STORMWATER MANAGEMENT REPORT

22-000251 – Norwest Marketown, Norwest

Revision 01

1 September 2023

ISSUE	DATE	ISSUE DETAILS	AUTHOR	CHECKED	APPROVED
00	06/06/2023	Draft for Review	DM	TE	
01	01/09/2023	Updated Draft	NL	TE	

Contents

Tables

Figures

1. Introduction

1.1 Purpose

The purpose of this assessment is to determine the potential surface water quality and hydrology impacts that may be generated by construction and operation of the project. It will also present a proposed approach to the management of these impacts. The study will canvass both construction and operational water quality and flow management strategy that guided the design.

1.2 Background

The subject site is located within Lot 2 DP 121372 and Lot 5080 DP 1008602. The site is within jurisdiction of Hills Shire Council and has a B2 local centre zoning under The Hills Local Environmental Plan 2019. The site is located adjacent to the SP2 (drainage) area, a constructed Norwest Lake that provides detention/flood management for the surrounding catchment (including the existing site) and a public (recreation) amenity. The location of the proposed site is shown in Figure 1 below.

Figure 1: Site Location

The planning proposal includes the redevelopment of the current Norwest Marketown shopping complex and Carlile Swim Centre to mixed use towers with public amenities. The proposal is to construct a mix of low and high-rise towers that incorporate a wide range of uses including, commercial and office floorspace, retail, community, tourist/visitor accommodation and serviced apartments. The overview of the proposed development is shown in Figure 2 below.

Figure 2: Indicative Reference Plan – Roof Level

1.3 Overview of potential impacts

The construction activities have the potential to impact various aspects of the water quality and hydrology including:

- Erosion and sedimentation of soils
- Reduced water quality from elevated turbidity, increased nutrients, and other contaminants.
- Changes to flow rates, volume, and flow paths within drainage lines.
- Changes to flood levels, flows and velocities caused by alteration of flood flows, and the impact in neighbouring properties.

The potential impacts are common on construction projects and with the application of the standard mitigation measures outlined herein, the potential impacts on surface water quality and quantity are considered minor and manageable.

1.4 Scope

The scope of the study is listed below:

- Assessment of pre and post development hydrology, identification of any impacts on the existing hydrology and constraints and opportunities associated with the hydrological management.
- Assessment of the post development water quality using MUSIC modelling and water quality mitigation measures.
- Sizing and concept design documentation of onsite detention and water quality treatment devices.
- Assessment of pre and post development flood behaviour, ensure no exaggerating of flood levels on adjacent

properties.

2. Review on Previous Studies

As part of the preliminary study, the detail analysis of the several projects located within the periphery of the proposed development has been carried out. The review of the few projects are presented below.

2.1 Norwest Development Area 1 Stormwater Drainage Master Plan for Catchment 1, 1998

The stormwater drainage master plan has been prepared in conjunction with the preliminary analysis and design of the drainage system for Catchment 1 in Development Area 1 of the Norwest Business Park. Catchment Area 1 shown in Figure 3 below is approximately 90.3 Ha in area, 25% of which is off-site rural land along Barina Downs Road to the south.

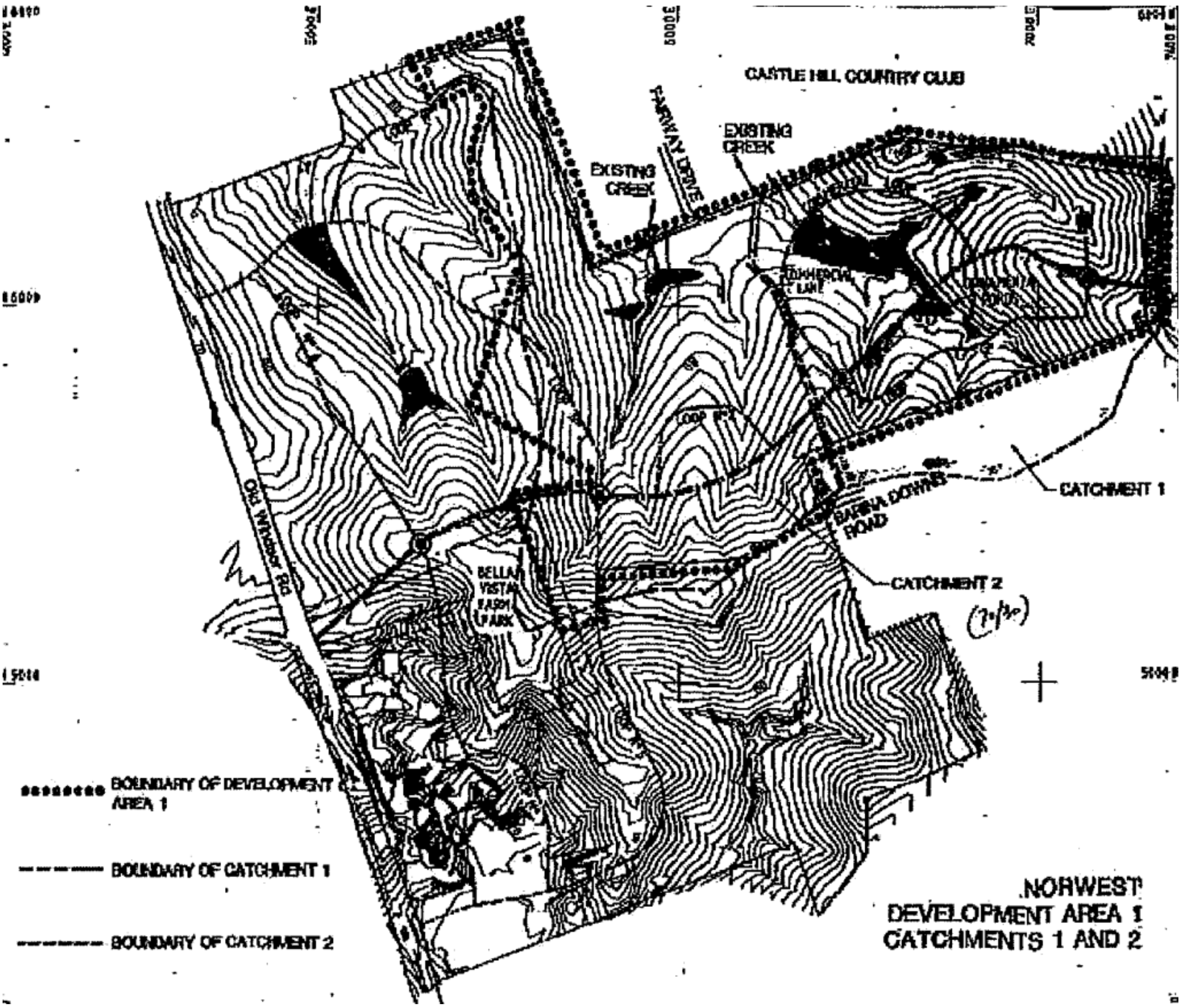

Figure 3: Norwest Development Area

The Department of Water Resources has investigated the major catchment, into which Catchment 1 discharges, in order to determine flood levels in the major creek system. The Norwest site is considered to be unaffected by 100-year ARI flooding in the creeks downstream of the site as it is at the upstream extremity of the total catchment.

Catchment 1 indicated in Figure 3 contains the commercial lake. The design of the dam wall and spillway for this lake will be in accordance with current engineering practice, with the outlet structure designed to pass the 100-year ARI storm.

The structure required to pass the flow allows for controlled routing of the peak runoff discharge during the 100-year ARI event.

The commercial lake, with an approximate capacity of 70ML, is a central landscape feature of Norwest and as such, tight control over water quality and water level movements must be exercised. The operational criteria for the lake dictate that only a 1.0m maximum change in the water level will be permitted under any circumstances other than during the PMF. The outlet structure for the lake will be designed to reduce the peak of 22.5m^3/s to 10m^3/s. The lake water level will rise less than 1m during a 45 minute 100 year ARI event. During the 45 minute 20 year ARI event, the lake will rise approximately 0.65m.

An analysis has also been carried out for the probable maximum flood (PMF) event to assess compliance with dam safety criteria. The PMF peak discharge into the dam is 48 m^3/s and this will cause the outlet structure to be submerged and flows over the commercial loop road (emergency lake spillway) approximately 0.3m deep to occur. Thus, for the PMF, the top water level of the lake and the minimum (floor) levels for “high risk” areas will be 1.8m above the lakes normal level of 74.5m AHD. The PMF outflow from the dam is predicted to be 40m^3/s.

All the buildings along the banks of this lake should have floor levels above the probable maximum flood level, where practicable, but in all cases above the 100-year flood level.

2.2 40 Solent Circuit, Norwest (Norwest Quarter)

The detail study of the stormwater management report for the mixed development project prepared by Stantec Revision 007 dated 30.06.22 has been conducted.

The report includes the response email from Council which states that the overall stormwater strategy of the Norwest Development Area shown in Figure 3 has been conducted by Council assuming 60% impervious and 40% pervious area. As such, developments within the catchment area of Norwest Development Area will not require OSD if the impervious area is less than or equal to 60%. Any additional impervious area will require OSD for attenuation.

The proposed development at 40 Solent Circuit, Norwest consist of 83% impervious and 17% Pervious area. The stormwater management report for 40 Solent Circuit states that the on-site detention (OSD) has only been provided for the catchment area that exceeds 60% of impervious area. The Figure 4 provides the summary of OSD calculation.

