Stormwater Management Plan

Hub68 Centre of Excellence – Aging & Wellness
58-68 Delancey Street, Ormiston

The Hub Precinct Pty Ltd

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Executive Summary

This report has been prepared on behalf of The Hub Precinct Pty Ltd 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 quantity, a single underground detention tank has been proposed within Catchment A3. The proposed detention tank will also include a Stormfilter System (Ocean Protect or similar alternatives subject to engineering approval) for quality management of post development A3. The filter system will be separated within the tank via an internal wall (cast in-situ). The proposed tank design includes an estimated detention volume of 62 m^3 (excluding treatment volume). Modelling of the detention tank and its associated outlet structures indicate that pre-developed flows can be maintained for all nominated ARI events at PD-A.

Proprietary devices (Stormfilter Systems by Ocean Protect or similar alternatives subject to engineering approval) have been proposed for stormwater quality management of the site. These devices include;

- Twenty (20) OceanGuard basket systems for coarse sediment and gross pollutant removal (road surface flows) installed upstream of the StormFilter systems;
- Four (4) StormFilter cartridges for sediment and nutrient removal housed within a precast 1460mm dia Manhole to be located in an offline arrangement; and
- An additional forty two (42) StormFilter cartridges for sediment and nutrient located within the proposed underground detention tank (located in a separated chamber via an internal wall).

MUSIC v6 modelling of the stormwater treatment train has been undertaken by Ocean Protect and has shown pollutant removal efficiencies of 80%, 60%, 45% and 90% for TSS, TP, TN and gross pollutants respectively for the developed catchments can be achieved.

The level of detail provided within this report is suitable for development assessment only and should not be relied upon for construction purposes. Detailed design documentation should be prepared in conjunction with civil operational works to finalise the stormwater concepts presented in this report.

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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1 Introduction

This conceptual stormwater management plan has been prepared so as to be considered as part of a Development Application for a Ministerial Infrastructure Designation (MID) over Lot 0 on SP 308738, Lot 4 on SP308740, and Lots 10-16 on SP314782 at 56-68 Delancey Street, Orimston.

The report has been prepared on behalf of The Hub Precinct Pty Ltd 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. Detailed design documentation should be prepared in conjunction with civil operational works to finalise the stormwater concepts presented in this report.

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. In addition, the report aims to address the requirements of the Redland City Council – Healthy Waters Code (Appendix A).

The following objectives are to be achieved.

Operational Phase Objective (Quantity)	Achieve 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 site is located within the Redland City Council local area at 56-68 Delancey Street, Orimston and comprises seven allotments; Lot 0 on SP 308738, Lot 4 on SP308740, and Lots 10-16 on SP314782. The lots have a total area of approximately 5.2 ha, however the development proposal subject to this report covers an area of approximately 2.5 ha and is referred to as the ‘subject site’.

The subject site is bounded by Finucane Road to the south, existing commercial buildings to the east, residential allotments to the north and environmental reserves to the west. The site is currently accessed via Delancey Street to the east of the site.

The subject site consists predominantly of cleared grassed areas. There is an existing hardstand carparking area within the south-eastern corner of the site associated with the neighbouring commercial buildings. The site slopes east to west to a densely vegetated area within the western portion of the greater lot. There is an existing waterbody within the western vegetated area which drains to Hilliards Creek via the Finucane Road Bushland Refuge to the north west of the lot. The remainder of the greater lot consist of parking areas adjacent to the commercial buildings east of the lot.

Refer to Figure 2.1 below which presents an aerial map depicting the site’s location and surrounding road network.

Figure 2.1 Site Location (Queensland Globe, 2022)

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	145.0	182.0	212.0	244.0	286.0	318.0
10 minute	119.0	149.0	172.0	196.0	229.0	253.0
15 minute	101.0	126.0	146.0	166.0	194.0	214.0
20 minute	88.0	110.0	127.0	145.0	169.0	187.0
25 minute	78.2	97.9	113.0	130.0	151.0	168.0
30 minute	70.6	88.5	102.0	118.0	138.0	153.0
45 minute	55.2	69.5	80.7	93.1	110.0	122.0
60 minute	45.8	58.0	67.6	78.2	92.6	104.0
90 minute	35.0	44.5	52.1	60.6	72.3	81.4
120 minute	28.8	36.8	43.2	50.5	60.4	68.3
180 minute	21.9	28.1	33.2	38.9	46.9	53.2

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 a single location to the west of the site:

PD-A The existing waterbody within the western portion of Lot 0 on SP 308738 . Flows from the site are conveyed west as sheet flow to an existing waterbody within the western portion of the greater Lot. Runoff collected within the existing waterbody ultimately overflows into Hilliards Creek via a drainage line located within the neighbouring Finucane Road Bushland Refuge (Lot 900 SP 101187).

This Point of Discharge (PD-A) will be relied upon for comparison of peak discharge. The existing discharge location and contributing catchments are shown on Drawing DWG-200 – Appendix B.

3.2 Existing Case – External Catchments

A small portion of the Finucane Road reserve currently contributes flows onto the subject site at the southern boundary. Table 3.1 presents a summary of the characteristics of the external catchment.

Table 3.1 Existing Case – External Catchment Characteristics

Catchment ID	Area (ha)	Cover (%)	Discharge Condition	PD ID
A (Ext)	0.04	100 - Grassed	Sheet/Channel	PD-A

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 B.

Table 3.2 Existing Case – Catchment Characteristic

Catchment ID		Area (ha)	Cover (%)	Discharge Condition	PD ID
Internal	A1	2.20	5.5– Buildings/Carpark 94.5 – Cleared pasture	Sheet/Channel	PD-A
	A2	0.19	100 – Cleared pasture	Sheet/Channel	PD-A

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 based on information obtained from the Australian Rainfall and Runoff Data Hub tool (reference: https://data.arr-software.org)..

Temporal Patterns and Rainfall Data

Site specific rainfall and temporal pattern data used in modelling was sourced from the Australian Rainfall and Runoff (ARR) Data Hub (2019). Refer to Appendix C for a summary of the data obtained.

Critical Storm Duration Assessment

The critical storm duration for each catchment was determined utilising the Ensemble Statistics Utility in *xpstorm*. From the critical storm duration, the median storm ensemble was utilised to determine peak flows for each respective catchment. Table 3.3 presents the critical storm duration and chosen median storm ensemble for each of the modelled catchments. Box and Whisker Plots showing the 1% AEP peak flows for the range of durations modelled is contained within Appendix D.

Table 3.3 Existing Case – Critical Storm Assessment

Catchment ID	Critical Storm	Annual Exceedance Probability (AEP)					
		39.3% (2 yr ARI)	18.1% (5 yr ARI)	9.5% (10 yr ARI)	4.9% (20 yr ARI)	2% (50 yr ARI)	1% (100 yr ARI)
A1	Duration (min)	60	60	30	30	25	25
	Median Storm	4	5	4	8	5	4
A2	Duration (min)	90	30	30	30	15	15
	Median Storm	10	9	6	9	2	6
A (EXT)	Duration (min)	30	30	30	30	15	15
	Median Storm	9	9	9	10	2	2
PD-A	Duration (min)	60	60	30	30	30	25
	Median Storm	4	10	4	8	2	4

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

Table 3.4 Existing Case – *xpstorm* Catchment Details

Catchment ID		Impervious Area		Pervious Area	
		Area (ha)	Slope (%)	Area (ha)	Slope (%)
External	A (Ext)	-	-	0.041	10.6
Internal	A1	0.122	7.6	2.077	7.6
	A2	-	-	0.188	8.8

Table 3.5 Existing 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	39.3% - 1%	26	1.7	0.040

Table 3.6 Existing Case – *xpstorm* Peak Discharge (m^3/s)

Catchment/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)	0.008	0.013	0.016	0.019	0.023	0.026
A1	0.297	0.480	0.594	0.722	0.887	1.012
A2	0.033	0.051	0.063	0.082	0.092	0.109
PD-A	0.332	0.534	0.655	0.798	0.987	1.124

3.5 Existing Case – Model Validation (Rational Method)

For validation purposes, peak discharge values were calculated for 0.01 AEP using Rational Method and compared to those generated using *xpstorm.* 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 E.

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

Catchment & Point of Discharge ID		*xpstorm* (m^3/s)	Rational (m^3/s)	Difference (%)
External	A (EXT)	0.026	0.023	11.5
Internal	A1	1.012	1.081	-6.8
	A2	0.109	0.094	13.8

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

4 Proposed Development

The development proposal is a Ministerial Infrastructure Designation (MID) for an integrated health and education precinct and will include:

- An internal road network and carparking areas including basement parking;
- An internal stormwater network with end of line underground stormwater treatment measures;
- A new site access to Finucane Road; and
- Upgrades to the road/carparking areas allowing connection to the existing commercial development in the eastern portion of the Lot.

It should be noted that the development proposes underground stormwater management measures that are to be maintained under private ownership.

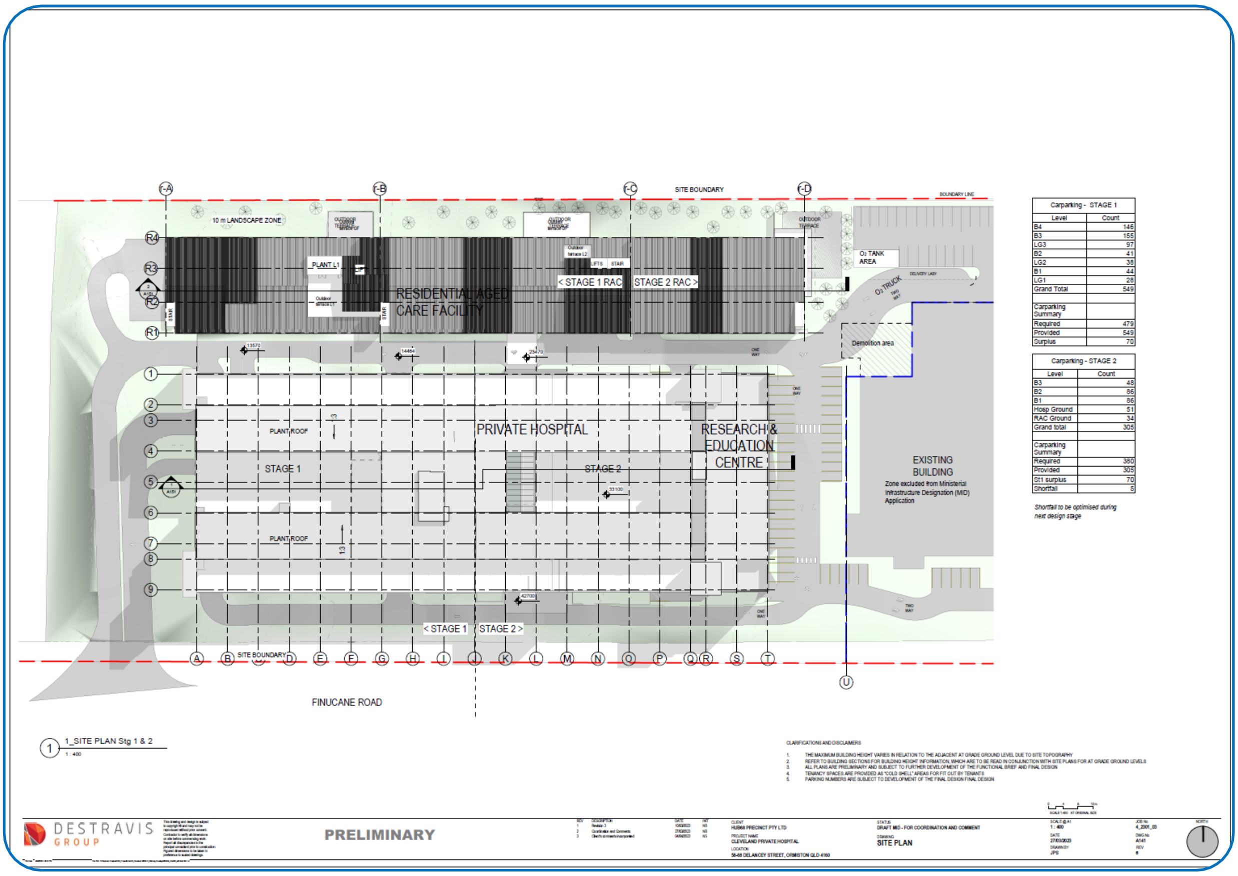


Figure 4.1 Preliminary Site Plan (Destravis Group, 2023)

5 Developed Case – Hydrological Assessment

xpstorm was utilised to assess the site's developed hydrology and generate hydrographs and peak discharge rates 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 catchment A (Ext) will increase due to the construction of a site access to Finucane Road. The access connection will divert major flows (9.5%-1% AEP) from a greater portion of Finucane Road to the internal road network of the site. Minor flows (<9.5% AEP) from A (Ext) will be collected within a minor stormwater network within Finucane Road which conveys flows west and outlets to the existing swale within the Finucane Road Reserve.

The characteristic of the site's developed external catchment is detailed in Table 5.1 below and has been delineated on Drawing 201 – Appendix B.

Table 5.1 Developed Case – External Catchment Characteristic

Catchment ID		Area (ha)	Cover (%)	Discharge Condition	PD ID
External	A (Ext)	0.382	100 – Road Reserve	Road Kerb & Channel (Major Flows 9.5%-1% AEP) Piped (Minor Flows – <9.5% AEP)	PD-A (Major Flows 9.5%-1% AEP) Existing Swale within Finucane Road Reserve (Minor Flows <9.5% AEP)

5.2 Developed Case – Internal Catchments

The site will undergo substantial earthworks to profile the development area. Underground piped drainage will be installed to collect minor stormwater flows, with major flows conveyed via an internal road network.

Two (2) major and one (1) minor post development catchments have been delineated based on the preliminary civil designs by Mortons Urban Solutions. The characteristics of the site's catchments are detailed in Table 5.2 below and have been delineated on Drawing 201 – Appendix B.

Table 5.2 Developed Case – Catchment Characteristic

Catchment ID		Area (ha)	Cover (%)	Discharge Condition	PD ID
Internal	A1	0.05	100 – Ground/Batter	Sheet/Batter	PD-A
	A2	0.22	100 – Comm Dev	Pipe – Sheet	PD-A
	A3	2.21	100 – Comm Dev	Pipe	PD-A

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 the PD represent the combined catchment inflows at this point.

Table 5.3 Developed Case – *xpstorm* Catchment Details

Catchment ID		Impervious Area		Pervious Area	
		Area (ha)	Slope (%)	Area (ha)	Slope (%)
External	A (Ext)	0.306	4.5	0.076	4.5
Internal	A1	0.016	12.5	0.036	12.5
	A2	0.086	3.3	0.129	7.6
	A3	0.571 1.418	5.0 22.5*	0.221	5.0

*Assumed roof pitch

Table 5.4 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	39.3% - 1%	26	1.7	0.040

Table 5.5 Developed Case – *xpstorm* Peak Discharge (m^3/s)

Catchment/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)	0.134	0.167	0.183	0.210	0.245	0.271
A1	0.011	0.017	0.021	0.024	0.031	0.035
A2	0.039	0.063	0.076	0.095	0.108	0.125
A3	0.864	1.071	1.174	1.339	1.566	1.734
PD-A	0.900	1.117	1.227	1.402	1.641	1.832

5.3.1 Validation of Flows

Table 5.6 illustrates that the peak discharges generated using both methods compare well for the 1% AEP as both hydrological methods are within 20% of each other. The modelling is therefore considered to be appropriately validated.

