregular in shape and fall generally from north-west to south-east at an average slope of around 2%, ranging from 0% to 4% sitewide. The site is located within the Northern Beaches Local government Area.

1.2 Proposed Works

The proposed development consists of 28 residential lots plus 1 community lot, and associated infrastructures including roads, stormwater and utility services.

The proposed works for stormwater management includes a construction of a bio-retention basin.

1.3 Reference Policies and Guidelines

The following documents have been referenced in developing the stormwater drainage and water sensitive urban design strategy for the proposed development:

- Pittwater Council, 2021, Pittwater 21 Development Control Plan
- Pittwater Council, 2001, Warriewood Valley Urban Land Release - Water Management Specification
- Engineers Australia, Australian Rainfall & Runoff: A Guide to Flood Estimation
- Commonwealth of Australia, 2019, Australian Rainfall & Runoff: A Guide to Flood Estimation
- NSW Government, 2010, Draft NSW MUSIC Modelling Guidelines

2 Water Cycle Assessment

The Warriewood Valley Water Management Specification requires a water cycle assessment be carried out for the development. This is to ensure that development does not have detrimental impacts on the Warriewood Valley catchment with regards to peak surface water flow rates, and peak flow volumes of surface runoff.

Craig & Rhodes has carried out an assessment for both peak flow rates and volumes of runoff for the development under three conditions, a low rainfall year, and average rainfall year, and the high rainfall year. The average rainfall for the Warriewood Valley was determined from the Bureau of Meteorology Automatic Weather Station (AWS) at Ingleside (Station 066183). This was considered to provide an appropriate representation of rainfall within the Warriewood Valley.

The average rainfall at Northern Beaches Council is 1477 mm per annum. The 10th percentile rainfall is approximately 1118 mm per annum and the 90th percentile is approximately 2002 mm per annum. The rainfall adopted for the Water Cycle Assessment of the proposed development utilised daily rainfall for the following years:

Percentile	Year	Rainfall (mm)
10th	2002	1118
50th	1984	1477
90th	1998	2002

Table 1 - Adopted Rainfall

An additional model was also prepared to look at water balance over a longer period than the individual rainfall years as above. The period covered a 28-year period from 1984 to 2012.

2.1 Treatment Measures

The aim of the water cycle assessment is to determine the changes in surface runoff from the development as result of changing the site conditions. An increase in imperviousness of the catchment increases the peak flow rates and volume of runoff from the catchment. The Warriewood Valley Management Specification requires that the volume of runoff maintain existing conditions where possible.

The primary method for maintaining peak volume of runoff is detaining runoff volumes exceeding the existing volumes via on-site detention basin.

2.1.1 Rainwater tank

As per the Architectural design prepared by PBD Architects, proposed houses are generally three-bedroom dwellings, and it is appropriate to adopt values that reflect a three-bedroom dwelling as a minimum.

The proposed dwellings will require 1,500 L rainwater tanks for on-lot reuse of stormwater collected from roofs for external use as per the requirements of BASIX (prepared by others)

Rainwater tanks will collect runoff the roofs of the proposed dwellings. The reuse requirements of the BASIX report states reuse for irrigation of the external lot landscape. The MUSIC modelling treatment train incorporates the rainwater reuse for irrigation of landscape.

As the Warriewood Valley Water Management Specification does not provide reuse values to be assumed for use within the water balance, an assumed value needs to be determined.

There are several sources which can be considered when determining water use patterns within residential developments. There are two local government areas within the Sydney Basin that are generally accepted for water reuse values for residential development, these councils are Blacktown City and Ku-ring-gai Council. Alternatively, the Sydney Catchment Authority (CMA) adopts the recommendations from Coombes et al (2003). The following table summarised these accepted sources:

Source	Yearly External Use
Blacktown Council Ku-ring-gai Council	25kL/yr (<320m^2 block) 50kL/yr (320-520m^2 block)
Coombes et al (2003) (Toilet & Laundry)	West Sydney – 55kL/yr Adelaide – 146kL/yr Brisbane – 126kL/yr Melbourne – 81kL/yr (all dwellings)

Table 2 – Rainwater Tank Reuse

As the majority of lots are less than 320m^2 in area, the reuse values adopted by Blacktown Council are the most appropriate for the site.