Site Area (ha)	Impervious Area Exempt from OSD (60%) (ha)	Proposed Impervious area (ha)*	Impervious Area Exceeding OSD Exemption (ha)
0.90	0.540	0.746*	0.206**

*Green roof and landscape areas on suspended slabs have been considered impervious
** 0.21 Hectares have been adopted for the calculation

The portion of the site that requires OSD is 0.2066 (0.21 ha has been adopted) resulting in the following attenuation requirement controls for the tank as calculated in Appendix B:

Requirement	Council Requirements	Site Requirements
Permissible Site Discharge	104 L/s/ha	21.8L/s
Site Storage Requirements	362 m^3/ha	79.7m^3

Figure 4: OSD Calculation Table
(*Extracted from Stormwater Management Report, 40 Solent Circuit*)

2.3 11-13 Solent Circuit, Norwest (The Esplanade)

The detail study of the stormwater management report for the mixed used development project prepared by Van Der Meer Revision D dated March 16, 2016 has been conducted.

The report includes the statement that “Council has advised that it will be necessary to restrict the discharge from the developed site to an equivalent of 40% impervious area”.

An OSD calculation has been carried out based on assumption that for pre-development scenario impervious area is 40% of the total site area. The OSD Tank as required by Council has been provided to reduce the peak 100yr and 20yr storm. The analysis has been carried out in the DRAINS Model. Table 1 below outlines the pre and post peak flow and the storage required to reduce the post flows obtained from the DRAINS Model.

Table 1: Drains Results

Storm	40% Impervious Q (l/s)	Post development Q (l/s)	OSD Storage Required (m^3)
20 Year	464	460	22.0
100 Year	563	540	37.2

3. Relevant Guidelines

3.1 Hills Shire Council Requirements

The site is located within the Hills Shire Council local government area (LGA).

3.1.1 Hills Shire Council Development Control Plan – Part B Section 6 – Business (2021)

This plan provides guidance on Council's minimum requirements for all Business zoned land. It provides detailed criteria to assist Council in assessing development applications as required by the provisions of the Environmental Planning and Assessment Act.

3.1.2 Hills Shire Council Development Control Plan – Appendix B Water Sensitive Urban Design (2014)

This plan provides guidance on type of Water Sensitive Urban Design measures required for the development.

3.1.3 Hills Shire Council Development Control Plan – Part C Section 6 – Flood Controlled Land (2012)

This Plan helps to determine the flood prone land and minimise risk to life and damage to property by controlling development on flood prone land. The specification ensures that the development on the flood plain is consistent with NSW Flood Prone Land Policy and NSW Floodplain Development Manual.

3.2 Engineers Australia – Australian Rainfall & Runoff

This specification contains technical design data for the calculation of flows, flood elevations and velocities along with technical standards for the design of drainage infrastructure. The hydrologic parameters include rainfall intensity charts and runoff parameters for flow estimation. The document also outlines hydraulic parameters and design requirements for pits, culverts, and pipes.

3.3 Water Management Act 2000

The key NSW legislation governing the management of the state's water resources are the Water Management Act 2000 and the Water Act 1912. The Water Management Act 2000 is progressively replacing the Water Act 1912, which represented outdated principles in water management.

The objective of the Water Management Act 2000 is to provide sustainable and integrated management of water resources for the benefit of both present and future generations (NSW Office of Water, 2014). The NSW Office of Water administers the Water Management Act 2000 and regulates controlled activities carried out around and on waterfront land.

4. Stormwater Quantity Management

Urbanisation has the potential to affect the hydrology and hydraulics within the development site and downstream areas and watercourses. Urbanised catchments are characterised with increase impervious areas, which are smoother and allow stormwater to flow and concentrate faster. As a result, post-development catchments discharge greater stormwater volumes at higher flow rates leading to more frequent high flow events when stormwater runoff is not managed. Potential impacts of increased stormwater runoff quantity include:

- Increases in channel forming flows. The increased frequency of high flow events changes the channel forming flow and affects channel shape. This may damage or destroy important in-stream and bank habitats.
- Increases in peak flows. Increased peak flows increases downstream flood risks and place greater pressure on downstream drainage infrastructure.
- Increases in flood levels. Higher flood levels may pose risks to public safety and subdivision assets.

As a result, a stormwater quantity management strategy is required to mitigate the risks and consequences of urbanisation on the existing catchments.

The stormwater quantity management strategy aims to match post-development peak flows from the catchments that drain to the ultimate basin to the PSD in all storm events from the 2yr to the 100yr ARI as per Hills Shire Council Requirements.

4.1 Hydrological Analysis

4.1.1 Rainfall Data

The Intensity Frequency Duration (IFD) rainfall data for the site is based on data presented in Australian Rainfall and Runoff (2016 IFD data) and site-specific calculations.

4.1.2 Hydrological Setting of the Project

The Hills Shire Council Design Guidelines states that On-site detention shall be provided for all new developments. The site is located with the Hawkesbury River Catchment, the site’s Permitted Site Discharge (PSD) and Site Storage Requirement (SSR) is governed by Table shown in Appendix F of UPRCT design guidelines (Third Edition) shown in Table 3 below.

Table 2: Parameters to be used for Catchments in UPRCT

Local Government Area	Catchment	Site Slope *BHSC only	PSD (l/s/ha)	SSR (m3/ha)
BHSC	Hawkesbury River	>15%	136	298
BHSC	Hawkesbury River	10% to 15%	115	336
BHSC	Hawkesbury River	6% to 10%	104	362
BHSC	Hawkesbury River	3% to 6%	92	396
BHSC	Hawkesbury River	0% to 3%	87	412
HCC	A'Becketts Creek		140	300
HCC	Duck Creek		140	300
HCC	Prospect Creek		140	300
PCC	A'Becketts and Duck River/Creek		80	470
PCC	Claycliff Creek		235	215
PCC	Devlins Creek		210	250
PCC	Parramatta River – North Side - Charles St to Vineyard Creek		208	235
PCC	Parramatta River – North Side – East of Vineyard Creek		280	190
PCC	Parramatta River –South Side –		80	470
PCC	Ponds/Subiaco Creek		130	330
PCC	Terrys Creek		210	250
PCC	Vineyard Creek		160	285

Given the site slope of 5.2%, the following PSD and SSR is required for the site.

Table 3: PSD and SSR Parameters

Site Slope	PSD (l/s/ha)	SSR (m^3/ha)
3% to 6%	92	396

The site is located within the Norwest Development Area catchment shown in Figure 3 and has been considered in the regional stormwater strategy assuming a maximum impervious area of 60%. As per Council requirement developments within the catchment area will not require OSD if the impervious area is less than or equal to 60%. Any additional impervious area above this will require OSD for attenuation. OSD will be provided for the impervious area that exceeds the 60% as shown below in Table 4.

Table 4: OSD Area

Site Area (Ha)	Impervious Area Exempt from OSD – 60% (Ha)	Proposed Impervious Area (Ha)	Impervious Area Exceeding OSD Exemption (Ha)
4.77	2.862	4.53	1.668

(*Note: 1.668 Hectares have been adopted for the calculation*)

The portion of the site that requires OSD is 1.668Ha resulting in the attenuation requirement controls. The calculation table for Hawkesbury catchment is shown in Table 5 below.

Table 5: UPRCT Calculation Sheet for Hawkesbury River Catchment

Project	**Mixed Development**					
Site address	**Norwest Marketplace**					
Job No	**22-000251**					
Design by	**Calibre Group**					
Phone	**(02) 88085162**					
Catchment	**Hawkesbury River**					
Site area	1.6680	ha	(A)	SSR	396	m3/ha
Basic storage Volume	660.53	m3	(B)	PSD	92	L/s/ha
Basic discharge	153.46	L/s	(C)			
Site draining to storage	1.6680	ha	(D)			
Percentage of side	100.0	%	(E)			
Storage/hectare of contributing area	396.00	m3/ha	(F)			
Adjust PSD	102	L/s/ha	(G)			
PSD for site	170.22	L/s	(H)			
Max head to orifice centre	3.2	m	(K)			
Diameter of orifice	0.210	m	(J)			
Maximum discharge	170.22	L/s	(L)			
Head for high early discharge	3.10	m	(M)			
HED	167.54	L/s	(N)			
HED %	98.4	%				
Mean discharge	168.88	L/s	(P)			
Average Discharge per hectare	101.2	L/s/ha	(Q)			
SSR	398	m3/ha	(R)			
Final SSR	664.28	m^3	(S)			
Total volume provided	-	m^3	-			

The summary of the OSD is presented in Table 6 below.

Table 6: OSD Storage Summary

Requirement	Council Requirements	Site Requirements
PSD	92 L/s/ha	170.22
SSR	396 m^3/ha	665

OSD is to be provided with a total storage volume of minimum 665 m^3. The site has been subdivided such that the catchment from the development site will be conveyed to two OSD tanks. The site will also contain the bypass area that will not be attenuated by OSD tanks. The proposed tentative location of OSD Tanks along with associated catchment area is shown in Figure 5 below.