Table 5.6 Developed Case – Peak Flow Validation *xpstorm* vs Rational

Catchment/Point of Discharge		*xpstorm* (m^3/s)	Rational (m^3/s)	Difference (%)
External	A (EXT)	0.271	0.315	-16.2
Internal	A1	0.035	0.039	-11.4
	A2	0.125	0.150	-20.0
	A3	1.734	1.660	4.3

5.3.2 Peak Discharge Comparison (m^3/s) – Existing vs Developed (Unmitigated)

Table 5.7 presents a comparison of the peak discharges expected at each PD. Results indicate increases in peak discharge are expected a PD-A due to the creation of additional hardstand area within the site catchments and diversion of a portion of Finucane Road reserve due to the creation of the site access.

Table 5.7 Peak Discharge Comparison (m^3/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	2.43	0.332	0.534	0.655	0.798	0.987	1.124
	Developed (Unmitigated)	2.86	0.900	1.117	1.227	1.402	1.641	1.832
	Difference		**+0.568**	**+0.58.**	**+0.572**	**+0.604**	**+0.654**	**+0.708**

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 B.

6.1.1 External Drainage

In the developed case the access connection will divert major flows (9.5%-1% AEP) from a portion of Finucane Road to the internal road network of the site. Minor flows (<9.5% AEP) from A (Ext) will be collected within a minor stormwater network within Finucane Road which conveys flows west and outlets to the existing swale within the Finucane Road Reserve.

6.1.2 Internal Drainage

The site's internal catchments will be developed which will be graded so as to allow minor stormwater flows to be collected within the road piped drainage systems with higher flows conveyed with road reserves.

Piped flows from the development site will be directed to proprietary stormwater management measures for treatment prior to discharge.

A single underground detention tank has been proposed for the management of stormwater quantity. The proposed detention tank will also include a StormFilter System (Ocean Protect or similar alternatives subject to engineering approval) for quality management of post development A3.

A precast StormFilter manhole (Ocean Protect or similar alternatives subject to engineering approval) has been proposed for treatment of Catchment A2.

It is proposed that all inlet pits upstream of the StormFilter systems (or similar alternatives subject to engineering approval) within Catchments A2 and A3 be fitted with Ocean Guard systems (litter baskets). This will enable pre-treatment of flows (coarse sediment and gross pollutant removal) prior to discharge to the StormFilter systems.

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. An underground detention tank has been proposed to detain stormwater flows so as to ensure that there is no increase in discharge to downstream properties for all nominated AEP's.

The detention tank is to be located on the western site boundary adjacent to the proposed environmental reserve. The detention tank has been designed with multiple outlets to assist in distribution of flows into the environmental reserve.

6.2.1 *xpstorm* Modelling Parameters

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

xpstorm requires a depth area relationship to be defined when modelling an onsite detention (OSD). As a separate chamber will be installed within the detention tank to house the treatment filter cartridges controlled via a 0.92m high internal weir, the depth area has been modified to exclude detention within this chamber.

A summary of the total depth-area relationship applied to the storage node of the *xpstorm* model in the post-development (mitigated) scenario is contained in Table 6.1. 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 Depth Area Relationship

Detention ID	RL (m AHD)	Depth (m)	Surface Area (m^2)
Detention Tank	13.1	0.0	270
	14.01	0.91	270
	14.02	0.92	370
	15.2	2.1	370

Table 6.2 Outlet Structures

Detention ID	Low Orifice	Mid Orifice	Internal Weir	Outlet Pipe(s)
Detention Tank	3x100 mm @ RL 13.1 m AHD 5x150 mm @ RL 13.1m AHD	8x150 mm @ RL 14.3 m AHD	8 x 1 m Wide weir, crest @ RL 14.95 m AHD	8 x 0.2m (High) x 1.0m (Wide) Rectangular Slot outlet.

6.2.2 Modelling Results

The results of *xpstorm* modelling indicate that the inclusion of the 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 discharge during nominated ARI events for the pre- and post-development mitigated cases at the PD-A. Figure 6.1 illustrates a comparison of the outlet hydrographs at PD-A where the majority of site flow will ultimately discharge.

Table 6.3 Peak Discharge Comparison (m^3/s) – PD-A

Scenario	Contributing Catchments	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)
Pre-Development	A (Ext), A1, A2	2.43	0.332	0.534	0.655	0.798	0.987	1.124
Post-Development (Unmitigated)	A (Ext)-major flows, A1, A2	2.86	0.900	1.117	1.227	1.402	1.641	1.832

Post-Development (Mitigated)	A (Ext)-major flows, A1, A2	2.86	0.324	0.450	0.566	0.671	0.840	1.087
Difference (Pre vs Post Mitigated)			**-0.008**	**-0.084**	**-0.089**	**-0.127**	**-0.147**	**-0.037**

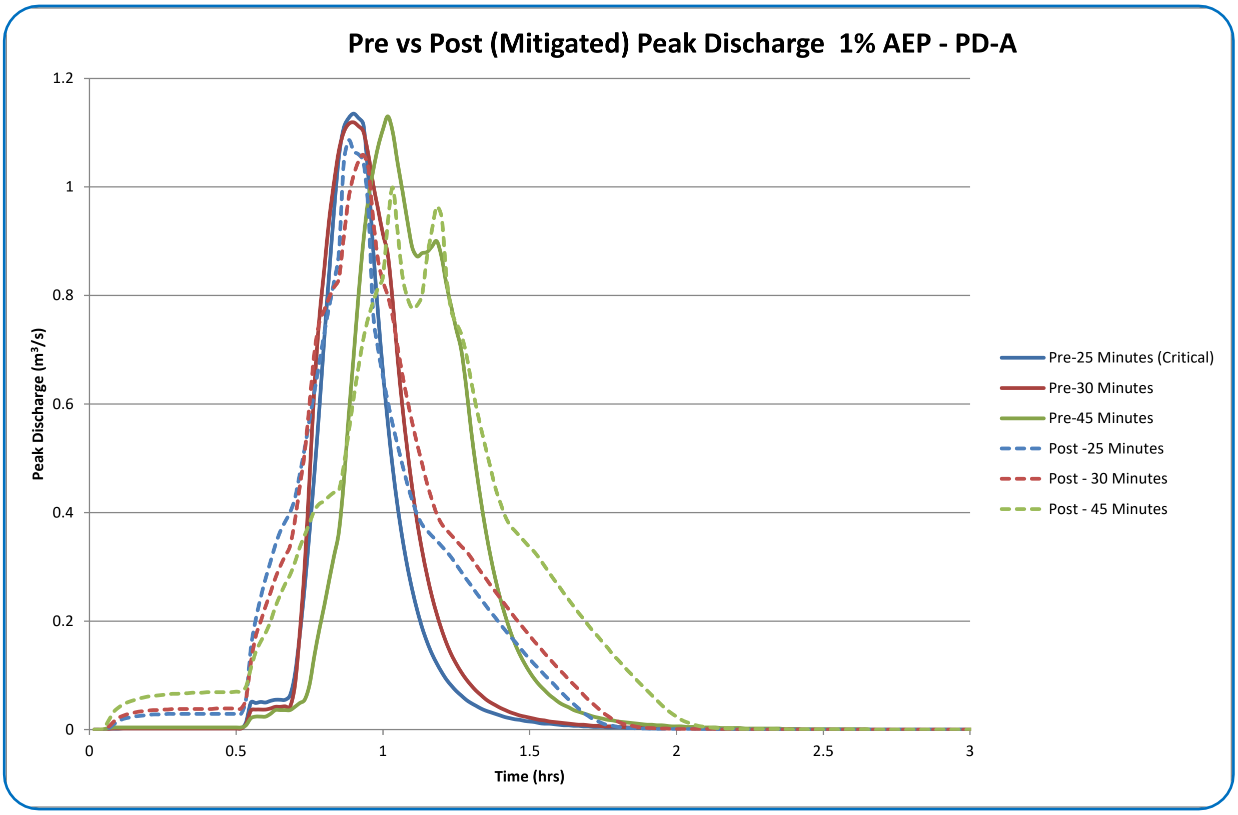


Figure 6.1 Comparison 100 year ARI Hydrography at PD-A

6.2.3 Detention Storage Details, Depths and Volumes

Table 6.4 presents the peak water levels, depths and volumes expected within the detention during both the 20 year ARI and 100 year ARI.

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

	0.049 (20 yr ARI)	0.01 (100 yr ARI)
Base Level (m AHD)	13.10	13.10
Internal Top of Tank Level (m AHD)	15.20	15.20
Weir Level (m AHD)	14.95	14.95
Peak Water Surface (m AHD)	14.72	15.02
Peak Depth of Water (m)	1.62	1.92
Peak Volume (m^3)	510	620
Freeboard Achieved (m)	0.48	0.18
Depth of Weir Flow (m)	-	0.07

6.2.4 Sensitivity Analysis

Consideration has been given to the consequences blockage of the proposed tank orifices. Table 6.5 illustrates the expected peak water levels within the tank if both the low flow and mid flow orifices became fully blocked. In this event, water levels would increase in the tank with all flow discharging over the internal weir structure.

Table 6.5 Sensitivity Analysis Results for 100 Year ARI Event

Peak Water Level (m AHD)	Internal Top of Tank Level (m AHD)	Depth of Weir Flow (m)
15.18	15.20	0.23

Based on the tank outlet configuration, peak water levels would not be expected to exceed the reach the internal top of the tank during the 100 year ARI. The expected maximum depth of flow over the internal weir has 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.

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 has been obtained from the Bureau of Meteorology (BOM) and is summarised within Table 6.6 below.

Table 6.6 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 Catchment Parameters

The developed site has been modelled as having an Commercial land use. Each internal catchment has been split into roof, road and ground level source nodes. Table 6.7 summarises the sub-catchment areas and Drawing DWG-210 – Appendix B 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 6.8 and 6.9.

Table 6.7 *MUSIC v6* Sub-Catchment Areas

Catchment ID	Land Use	Area (ha)	Total Impervious (%)
Catchment A2	Commercial – Road	0.05	100
	Commercial – Ground Level	0.17	20
Catchment A3	Commercial – Roof	1.42	100
	Commercial – Road	0.79	80
Total (ha)	**-**	**2.43**	**-**

Table 6.8 Rainfall Runoff Parameters

Parameter	All Nodes
Landuse	Commercial
Rainfall threshold (mm)	1
Soil storage capacity (mm)	18
Initial storage (% capacity)	10
Field capacity (mm)	80
Infiltration capacity coefficient a	243
Infiltration capacity exponent b	0.6
Initial depth (mm)	50
Daily recharge rate (%)	0
Daily baseflow rate (%)	31
Daily deep seepage rate (%)	0

Table 6.9 Pollutant Export Parameters (log mg/L)

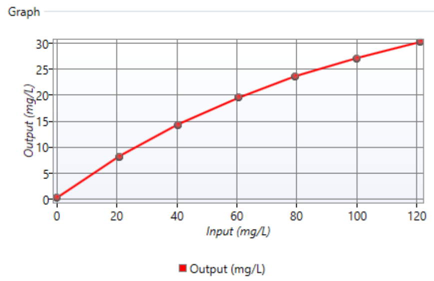
Flow Type	Surface Type	Total Suspended Solids ($\log_{10}$ mg/L)		Total Phosphorous ($\log_{10}$ mg/L)		Total Nitrogen ($\log_{10}$ mg/L)	
		Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
Commercial							
Base Flow	Roof	N/A	N/A	N/A	N/A	N/A	N/A
	Road	0.78	0.39	-0.60	0.50	0.32	0.30
	Ground	0.78	0.39	-0.60	0.50	0.32	0.30
Storm Flow	Roof	1.30	0.38	-0.89	0.34	0.37	0.34
	Road	2.43	0.38	-0.30	0.34	0.37	0.34
	Ground	2.16	0.38	-0.39	0.34	0.37	0.34

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".

Inlet Gully Baskets (Gross Pollutant Removal)
For gross pollutant removal inlet gully baskets are to be installed on all inlet pits discharging to the filter cartridge systems. For conceptual design purposes, modelling has been based on a minimum of one gully basket per 1,000 m^2 of catchment. Ocean Protect have provided a MUSIC node for their OceanGuard 200 System which has been based on 2nd and 3rd party field testing product data. This data is available from the manufacturer upon request. Table 6.10 presents the parameters utilised within the MUSIC model.

Table 6.10 Inlet Gully Basket Parameters

OceanGuard 200 (GPT) Parameters	Catchment A2	Catchment A3
No. Systems (min)	2	8
High Flow by-pass (m^3/s)	0.04	0.16
Low Flow	0.000	0.000
Are the proposed pollutant reduction efficiencies independently verified using a method suited to local conditions?	Yes	
Does the data provided include performance results under dry weather flows (to account for potential pollutant leeching?)	Yes	
It the assumed high-flow bypass rate consistent with manufacturer specifications?	Yes	
TSS Input (mg/L)/Output (mg/L)		
TN Input (mg/L) Output (mg/L)	50.0 39.5	
TP Input (mg/L) Output (mg/L)	10.00 7.0	
Gross Pollutants Input (kg/ML) Output (kg/ML)	14.99 0.00	

Cartridge Filter System

Cartridge filter systems rely on a flow-through filtration system, designed to improve the quality of stormwater runoff. Stormwater is passed through each media-filled cartridge, which traps particulate and adsorb materials such as dissolved metals and hydrocarbons. The cartridge systems are generally contained within underground vaults.

It has been demonstrated that these systems are effective in the treatment of first flush flows and controlled flows during the latter part of a storm. The primary target pollutants for removal are: sediments (TSS), soluble metals, soluble phosphorus, nitrates, and oil and grease.

It is proposed that two (2) cartridge systems be incorporated into the development.

For conceptual design purposes, modelling has been based on the Ocean Protect StormFilter (PSorb) cartridges. It is noted that similar alternatives may also be used subject to engineering approval. MUSIC nodes were supplied by Ocean Protect and are based on 2nd and 3rd party field testing product data. These test results and papers are available upon request from Ocean Protect.

General set-out details for the proposed systems are contained in Appendix B.

The StormFilter parameters utilised within MUSIC are summarised in Table 6.11.

Table 6.11 StormFilter Parameters

StormFilter (PSorb) Parameters	Catchment A2	Catchment A3
No. of Cartridges	4	42
High Flow by-pass (m^3/s)	0.004	0.038
Pit Size (mm)/Manhole Size (mm)/Vault Size (m^2)/Chamber Size (m^2)	Precast Manhole 1,460mm dia – 1.44 m^2	SF Chamber (Within Detention Tank) – 100 m^2
Low Flow	0.000	0.000
Cartridge Type (height & media type)	690 mm PSorb	
Are the proposed pollutant reduction efficiencies independently verified using a method suited to local conditions?	Yes	
Does the data provided include performance results under dry weather flows (to account for potential pollutant leeching?)	Yes	
It the assumed high-flow bypass rate consistent with manufacturer specifications?	Yes	
TSS Input (mg/L) Output (mg/L)	1000 96	
TN Input (mg/L) Output (mg/L)	100 44.1	
TP Input (mg/L) Output (mg/L)	10.00 1.39	
Gross Pollutants Input (kg/ML) Output (kg/ML)	14.99 0.00	

6.4.4 Modelling Results

Results of the *MUSIC v6* modelling for the treatment train effectiveness are summarised in Table 6.12. The results indicate the 80%, 60%, 45% and 90% reduction target for TSS, TP, TN and GP respectively are achieved for the rainfall data set simulated for all flows captured and conveyed to the proposed bioretention basin. A screen capture of the *MUSIC v6* modelling results is included as Figure 6.2.

