

Stormwater Management Plan



17-19 Weinam Street &
55-61 Hamilton Street, Redland Bay

Palm Lake Works

PLANS AND DOCUMENTS
referred to in the PDA
DEVELOPMENT APPROVAL

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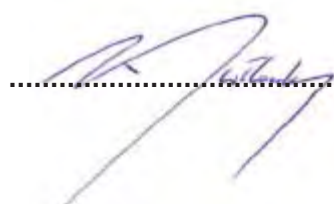
Report Title: Conceptual Stormwater Management Plan
17-19 Weinam Street & 55-61 Hamilton Street, Redland Bay

Prepared By: BIOME Consulting Pty Ltd

Author: Anna Kleinschmidt
BEnvEng, BSc

Reviewed by: Brad Comley
MSc, BAppSc, MEngPrac, NER, RPEQ




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Executive Summary

This report has been prepared on behalf of Palm Lake Works and presents a comprehensive review of available Stormwater Quality Improvement Devices (SQID) and stormwater Best Management Practices (BMP) to ensure that the proposed development adequately addresses the management of stormwater quantity and quality during the operational phase of the development.

In order to address the management of stormwater quality, four (4) stormwater treatment basins have been proposed. All of the proposed basins will be bioretention systems in planter type boxes, incorporating engineered filter media and planted with relevant plant species to enhance nutrient uptake.

The bioretention system filter areas have been optimised for the treatment of the site's internal catchments such that the required stormwater treatment objectives can be achieved. The proposed design includes bioretention basins with filter areas of 23 m², 28 m², 24 m² and 15 m² within Catchments A1, A2, B1 and B2, respectively. It has been demonstrated utilising *MUSIC* Version 6 that this design can achieve pollutant removal efficiencies of 80%, 60%, 45% and 90% for TSS, TP, TN and gross pollutants respectively.

In order to address the management of stormwater quantity, a dedicated detention tank with an estimated detention volume of 83 m³ has been provided underneath the visitor/staff carparking area of Catchment A1. Modelling of this detention tank and its associated outlet structures indicate that pre-developed flows can be maintained for all nominated ARI events at PD-A.

Catchment reductions in the post-development case have resulted in subsequent reductions in peak discharge at PD-B for the modelled 50 and 100 year ARI events. The outlets of Bioretention Basins B1 and B2 have been configured to mitigate the increases in flow predicted during lower events at PD-B.

The level of detail provided within this report is suitable for development assessment only and should not be relied upon for construction purposes. A Detailed Stormwater Management Plan containing detailed engineering designs will be needed to finalise the stormwater concepts presented in this report. Detailed design documentation should be prepared in conjunction with civil operational works.

This report has been reviewed by a Registered Professional Engineer of Queensland (RPEQ), and certification has been provided that if the design parameters set out in this report are included within the development:

- there should be no worsening in peak discharge as a result of the proposed development; and
- stormwater pollutant load reductions in accordance with best practice should be achieved.

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Appendix A – Stormwater Management Design Drawings

Appendix B – Rational Method Validation

1 Introduction

This conceptual stormwater management plan has been prepared so as to be considered as part of a Development Application for a Material Change of Use (MCU) over Lot 2 on SP115173 and Lot 1 on SP169111 at 17-19 Weinam Street and 55-61 Hamilton Street (the subject site).

The report has been prepared on behalf of Palm Lake Works and presents a comprehensive review of available Stormwater Quality Improvement Devices (SQID) and stormwater Best Management Practices (BMP) to ensure that the proposed development adequately addresses the management of stormwater quantity and quality during the operational phase of the development.

The level of detail provided within this report is suitable for development assessment only and should not be relied upon for construction purposes. A Detailed Stormwater Management Plan containing detailed engineering designs will be needed to finalise the stormwater concepts presented in this report. Detailed design documentation should be prepared in conjunction with civil operational works.

1.1 Objectives

The overarching objective of this report is to present practical conceptual stormwater designs which can be integrated into the development proposal so as to ensure that the development does not cause an unacceptable impact or nuisance which could result in actionable damage to downstream properties and receiving environments during the operational phase of development.

The following objectives are to be achieved.

Operational Phase Objective
(Quantity)

Maintain a Lawful Point of Discharge (LPD) for all site catchments in accordance with QUDM (2016).

Operational Phase Objective
(Quality)

Stormwater discharged from the site achieves the specified load based reduction targets in accordance Queensland Water Quality Guidelines (2009). For the development site relevant targets are TSS 80%, TP 60%, and TN 45%.

2 Site Location

The subject site is located within the Redland City Council local area, comprises two (2) allotments, Lot 2 on SP115173 and Lot 1 on SP169111 at 17-19 Weinam Street and 55-61 Hamilton Street, Redland Bay. The site has a total area of 7,026 m² and has street frontage to Pitt Street, Weinam Street and Hamilton Street. Hamilton Street and Weinam Street are currently used as access points.

The existing site consists of a grassed surface over 17-19 Weinam Street and a retirement village over 55-61 Hamilton Street, with multiple buildings and carpark areas.

Refer to Figure 2.1 below which presents a Google map depicting the site's location and surrounding road network.



Figure 2.1 Site Location

2.1 Rainfall

The hydrologic analysis undertaken in this report will rely on Australian Rainfall and Runoff (ARR) temporal pattern and IFD data obtained for the site from the BOM (Table 2.1).

Table 2.1 Adopted Intensity Frequency Data (mm/hr)

Storm Duration	Annual Exceedance Probability (AEP)					
	0.393 (2 yr ARI)	0.181 (5 yr ARI)	0.095 (10 yr ARI)	0.049 (20 yr ARI)	0.02 (50 yr ARI)	0.01 (100 yr ARI)
5 minute	131.0	180.0	213.0	245.0	289.0	322.0
10 minute	107.0	146.0	172.0	196.0	228.0	253.0
15 minute	91.0	124.0	145.0	166.0	193.0	213.0
20 minute	79.3	108.0	127.0	145.0	169.0	187.0
25 minute	70.5	96.1	113.0	130.0	152.0	168.0
30 minute	63.6	86.9	103.0	118.0	138.0	153.0
45 minute	49.9	68.5	81.3	93.9	111.0	124.0
60 minute	41.5	57.3	68.3	79.3	94.1	106.0
90 minute	31.8	44.3	53.0	61.9	74.2	83.9
120 minute	26.3	36.7	44.2	51.8	62.4	70.9
180 minute	20.1	28.3	34.2	40.3	48.8	55.7

3 Existing Case – Hydrological Assessment

xpstorm was utilised to assess the site's existing hydrology and generate hydrographs to represent the stormwater flows expected at the site's existing points of discharge (PD). Modelling was based on existing catchment areas and surface characteristics. Peak discharge rates for nominated Annual Exceedance Probabilities (AEPs) were derived from the output hydrographs. The following sections detail the input parameters used in the *xpstorm* modelling. Catchments have been delineated on Drawing DWG-200 – Appendix A.

3.1 Existing Case – Discharge Locations

Flows from the subject site currently discharge at two (2) Points of Discharge (PD) including:

- PD-A Hamilton Street road reserve. Stormwater discharges across the north western and north eastern boundaries of the site at several locations as both piped and overland flow. Flows which discharge across the north western site boundary flow onto the adjacent grassed park area and are conveyed north east to the existing Hamilton Street drainage channel. Flows which discharge across the north eastern boundary are conveyed to Hamilton Street. From the kerb and channel of Hamilton Street stormwater enters Council's network and drains in a north eastern direction.
- PD-B The table drain within Pitt Street reserve. Stormwater sheet flows over the north western boundary and through the adjacent grassed park area, and over the south western boundary into the existing table drain. Flows are conveyed to the north.

The existing discharge locations are shown on Drawing DWG-200 – Appendix A.

For hydrological assessment purposes, flows from the site combine with upstream catchments and two (2) Points of Discharge, PD-A and PD-B, will be relied upon for comparison of peak discharge.

3.2 Existing Case – External Catchments

There are two (2) small external upstream catchments that contribute flows directly onto the subject site. These catchments include the external grassed batter of Weinam Street (A(Ext)) and a portion of a residential allotment south of Weinam Street (B(Ext)). Table 3.1 summarises the characteristics of the identified External Catchments which are also delineated on DWG-200 – Appendix A.

Table 3.1 Existing Case – External Catchment Characteristic

Catchment ID	Area (ha)	Cover (%)	Discharge Condition	PD ID
A (Ext)	0.01	100% - Grassed Batter	Sheet	PD-A
B (Ext)	0.09	100% - Grassed Residential	Sheet	PD-B

3.3 Existing Case – Internal Catchments

The subject site has been divided into two (2) internal catchment areas. The characteristic of the site's catchments are detailed in Table 3.2 below and have been delineated on Drawing 200 – Appendix A.

Table 3.2 Existing Case – Catchment Characteristic

Catchment ID		Area (ha)	Cover (%)	Discharge Condition	PD ID
Internal	A	0.25	76 – Buildings/Hardstand 24 – Landscape	Piped/Channel/Sheet	PD-A
	B	0.45	86 – Cleared pasture 14 – Impervious Driveway	Sheet	PD-B

3.4 Existing Case – *xpstorm* Runoff

The “Laurenson” routing method was applied to *xpstorm* for hydrological calculation and hydrograph generation. The contributing catchment was split into pervious (with 0% impervious fraction) and impervious (with 100% impervious fraction) areas. Adopted parameters for the Laurenson routing method include a Manning's roughness coefficient (n) for impervious and pervious areas respectively. Infiltration uniform losses have been applied to the hydrologic model. The tables below contain the modelling parameters relied upon and present the resulting peak discharges expected for each catchment. The flows reported at each PD represent the combined catchment inflows at this point.

Table 3.3 Existing Case – *xpstorm* Catchment Details

Catchment ID		Impervious Area		Pervious Area	
		Area (ha)	Slope (%)	Area (ha)	Slope (%)
External	A (Ext)	-	23.3	0.01	23.3
	B (Ext)	0.01	7.3	0.08	7.3
Internal	A	0.19	2.8	0.06	2.8
	B	0.06	2.2	0.39	2.2

Table 3.4 *xpstorm* Rainfall Multipliers Applied to Temporal Patterns (mm)

Storm Duration	Annual Exceedance Probability (AEP)					
	0.393 (2 yr ARI)	0.181 (5 yr ARI)	0.095 (10 yr ARI)	0.049 (20 yr ARI)	0.02 (50 yr ARI)	0.01 (100 yr ARI)
5 minute	10.9	15.0	17.8	20.4	24.1	26.8
10 minute	17.8	24.3	28.7	32.7	38.0	42.2
15 minute	22.8	31.0	36.3	41.5	48.3	53.3
20 minute	26.4	36.0	42.3	48.3	56.3	62.3
25 minute	29.4	40.0	47.1	54.2	63.3	70.0
30 minute	31.8	43.5	51.5	59.0	69.0	76.5
45 minute	37.4	51.4	61.0	70.4	83.3	93.0
60 minute	41.5	57.3	68.3	79.3	94.1	106.0
90 minute	47.7	66.5	79.5	92.9	111.3	125.9
120 minute	52.6	73.4	88.4	103.6	124.8	141.8
180 minute	60.3	84.9	102.6	120.9	146.4	167.1

Table 3.5 Existing Case – *xpstorm* Adopted Initial and Continuing Losses

Impervious Area			Pervious Area			
IL (mm)	CL (mm/hr)	Manning's n	AEP	IL (mm)	CL (mm/hr)	Manning's n
0	0	0.014	0.393-0.049	15	2	0.040
			0.020-0.010	5	2	

Table 3.6 Existing Case – *xpstorm* Peak Discharge (m³/s)

Point of Discharge	Annual Exceedance Probability (AEP)					
	0.393 (2 yr ARI)	0.181 (5 yr ARI)	0.095 (10 yr ARI)	0.049 (20 yr ARI)	0.02 (50 yr ARI)	0.01 (100 yr ARI)
A (Ext)	0.004	0.005	0.006	0.007	0.008	0.008
B (Ext)	0.02	0.04	0.05	0.06	0.07	0.07
A	0.08	0.11	0.14	0.16	0.18	0.20
B	0.05	0.10	0.12	0.15	0.23	0.27
PD-A	0.08	0.11	0.14	0.16	0.18	0.20
PD-B	0.07	0.12	0.15	0.18	0.28	0.32

3.5 Existing Case – Model Validation (Rational Method)

The peak discharge from each catchment was calculated for 0.01 AEP using Rational Method and compared to those generated using *xpstorm* for validation purposes. The comparison is shown in Table 3.7 below and Rational calculations, which are in accordance with QUDM 2016 Section 4, are detailed within Appendix B.

Table 3.7 Existing Case – Peak Flow Validation *xpstorm* vs Rational

Catchment ID		<i>xpstorm</i> (m ³ /s)	Rational (m ³ /s)	Difference (%)
External	A (Ext)	0.008	0.007	7.4
	B (Ext)	0.07	0.06	16.4
Internal	A	0.20	0.21	-7.0
	B	0.27	0.23	13.5

The peak discharge calculated using Rational method is within 20% the value generated using *xpstorm* for the 1% AEP. The modelling is therefore considered to be appropriately validated.

4 Proposed Development

The development involves reconfiguring the existing site into a single lot and the construction of an aged care facility (Figure 4.1). The five-storey development will include 188 residential rooms and common, carparking and landscaping areas.

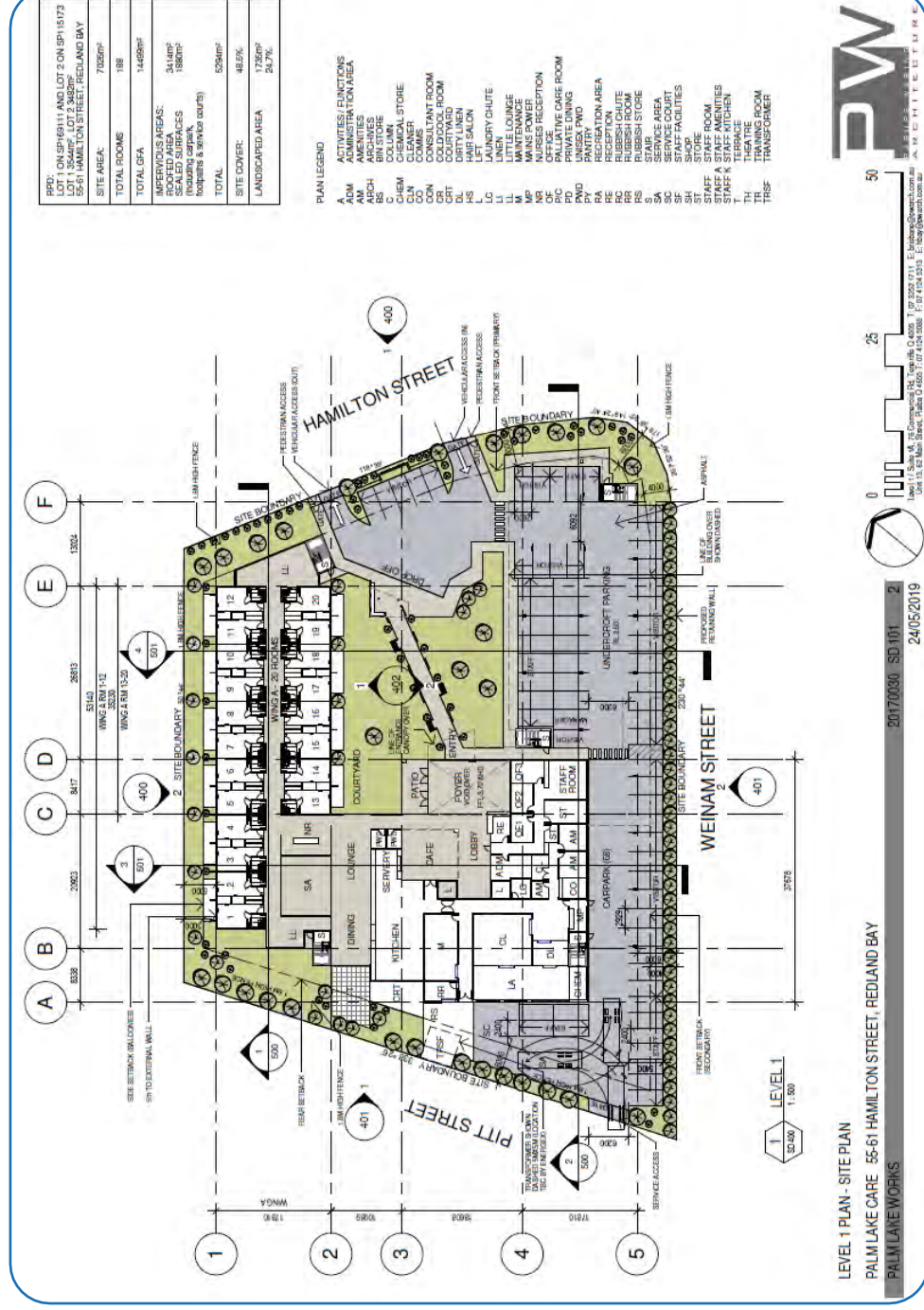


Figure 4.1 Proposed Development Layout

5 Developed Case – Hydrological Assessment

xpstorm was utilised to assess the site’s developed hydrology and generate hydrographs and peak discharge rates from each catchment and at each PD. The following sections detail the parameters used in the *xpstorm* modelling. Catchments have been delineated on Drawing DWG-201 – Appendix A.

5.1 Developed Case – External Catchments

In the developed case the external catchments will remain unchanged.

5.2 Developed Case – Internal Catchments

The site will undergo earthworks to profile the development area. This stormwater management plan relies on both surface runoff and underground piped drainage to collect minor and major stormwater flows.

Two (2) major post development catchments have been delineated based on the architectural designs by PW Architecture. These catchments have been further split into sub-catchments. The characteristic of the site’s catchments are detailed in Table 5.1 below and have been delineated on Drawing 201 – Appendix A.

Table 5.1 Developed Case – Catchment Characteristic

Catchment ID		Area (ha)	Cover (%)	Discharge Condition	PD ID
Internal	A1	0.19	100 – Residential Dev	Point & Sheet	PD-A
	A2	0.22	100 – Residential Dev	Point & Sheet	PD-A
	B1	0.19	100 – Residential Dev	Point & Sheet	PD-B
	B2	0.10	100 – Residential Dev	Point & Sheet	PD-B

5.3 Developed Case – *xpstorm* Runoff

The “Laurenson” routing method was applied to *xpstorm* for hydrological calculation and hydrograph generation. The contributing catchment was split into pervious (with 0% impervious fraction) and impervious (with 100% impervious fraction) areas. Adopted parameters for the Laurenson routing method include a Manning’s roughness coefficient (n) for impervious and pervious areas respectively. Infiltration uniform losses have been applied to the hydrologic model.

The tables below contain the modelling parameters relied upon and present the resulting peak discharges expected for each catchment. The flows reported at each PD represent the combined catchment inflows at this point.

Table 5.2 Developed Case – *xpstorm* Catchment Details

Catchment ID		Impervious Area		Pervious Area	
		Area (ha)	Slope (%)	Area (ha)	Slope (%)
Internal	A1	0.14	2.8	0.05	2.8
	A2	0.16	2.8	0.06	2.8
	B1	0.17	2.2	0.02	2.2
	B2	0.07	2.2	0.03	2.2

Table 5.3 Developed Case – Adopted Initial and Continuing Losses

Impervious Area			Pervious Area			
IL (mm)	CL (mm/hr)	Manning's n	AEP	IL (mm)	CL (mm/hr)	Manning's n
0	0	0.014	0.393-0.049	15	2	0.040
			0.020-0.010	5	2	

Table 5.4 Developed Case – *xpstorm* Peak Discharge (m³/s)

Catchment/Point of Discharge ID	Annual Exceedance Probability (AEP)					
	0.393 (2 yr ARI)	0.181 (5 yr ARI)	0.095 (10 yr ARI)	0.049 (20 yr ARI)	0.02 (50 yr ARI)	0.01 (100 yr ARI)
A (Ext)	0.004	0.005	0.006	0.007	0.008	0.008
B (Ext)	0.02	0.04	0.05	0.06	0.07	0.07
A1	0.07	0.10	0.12	0.14	0.15	0.17
A2	0.06	0.09	0.11	0.14	0.16	0.17
B1	0.07	0.10	0.11	0.13	0.14	0.16
B2	0.03	0.04	0.05	0.06	0.07	0.08
PD-A	0.12	0.18	0.22	0.27	0.29	0.32
PD-B	0.11	0.16	0.20	0.24	0.27	0.30

5.3.1 Validation of Flows

Table 5.5 illustrates that the peak discharges generated using both *xpstorm* and Rational Method compare well for the 1.0 % AEP as both hydrological methods are within 20% of each other for the 1% AEP. The modelling is therefore considered to be appropriately validated.

Table 5.5 Developed Case – Peak Flow Validation *xpstorm* vs Rational

Catchment ID	<i>xpstorm</i> (m ³ /s)	Rational (m ³ /s)	Difference (%)
A1	0.17	0.16	5.9
A2	0.17	0.19	-11.8
B1	0.16	0.16	0
B2	0.08	0.09	-12.5

5.3.2 Peak Discharge Comparison (m³/s) – Existing vs Developed (Unmitigated)

Table 5.6 presents a comparison of the peak discharges expected at each PD. Modelling results indicate increases in peak discharge are expected a PD-A. Decreases in peak discharge to PD-B are expected for the 0.02 and 0.01 AEP events due to catchment area reductions however for the lower events the peak discharge is expected to increase.

Table 5.6 Peak Discharge Comparison (m³/s)

PD	Scenario	Contributing Catchment Area (ha)	Annual Exceedance Probability (AEP)					
			0.393 (2 yr ARI)	0.181 (5 yr ARI)	0.095 (10 yr ARI)	0.049 (20 yr ARI)	0.02 (50 yr ARI)	0.01 (100 yr ARI)
PD-A	Existing	0.25	0.08	0.11	0.14	0.16	0.18	0.20
	Developed (Unmitigated)	0.41	0.12	0.18	0.22	0.27	0.29	0.32
	Difference		+0.04	+0.07	+0.08	+0.11	+0.11	+0.12
PD-B	Existing	0.45	0.07	0.12	0.15	0.18	0.28	0.32
	Developed (Unmitigated)	0.24	0.11	0.16	0.20	0.24	0.27	0.30
	Difference		+0.04	+0.04	+0.05	+0.06	-0.01	-0.02

6 Stormwater Management – Operational Phase

In order to ensure that the operational phase objectives outlined within Section 1.1 of this report can be achieved, a network of stormwater management measures are proposed for inclusion within the development.

To achieve these objectives, both external and internal flows will need to be adequately managed prior to discharge to the site's points of discharge.

6.1 Schematic Design Plan

With consideration given to the existing site characteristics, the proposed development configuration and the range of available stormwater management control measures, a set of conceptual stormwater management designs have been proposed and detailed within the drawing set contained within Appendix A.

6.1.1 External Drainage

Raised garden beds have been proposed within the southern boundary of the site to divert flows from the minor external catchments which contribute flows to the site. Flows from Ext (B) will be diverted west to the existing drainage channel adjacent to Pitt Street.

6.1.2 Internal Drainage

Storm flows from the development will be collected and conveyed to stormwater management measures via an internal pipe network. Four (4) stormwater treatment basins have been proposed for the management of stormwater. Basins A1, A2, B1 and B2 will be planter box type bioretention systems for the management of stormwater quality. It is noted that the outlets of Bioretention Basins B1 and B2 have been sized to mitigate the increases in flow for the minor events at PD-B.

6.2 Quantity Control – Detention

The proposed development will result in an increase in impervious and hardstand area and therefore an increase in peak discharge.

A dedicated underground detention tank has been proposed to detain stormwater flows so as to ensure that there is no increase in discharge to PD-A for all nominated AEP's. The underground detention tank is to be located towards the eastern site boundary, underneath the visitor/staff carparking area. This tank has been sized to detain minor and major flows from Catchment A1 via capturing minor and major outflows from Bioretention Basin A1.

Detention will be provided over the 300 mm extended detention depth of each bioretention basin within Sub-catchments B1 and B2 to mitigate minor flows at PD-B. Attenuation of major flows is not required due to catchment area reductions.

6.2.1 *xpstorm* Modelling Parameters

xpstorm has been relied upon to size the required detention measures and develop appropriate outlet configurations.

xpstorm requires a depth area relationship to be defined when modelling an onsite detention (OSD) system. As an underground detention tank has been proposed for stormwater quantity management, a constant area of 90 m² was applied to the storage node A1 within the model.

Table 6.1 provides a summary of the depth-area relationships applied to the *xpstorm* storage nodes included in the post-development (mitigated) scenario. The dimensions and proposed levels of the outlet structures used to mitigate the developed case peak discharge and achieve the required detention volumes are detailed in Table 6.2

Table 6.1 Modelled Depth Area Relationship

Detention ID	RL (m AHD)	Depth (m)	Surface Area (m ²)
Tank A1 (Primary Chamber)	2.1	0	90
	3.1	1	90
Tank A1 (Secondary Chamber)	2.1	0	1
	3.1	1	1
Bioretention B1	2.9	0	24
	3.3	0.4	24
Bioretention B2	2.9	0	15
	3.3	0.4	15

Table 6.2 Modelled Outlet Structures

Detention Basin ID		Orifice	Outlet Riser(s) & Pipe(s)	Weir
Detention Tank A1	Primary Chamber	1x150 mm @ RL 2.1 m AHD 1x150 mm @ RL 2.8 m AHD	-	1 x 2 m Wide internal weir to Secondary Chamber, crest @ RL 3.0 m AHD
	Secondary Chamber	-	1x 375 mm dia RCP US IL @ RL 2.1 m AHD	-
Bioretention Basin B1		-	1x600x600 with two (2) sides engaging, crest @ RL 2.9 1x 150 mm dia Pipe US IL @ RL 1.7 m AHD	1 x 12 m wide weir crest @ RL 3.15 m AHD
Bioretention Basin B2		-	1x600x600 with two (2) sides engaging, crest @ RL 2.9 1x 150 mm dia Pipe US IL @ RL 1.7 m AHD	1 x 2.5 m wide weir crest @ RL 3.2 m AHD

6.2.2 Modelling Results

The results of *xpstorm* modelling indicate that the inclusion of the underground detention tank along with the proposed catchment delineation will mitigate the expected increases in peak discharge at the nominated points of discharge location during all nominated ARI events.

Table 6.3 presents a comparison between the expected peak discharges during nominated ARI events for the pre- and post-development mitigated cases at the PDs. Figures 6.1 and 6.2 illustrates a comparison of the outlet hydrographs at PD-A where the majority of site flow will ultimately discharge and PD-B.

Table 6.3 Peak Discharge Comparison (m³/s)

PD	Scenario	Contributing Catchment Area (ha)	Annual Exceedance Probability (AEP)					
			0.393 (2 yr ARI)	0.181 (5 yr ARI)	0.095 (10 yr ARI)	0.049 (20 yr ARI)	0.02 (50 yr ARI)	0.01 (100 yr ARI)
PD-A	Existing	0.25	0.08	0.11	0.14	0.16	0.18	0.20
	Developed (Unmitigated)	0.41	0.12	0.18	0.22	0.26	0.29	0.33
	Developed (Mitigated)	0.41	0.07	0.11	0.13	0.16	0.18	0.20
	Difference (Pre-Development vs Developed(Mitigated))		-0.01	0.00	-0.01	0.00	0.00	0.00
PD-B	Existing	0.45	0.07	0.12	0.15	0.18	0.28	0.32
	Developed (Unmitigated)	0.24	0.11	0.16	0.20	0.24	0.27	0.30
	Developed (Mitigated)	0.24	0.06	0.08	0.09	0.11	0.13	0.16
	Difference (Pre-Development vs Developed(Mitigated))		-0.01	-0.04	-0.06	-0.07	-0.15	-0.16