For water reuse drawn from the proposed rainwater tanks, an annual use of 25kL per dwelling per year has been adopted (for irrigation purposes) for the water balance and MUSIC modelling.

Based on the above demands, an annual yearly demand for the development of 28 lots is 700 KL per year.

2.1.2 Ground Infiltration

To assist with water retention the infiltration of treated stormwater to groundwater is proposed. This will reduce the volume of surface runoff, as required by the Warriewood Valley Water Management Specification.

It is proposed to construct the combined WSUD and Detention basin without an impervious liner. Without an impervious liner, the infiltration of treated stormwater, particularly for frequent rainfall events, will ensure that the ground water is contributed to.

Soils within the Warriewood Valley are generally deep sandy soils that are highly permeable. The Water Balance model assumes conservatively an infiltration rate of 10 mm/hour for the bioretention filtration media. This is lower than the generally accepted infiltration range for sandy soils (Max. 180 mm/hour).

2.2 Water Balance Results

Annual flows from the development have been assessed for a dry, average and wet rainfall years utilising daily rainfall data from 2002, 1984 and 1998 respectively.

The results of the water balance have been summarised in the following table:

Percentile	Pre-Development Annual Surface Runoff (ML/year)	Post-Development Annual Surface Runoff (ML/year)	Reduction (%)
10th (dry year)	6.07	2.2	63.76
50th (average year)	9.91	3.35	66.20
90th (wet year)	17.3	6.29	63.64
Long Term Average			
1984 – 2012	7.84	2.9	63.01

Table 3 – Water Balance Summary

During a dry year, there is a decrease in the volume of runoff from the catchment by up to 63.76%. The average year indicates that the volume of runoff under post-development conditions is reduced by up to 66.20% compared to pre-development conditions.

The modelling indicates that in wet years the volume of runoff under post-development conditions is reduced by up to 63.64%.

Looking at rainfall over a 28-year period, the average volume of stormwater runoff from the post-development is reduced by 63.01% from the pre-development scenario.

Overall, it is expected that there will be a reduction in the volume of runoff in post development conditions, however individual years may vary, and this is to be expected due to seasonal climatic changes.

3 Stormwater Quantity Management

3.1 Objective

The stormwater management objectives for the proposed development are controlled by *Water Management for Development Policy* (WMDP) from Northern Beaches Council. The site region is classified as region 1. Therefore, an onsite detention system is required in accordance with section 9.3.1 of WMDP.

OSD basin has been designed to detain stormwater runoff and release it at a flow rate that does not exceed the existing site flow rates from the catchment during storm events of 1% AEP, 5% AEP, and 20%AEP.

According to WMDP section 6.4, drainage must be designed to cater for 5% AEP event (Minor storm) whereas all storm events up to and including the major storm (1 in 100-year ARI) shall be conveyed within the road reserve.

3.2 Hydrology

An ILSAX model in DRAINS was prepared to design the proposed drainage network for the proposed development. The relevant DRAINS files used for the design and assessment for the stormwater drainage are summarised in Table 1 below:

Table 1 - DRAINS Model Files

Scenario	File Name
Pre-development and Post-Development with Climate Change	048-22_DA_003 DESIGN MAJOR
Pre-development and Post-Development without Climate Change	048-22_DA_003 DESIGN MINOR

The following table is a summary of the input parameters used in the ILSAX model. The Climate Change Rainfall Multiplier is adopted as 1.3 for major storm only.

Table 2 – DRAINS/ILSAX Model Parameters

Parameter	Value
Paved (Impervious) Area Depression Storage	1.0 mm
Grassed (Pervious) Area Depression Storage	5.0 mm
Soil Type	3
AMC	3
Overland Flow Equation	Kinematic Wave

3.2.1 Rainfall

For sizing the stormwater network and basin, rainfall intensities for use in the DRAINS model have been obtained from the Bureau of Meteorology as per the Australia Rainfall & Runoff 2019 (ie adopting the latitude and longitude of the site) and Council's requirements. For

stormwater quality modelling (ie MUSIC modelling) rainfall depths have been obtained from Bureau of Meteorology Automatic Weather Station (AWS) at Ingleside (Station 066183) as per Council's requirements. Refer also to section 6.4.1.