Table 6.12 Treatment Train Effectiveness

Catchment ID	Pollutant	Inflows (kg/yr)	Outflows (kg/yr)	Reduction (kg/yr)	Reduction (%)	Water Quality Objective (%)
TOTAL	TSS	3,713	406	3,300	**89.1**	80.0
	TP	8.4	2.6	5.80	**69.1**	60.0
	TN	74.1	40.6	33.4	**45.1**	45.0

NOTE: All simulations have been run with pollutant export estimation set to “stochastic generation”.

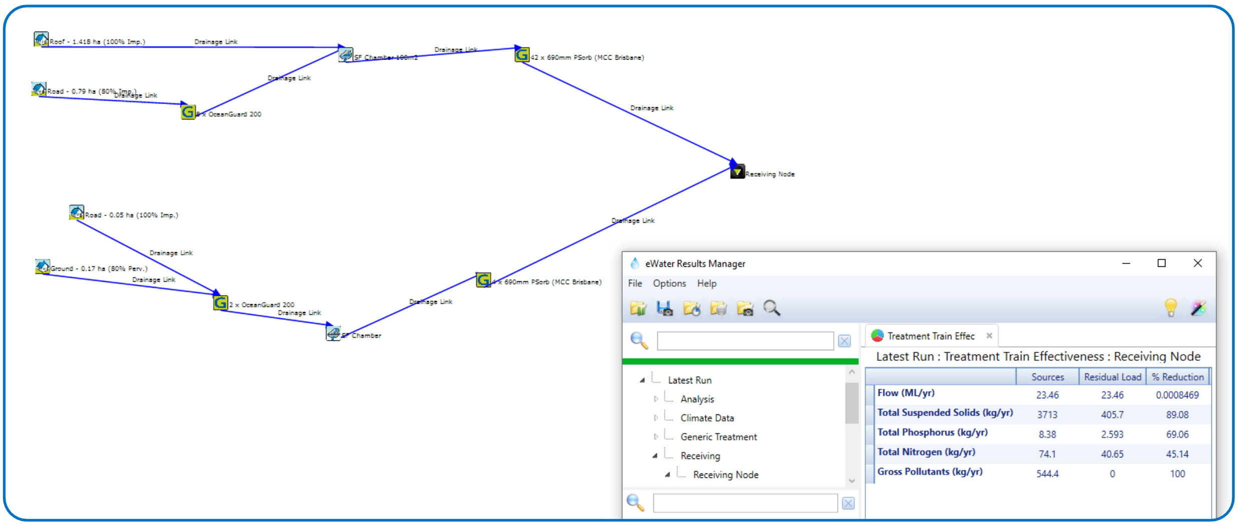


Figure 6.2 Screen Capture of MUSIC Modelling Results

6.5 Maintenance Access

In order to enable regular maintenance of the StormFilter systems, including cleanouts, and replacing cartridges, 900x900 mm accesses will be provided to the ceiling of the proposed manhole and the detention tank which house the cartridges.

6.6 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.

6.6.1 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 6.13 specifies the sampling parameters and frequencies required. 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 6.13 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 6.14 sets the water quality criteria for water discharged from the development site.

Table 6.14 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	

6.6.2 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. All maintenance and operation of the proprietary treatment devices should be in accordance with manufacturers specifications. An operational and maintenance manual is available from Ocean Protect upon request. 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 The Hub Precinct Pty Ltd 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 stormwater treatment train proposed for the development site includes the installation of proprietary devices including;

- Twenty (20) OceanGuard basket systems (or similar alternatives subject to engineering approval) for coarse sediment and gross pollutant removal (road surface flows) installed upstream of the StormFilter systems;
- Four (4) StormFilter cartridges (or similar alternatives subject to engineering approval) for sediment and nutrient removal housed within a precast 1460mm dia Manhole to be located in an offline arrangement; and
- An additional forty two (42) StormFilter cartridges (or similar alternatives subject to engineering approval) for sediment and nutrient located within the proposed underground detention tank (located in a separated chamber via an internal wall).

MUSIC v6 modelling of the stormwater treatment train has been undertaken by Ocean Protect and has shown pollutant removal efficiencies of 80%, 60%, 45% and 90% for TSS, TP, TN and gross pollutants respectively for the developed catchments can be achieved.

In order to address the management of stormwater quantity, a single underground detention tank has been proposed within Catchment A3. The proposed detention tank will also include a Stormfilter System (Ocean Protect) for quality management of post development A3. The filter system will be separated within the tank via an internal wall (cast in-situ). The proposed tank design includes an estimated detention volume of 620 m^3 (excluding treatment volume). Modelling of the detention tank and its associated outlet structures indicate that pre-developed flows can be maintained for all nominated ARI events at PD-A.

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.

……………………………………………………………… 14.04.23 ………………………………………………

Brad Comley **RPEQ 17706** **DATE**

9 References

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Appendix A

Healthy Waters Code

Healthy waters code (Redland City Plan 2018 – Version 8)

9.3.1.1 Application

This code applies to development where the healthy waters code is identified as applicable in the tables of assessment.

When using this code, reference should be made to section 5.3.2 and, where applicable, section 5.3.3, in Part 5.

9.3.1.2 Purpose

(1) The purpose of the Healthy waters code is to ensure that development manages stormwater run-off and protects the receiving waterways.
(2) The purpose of the code will be achieved through the following overall outcomes:
  (a) The environmental values of the city's waterways are protected or enhanced;
  (b) stormwater run-off does not adversely impact on the quality of receiving waters, including waterways, wetlands and Moreton Bay;
  (c) stormwater is managed to ensure the impacts of overland flow or flooding are not worsened for people or property;
  (d) a natural flow regime, including flow paths and quantity, is maintained as far as possible;
  (e) potential adverse impacts as a result of disturbing acid sulfate soils, erosion or sediment flow are avoided;
  (f) stormwater, water quality and erosion control infrastructure is provided in a cost- effective and efficient manner; and
  (g) stormwater, water quality and erosion control infrastructure is designed and located to minimise whole-of-lifecycle costs.

Editor's note: The location, design and functionality of the trunk stormwater network is identified in the local government infrastructure plan which forms part 4 of this planning scheme.

9.3.1.3 Healthy Waters Code – Specific Benchmarks for Assessment

Table 9.3.1.3.1: Benchmarks for Assessable Development

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? If not, justify how the proposal meets either the performance outcome or overall outcome
For Assessable Development		
Stormwater Drainage Editor's note: In order to demonstrate compliance with the performance outcomes in this section, a stormwater management plan is likely to be required. This should be prepared in accordance with the matters specified in Planning Scheme Policy 2 Infrastructure works.		
PO1 To the extent practicable, natural drainage lines are retained, and their hydraulic capacity and channel characteristics are maintained or re-established.	**AO1.1** All existing natural waterways and overland flow paths are retained.	
	AO1.2 The stormwater management system is designed in accordance with Planning *Scheme Policy 2 - Infrastructure works.*	**COMPLIES WITH AO1.2** The proposed stormwater management system has been designed in accordance with Planning Scheme Polity 2 – Infrastructure Works.
PO2 On-site stormwater management systems do not rely on the retention of existing artificial water bodies, except where such water bodies: (1) perform significant ecological, water quality or recreation functions; (2) do not pose a significant risk to stream health or water quality; (3) are structurally sound; (4) do not pose any risk to community health and safety; and (5) will not impose a significant maintenance or cost burden on the community in the short or long terms.	No acceptable outcome is nominated. *Editor's Note: Council would generally expect that such waterbodies are not retained as many are currently in poor condition and need substantial remediation. Where an existing waterbody is proposed to be retained as an integral component of water management on the site, an assessment should be done in accordance with Planning Scheme Policy 2 Infrastructure works. This assessment should be done in conjunction with an ecological assessment report so that conflicts between competing environmental values can be identified and resolved.*	**COMPLIES WITH PO2** The on-site stormwater management system does not rely on the retention of existing artificial waterbodies. Stormwater management on-site will rely on a detention tank and treatment via proprietary filter devices. .
PO3 The stormwater drainage system maintains pre-development velocity and	**AO3.1** Stormwater drainage is designed in accordance with Planning Scheme Policy 2	**COMPLIES WITH AO3.1** Stormwater drainage is designed in accordance with Planning Scheme Policy 2

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? **If not, justify how the proposal meets <u>either</u> the performance outcome or overall outcome**
volume of run- off external to the site and does not otherwise worsen or cause nuisance to adjacent, upstream and downstream land.	Infrastructure works.	Infrastructure works.
PO4 Stormwater drainage is designed and constructed to convey stormwater flow resulting from the relevant design storm event under normal operating conditions.	**AO4.1** Stormwater drainage design meets the stormwater flow capacity requirements of the following design storm events: (1) where for the minor drainage system - as detailed in Table 9.3.1.3.2 - Minor Drainage System Design Storm Event by Road Frontage Classification and Zone; or (2) where for the major drainage system 1% AEP. *<u>Editor's Note:</u> Refer to section 7 of the Queensland Urban Drainage Manual for descriptions of major and minor drainage systems.*	**COMPLIES WITH AO4.1** Minor stormwater flows are to be collected within a pipe network with major drainage to occur within road reserves.
PO5 The stormwater drainage system is designed to function in the event of a minor system blockage.	**AO5.1** The major drainage system caters for 50% blockage in the minor drainage system without causing inundation of building floor levels.	**COMPLIES WITH AO5.1** Major outlet structures have been designed to convey flows in the event of 50% blockage to the minor flow outlets.
PO6 Roof and surface run-off is managed to prevent stormwater flows from entering buildings and be directed to a lawful point of discharge.	**AO6.1** Roof and allotment drainage is provided in accordance with Planning Scheme Policy 2 Infrastructure works.	**COMPLIES WITH AO6.1** Roof runoff from the proposed buildings are to be directed to the internal road network. Minor flows from the internal road network are collected and conveyed within the underground stormwater pipe network to the proposed stormwater treatment devices. Major flows in excess of the piped network capacity will be conveyed within the road reserve to the stormwater detention measure.
PO7 Where located within open space, stormwater devices or functions do not reduce the utility of that space for its intended recreational or ecological functions.	No acceptable outcome is nominated.	**COMPLIES WITH PO7** Proposed stormwater management measures are located underground therefore will not impact on the function of open space.

<table>
<tr><th>Performance outcomes</th><th>Acceptable outcomes</th><th>Does the proposal meet the acceptable outcome?
If not, justify how the proposal meets <u>either</u> the performance outcome or overall outcome</th></tr>
<tr><td>PO8
Maintenance requirements and costs associated with the devices used within the system are minimised.</td><td>No acceptable outcome is nominated.</td><td>COMPLIES WITH AO8
All stormwater treatment devices are to be designed with maintenance provisions in accordance with manufacturers guidelines.</td></tr>
<tr><td colspan="3">Water Quality – General
<u>Editor's note</u>: In order to demonstrate compliance with the performance outcomes in this section, a waste water and stormwater quality management plan may be required. Such assessments should be prepared in accordance with the matters specified in Planning Scheme Policy 2 Infrastructure works.</td></tr>
<tr><td>PO9
Development protects and does not adversely impact the environmental values or water quality of receiving waterways.</td><td>For development involving a site area of 2,500m² or more, or six or more residential lots or dwellings:

AO9.1
Stormwater run-off complies with the following design objectives:

<table><tr><td colspan="4">Minimum reductions in mean annual load from unmitigated development (%)</td></tr><tr><td>Total Suspended Solids (TSS)</td><td>Total Phosphorous (TP)</td><td>Total Nitrogen (TN)</td><td>Gross Pollutants >5 mm (GPs)</td></tr><tr><td>80</td><td>60</td><td>45</td><td>90</td></tr></table>
Otherwise, no acceptable outcome is nominated.</td><td>COMPLIES WITH AO9.1
Stormwater runoff from the proposed development is to be conveyed to two proprietary filter systems for stormwater treatment purposes. These systems have been sized to achieve the minimum reductions in mean annual load as specified in AO9.1. MUSIC modelling indicates the proposed stormwater treatment train achieves these reductions.</td></tr>
<tr><td>PO10
The entry to and transport of contaminants in stormwater or waste water is avoided.</td><td>No acceptable outcome is nominated.

<u>Editor's Note:</u> Applicants should refer to Planning Scheme Policy 2 Infrastructure works for guidance.</td><td>N/A</td></tr>
<tr><td colspan="3">Water Quality – Erosion Prevention and Sediment Control</td></tr>
</table>

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? **If not, justify how the proposal meets either the performance outcome or overall outcome**
Editor's note: In order to demonstrate compliance with the performance outcomes in this section, an erosion and sediment control plan is likely to be required. An erosion hazard assessment may also be required to establish the level risk for erosion and sediment pollution. Such assessments should be prepared in accordance with the matters specified in Planning Scheme Policy 2 Infrastructure works..		
PO11 Development does not increase either: (1) sediment concentration in waters or stormwater outside the development's sediment treatment train; or (2) run-off which causes erosion either on- site or off-site.	No acceptable outcome is nominated.	**COMPLIES WITH PO11 THROUGH CONDITIONS** It is considered suitable that conditions be placed on the development approval that required the preparation of an Erosion and Sediment Control plan as part of future Operational Works.
PO12 Development avoids unnecessary disturbance to soil, waterways or drainage channels.	No acceptable outcome is nominated.	**COMPLIES WITH PO12** The development has been proposed within the existing cleared area which is free of waterways and drainage channels. Environmental/vegetated areas are proposed for conservation.
PO13 All soil surfaces are effectively stabilised against erosion.	No acceptable outcome is nominated.	**COMPLIES WITH PO13 THROUGH CONDITIONS** It is considered suitable that conditions be placed on the development approval that required the preparation of an Erosion and Sediment Control plan as part of future Operational Works.
PO14 The functionality of the stormwater treatment train is protected from the impacts of erosion, turbidity and sedimentation, both within and external to the development site.	No acceptable outcome is nominated.	**COMPLIES WITH PO14 THROUGH CONDITIONS** It is considered suitable that conditions be placed on the development approval that required the preparation of an Erosion and Sediment Control plan as part of future Operational Works.
PO15 Areas outside the development site are not adversely impacted by erosion or sedimentation.	No acceptable outcome is nominated.	**COMPLIES WITH PO15 THROUGH CONDITIONS** It is considered suitable that conditions be placed on the development approval that required the preparation of an Erosion and Sediment Control plan as part of future Operational Works.

