WarriewoodVale Pty Ltd
C/ - Jackson Teece

Water Cycle Management Report:
8 Forest Road,
Warriewood, NSW

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P1504988JR05V02
October 2020

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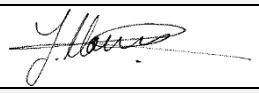
Sayana Sorourian		Stanley Leung		Terry Harvey		
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All enquiries regarding this project are to be directed to the Project Manager.

Contents

1 Background

1.1 Scope

This report has been prepared by Martens & Associates Pty Ltd (MA) to support a development application (DA) for the proposed residential development at 8 Forest Road, Warriewood, NSW. It provides an assessment of the proposed development with respects to stormwater management, including water quality and quantity.

We understand the proposed development will be undertaken in 2 stages:

Stage 1: demolition of the existing dwelling, construction of internal roads, and subdivision of land to provide 17 Torrens title residential lots, one superlot, two lots for the construction of private internal roads with associated civil and stormwater works and one community lot.

- Stage 2: construction of a residential flat building within the superlot. The proposed building comprises 64 residential apartment units with a single level basement car park.

We note that all the proposed stormwater detention and quality infrastructures required for the ultimate development including both of the residential subdivision lots and residential flat buildings will be constructed as part of Stage 1 works. Modelling approach undertaken in this report is based on the ultimate stage development, which would be consider appropriate for both Stage 1 and Stage 2 developments.

1.2 Relevant Guidelines

This report has been prepared in accordance with the following standards/guidelines:

- BMT WBM (2015), *NSW MUSIC Modelling Guidelines*.
- Pittwater Council (2001), *Warriewood Valley Urban Land Release: Water Management Specification (WMS)*.
- Pittwater Council (2019), *Pittwater 21 Development Control Plan (DCP) - Part B: B5 Water Management and Part C: C6 Design Criteria for Warriewood Valley Release Area*.

2 Site Description

Site description summary is provided in Table 1.

Table 1: Site description summary.

Element	Site Details
Site Area	56,806 m^2
Address	8 Forest Road, Warriewood, NSW
Lot/DP	Lot 1, DP 5055
Flood Hazard	Category 1 – High Flood Risk (from online Pittwater Council database)
Existing site development	Rural residential
Neighbouring environment	Light industrial/commercial to north, low density residential to east and bushland to west and south.
Site elevation	17.2 – 65.7 mAHD
Site grading & Aspect	Approx. 5 – 38%, NNE aspect.
Local Government Area	Pittwater Council / Northern Beaches Council

We note the following regarding site and upstream catchment conditions:

- Existing site maintains a rural residential land use which is primarily grassed at lower elevations and bushland at higher elevations.
- Narrabeen Creek runs through the northern section of the site.
- Total upstream catchment area for the overland flow path is primarily bushland and rural residential, approximately 81.6 ha.
- Site is located within a minor overland flow path for the Narrabeen Creek catchment.

Proposed development includes:

- A three-storey residential apartment building comprising 64 units with central courtyard and a single level basement carpark.
- Seventeen subdivision lots allocated for low density housing.
- Two above ground bioretention/detention basins and one below ground OSD tank (refer to MA planset PS05-E100 for details).

3 Stormwater Quality Assessment

3.1 Water Quality Objectives

Pittwater Council's (now Northern Beaches Council) Warriewood Valley Urban Land Release Water Management Specification (2001) requires the following objectives be achieved:

- Water cycle assessment, based on modelling (for wet, dry and average years, with no statement of underlying assumptions about water reuse for the proposed dwellings).
- Water quality assessment and monitoring.
- Water quality management based on local conditions and local water acceptance criteria.
- Demonstration of modelling to support the derivation of the stormwater quantity designs (for wet, dry, and average years and for the appropriate pre-development condition).

3.2 Modelling Methodology

3.2.1 Overview

Model for Urban Stormwater Improvement Conceptualisation (*MUSIC*, Version 6.3) developed by the Cooperative Research Centre for Catchment Hydrology (CRCCH) was used to evaluate the following two scenarios for water quality improvements:

- *Scenario 1: Pre-development (modelled as existing insitu) VS post-development to achieve at least a zero net change.*
- *Scenario 2: Pre-development (modelled as forest with a 20% increase in pollutant load) VS post-development to achieve zero net change in pollutant loads.*
- *Scenario 3: Post-development (modelled with no treatment) VS Post-development (modelled with treatment) also referred to as Treatment Train Effectiveness (TTE) and used in 31 local councils across NSW. Furthermore, TTE objectives were set to:*

i. *Total Suspended Solids – 85%*

ii. *Total Phosphorus – 65%*

iii. *Total Nitrogen – 45%*

The existing site condition was set to be prior to carrying out demolition works.

A MUSIC model was also used to provide an assessment of the water balance. For this an existing water balance was determined using locally sourced long-term data and compared with the modelled post-development conditions.

3.2.2 Approach

An iterative approach was used for post-development modelling to determine appropriate types and sizes of stormwater treatment devices and for modelling scenarios to achieve the stated objectives.

3.2.3 Rainfall Data

It is understood that council requires long-term rainfall data acquired from a local source. Daily rainfall data was sourced the Bureau of Meteorology (BOM) from the gauge located at Ingelside (Animal Welfare League), station number 066183 (1984 - 2013). This was determined to be the closest suitable station to obtain appropriate rainfall information. The data from three different years was modelled to consider:

- A wet year which occurred in 1998 with an annual rainfall of 2078.0 mm
- A dry year which occurred in 2000 with an annual rainfall of 1118.4 mm
- A typical year which occurred in 1984 with an annual rainfall of 1477.0 mm

Daily rainfall data was extracted for each year and used in individual models to comply with council requirements, rainfall data is available in Attachment A.