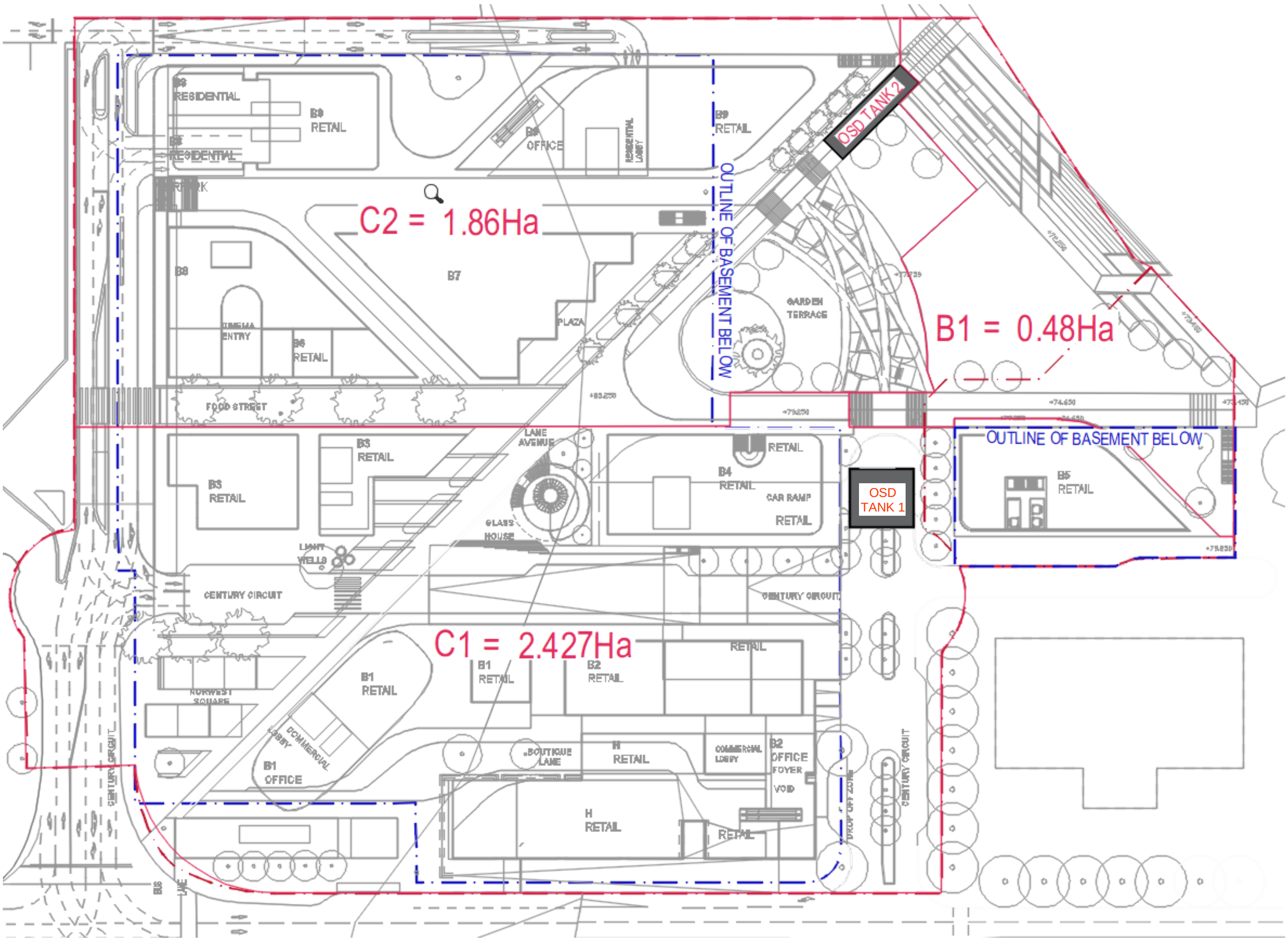

Figure 5: Tentative location of OSD Tanks and Catchment Distribution

4.2 Drains Modelling

For a detailed analysis a Drains model was created for the subject site. The proposal is to attenuate flows from the proposed development by installing two OSD tanks which will attenuate the flows from the 2-year to 100-year ARI storm events. The following parameters have been set in the Drains Model.

1. The table below shows the catchment area draining to each OSD tank and nominated impervious area.

Table 7: Parameters in Drains Model

Description	Catchment Area (Ha)	Post Development Impervious Area (%)
Catchment Area Draining to OSD Tank 1	2.427	90
Catchment Area Draining to OSD Tank 2	1.86	90
Catchment Area Bypassing OSD System	0.48	30

(*Note: For Pre-Development Scenario, Analysis has been carried out for total site considering 60% Impervious Area*)

2. The following manning coefficient has been used:
    a. Paved = 0.013
    b. Supplementary = 0.025
    c. Grassed = 0.04
3. Simulation has been carried out for the storm event ranging from 2-year ARI to 100-year ARI storm event.

The layout of the Drains model is shown in Figure 6 below:

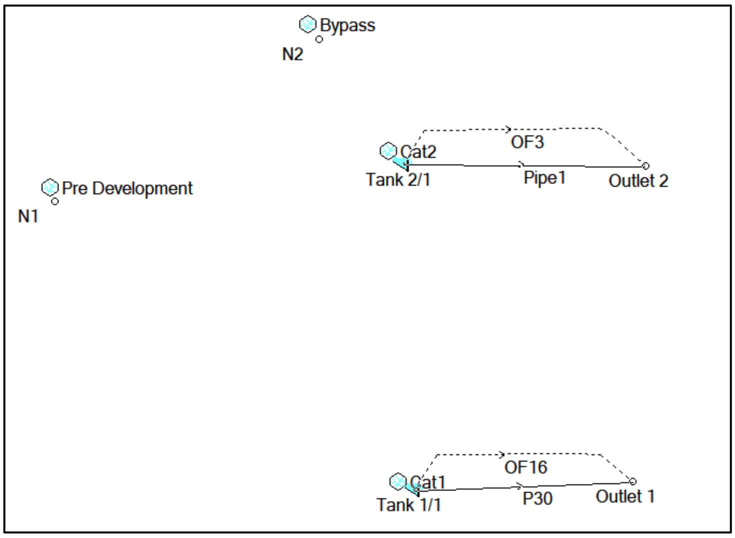

Figure 6: DRAINS Model Layout

The summary results from the DRAINS model for Pre and Post Development Scenarios are shown in Table 8 below.

Table 8: Drains Results

ARI Event	Pre-Development flow (m3/s)	OSD Tank 1		OSD Tank 2		Bypass	Total Post Development Flow (m3/s)
		Storage	**Flow (m3/s)**	**Storage**	**Flow (m3/s)**		
2	0.736	56	0.369	48	0.279	0.060	0.708
5	1.17	125	0.429	102	0.337	0.106	0.872
10	1.51	195	0.484	152	0.387	0.14	1.011
20	1.77	260	0.532	197	0.428	0.169	1.129
50	2.12	340	0.589	257	0.479	0.204	1.272
100	2.45	410	0.636	307	0.520	0.232	1.88

The results in Table 8 indicate that the storage of 410m^3 and 307m^3 provided in OSD Tank 1 and OSD Tank 2 will be adequate to attenuate the post-development flow to pre-development flow for the storm events ranging from the 2-year ARI to 100-year ARI events.

4.3 Additional Storage in Norwest Lake

Norwest Lake provides detention for Norwest Development area and the analysis has been carried out on the possible impact on the lake water level if the on-site detention is not provided for the proposed mixed-use development. The detail analysis has been carried out using the TUFLOW model and is presented in Section 6.

5. Flood Management

The flood modelling addresses the changes in the flood regime due to modelling the density of development and change in materials of the proposed development. The development has been represented with the development terrain being included along with the changes to impervious ratios and developed surface roughness.

5.1 TUFLOW Modelling

An investigation has been carried out to analyse the possible impact in flood level in the downstream area because of proposed development being constructed without providing On-Site Detention. The site was modelled within the TUFLOW flood modelling software (Build 2020-10-AA). TUFLOW modelling has been setup to gauge the impact of the 1% AEP storm event within and surrounding the site. The TUFLOW model was run for multiple storm durations for the 1% AEP event. The critical storm was selected based on the magnitude of flow in RAFTS, which is the 1% AEP 10-minute storm, temporal pattern 3.

5.2 Data Sources

The following outlines the sources of data used in the hydrology and hydraulic analysis of the site.

5.2.1 Topographic Data

The initial topographic data for the base model was obtained from the ELVIS (Elevation and Depth – Foundation Spatial Data) web portal as operated by the Intergovernmental Committee on Surveying and Mapping (ICSM). The ELVIS web portal provides access to data from contributing state government bodies including NSW Spatial Services and ACT Government.

From the ELVIS web portal, Digital Elevation model (DEM) tiled data with a 1 metre horizontal resolution was downloaded. The DEM tiles were created by NSW Spatial Services and are based on the latest Light Detection and Ranging Systems Technology (LiDAR).

5.2.2 Survey Data

In addition to the LiDAR, the survey terrain was read into the model over LiDAR to ensure that the terrain was recent and correctly modelled.

5.3 Building Footprint

The footprints of buildings within critical flow paths are modelled as obstructions within the 2D domain. Building footprints were digitalised and removed from the active domain to prevent floodwaters entering buildings and so represent the flow characteristics of building blockages. Building outlines were determined from aerial photographs. The building of the proposed development was determined from the latest architecture plan.

5.4 Norwest Lake Normal Water Level

The normal water level of the Norwest Lake is RL 74.50. The LiDAR data obtained from ELVIS shows the surface of Norwest Lake is RL 74.50 which is the normal water level of RL 74.50. Therefore, the analysis is carried out assuming that during the storm event, the Norwest Lake is full up to the normal water level of RL 74.50

5.5 Catchment Mapping

The local catchment area for the development site was determined using a combination of LIDAR data from the NSW Land and Property Information department. The external catchments upstream and surrounding the site shown in Figure 7 drain to Strangers Creek.

Figure 7: Catchment Area

5.6 Hydrological Modelling Data

The catchments draining to Strangers Creek were modelled using RAFTS 2018.1.3 for both the existing and developed scenarios. The catchment parameters and other hydrological parameters used for input in RAFTS are listed below.