Performance outcomes	Acceptable outcomes	Does the proposal meet the acceptable outcome? **If not, justify how the proposal meets either the performance outcome or overall outcome**
Water Quality – Acid Sulfate Soils		
PO16 Within the areas identified as potential acid sulfate soils on Figure 9.3.1.3.1 Potential acid sulfate soils, the generation or release of acid and metal contaminants into the environment is avoided by: (1) not disturbing acid sulfate soils when excavating or otherwise removing soil or sediment, draining or extracting groundwater, and not undertaking filling that results in actual acid sulfate soils being moved below the water table or previously saturated acid sulfate soils being aerated; or (2) where disturbance of acid sulfate soils will not be avoided, development: a. neutralises existing acidity and prevents the generation of acid and metal contaminants; and b. prevents the release of surface or groundwater flows containing acid and metal contaminants into the environment. *Editor's Note: Where works are proposed within the areas identified as potential acid sulfate soils, it is likely that an on-site acid sulfate investigation will be requested. Such an investigation should conform to the Queensland Sampling Guidelines and the Laboratory Methods Guidelines or Australian Standard 4969. Where acid sulfate soils will be disturbed, an environmental management plan must be prepared which outlines how the release of acid and metal contaminants will be prevented.*	**AO16.1** Development does not involve: (1) excavating or otherwise removing $100m^3$ or more of soil or sediment at or below 5m AHD; or (2) permanently or temporarily extracting groundwater resulting in the aeration of saturated acid sulfate soils; or (3) filling in excess of $500m^3$ with an average depth of 0.5m or greater that results in: a. actual acid sulfate soils being moved below the water table: or b. previously saturated acid sulfate soils being aerated.	**COMPLIES WITH A016.1 THROUGH CONDITIONS** It is considered suitable that conditions be placed on the development approval that required the preparation of a geotechnical investigation and if necessary a Acid Sulfate Soil Management Plan as part of future Operational Works.

Appendix B

Stormwater Management Design Drawings

DATE:	13.04.23
PROJECT No. :	BC -19142
DRAWING No. :	DWG -100
REVISION No. :	B

BIOME
WATER AND ENVIRONMENTAL CONSULTING

CONCEPTUAL STORMWATER MANAGEMENT DESIGN DRAWINGS

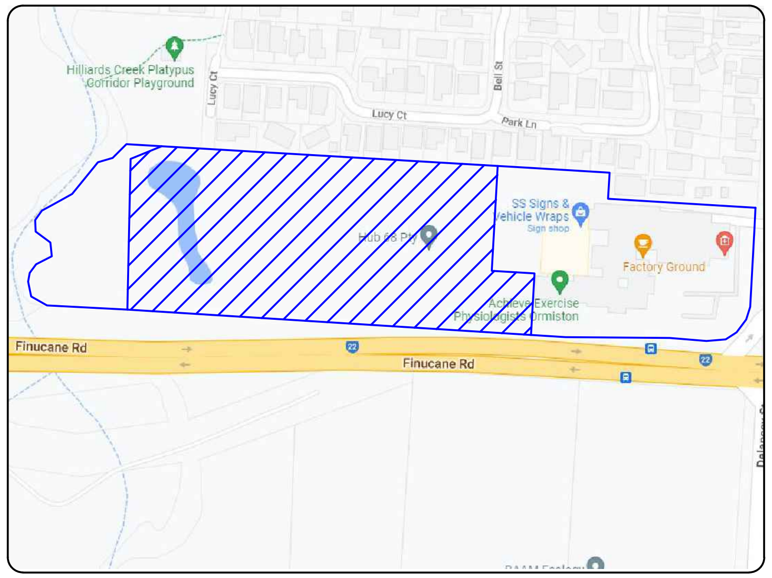
HUB68 CENTRE OF EXCELLENCE - AGING & WELLNESS
56-68 DELANCEY STREET, ORMISTON

for

THE HUB PRECINCT PTY LTD

Project No: BC -19142

April 2023



Site Location

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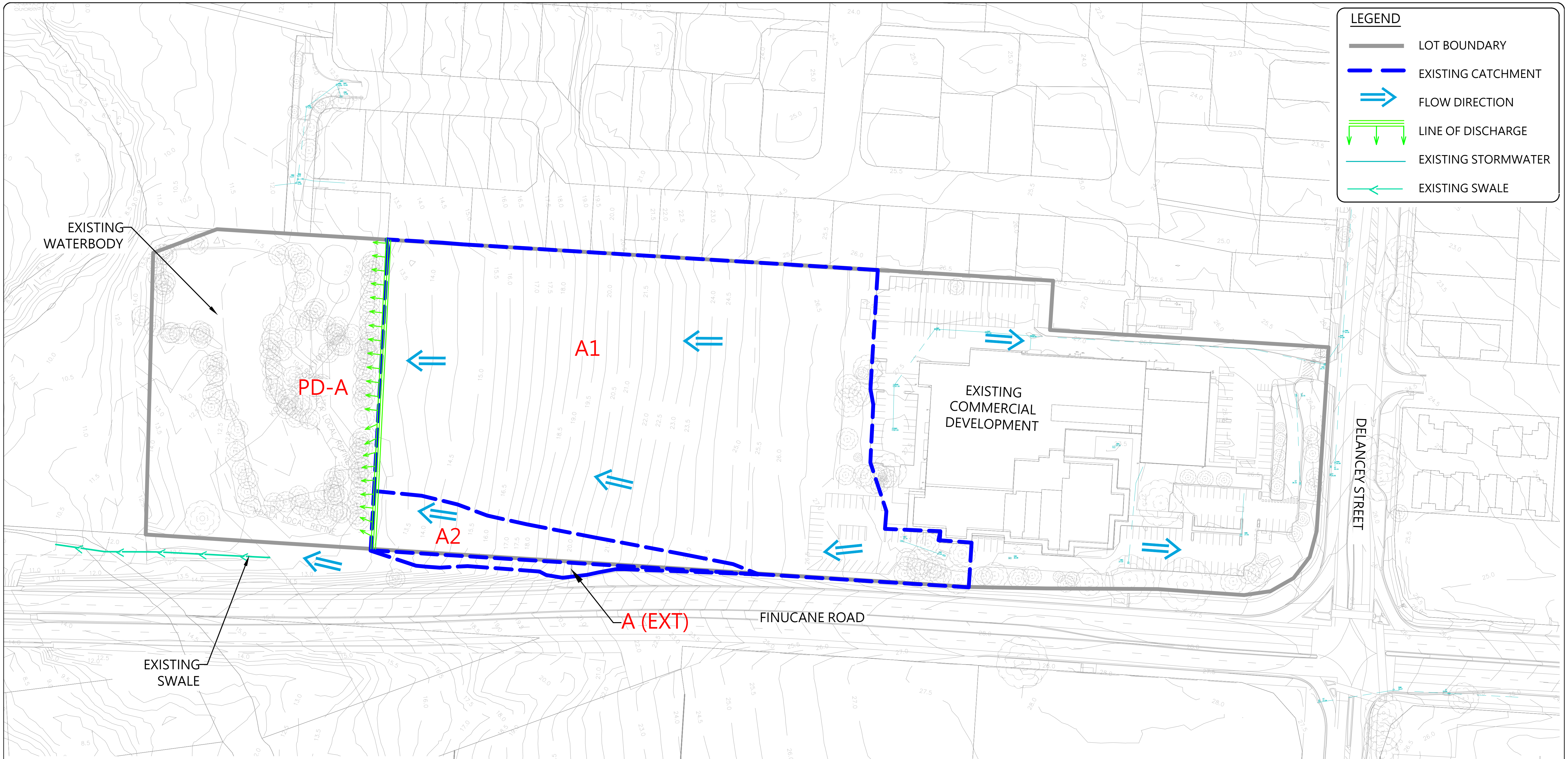
SCHEDULE OF DRAWINGS

Drawing No.	Drawing Title
DWG - 100	LOCALITY AND DRAWING INDEX PLAN
DWG - 200	EXISTING CATCHMENT PLAN
DWG - 201	DEVELOPED CATCHMENT PLAN
DWG - 300	OPERATIONAL CONTROL PLAN
DWG - 310	DETENTION TANK - SECTION DETAILS
DWG - 311	STORMFILTER PRE-CAST MANHOLE & OCEAN GUARD TYPICAL DETAILS



EXSITING CATCHMENT PARAMETERS

CATCH ID	A(EXT)	A1	A2
AREA (ha)	0.04	2.20	0.19
SLOPE (%)	10.6	7.6	8.8
IMPERVIOUSNESS (%)	0	5.5	0
DISCHARGE CONDITION	CHANNEL/SHEET	CHANNEL/SHEET	CHANNEL/SHEET
DISCHARGE LOCATION	PD-A	PD-A	PD-A

DATE: 13.04.23
PROJECT No.: BC-19142
DRAWING No.: DWG-200
REVISION No.: B

PROJECT: HUB68 CENTRE OF EXCELLENCE - AGING & WELLNESS
DRAWING TITLE: EXISTING CATCHMENT PLAN
CLIENT: THE HUB PRECINCT PTY LTD
ADDRESS: 56-68 DELANCEY STREET, ORMISTON

DRAFTED BY:	DESIGNED BY:	CHECKED BY:	PAPER SIZE:	SCALE:
EM	AK	BC	A3	1:1500

APPROVED FOR AND ON BEHALF OF BIOME CONSULTING PTY LTD
ACN 166 087 476
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A	ORIGINAL ISSUE		07.12.22
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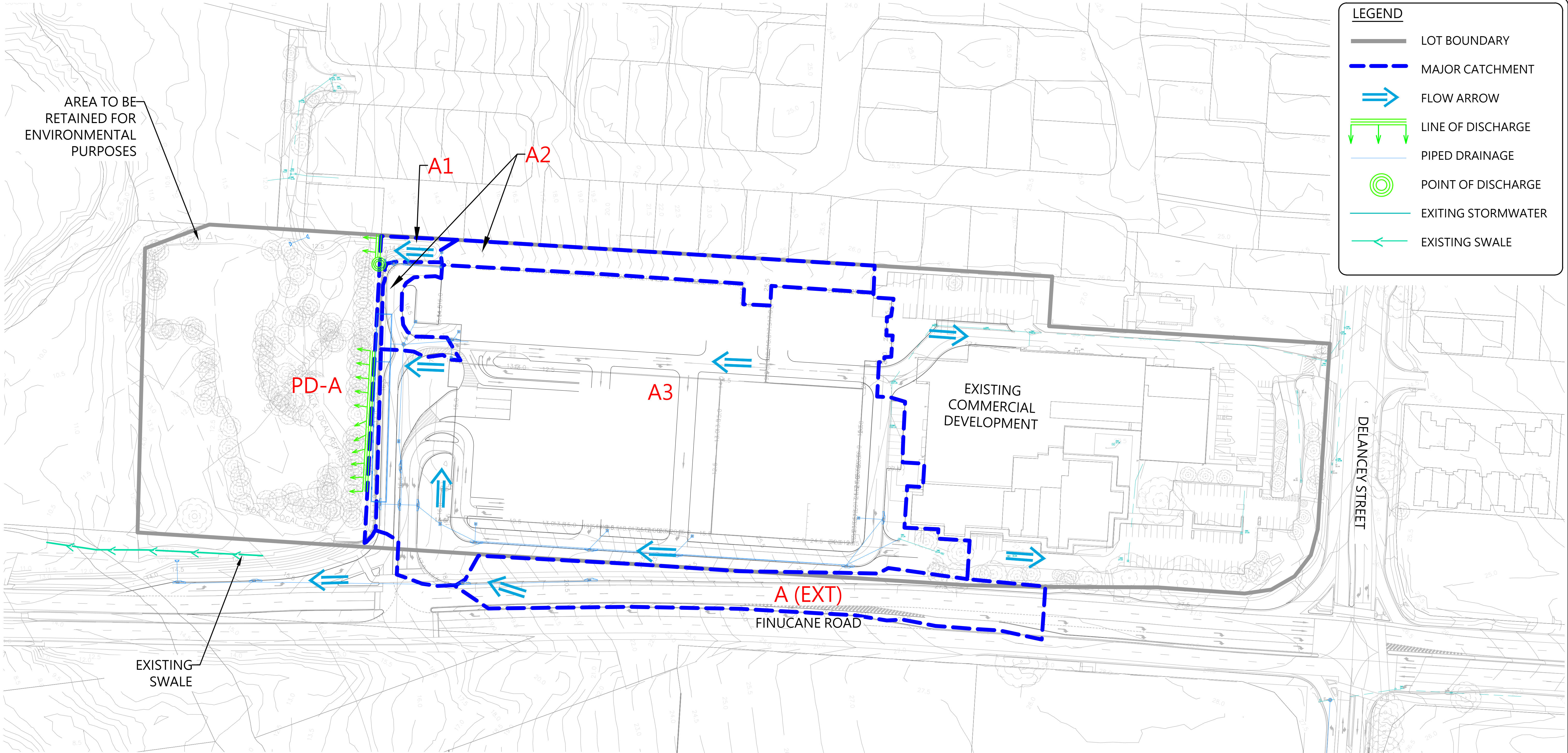
ORIGINAL SCALE BEFORE REDUCTION
15 0 15 30 45 60 75
1 : 1500 (FULL SIZE) (metres)

CERTIFIED BY

N



DEVELOPED CATCHMENT PARAMETERS

CATCH ID	A (EXT)	A1	A2	A3
AREA (ha)	0.382	0.052	0.216	2.210
SLOPE (%)	4.5	12.5	7.6	5.0
IMPERVIOUSNESS (%)	80.0	30.0	40.0	90.0
DISCHARGE CONDITION	PIPE/ROAD	BATTER/CHANNEL	PIPE/BATTER	PIPE
DISCHARGE LOCATION	PD-A	PD-A	PD-A	PD-A

DATE
13.04.23

PROJECT No. :
BC-19142

DRAWING No. :
DWG-201

REVISION No. :
B

PROJECT
HUB68 CENTRE OF EXCELLENCE - AGING & WELLNESS

DRAWING TITLE
DEVELOPED CATCHMENT PLAN

CLIENT
THE HUB PRECINCT PTY LTD

ADDRESS:
56-68 DELANCEY STREET, ORMISTON

DRAFTED BY :	DESIGNED BY :	CHECKED BY:	PAPER SIZE :	SCALE :
EM	AK	BC	A3	1:1500

APPROVED FOR AND ON BEHALF OF BIOME CONSULTING PTY LTD ACN 166 087 476

RPEQ No. :

VER.	DESCRIPTION	APPR.	DATE
A	ORIGINAL ISSUE		07.12.22
B	REVISED LAYOUT		13.04.23

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WATER AND ENVIRONMENTAL CONSULTING
BIOME Consulting Pty Ltd
PO Box 3469, Australia Fair, Southport
M 0415 935 222
E brad@BIOMEconsulting.com.au
ABN 86 166 087 476

ORIGINAL SCALE BEFORE REDUCTION
15 0 15 30 45 60 75
1 : 1500 (FULL SIZE) (metres)