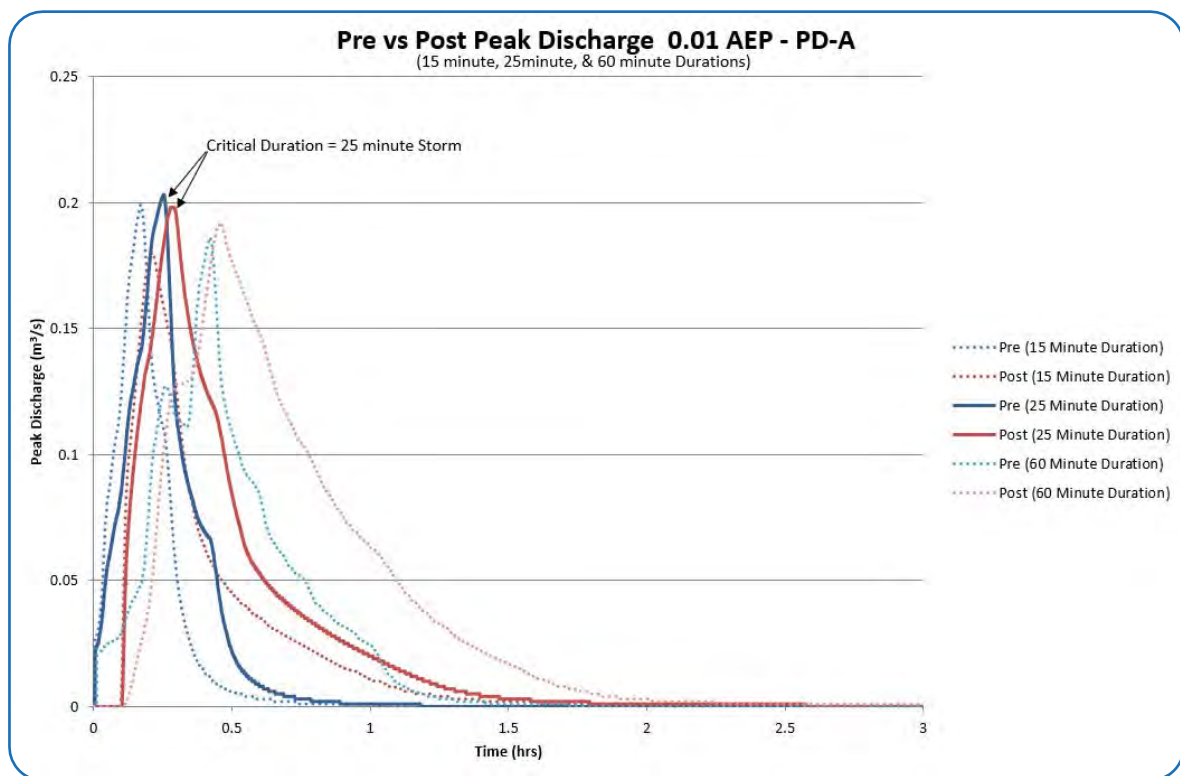


Figure 6.1 Comparison 100 year ARI Hydrography at PD-A

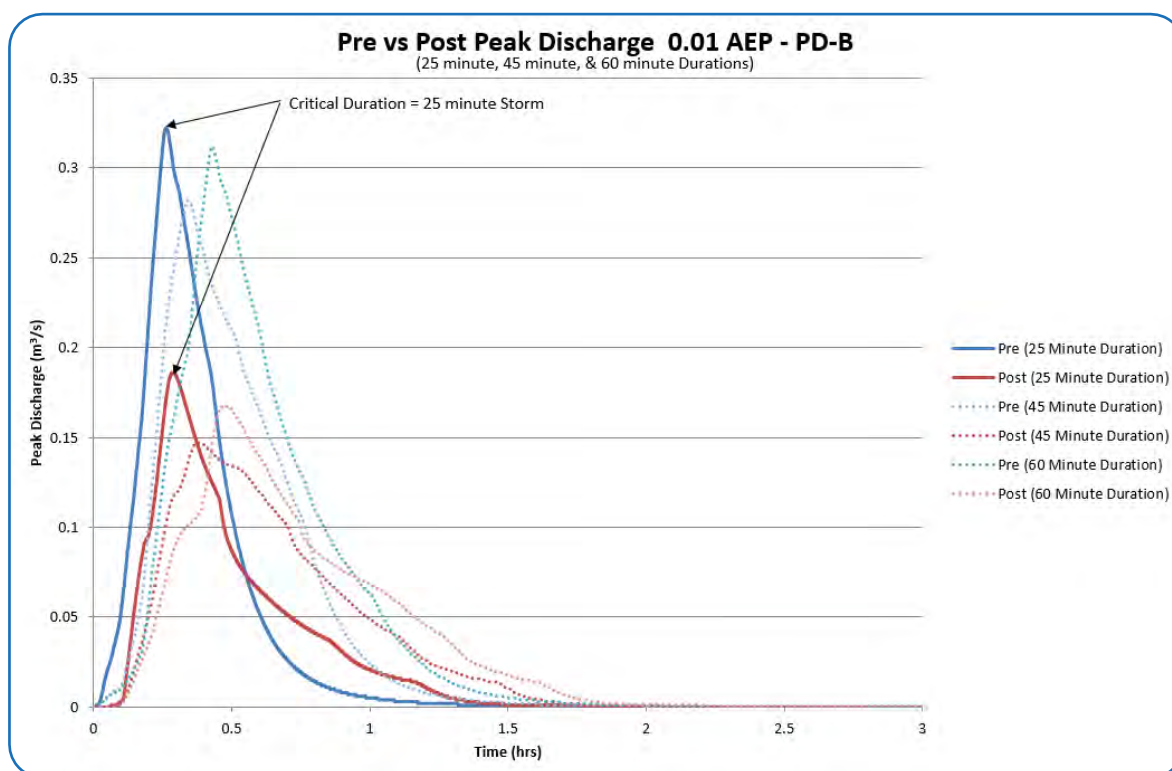


Figure 6.2 Comparison 100 year ARI Hydrography at PD-B

6.2.3 QUDM Minimum Design Safety Standards – Detention Depth

In accordance with the QUDM the depth of water in a detention basin is not to exceed 1.2 m during the 20 year ARI and is to be limited to less than 1.5 m for the 100 year ARI. A freeboard of 300 mm should also be achieved, along with a weir flow depth of no greater than 300 mm.

As Detention Tank A1 is proposed as an underground detention tank, assessment against the QUDM safety design standards is not necessary. Bioretention Basins B1 and B2, however, will be required to meet the above safety requirements.

Table 6.4 – 6.6 below present the peak water levels, depths and volumes expected within the detention tank and bioretention basins during both the 20 year ARI and 100 year ARI's. Based on the *xpstorm* modelling of the proposed post-development scenario, the proposed stormwater management measures will not result in water depths outside the recommended design criteria.

Table 6.4 Detention Storage Details, Depths and Volumes (Detention Tank A)

	0.049 (20 yr ARI)	0.01 (100 yr ARI)
Base Level (m AHD)	2.1	2.1
Top of Tank Level (m AHD)	3.1	3.1
Internal Weir Level (m AHD)	3.0	3.0
Peak Water Surface (m AHD)	2.86	3.02
Peak Depth of Water (m)	0.76	0.92
Peak Volume (m³)	64	83

Table 6.5 Detention Storage Details, Depths and Volumes (Bioretention Basin B1)

	0.049 (20 yr ARI)	0.01 (100 yr ARI)
Base Level (m AHD)	2.60	2.60
Top of Bund Level (m AHD)	3.50	3.50
Weir Level (m AHD)	3.15	3.15
Peak Water Surface (m AHD)	3.16	3.18
Peak Depth of Water (m)	0.56	0.58
Peak Volume (m ³)	6.2	6.7
Freeboard Achieved (m)	0.34	0.32
Weir Flow Depth (m)	0.01	0.03

Table 6.6 Detention Storage Details, Depths and Volumes (Bioretention Basin B2)

	0.049 (20 yr ARI)	0.01 (100 yr ARI)
Base Level (m AHD)	2.60	2.60
Top of Bund Level (m AHD)	3.50	3.50
Weir Level (m AHD)	3.20	3.20
Peak Water Surface (m AHD)	3.05	3.10
Peak Depth of Water (m)	0.45	0.50
Peak Volume (m ³)	2.3	3.0
Freeboard Achieved (m)	0.45	0.40
Weir Flow Depth (m)	0.00	0.00

6.2.4 Sensitivity Analysis

In accordance with the requirements of QUDM Section 5.9.3, consideration has been given to the consequences of a fully blocked outlet pipe.

A sensitivity test has not been undertaken for Detention Tank A1 and Bioretention Basin A1. The tank and basin have been designed such that if the outlet were to become fully blocked, stormwater would surcharge within the bioretention pit and flow overflow via the western bioretention edge and the tank access grate, and sheet flow down the driveway to Hamilton Street.

Table 6.7 illustrates the expected peak water levels within Bioretention Basins B1 and B2 if the proposed pipe outlets became fully blocked. In this event, water levels would increase in the basins with all flow discharging over the basin weirs to the Pitt Street channel.

Table 6.7 Sensitivity Analysis Results for 100 Year ARI Event

Basin	Peak Water Level (m AHD)	Top of Bund (m AHD)	Depth of Weir Flow (m)
B1	3.19	3.5	0.04
B2	3.27	3.5	0.07

Based on the proposed basin and weir configurations, peak water levels would not be expected to exceed the Top of Bund during the 100 year ARI. The expected maximum flow depths over the weirs have been modelled at less than 0.3 m.

6.3 Lawful Point of Discharge

The criteria for determining a Lawful Point of Discharge (LPD) as specified within the Queensland Urban Drainage Manual (2016) is as follows:

- (i) Will the proposed development alter the site's stormwater discharge characteristics in a manner that may substantially damage a third party property?
 - If not, then no further steps are required to obtain tenure for a lawful point of discharge (assuming any previous circumstances and changes were lawful).
 - If there is a reasonable risk of such damage then consider (ii) or (iii).
- (ii) Is the location of the discharge from the development site under the lawful control of the local government or other statutory authority from whom permission to discharge has been received? This will include a park, watercourse, drainage or road reserve, stormwater registered drainage easement, or land held by local government (including freehold land).
 - If so, then no further steps are required to obtain tenure for a lawful point of discharge
 - If not, then consider issue (iii). A land owner or regulator may require that the developer obtain an authority to discharge as described in (iii) in order for the stormwater to ultimately flow to a location described in (ii).
- (iii) An authority to discharge over affected properties will be necessary. In descending order of certainty, an authority may be in the form of:
 - Dedication of a drainage reserve or park;
 - A registered easement for stormwater discharge/works; or
 - Written approval.

Each point of discharge has been assessed against the above criteria and it is considered that a Lawful Point of Discharge will be achieved at each discharge location. Provided that the design measures set out in this report are implemented it is not anticipated that substantial damage will be caused to a third party property at any discharge point. Additionally, all discharges will be directed into land under the control of Council.

6.4 Quality Control – Pollutant Reduction

In accordance with the State Planning Policy for Healthy Waters and the Queensland Water Quality Guidelines (2009), treatment measures have been included to achieve the minimum mean annual load based reductions of 80% for Total Suspended Solids (TSS); 60% for Total Phosphorus (TP), 45% for Total Nitrogen (TN), and 90% for Gross Pollutants (GP).

The Model for Urban Stormwater Improvement Conceptualisation (*MUSIC* v6) has been used to estimate the potential pollutant loads generated by the development and to size the proposed treatment measures. The following sections outline the parameters relied upon within the *MUSIC* v6 modelling.

6.4.1 Rainfall and Evapotranspiration Data

Rainfall and evapotranspiration data have been obtained from the Bureau of Meteorology (BOM) and is included within Table 6.8 below.

Table 6.8 Meteorological and Rainfall Runoff Data Reporting

Station	Redlands HRS (40265)
Period	1/01/1997 to 31/12/2006 (10 years)
Time step	6 minute
Mean annual rainfall (mm)	1,088
Evapotranspiration	1,569

6.4.2 Developed Case – Catchment Parameters

The developed site has been modelled as having an urban residential land use. Each internal catchment has been split into roof, road and ground level source nodes. Table 6.9 summarises the sub-catchment areas and Drawing DWG-210 – Appendix A presents the sub-catchment delineation. The adopted pollutant export and runoff parameters for each sub catchment are based on data from the Water by Design *MUSIC* v6 Modelling Guidelines (2010), as summarised in Tables 6.10 and 6.11.

Table 6.9 MUSIC v6 Sub-Catchment Areas

Catchment ID	Land Use	Area (ha)	Total Impervious (%)
Catchment A1	Urban Residential – Roof	0.11	100
	Urban Residential – Road	0.01	100
	Urban Residential – Ground Level	0.07	50
Catchment A2	Urban Residential – Roof	0.10	100
	Urban Residential – Road	0.04	100
	Urban Residential – Ground Level	0.08	50
Catchment B1	Urban Residential – Roof	0.12	100
	Urban Residential – Road	0.05	100
	Urban Residential – Ground Level	0.02	50
Catchment B2	Urban Residential – Roof	0.06	100
	Urban Residential – Road	-	-
	Urban Residential – Ground Level	0.04	50
Total (ha)	-	0.70	

Table 6.10 Rainfall Runoff Parameters

Parameter	All Nodes
Landuse	Residential
Rainfall threshold (mm)	1
Soil storage capacity (mm)	500
Initial storage (% capacity)	10
Field capacity (mm)	200
Infiltration capacity coefficient a	211
Infiltration capacity exponent b	5.0
Initial depth (mm)	50
Daily recharge rate (%)	28
Daily baseflow rate (%)	27
Daily deep seepage rate (%)	0

Table 6.11 Pollutant Export Parameters (log mg/L)

Flow Type	Surface Type	TSS		TP		TN	
		Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
Base Flow	Roof	N/A	N/A	N/A	N/A	N/A	N/A
	Road	1.00	0.34	-0.97	0.31	0.20	0.20
	Ground	1.00	0.34	-0.97	0.31	0.20	0.20
Storm Flow	Roof	1.30	0.39	-0.89	0.31	0.26	0.23
	Road	2.43	0.39	-0.30	0.31	0.26	0.23
	Ground	2.18	0.39	-0.47	0.31	0.26	0.23

6.4.3 Treatment Measures

In order to determine the design requirements for the necessary stormwater treatment measures, key “Treatment Nodes” were added to the *MUSIC* v6 model. The following sections outline the modelling parameters relied upon for each “Treatment Node”.

Bioretention

It is proposed that bioretention measures be incorporated into the development layout to provide the necessary load based reductions. Bioretention systems operate by capturing and retaining water in an extended ponding area (for a maximum of four (4) days to prevent anaerobic conditions, plant death and insect breeding), before filtering through a soil media. The devices remove pollutants via the following physical processes:

- Sedimentation in the extended detention storage;
- Filtration by filter media;
- Nutrient uptake by biofilms;
- Nutrient adsorption and pollutant decomposition by soil bacteria; and
- Adsorption of metals and nutrients by filter particles (Somes & Crosby, 2007).

In accordance with Water by Design Guidelines, Table 6.12 summarises the treatment node parameters used in the *MUSIC* v6 modelling whilst Figure 6.3 provides typical design parameters for the proposed bioretention devices.

Table 6.12 Bioretention Parameters

Bioretention Parameter	Bioretention A1	Bioretention A2	Bioretention B1	Bioretention B2
Surface area (m ²)	23	28	24	15
Extended detention depth (m)	0.3	0.3	0.3	0.3
Filter area (m ²)	23	28	24	15
Unlined filter media perimeter (m)	0.01	0.01	0.01	0.01
Saturated hydraulic conductivity (mm/hr)	200	200	200	200
Filter depth (m)	0.5	0.5	0.5	0.5
TN content of filter media (mg/kg)	400*	400*	400*	400*
Proportion of organic material in filter (%)	< 5	< 5	< 5	< 5
Orthophosphate content of filter media (mg/kg)	30*	30*	30*	30*
Is the base lined?	Yes	Yes	Yes	Yes
Effectiveness of plant TN removal	Effective	Effective	Effective	Effective
Overflow weir width (m)	Surface Area/10	Surface Area/10	Surface Area/10	Surface Area/10
Exfiltration rate (mm/hr)	0.00	0.00	0.00	0.00
Underdrain present?	Yes	Yes	Yes	Yes
Submerged zone with carbon present?	No	No	No	No
Confirmation that K and C* remain default?	Yes	Yes	Yes	Yes

*As per Healthy Land and Water Recommendations for MUSICv6 modelling

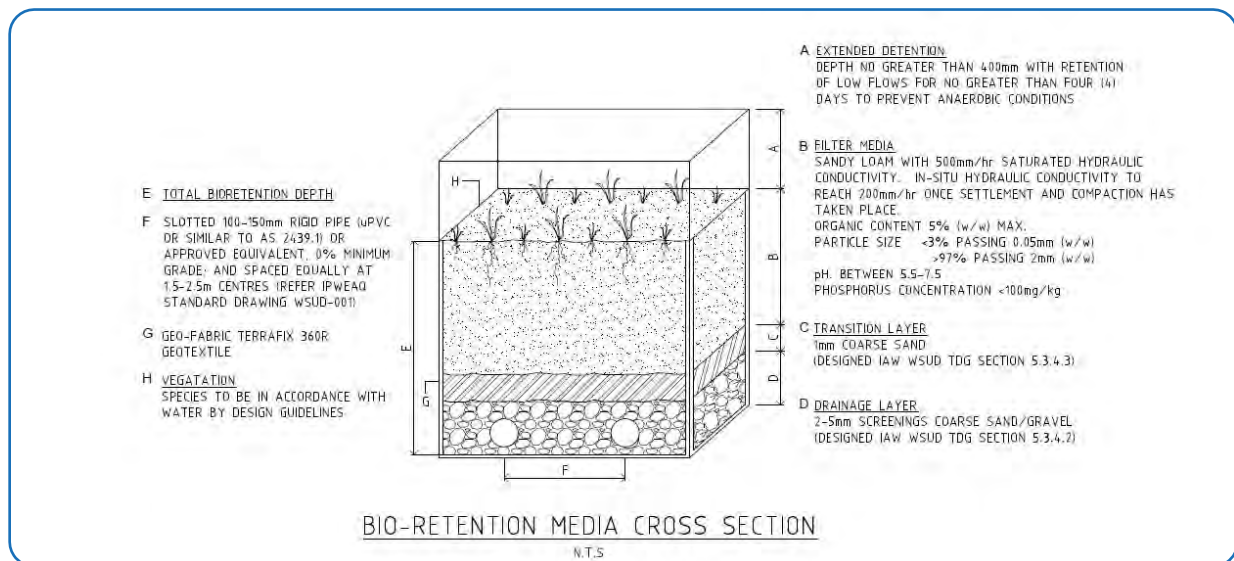


Figure 6.3 Bioretention specifications

6.4.4 Acid Sulfate Soils

The subject site is located within the acid sulfate soils overlay, with much of the site at an elevation of less than 5 m AHD. A desktop interrogation of ASRIS (Australian Soil Resource Information System) indicates that there is a low likelihood that there is a low probability of acid sulfate soils being present on site, however, there is also low confidence in this assessment.

It is therefore recommended that geotechnical testing be undertaken onsite for the presence of acid sulfate soils. If it is determined that acid sulfate soils are present, a Type 2 sealed bioretention basin should be utilised onsite (instead of the Type 3 conventional). The system

would therefore be contained within a unit that would not allow interaction with the adjacent soil environment.

6.4.5 Bioretention Basin Staged Construction and Establishment

In accordance with the Water by Design Construction and Establishment Guidelines: Swales Bioretention Systems and Wetlands (C & E Guidelines), inflow of sediment-laden runoff during the building stage is a major risk to the successful and long-term functioning of bioretention systems.

During the building phase of developments, sediment can seal the surface of the filter media, move into and clog the filter media and accumulate in the under-drainage. Within the C & E Guidelines, there are four (4) options recommended to overcome the challenges associated with delivering bioretention systems. These generally include the following options:

- Option 1: Surface Protection
- Option 2: Bypass flows and early establishment of vegetation;
- Option 3: Sediment basin and bioretention function; and
- Option 4: Leave as sediment basin.

It is recommended that Option 1 method for staged construction and establishment of the bioretention system be implemented for the proposed development. This method will generally include the following:

- Construction of the civil infrastructure, including under-drainage and media, for the bioretention system;
- Installation of a protective layer on the surface of the filter media, allowing it to operate as a shallow sediment basin during the building phase. It is recommended that filter cloth (geofab), topsoil and turf be installed for surface protection; and
- When 80-90% of building in the catchment is complete, remove the protective layers and establish vegetation in the bioretention system.

For details of the procedure and order of construction for Option 1 method please refer to Section 3.9 (Steps 1-40) of the C & E Guidelines.

6.4.6 Modelling Results

Results of the *MUSIC v6* modelling are summarised in Table 6.13 and screen captures shown in Figures 6.4 – 6.6. The modelling achieved the required 80%, 60%, 45% and 90% reduction targets for TSS, TP, TN and GP respectively for the rainfall data set simulated.

Table 6.13 Treatment Train Effectiveness

PD ID	Pollutant	Inflows (kg/yr)	Outflows (kg/yr)	Reduction (kg/yr)	Reduction (%)	Water Quality Objective (%)
PD-A	TSS	450	87.2	363	80.6	80
	TP	1.04	0.30	0.74	71.2	60
	TN	7.44	3.68	3.76	50.5	45
PD-B	TSS	327	63.0	264	80.7	80
	TP	0.78	0.22	0.56	72.0	60
	TN	5.5	2.7	2.8	50.9	45
Site (Total)	TSS	777	150	627	80.7	80
	TP	1.82	0.52	1.30	71.5	60

	TN	12.9	6.39	6.51	50.7	45
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NOTE: All simulations have been run with pollutant export estimation set to "stochastic generation".

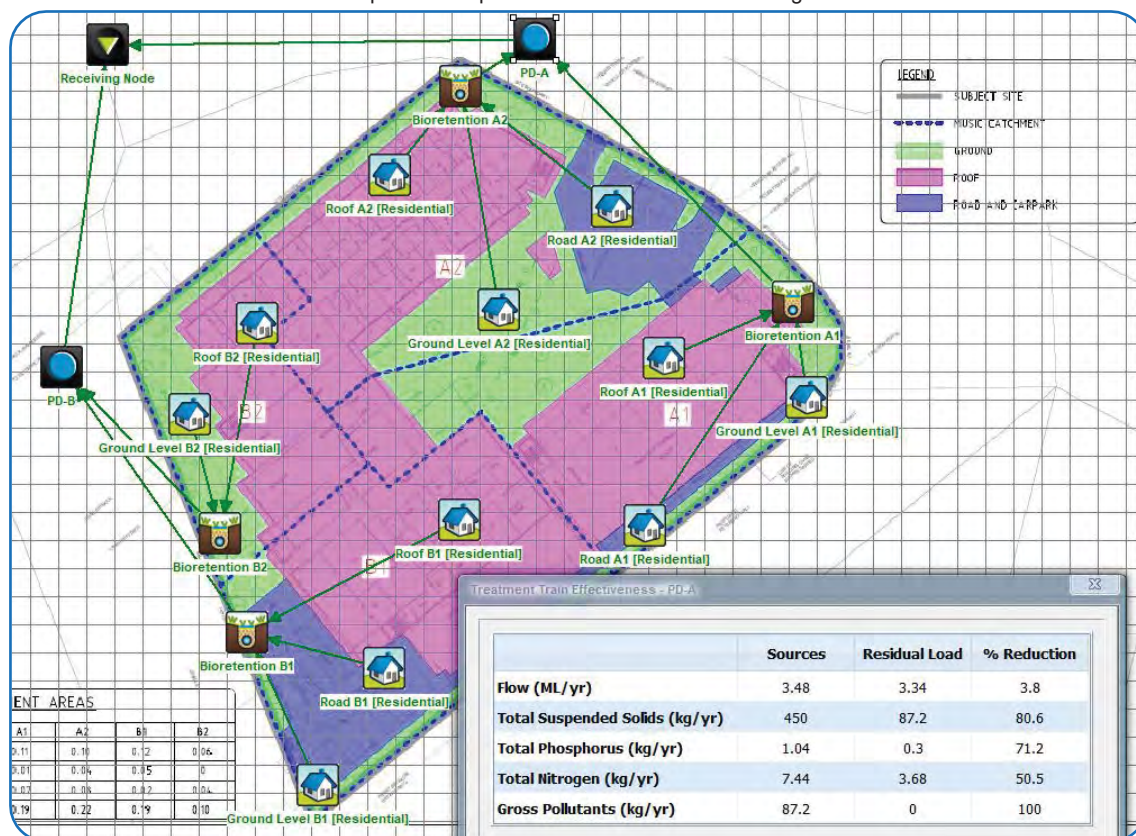


Figure 6.4 Screen Capture of MUSIC Modelling Results (PD-A)



Figure 6.5 Screen Capture of MUSIC Modelling Results (PD-B)



Figure 6.6 Screen Capture of MUSIC Modelling Results (Whole of Site)

6.5 Water Quality Monitoring and Maintenance

In order to ensure that the stormwater management measures detailed within this management plan function correctly in the long term and to ensure that impacts to downstream receiving environments are mitigated, appropriate operational phase water maintenance and monitoring is to be undertaken. The following sections detail the minimum requirements for each specific control device.

6.5.1 Operational Phase Water Quality Monitoring

Monitoring during the operational phase will be undertaken to determine the impact of activities on the receiving waters. Surface water quality monitoring is to be undertaken at discharge points from the site. Samples should be collected for TSS, pH, dissolved oxygen (DO), TP, TN and hydrocarbons. Sampling is to be performed in accordance with procedures set out in the Environmental Protection Authority's Water Quality Sampling Manual. A NATA registered laboratory is to be used to analyse the collected samples.

Table 6.14 specifies the sampling parameters and frequencies required. Table 6.15 sets the water quality criteria for water discharged from the development site. Results of the monitoring program are to be compiled monthly into an ongoing Water Quality Monitoring Report. A copy of the report and monitoring data is to be maintained at all times.

Table 6.14 Operational Phase Water Quality Parameters and Sampling Frequencies

Sampling Parameter	Sampling Frequency
TSS	Water quality monitoring will be completed following a rainfall event of 25 mm or greater in any 24 hour period monthly for a minimum period of 12 months, or as specified by the Local Authority conditions of approval for the development.
pH	
Dissolved Oxygen (DO)	
TN	
TP	
Hydrocarbons	

Table 6.15 Operational Phase Water Quality Discharge Criteria

Water Quality Parameter	Discharge Criteria
TSS	No net deterioration of the downstream receiving environment as a result of discharge from the development.
Turbidity (NTU)	
pH	
DO	
TN	
TP	
Hydrocarbons	

6.5.2 Operational Phase Device Maintenance

In order for each of the proposed stormwater treatment devices to achieve the necessary pollutant removal efficiencies regular maintenance is necessary. Poorly maintained devices will result in under performance and in some instances may cause leaching of pollutants to downstream receiving environments. Based on the proposed treatment train Table 6.16 details appropriate maintenance regimes for each treatment device.

Table 6.16 Operational Phase Device Maintenance Requirements

Treatment Device	Maintenance Action
Bioretention	Routine inspection to identify obvious increased sediment deposition. Remove sediment when flow within the bioretention is impeded or smothering of vegetation occurs.
	Routine inspection of inlet and outlet pit to identify any areas of scour, litter build up or blockages.
	Tilling of the bioretention surface if there is evidence of clogging.
	Regular watering of vegetation until plants are established.
	Removal and management of invasive weeds.
	Removal and replacement of dead and dying vegetation.
	Regular inspection and removal of litter and gross pollutants.
	Resetting (i.e. complete reconstruction) of the bioretention will be required if the flow within the bioretention system is reduced by 25% due to an accumulation of sediment.

All material removed during maintenance, whether solid or liquid, is to be disposed of in a manner that does not cause ongoing soil erosion or environmental harm.

7 Conclusions

The report has been prepared on behalf of Palm Lake Works and presents a comprehensive review of available Stormwater Quality Improvement Devices (SQID) and stormwater Best Management Practices (BMP) to ensure that the proposed development adequately addresses the management of stormwater quantity and quality during the operational phase of the development.

In order to achieve the required quantity and quality operational phase objectives, a single detention tank and four (4) stormwater quality treatment basins (bioretention) are proposed.

The bioretention system filter areas have been optimised for the treatment of the site's internal catchments such that the required stormwater treatment objectives can be achieved. The proposed design includes bioretention basins with filter areas of 23 m², 28 m², 24 m² and 15 m² within Catchments A1, A2, B1 and B2, respectively. It has been demonstrated utilising *MUSIC* Version 6 that this design can achieve pollutant removal efficiencies of 80%, 60%, 45% and 90% for TSS, TP, TN and gross pollutants respectively.

In order to address the management of stormwater quantity, a dedicated detention tank with an estimated detention volume of 83 m³ has been provided underneath the visitor/staff carparking area of Catchment A1. Modelling of this detention tank and its associated outlet structures indicate that pre-developed flows can be maintained for all nominated ARI events at PD-A.

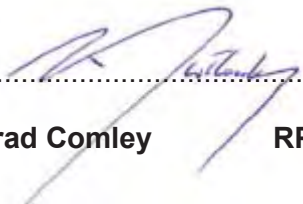
Catchment reductions in the post-development case have resulted in subsequent reductions in peak discharge at PD-B for the modelled 50 and 100 year ARI events. The outlets of Bioretention Basins B1 and B2 have been configured to mitigate the increases in flow predicted during lower events at PD-B.

8 RPEQ Certification

I am aware that Council may rely upon the contents and findings of this assessment for the purposes of development assessment. In my opinion, the Council can rely upon the information contained within the report and there are no reservations or qualifications in respect to the information other than set out in the report.

I confirm that if the design parameters set out in this report are included within the development:

- there should be no worsening in peak discharge, as a result of the proposed development that would result in actionable damage to downstream properties; and
- stormwater pollutant load reductions in accordance with best practice should be achieved.

	<i>07.06.19</i>
.....	
Brad Comley	RPEQ 17706
	DATE

9 References

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Appendix A

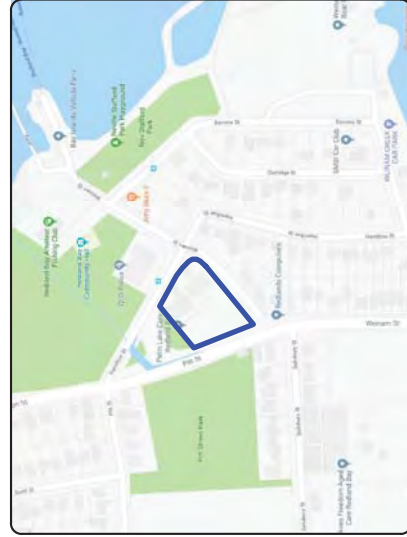
Stormwater Management Design Drawings

CONCEPTUAL STORMWATER MANAGEMENT DESIGN DRAWINGS

Proposed Aged Care Development
55-61 Hamilton & 17-19 Weinam Street

for
Palm Lake Works

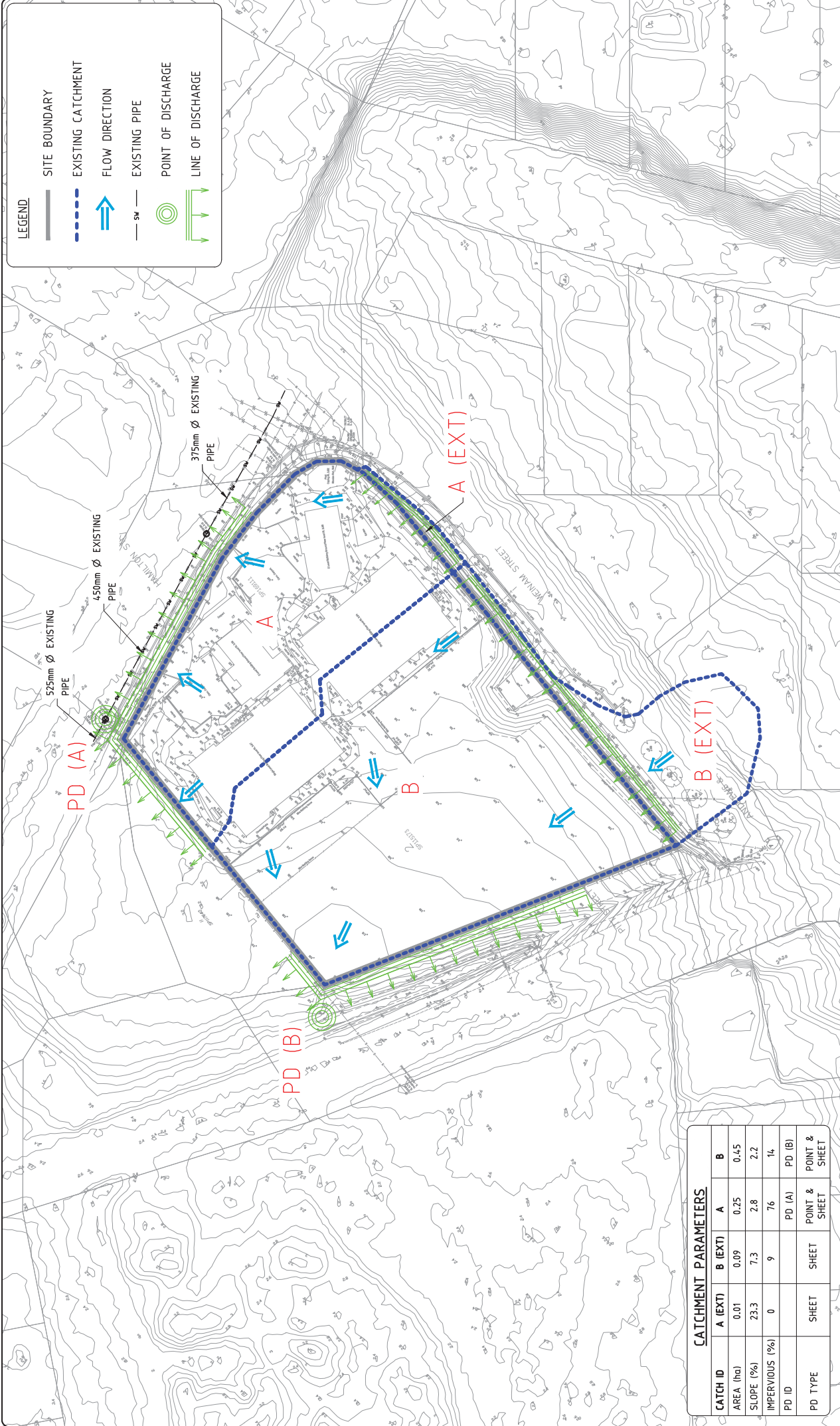
Project No: BC-18058
June 2019



Site Location

BIOME Consulting Pty Ltd
Unit 30201, Southport Central Tower 3,
9 Lawson St, Southport QLD 4215
PO Box 3469, Australia Fair, Southport
O 07 5532 7779
M 0415 935 222
E brad@BIOMEconsulting.com.au
W www.BIOMEconsulting.com.au
ABN 86 166 087 476

SCHEDULE OF DRAWINGS	
Drawing No.	Drawing Title
DWG-100	LOCALITY AND DRAWING INDEX PLAN
DWG-200	EXISTING CATCHMENT PLAN
DWG-201	DEVELOPED CATCHMENT PLAN
DWG-210	MUSIC CATCHMENT PLAN
DWG-300	OPERATIONAL CONTROL PLAN
DWG-310	DETENTION TANK A1 & BIORETENTION BASIN A1 LAYOUT
DWG-311	BIORETENTION BASIN A2 LAYOUT
DWG-312	BIORETENTION BASIN B1 LAYOUT
DWG-313	BIORETENTION BASIN B2 LAYOUT
DWG-320	DETENTION TANK A1 & BIORETENTION BASIN A1 - SECTIONS
DWG-321	BIORETENTION BASIN A2 - SECTION
DWG-322	BIORETENTION BASIN B1 - SECTION
DWG-323	BIORETENTION BASIN B2 - SECTION
DWG-330	BIORETENTION BASIN - FILTER MEDIUM & UNDERDRAINAGE DETAILS
DWG-350	BIORETENTION STANDARD NOTE



- LEGEND**
- SITE BOUNDARY
 - EXISTING CATCHMENT
 - FLOW DIRECTION
 - EXISTING PIPE
 - POINT OF DISCHARGE
 - LINE OF DISCHARGE

CATCHMENT PARAMETERS						
CATCH ID	A (EXT)	B (EXT)	A	B		
AREA (ha)	0.01	0.09	0.25	0.45		
SLOPE (%)	23.3	7.3	2.8	2.2		
IMPERVIOUS (%)	0	9	76	14		
PD ID			PD (A)	PD (B)		
PD TYPE	SHEET	SHEET	POINT & SHEET	POINT & SHEET		

DATE
07.06.19

PROJECT No. :
BC-18058

DRAWING No. :
DWG-200

REVISION No. :
A

PROJECT
PROPOSED AGED CARE DEVELOPMENT

DRAWING TITLE
EXISTING CATCHMENT PLAN

CLENT
PALM LAKE WORKS

ADDRESS
55-61 HAMILTON & 17-19 WEINAM STREET
REDLAND BAY

DRAFTED BY :
TP / KP

DESIGNED BY :
AK

CHECKED BY :
BC

PAPER SIZE :
A3

SCALE :
1:750

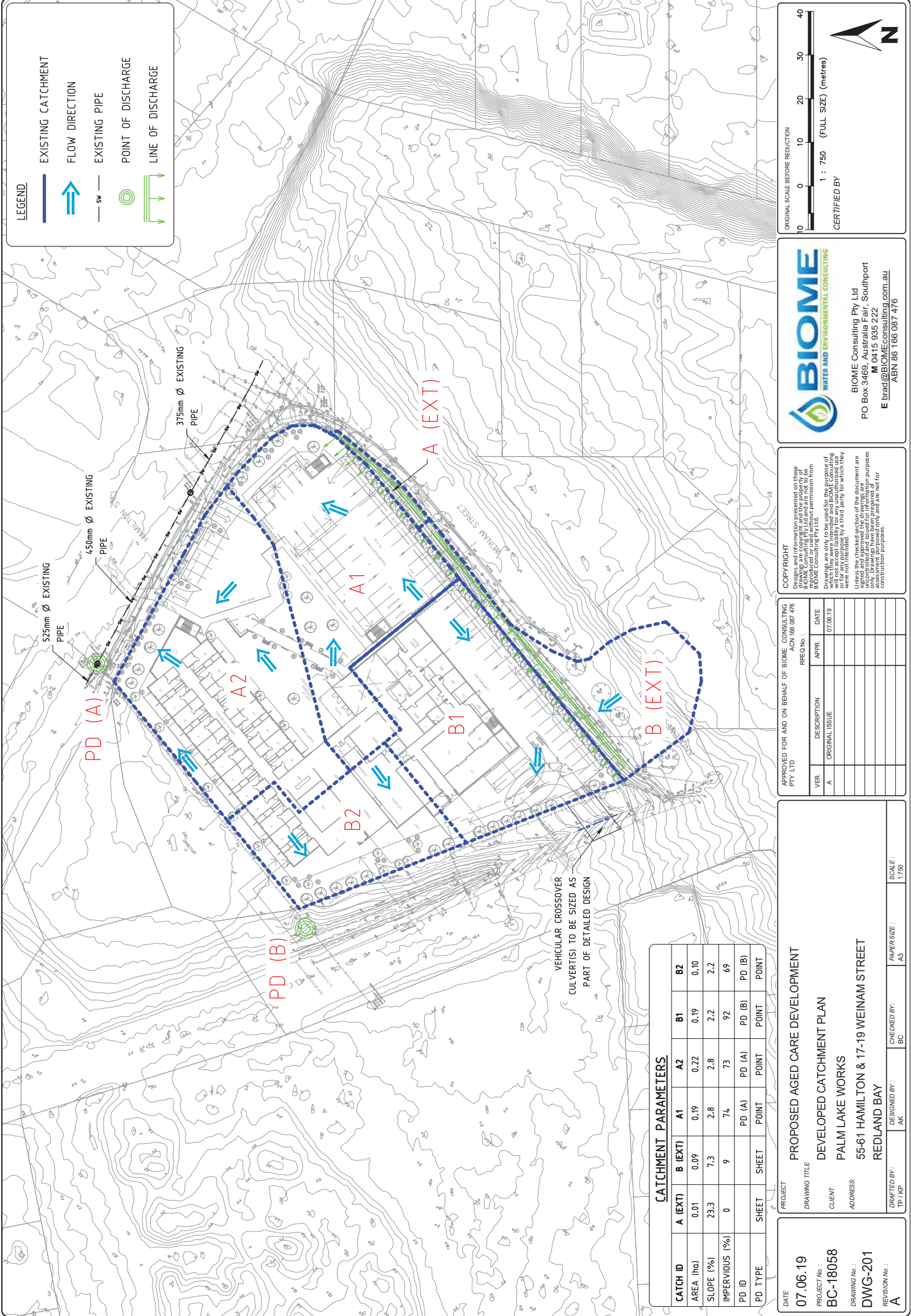
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WATER AND ENVIRONMENTAL CONSULTING

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M 04 15 935 222
E brad@biomeconsulting.com.au
ABN 86 166 087 476

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ACN 166 087 476
REG No. :
VER. :
A
DESCRIPTION :
ORIGINAL ISSUE
DATE :
07.06.19
APPR. :
DATE :
07.06.19

ORIGINAL SCALE BEFORE REDUCTION
10 0 10 20 30 40
1 : 750 (FULL SIZE) (metres)
CERTIFIED BY



LEGEND

- EXISTING CATCHMENT
- FLOW DIRECTION
- EXISTING PIPE
- POINT OF DISCHARGE
- LINE OF DISCHARGE

CATCHMENT PARAMETERS											
CATCH ID	A (EXT)	B (EXT)	A1	A2	B1	B2					
AREA (ha)	0.01	0.09	0.19	0.22	0.19	0.10					
SLOPE (%)	23.3	7.3	2.8	2.8	2.2	2.2					
IMPERVIOUS (%)	0	9	74	73	92	69					
PD ID			PD (A)	PD (A)	PD (B)	PD (B)					
PD TYPE	SHEET	SHEET	POINT	POINT	POINT	POINT					

DATE
07.06.19

PROJECT No.:
BC-18058

DRAWING No.:
DWG-201

REVISION No.:
A

DRAFTED BY:
TP / KP

DESIGNED BY:
AK

CHECKED BY:
BC

PAPER SIZE:
A3

SCALE:
1:750

PROJECT
PROPOSED AGED CARE DEVELOPMENT

DRAWING TITLE
DEVELOPED CATCHMENT PLAN

CLIENT
PALM LAKE WORKS

ADDRESS
55-61 HAMILTON & 17-19 WEINAM STREET
REDLAND BAY

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ACN 166 087 476
REQ No.:
A

VER.	DESCRIPTION	APPR.	DATE
A	ORIGINAL ISSUE		07.06.19

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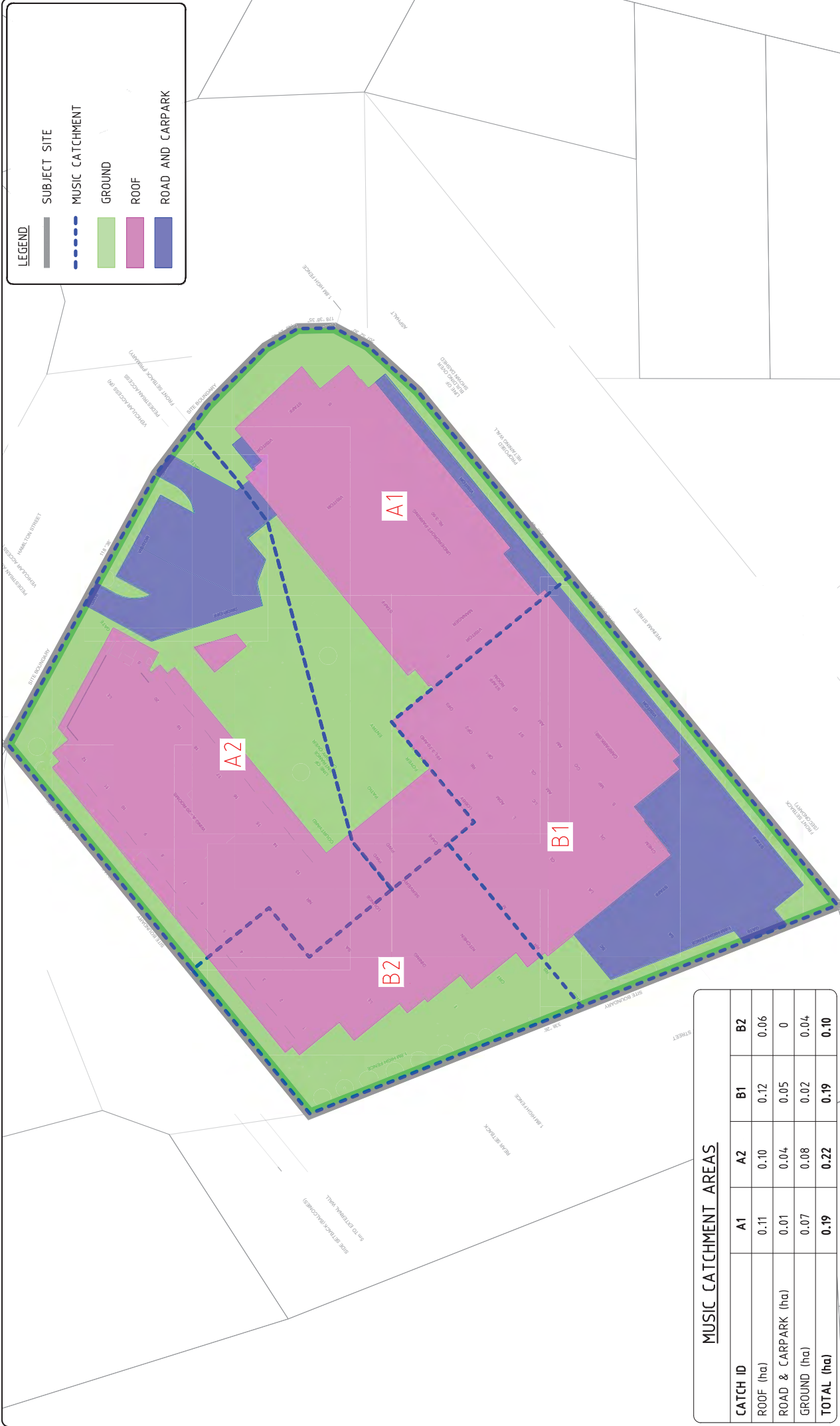
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10 0 10 20 30 40
1 : 750 (FULL SIZE) (metres)

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MUSIC CATCHMENT AREAS					
CATCH ID	A1	A2	B1	B2	
ROOF (ha)	0.11	0.10	0.12	0.06	
ROAD & CARPARK (ha)	0.01	0.04	0.05	0	
GROUND (ha)	0.07	0.08	0.02	0.04	
TOTAL (ha)	0.19	0.22	0.19	0.10	

DATE
07.06.19

PROJECT No. :
BC-18058

DRAWING No. :
DWG-210

REVISION No. :
A

PROJECT TITLE
MUSIC CATCHMENT PLAN

CLIENT
PALM LAKE WORKS

ADDRESS
55-61 HAMILTON & 17-19 WEINAM STREET
REDLAND BAY

DRAFTED BY :
TP / KP

DESIGNED BY :
AK

CHECKED BY :
BC

PAPER SIZE :
A3

SCALE :
1:500

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A	ORIGINAL ISSUE		07.06.19

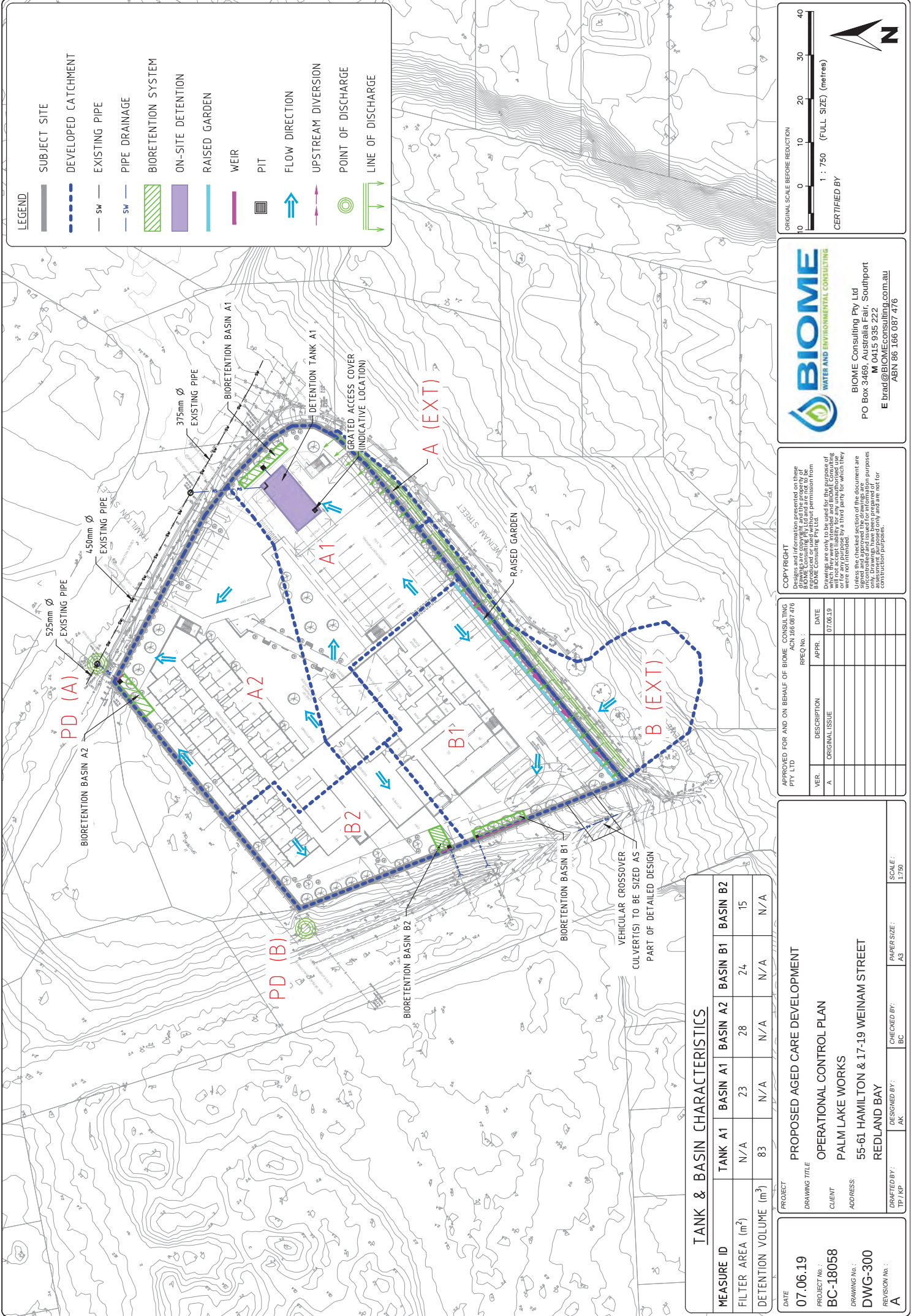
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ORIGINAL SCALE BEFORE REDUCTION
5 0 5 10 15 20 25
1 : 500 (FULL SIZE) (metres)
CERTIFIED BY



LEGEND

- SUBJECT SITE
- DEVELOPED CATCHMENT
- EXISTING PIPE
- PIPE DRAINAGE
- BIORETENTION SYSTEM
- ON-SITE DETENTION
- RAISED GARDEN
- WEIR
- PIT
- FLOW DIRECTION
- UPSTREAM DIVERSION
- POINT OF DISCHARGE
- LINE OF DISCHARGE

ORIGINAL SCALE BEFORE REDUCTION

10 0 10 20 30 40

1 : 750 (FULL SIZE)

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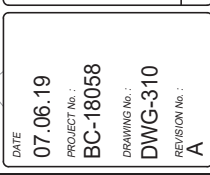
VER.	DESCRIPTION	APPR.	DATE
A	ORIGINAL ISSUE		07.06.19

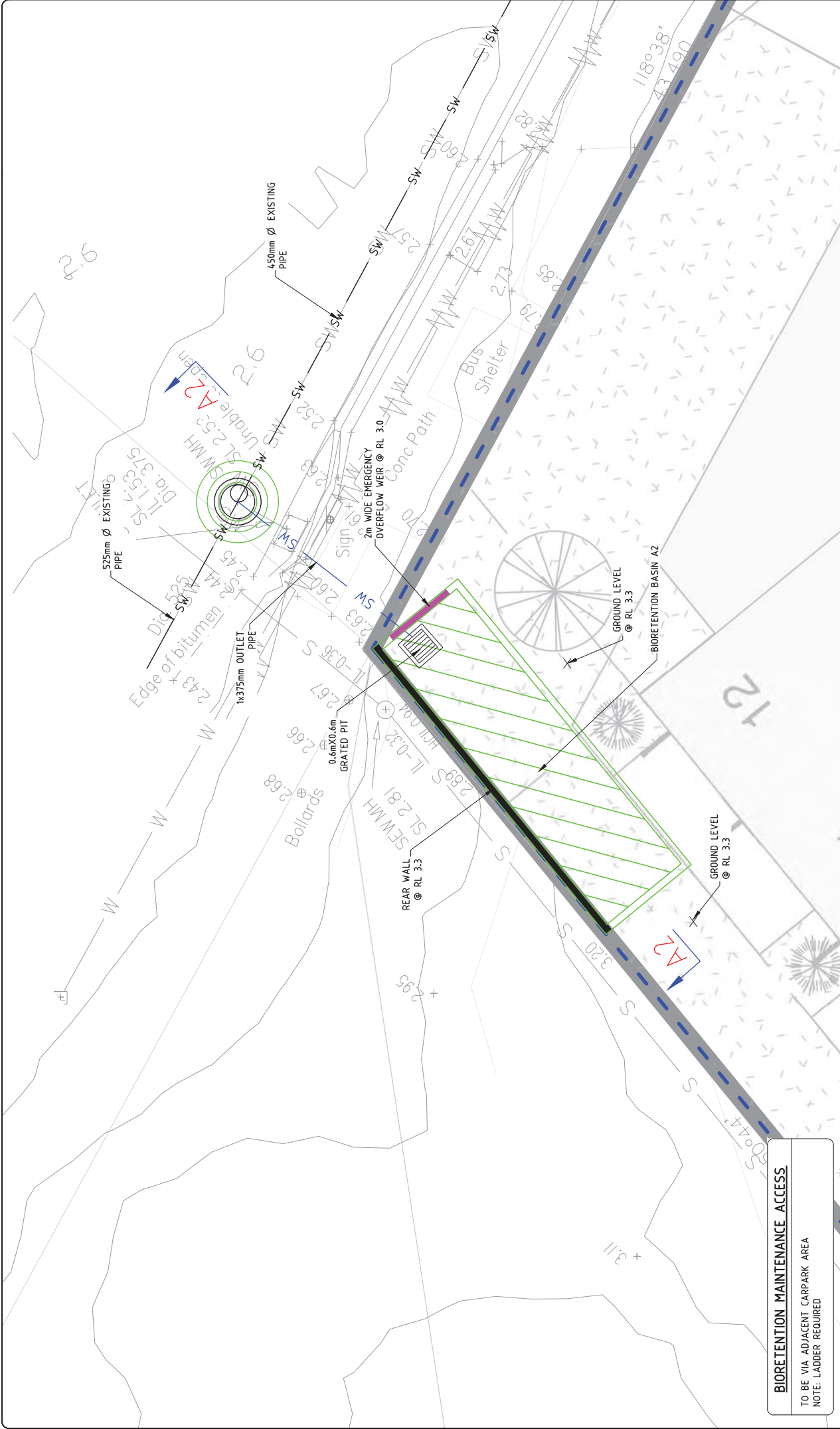
PROJECT			
PROPOSED AGED CARE DEVELOPMENT			
DRAWING TITLE			
OPERATIONAL CONTROL PLAN			
CLIENT			
PALM LAKE WORKS			
ADDRESS			
55-61 HAMILTON & 17-19 WEINAM STREET			
REDLAND BAY			
DRAFTED BY:	DESIGNED BY:	CHECKED BY:	PAPER SIZE:
TP / KP	AK	BC	A3
			SCALE:
			1:750

DATE	07.06.19
PROJECT No. :	BC-18058
DRAWING No. :	DWG-300
REVISION No. :	A

TANK & BASIN CHARACTERISTICS					
MEASURE ID	TANK A1	BASIN A1	BASIN A2	BASIN B1	BASIN B2
FILTER AREA (m ²)	N/A	23	28	24	15
DETENTION VOLUME (m ³)	83	N/A	N/A	N/A	N/A

VEHICULAR CROSSOVER
CULVERT(S) TO BE SIZED AS
PART OF DETAILED DESIGN





BIORETENTION MAINTENANCE ACCESS

TO BE VIA ADJACENT CARPARK AREA
NOTE: LADDER REQUIRED

DATE
07.06.19

PROJECT No. :
BC-18058

DRAWING No. :
DWG-311

REVISION No. :
A

PROJECT
PROPOSED AGED CARE DEVELOPMENT

DRAWING TITLE
BIORETENTION BASIN A2 LAYOUT

CLIENT
PALM LAKE WORKS

ADDRESS
55-61 HAMILTON & 17-19 WEINAM STREET
REDLAND BAY

DRAFTED BY :
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DESIGNED BY :
AK

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PAPER SIZE :
A3

SCALE :
1:100

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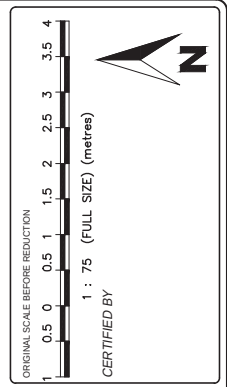
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PO Box 3469, Australia Fair, Southport
QLD 4215 935 222
E brad@biomeconsulting.com.au
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ORIGINAL SCALE BEFORE REDUCTION
1 0 1 2 3 4 5
1 : 100 (FULL SIZE) (metres)
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118°38' 43'490"



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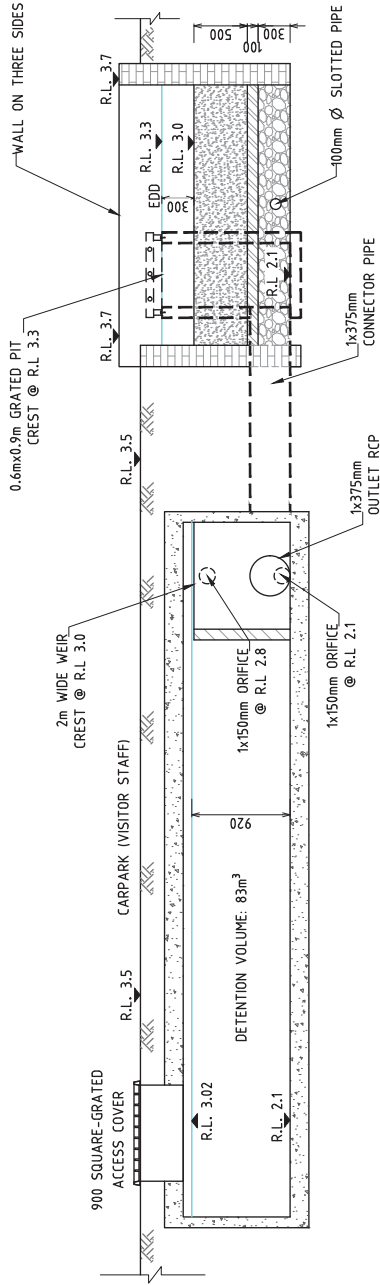
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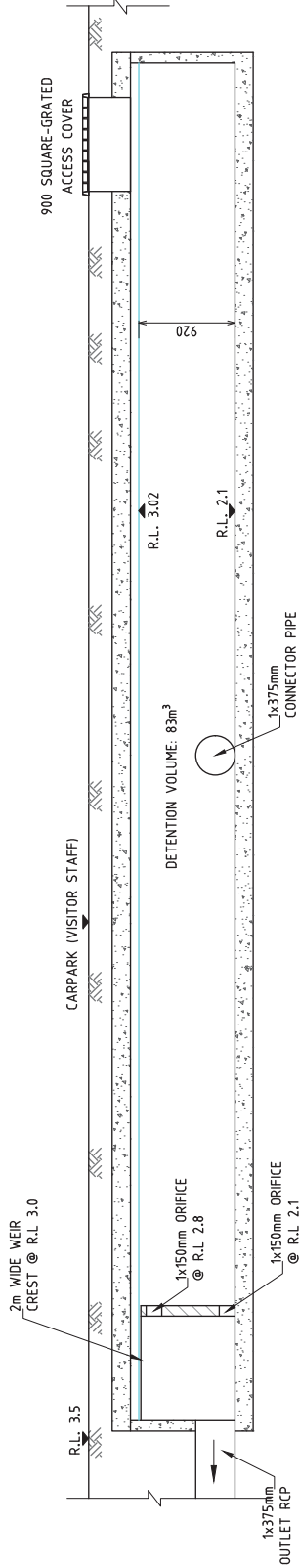
PROJECT	PROPOSED AGED CARE DEVELOPMENT		
DRAWING TITLE	BIORETENTION BASIN B2 LAYOUT		
CLIENT	PALM LAKE WORKS		
ADDRESS	55-61 HAMILTON & 17-19 WEINAM STREET REDLAND BAY		
DRAWN BY : TP / KP	DESIGNED BY : AK	CHECKED BY : BC	PAPER SIZE : A3
			SCALE : 1:1

DATE
07.06.19
PROJECT No. :
BC-18058
DRAWING No. :
DWG-313
REVISION No. :
A

NOT FOR CONSTRUCTION
I.B.C as part of detailed design



TANK & BASIN A1 SECTION A1a-A1a



TANK A1 SECTION A1b-A1b



DATE
07.06.19
PROJECT No :
BC-18058
DRAWING No :
DWG-320
REVISION No :
A

PROJECT
PROPOSED AGED CARE DEVELOPMENT
DRAWING TITLE
DETENTION TANK A1 & BIORETENTION BASIN A1 - SECTIONS
CLIENT
PALM LAKE WORKS
ADDRESS
55-61 HAMILTON & 17-19 WEINAM STREET
REDLAND BAY
DRAFTED BY :
TP / KP
DESIGNED BY :
AK
CHECKED BY :
BC
PAPER SIZE :
A3
SCALE :
1:50

VER.	DESCRIPTION	APPR.	DATE
A	ORIGINAL ISSUE		07.06.19

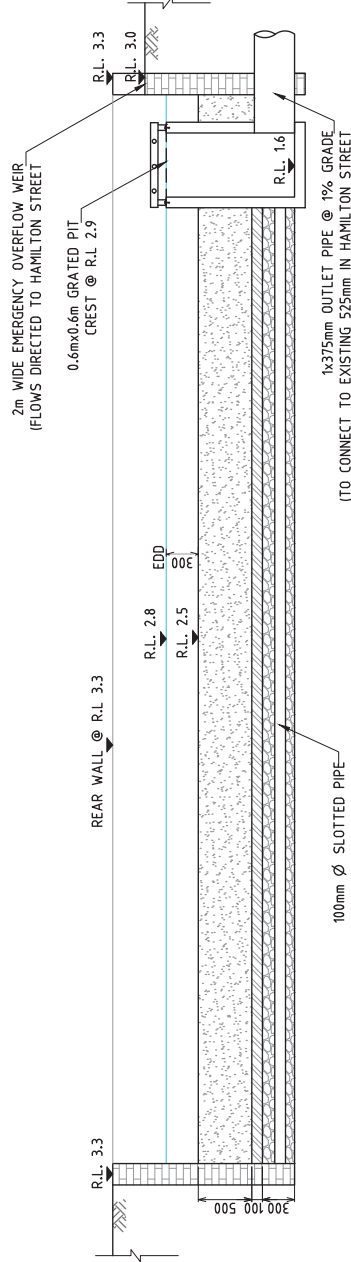
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All hydraulic details and levels
T.B.C as part of detailed design



BIORETENTION BASIN A2 SECTION A2 - A2

DATE
07.06.19
PROJECT No.:
BC-18058
DRAWING No.:
DWG-321
REVISION No.:
A

PROJECT
PROPOSED AGED CARE DEVELOPMENT
DRAWING TITLE
BIORETENTION BASIN A2 - SECTION
CLIENT
PALM LAKE WORKS
ADDRESS
55-61 HAMILTON & 17-19 WEINAM STREET
REDLAND BAY
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DESIGNED BY:
AK
CHECKED BY:
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PAPER SIZE:
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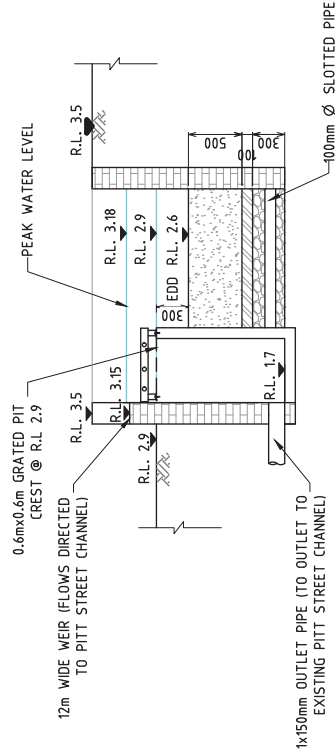
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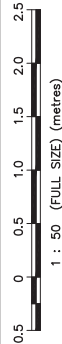
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All hydraulic details and levels
T.B.C as part of detailed design



BIORETENTION BASIN B1 SECTION B1 - B1



DATE
07.06.19
PROJECT No. :
BC-18058
DRAWING No. :
DWG-322
REVISION No. :
A

PROJECT
PROPOSED AGED CARE DEVELOPMENT
DRAWING TITLE
BIORETENTION BASIN B1 - SECTION
CLIENT
PALM LAKE WORKS
ADDRESS
55-61 HAMILTON & 17-19 WEINAM STREET
REDLAND BAY
DRAFTED BY :
TP / KP
DESIGNED BY :
AK
CHECKED BY :
BC
PAPER SIZE :
A3
SCALE :
1:50

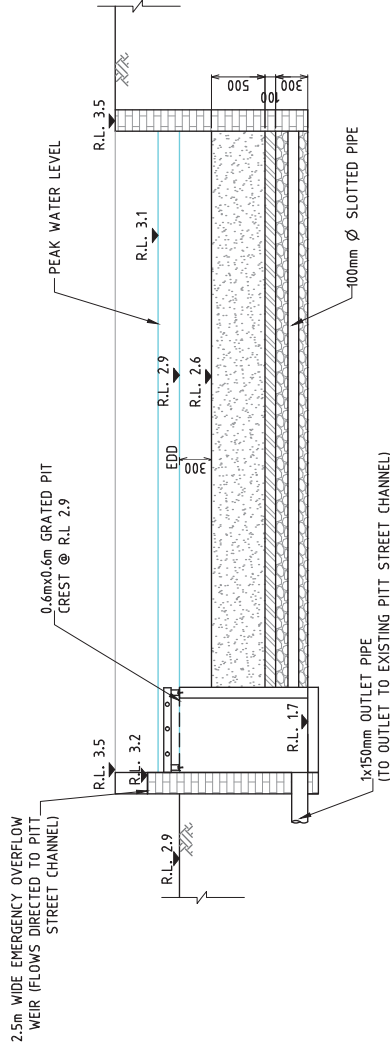
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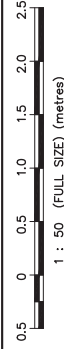
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All hydraulic details and levels
to be as part of detailed design



BIORETENTION BASIN B2 SECTION B2 - B2



DATE
07.06.19

PROJECT No. :
BC-18058

DRAWING No. :
DWG-323

REVISION No. :
A

PROJECT TITLE
PROPOSED AGED CARE DEVELOPMENT

CLIENT
BIORETENTION BASIN B2 - SECTION
PALM LAKE WORKS

ADDRESS
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REDLAND BAY

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SCALE :
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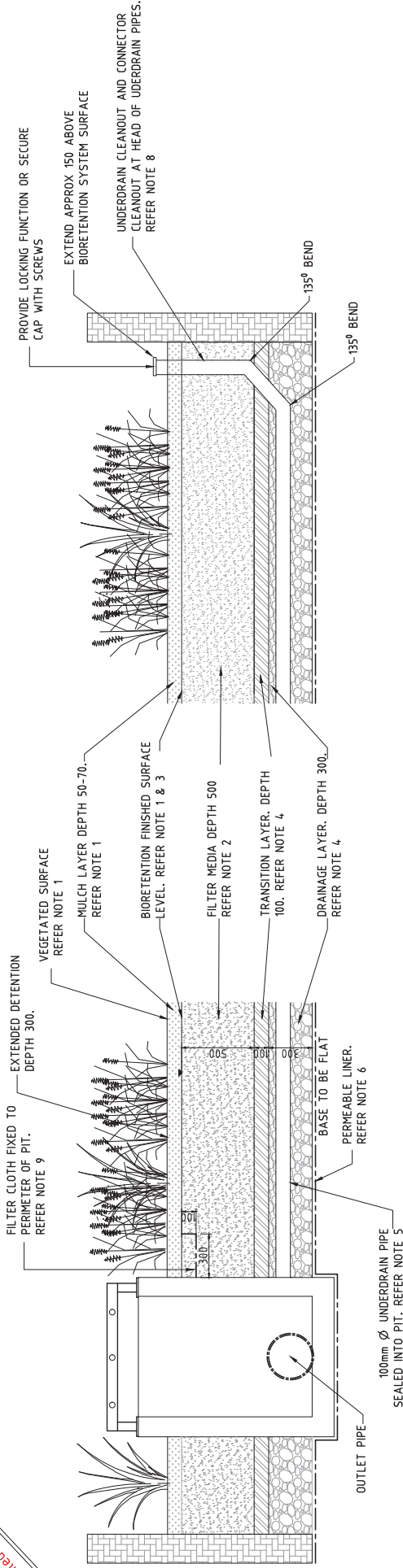
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All hydraulic details and levels
T.B.C as part of detailed design



BIORETENTION MEDIA (TYPE 3-CONVENTIONAL) (CROSS SECTION)

N.T.S

BIORETENTION BASIN SUBSOIL DRAIN CLEANOUT (TYPE 3-CONVENTIONAL)

N.T.S

NOTES (IN ACCORDANCE WITH IPWEAQ STANDARD DRAWINGS DS-070 AND DS-073):

- BIORETENTION SYSTEM SURFACE LEVEL IS TOP OF FILTER MEDIA. SURFACE TO BE MULCHED AND PLANTED AS PER THE 'BIORETENTION TECHNICAL DESIGN GUIDELINES' (WATER BY DESIGN).
- FILTER MEDIA SPECIFICATION SHALL BE IN ACCORDANCE WITH THE 'ADOPTION GUIDELINES FOR STORMWATER BIOFILTRATION SYSTEMS (CRC FOR WATER SENSITIVE CITIES)' AND THE BIORETENTION TECHNICAL DESIGN GUIDELINES (WATER BY DESIGN). BIORETENTION HYDRAULIC CONDUCTIVITY SHALL BE IN ACCORDANCE WITH PRACTICE NOTE 1: IN SITU MEASUREMENT OF HYDRAULIC CONDUCTIVITY (IFAWB). THE NUMBER OF SAMPLES TO BE TESTED SHALL BE IN ACCORDANCE WITH THE 'CONSTRUCTION AND ESTABLISHMENT GUIDELINES' - SWALES, BIORETENTION SYSTEMS AND 'WETLANDS' (WATER BY DESIGN).
- CONSTRUCTION TOLERANCES SHALL BE IN ACCORDANCE WITH THE 'CONSTRUCTION AND ESTABLISHMENT GUIDELINES' -SWALES, BIORETENTION SYSTEMS AND 'WETLANDS' (WATER BY DESIGN)
- TRANSITION LAYER AND DRAINAGE LAYER DEPTHS AND SPECIFICATION TO BE IN ACCORDANCE WITH THE 'BIORETENTION TECHNICAL DESIGN GUIDELINES' (WATER BY DESIGN)
- UNDERDRAIN. SLOTTED RIGID PIPE LAID FLAT. PIPE SHOULD NOT BE INSTALLED WITH A FILTER SOCK SURROUNDING PIPE. UNDERDRAIN PIPES SHALL BE SEALED INTO PITS USING GROUT OR OTHER APPROVED WATERTIGHT SEAL.
- PERMEABLE LINER, NON-WOVEN GEOTEXTILE FILTER CLOTH TO BASE AND SIDES OF BIORETENTION SYSTEM. FILTER CLOTH NOT TO BE PLACED BETWEEN ANY FILTER LAYERS. PERMEABLE LINER AS PER 'BIORETENTION TECHNICAL DESIGN GUIDELINES' (WATER BY DESIGN).
- VEGETATED BATTER, SLOPE AND PLANTING TO BE IN ACCORDANCE WITH 'BIORETENTION TECHNICAL DESIGN GUIDELINES' (WATER BY DESIGN).
- INSPECTION/CLEANOUT POINT. VERTICAL SOLID PIPE SECTION ATTACHED TO THE END OF EACH UNDERDRAIN IN ACCORDANCE WITH THE 'BIORETENTION TECHNICAL DESIGN GUIDELINES'(WATER BY DESIGN)
- FILTER CLOTH TO BE FIXED TO PERIMETER OF PIT TO AVOID RUNNELLING OF WATER BETWEEN PIT AND SOIL INTERFACE. BEGIN FILTER CLOTH 100 ABOVE SURFACE. EXTEND TO 100 BELOW SURFACE. CONTINUE 300 HORIZONTALLY INTO FILTER MEDIA.
- FOR GENERAL DESIGN AND CONSTRUCTION NOTES REFER TO DS-078
- ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED.

DATE
07.06.19
PROJECT No. :
BC-18058
DRAWING No. :
DWG-330
REVISION No. :
A

PROJECT
DRAWING TITLE
BIORETENTION BASIN - FILTER MEDIUM & UNDERDRAINAGE DETAILS
CLIENT
PALM LAKE WORKS
ADDRESS
55-61 HAMILTON & 17-19 WEINAM STREET
REDLAND BAY
DRAFTED BY :
TP / LD
DESIGNED BY :
AK
CHECKED BY :
BC
PAPER SIZE :
A3
SCALE :
N.T.S

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BIORETENTION SYSTEM SPECIFICATION

1. Referenced documents.

The following documents are incorporated into this specification by reference:

- Standards1.1. AS 1289 - Methods of Testing Soils for Engineering Purposes1.1.2. AS 1289.5.4.1-2007 - Soil Compaction and Density Tests-Compaction Control Test-Dry Density Ratio, Moisture Variation and Moisture Ratio1.1.3. AS 1289.5.7.1-2006 - Soil Compaction and Density Tests - Compaction control Test-Half Density Ratio and Half Moisture Variation (rapid method)1.1.4. AS 2758 - Aggregates and Rock for Engineering Purposes1.1.5. AS 4419 - Soils for Landscaping and Garden Use1.1.6. AS 4454 - Composts, Soil Conditioners and Mulches1.2. Other publications1.2.1. Guidelines for Soil Filter Media in Bioretention Systems (FAWB) - the current version of the guideline can be found at <http://www.monash.edu.au/FAWB/>1.2.2. Construction and Establishment Guidelines - Swales, Bioretention Systems and Wetlands (Water by Design) <http://waterbydesign.com.au/ceguide/>1.2.3. Transferring Ownership of Vegetated Stormwater Assets (Water by Design) <http://waterbydesign.com.au/transferguide/>1.2.4. Transferring Ownership of Vegetated Stormwater Assets (Water by Design) <http://waterbydesign.com.au/transferguide/>1.2.5. Bioretention Technical Design Guidelines (Water by Design) <http://waterbydesign.com.au/techguide/>1.2.6. Water Sensitive Urban Design Field Guide (Water by Design)

2. Abbreviations and definitions

- The bioretention system specification consists of the following abbreviations and definitions:
 - Filter soil layer which acts as a pollutant filter and supports plant growth.
 - Impermeable liners: the liner that prevents water movement between the filter and the surrounding soils and defines the edge of the system.
 - Transition layer: layer to separate filter layer from the drainage layer
 - To avoid migration of soils from the filter to the drainage layer
 - To the under-drainage.
 - Under-drains: sloped drains collect treated stormwater from the drainage layer at the base of the bioretention system.

3. Test methods and standards

- The following test methods and standards are to be used as specified in the above guidelines when conducting tests associated with this specification:
 - The hydraulic conductivity of potential filter media shall be measured using the ASTM F895-11 method
 - Particle size distribution: AS1289.3.6.1 - 1995
 - Soils for landscaping and garden use: AS4419 - 2003.

4. Materials

- Materials shall meet the required specifications detailed in Section 8
 - Filter media, Section 9, Transition layer, Section 10, Drainage layer, Section 11 Under drainage, Section 12, Permeable liner, Section 13 Impermeable liner and section 14, landscaping of this document.
- All materials must be certified by the supplier with certification and delivery supply dockets shall be provided on request to certify the material delivered is the material tested.

5. Timing and erosion and sediment control

- The timing of civil and landscape works for bioretention systems must be carefully planned to ensure that both the bioretention system and the downstream waterways, are not impacted by stormwater and sediment (e.g. through best practice erosion and sediment control). In particular, the drainage layer, transition layer and filter media must not be placed until the risk of high sediment loading from upstream construction activities has been mitigated. The construction sequence must be approved by the superintendent
 - Erosion and sediment control during construction must be delivered in accordance with all legislative requirements including, where required, the preparation of site-specific ESC plan/s in accordance with current Best Practice Erosion and Sediment Control (e.g. ECCA 2008, or later version).

6. Earthworks and hydraulic structures

- The construction of hydraulic structures must ensure the design levels are achieved. Bunds/ embankments surrounding the system shall be at correct levels. The below table summarises the construction tolerances for each element of a typical bioretention system.
- Bioretention systems tolerances

DATE

07.06.19

PROJECT TITLE

BIORETENTION STANDARD NOTE

CLIENT

PALM LAKE WORKS

ADDRESS

55-61 HAMILTON & 17-19 WEINAM STREET

RELAND BAY

DRAFTED BY:

TP / LD

CHECKED BY:

AK

DESIGNED BY:

BC

SCALE:

N.T.S.

PROJECT

PROPOSED AGED CARE DEVELOPMENT

BIORETENTION STANDARD NOTE

PALM LAKE WORKS

ADDRESS

55-61 HAMILTON & 17-19 WEINAM STREET

RELAND BAY

APPROVED FOR AND ON BEHALF OF BIOME CONSULTING

PTY LTD

REFNO.:

ACN 168 087 476

VER.

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DESCRIPTION

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DATE

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APPR.

Bioretention element	Tolerance (units specified otherwise)
Hydraulic structures	+/-25 mm (+/-15 mm for streetscape systems)
Earthworks	+/-25 mm
Under-drainage	+/-25 mm
Drainage transition layers	+/-25 mm
Surface level	+/- 25mm +/- 40mm for filter media >30m ² provided the average extended detention requirement is within 25mm of the design requirement.
Embankments and bunds	+/- 25 mm + 50 mm

Maintenance access.

Maintenance access is provided in accordance with the design drawings.

Filter media

A fundamental part of bioretention systems is the filter media. The main role of the filter media is to support vegetation and remove pollutants. Filter media should be loamy sand that has high permeability when compacted. It should contain some organic matter to improve water-holding capacity and plant health, but it should be low in nutrient content. The filter media must be compliant with AS 4419 - Soils for Landscaping and Garden Use, and meet the following requirements:

Parameter	Test method in accordance with	Requirement
Saturated hydraulic conductivity	ASTM F895-11	50 - 500 mm/hr (200 preferred)
pH	AS 4419	5.5 - 7.5
Electrical conductivity	AS 4419	<12 dS/m
Nitrogen content	AS 4419	<800 mg/kg
Phosphorus content	AS 4419	<40 mg/kg
Organic content	AS 4419	3%-10% Where organic content is below this threshold, the filter media may be ameliorated by adding 50mm of loamy sand to the top 150mm of filter media.
Particle size distribution	AS 1289.3.6.1 - 1995	Clay & silt <3-4% (d<0.075mm) Very fine sand 5-30% (0.075-0.425mm) Fine sand 10-50% (0.425-0.75mm) Medium sand 10-30% (0.75-1.05mm) Coarse sand 7-10% (1.05-2.0mm) Fine gravel <3% (2.0-3.4%)

Source: Guidelines for Soil Filter Media in Bioretention Systems (FAWB) and Bioretention Technical Design Guidelines (Water by Design)
Filter media must be free of weeds and propagates. Other characteristics of the filter media required for plant growth should be confirmed with a soil analysis or confirmed with a horticulturist/landscape architect.

Soil filter frequency
Satisfying filter media can be delivered to site or imported sand can be ameliorated to meet the above specification. In either case, the media shall be tested against the above parameters at one sample per 50m² of filter media. For soil supplied to site, testing must be undertaken on the actual material. The supplier will be responsible for ensuring the filter media meets the specification and the correct material is delivered to site prior to installation.

When installing, the following specifications shall be applied:

- Filter media shall be laid out and compacted in 150mm lifts for depths of over 300mm.
- The top surface of the drainage layer shall be level and free from localised depressions to ensure even distribution of stormwater flows across the surface and prevent localised ponding.
- Filter fabric must not be used between drainage layer, transition layer and filter media layers or wrapped around the under-drainage

Transition layer

- Transition layers prevent filter media migrating into the drainage layer.
- Materials

- Transition layer shall be minimum thickness of 100 mm coarse sand unless otherwise specified typically 1mm particle size diameter) with <2% fines.
- A particle size distribution for the sand shall be obtained to ensure that it meets the following criteria (VicRoads).
 - D5 (Transition layer) <= 5x D85 (filter media)
- Testing
A sample of the proposed transition layer is to be provided to the superintendent for approval prior to installation. The superintendent may require the transition layer to be tested to ensure its particle size.

Drainage layer

Drainage layers convey infiltrated water into the sloped under-drainage pipes.
Materials
Drainage layer shall be comprised of fine gravel (nominal 2-5mm) with <2% fines and a minimum saturated hydraulic conductivity of 400mm/hr. The depth of the drainage layer shall ensure at least 50mm of aggregate cover over all perforated under-drainage pipes.
A particle size distribution for the gravel shall be obtained to ensure that it meets the following bridging criteria (VicRoads): D15 (drainage layer) <= 5x D85 (transition layer)

- A sample of the proposed drainage layer is to be provided to the superintendent for approval prior to installation. The superintendent may require the drainage layer to be tested to ensure its particle size.

Under-drainage

- Materials
Either sloped rigid pipe (HDPE or similar) or ag-pipe can be used for under-drainage as specified in the construction drawings. When installing, the following specifications shall be considered:
 - Typically 100mm-sloped rigid pipe is the preferred type of rigid pipe.
 - The slots in the pipe shall not allow the drainage layer aggregate to freely enter the pipe (under-drainage with slot width of 2mm or smaller is preferred).
 - Under-drainage pipes must not be surrounded by any geofabric or sock.
- Installation
The maximum spacing of under-drains for bio-retention systems <100m² is 1.5m from centre to centre. For bioretention systems >100 m² the maximum spacing can be increased to 2.0-2.5m if specified in the construction drawings.
- The under-drains shall be sloped towards the outlet pit (min. 0.5% longitudinal grade) and the base of filtration trench shall be free from trapped debris. For bioretention systems with a saturated zone a 0% pipe grade is acceptable.
- All junctions and connections shall be appropriately sealed.
- Under-drainage pipes shall be sealed into the overflow pit
- All under-drainage pipes to have raised level out points constructed from non-sloped pipes which extend to 150mm above filter media surface

Permeable liner (where specified)

- A permeable geotextile liner fabric must be used to line the outside of the bioretention system.
 - The liner must extend at least 500mm beyond the top of the sides and must be keyed into batter and covered by at least 200mm of topsoil.
- The liner must be resistant to all soil acids and alkalis, resistant to microorganisms and comply with the requirements of AS 3706.12 and AS 3706.13.

Impermeable liner (where specified)

- Materials
Liner options include day, geosynthetic bentonite day liners or high-density poly ethylene (HDPE) liners. Refer to the project drawings for liner details.
 - Installation
Installation must be in accordance with manufacturers' specifications and design drawings and achieve the following:
 - The liners shall be keyed into the batters and to the embankments.
 - Liners must be sealed around protrusions such as outlet pipes.
 - Must achieve a maximum permeability of 1 x 10⁻⁹ m/s

Landscaping

- Refer to landscape design drawings.
 - Batter slopes must have min 200mm topsoil which must be tested by a NATA-accredited laboratory in accordance with AS 4419.
 - Subsoils to be cultivated to 150mm prior to placing topsoil on batter slopes.
- Planting densities and species must be consistent with the landscape design drawings. No substitutions should be made unless approved by the superintendent.
- Plants supplied to site must:

- Be grown in clean, weed-and pest-free conditions;
 - Be well developed, sun-hardened and contain a fully established root ball that does not crumble when removed from its container.
- Be at least 200mm high.
- Show no sign of pest and disease
- Show no signs of nutrient deficiency
- Be free from weeds
- Be clearly labelled
- Be supplied in a container that is at least 90mm high x 50mm wide at least 10 g of slow-release native fertilizer in granular or tablet form.
- Pre-hydrated water crystals may be applied at 1-2% by weight
- Mulch must be applied in accordance with the design drawings, be applied prior to planting, provide coverage of the soil and not exceed 75mm thickness, and be kept 50 mm clear of plant stems. Unless otherwise specified, mulch should be fine sugar cane mulch secured in place by a loose weave jute net pinned at 500mm centres.
- Filter media surface and plant stock are to be watered immediately prior to planting. Unless otherwise specified, plants should be planted in clumps of the same species, and large monocultures avoided.
- Plant method must minimise soil compaction and ensure that all roots are covered by at least 10-20mm of soil, avoid covering plant crowns.
- Unless specified otherwise, the following irrigation schedule applies during plant establishment at 2.5 - 5L per plant per week:
 - Week 1 - 5 five waterings per week
 - Week 6-10 three waterings per week
 - Week 11-15 two waterings per week
 - Thereafter as required to sustain plants until successful establishment
- Replanting must occur during the establishment period if less than 90% of plants survive.
- Successful plant establishment in bioretention systems is considered when the plants are robust and self-sustaining, and meet the following criteria:
 - Vegetation must cover at least 90% of the bioretention surface with much covering the remainder (< 10% much visible from above)
 - Average groundcover plant height must be greater than 500mm.
 - Plants must be healthy and free from disease.
 - No weeds or litter to be present.

Certification and chain of custody

- The following certification and the chain of custody applies to bioretention media:
 - The supplier and contractor are responsible for ensuring the bioretention media meets the specifications outlined in these guidelines and that the correct media is supplied to site. The supplier must provide a signed copy of the filter media by soil laboratory lifted for the method in accordance with the requirements listed above on the basis of the testing in the soil laboratory and supplier must certify the material meets these specifications. The supplier must provide the certification and laboratory test results to the contractor with the supply docket.
 - The contractor provides a copy of the supplier's certification, test results and supply docket to the site superintendent or bioretention designer for review.
 - Following review of the certification, test results and the supply docket, the site superintendent or bioretention designer approves installation of the bioretention media.
 - The relevant sections of the bioretention media sign-off form as per the construction and establishment guidelines (Water by Design) should be completed and signed. This sign-off form is provided as part of the construction certification by the site superintendent or bioretention designer.

Hold points

- The following hold points must be observed in accordance with the most recent Water by Design construction checklists and superintendent approval is required for works to proceed:
 - Prestart meeting
 - Completion of hydraulic structures and under-drainage
 - Prior to placing filter media
 - Prior placement of filter media (prior to applying mulch and planting).

Compliance testing (for on-maintenance or off-maintenance)

- Compliance testing must be in accordance with chapter 5 of Transferring Ownership of Vegetated Stormwater Assets (Water by Design). Checklists must be completed and signed by the superintendent.
- Disclaimer: It is the responsibility of the certifying registered professional engineer to ensure these standard notes are applied to the specific needs of the project. It is expected that additional drawing notes would be required to cover other important project issues (e.g. Workplace Health and Safety, Environmental Protection, Erosion and Sediment Control, etc). Healthy waterways, IPWEA and all contributors to this document accept no liability for the use, misuse or any omission or inaccuracy in this document.

ORIGINAL SCALE BEFORE REDUCTION

CERTIFIED BY



BIOME Consulting Pty Ltd

PO Box 3469, Australia Fair, Southport

M 0415 935 222

E brad@biomeconsulting.com.au

ABN 86 160 087 476

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Appendix B

Rational Method Model Validation

The Rational Method has been relied upon to validate the flows reported within *xpstorm* for both the pre and post development cases. In accordance with QUDM 2016 Section 4, the Rational Method provides a simple means of estimating peak discharge and is therefore considered suitable for validation purposes. Equation 4.2 from QUDM has been relied upon.

$$Q_y = (C_y \cdot I_y \cdot A)/360$$

where:

Q_y	=	peak flow rate (m ³ /s) for annual exceedance probability (AEP) of 1 in 'y' years
C_y	=	coefficient of discharge for AEP of 1 in 'y' years
A	=	area of catchment (ha)
I_y	=	average rainfall intensity (mm/h) for a design duration of 't' hours and an AEP of 1 in 'y' years
t	=	the nominal design storm duration as defined by the time of concentration (t)

Coefficient of Discharge

Based on the infiltration characteristics of the internal and external catchments, the following discharge coefficients have been calculated using the method presented within Book 8 of Australian Rainfall and Runoff (1998) and based on Equation 4.3 from QUDM (2016).

$$C_y = F_y \cdot C_{10}$$

where:

C_y	=	coefficient of discharge for AEP of 1 in 'y' years
F_y	=	frequency factor for AEP of 1 in 'y' years
C_{10}	=	10 year discharge coefficient value for Tables 4.5.3 and 4.5.4 of QUDM

Fraction impervious (f_i) values for the existing and developed catchments were derived from aerial photography, and development and landscaping plans. Using these values, and the local I_{10} (1 hour rainfall intensity for the 10 year ARI) value sourced from BOM, the C_{10} for each catchment was determined and utilised to calculate the runoff coefficients for each nominated event.

The fraction impervious and coefficient of discharge values for the nominated AEP's for the existing case and developed case are contained within Tables B.1 and B.2, respectively.

Table B.1 Coefficient of Discharge – Existing Case

Catchment ID		f_i	C_2	C_5	C_{10}	C_{20}	C_{50}	C_{100}
External	A (Ext)	0.09	0.59	0.66	0.69	0.72	0.79	0.83
	B (Ext)	0.07	0.58	0.65	0.69	0.72	0.79	0.82
Internal	A	0.76	0.71	0.80	0.84	0.88	0.97	1.00
	B	0.14	0.59	0.66	0.70	0.73	0.80	0.83

Table B.2 Coefficient of Discharge – Developed Case

Catchment ID		f_i	C_2	C_5	C_{10}	C_{20}	C_{50}	C_{100}
Internal	A1 and A2	0.74	0.71	0.79	0.84	0.88	0.96	1.00
	B1 and B2	0.84	0.73	0.82	0.86	0.91	0.99	1.00

Time of Concentration

The time of concentration (t_c) for each catchment was calculated in accordance with Section 4.6 of QUDM (2016). A standard inlet time of concentration of 5 min has been adopted within the relevant developed catchments as per Table 4.6.2 of QUDM.

The time of concentration (t_c) for the overland flow length within the undeveloped catchments and the relevant developed catchments was estimated using Friend's Equation for overland flow (QUDM Section 4.6.6).

$$t_c = (107nL^{0.333})/S^{0.2}$$

where:

t_c	=	Time of concentration (min)
n	=	Horton's roughness value (estimated using QUDM Table 4.6.5)
L	=	Overland sheet flow path length (m)
S	=	Slope (%)

For channel flow, times were estimated using Manning's equation as provided in the Technical notes for Figure 4.6 of QUDM, shown below:

$$t_c = 0.025L/S^{0.5}$$

where:

t_c	=	Time of concentration (min)
L	=	Length of gutter flow (m)
S	=	Slope (%)

Tables B.3 and B.4 below present the parameters relied upon to calculate the time of concentration (t_c) to the discharge point of each catchment (site's PD) for the existing and developed case, respectively.

Table B.3 t_c Parameters – Existing Case

Parameter	External		Internal	
	A (Ext)	B (Ext)	A	B
Standard Inlet Time				
t_c (min)	-	-	5	-
Sheet Flow				
Flow Length (m)	10	20	-	85
Horton's Roughness Value	0.035	0.035	-	0.035
Slope (%)	25.0	7.3	-	2.2
t_c (min)	4.2	6.8	-	14.0
Pipe Flow				
Flow Length (m)	-	-	60	-
Velocity (m/s)	-	-	1.0	-
t_c (min)	-	-	1.0	-
TOTAL t_c (min)	4.2	6.8	5.0	14.0

Table B.4 t_c Parameters – Developed Case

Parameter	Internal			
	A1	A2	B1	B2
Standard Inlet Time				
t_c (min)	5	5	5	5
Pipe Flow				
Flow Length (m)	60	50	50	20
Velocity (m/s)	1.0	1.0	1.0	1.0
t_c (min)	1.0	0.83	0.83	0.33
TOTAL t_c (min)	6.0	5.83	5.83	5.33

Rainfall Intensity

Based on the calculated t_c for each catchment, Intensity-Frequency-Duration data (IFD) has been obtained from the Bureau of Meteorology for nominated AEP's and the existing and developed cases are presented in Tables B.5 and B.6, respectively.

Table B.5 Rainfall Intensity (mm/h) – Existing Case

Catchment ID		I_2	I_5	I_{10}	I_{20}	I_{50}	I_{100}
External	A (Ext)	131.0	180.0	213.0	245.0	289.0	322.0
	B (Ext)	122.3	167.6	198.1	227.2	266.8	296.9
Internal	A	126.2	173.2	204.8	235.2	276.8	308.2
	B	94.1	128.2	150.2	171.8	199.7	220.7

Table B.6 Rainfall Intensity (mm/h)– Developed Case

Catchment ID		I_2	I_5	I_{10}	I_{20}	I_{50}	I_{100}
Internal	A1	126.2	173.2	204.8	235.2	276.8	308.2
	A2	126.2	173.2	204.8	235.2	276.8	308.2
	B1	126.2	173.2	204.8	235.2	276.8	308.2
	B2	131.0	180.0	213.0	245.0	289.0	322.0

Peak Discharge

Based on the above parameters, estimates of expected peak discharges have been calculated for nominated AEP's for the site's existing and developed catchments, and are presented in Tables B.7 and B.8, respectively.

Table B.7 Peak Discharge (m³/s) – Existing Case

Catchment ID		Q_2	Q_5	Q_{10}	Q_{20}	Q_{50}	Q_{100}
External	A (Ext)	0.002	0.003	0.004	0.005	0.006	0.007
	B (Ext)	0.018	0.027	0.034	0.041	0.053	0.061
Internal	A	0.063	0.096	0.119	0.144	0.186	0.214
	B	0.069	0.106	0.130	0.157	0.200	0.230

Table B.8 Peak Discharge (m³/s) – Developed Case

Catchment ID		Q_2	Q_5	Q_{10}	Q_{20}	Q_{50}	Q_{100}
Internal	A1	0.047	0.072	0.091	0.109	0.140	0.163
	A2	0.055	0.084	0.105	0.126	0.162	0.188
	B1	0.049	0.075	0.093	0.113	0.145	0.163
	B2	0.027	0.041	0.051	0.062	0.079	0.089