5.6.1 Catchment Parameter

The Norwest Lake has been designed to attenuate the flow from the upstream catchment of 90.3Ha by assuming that 60% of the total upstream catchment area is impervious. Thus, the RAFTS model for the existing scenario has been created by assuming the impervious area of 60% for all the sub catchments shown in Figure 7.

Regarding the post development scenario, RAFTS has been modified with impervious area for all sub-catchment as 60% whereas the sub-catchment C9 (proposed development site area) shown in Figure 7 has been modified to 90% impervious area.

The following generic Manning's n roughness values has been used for modelling as presented below.
Impervious mannings "n" Value = 0.013
Pervious mannings "n" Value = 0.04

5.6.2 Hydrological RAFTS input parameters

The hydrological parameters which are used in RAFTS modelling are outlined in the following Table 9.

Table 9: Hydrological RAFTS Input Parameter

	Parameter
Initial-Continuing Losses Pervious	
Initial Loss	10
Continuing Loss – Absolute	2.5
Initial-Continuing Losses Pervious	
Initial	1.5
Continuing Loss – Absolute	0

5.7 Model Inflows

The TUFLOW model has been developed using the sub-catchment delineation hydrological model. The inflow hydrograph for each sub-catchment is generated from the RAFTS Hydrologic model and has been used as 2d_sa polygons into the TUFLOW model as shown in Figure 8. The outlet boundary is modelled as a stage discharge boundary (HQ).

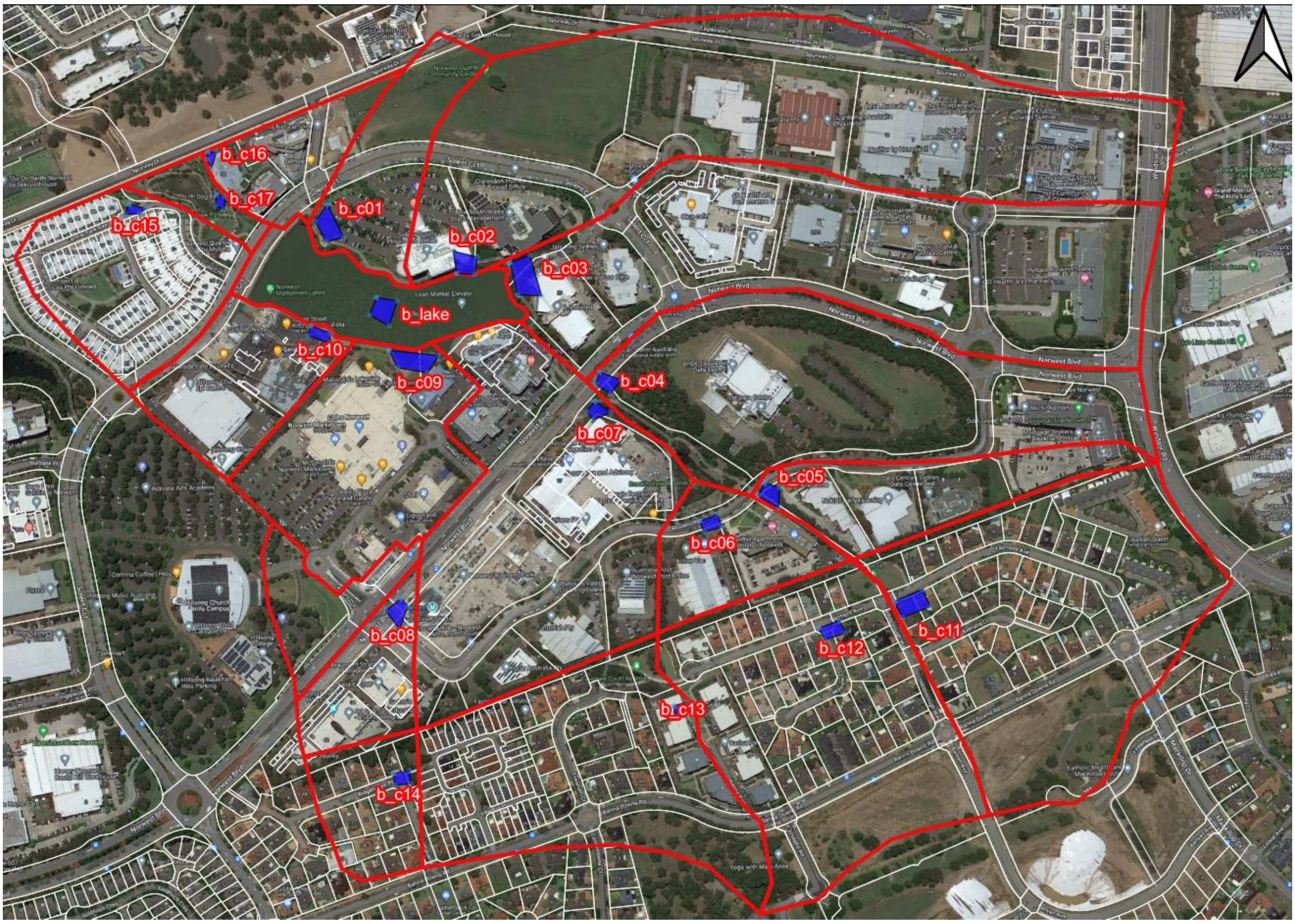

Figure 8: 2d code area and Boundary Condition

5.8 Results and Mapping

This section provides a summary of the results of the flood modelling for the existing development.

5.8.1 Pre-Development Peak Flood Depth and Velocity Classification

The TUFLOW model results for the existing scenario during the 1% AEP storm event is shown in Figure 9 and Figure 10. The flood depth map shows the extent of flood in and around Strangers Creek. The flood depth map also shows the location of Norwest Lake downstream of the proposed development site. The flood depth map shows that the maximum flood level in the Norwest Lake during 1% AEP storm event is RL 75.35.

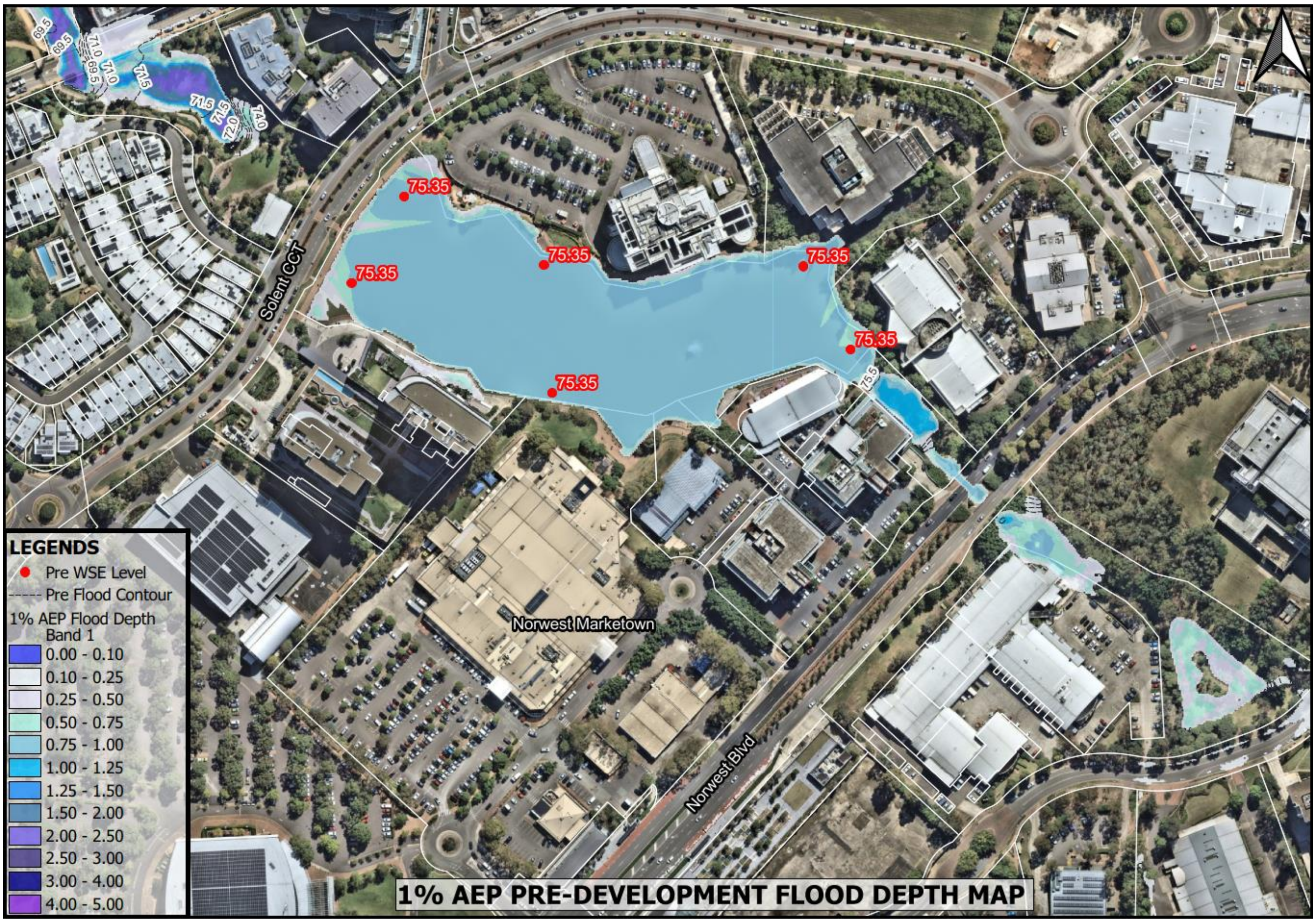

Figure 9: 1% AEP Flood Depth Map for Existing Scenario

The flood velocity map for the existing scenario shown in Figure 10 shows that the velocity for the flow in Strangers Creek will exceed up to 6.0m/s.