3.2.2 Drainage Network

The drainage network and basins have been modelled in DRAINS software in detail to represent the post-development conditions of the site.

Imperviousness area has been determined by the architect, PBD at 4922m^2.

The DRAINS model confirms that both the pipe network and surface overland flows are within Council's stormwater drainage requirements.

3.3 Internal Catchment

The existing site falls from west to east and includes of existing commercial structures. The site survey was used to determine the flow direction and approximate slope of the site.

It is considered that approx. 30% of the predeveloped site is impervious surface.

The upstream overland flow paths are contained within Narrabeen Creek and Macpherson Street. Surface runoff from adjacent properties are managed by their own internal drainage network. The internal drainage network conveys the local internal site catchment. No external catchment enters the internal drainage network.

The time of concentration for these catchments has been calculated by DRAINS software using Kinematic Wave equation.

3.4 Post-development Internal Catchment

An ultimate catchment plan has been prepared to show the sub-catchments draining to the proposed pits and pipes and discharge into proposed and OSD basin.

Refer to Figure 3 for Post-Development catchment plan.

Figure 3 – Post-Development Catchment Plan

3.5 Tailwater conditions

As there is a flood issue during major storm event, to model the OSD basin the tail water condition has been set to discharge to atmosphere.

3.6 Modelling summary for OSD Basins

The following Table 3 & 4 summarises the performance of the on-site detention basin and the comparison between the pre-development flow and post-development flow for both with and without climate change effect. The annual exceedance probability of the storms required are 1%, 5% & 20% according to Water Management for Development Policy section 9.3.2.6. Note 30% Climate change has been applied to the 1% AEP hydraulic results below.

Table 3 – On-Site Detention Basin Summary Table

Storm Event (AEP)	1%	5%	20%
Post-Development Flow Rate (cu.m/s)	0.57	0.20	0.14
Top Water Level (m)	4.48	4.33	4.14

Table 4 – Pre-Development and Post-Development Flow

Storm Event (AEP)	**1%**	**5%**	**20%**
Pre-Development Flow Rate (cu.m/s)	0.70	0.36	0.24
Post-Development Flow Rate (cu.m/s)	0.57	0.20	0.14

4 Stormwater Drainage Concept Plan

The elements of the proposed stormwater drainage concept plan for the subject site are illustrated by the **Craig & Rhodes Drawings 048-22C-DA-0101 & 048-22C-DA-0102 Revision B** and are summarised as follows:

- All roof water is firstly captured by rainwater tanks on each lot and then reused for landscape irrigation;
- Impervious surface is restricted to maximize infiltration (which is 4922m^2 or 48.6% of the site area);
- Runoff will be collected by pit and pipe networks and detained by proposed OSD basin;
- A 5% AEP (minor) capacity drainage system will convey all local site flows to the bio–retention/detention basin. Flows in excess of the 5% AEP and up to the 1% AEP + 30% Climate Change (major) shall be conveyed by the road carriageway into the basin. All flows will then discharge to Narrabeen Creek;
- SPEL's Stormsacks will be acting as primary treatment (western catchment)
- Gross Pollutant Trap will be acting as primary treatment (eastern catchment)
- Bio-retention basin will be acting as secondary treatment.

Stormwater detention measures are proposed, primarily in the form of free storage. These measures ensure flows generated by the site do not exceed those under existing conditions. Runoff water quality is proposed to be managed through a combination of treatment measures. These measures ensure post development stormwater loads generated by the site do not exceed those under existing conditions.

The proposed development generally complies with Council guidelines and achieves best practice standards in sustainability and stormwater management.

5 Water Quality Assessment

5.1 Water Quality Monitoring

Water quality monitoring requirements for the project will be established in consultation with Council. It is understood that water quality monitoring data for Narrabeen Creek is available from various sources and previous DAs undertaken within the nearby vicinity of the site, particularly by Marine Pollution Research (MPR).

For the purposes of this project, we have allowed to undertake water quality monitoring within Narrabeen Creek at the following 3 locations:

- Just upstream of the proposed development site;
- An intermediate location (likely mid-point of the creek alignment through the subject site); and
- Just downstream of the proposed development site.