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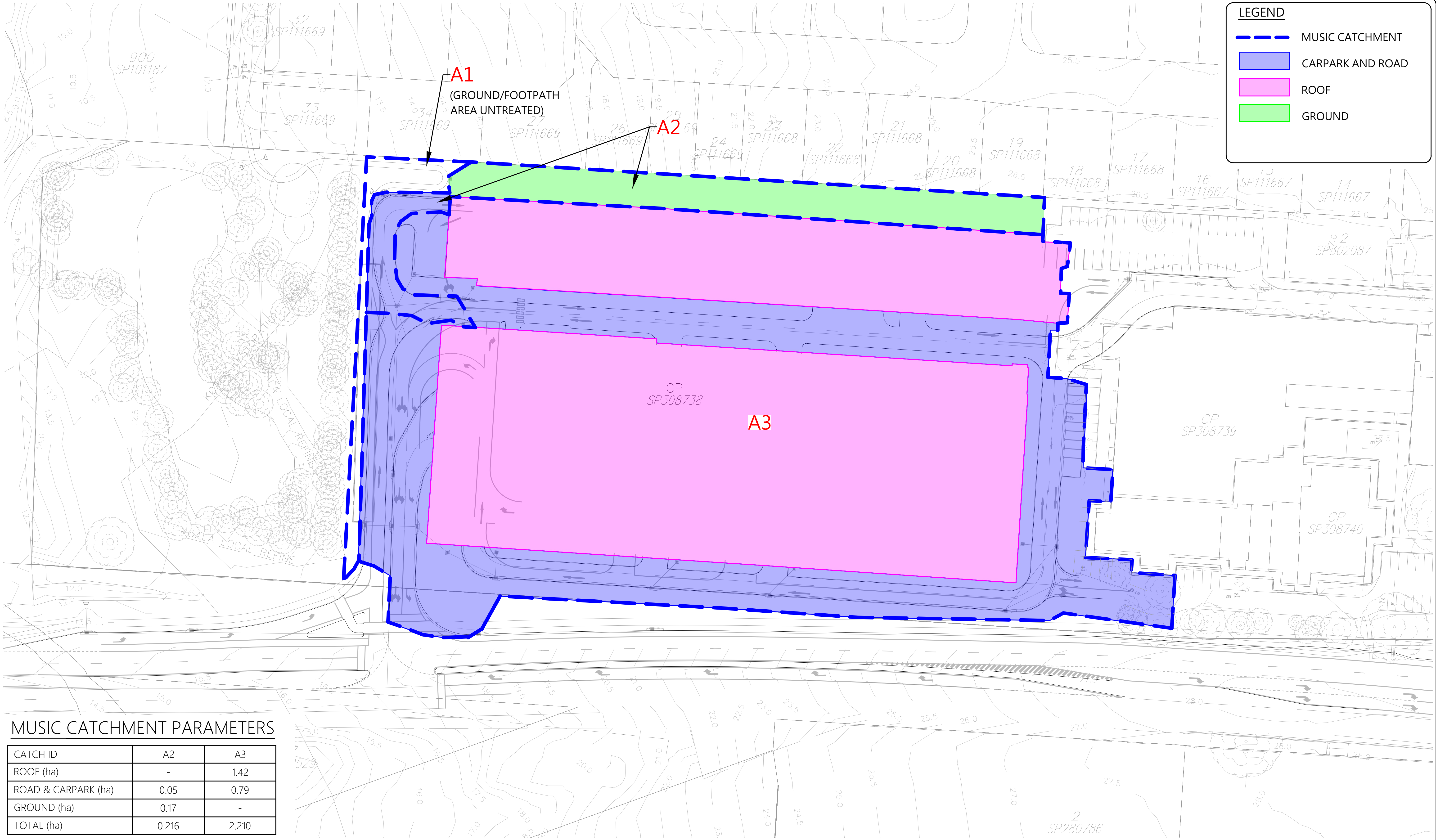
N



MUSIC CATCHMENT PARAMETERS

CATCH ID	A2	A3
ROOF (ha)	-	1.42
ROAD & CARPARK (ha)	0.05	0.79
GROUND (ha)	0.17	-
TOTAL (ha)	0.216	2.210

DATE 13.04.23

PROJECT No. : BC-19142

DRAWING No. : DWG-210

REVISION No. : B

PROJECT: HUB68 CENTRE OF EXCELLENCE - AGING & WELLNESS

DRAWING TITLE: MUSIC CATCHMENT PLAN

CLIENT: THE HUB PRECINCT PTY LTD

ADDRESS: 56-68 DELANCEY STREET, ORMISTON

DRAFTED BY :	DESIGNED BY :	CHECKED BY:	PAPER SIZE :	SCALE :
EM	AK	BC	A3	1:1000

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RPEQ No. :

VER.	DESCRIPTION	APPR.	DATE
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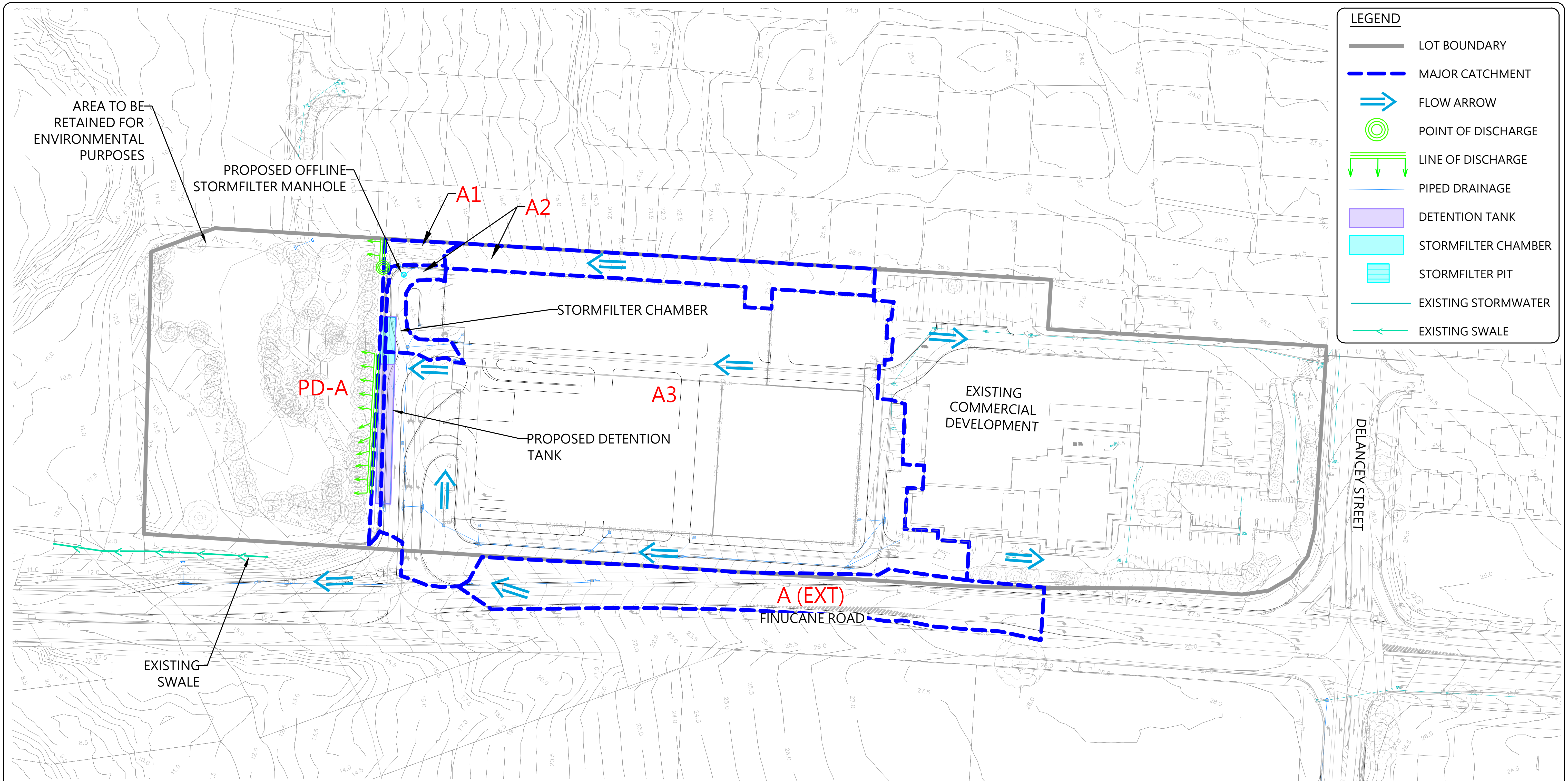
ORIGINAL SCALE BEFORE REDUCTION

10 0 10 20 30 40 50

1 : 1000 (FULL SIZE) (metres)

CERTIFIED BY

N



STORMWATER MANAGEMENT MEASURES

CATCHMENT ID	A2	A3
No. 690 mm PSORB Stormfilter Catridges	4	42
Stormfilter Housing	1460 mm Manhole (pre-cast)	100 m2 Chamber within Detention Tank
No. OceanGuard Systems	2	18
1% AEP Volume (m3) within Detention Tank - exc. treatment volume	-	620

DATE: 13.04.23

PROJECT No.: BC-19142

DRAWING No.: DWG-300

REVISION No.: B

PROJECT: HUB68 CENTRE OF EXCELLENCE - AGING & WELLNESS

DRAWING TITLE: OPERATIONAL CONTROL PLAN

CLIENT: THE HUB PRECINCT PTY LTD

ADDRESS: 56-68 DELANCEY STREET, ORMISTON

DRAFTED BY:	DESIGNED BY:	CHECKED BY:	PAPER SIZE:	SCALE:
EM	AK	BC	A3	1:1500

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VER.	DESCRIPTION	APPR.	DATE
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B	REVISED LAYOUT		13.04.23

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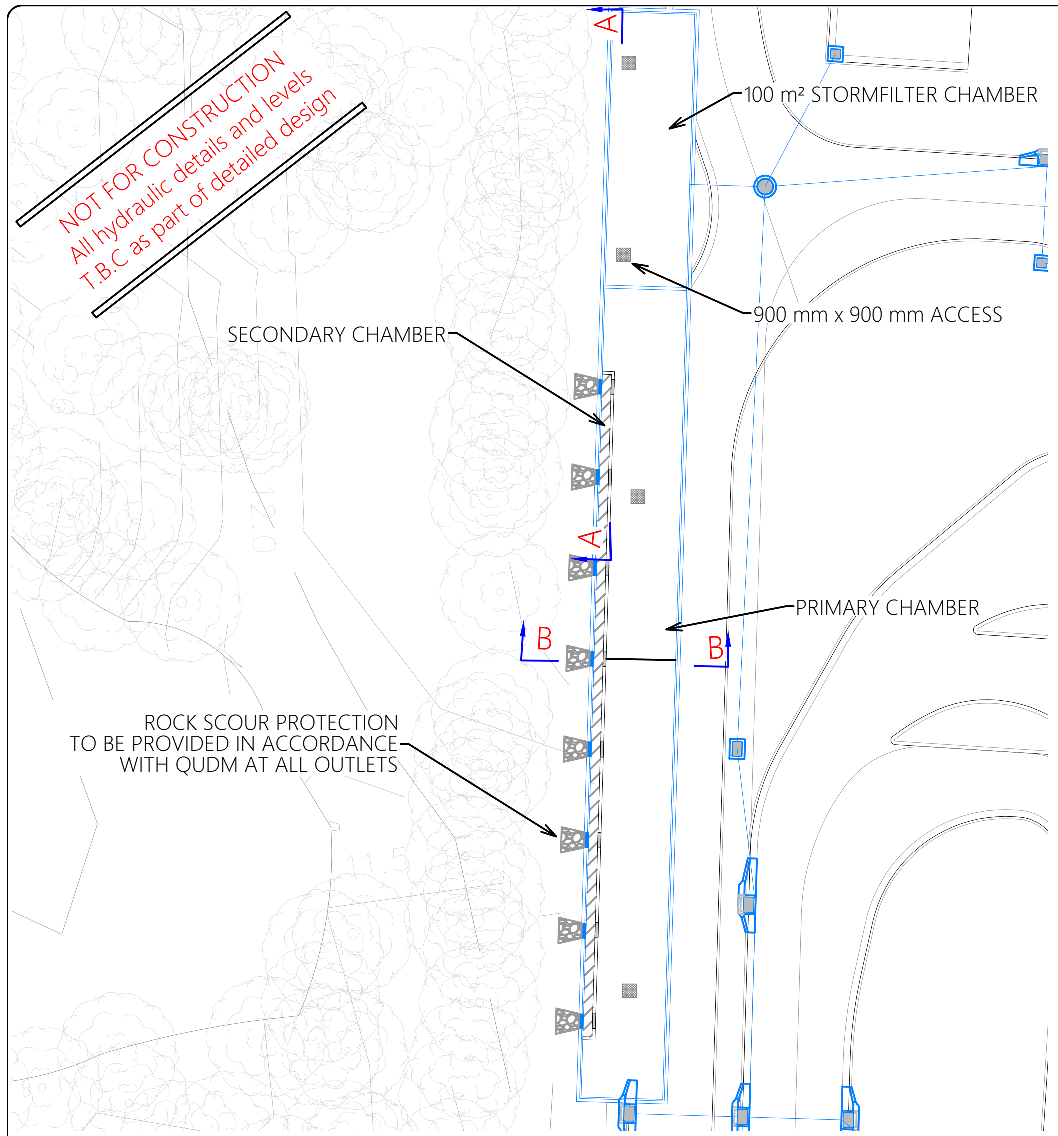
ORIGINAL SCALE BEFORE REDUCTION

15 0 15 30 45 60 75

1 : 1500 (FULL SIZE) (metres)

CERTIFIED BY

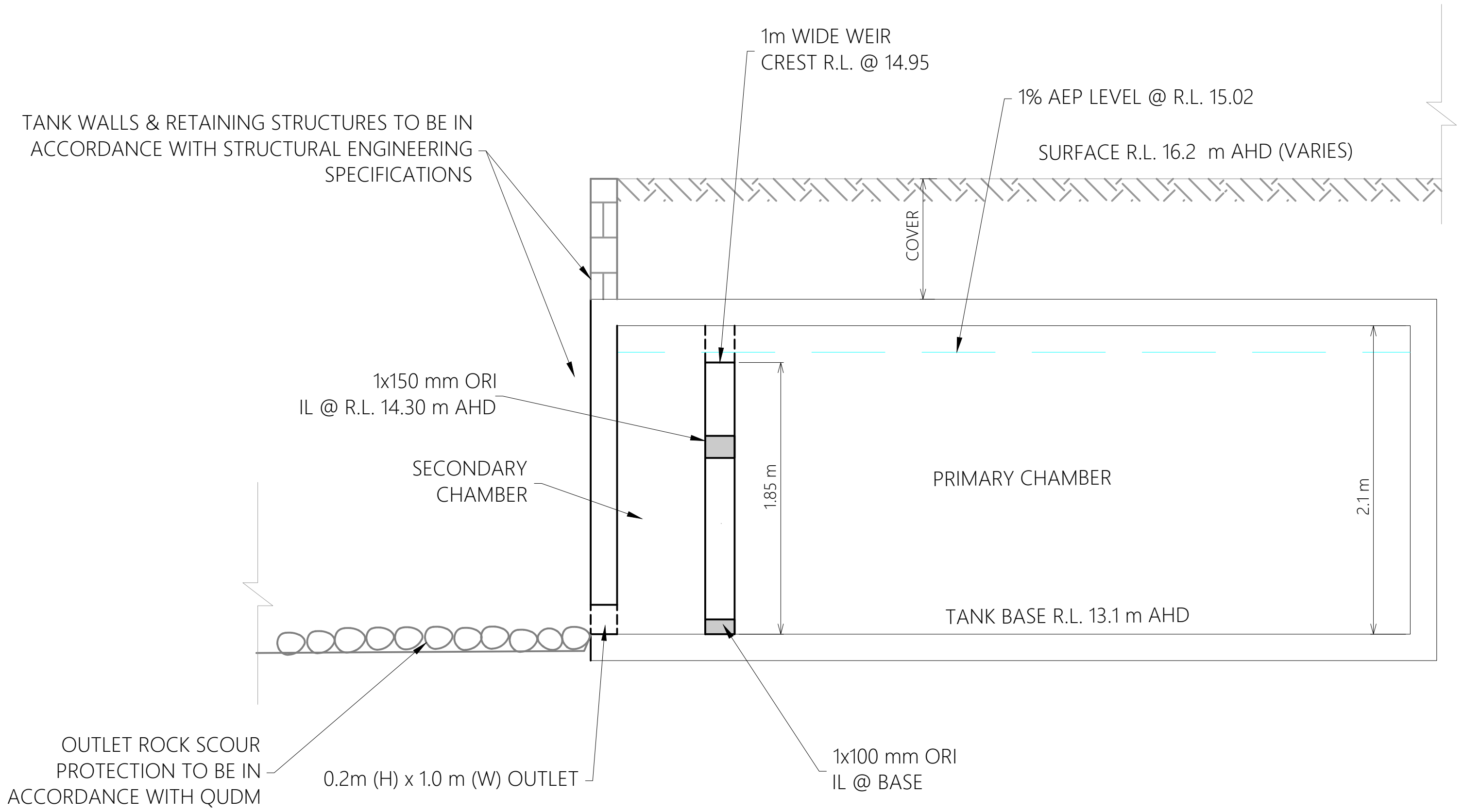
N



DETENTION TANK - PLAN LAYOUT

4 0 4 8 12 16 20

1 : 400 (FULL SIZE) (metres)



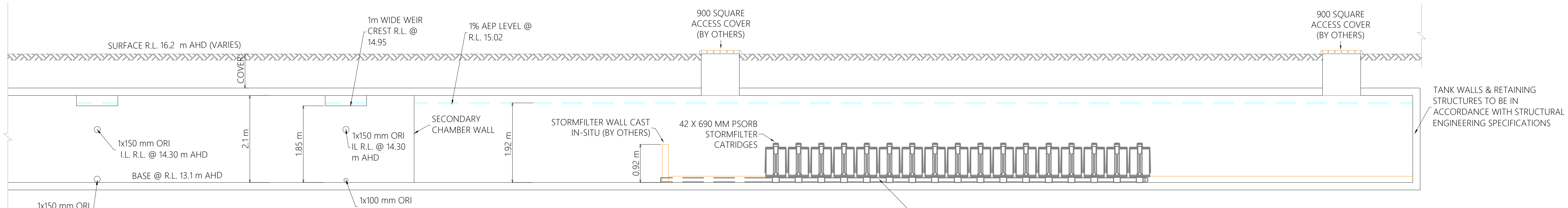
SECTION DETAIL B-B

1 0 1 2 3 4 5

1 : 100 (FULL SIZE) (metres)

DETENTION TANK OUTLET CONFIGURATION	
PRIMARY CHAMBER OUTLET	SECONDARY CHAMBER OUTLET
5 x 150 mm I.L. @ TANK BASE 3 X 100 mm I.L. @ TANK BASE 8 x 150 mm I.L. @ R.L. 14.30 m AHD	8 x 0.2 m (H) x 1 m (W) OUTLET
8 x 1 m CREST @ R.L. 14.95 m AHD	

NOTE: PRIMARY OUTLET LOCATIONS TO ALIGN WITH SECONDARY OUTLETS



SECTION DETAIL - A-A

1 0 1 2 3 4 5

1 : 100 (FULL SIZE) (metres)

DATE
13.04.23

PROJECT No. :
BC-19142

DRAWING No. :
DWG-310

REVISION No. :
B

PROJECT
HUB68 CENTRE OF EXCELLENCE - AGING & WELLNESS

DRAWING TITLE
DETENTION TANK - SECTION DETAILS

CLIENT
THE HUB PRECINCT PTY LTD

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EM	AK	BC	A3	AS SHOWN

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ACN 166 087 476
RPEQ No. :

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A	ORIGINAL ISSUE		07.12.22
B	REVISED LAYOUT		13.04.23

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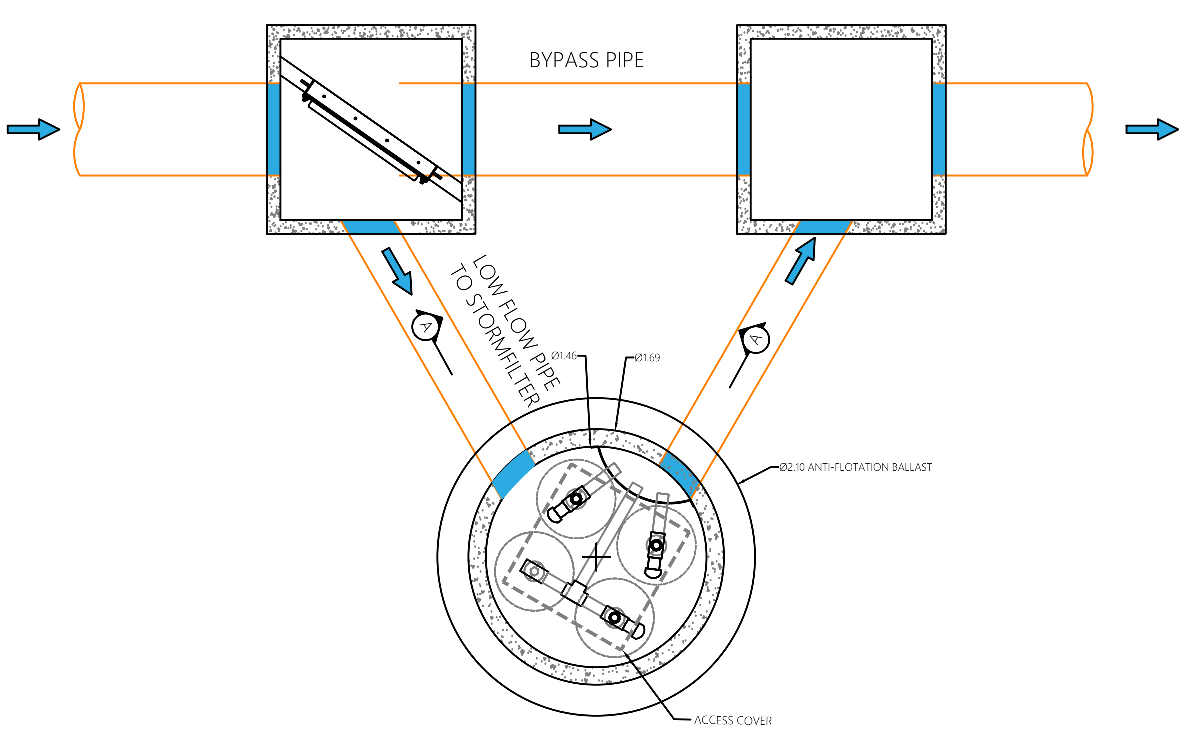
ORIGINAL SCALE BEFORE REDUCTION

CERTIFIED BY

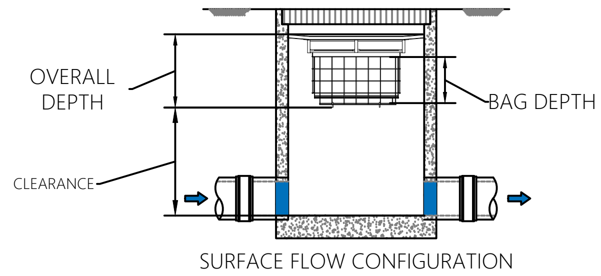
N

NOT FOR CONSTRUCTION
All hydraulic details and levels
T.B.C as part of detailed design

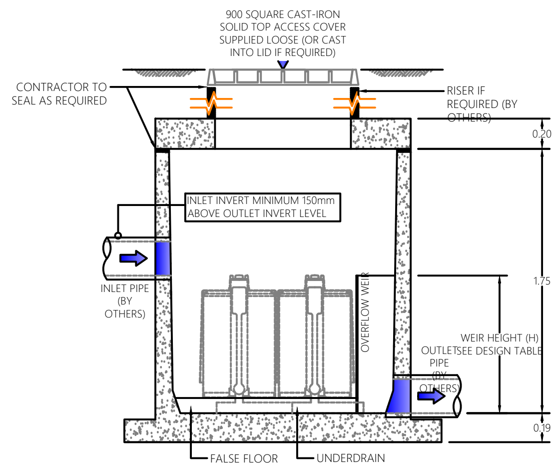
NOTE: FIELD INLET PITS UPSTREAM OF STORMFILTER SYSTEMS TO BE FITTED WITH OCEANGUARD SYSTEMS



PLAN OF TYPICAL OFFLINE LAYOUT



TYPICAL SECTION OF OCEANGUARD SYSTEM
(BY OCEAN PROTECT)



SECTION A-A

STORMWATER QUALITY MANAGEMENT	
CATCH ID	A2
NO. 690 PSORB STORMFILTER CATRIDGES	4
STORMFILTER HOUSING	1,460 mm MH
NO. OCEANGUARD SYSTEMS	2

NOTE: DRAWING ADAPTED FROM 3C-SFCP-1212-1A SFMH_OFFLINE_TYP_2, & OG-SD BY OCEAN PROTECT.

DATE
13.04.23
PROJECT No. :
BC-19142
DRAWING No. :
DWG-311
REVISION No. :
B

PROJECT
HUB68 CENTRE OF EXCELLENCE - AGING & WELLNESS
DRAWING TITLE
STORMFILTER MANHOLE & OCEAN GUARD TYPICAL DETAILS
CLIENT
THE HUB PRECINCT PTY LTD
ADDRESS:
56-68 DELANCEY STREET, ORMISTON

DRAFTED BY :	DESIGNED BY :	CHECKED BY:	PAPER SIZE :	SCALE :
EM	AK	BC	A3	1:400

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ACN 166 087 476
RPEQ No. :

VER.	DESCRIPTION	APPR.	DATE
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B	REVISED LAYOUT		13.04.23

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ORIGINAL SCALE BEFORE REDUCTION
0.5 0 0.5 1.0 1.5 2.0 2.5
1 : 50 (FULL SIZE) (metres)
CERTIFIED BY

N

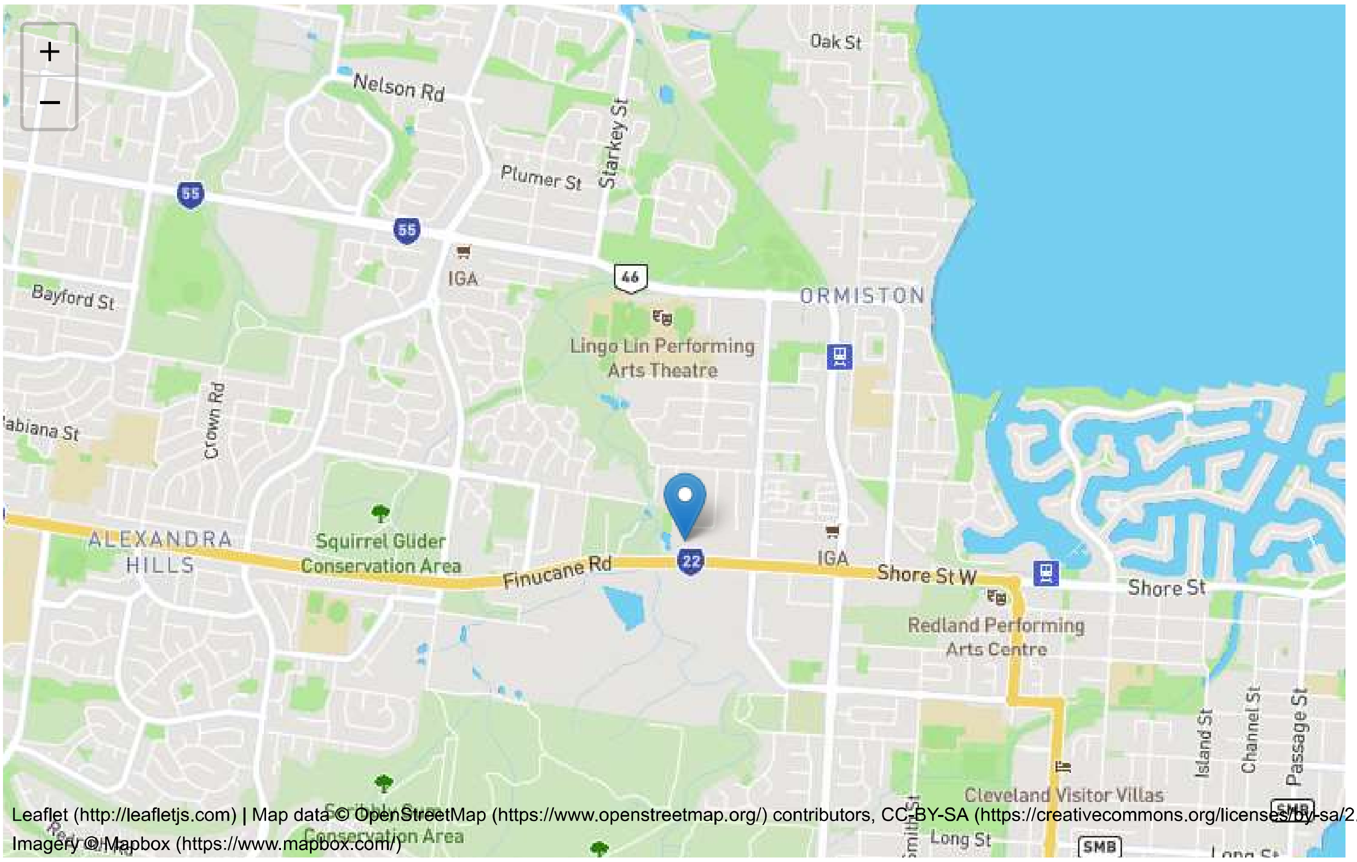
Appendix C

ARR Data Hub Summary Output

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	153.248
Latitude	-27.523
Selected Regions (clear)	
Storm Losses	show
Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
LIMB 2020 IFD - High Resolution	show
LIMB 2020 IFD - Enveloped	show
LIMB 2020 IFD - BoM Resolution	show



Data

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

ID	24190.0
Storm Initial Losses (mm)	26.0
Storm Continuing Losses (mm/h)	1.7

Layer Info

Time Accessed	18 November 2022 11:12AM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/ECnorth.zip)

code	ECnorth
Label	East Coast North

Layer Info

Time Accessed	18 November 2022 11:12AM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-27.52283&longitude=153.24792&sdmin=true&sdhr=true&sdday=true&user_label=) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	18 November 2022 11:12AM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	2.6 (0.064)	8.7 (0.153)	12.7 (0.187)	16.5 (0.211)	12.4 (0.133)	9.2 (0.089)
90 (1.5)	4.2 (0.089)	11.2 (0.171)	15.8 (0.203)	20.3 (0.223)	16.1 (0.149)	13.0 (0.106)
120 (2.0)	3.6 (0.070)	10.5 (0.145)	15.0 (0.174)	19.4 (0.192)	20.2 (0.167)	20.8 (0.152)
180 (3.0)	7.2 (0.122)	18.3 (0.222)	25.7 (0.258)	32.7 (0.280)	42.2 (0.300)	49.4 (0.309)
360 (6.0)	7.5 (0.100)	20.3 (0.192)	28.8 (0.224)	36.9 (0.244)	64.8 (0.353)	85.7 (0.409)
720 (12.0)	8.7 (0.089)	21.0 (0.152)	29.2 (0.174)	37.0 (0.186)	61.8 (0.255)	80.4 (0.290)
1080 (18.0)	9.0 (0.080)	16.8 (0.104)	21.9 (0.111)	26.8 (0.114)	50.3 (0.176)	67.9 (0.207)
1440 (24.0)	6.5 (0.052)	12.2 (0.067)	16.0 (0.072)	19.6 (0.074)	35.3 (0.109)	47.0 (0.127)
2160 (36.0)	0.2 (0.001)	5.1 (0.024)	8.4 (0.032)	11.5 (0.037)	26.2 (0.069)	37.2 (0.085)
2880 (48.0)	0.0 (0.000)	2.2 (0.009)	3.6 (0.013)	5.0 (0.015)	18.0 (0.043)	27.7 (0.057)
4320 (72.0)	0.0 (0.000)	0.7 (0.003)	1.1 (0.003)	1.6 (0.004)	9.7 (0.020)	15.8 (0.028)