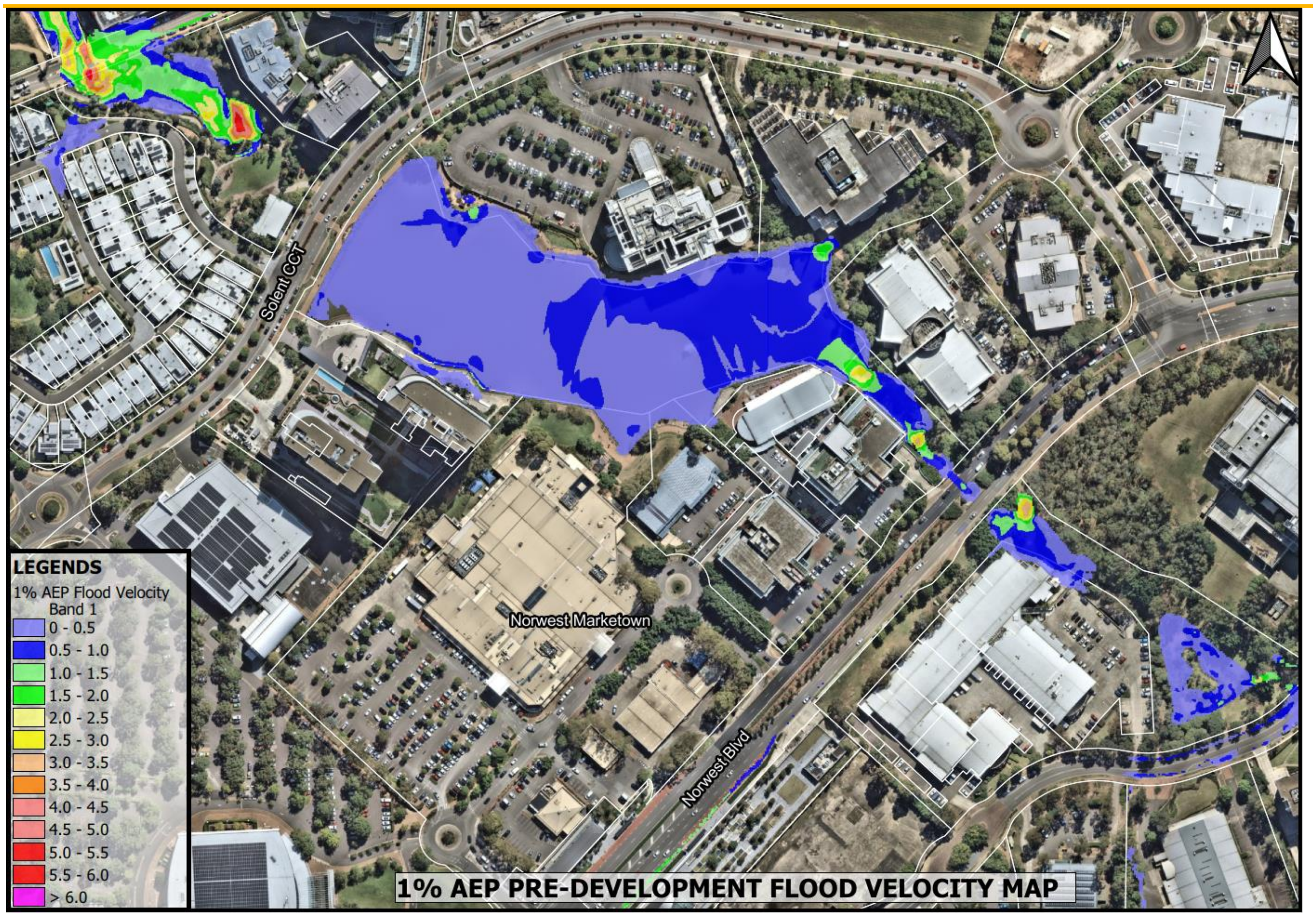

Figure 10: 1% AEP Flood Velocity Map for Existing Scenario

5.8.2 Post-Development Peak Flood Depth and Velocity Classification

The TUFLOW model results for the developed scenario during the 1% AEP storm event is shown in Figure 11 and Figure 12. The flood depth map shows that the flood path and flood extent remain the same as in the pre-development scenario. The flood level presented in Figure 11 shows that the flood level in Norwest Lake has increased by 10mm to RL 75.36 as the result of discharging uncontrolled flow from the proposed development into Norwest Lake.

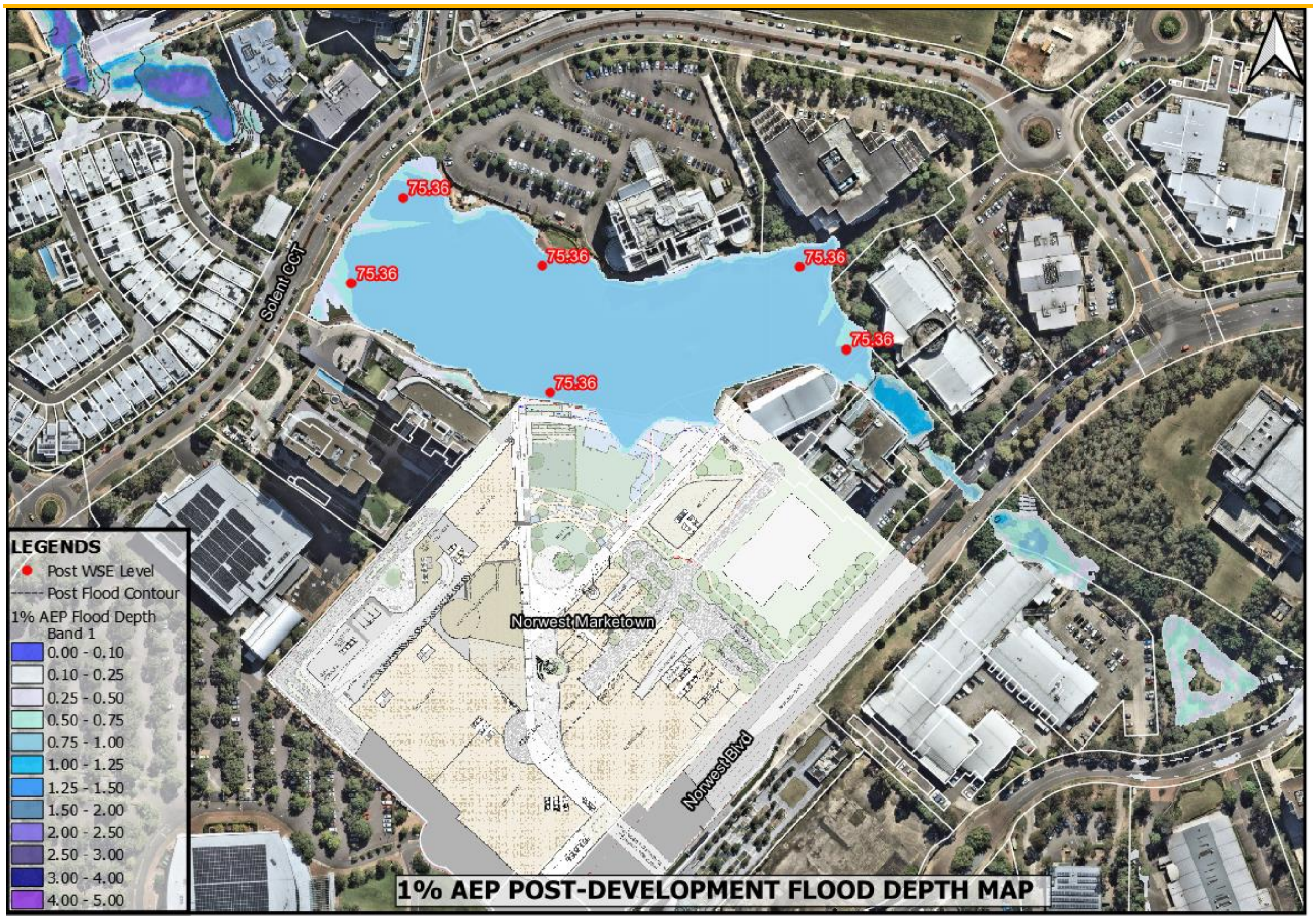

Figure 11: 1% AEP Flood Depth Map for Developed Scenario

The flood velocity map shown in Figure 12 shows that the flood velocity in the downstream waterway due to the proposed development will remain the same as in the pre-development scenario.