Detailed water quality monitoring data is to be obtained and report on in the subdivision works certificate phase of the project.

6 Stormwater Quality Management

Stormwater runoff from the development site undergoes two stages, the construction stage and the post-development stages. These two phases are handled with two different methodologies due to the unique loads each of them generates. These will be handled as required to meet several guidelines from various sources and requirements.

6.1 Construction Stage

During the bulk earthworks and construction phase of the development, sediment and erosion control facilities will be designed and constructed/installed in accordance with Council's specifications and requirements of the NSW DECC publication titled "Managing Urban Stormwater – Soils & Construction" January 2008.
A sediment and erosion control plan has been prepared Refer **Craig & Rhodes Drawings 048-22C-DA-0901 - 0902 Revision B**.
A summary of the principal elements applied to the sediment erosion control plan for the site is summarised below:

- Minimising the extent of disturbed surfaces as any one time through staging of works;
- Stabilising disturbed surfaces immediately following completion of works;
- Protecting stockpiles via silt fencing or diversion bunds;
- Application of silt fencing on the downslopes of disturbed areas;
- Application of silt socks around drainage structures;
- Protection of exposed slopes;
- Restriction of construction vehicles to particular points of entry/exit locations; and
- Application of stabilised site access point and vehicle wash down bays.

Details for the construction stages of the development have been documented indicatively as part of the DA plans and managed ongoing through the construction process by the selected contractor.

6.2 Post-Development Stage

The proposed water quality treatment for the site consists of the following elements:

- On-lot rainwater tanks (1.5kL per lot) and associated external re-use;
- Bio-retention Basin (estimated total surface area 277m^2)

An assessment of the post-development stage of proposed development has been carried out using MUSIC and is detailed in the following sections of the report.

6.3 Objectives and proposed works

The stormwater quality objective for the proposed development is controlled by Warriewood Valley Urban Land Release-Water Management Specification, section 4.3.3. The aim is to not worsen the existing conditions and to improve the water quality of the stormwater discharge as it enters downstream eco-systems (ie Narrabeen Creek).

Existing conditions and proposed conditions are modelled in MUSIC program to determine whether the water treatment design conform to the specification as per council requirements. As required in section 4.3.1, 10th percentile, 50th percentile, and 90th percentile rainfall is

modelled in MUSIC programme. Rainwater tanks and bio retention basin are utilised to achieve the target. Table 5 below shows the water quality results for both pre-development and post-development.

Table 5 - Stormwater Quality Performance Pre-Development and Post-Development

	Pollutant	Pre-Development Average Annual Load	Post-Development Average Annual Load
10th Percentile Rainfall	Total Suspended Solids	826.00	219
	Total Phosphorus	1.56	0.631
	Total Nitrogen	12.00	3.61
	Gross Pollutants	124.00	3.45
50th Percentile Rainfall	Total Suspended Solids	857.00	268
	Total Phosphorus	1.66	0.691
	Total Nitrogen	14.90	5.16
	Gross Pollutants	156.00	4.59
90th Percentile Rainfall	Total Suspended Solids	2260.00	440
	Total Phosphorus	34.24	1.62
	Total Nitrogen	31.50	10.2
	Gross Pollutants	169.00	4.90

6.4 Methodology

The stormwater quality management modelling has been prepared using MUSIC (Model for Urban Stormwater Improvement Conceptualisation) Version 6.3.

6.4.1 Data Inputs

Climate Data

As the site is outside of the Sydney drinking water catchment area, the rainfall data has been adopted from Bureau of Meteorology Automatic Weather Station (AWS) at Ingleside (Station 066183).

Data for the 1984 to 2012 period has been adopted for MUSIC modelling. The data for this period has a mean annual rainfall that is representative of the long term mean annual rainfall record at this rainfall station.

Evaporation data for Sydney was sourced from the Bureau of Meteorology. This was combined with the rainfall data in the MUSIC models.

Catchments

The total site area is 1.172 hectares. 0.84 hectares is being developed. The MUSIC modelling will only cater for the area being developed. Each scenario has been separated into land-use catchments representative of the overall site. The summary of the catchment properties is outlined in the following table.