3.2.4 Input Parameters

Input parameters for source and treatment nodes are consistent with BMT WBM (2015) NSW MUSIC modelling guidelines.

3.2.5 Catchment Parameters

Pre-development and post-development percentage of impervious and pervious catchment areas are provided in MA planset PS05-E100.

3.2.6 Model Parameters

Section 4.3.3 of the Warriewood WMS (2001) provides the suggested event mean concentrations to be used for modelling water quality management. The event mean concentrations (EMC) were converted to a logarithm base and input into MUSIC as the storm flow concentration parameters.

The Warriewood WMS (2001) does not provide values for base flow concentrations which are necessary for MUSIC modelling. The values from BMT WBM (2015) guidelines were adopted for base flow concentrations.

The combination of adopted values for modelling from the Warriewood WMS (2001) and BMT WBM (2015) are presented below in Table 2.

Table 2: Adopted pollutant concentrations for MUSIC modelling

		Base Flow Concentrations		Event Mean Concentrations	
Land use	**Parameter**	**Log (mean)**	**Log (stdev)**	**Log (mean)**	**Log (stdev)**
Urban	TN	0.110	0.12	0.176	0.19
	TP	-0.850	0.19	-0.523	0.25
	TSS	1.200	0.17	2.000	0.32
Forest	TN	-0.52	0.13	-0.495	0.24
	TP	-1.22	0.13	-1.523	0.22
	TSS	0.78	0.13	1.000	0.20
Rural	TN	-0.05	0.12	0.000	0.19
	TP	-1.22	0.19	-1.00	0.25
	TSS	1.15	0.17	1.544	0.32
Roof	TN	N/A	N/A	0.176	0.19
	TP	N/A	N/A	-0.523	0.25
	TSS	N/A	N/A	2.000	0.32

Notes:

1. Base flow concentrations obtained from BMT WBM (2015)
2. Event mean concentrations obtained from Warriewood WMS (2001)

3.3 Treatment Train Philosophy

The preferred stormwater treatment strategy for the site utilises roof water capture and reuse as well as end source controls to ensure treatment

objectives are satisfied. Individual stormwater quality improvement devices (SQIDs) are outlined in the following sections.

3.3.1 Rainwater Tanks

Results from a BASIX certificate were used to determine the minimum rainwater tank volumes and connections for reuse. However, modelling to maintain the water balance necessitated an overall increase in the volume and reuse of the rainwater tanks. These changes will increase the water efficiency of the development above the BASIX threshold.

In terms of rainwater tanks, the following assumptions were made:

- Low density housing:
    i. We propose 2 kL tanks for each of the anticipated dwelling.
- Residential flat building:
    i. The BASIX certificate indicated that 5kL rainwater tanks or reuse was necessary to meet BASIX targets.
    ii. For our MUSIC models, we propose that the residential flat building has a communal tank of 114kL.

In terms of rainwater tank reuse, the following assumptions were made:

i. Dwellings were modelling with an external reuse rate of 0.151 kL/year/dwelling and an internal reuse rate of 0.08 kL/day/dwelling, based on indoor use for toilets in accordance with Table 6-2 for 3 occupants of BMT WBM (2015).

ii. Residential flat building was modelled with a reuse rate of 0.2 kL/day/units, based on all indoor reuse (toilets, washing machine and hot water) in accordance with Table 6-2 for 2.35 occupants of BMT WBM (2015).

It is recommended that the roof drainage system be fitted with first flush devices, gutter mesh and be connected directly to the rainwater tank. Further details of devices to be used can be provided at the design stage.

3.3.2 Bioretention Basins

Two bioretention structures have been proposed to treat water before leaving the site. The basins provide treatment of water through filtration,

biological uptake of nutrients, infiltration, evapotranspiration and detention. The basins have been appropriately sized to provide the necessary treatment to meet Council requisites.

3.3.3 StormFilter Cartridges

This treatment system uses rechargeable, self-cleaning, media-filled cartridges to absorb and retain pollutants from stormwater runoff. 6 StormFilter cartridges are used on the site. The indicative location of these devices is provided in MA planset.

3.3.4 Pit Inserts

Pit inserts are proposed to be implemented in the pits immediately upstream of the bioretention basins. This gross pollutant trap (GPT) device will be used to capture litter, debris and other pollutants. Pit inserts are not required to meet water quality targets and thus have not been included in the MUSIC models. However, they have been proposed to reduce the burden and ease maintenance requirements of the bioretention basins.

3.4 MUSIC Water Quality Results

3.4.1 Scenario 1: Pre-development (Existing) vs Post-development.

Modelling against the NorBE criteria for the site has been undertaken with the results provided in Table 3.

Table 3: Scenario 1 - Pre-development VS Post-development (NorBE).

	Dry Year		Average Year		Wet Year	
Parameter	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
TSS (kg/year)	354	106	558	164	1360	630
TP (kg/year)	1.3	0.85	1.69	1.26	3.61	3.0
TN (kg/year)	10.2	8.12	16.9	12.8	29.5	23.6
GP (kg/year)	285	21.6	352	26	371	27.5

These results demonstrate that the NorBE criteria are achieved for all climate scenarios considered. Water quality controls proposed reduce developed site pollutant loads below pre-development loads.

3.4.2 Scenario 2: Pre-development (Forest) vs Post-development

Assessment of the pre-development modelled as forest with a 20% increase in pollutant loads against post-development has been undertaken with results provided in Table 4.

Table 4: Scenario 2 - Pre-development (forest) VS Post-development.

	Dry Year		Average Year		Wet Year	
Parameter	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
TSS (kg/year)	26.6	106	80.1	164	221	630
TP (kg/year)	0.12	0.85	0.33	1.26	0.86	3.0
TN (kg/year)	0.894	8.12	3.39	12.8	10.1	23.6
GP (kg/year)	0	21.6	0	26	0	27.5

MUSIC results show that the criteria for pre-development loads equivalent to that of a forest node with 20% increase in pollutant load, is unachievable for the site.

3.4.3 Scenario 3: Post-development Treatment Train Effectiveness (TTE)

Results of post-development with no treatment devices against post-development with treatment devices is provided in Table 5.

Table 5: Scenario 3 - Post-development Treatment Train Effectiveness.

	Dry Year			Average Year			Wet Year		
Parameter	**PRE TTE**	**Post TTE**	**% Diff**	**PRE TTE**	**Post TTE**	**% Diff**	**PRE TTE**	**Post TTE**	**% Diff**
TSS (kg/year)	1780	106	-94	2580	164	-93.6	4230	630	-85.1
TP (kg/year)	5.51	0.85	-84.6	8.15	1.26	-84.5	12.8	3.0	-76.6
TN (kg/year)	26.9	8.12	-69.8	38.7	12.8	-66.9	58.6	23.6	-59.7
GP (kg/year)	475	21.6	-95.5	569	26	-95.4	605	27.5	-95.5

MUSIC results demonstrate that the TTE criteria are achievable for all years. The treatment train measures applied to the model demonstrate compliance with Warriewood Valley WMS (2001) in reducing gross pollutant loads.

3.5 MUSIC Water Balance Results

An assessment of the water balance of the existing site against the proposed developed site has been conducted and the results are provided in Table 6.

Table 6: Water balance – Pre-development VS Post-development.

	Dry Year		Average Year		Wet Year	
Parameter	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Runoff (ML/yr)	9.0	11.5	16.5	18.9	31.2	32.2

The volumetric runoff coefficient was determined as a ratio of runoff volume to the amount of yearly precipitation. The runoff volumes were derived from MUSIC modelling while the precipitation volume was

calculated using the site area and annual precipitation for the respective wet, dry and average years. The results are contained within Tables 7.

Table 7: Pre-development VS Post-development.

	Runoff Volume		Precipitation Volume		Volumetric Runoff Coefficient	
	Pre (m^3/year)	Post (m^3/year)	Annual Rainfall (m)	Site Area (m^2)	Pre	Post
Dry Year	9000	11500	1.118	21100	0.38	0.49
Average Year	16500	18900	1.477	21100	0.53	0.61
Wet Year	31200	32200	2.078	21100	0.71	0.73

3.6 Discussion and Conclusions

Results from the MUSIC model demonstrated that no increase compared to existing sediment, nitrogen and phosphorus loads (NorBe) is achieved with proposed water sensitive urban design devices. The proposed water quality improvement devices are also able to comply with the objectives of post-development treatment train effectiveness. These outcomes were achieved for all three rainfall conditions (wet, dry and average year) as outlined by Council.

If the site is modelled as though it were a forest with 20% pollutant increase, the proposed development was found to increase sediment and nutrient loads. This is inconsistent with Warriewood WMS (2001) objectives, however, to not achieve this is consistent with local practice. Other developments that are subject to the Warriewood WMS (2001) regulation have been accepted by Council provided they achieve sediment and nutrient loads demonstrating compliance to NorBe.

The Warriewood WMS (2001) does not provide a performance standard for changes between the pre- and post-development water balance, however, Section 4.6.4. states that:

> A second objective is to keep the total volume of runoff after development as close to pre-development levels as possible, in order to keep the overall water balance to a similar level.

In terms of the changes to site water balances, the percentage changes are +28% in dry years, +14% in average years and +3% in wet years. These changes are similar to the existing creek flow regime and will not result in any material impact to the downstream riparian corridor or ecosystem. The increase in base flow during dry and average years will ultimately be beneficial to the receiving environment. We note that further reuse could be undertaken by way of irrigation of communal landscaped areas within the site should this be required.

4 Stormwater Quantity Assessment

4.1 Overview

This assessment has been completed to determine onsite detention (OSD) requirements for the proposed development. DRAINS hydrological and hydraulic modelling package was used to perform hydraulic analysis.

4.2 Water Quantity Objectives

Stormwater quantity management is to comply with the objectives of Warriewood Valley WMS (2001). The site is located within Sector 501 and requires that the OSD satisfies the following criteria:

- Minimum site storage requirements (SSR) are achieved, from Table A.1.
- Permissible site discharges (PSD) not to be greater than those nominated in Table A.2.
- The post-development hydrograph is not more than 10% greater than the pre-development hydrograph.

Further to the requirements of the Warriewood Valley WMS (2001), Pittwater Council's Development Control Plan (2015) *Part B5 Water Management* includes the following objectives:

- The drainage system is to be designed to carry all flows during the minor storm event (5% AEP flood event), by way of the pit and pipe network.
- The drainage system is to be designed to carry all flows during the major storm event (1% AEP storm event), by way of overland flow paths.

4.3 Modelling Methodology and Approach

4.3.1 Approach

The Warriewood WMS (2001) provides a minimum OSD requirement of 368 kL/ha for sites in Sector 5 (now Sector 501). Site specific modelling has been completed to ensure that the design for OSD is able to achieve prescriptive PSDs. For reference, the minimum OSD volume for site would be 776 kL.

An iterative approach was used for post-development modelling to determine appropriate types, sizes and location for an on-site detention configuration.

4.3.2 Rainfall/IFD Data

IFD data that was used for the model was sourced from the Bureau of Meteorology (BOM). The 1% AEP storms were examined with current rainfall intensities and also with rainfall intensities increased by 30% as a result of climate change. These increases in rainfall intensity were modelled by manually increasing the rainfall intensities for each storm by a factor of 1.3. This represents a 30% increase in rainfall intensities due to potential future climate change.

4.3.3 Catchments

The site naturally grades to the north, towards Narrabeen Creek. In the post-development scenario, discharge from the development area will be directed to either of two separate bioretention and OSD basins to be constructed outside the riparian zone of Narrabeen Creek. For this reason, post-development discharge has been compared to the pre-development discharge of the same area and to Council's prescriptions. Refer to MA planset PS05-E600 for the catchment plan.

4.4 Results

Based on the storage requirements specified in the Warriewood Valley WMS (2001) permissible site discharge requirements and results have been provided in Table 9.

Table 8: Peak 1% AEP & 1% AEP + 30% rainfall intensity event site discharge values.

Storm Duration (hr)	Council PSD requirement[1] (l/s/ha)	Site PSD (l/s)	Pre-Development (l/s)	Post-Development with OSD[2] (l/s)	Climate Change Post-Development with OSD (l/s)
0.5	229	483	903	401	482
1	331	698	935	428	608
2	390	823	933	426	614
3	279	589	685	368	449
6	235	496	463	306	377

Notes:

1. Values obtained from Warriewood Valley WMS (2001) Table A.2.
2. Values obtained from DRAINS modelling.

The results in Table 8 demonstrate that the PSD requirement for all storm durations is achievable and that post-development flow rates were less than pre-development flow rates.

When considering the impacts of climate change, the DRAINS modelling shows that the OSD is adequately sized to account for increases in rainfall intensity. The proposed basins are able to limit discharge to Council's prescribed PSD and the pre-development discharge.

As shown in Attachment B, It is observed that the site PSD prescribed in the Warriewood WMS (483 L/s for 30 minute storm) is not within the range of ±10% in the rising or falling limb of the pre-development hydrograph, thus the post-development hydrograph is not able to be within the 10% range either, if Council's prescribed PSD is to be maintained.

4.5 Conclusion

Hydraulic modelling shows that the proposed OSD system complies with the SSR and PSD objectives outlined by the Warriewood Valley WMS (2001).

The OSD design criteria were based on limiting peak post-development flows discharges for the storm durations from 30 minutes to 6 hours. This assessment found that two detention basins with a volume of approximately 830 kL and 200 kL and a detention tank with approximate volume of 260 kL are required to contain peak flows. Compliance with Council's prescribed PSD was achieved.

Assessment was undertaken to identify the rising and falling limb of the pre-development and post-development hydrograph. Compliance with Council's prescribed PSD was achieved however this means that the pre-development hydrograph is unable to be maintained.

5 References

BMT WBM (2015). *NSW MUSIC Modelling Guidelines*

EPA (1997). *Managing Urban Stormwater: Treatment Techniques*

FAWB (2009). *Adoption Guidelines for Stormwater Biofiltration Systems*, Facility for Advancing Water Biofiltration, Monash University, June 2009.

LANDCOM (2009). *Water Sensitive Urban Design: Book 4 - Maintenance,* Parramatta

Pittwater Council (2001). *Warriewood Valley Urban Land Release: Water Management Specification.*

Pittwater Council (2019). *Pittwater 21 DCP Part B – General Controls*.

6 Attachment A – Rainfall Data

Monthly Rainfall (millimetres)

INGLESIDE (ANIMAL WELFARE LEAGUE NSW)

Station Number: 066183 · State: NSW · Opened: 1984 · Status: Open · Latitude: 33.67°S · Longitude: 151.27°E · Elevation: 160 m

Statistics for this station calculated over all years of data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	119.4	180.4	116.8	170.1	115.9	120.3	77.3	96.3	66.3	81.2	122.4	96.0	1440.7
Lowest	10.0	39.4	24.4	8.0	4.2	8.0	2.8	2.2	2.8	3.0	31.8	22.6	945.8
5th percentile	18.6	43.3	33.9	12.7	7.0	15.3	15.9	4.2	5.6	16.9	36.9	34.5	960.6
10th percentile	45.7	54.8	37.7	27.0	28.7	28.3	22.2	8.6	9.8	21.1	43.0	49.2	1071.4
Median	109.1	133.4	102.6	94.0	87.0	108.4	72.4	58.9	49.4	51.0	124.8	85.9	1336.8
90th percentile	192.1	374.3	234.1	411.0	211.3	257.1	155.8	237.9	135.2	201.9	195.2	184.6	2094.5
95th percentile	295.1	501.8	261.6	439.3	257.5	337.1	166.9	312.4	149.2	278.0	256.0	200.6	2137.3
Highest	351.8	720.8	299.0	645.2	373.0	360.8	184.0	556.0	196.0	304.0	312.7	216.4	2160.8

Daily Rainfall (millimetres)

INGLESIDE (ANIMAL WELFARE LEAGUE NSW)

Station Number: 066183 · State: NSW · Opened: 1984 · Status: Open · Latitude: 33.67°S · Longitude: 151.27°E · Elevation: 160 m

2000	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	0.8	36.0	6.4	0	0	0	0.4	0	0	0	0	18.8
2nd	19.4	0	0	4.6	24.0	0	0.4	1.6	12.8	0	0	10.6
3rd	2.2	0	0	1.4	3.6	1.4	1.0	0	0	0	1.2	0
4th	0	0	0	0	0.4	0	3.0	0	0	0	0	0
5th	0	0	0	17.6	3.2	0	4.4	0	0	0	0	0
6th	0	0	5.2	7.0	12.4	0	0	2.2	0	0	0.2	0
7th	0	1.8	34.0	0.6	0	0	1.2	1.6	0	0	3.0	6.8
8th	6.8	0	25.6	0	0	0	0.6	0	1.0	0	1.0	0.6
9th	17.2	0	101.0	0.2	0	0	0	1.2	0	38.4	0	0
10th	0.4	0	1.0	0	0.4	0	0.6	0	0	20.0	0	0
11th	1.2	0	9.8	0	9.4	0	0	0	0	7.8	0	0
12th	3.6	0.6	6.6	0	0	5.2	0	0	0.8	0	0.2	0
13th	2.8	26.0	0	0	0	0.8	0	↓	0	0.4	4.2	0
14th	4.0	0	1.6	0	0	0	0	22.6	0	15.6	8.0	15.4
15th	1.0	0	4.6	0.6	0	0	0	0	0	0	53.4	1.6
16th	0	0	0	0	0	0	0	0.4	0	0	51.0	0
17th	3.0	0	0.4	14.0	0	0	3.0	3.0	0	2.0	17.4	0
18th	7.4	0	0	0	0	0	0	0	0	0.8	0.2	0
19th	0	0	0	0	0	24.6	0.4	0.6	0	7.8	8.6	0.2
20th	0.4	0	0	1.8	0	2.6	0	0	0	1.6	1.6	0.6
21st	0	0	51.0	0	5.4	1.4	0	0	0	1.8	14.0	0
22nd	0	0	35.2	0	0	1.8	0	0	0.2	0	0	0
23rd	0	0	12.6	0	0	0	0	0	0	0	0	0
24th	0	0	4.0	0	0	0	0	0	0	0	0	4.2
25th	2.2	0	0	1.2	1.6	0	0	0	4.8	4.4	0	0
26th	1.4	0	0	3.8	0.6	0	5.2	0	2.0	0	0	0
27th	13.0	1.4	0	2.2	0.4	0	0	0	21.6	0.8	3.2	0
28th	5.8	4.6	0	0.6	0	3.8	25.0	1.0	8.4	0	0	1.6
29th	0.6	0	0	0.8	0	1.0	0	7.2	0	1.0	0	0
30th	0		0	0.2	0	17.0	0	0	0	0	0.8	7.4
31st	1.2		0		0		0	0.6		0		0
Highest daily	19.4	36.0	101.0	17.6	24.0	24.6	25.0	7.2	21.6	38.4	53.4	18.8
Monthly Total	94.4	70.4	299.0	56.6	61.4	59.6	45.2	42.0	51.6	102.4	168.0	67.8

Annual total for 2000 = 1118.4mm

DATA: DRY YEAR (2000)

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	SS	**RAINFALL DATA**	DRAWING **FIGURE 1**
Approved:			
Date:	08.09.2020		
Scale:	NA		Job No: P1504988

martens

Daily Rainfall (millimetres)

INGLESIDE (ANIMAL WELFARE LEAGUE NSW)

Station Number: 066183 · State: NSW · Opened: 1984 · Status: Open · Latitude: 33.67°S · Longitude: 151.27°E · Elevation: 160 m

1984	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	2.0	0.1	0	0	0	0	0	0	0	0.8	0	0.4
2nd	13.0	0.4	1.2	0	0	0	0	0	6.0	0	0	0
3rd	0	0	0	0	0	0	0	0	0	0	0	0.2
4th	0	0	0	1.6	0	0	7.8	0	0	1.2	8.2	0
5th	8.0	5.2	0	20.0	3.6	0	36.4	0	3.0	0	0.2	0
6th	0.2	10.4	0	0	26.0	0	0	2.6	0.2	1.2	19.8	0
7th	0	0	0	0	10.6	0	0	1.0	0	0	67.6	0.6
8th	0	4.0	0	14.4	19.4	0	0	0	0	0	56.4	17.0
9th	11.2	8.2	0	33.4	0	0	0.2	0	0	0	57.8	2.4
10th	0.4	4.0	0.2	1.6	2.4	0	3.2	0.1	0	0.2	0.1	2.4
11th	0	0	0	0.8	0.1	0.2	3.6	3.4	0	0	0	6.2
12th	0	0	0	0	0	0	0	0	1.0	0	68.6	13.4
13th	16.4	0	0	29.0	0	0	0	0	0	0	17.6	0
14th	13.0	0	4.4	1.6	0	0	1.8	0	0.2	0.8	0	0
15th	7.0	2.4	0	0	0	0.8	4.0	0	0.6	0	0	0.2
16th	11.4	2.2	0.4	0	0	4.0	4.6	0	0	0	4.6	0
17th	5.6	0	3.6	0	0	0.4	3.4	0.1	0	0	0	0
18th	0	3.6	0.8	0	2.8	0.2	1.2	0.2	16.4	0	0	0.1
19th	0	27.0	0	0	1.4	0	0	0	0.5	0	0	0
20th	0	0.1	16.0	30.6	8.0	30.4	0	0.1	0.4	0	0	0
21st	0	0	77.4	6.8	4.2	24.2	0	1.2	2.6	0.4	0	0
22nd	4.0	19.8	19.6	0	0.1	0	0.6	0	0	13.6	0	0
23rd	0	5.2	23.4	0	0	0	9.8	0	0.8	0.2	9.0	0
24th	0	1.4	74.2	0.4	0	0	0	0	1.0	0	0	0
25th	0	15.4	2.4	0	0	0	0	0	0	0	2.8	0
26th	0.2	5.6	5.2	0	0	0	2.2	0	0	1.0	0	5.0
27th	0	0	0	0	0	0	52.2	0	0	6.4	0	0
28th	0	0	2.0	0	0	8.2	53.0	0.4	0	2.0	0	0
29th	0.1	0.8	2.2	0	0.4	2.0	0	0.4	0	6.6	0	22.3
30th	60.4		0	0	0	0	0	0	0	12.8	0	17.6
31st	0		0		0.2		0	0		5.4		6.2
Highest daily	60.4	27.0	77.4	33.4	26.0	30.4	53.0	3.4	16.4	13.6	68.6	22.3
Monthly Total	152.9	115.8	233.0	140.2	79.2	70.4	184.0	9.5	32.7	52.6	312.7	94.0

Annual total for 1984 = 1477.0mm

DATA: AVERAGE YEAR (1984)

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	SS	**RAINFALL DATA**	DRAWING **FIGURE 2**
Approved:			
Date:	08.09.2020		
Scale:	NA		Job No: P1504988

Daily Rainfall (millimetres)

INGLESIDE (ANIMAL WELFARE LEAGUE NSW)

Station Number: 066183 · State: NSW · Opened: 1984 · Status: Open · Latitude: 33.67°S · Longitude: 151.27°E · Elevation: 160 m

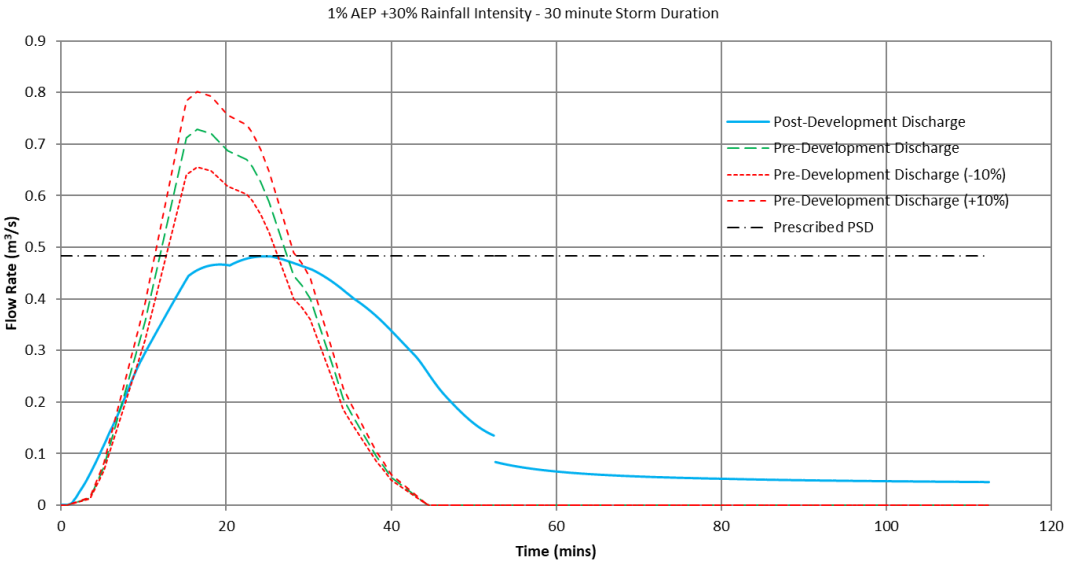
1998	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	0	0	0.6	0	0.8	0	9.8	0	0	0	3.8	9.6
2nd	0	0	0	2.4	16.2	1.4	0	0	0	0	2.8	1.8
3rd	0	0	0	0	19.0	35.0	0	0	0	0	1.8	0
4th	4.6	0	0	0	10.6	27.4	0	0	0	0	0	0
5th	1.0	0	0.4	0	64.0	8.2	0	1.0	3.8	0	0	2.0
6th	13.0	0	1.8	0	34.2	0	0	132.0	7.8	0.2	0	2.0
7th	1.8	0	0	0	0	0.4	0	126.0	0	1.4	3.2	0
8th	0	11.2	4.2	0	0	2.2	0	127.0	0	1.4	9.6	32.0
9th	4.6	1.4	0	0	0	0	0	4.2	0	0	8.8	0.2
10th	2.6	0.4	0	48.0	0	3.6	0	0	0	13.8	0	0
11th	0	2.4	0	250.0	0	4.2	4.4	0	0	0.2	0	0
12th	0	0	0	0.2	0	0.4	0	0	4.8	0	0	0
13th	0	0	0	0.4	0	0	0.2	0	10.0	0	10.0	0
14th	0	0	0	0	7.8	0	0.2	0	0	0	0	0
15th	2.2	0	7.0	0	0.6	0	0	0	0	0	0	5.0
16th	0.4	3.6	13.6	59.0	4.4	0	0	47.6	1.6	0	0	12.4
17th	0	0	0	1.0	19.6	0.6	0	55.8	0	0	1.8	2.2
18th	0	0	0	0.2	97.4	17.4	0.2	28.4	0	0	3.0	0
19th	2.2	0	0	0	83.8	0	13.6	0	0	5.0	8.8	0.2
20th	6.4	0	0	0	14.6	0	16.4	17.8	4.4	15.0	3.2	0
21st	11.0	0.8	0	0.4	0	0.2	0	2.6	2.4	0	0	1.4
22nd	0	0	0	4.8	0	0.6	0.2	0	1.6	0	0	1.4
23rd	0	0	0	60.6	0	26.0	0	6.4	0	3.2	0	0
24th	1.8	0.2	0	15.2	0	1.6	7.0	0	2.2	0	21.0	0.2
25th	45.6	0	0.6	0.2	0	0	18.6	0.4	3.6	0	0.4	0
26th	14.0	0	1.8	0	0	0	17.4	2.2	2.0	0	44.0	0
27th	0	0	3.4	0	0	0	7.6	0.2	0	8.2	1.0	0
28th	0	19.4	0	0	0	0	7.6	4.4	0	1.8	0.4	0
29th	0		0	0	0	0	0.2	0	0	0	1.2	0
30th	0		0	0	0	0	0	0	0	0	0	0
31st	0		0		0		0	0		0.2		0.2
Highest daily	45.6	19.4	13.6	250.0	97.4	35.0	18.6	132.0	10.0	15.0	44.0	32.0
Monthly Total	111.2	39.4	33.4	442.4	373.0	129.2	103.4	556.0	44.2	50.4	124.8	70.6

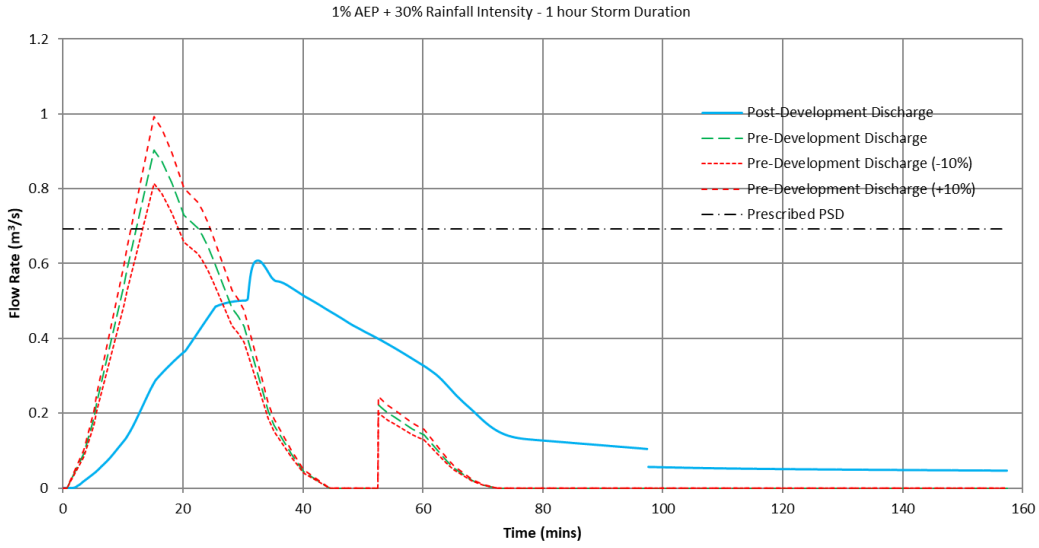
Annual total for 1998 = 2078.0mm

DATA: WET YEAR (1998)

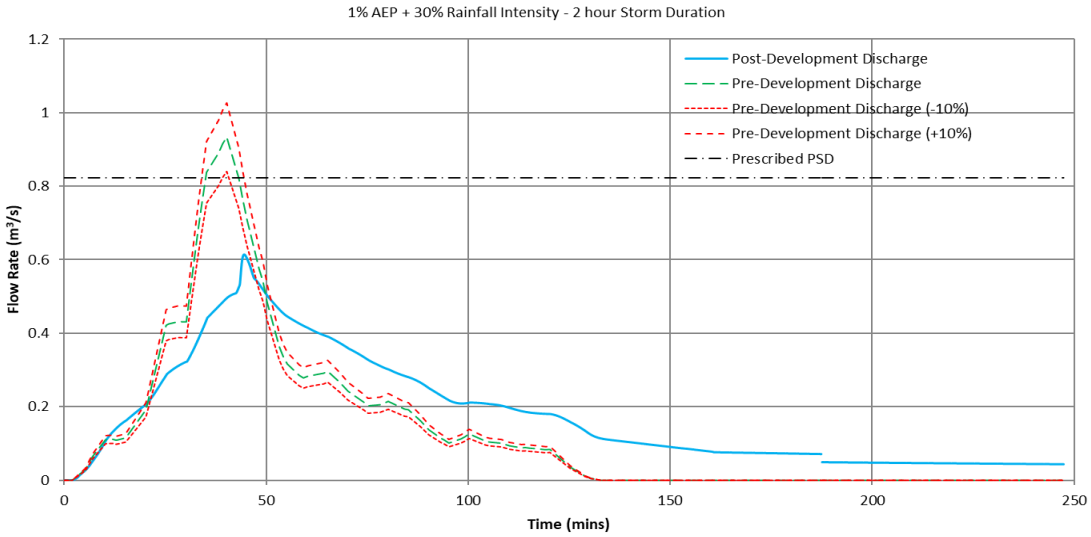
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	EZ	**RAINFALL DATA**	DRAWING **FIGURE 3**
Approved:			
Date:	13.05.2020		
Scale:	NA		Job No: P1504988