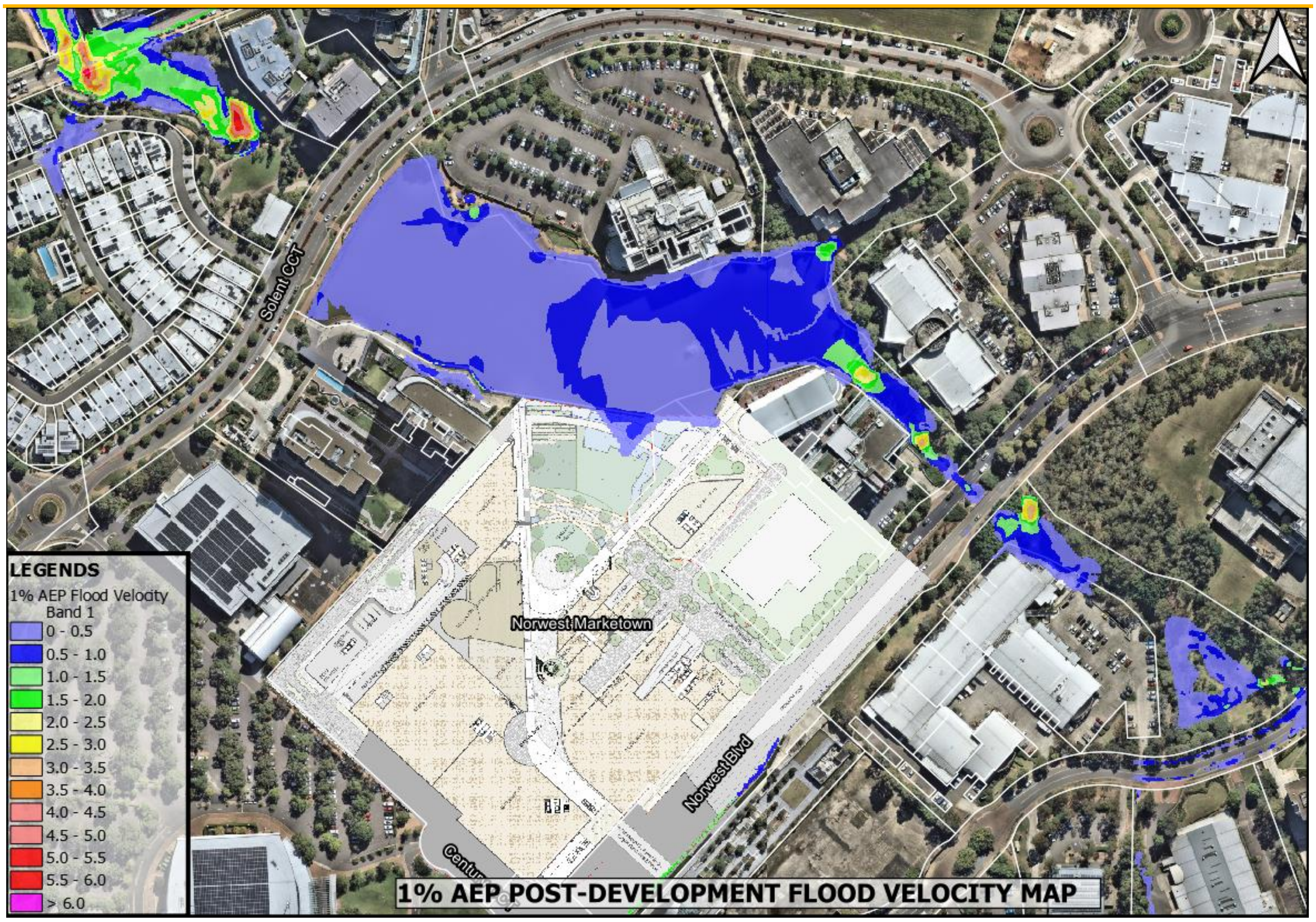

Figure 12: 1% AEP Flood Velocity Map for Developed Scenario

5.8.3 Afflux

The afflux for the 1% AEP storm event between the developed and existing scenario is shown in Figure 13. The afflux map shows no negative impact to upstream and downstream properties due to the proposed development. The increase in flood depth is only evident in Norwest Lake which is less than 10mm. The increase in flood depth is due to the discharge of unattenuated flow from the proposed development.

The map also shows the excess runoff generated from the proposed development due to the increase in impervious area will be distributed within the whole lake area. Therefore, it can be stated that without providing on-site detention there will be an increase in flood levels up to 10mm in Norwest Lake which will not have a negative impact to neighbouring properties.

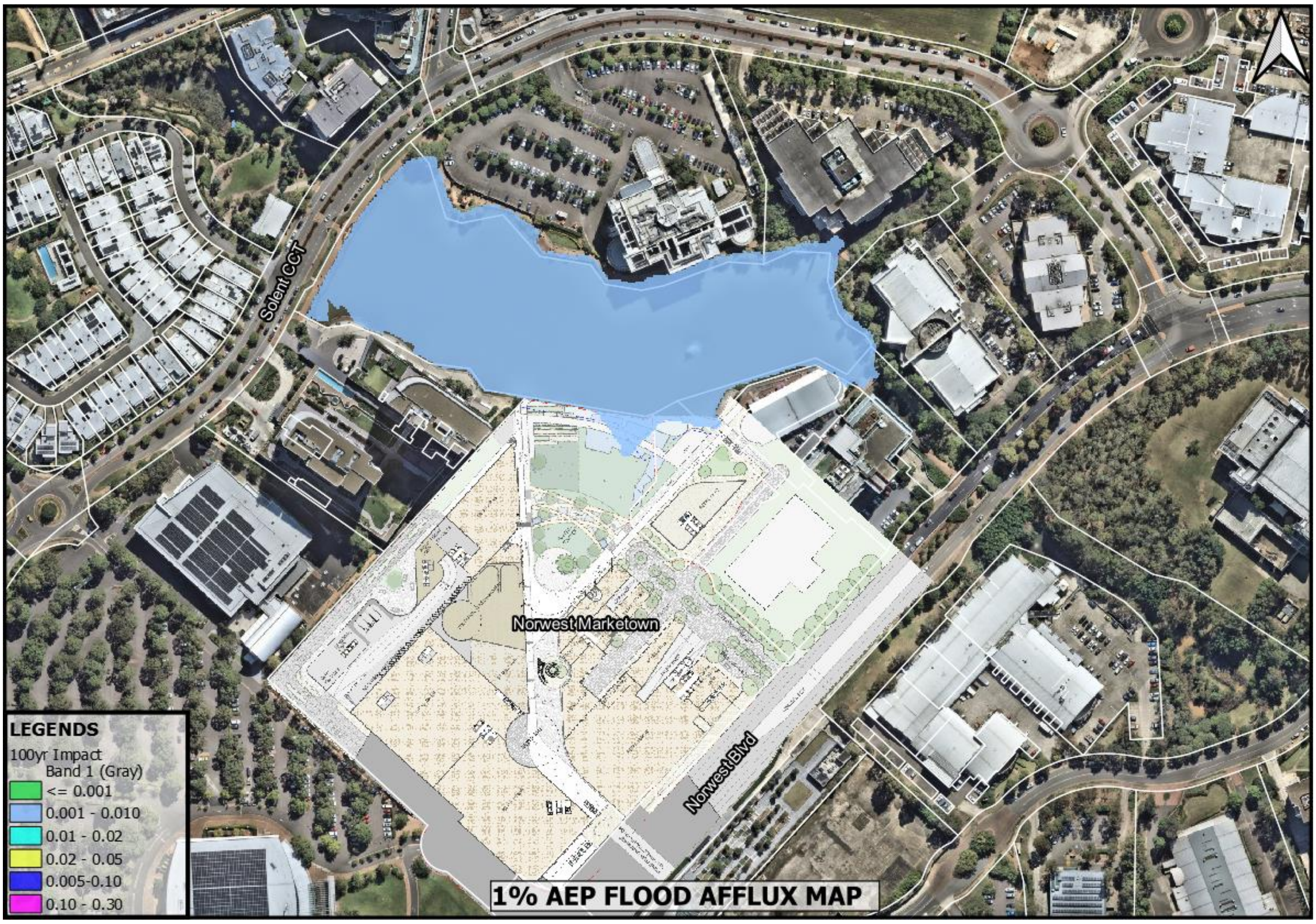

Figure 13: 1% AEP Flood Afflux Map

6. Stormwater Quality Management

Sydney Water are currently undertaking water quality testing on the Norwest Lake, the lake has been identified as being disturbed from upstream catchments and Carp within the water water bodies. Initial baseline water quality testing showed a number of pollutant targets were not met for receiving water bodies (ANZEEC guidelines) including dissolved oxygen. It is understood that initial attempts to remove the carp was undertaken in July/August 2023 and continued water quality sampling will be undertaken.

Section 6 focus on the water quality treatment from the future development, the water quality of the lake will form part of future studies.

6.1 General overview

Project operation would lead to a change in catchment hydrology, with the most obvious effect being an increase in stormwater flow. Stormwater from impervious surfaces is typically of poorer quality than runoff from pervious catchment and may result in a progressive deterioration of the environmental values of downstream waterways. Additionally, stormwater runoff from parking areas contains pollutants that are not typically found in runoff from pervious catchments (including litter/gross pollutants, rubber, suspended solids, nitrogen, phosphorus, oil and grease, hydrocarbons, petroleum lead, zinc, iron, copper, cadmium, chromium, nickel, manganese, pesticides, and herbicides).

Pollutants loads for developments are typically expressed by four major variants – Total Phosphorous (TP), Total Nitrogen (TN), Total Suspended Solids (TSS) and Gross Pollutants (GP).

6.2 Water Quality Modelling Introduction

Post development sediment and pollutant loads were modelled using MUSIC (Model for Urban Stormwater Improvement Conceptualisation), developed by eWater. MUSIC contains algorithms based on the known stormwater runoff, pollutant generation from typical land uses and the performance characteristics of common stormwater quality treatment measures. These data are derived from research undertaken by eWater and others in Australia and overseas. Statistics are produced in MUSIC for the following parameters:

- Flow (ML/yr)
- TSS - Total Suspended Solids (kg/yr)
- TP - Total Phosphorus (kg/yr)
- TN - Total Nitrogen (kg/yr)
- Gross Pollutants (kg/yr)

Hills Shire Council Strategy for stormwater quality control requires reduction of these major pollutants. The stormwater pollutant and reduction to be achieved by Music Model program for the proposed mixed-use development is as shown in Table 10 below:

Table 10: Pollutant Reduction Target as per Hills Shire Council

Pollutant	% Post development average annual load reduction
Gross Pollutants	90
Total Suspended Solids	85
Total Phosphorous	65
Total Nitrogen	45

6.3 Water Quality Modelling

The performance of the proposed water quality treatment strategy has been modelled using the MUSIC program. The source nodes and treatment parameters are generated in accordance with Blacktown City Council MUSIC-Link system as Hills Shire Council does not have its own MUSIC-Link. To ensure the satisfaction of the minimum pollutant load reductions required by Council two water quality treatment options have been analysed as listed below:

6.3.1 Option 1: Filter Cartridge Provided within OSD Tanks

The first option is to provide SPEL filter cartridges within OSD Tanks in a few upstream pits, such as the SPEL StormSack baskets. The SPEL StormSack baskets can be fitted into the pits and an example of the features and standards is shown in Figure 14 and Figure 15.