Table 6 - Stormwater Quality Performance Pre-Development and Post-Development

Catchment	Area (ha)	Impervious Fraction (%)
Pre- Development		
Entire Site	1.172	30
Post- Development		
Roof Area	0.302	100
Landscaped Area	0.473	0
Road Area	0.141	100
Footpath Area	0.049	100

Treatment Train

The proposed stormwater quality treatment for the development includes a bio-retention basin.

It is proposed that bio-retention filter media components to be constructed within the OSD basins.

The proposed filtration area within the bio-retention basin is 277m^2.

As part of the treatment train a minimum 1.5kL of rainwater tank (RWT) is proposed at each residential lot.

An extended detention depth (EDD) of 300mm has been allowed for.

The MUSIC model layout can be seen in figure 4.

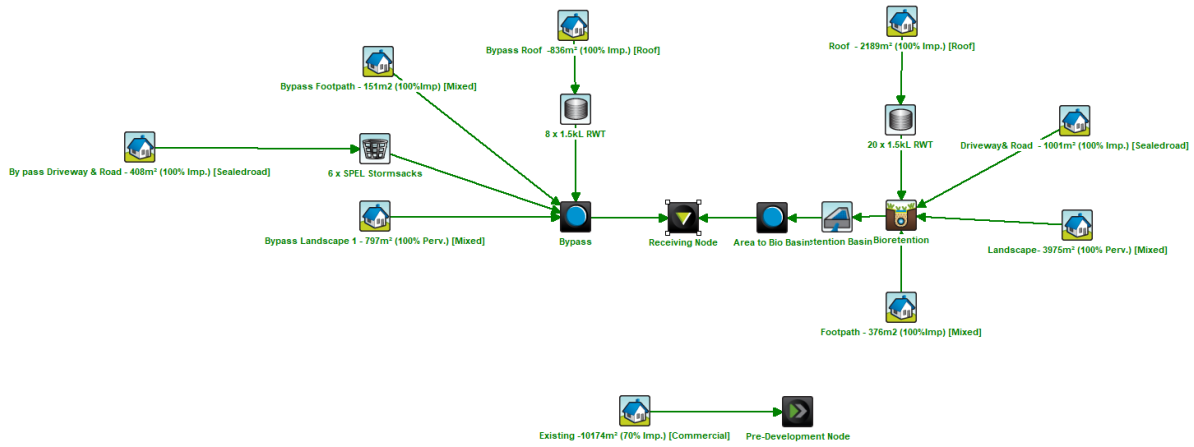

Figure 4 - MUSIC Model Layout

6.5 Overall Treatment Effectiveness

The MUSIC model indicates that the proposed treatment train consisting of on-lot rainwater tanks and bio-retention filtration areas exceeds Council's Stormwater Management Objectives as outlined in Table .

A printout of the results from MUSIC has been provided in table 5.

6.6 Ongoing Requirements

Upon completion of the proposed development, the Water Management Specification (WMS) requires ongoing monitoring and maintenance for the Stormwater Quality Improvement Devices

Monitoring of the stormwater treatment train shall include, but not limited to:

- Discrete sampling of stormwater at the inlet & outlet of the proposed bio-retention basin;
- Qualitative assessment of effectiveness of other proposed water quality control measures.

Operations and maintenance of the stormwater and WSUD devices are discussed in chapter 7.

All reporting shall conform to the requirements outlined in the WMS and forwarded to Council as required.

6.7 Mosquito Risk Assessment

The development does not propose to provide permanent waterbodies. As there are no proposed permanent waterbodies, the risk of mosquito activity is low.

There are two areas of potential concern regarding mosquito activity. The stormwater drainage network for the development, and the creek corridor.

The stormwater drainage network consists of a pit and pipe network, with a bio-retention basin. The stormwater network has been designed to drain and not provide areas for

stagnant water to collect and allow mosquito and insects to breed. The combined bio-retention and on-site detention basin is not expected to detain stormwater for a period greater than a few hours. Provided the basin is designed, constructed and maintained in line with the industry best practices, there is minimal risk that the basin will act as a mosquito habitat.

The lot-based rainwater tanks pose a minimal risk for mosquito breeding and habitat. Rainwater tanks must be adequately maintained with an emphasis on screening the inlets to the rainwater tank to prevent insects and pests from entering the tank.

The typical section proposed for the creek is to continually fall towards the creek centreline. As the section does not propose permanent pools of water along the creek line, the risk for mosquito forming habitats will be reduced. Natural depressions will form over time which may allow for mosquito habitats to form, however this is not unlike the existing natural site conditions.

At this stage it is expected that there is a low risk of forming additional mosquito and insect habitats from what currently exists. It is expected that mosquito habitats will remain static or be reduced due to the proposed works.

A further mosquito risk assessment shall be undertaken as required during the Construction Certificate and Construction stages of the development to ensure that mosquito habitats are not encouraged or formed during the construction process.

6.8 Watercourse and Creekline Corridor Preservation/Restoration

The subject development has a frontage to Narrabeen Creek to the northeast where it is proposed to dedicate a portion of the site to Council as Public Reserve.

The Warriewood Valley Water Management Specification calls for a creek corridor of up to 100m wide. This is comprised of a 50m publicly owned corridor, with a 25m wide buffer held in private ownership outside of the 50m corridor.

7 Maintenance Operations and Checklist

7.1 Maintenance Objectives

The stormwater quality devices constructed and occurring naturally within an urban environment suffer from several constraints placed upon them by disturbance within the upstream contributing catchment. Consequently, these structures will not be able to perform efficiently and continuously without regular maintenance.

Maintenance is required to increase the functionality of each design element and increases the aesthetic amenity and reduces public health and safety risks.

The purpose for this maintenance manual is as follows:

- To set out the procedures of maintenance operations and checklists whereby it can be maintained to a standard that ensure it remains operation in accordance with its original design objectives and intent;
- To provide a systematic monitoring and review procedures for the water quality devices, so that they will remain functionally effective as its original design throughout the design life of the structure.

An overall summary of the maintenance operations related to the stormwater quality improvement devices associated with the development are summarised in the following sections.

7.2 Signage

Signage outlining the nature of hazards and descriptions for the stormwater detention and water quality devices shall be inspected twice yearly for vandalism. Signs should be repaired or replaced as required.

7.3 Stormwater Pits & Pipes

Stormwater pits and pipes are designed to convey stormwater runoff during significant rainfall events so that surface flows are reduced to reduce inconvenience to users. Pits and pipes should minimise ponding of surface water but if ponding persists after rainfall events, it is likely that maintenance is required.

Pits and pipes should be checked for blockages after each storm event to ensure they continue to function effectively. The build-up of sludge and sediment depends on the upstream catchment and stormwater flows. More frequent maintenance may be required in areas where there is significant bare earth or heavy leaf litter material is conveyed in surface runoff.

In general, land managers could maintain pit and pipe systems where the depth is less than 1.2 metres. For pits deeper than 1.2m, experienced personnel with appropriate experience and qualifications (i.e. confined space training) should maintain the system.

7.4 Rainwater tanks

Rainwater tanks are designed to store water for reuse and overflow when the storage is full via the overflow pipe.

Tanks and connecting pipes should be checked for blockages after each storm event to ensure they continue to function effectively. The build-up of sludge and sediment inside the tank and pipes will gradually occur overtime. And this will also reduce the effective reuse storage overtime as well.

7.5 Water Sensitive Urban Design

There are several WSUD devices proposed for this development that operate in a treatment train approach. The recommended maintenance procedures by the manufacturers of these products are summarised in this section. The detailed maintenance procedure is included in the appendices.

Bio-Retention Basin

Following its construction, the bio-retention basin should be inspected every 1 to 3 months (and after each major rainfall event) during the initial vegetation establishment period to determine whether the bio-retention zone requires maintenance, or the media requires replacement. The following critical items should be monitored:

- Ponding, clogging and blockage of the filter media;
- Establishment of desired vegetation/plants and density; and
- Blockage of the outlet from the bio-retention system.

After the initial establishment period (typically 1 to 2 years), inspections may be extended to the frequencies shown in the maintenance frequency table below.

If the bio-retention system is not maintained frequently, the entire filter media may need to be replaced due to clogging of the media material with fine particles. This can result in frequent maintenance being more cost effective in the long-term.

Access to the basin will be via crane and bobcat. Maintenance personnel will access the basin via gate and step irons/ladder. Maintenance for the bioretention component shall again be undertaken by a Maintenance Contractor. For major cleans and filter media replacement, a small bobcat shall be floated into the basin to move/remove material. Excess material (i.e. large debris) that cannot be manually moved by hand shall be removed by lifting out of the basin via mechanical means.

The following maintenance activities will be required with inspection frequencies shown below.

- Maintenance of flow to and through the system;
- Maintaining the surface vegetation;
- Preventing undesired overgrowth vegetation/weeds from taking over the area;
- Removal of accumulated sediments; and
- Debris removal

The recommended maintenance frequency for the bio-retention basin is provided below.

Table 7 - Bio-retention Basin Maintenance

Item	Period	Responsibility	Maintenance Procedure
Inspection – Minor Maintenance	3 months and after major storms	Maintenance Contractor	• Check for sediment deposition, oily or clayey sediment on filtration media • Remove depositions or sediment
Inspection – Minor Maintenance	3 months and after major storms	Maintenance Contractor	• Check for erosion and scour of filtration media • Infill holes and repair erosion and scour
Inspection – Minor Maintenance	3 months and after major storms	Maintenance Contractor	• Check for litter • Remove both organic and anthropogenic litter
Inspection – Minor Maintenance	3 months	Maintenance Contractor	• Assess plants for disease and pest infestation • Check plants for signs of stunted growth or die off • Check original plant densities are maintained • Treat and replace plans as necessary
Inspection – Minor Maintenance	3 months	Maintenance Contractor	• Check for presence of weeds • Manually remove weeds where possible or use spot treatment with herbicide appropriate for use near waterways
Inspection – Minor Maintenance	Annually and after major storms	Maintenance Contractor	• Check underdrains are not blocked with sediment or roots • Clear underdrains as required
Inspection – Minor Maintenance	3 months and after major storms	Maintenance Contractor	• Pit and grate conditions. Evidence of cracking or spalling of concrete structures.
Major Maintenance	2 years	Maintenance Contractor	• In situ hydraulic conductivity testing • Replace transition layer and filtration media when hydraulic conductivity falls below Council acceptable limits

7.6 Annual Review

An annual review of all stormwater drainage and water quality infrastructure should be carried out to record changes for the infrastructure over time. This should be in the form of photographs and documentation.

7.6.1 Annual Review

Monitoring should incorporate photography of the infrastructure to record changes. Annual photos should generally be taken at the same time of year from the same location.

7.6.2 Procedures

The monitoring and maintenance program should be reviewed each year to determine if the maintenance objectives are being fulfilled and to ensure that maintenance staff are finding that the maintenance program is adequate for performing maintenance tasks.

The yearly review should include and assessment of the maintenance database to determine the effectiveness of inspections, reporting mechanisms and scheduled maintenance tasks that are effective.

Information in the database should be assessed to determine whether any noticeable changes are evident in vegetation, bird usage of the basin, and operational efficiency of any structure. This will further provide indications as to whether sufficient information is being recorded for management purposes.

8 Conclusions

The main conclusions on the design elements are as follows:

Drainage Networks:

- A conventional pit and pipe network within the road reserves to convey minor storm flows.
- The flows from major storms are managed by overland flows within the roads.

Water Quantity Management:

- Permanent aboveground OSD basin has been provided within the development site to detain stormwater runoff and release it at a flow that does not exceed the pre-development site flows from the catchment.

Water Quality Management:

- Permanent bio-retention filter area (rain garden) with 300mm extended detention depth (minimum) provided.
- The water quality management for the development site applies minimum 1.5KL Rainwater Tanks for each residential lot in line with WSUD principals.

Appendix A - Council's Water Management Specification Form

DOCUMENTATION CHECKLIST - DEVELOPMENT APPLICATION

(Detach and include with submissions)

Section	Item	Requirement	Check (√)
4.1	Water Cycle Assessment - Water Balance Modelling Pre & Post Development	++++++++++	✓
4.1.1	Stream Gauging, infiltration testing and use of local rainfall data for modelling	♦♦♦♦♦♦♦♦	Note
4.2.1	Water Quality Monitoring Plan	♦♦♦♦♦♦♦♦	✓
4.2.1	Water Quality Monitoring Sites Shown on Plan (at least three)	♦♦♦♦♦♦♦♦	Note
4.2.1, 2, C	Water Quality Monitoring Data	♦♦♦♦♦♦♦♦	Note
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data	♦♦♦♦♦♦♦♦	Note
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data from SQID's		
4.3	Water Quality Management Assessment - Load Modelling Pre and Post Development	++++++++++	✓
4.3.1, 3	Justification of assumptions for Event Mean Concentrations	♦♦♦♦♦♦♦♦	✓
4.3.2	Identification of and details for Stormwater quality facilities		✓
4.3.2, 4.4.5	Mosquito Risk Assessment for both Watercourse and Water Quality/Quantity features	♦♦♦♦♦♦♦♦	Note
4.3.6, 4.6.5	Inspection and Cleaning Reports for SQID's and OSD		
4.3.6	Management Plan for Stormwater Quality Improvement Devices	♦♦♦♦♦♦♦♦	✓
4.3.5	Environmental Management Plan (Soil and Water Aspects)		
4.3.4	Erosion and Sediment Control Plan		
4.4.3, 4, 5	Existing and Proposed Creek Corridor in plan with cross/long sections with flood levels	♦♦Note 1♦♦	✓
4.4.4	Proposed Creek Corridor Planting Schedule	Note 1	Note
4.4.5	Creek Corridor Vegetation Monitoring and Management Plan	Note 1	Note
4.4.5	Vegetation and Creek Maintenance and Monitoring Reports		
4.5	Flood Analysis – existing and design conditions		Note
4.5.2	Compliance of structures and creek corridor with flood planning levels		✓
4.5.4	Details of Interim Flood Protection Works		✓
4.6.3	Design Storm Hydrological Modelling of Site - Pre and Post Development	++++++++++	✓
4.6.3	On-Site Detention Facilities		✓
4.6.4	Stormwater Retention Facilities		✓
4.7	Stormwater Concept Drainage Plan	♦♦♦♦♦♦♦♦	✓

Refer to the supplement notes on the next page

KEY:

	Preliminary Calculations/Assessment Required		*Work as Executed Plans*
	Concept Design Required	♦♦♦♦♦♦	*Required/Reviewed/Updated*
+++++++	*Detailed Assessment/Calculations/Design*		*Not required*

Note 1 Even if the works are not to be constructed by the Applicant on the land to be transferred to Council under the Material Public Benefit Option in the Section 94 Plan, preliminary investigation for Rezoning and concept design at DA stage is required

Completed by Principal Certifier:

Name: .....

Title: .....

Organisation: .....

Signature: .....

Date: .....

CRAIG & RHODES
TAKE THE LEAD

Item	Description
4.1.1	Local rainfall data has been used in the DRAINS and MUSIC modelling. Infiltration testing will be carried out during detailed design by the project geotech
4.2.1	Water Quality Monitoring Plan has been discussed in the Water Cycle Management Report
4.2.1	Water Quality Monitoring Consultant will undertake the monitoring work during detailed design phase. As part of their work they will produce a Water Quality Monitoring Drawing showing at least three monitoring sites
4.2.1, 2, C	Water Quality Monitoring Consultant during detailed design phase will collect the data as part of their monitoring works
4.2.1, 2, C	Water Quality Monitoring Consultant will during detailed design phase produce a report which displays, interprete and assesses the data collected
4.3.2, 4.4.5	Mosquito Assessment has been discussed in the Water Cycle Management Report. A further Mosquito assessment will be undertaken during detailed design by the specialist consultant
4.4.4	Proposed Creek Corridor Planting Schedule will be produced by a landscape architect during detailed design phase
4.4.5	Creek Corridor Vegetation Monitoring and Management Plan will be undertaken by the specialist consultant during detailed design phase
4.4.5	Vegetation and Creek Maintenance Plan will be undertaken by the specialist consultant during detailed design phase
4.5	Flood Analysis - existing and design conditions has been undertaken by others.