Layer Info

Time Accessed	18 November 2022 11:12AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

LIMB 2020 IFD - High Resolution

min (h)\AEP(%)	63.23	50.0	39.35	20.0	18.13	10.0	5.0	2.0	1.0	0.5	0.2	0.1	0.05
5 (0.08)	10.2	11.4	12.3	14.8	15.1	17.0	18.7	21.0	22.5	25.4	29.6	33.1	36.7
10 (0.17)	16.7	18.7	20.3	24.4	24.9	27.7	31.2	35.2	38.1	42.7	49.7	55.3	61.2
15 (0.25)	21.1	23.6	25.7	30.9	31.5	35.3	40.0	45.6	49.6	55.7	64.8	72.1	79.8
20 (0.33)	24.3	27.1	29.6	35.7	36.5	41.0	46.7	53.6	58.7	65.9	76.7	85.4	94.7
25 (0.42)	26.8	29.9	32.7	39.5	40.4	45.7	52.1	60.1	66.1	74.3	86.6	96.4	106.8
30 (0.5)	28.9	32.2	35.2	42.7	43.7	49.5	56.5	65.6	72.4	81.5	94.9	105.9	117.5
45 (0.75)	33.5	37.3	40.9	49.7	51.0	58.4	66.8	78.2	87.0	97.9	114.5	127.7	141.9
60 (1.0)	36.8	41.1	45.1	55.0	56.4	64.9	74.4	87.5	97.9	110.3	128.9	144.0	159.8
90 (1.5)	41.8	46.8	51.4	62.9	64.6	74.8	85.8	101.5	114.0	128.4	150.0	167.4	185.8
120 (2.0)	45.7	51.2	56.4	69.2	71.1	82.5	94.7	112.3	126.3	142.3	166.0	184.8	205.5
180 (3.0)	52.0	58.4	64.5	79.4	81.6	94.6	109.0	129.3	145.4	163.2	190.1	211.8	235.0
270 (4.5)	59.4	67.1	74.2	91.7	94.2	109.0	126.0	149.3	167.5	187.3	217.9	242.5	268.5
360 (6.0)	65.5	74.2	82.2	102.0	104.8	120.9	140.2	165.8	185.7	207.7	241.6	268.0	296.5
540 (9.0)	75.4	85.9	95.5	119.1	122.2	140.7	163.9	193.4	216.1	241.5	279.9	310.7	343.2
720 (12.0)	83.2	95.2	106.1	133.1	136.6	157.2	183.6	216.5	241.6	270.1	313.1	347.6	384.2
1080 (18.0)	95.2	109.7	122.8	155.2	159.4	184.0	215.6	254.7	284.4	318.2	369.8	411.1	454.6
1440 (24.0)	104.0	120.5	135.4	172.3	177.2	205.6	241.3	286.0	320.1	359.7	419.2	466.7	517.4
1800 (30.0)	110.9	129.0	145.5	186.1	191.6	223.5	262.7	312.7	350.8	400.1	469.7	526.8	587.6
2160 (36.0)	116.5	135.9	153.7	197.5	203.5	238.9	280.9	335.8	377.9	434.1	511.8	576.4	645.6
2880 (48.0)	125.0	146.6	166.4	215.5	222.5	263.8	310.5	374.2	423.8	490.1	581.0	656.6	738.4
4320 (72.0)	136.8	161.0	183.8	240.0	248.6	298.7	352.7	430.7	492.6	568.9	676.5	765.9	863.6
5760 (96.0)	145.3	171.2	195.9	256.9	266.3	321.7	381.9	470.2	541.4	621.2	739.4	837.3	943.0
7200 (120.0)	152.7	179.8	205.8	270.1	279.9	337.7	403.6	499.2	576.9	658.7	784.4	887.5	999.4
8640 (144.0)	159.8	187.8	214.8	281.4	291.3	349.1	420.8	521.1	603.0	687.8	818.2	925.4	1041.6
10080 (168.0)	167.1	195.8	223.5	291.9	301.5	357.4	435.1	538.0	622.1	710.2	844.6	955.5	1074.7

Layer Info

Time Accessed	18 November 2022 11:12AM
Version	2022_v1

Note	The LIMB 2020 IFDs were developed for four local governments, including Ipswich City Council (ICC), Lockyer Valley Regional Council (LVRC) and Moreton Bay Regional Council (MBRC), as it was found the 2016 IFDs were not fully representative of these catchments. The LIMB 2020 IFDs were informed by additional council sub-daily rainfall gauge data, and were developed using methods that placed higher weighting on this data. They resulted in a reduction in local biases across all AEPs, durations and areas, compared to the 2016 IFDs. The LIMB 2020 IFDs come in three formats; high resolution, BOM resolution, and envelope of 2016/2020 IFDs. This dataset is the high resolution dataset, being gridded 2020 IFD output at fine resolution (0.005 degrees). More information on the 2020 IFDs is available under the Jurisdiction Specifics menu option of this website. Practitioners undertaking works for either ICC, LVRC or MBRC in general should utilise the Envelope of the BOM 2016 IFDs and LIMB 2020 IFDs. Where project objectives and scope indicate a benefit of utilising the High Resolution LIMB 2020 IFDs, practitioners working for these councils should contact the relevant council directly to discuss. All other practitioners working within the regions for which 2020 IFDs are available should consider the guidance of Australian Rainfall and Runoff on their use.

LIMB 2020 IFD - Enveloped

min (h)\AEP(%)	63.23	50.0	39.35	20.0	18.13	10.0	5.0	2.0	1.0	0.5	0.2	0.1	0.05
5 (0.08)	10.2	11.5	12.4	14.9	15.2	17.6	20.3	23.8	26.5	29.9	34.9	38.9	43.2
10 (0.17)	16.8	18.5	20.2	24.5	24.9	28.6	32.7	38.1	42.2	47.3	55.1	61.3	67.9
15 (0.25)	21.2	23.3	25.6	31.0	31.7	36.4	41.6	48.4	53.5	60.0	69.9	77.8	86.2
20 (0.33)	24.4	26.9	29.5	36.0	36.7	42.3	48.5	56.4	62.5	70.2	81.7	91.0	101.0
25 (0.42)	26.9	29.8	32.6	40.0	40.8	47.1	54.0	63.1	70.0	78.7	91.7	102.0	113.0
30 (0.5)	29.0	32.1	35.3	43.4	44.2	51.2	58.8	68.8	76.4	86.0	100.0	112.0	124.0
45 (0.75)	33.5	37.5	41.4	51.1	52.1	60.6	69.9	82.3	91.8	103.0	121.0	135.0	150.0
60 (1.0)	36.8	41.4	45.8	56.8	58.0	67.6	78.2	92.6	104.0	117.0	137.0	153.0	169.0
90 (1.5)	41.8	47.3	52.5	65.4	66.7	78.2	91.0	108.0	122.0	138.0	161.0	180.0	199.0
120 (2.0)	45.7	51.9	57.6	72.1	73.5	86.4	101.0	121.0	137.0	154.0	180.0	200.0	223.0
180 (3.0)	52.0	59.2	65.7	82.7	84.4	99.6	117.0	141.0	160.0	179.0	209.0	233.0	258.0
270 (4.5)	59.5	67.8	75.3	95.3	97.2	115.0	136.0	164.0	187.0	209.0	243.0	271.0	300.0
360 (6.0)	65.6	75.0	83.2	106.0	108.0	128.0	151.0	183.0	209.0	234.0	272.0	302.0	334.0
540 (9.0)	75.9	86.9	96.5	123.0	126.0	150.0	177.0	215.0	246.0	275.0	319.0	354.0	391.0
720 (12.0)	84.3	96.8	107.0	138.0	141.0	168.0	199.0	242.0	277.0	310.0	359.0	399.0	441.0
1080 (18.0)	98.0	113.0	125.0	162.0	165.0	198.0	235.0	286.0	329.0	368.0	428.0	476.0	526.0
1440 (24.0)	109.0	126.0	140.0	182.0	185.0	222.0	264.0	323.0	371.0	417.0	486.0	541.0	600.0
1800 (30.0)	118.0	136.0	151.0	198.0	202.0	242.0	288.0	353.0	406.0	463.0	544.0	610.0	681.0
2160 (36.0)	125.0	145.0	161.0	211.0	216.0	259.0	309.0	379.0	437.0	502.0	592.0	667.0	748.0
2880 (48.0)	137.0	159.0	177.0	233.0	238.0	287.0	342.0	422.0	487.0	563.0	668.0	755.0	850.0
4320 (72.0)	153.0	178.0	198.0	262.0	267.0	324.0	387.0	480.0	556.0	642.0	764.0	865.0	976.0
5760 (96.0)	163.0	190.0	211.0	279.0	285.0	345.0	414.0	514.0	597.0	685.0	816.0	925.0	1040.0
7200 (120.0)	170.0	197.0	219.0	289.0	295.0	357.0	429.0	533.0	620.0	708.0	844.0	955.0	1080.0
8640 (144.0)	175.0	202.0	224.0	294.0	300.0	363.0	436.0	541.0	630.0	719.0	856.0	969.0	1090.0
10080 (168.0)	178.0	205.0	227.0	296.0	302.0	365.0	438.0	542.0	631.0	721.0	858.0	971.0	1090.0

Layer Info

Time Accessed	18 November 2022 11:12AM
Version	2022_v1
Note	The LIMB 2020 IFDs were developed for four local governments, including Ipswich City Council (ICC), Lockyer Valley Regional Council (LVRC) and Moreton Bay Regional Council (MBRC), as it was found the 2016 IFDs were not fully representative of these catchments. The LIMB 2020 IFDs were informed by additional council sub-daily rainfall gauge data, and were developed using methods that placed higher weighting on this data. They resulted in a reduction in local biases across all AEPs, durations and areas, compared to the 2016 IFDs. The LIMB 2020 IFDs come in three formats; high resolution, BOM resolution, and envelope of 2016/2020 IFDs. This dataset is the envelope dataset, being the maximum of the BOM 2016 IFD dataset or the 2020 IFD (resolution aligned to BOM 2016 IFDs). More information on the 2020 IFDs is available under the Jurisdiction Specifics menu option of this website. Practitioners undertaking works for either ICC, LVRC or MBRC in general should utilise the Envelope of the BOM 2016 IFDs and LIMB 2020 IFDs. Where project objectives and scope indicate a benefit of utilising the High Resolution LIMB 2020 IFDs, practitioners working for these councils should contact the relevant council directly to discuss. All other practitioners working within the regions for which 2020 IFDs are available should consider the guidance of Australian Rainfall and Runoff on their use.

LIMB 2020 IFD - BoM Resolution

min (h)\AEP(%)	63.23	50.0	39.35	20.0	18.13	10.0	5.0	2.0	1.0	0.5	0.2	0.1	0.05
5 (0.08)	10.2	11.5	12.4	14.9	15.1	17.6	20.3	23.8	26.5	29.9	34.9	38.9	43.2
10 (0.17)	16.8	18.5	20.2	24.5	24.9	28.6	32.7	38.1	42.2	47.3	55.1	61.3	67.9
15 (0.25)	21.2	23.3	25.6	31.0	31.7	36.4	41.6	48.4	53.5	60.0	69.9	77.8	86.2
20 (0.33)	24.4	26.9	29.5	36.0	36.6	42.3	48.5	56.4	62.5	70.2	81.7	91.0	101.0
25 (0.42)	26.9	29.8	32.6	40.0	40.5	47.1	54.0	63.1	70.0	78.7	91.7	102.0	113.0
30 (0.5)	29.0	32.1	35.2	43.4	43.7	51.2	58.8	68.8	76.4	86.0	100.0	112.0	124.0
45 (0.75)	33.5	37.5	41.0	51.1	50.9	60.6	69.9	82.3	91.8	103.0	121.0	135.0	150.0
60 (1.0)	36.8	41.4	45.2	56.8	56.2	67.6	78.2	92.6	104.0	117.0	137.0	153.0	169.0
90 (1.5)	41.8	47.3	51.6	65.4	64.2	78.2	91.0	108.0	122.0	138.0	161.0	180.0	199.0
120 (2.0)	45.7	51.9	56.5	72.1	70.5	86.4	101.0	121.0	137.0	154.0	180.0	200.0	223.0
180 (3.0)	52.0	59.2	64.4	82.7	80.8	99.6	117.0	141.0	160.0	179.0	209.0	233.0	258.0
270 (4.5)	59.5	67.8	73.7	95.3	93.2	115.0	136.0	164.0	187.0	209.0	243.0	271.0	300.0
360 (6.0)	65.6	75.0	81.4	106.0	103.8	128.0	151.0	183.0	209.0	234.0	272.0	302.0	334.0
540 (9.0)	75.9	86.9	94.2	123.0	121.3	150.0	177.0	215.0	246.0	275.0	319.0	354.0	391.0
720 (12.0)	84.3	96.8	104.6	138.0	135.8	168.0	199.0	242.0	277.0	310.0	359.0	399.0	441.0
1080 (18.0)	98.0	113.0	121.1	162.0	159.0	198.0	235.0	286.0	329.0	368.0	428.0	476.0	526.0
1440 (24.0)	109.0	126.0	134.1	182.0	177.0	222.0	264.0	323.0	371.0	417.0	486.0	541.0	600.0
1800 (30.0)	118.0	136.0	144.5	198.0	191.6	242.0	288.0	353.0	406.0	463.0	544.0	610.0	681.0
2160 (36.0)	125.0	145.0	153.3	211.0	203.7	259.0	309.0	379.0	437.0	502.0	592.0	667.0	748.0
2880 (48.0)	137.0	159.0	167.1	233.0	222.9	287.0	342.0	422.0	487.0	563.0	668.0	755.0	850.0
4320 (72.0)	153.0	178.0	185.9	262.0	248.9	324.0	387.0	480.0	556.0	642.0	764.0	865.0	976.0
5760 (96.0)	163.0	190.0	198.2	279.0	266.5	345.0	414.0	514.0	597.0	685.0	816.0	925.0	1040.0
7200 (120.0)	170.0	197.0	207.1	289.0	279.8	357.0	429.0	533.0	620.0	708.0	844.0	955.0	1080.0
8640 (144.0)	175.0	202.0	214.1	294.0	291.0	363.0	436.0	541.0	630.0	719.0	856.0	969.0	1090.0
10080 (168.0)	178.0	205.0	219.8	296.0	301.1	365.0	438.0	542.0	631.0	721.0	858.0	971.0	1090.0

Layer Info

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Version	2022_v1

Note	The LIMB 2020 IFDs were developed for four local governments, including Ipswich City Council (ICC), Lockyer Valley Regional Council (LVRC) and Moreton Bay Regional Council (MBRC), as it was found the 2016 IFDs were not fully representative of these catchments. The LIMB 2020 IFDs were informed by additional council sub-daily rainfall gauge data, and were developed using methods that placed higher weighting on this data. They resulted in a reduction in local biases across all AEPs, durations and areas, compared to the 2016 IFDs. The LIMB 2020 IFDs come in three formats; high resolution, BOM resolution, and envelope of 2016/2020 IFDs. This dataset is the BOM resolution dataset, being gridded 2020 IFD output aligned to resolution of 2016 BOM IFDs (0.02479 degrees). More information on the 2020 IFDs is available under the Jurisdiction Specifics menu option of this website. Practitioners undertaking works for either ICC, LVRC or MBRC in general should utilise the Envelope of the BOM 2016 IFDs and LIMB 2020 IFDs. Where project objectives and scope indicate a benefit of utilising the High Resolution LIMB 2020 IFDs, practitioners working for these councils should contact the relevant council directly to discuss. All other practitioners working within the regions for which 2020 IFDs are available should consider the guidance of Australian Rainfall and Runoff on their use.

Location

Label: Delancey St

Latitude: -27.523 [Nearest grid cell: 27.5125 (S)]

Longitude:153.249 [Nearest grid cell: 153.2375 (E)]

IFD Design Rainfall Intensity (mm/h)

Issued: 05 December 2022

Rainfall intensity for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	162	183	250	295	338	395	438
2 min	135	153	211	251	292	348	391
3 min	127	143	197	235	272	322	361
4 min	121	137	187	222	257	303	338
5 min	116	131	179	212	244	286	318
10 min	94.9	107	146	172	196	229	253
15 min	80.5	91.1	124	146	166	194	214
20 min	70.1	79.3	108	127	145	169	187
25 min	62.2	70.5	96.0	113	130	151	168
30 min	56.1	63.6	86.8	102	118	138	153
45 min	43.8	49.7	68.1	80.7	93.1	110	122
1 hour	36.4	41.3	56.8	67.6	78.2	92.6	104
1.5 hour	27.8	31.5	43.6	52.1	60.6	72.3	81.4
2 hour	22.8	25.9	36.1	43.2	50.5	60.4	68.3
3 hour	17.3	19.7	27.6	33.2	38.9	46.9	53.2
4.5 hour	13.2	15.1	21.2	25.6	30.1	36.4	41.5
6 hour	10.9	12.5	17.6	21.4	25.2	30.5	34.9
9 hour	8.43	9.66	13.7	16.7	19.7	23.9	27.4
12 hour	7.03	8.07	11.5	14.0	16.6	20.2	23.1
18 hour	5.44	6.27	9.01	11.0	13.0	15.9	18.3
24 hour	4.53	5.24	7.57	9.25	11.0	13.4	15.4
30 hour	3.92	4.54	6.59	8.07	9.60	11.8	13.5
36 hour	3.48	4.03	5.87	7.21	8.58	10.5	12.1
48 hour	2.86	3.32	4.86	5.98	7.13	8.79	10.1
72 hour	2.13	2.48	3.64	4.49	5.38	6.67	7.72
96 hour	1.70	1.98	2.91	3.60	4.31	5.36	6.22
120 hour	1.42	1.64	2.41	2.98	3.58	4.44	5.16
144 hour	1.21	1.40	2.04	2.52	3.03	3.76	4.37
168 hour	1.06	1.22	1.76	2.17	2.61	3.22	3.76

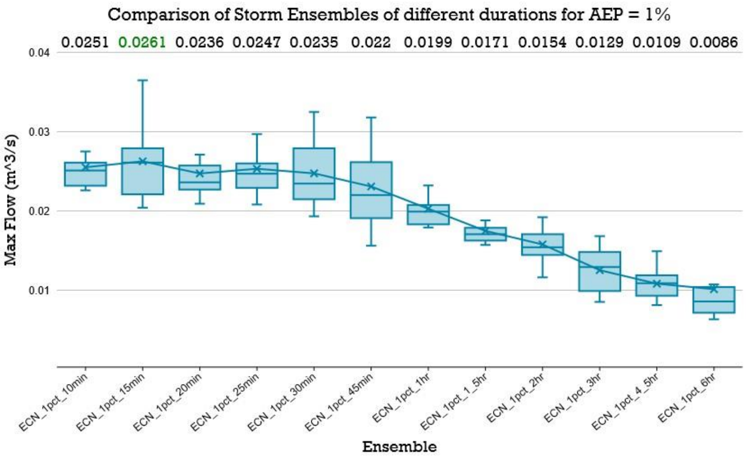
Note:
The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

This page was created at **00:31 on Monday 5 December 2022 (UTC)**

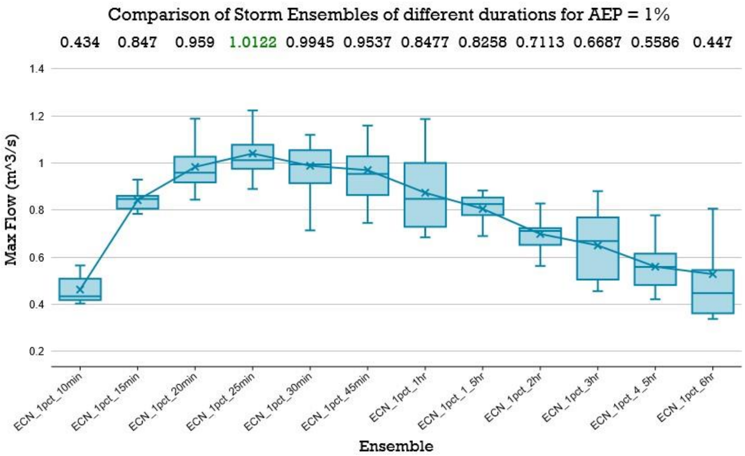
Appendix D

1 % AEP Box and Whisker Plots for Modelled Durations

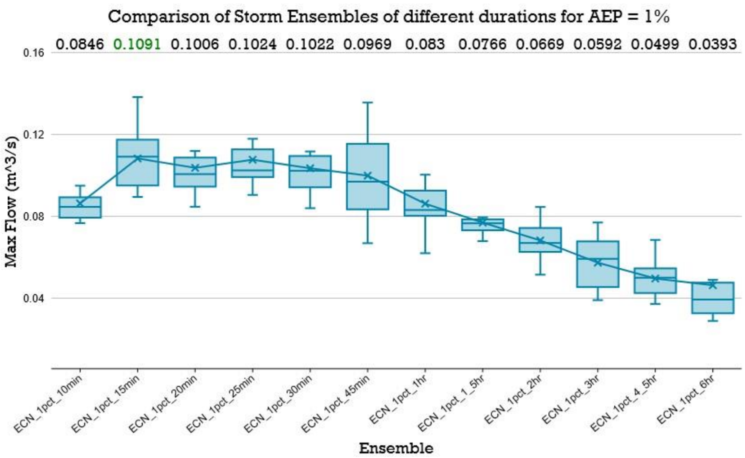
A (EXT)


Comparison of Storm Ensembles of different durations for AEP = 1%
0.0251 0.0261 0.0236 0.0247 0.0235 0.022 0.0199 0.0171 0.0154 0.0129 0.0109 0.0086
Max Flow (m^3/s)
0.04
0.03
0.02
0.01
ECN_1pct_10min
ECN_1pct_15min
ECN_1pct_20min
ECN_1pct_25min
ECN_1pct_30min
ECN_1pct_45min
ECN_1pct_1hr
ECN_1pct_1_5hr
ECN_1pct_2hr
ECN_1pct_3hr
ECN_1pct_4_5hr
ECN_1pct_6hr
Ensemble

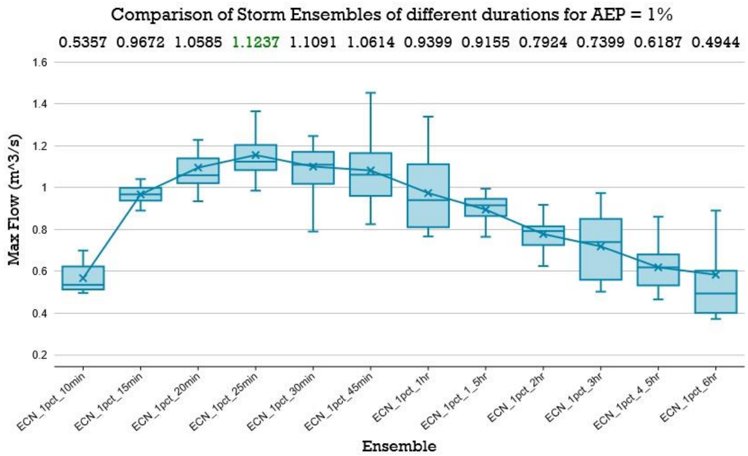
A1


Comparison of Storm Ensembles of different durations for AEP = 1%
0.434 0.847 0.959 1.0122 0.9945 0.9537 0.8477 0.8258 0.7113 0.6687 0.5586 0.447
Max Flow (m^3/s)
1.4
1.2
1
0.8
0.6
0.4
0.2
ECN_1pct_10min
ECN_1pct_15min
ECN_1pct_20min
ECN_1pct_25min
ECN_1pct_30min
ECN_1pct_45min
ECN_1pct_1hr
ECN_1pct_1_5hr
ECN_1pct_2hr
ECN_1pct_3hr
ECN_1pct_4_5hr
ECN_1pct_6hr
Ensemble

A2


Comparison of Storm Ensembles of different durations for AEP = 1%
0.0846 0.1091 0.1006 0.1024 0.1022 0.0969 0.083 0.0766 0.0669 0.0592 0.0499 0.0393
Max Flow (m^3/s)
0.16
0.12
0.08
0.04
ECN_1pct_10min
ECN_1pct_15min
ECN_1pct_20min
ECN_1pct_25min
ECN_1pct_30min
ECN_1pct_45min
ECN_1pct_1hr
ECN_1pct_1_5hr
ECN_1pct_2hr
ECN_1pct_3hr
ECN_1pct_4_5hr
ECN_1pct_6hr
Ensemble

PD-A


Comparison of Storm Ensembles of different durations for AEP = 1%
0.5357 0.9672 1.0585 1.1237 1.1091 1.0614 0.9399 0.9155 0.7924 0.7399 0.6187 0.4944
Max Flow (m^3/s)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
ECN_1pct_10min
ECN_1pct_15min
ECN_1pct_20min
ECN_1pct_25min
ECN_1pct_30min
ECN_1pct_45min
ECN_1pct_1hr
ECN_1pct_1_5hr
ECN_1pct_2hr
ECN_1pct_3hr
ECN_1pct_4_5hr
ECN_1pct_6hr
Ensemble

Appendix E

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.

$$Q_y = (C_y \,.\, {}^{t}I_y \,.\, A)/360$$

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)
${}^{t}I_i$ '*y*'	=	average rainfall intensity (mm/h) for a design duration of '*t*' hours and an AEP of 1 in 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).

$$C_y = F_y \,.\, C_{10}$$

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 plans, respectively. Using these values, and the local ${}^{1}I_{10}$ (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 C.1 and C.2, respectively.

Table C.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)	0.00	0.56	0.63	0.66	0.69	0.76	0.79
Internal	A1	0.06	0.57	0.64	0.67	0.71	0.77	0.81
	A2	0.00	0.56	0.63	0.66	0.69	0.76	0.79

Table C.2 Coefficient of Discharge – Developed Case

Catchment ID		f_i	C_2	C_5	C_{10}	C_{20}	C_{50}	C_{100}
External	A (EXT)	0.80	0.72	0.81	0.85	0.89	0.98	1.00
Internal	A1	0.30	0.62	0.70	0.74	0.77	0.85	0.88
	A2	0.40	0.65	0.72	0.76	0.80	0.87	0.91
	A3	0.90	0.75	0.84	0.88	0.92	1.00	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 where 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 C.3 and C.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 C.3 t_c Parameters – Existing Case

Parameter	External	Internal	
	A (EXT)	A1	A2
Standard Inlet Time			
t_c (min)	-	-	-
Sheet Flow			
Flow Length (m)	47	100	100
Horton's Roughness Value	0.04	0.04	0.04
Slope (%)	10.6	7.2	9.5
t_c (min)	9.6	13.4	12.6
Channel Flow			
Flow Length (m)	-	90	39
Velocity (m/s)	-	1.5	0.9
Slope (%)	-	8.0	7.2
t_c (min)	-	1.0	0.7
Pipe Flow			
Flow Length (m)	-	-	-
Velocity (m/s)	-	-	-
Slope (%)	-	-	-
t_c (min)	-	-	-
TOTAL t_c (min)	**9.6**	**14.4**	**13.4**

Table C.4 t_c Parameters – Developed Case

Parameter	External	Internal		
	A (EXT)	A1	A2	A3
Standard Inlet Time				
t_c (min)	5	-	5	5
Sheet Flow				
Flow Length (m)	-	12.5	-	-
Horton's Roughness Value	-	20	-	-
Slope (%)	-	0.035	-	-
t_c (min)	-	6.1	-	-
Channel Flow				
Flow Length (m)	-	-	150	-
Velocity (m/s)	-	-	0.9	-
Slope (%)	-	-	7.5	-
t_c (min)	-	-	2.8	-
Pipe Flow				
Flow Length (m)	100	-	35	220
Velocity (m/s)	1.0	-	1.0	1.0
Slope (%)	1.0	-	1.0	1.0
t_c (min)	1.7	-	0.6	3.7
TOTAL t_c (min)	**6.7**	**6.1**	**8.4**	**8.7**

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 C.5 and C.6, respectively.

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

Catchment ID		I_2	I_5	I_{10}	I_{20}	I_{50}	I_{100}
External	A (EXT)	121.0	151.5	175.0	199.6	233.3	257.9
Internal	A1	103.3	128.9	149.3	169.8	198.4	218.9
	A2	106.9	133.5	154.5	175.8	205.4	226.7

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

Catchment ID		I_2	I_5	I_{10}	I_{20}	I_{50}	I_{100}
External	A (EXT)	136.3	171.0	198.6	228.0	267.0	296.3
Internal	A1	138.9	174.3	202.6	232.8	272.7	302.8
	A2	127.5	159.8	185.1	211.7	247.7	274.3
	A3	125.9	157.8	182.6	208.8	244.2	270.3

Peak Discharge

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

Table C.7 Peak Discharge (m^3/s) – Existing Case

Catchment 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)
External	A (EXT)	0.01	0.01	0.01	0.02	0.02	0.02
Internal	A1	0.36	0.50	0.61	0.73	0.94	1.08
	A2	0.03	0.04	0.05	0.06	0.08	0.09

Table C.8 Peak Discharge (m^3/s) – Developed Case

Catchment 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)
External	A (EXT)	0.10	0.15	0.18	0.22	0.28	0.31
Internal	A1	0.01	0.02	0.02	0.03	0.03	0.04
	A2	0.05	0.07	0.08	0.10	0.13	0.15
	A3	0.58	0.81	0.99	1.18	1.50	1.66