Figure 14: SPEL StormSack basket

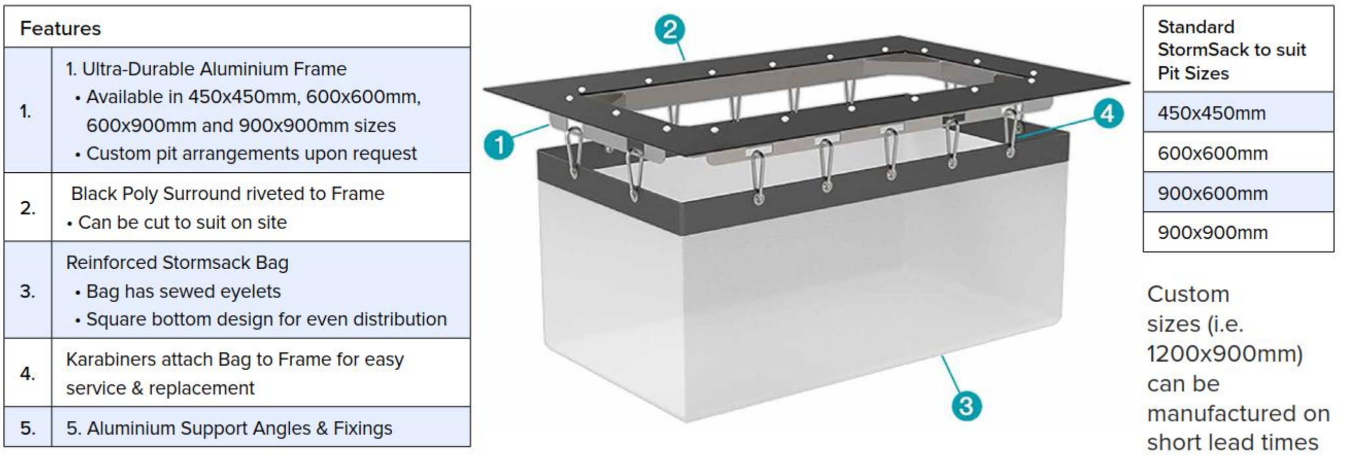

Figure 15: SPEL StormSack basket features and sizes

The MUSICX model layout with treatment nodes and catchments is presented in Figure 16.

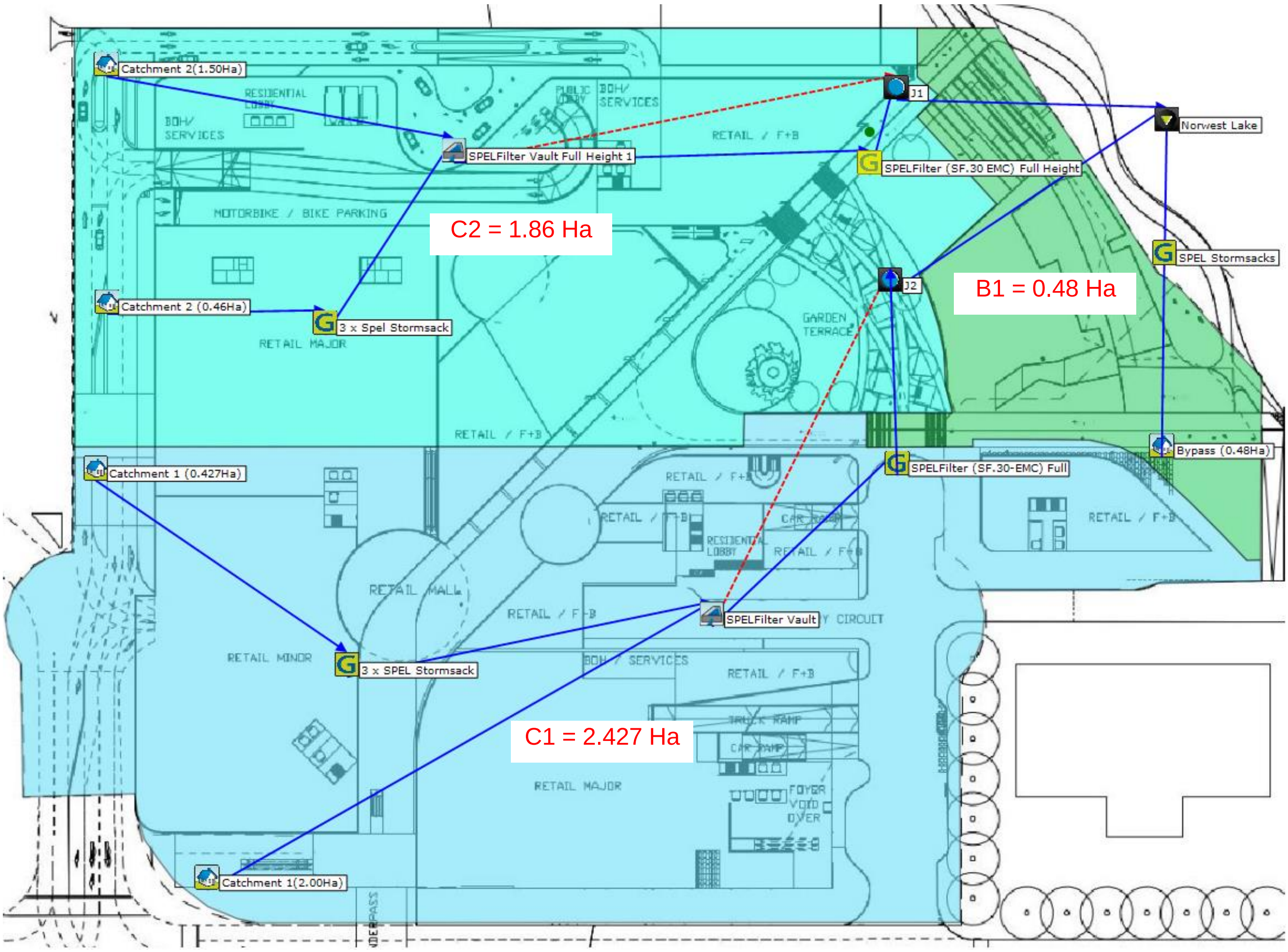

Figure 16: MUSIC Model Layout with Filter Cartridges

As presented in Figure 16, SPEL filter cartridges and SPEL StormSack have been used for water quality treatment. The filter chamber configuration to be fitted within OSD Tanks is shown in Table 11 below.

Table 11: Filter Chamber Summary

Tank	Filter Chamber Area (m^2)	Filter Cartridge	No. of Filter Cartridge	Outlet Pipe Diameter (mm)
OSD Tank 1	65	SPELFilter (SF.30 EMC) Full Height or Equivalent	35	259
OSD Tank 2	55	SPELFilter (SF.30 EMC) Full Height or Equivalent	40	273

The water quality treatment train pollutant removal results obtained from the MUSIC Model is shown in Table 12 below.

Table 12: Pollutant Removal Rates - MUSIC Modelling Results (Filter Cartridge)

Pollutant	Water Quality Targets (% Removal)	Sources (kg/year)	Residual Load (kg/year)	Removal Rate Achieved (%)
Total Suspended Solids	85	6084	902.3	85.17
Total Phosphorous	65	9.753	2.724	72.07
Total Nitrogen	45	71.96	37.48	47.92
Gross Pollutants	90	860.7	0.3608	99.96

Table 12 illustrates that the stormwater runoff from the proposed development will meet the pollutant removal targets set by Council outlined in Table 10.

6.3.2 Option 2: Bioretention Basins and SPEL Vortceptor SVI.500 GPT

The second option is to provide bioretention basin for treating stormwater from whole site before discharging it into Norwest Lake. The stormwater runoff from the site will be collected and treated by Vortceptor SVI.500 GPT or equivalent and then will be treated by bioretention basin. The approximate location and size of bioretention basin is shown in Figure 17 below which is subject to be detailed in future.