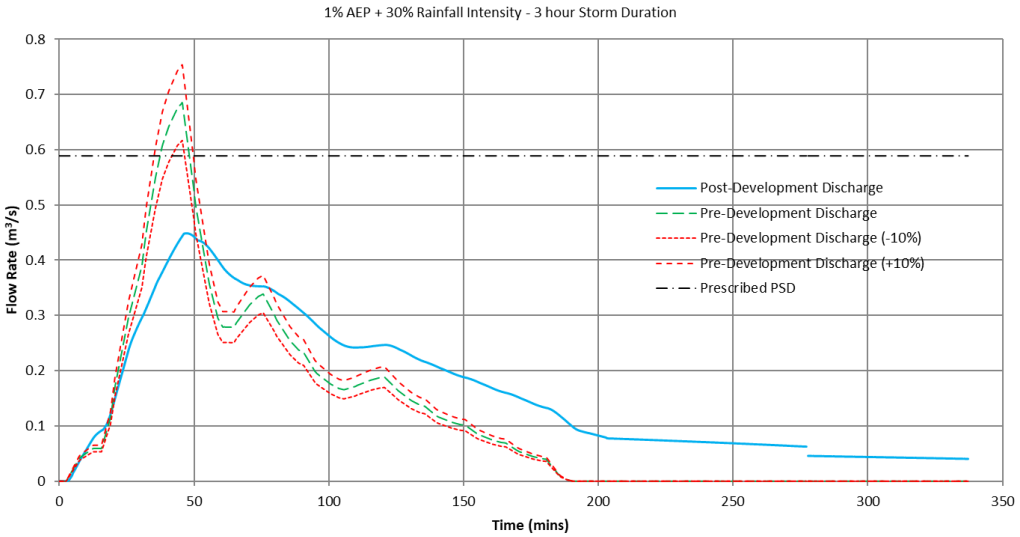
7 Attachment B – 1% AEP event +30% Rainfall Intensity Pre and Post-Development Hydrographs



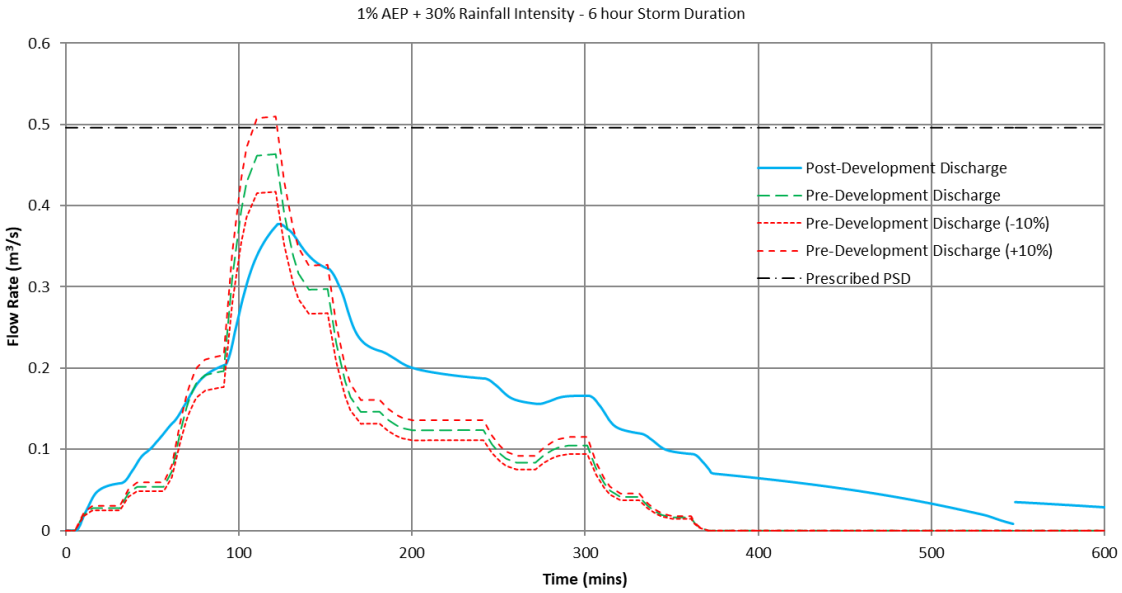


Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	AVG	**DRAINS HYDROGRAPHS**	DRAWING **FIGURE 4**
Approved:	SL		
Date:	09.02.2017		
Scale:	NA		Job No: P1504988





Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	SS	**DRAINS HYDROGRAPHS**	DRAWING **FIGURE 5**
Approved:	SL		
Date:	08.09.2020		
Scale:	NA		Job No: P1504988



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	SS	**DRAINS HYDROGRAPHS**	DRAWING **FIGURE 6**
Approved:	SL		
Date:	08.09.2020		
Scale:	NA		Job No: P1504988