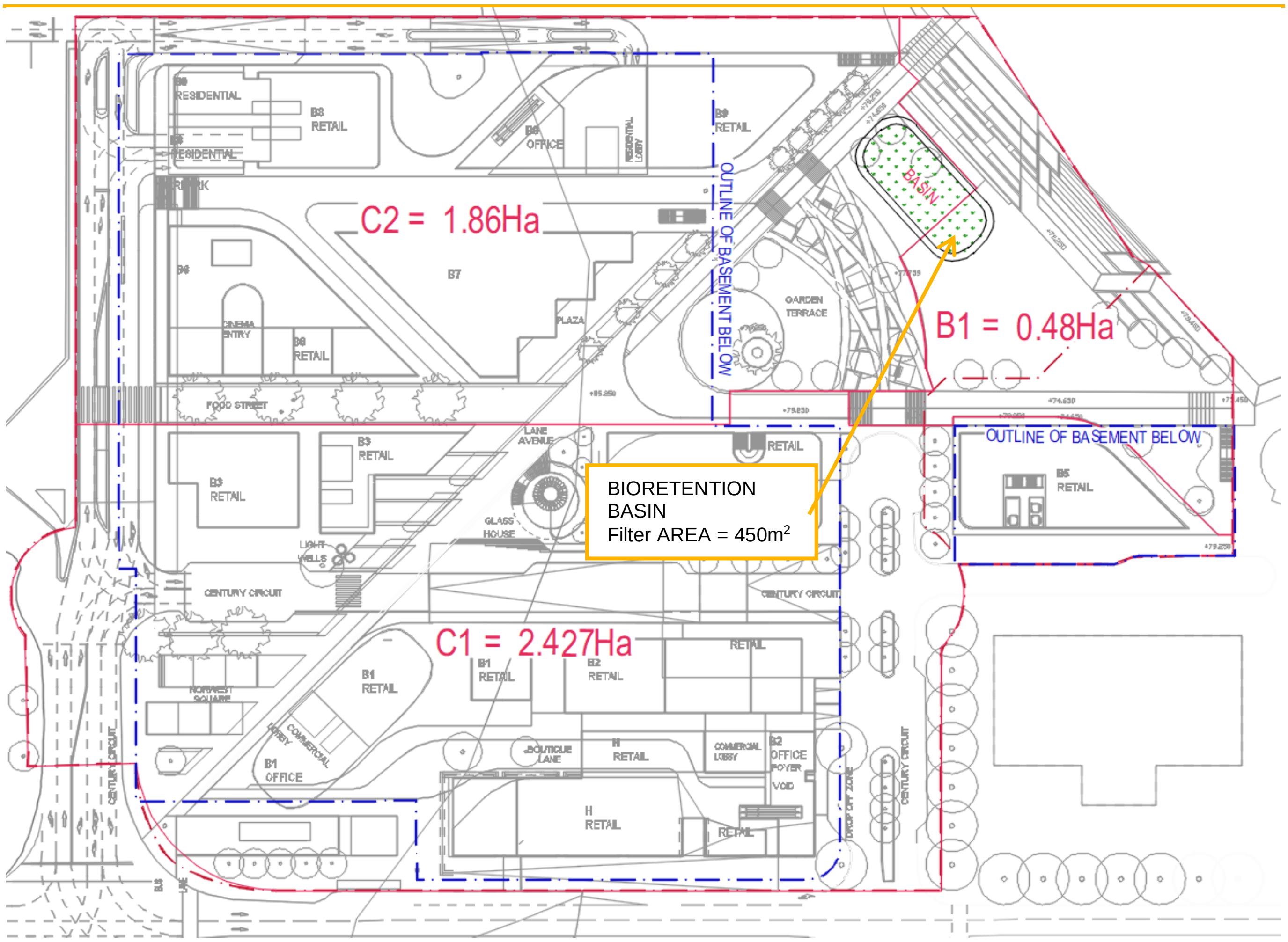

Figure 17: Approximate Location and Size of Bioretention Basin

The MUSIC model layout with treatment nodes and catchments is presented in Figure 18.

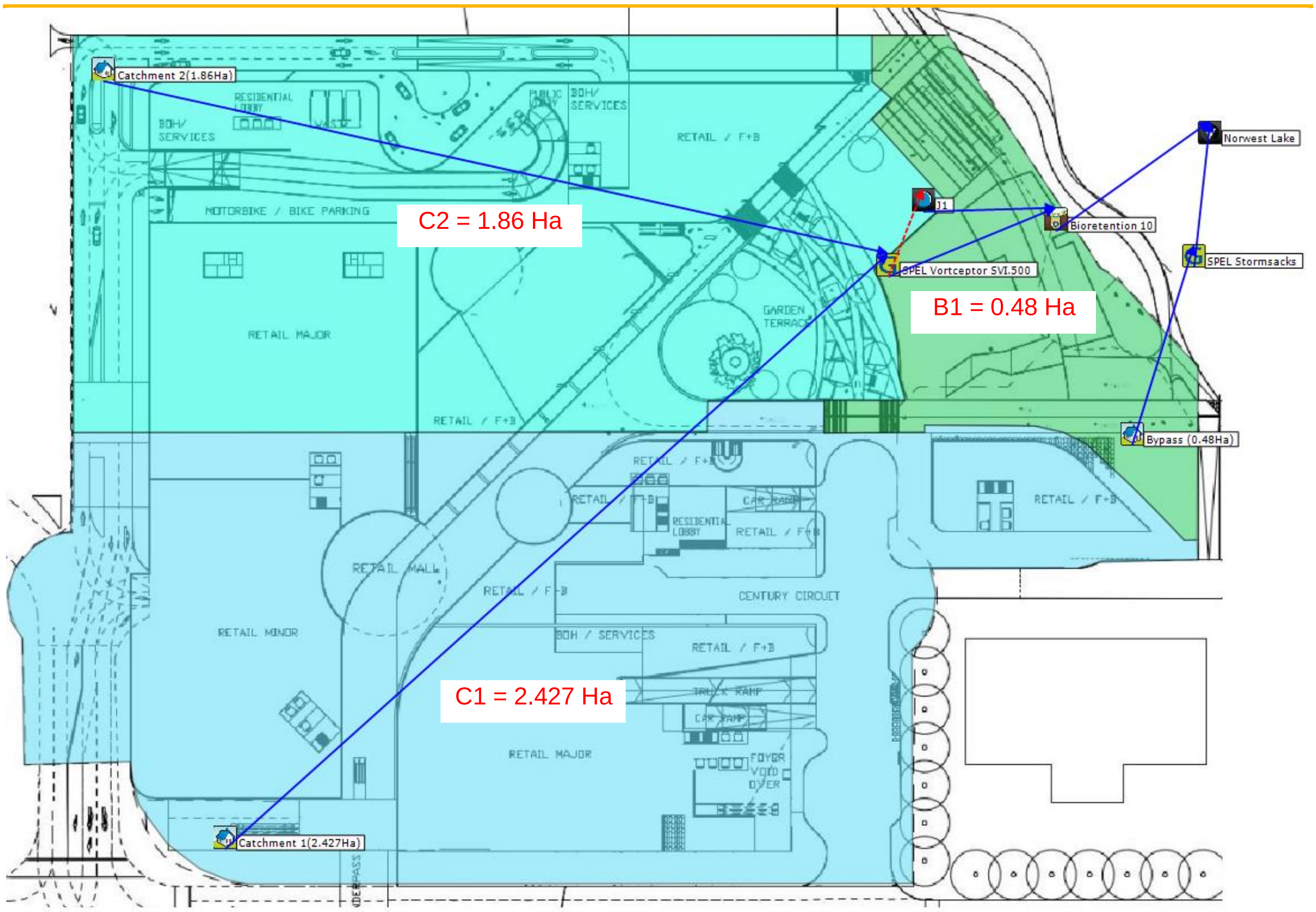

Figure 18: MUSICX Model Layout

The bioretention basin configuration is summarised in Table 13 below.

Table 13: Bioretention Basin Summary

Description	Filter Area (m^2)	Extended Detention Depth(mm)	Filter Media Depth(mm)	Gross Pollutant Trap
Bioretention Basin	450	300	500	SPEL Vortceptor SVI.500 or Equivalent

The Bioretention Basin shown in Figure 17 will receive major and minor flows from the whole site. The water quality treatment train pollutant removal obtained from MUSIC Model is shown in Table 14 below.

Table 14: Pollutant Removal Rates - MUSIC Modelling Results (Bioretention)

Pollutant	Water Quality Targets (% Removal)	Sources (kg/year)	Residual Load (kg/year)	Removal Rate Achieved (%)
Total Suspended Solids	85	5974	540	90.96
Total Phosphorous	65	9.729	3.376	65.3
Total Nitrogen	45	72.12	38.44	46.71
Gross Pollutants	90	860.7	0.3608	99.96

Table 14 illustrates that the stormwater runoff from the proposed subdivision will meet the pollutant removal targets set by Council as outlined in. Table 10.

7. Conclusion

The study has been carried out to protect the downstream waterway from both water quality and quantity impacts from the proposed redevelopment of the Norwest Marketown shopping complex and Carlile Swim Centre. The two (2) options have been analysed as part of this study. The summary of both the options are presented below.

Option 1: OSD Tanks with a storage capacity of $410m^3$ and $307m^3$ to attenuate the post-development flow to pre-development flow for the storm events ranging from 2-year to 100-year ARI. The OSD Tanks will be fitted with filter chambers and cartridges as outlined in Table 11.

Option 2: The flow from the proposed development is allowed to flow to the Norwest Lake without attenuation i.e., without providing on-site detention. The TUFLOW model has been setup to analyse the impact on downstream properties. The flood mapping results from TUFLOW shows that there will be an increase in flood levels in Norwest Lake by up to 10mm. As increase in flood level of 10mm will not create a negative impact to surrounding properties and it is feasible to construct the proposed development without providing on-site detention.

For Option 2, a Bioretention basin with Gross Pollutant trap fitted at the inlet has been designed to treat stormwater from the proposed development. The Music modelling concludes that the proposed development will meet the pollutant removal targets.

Appendix A Abbreviations, Terms and Definitions

Table 15: Abbreviations, Terms and Definitions

Abbreviation / Term	Definition
AEP	Annual Exceedance Probability
ARI	Annual Recurrence Interval
ARR	Australian Rainfall and Runoff
CBD	Central Business District
AEP	Annual Exceedance Probability
DCP	Development Control Plan
GP	Gross Pollutants
GPT	Gross Pollutant Trap
LEP	Local Environmental Plan
LGA	Local Government Area
IFD	Intensity Frequency Duration
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
OSD	On-site Detention
SWMP	Soil and Water Management Plan
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids