Water Cycle Management Strategy Report

Walker Corporation

Appin (Part 2) Precinct

October 2024

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Issue	Author	Reviewer	Approver	Date approved
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C – Minor Amendments	Troy McLeod	Sabina Lohani	Sabina Lohani	25/08/2023
D – Ownership Plan Update	Troy McLeod	Sabina Lohani	Sabina Lohani	30/08/2023
E – Precinct Boundary Adjustment	Elham Tavakoli	Troy McLeod	Sabina Lohani	5/09/2024
F – Precinct Boundary Adjustment	Troy McLeod	Troy McLeod	Sabina Lohani 	8/10/2024

EXECUTIVE SUMMARY

J. Wyndham Prince have been engaged by Walker Corporation Pty Ltd and Walker Group Holdings Pty Ltd (together the Proponent) to prepare a Water Cycle Management Strategy (WCMS) to support the Appin (Part 2) Precinct Structure Plan.

Appin (Part 2) Precinct directly adjoins the Appin (Part) Precinct and consists of two (2) parcels of land, named Kings Land and Dunbier Land. The Kings Land is located at the head of Ousedale Creek and is bisected by Wilton Road. The Dunbier Land is bisected by a ridgeline and discharges directly to Ousedale Creek in the east and Elladale Creek in the west. The existing sites are occupied by rural residential dwellings and grass pastures.

The WCMS report presents details on the planning proposal for the Appin (Part 2) Precinct. The assessment includes hydrologic analysis, water quality analysis, riparian corridor assessment and consideration of the potential ecological impacts of the development.

Water quality will be managed by a variety of controls in order to deliver the adopted water quality objectives. Devices have been sized indicatively based on a 10-ha typical catchment assumption for both the low-density and commercial areas proposed within the precinct plan. Further discussion on the water quality approach can be found in Section 5 of the report.

The water quantity modelling undertaken to support the Appin (Part) Precinct determined that flows are not detrimentally increased in the major downstream watercourses (Nepean River and Cataract River) as a result of the development. Some local flow increases were observed within the local catchments of the site; however, these increases were generally located within the proposed environmental conservation areas. Once these flows reach the main waterways (Nepean and Cataract River), the localised increases are combined with flows from a significant larger catchment and do not result in overall flow increases.

Given that there is no increase in flows within the major watercourses, it was determined that a merit-based detention approach is considered suitable for further investigation as the staged delivery of the Precinct occurs. Given the locality of the Appin (Part 2) Precinct (near the Appin (Part) Precinct) the same approach is proposed to be applied to detention. Refer to Section 6 of the report for further details on the proposed merit-based approach.

The impacts of the merit-based detention strategy have been carefully considered from an ecology and habitat management perspective. Various factors have been explored including peak flows, regular (frequent) runoff, pollutant reductions, velocity management, geomorphology, and flooding impacts. It is anticipated that while peak flows will be increased locally at the sites discharge points, the impacts on ecology will be manageable given the improvements that will be achieved in regular stormwater runoff and increased management of pollutants together with the resilience of the natural ecosystems that exist downstream of the development.

An illustration of the Water Cycle Management Plan for the Appin (Part 2) Precinct can be seen in Figure 1-1 in Appendix A.

The Water Cycle Management Strategy proposed for the Appin (Part 2) Precinct is therefore functional; it delivers the required technical performance, lessens environmental degradation and pressure on downstream ecosystems and infrastructure and provides for a ‘soft’ sustainable solution for water cycle management. The Proposal can be supported in its current form.

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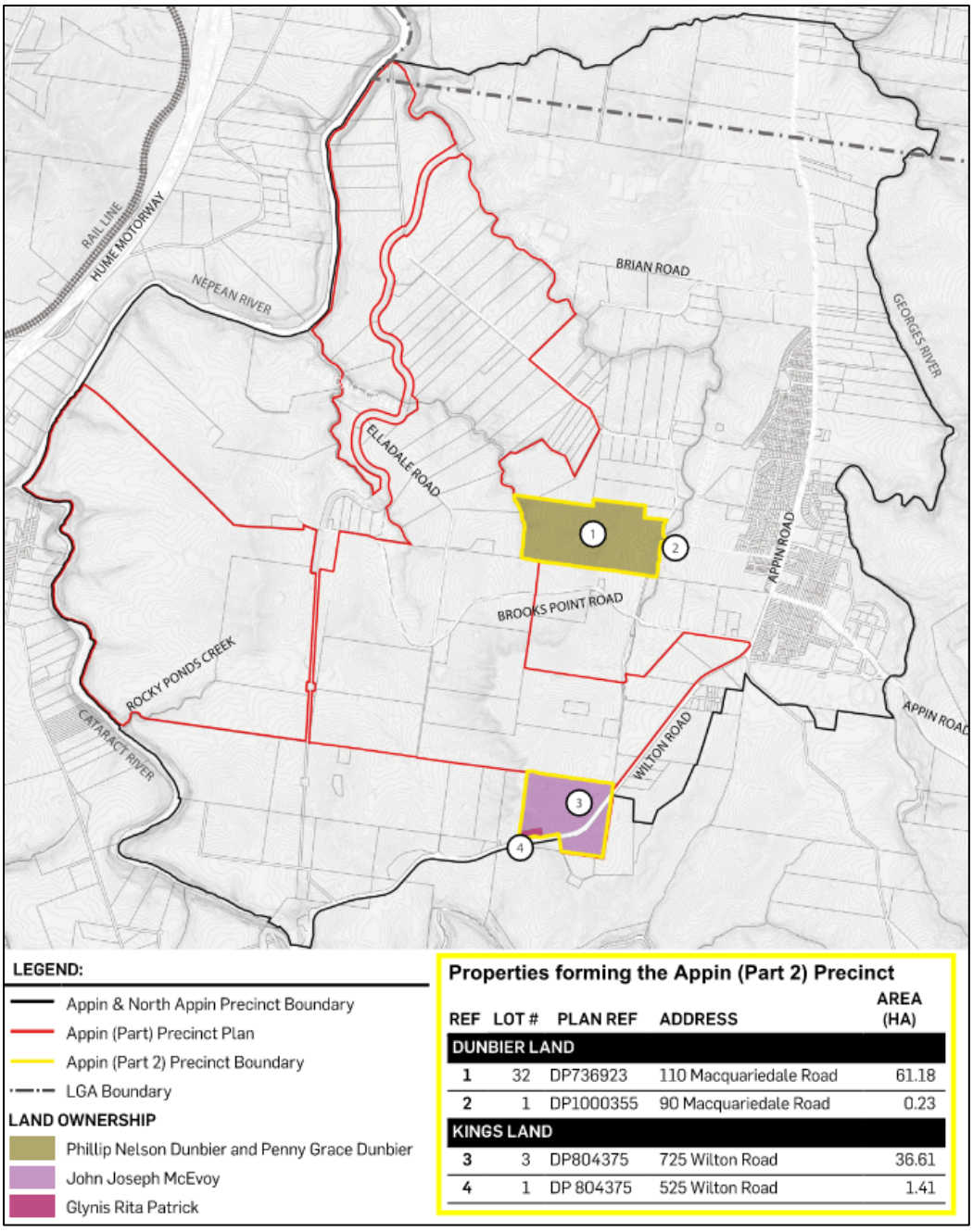
1. INTRODUCTION

1.1. The Proposal

The Proponent has prepared the subject submission to rezone 91.72 hectares of land (the Site) within the Appin Precinct from RU2 Rural Landscape to the following zones:

- Urban Development Zone
  - Zone 1 Urban Development (UD)
- Conservation Zone
  - Zone C2 Environmental Conservation (C2)

The Site is known as the Appin (Part 2) Precinct. The Site directly adjoins the Appin (Part 1) Precinct – refer to Plate 1-1.



Properties forming the Appin (Part 2) Precinct

REF	LOT #	PLAN REF	ADDRESS	AREA (HA)
DUNBIER LAND				
1	32	DP736923	110 Macquariedale Road	61.18
2	1	DP1000355	90 Macquariedale Road	0.23
KINGS LAND				
3	3	DP804375	725 Wilton Road	36.61
4	1	DP 804375	525 Wilton Road	1.41

Plate 1-1 – Boundary of the Appin (Part 2) Precinct

1.2. The Appin (Part 1) Precinct Planning Proposal (PP-2022-3979)

In November 2022, Walker Corporation Pty Ltd and Walker Group Holdings Pty Ltd (the Proponent) lodged a Planning Proposal (PP-2022-3979) to rezone part of the Appin Precinct.

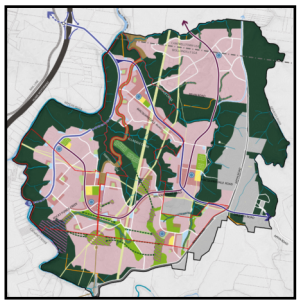
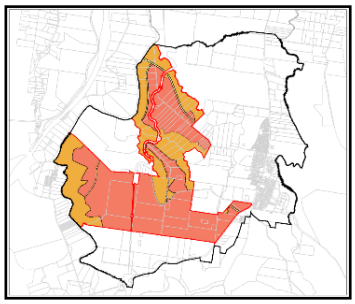
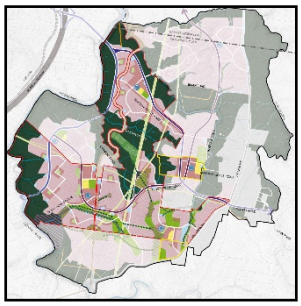
PP-2022-3979 (referred to as the Appin (Part 1) Precinct) proposes to rezone the land from RU2 Rural Landscape to Urban Development Zone (UDZ), C2 Environmental Conservation and SP2 Infrastructure via an amendment to State Environmental Planning Policy (Precincts – Western Parkland City) 2021.

The UDZ will facilitate approximately 12,000 dwellings. The C2 zone will facilitate the conservation of 470ha of endangered ecological community and help implement the Office of the NSW Chief Scientist & Engineer (NSW Chief Scientist) recommendations.

The new zones are accompanied by a structure plan outlining the intended land uses. In addition, the Proponent produced an Appin and North Appin Precincts Indicative Plan to illustrate how the new zones might fit within the broader precinct as land is developed. The Indicative Plan has no statutory weight and will be refined as further planning proposals are prepared.

These plans are summarised in Table 1-1.

Table 1-1 – PP-2022-3979 Title and Purpose of Plans

(1) APPIN & NORTH APPIN PRECINCTS INDICATIVE PLAN	(2) APPIN (PART) PRECINCT PLAN (THE PRECINCT PLAN)	(3) APPIN (PART) PRECINCT STRUCTURE PLAN (THE STRUCTURE PLAN)
Broader context and for information purposes only. It has no statutory weight. It identifies: • Higher-order transport network • Centres hierarchy • School sites • Conservation areas • Residential areas • Cultural sites and connections	It shows the land proposed to be rezoned and incorporated into a new schedule in the Western Parkland City SEPP 2021. The precinct plan contains the development provisions (clauses and maps) applicable to the site and is used in assessing development applications.	Structure plan for the site, showing staging of release areas. Development is to be generally consistent with the structure plan. It illustrates land use components including (but not limited to): • Low and medium-density residential • Retail and employment centres • School • Open space • Drainage network/basins • Transport network
 (21,000+ dwellings)	 (12,000 dwellings)	 (12,000 dwellings)

1.3. Population Growth

Greater Sydney's population is projected to grow to approximately 6.1 million by 2041 – over a million more people than currently live in the Sydney region.

The NSW Government has identified Growth Areas to accommodate the population that will choose to live in greenfield areas (new suburbs). The Greater Macarthur Growth Area (GMGA) is one such growth area and is a logical extension of the urban form of south-west Sydney. The GMGA is divided into precincts. The Appin Precinct and North Appin Precinct are the southernmost land release precincts of the GMGA. The goal is to deliver 21,000 dwellings.

The rezoning and release of land for development will achieve this goal.

1.4. The Appin (Part 2) Precinct Planning Proposal

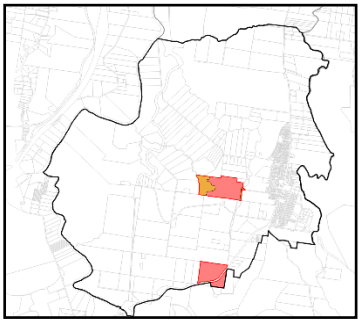
The Appin (Part 2) Precinct Plan (the precinct plan) shows the proposed new zones. 'The precinct plan' will be incorporated into the State Environmental Planning Policy (Precincts – Western Parkland City) 2021 and contain the provisions (clauses and maps) that will apply to 'the Site.' 'The precinct plan' envisages the delivery of the following:

- 1,312 dwellings (as a mix of low-density, medium density and apartments)
- 30,312 m² of gross lettable retail/commercial floor area
- 16.91 ha conservation land

The planning proposal submission is aligned with strategic land use planning, State and local government policies, infrastructure delivery and PP-2022-3979. The development potential is tempered by a landscape-based approach that protects the environment and landscape values, shaping the character of new communities. A series of residential neighbourhoods are to be delivered within the landscape corridors of the Nepean and Cataract Rivers, supported by local amenities, transit corridors and community infrastructure.

The submission includes a hierarchy of plans. The plans and their purpose are summarised in Table 1-2.

Table 1-2 – The subject Planning Proposal's Plans and Proposal

(1) APPIN & NORTH APPIN PRECINCTS INDICATIVE PLAN	(2) APPIN (PART 2) PRECINCT PLAN (THE PRECINCT PLAN)	(3) APPIN (PART 2) PRECINCT STRUCTURE PLAN (THE STRUCTURE PLAN)
Broader context and for information purposes only. It has no statutory weight. It identifies: • Higher-order transport network • Centres hierarchy • School sites • Conservation areas • Residential areas • Cultural sites and connections	It shows the land proposed to be rezoned and incorporated into a new schedule in the Western Parkland City SEPP 2021. The precinct plan contains the development provisions (clauses and maps) applicable to the site and is used in assessing development applications.	Structure plan for the site, showing staging of release areas. Development is to be generally consistent with the structure plan. It illustrates land use components including (but not limited to): • Low and medium-density residential • Retail and employment centres • School • Open space • Drainage network/basins • Transport network
 (21,000+ dwellings)	 (1,312 dwellings)	 (1,312 dwellings)

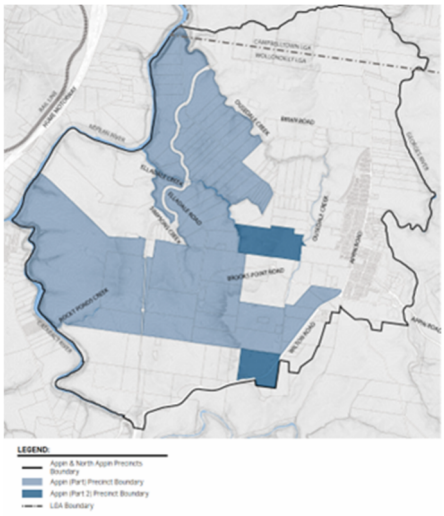
2. PURPOSE OF THIS REPORT

J. Wyndham Prince has been engaged by the Proponent to prepare a Water Cycle Management Strategy to support the Appin (Part 2) Precinct Plan (the precinct plan) and Appin (Part 2) Precinct Structure Plan (the structure plan).

Refer to Figure 1 and Table 3 for key attributes of the precinct plan and structure plan area.

The Appin (Part 2) Precinct Plan zones land for conservation and urban development. It establishes the statutory planning framework permitting the delivery of a range of residential typologies, retail, education, business premises, recreation areas, and infrastructure services and provides development standards that development must fulfil. Within the proposed urban development zone, 1,312 dwellings and more than 30,000 sqm of gross lettable floor area for retail and commercial space can be delivered.

Table 2-1 – Appin (Part 2) Precinct – summary of key attributes

Location		Key Attributes	
Appin (Part 2) Precinct		**Area**	Total – 100.1 ha Private Ownership – 100.1 ha
		LGA	Wholly Wollondilly LGA
		Proposed Dwellings	1,312
		Proposed retail & commercial floor space	30,000+
		Proposed Population	3,709

2.1. Objectives

This report summarises the site-specific assessment of stormwater quantity and quality management to ensure that there are manageable local impacts and no impacts external to the Appin (Part 2) Precinct. The objectives of the report are:

- To ensure that flows discharging to sensitive downstream waterways are not increased as a result of the development,
- To ensure that the water quality targets set out in Wollondilly Shire Council's Integrated Water Management Strategy and Policy (IWMS) are achieved,
- To maximise the reuse of non potable water,
- To ensure that the downstream environment and ecology is not degraded by the urbanisation of the catchment, and
- To provide a framework which will inform the future development applications (DA) for Appin (Part 2) Precinct.

The Proposal can be supported in its current form.

3. PREVIOUS STUDIES AND RELEVANT GUIDELINES

The following previous studies and control documents have been considered in the development of the Water Cycle Management Strategy for Appin (Part 2) Precinct:

- WSC Integrated Water Management Policy and Strategy (Wollondilly Shire Council, 2020);
- NSW MUSIC Modelling Guidelines (BMT WBM, 2015).
- Appin (Part) Precinct Water Cycle Management Strategy (JWP, 2022)

Details of the stormwater related objectives pertaining to this site are provided below.

3.1. Integrated Water Management Policy (2020)

Wollondilly Shire Council's Integrated Water Management Policy (IWMP) provides an overview of the objectives of the integrated water management strategy, outlining the overarching principles to be applied to new developments in the Wollondilly Local Government Area (LGA). The policy aims to deliver an integrated water solution for Wollondilly that protects the pristine waterways, endangered species, maintains and improves the condition of waterways, in the context of a growing population and changing land use. The policy lists the following objectives:

- Ensure stormwater and wastewater from urban development has a zero impact on local waterways;
- Decrease the use of potable water;
- Increase the amount of public and private water reuse and recycling;
- Use all sources of water to support sustainable development including community liveability, biodiversity, local economies including agriculture and climate resilience;
- Ensure water sensitive urban design elements are incorporated within public infrastructure and private development;
- Improve the condition of natural waterways, to remain swimmable, all year round;
- Ensure that residential, industrial, commercial and agricultural development doesn't affect the tributaries of the Georges and Nepean River within Wollondilly Local Government Area and downstream; and
- To support the water quality targets and associated treatment methods of urban water that are located in the Integrated Water Management Strategy.

3.2. Integrated Water Management Strategy (2020)

Wollondilly Shire Council's Integrated Water Management Strategy (IWMS) provides details of the proposed water management strategy to be implemented for new developments within the Wollondilly LGA. An alternate management approach is described in the IWMS which is aimed at achieving "zero impact" on the water cycle as a result of urban development. This approach is described in further detail in the IWMS and is also supported by a Water Sensitive Urban Design (WSUD) Guidelines which are newly adopted.

Importantly, the new Integrated Water Management Strategy outlines the new water quality and flow targets to be achieved by new developments (applied per hectare of new urban development area) in the Wollondilly LGA. They are listed as follows:

- Have between 2.5 and 3 ML of runoff on average, per year
- Reduce TN, TP and TSS by the ideal stormwater outcomes (85%, 95%, 95%) respectively
- Have either:
  - Five hundred square metres of green infrastructure to filter and infiltrate runoff
  - Two (2) megalitres of reuse of water per year
  - A combination of the above two (2) criteria

- Require zero downstream water quality assets, as all runoff and stormwater treatment are managed within development lots and precincts.

3.1. Wilton Growth Area Development Control Plan (2021)

In 2021, the NSW Department of Planning, Industry and Environment (DPIE) released the Wilton Growth Area Development Control Plan (DCP) which outlines the aims and objectives for new developments in the Wilton Growth Area which neighbours the Greater Macarthur Growth Area (GMGA). It is expected that similar controls and objectives will be adopted for the Appin (Part) Precinct (within the GMGA). Therefore, the objectives relating to flooding and water cycle management that have been considered in this strategy and are as follows:

- To manage the flow of stormwater from urban parts of the Precinct to replicate, as closely as possible, pre-development flows.
- To promote, at Precinct and Growth Area scale, an integrated approach to the provision of potable water, and the management of wastewater and stormwater.
- To ensure an integrated approach to drinking water, wastewater and stormwater services is considered to drive more sustainable water management outcomes
- To ensure that water management measures for development incorporate key principles of water sensitive urban design to help protect, maintain or restore waterway health of identified high value waterways with a minimum requirement of maintaining current health. This involves:
  - protecting existing hydrological and ecological processes of natural features and systems including watercourses, wetlands, lagoons and aquatic, riparian and groundwater dependant ecosystems
  - maintaining the natural hydrological behaviour of the catchment
  - where applicable, protecting the water quality of surface and groundwaters
  - minimising demand on reticulated water supply system
  - integrating water into the landscape to enhance ecological, visual, social, economic and cultural values.

Furthermore, this document outlines the water quality targets for the Wilton Growth Area which can be seen in Table 3-1 below.

Table 3-1 – Water Quality and Environmental Flow Targets

Element	Water quality % reduction in pollutant loads Gross Pollutants (>5mm)	Water quality % reduction in pollutant loads Total suspended solids; Total phosphorous; Total nitrogen	ENVIRONMENTAL FLOWS Stream erosion control ratio
Stormwater Management Objective	90	Neutral or Beneficial Effect on Water Quality - meaning loads of pollutants from future development must be equivalent to or less than that from the existing rural land use prior to development'	1:1

3.2. Appin (Part) Precinct Water Cycle Management Strategy (JWP, 2022)

The Appin (Part) Precinct Water Cycle Management Strategy (WCMS) report was prepared by J. Wyndham Prince in 2022 to support the rezoning of a portion of land within the Appin and North Appin Precinct. The WCMS report presents details on the planning proposal for the rezoning of 1,378 ha of land within the Appin and North Appin Precinct and is known as the Appin (Part) Precinct.

Water quality modelling was undertaken to determine the WSUD controls required to deliver the adopted water quality objectives. Devices were sized indicatively based on a 10-ha typical catchment assumption for both the low-density and commercial areas proposed within Appin (Part) Precinct. The modelling concluded that bioretention raingardens sized at 1.6% of the contributing catchments will be required for the proposed development at each discharge point to the downstream environment. The treatment train also consists of 5 kL rainwater tanks on each residential lot and a gross pollutant trap prior to discharge to each raingarden.

The hydrologic modelling assessment demonstrated that the proposed development of Appin (Part) Precinct will result in peak post-development discharges being restricted to less than the pre-development levels within the major receiving waterways (i.e. Nepean River and Cataract River). Preliminary modelling of detention basins within the site shows that introducing detention across the development will increase flows in Nepean and Cataract Rivers. Conversely, the urbanisation of the local sub-catchments within Appin (Part) Precinct means that local creeks and tributaries experience some localised increases in peak flows. Majority of the local increases in peak flows occur within the proposed environmental conservation zones which border the development edge (within the rezoning assessment area). As such, a detention strategy is proposed that focuses on providing strategic detention for areas of Appin (Part) Precinct that discharge to sensitive or higher order watercourses.

The impacts of the no detention strategy were carefully considered from an ecology and habitat management perspective. Various factors were explored including peak flows, regular (frequent) runoff, pollutant reductions, velocity management, geomorphology and flooding impacts. It is anticipated that while peak flows will be increased locally at the sites discharge points, the impacts on ecology will be manageable given the improvements that will be achieved in regular stormwater runoff and increased management of pollutants together with the resilience of the natural ecosystems that exist downstream of the development.

4. RIPARIAN CORRIDOR ASSESSMENT

The proposed rezoning area of the Appin (Part 2) Precinct is intersected by a series of existing watercourses. In accordance with the Guidelines for controlled activities on waterfront land (NRAR, 2018), the watercourses have each been identified to range between 1st to 3rd order riparian corridors based on the Strahler classification system using available 1:25,000 topographic maps. The guidelines state that where a watercourse does not exhibit the features of a defined channel with bed and banks, the NRAR may determine that the watercourse is not waterfront land for the purposes of the Water Management Act (2000) (WM Act).

Refer to Plate 4-1 and 4-2 for context of the watercourses that traverse the existing sites.

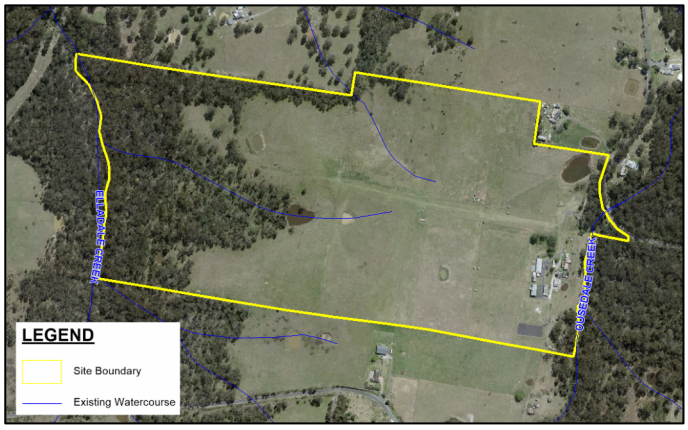


Plate 4-1 – Dunbier Land Existing Watercourses

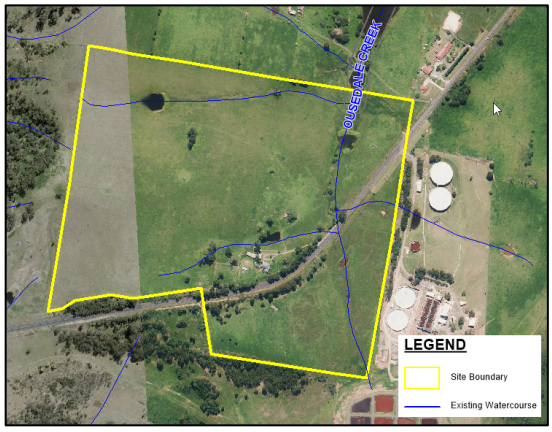


Plate 4-2 – Kings Land Existing Watercourses

A desktop review has been undertaken for the watercourses within the Appin (Part 2) Precinct to determine whether riparian features are present. Any watercourses that don't show signs of defined bed and banks or ecological value have been proposed to be removed. To support the proposed reclassification of these watercourses as waterfront land, a map has been prepared to show the Strahler classifications and watercourses proposed to be reclassified. Refer to Figure 4-1 in Appendix A.

The outcomes of the riparian mapping have been reached with consideration of the Waterfront land tool (NRAR, 2020) which has been developed to aid in the classification of "waterfront land" in accordance with the WM Act.

The 'Guidelines for controlled activities on waterfront land - Riparian corridors' (NRAR, 2018) outline that 1st order watercourses can be realigned/reengineered. Refer to Table 4-1 below. The 1st order watercourses that are located on urban capable land in the Appin (Part) Precinct development are proposed to be removed and replaced by street drainage networks (pit and pipe networks). In addition, any watercourse within 50m of the urban capable land of Appin (Part) Precinct is also proposed to be replaced by street drainage networks where suitable. Importantly, online detention basins are permitted on 1st and 2nd order watercourses.

Table 4-1 – Riparian Corridor Matrix (NRAR, 2018)

Stream order	Vegetated riparian zone(VRZ)	RC offsetting for non-RC users	Cycleways andpaths	Detention basins		Stormwater outlet structures and essential services	Stream realignment	Road crossings		
				Only within 50% outer VRZ	Online			Any	Culvert	Bridge
1st	10 m	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
2nd	20 m	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No
3rd	30 m	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes
4th	40 m	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes

5. WATER QUALITY ASSESSMENT

The stormwater quality analysis for this study was undertaken using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). This water quality modelling software was developed by the Cooperative Research Centre (CRC) for Catchment Hydrology which is based at Monash University and was first released in July 2002. Version 6.3 was adopted for this study.

MUSIC modelling provides the following features which are relevant to this assessment:

- Determines the source pollutant loads which are generated from a variety of land uses (i.e. commercial, roads, residential, rural residential, etc.)
- Ability to model the potential nutrient reduction benefits associated with Water Quality devices such as gross pollutant traps, constructed wetlands, grass swales, bio-retention systems, sedimentation basins, infiltration systems and ponds. MUSIC includes mechanisms which enable stormwater re-use to be used as a treatment technique
- Provides a mechanism to evaluate the attainment of mean annual runoff volume (MARV), pollutant load/concentration reductions and Stream Erosion Index (SEI) assessment.

The proposed WCMS assessed in MUSIC includes a “treatment train” of Water Quality Control devices to treat runoff from the proposed residential development areas prior to discharge to the downstream environment. This indicative “treatment train” includes proprietary vortex style gross pollutant traps and bio-retention raingardens to be located at each development discharge point.

While we note that “end of pipe” solutions are inconsistent with Wollondilly Shire Councils IWMS, the strategy provides limited details on how the new approaches (i.e. centralised road swales with increased infiltration) can be implemented on steep sites (>5%) together with the challenges with delivering the elevated pollutant removal targets using the available treatment approaches. The Appin (Part 2) Precinct development has used traditional treatment measures to strive toward the elevated water management targets in the IWMS, consistent with the Appin (Part) Precinct approach.

The adopted water quality objectives for this development are consistent with the Integrated Water Management Strategy (2020). In addition to this, we have also assessed stream erosion index (SEI) and neutral or beneficial effect (NorBE) which are included in the Wilton Growth Area DCP (2021) which provides an indication of the possible (future) Appin (Part 2) Precinct DCP. These objectives and targets are detailed in Section 3.

5.1. Modelling Inputs and Assumptions

The MUSIC model setup has been undertaken consistent with Councils ‘MUSIC Template’ (2020), ‘Integrated Water Management Strategy (2020) and ‘WSUD Guidelines’ (2020) as well as the ‘NSW MUSIC Modelling Guidelines’ (BMT WBM, 2015). For further detail about the modelling inputs and assumptions that have informed the modelling process, please refer to Appendix B.

As the development grading within Appin (Part 2) Precinct is unknown at this stage, a typical 10 ha low density residential catchment has been modelled to inform the anticipated size of the water sensitive urban design (WSUD) devices. These areas were then split to reflect the anticipated lot, road and open space areas within the typical urban development catchments.

In accordance with the NSW MUSIC Modelling Guidelines (2015), each of these areas has been further defined based on land uses including “Roof”, “Roads,” “Open Space,” “General Urban Impervious” and “General Urban Pervious” which constitute the different source node types in the model. The overall fraction impervious for the typical catchments aligns with those specified in Appendix A of Council’s IWMS (2020).

The existing conditions have been represented in a single 10 ha “agricultural” source node for the purpose of comparing pollutant loads and flows between existing and developed conditions. This catchment has been assigned a conservative fraction impervious value of 0% for the purpose of assessing stream erosion index (SEI) and neutral or beneficial effect (NorBE).

Further details on land use areas, modelling assumptions and parameters are summarised in Appendix B.

An overview of the model layout for low density development is shown in Plate 5-1.

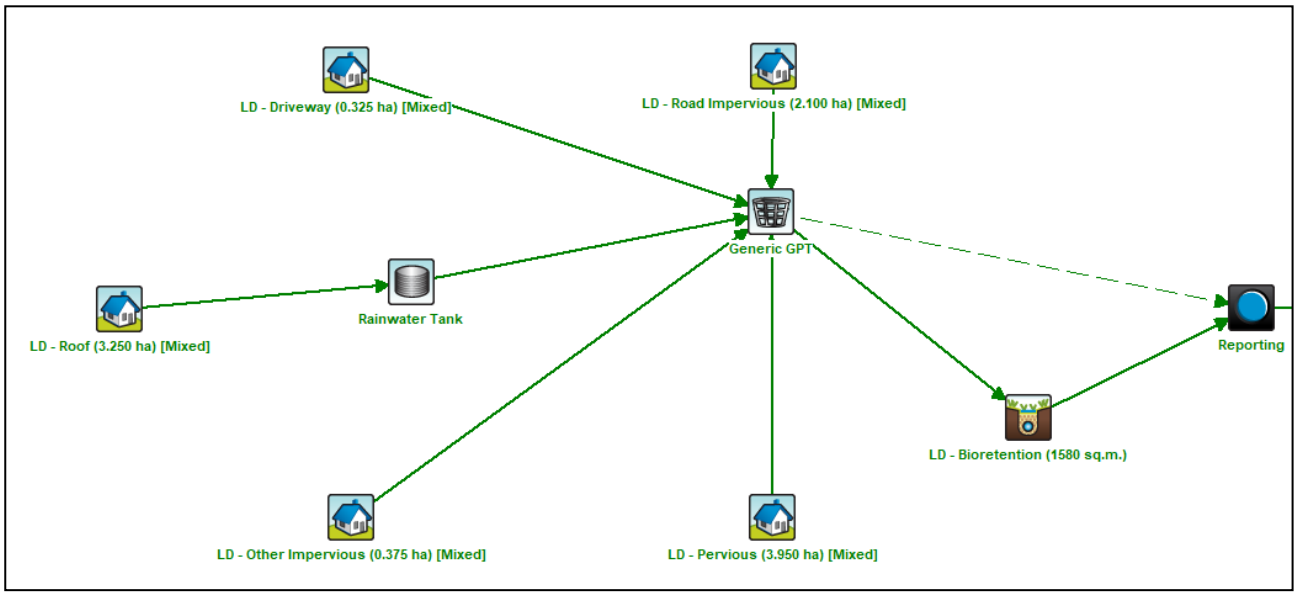


Plate 5-1 – MUSIC Model Layout
(Model Ref: 110628-02 MU02 IWMS.sqz)

5.2. Water Quality Management Measures

It is proposed that stormwater quality in Appin (Part 2) Precinct be managed using a treatment train approach. The treatment train of water quality devices that has been identified to achieve the water quality targets is as follows:

Residential land uses

- 5 kL rainwater tanks on each residential lot;
- Generic Gross Pollutant Traps (GPT) to pre-treat runoff prior to discharge into a tertiary treatment device; and
- The tertiary treatment consists of bioretention raingardens which will receive flows from the GPTs.

Commercial land uses

- For all commercial areas within Appin (Part 2) Precinct there will be a need for each development lot to deliver water quality management within the lot prior to discharge to the adjoining public road. Each commercial lot will need to account for their portion of the road reserves will need to be compensated for with their treatment measures. Alternatively, the developer can provide an end of line water quality treatment solution for the commercial areas which can be utilised by individual developments.

Further details regarding the adopted parameters for Gross Pollutant Trap(s) and Bioretention Raingarden(s) are provided in Appendix B.

It is important to note that this treatment train is only indicative and series of alternate arrangements such as open water bodies/wetlands, swales or proprietary devices for commercial areas, can deliver a similar water quality outcome and would form part of future consideration as the development process continues.

5.3. Modelling Results

Appin (Part 2) Precinct aims to achieve mean annual runoff volume (MARV) and pollutant load reduction requirements outlined in the WSC IWMS. The MUSIC Model was run using the stochastically generated estimated pollution loads from the source catchments.

5.3.1 MARV and Pollutant Loads

A comparison of the pollutant loads being generated on the site has been made between existing and developed conditions. Total annual pollutant loads being generated by the developed site have been derived from the MUSIC modelling and the pollutant load reductions and mean annual runoff results are presented in Table 5-1 below.

Table 5-1 - Summary of Pollutant Load Reductions for a Typical 10 ha Low-Density Residential Catchment

Pollutant	Total Developed Source Nodes	Total Residual Load from Site	Target Reduction Required	Total Reduction Achieved
	(kg/yr)	(kg/yr)	(%)	(%)
Total Suspended Solids	9200	949	95.0%	89.7%
Total Phosphorus	18.1	4	95.0%	78.5%
Total Nitrogen	129	39	85.0%	69.8%
Gross Pollutants	1240	3	90.0%	99.8%
MARV Results				
Flow (ML/yr)	32.3			
Flow Target (ML/yr/ha)	2.5 to 3.0			
Flow (ML/yr/ha)	3.23			
Raingarden Sizing				
Filter Area (m²)	1,580			
Pipe Flow (ML/yr)	21.96			
Hydraulic Loading Rate (m³/m²/yr)	13.90			

The results show that the pollutant reduction targets outlined in the IWMS are not achieved, however, it is noted that the results far exceed the typical statutory pollutant reductions which are widely accepted across the state. Many iterations of the water quality modelling have been undertaken with increasing treatment train sizes and it has shown that the target reductions from the IWMS cannot be achieved. The mean annual runoff volume (MARV) which has been achieved is 3.23 ML/yr/ha which is slightly greater than the IWMS targets of 2.5 to 3.0, however, is considered to be a suitable outcome, especially considering that neutral or beneficial effect (NorBE) targets are being achieved for the site. The resulting raingarden sizing for a typical 10 ha catchment is 1,580 m² or 1.58% of the contributing catchment.

Table 5-2 below details the indicative raingarden filter media areas for the various raingardens located across Appin (Part 2) Precinct.

Table 5-2 – Indicative Raingarden Areas

Raingarden ID	Catchment Area (ha)	Filter Area (m²)
R1	23.9	3,780
R2	1.6	260
R3	21.2	3,360
R4	4.8	760
R5	6.8	1,080
R6	4.6	740
R7	8.0	1,270

5.3.2 NorBE

Neutral or beneficial effect (NorBE) forms part of the water quality targets in the Wilton Growth Area DCP (2021). An assessment of the NorBE outcomes achieved by the proposed Appin (Part 2) Precinct treatment train has been undertaken.

Pollutant Loads

A comparison of the pollutant loads being generated on the typical catchment has been made between existing and developed conditions. A summary of the mean annual pollutant load for existing and developed conditions are shown below in Table 5-3 for a typical 10 ha Low Density Residential catchment.

Table 5-3 – NorBE Pollutant Load Comparison

Pollutant	Mean Existing Source Loads	Mean Developed Source Loads	Target Reduction Required	Total Reduction Achieved
	(kg/yr)	(kg/yr)	(%)	(%)
Total Suspended Solids	4540	949	≥10%	79.1%
Total Phosphorus	17.9	4	≥10%	78.2%
Total Nitrogen	87.8	39	≥10%	55.7%

Pollutant Concentrations

A comparison of the pollutant concentrations has also been undertaken in accordance with the requirements of a NorBE assessment. A NorBE assessment requires pollutant concentrations for TP and TN in the post-development case to be equal to or less than the pollutant concentrations for the pre-development case within the 50th to 98th percentile range when runoff occurs.

The pollutant concentration reductions are shown in Plate 5-3 for total phosphorus and Plate 5-4 for total nitrogen. The graphs show that reductions are achieved for both nutrients.

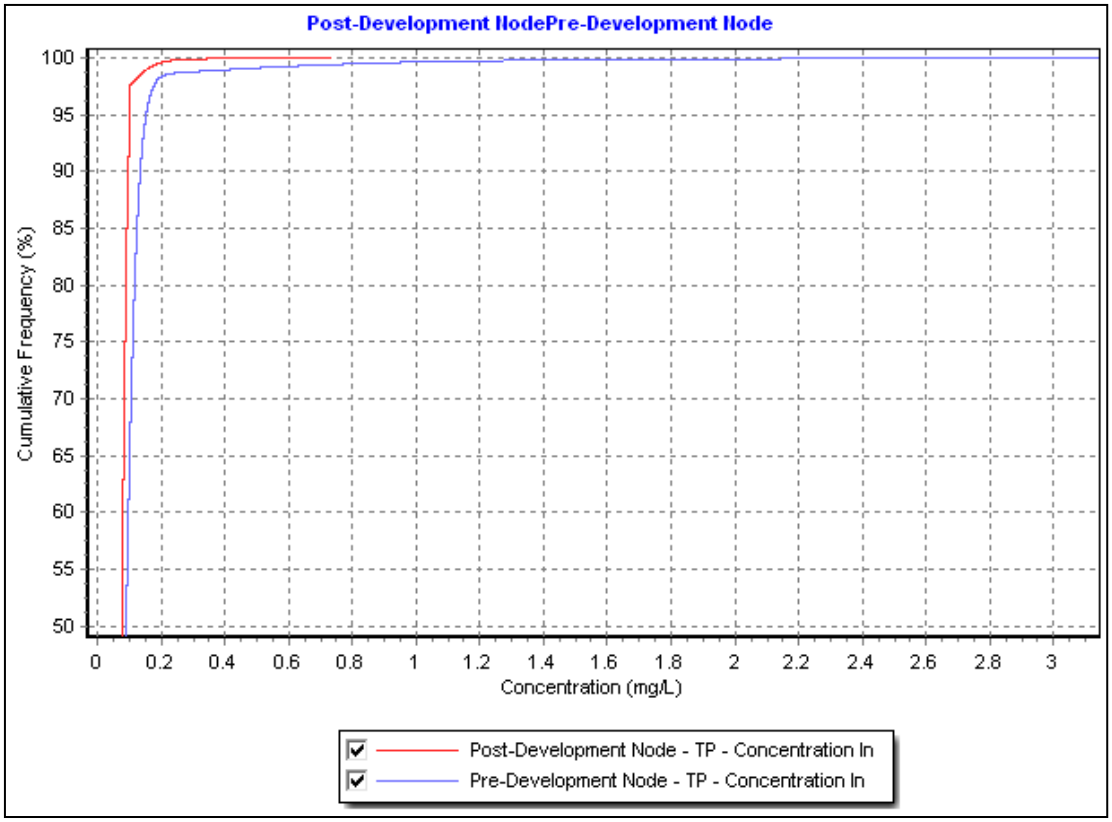


Plate 5-2 – Total Phosphorus – Pollutant Concentration Reduction

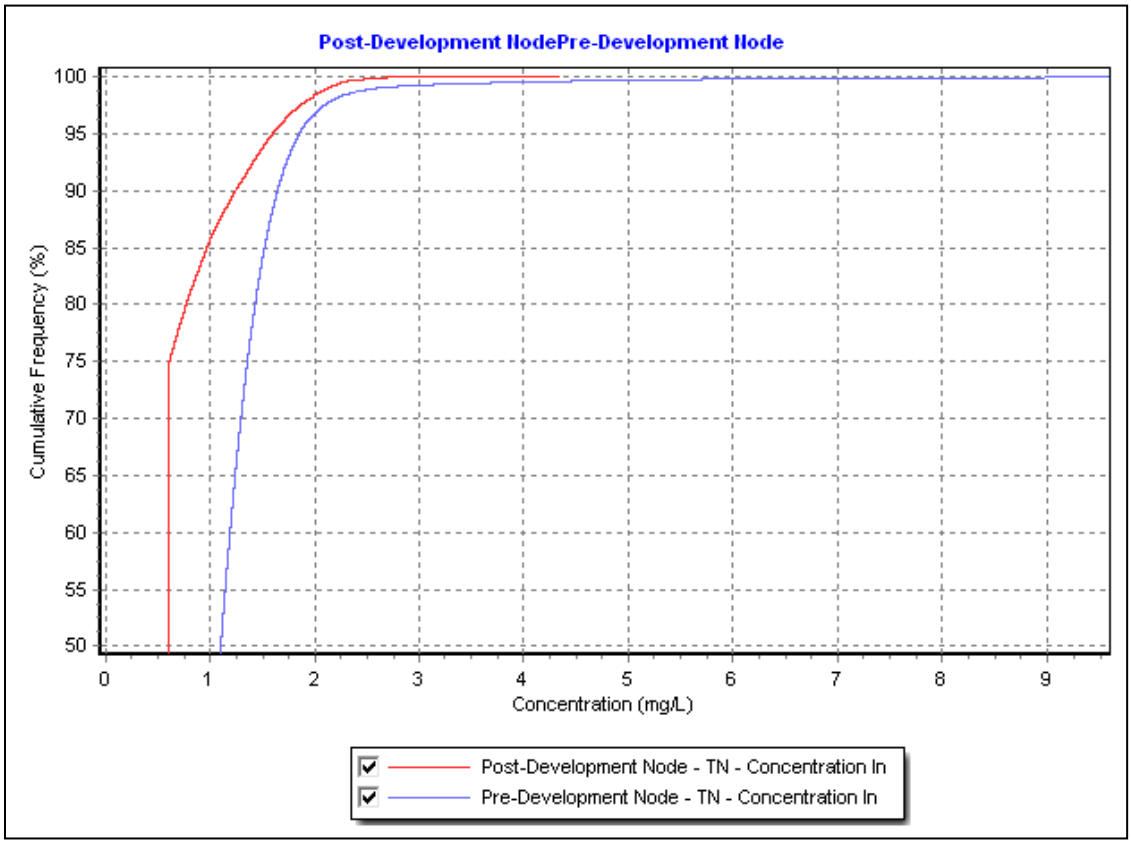


Plate 5-3 – Total Nitrogen – Pollutant Concentration Reduction

5.3.3 Results Discussion

An important part of this WCM Strategy involves the design of stormwater treatment systems that ensures the runoff from the urban development does not result in the pollution of the natural watercourse downstream. Nutrients such as Nitrogen and Phosphorus are potentially harmful pollutants to flora and fauna in natural ecosystems.

Significant reductions will be seen in the pollutants that are discharged to the natural streams due to the stringent water quality targets that have been adopted in this WCMS. The results of the water quality assessment shows that while the targets outlined in Council's Integrated Water Management Strategy (IWMS) have not been achieved, a solution has been provided that protects the pristine waterways by ensuring a significant reduction in the existing pollutants discharging to the downstream environment. This outcome is highlighted by the neutral or beneficial effect that has been achieved in the water quality solution which aligns with the objectives of Councils Integrated Water Management Policy (IWMP).

It is important to note that the NorBE targets which will also be achieved at Appin (Part 2) Precinct are normally applied to catchments discharging to the Sydney Drinking Water Catchment. NorBE targets are more stringent than the typical objectives of other growth areas in NSW (such as the North West and South West Growth Centres) and current standard industry practice. The typical targets for water quality in these areas generally involve achieving a pollutant load reduction (TN 45%, TP 65% and TSS 85%) from the developed catchment (without consideration of the existing loads). Therefore, the pollutant load removal and pollutant concentration reduction that will be achieved in Appin (Part 2) Precinct exceeds the standards of most developments across NSW and will result in a net reduction in pollutant impacts to the natural systems downstream of the site compared to the current land uses. This is aligned with the objectives outlined in Councils Integrated Water Management Policy.

5.3.4 Rainwater Tank Demand

It is understood that the water servicing strategy for Appin (Part 2) Precinct may include a recycled water scheme (purple pipe) to residential dwellings. It is anticipated purple pipes can be delivered in conjunction with the rainwater tanks and fill the reuse demand not met by the rainwater tanks alone.

The rainwater tank supply and demand for the residential catchment modelled in the MUSIC model is summarised in Table 5-4.

Table 5-4 – Rainwater Tanks Supply and Demand

	ML/yr	L/day/dwelling
Reuse Supplied	17.7	224
Reuse Requested	70.9	896
Shortfall (potable demand)	53.2	672
% Reuse Demand Met	25.0%	
% Reuse Demand Not Met	75.0%	

Table 5-4 shows that there is a 75% (53.2 ML/yr) shortfall of the available stormwater that could be reused for a typical 10 ha residential catchment. This means that there is an opportunity for Sydney Water's recycled water scheme to supply residential dwellings with an alternate water supply in order to meet the demands of households across the precinct and achieve a combined use system.

5.4. Stream Erosion Index

A Stream Erosion Index (SEI) assessment has been undertaken to ensure that the indicative treatment reduces the duration of post-development stream forming flows to no greater than the duration of pre-development stream forming flows. This is another requirement set out in the Wilton Growth Area DCP (2021) which gives a potential indication of the future development controls which may pertain to this site. The target specified in the Wilton Growth Area DCP is 1.0.

The modelling setup to assess the SEI has remained consistent with the assumptions and parameters that are outlined in Section 5.1.

The MUSIC modelling guidelines require the stream forming flow for the site to be determined using either the Probabilistic Rational Method (PRM) or Flood Frequency Analysis. As there are no stream gauge records available for Appin (Part 2) Precinct, the PRM method has been adopted. We note that the Rational method is no longer considered valid under the Australian Rainfall and Runoff (ARR 2019) guideline, however, we have utilised this method in accordance with Council's Design Specifications (2016) as the modelled catchments are classified as 'relatively small (approximately 10 ha)'.

The SEI for the typical catchment has been assessed against a range of downstream environment conditions. Specifically, the impacts of urbanisation on different soil types in the receiving creeks have been assessed. Given that the downstream conditions of all the receiving creeks are unknown at this stage, the SEI has considered the various soil conditions and the stream forming flow magnitudes (critical flows) for each soil type. The critical flows have been adopted in accordance with the NSW MUSIC Modelling Guidelines (2015). At the future DA stage, the receiving environments will be subject to separate and detailed environmental/ecological investigations to determine the sensitivity of the creek systems that the development will discharge to.

A summary table of the SEI assessment and results is provided in Table 5-5 and Table 5-6, respectively.

Table 5-5 – SEI Calculations

			Determination of Critical Flow					
Catchment	**Soil Type**	**Critical Flow**	**Area (km^2)**	**t_c (minutes)**	**I_2 (mm/hr)**	**C_2**	**Q_2 (m^3/s)**	**Q_{crit} (m^3/s)**
Low Density	Silty clays	25% of 2 year ARI flow	0.10	15	76.1	0.444	0.94	0.23
Low Density	Medium-heavy clays	50% of 2 year ARI flow	0.10	15	76.1	0.444	0.94	0.47
Low Density	Bedrock (assumed)	100% of 2 year ARI flow	0.10	15	76.1	0.444	0.94	0.94

Table 5-6 – SEI Results

			Stream Erosion Index		
Catchment	**Soil Type**	**Critical Flow**	**Pre Dev Outflow (ML/yr)**	**Post Dev Outflow (ML/yr)**	**SEI**
Low Density	Silty clays	25% of 2 year ARI flow	7.11	4.41	0.62
Low Density	Medium-heavy clays	50% of 2 year ARI flow	3.28	1.76	0.54
Low Density	Bedrock (assumed)	100% of 2 year ARI flow	0.82	0.36	0.44

The SEI results indicate that the proposed stormwater quality treatment train will ensure that the duration of post development stream forming flows would be no greater than the duration of existing conditions stream forming flows which is a requirement specified in the Wilton Growth Area DCP (2021). This is true for the various soil types that are likely to be present across the site. Notwithstanding this assessment, all development applications should undertake an SEI assessment at the design stage to confirm that the statutory SEI requirements are achieved for the specific site conditions.

5.5. Construction Stage

Erosion and sediment control measures across the site are an essential component that must be implemented during the construction phase in accordance with the requirements of Council and the guidelines set out in the "Blue Book" (2004).

The indicative treatment train for Appin (Part 2) Precinct includes 'bio-retention' (raingarden) water quality treatment systems which are sensitive to the impact of sedimentation. Thus, it is recommended that construction phase controls should generally be maintained until the majority of site building works (approximately 80% of the stormwater catchment) are complete to ensure the longevity of the devices.

5.6. Long Term Management

Regular maintenance of the stormwater quality treatment devices is required to control weeds, remove rubbish and monitor plant establishment and health (for raingardens). Some sediment build-up may occur on the surface of the raingardens and may require removal to maintain the high standard of stormwater treatment. Regular management and maintenance of the water quality control systems will ensure long-term, functional stormwater treatment. It is strongly recommended that a site-specific Operation and Maintenance (O & M) Manual is prepared for the system as part of future Development Applications. The O & M manual will provide information on the Best Management Practices (BMP's) for the long-term operation of the treatment devices. The manual will provide site-specific management procedures for:

- Maintenance of the GPT structures including rubbish and sediment removal;
- Management of the raingarden including plant monitoring, replanting guidelines, monitoring and replacement of the filtration media and general maintenance (i.e. weed control, sediment removal); and
- Indicative costing of maintenance over the life of the device.

6. WATER QUANTITY ASSESSMENT

The water quantity assessment for Appin (Part 2) Precinct has been undertaken using modelling previously undertaken in the Appin (Part) Precinct Water Cycle Management Strategy. This modelling was undertaken using AR&R 2019 methodologies within XP-RAFTS hydrologic modelling software. For full details of the modelling assumptions and outcomes, refer to the Appin (Part) Precinct Water Cycle Management Strategy Report (JWP, 2022).

The water quantity modelling undertaken to support the Appin (Part) Precinct determined that flows are not detrimentally increased in the major downstream watercourses (Nepean River and Cataract River) as a result of the development. Some local flow increases were observed within the local catchments of the site; however, these increases were generally located within the proposed environmental conservation areas. Once these flows reach the main waterways (Nepean and Cataract River), the localised increases are combined with flows from a significant larger catchment and do not result in overall flow increases.

Given that there is no increase in flows within the major watercourses, it was determined that a merit-based detention approach is considered suitable for further investigation as the staged delivery of the Precinct occurs. Given the locality of the Appin (Part 2) Precinct (near the Appin (Part) Precinct) the same approach is proposed to be applied to detention.

The following section describes how the merit-based approach would be applied for the precinct.

6.1. Merit Based Detention Approach

The detention basin approach for the Appin (Part 2) Precinct will involve a merit-based approach in applying detention to the urbanised catchments of the site. The hydrologic assessment that was undertaken in the Appin (Part) Precinct Water Cycle Management Strategy (JWP, 2022) for the ultimate site demonstrated that the urbanisation of the precinct does not have a reportable flow impact in the receiving rivers. It is expected that the extension of this development area to include Appin (Part 2) Precinct would also demonstrate the same outcome. However, due to the localised increases that will occur within the rezoning site (mostly within the environmental conservation areas) it is proposed that a considered investigation is undertaken in conjunction with the delivery of future neighbourhood plans to determine the level of sensitivity in the receiving environments. Table 6-1 outlines the different detention approaches that are intended to be applied to each stage of the Appin (Part) Precinct and also now the Appin (Part 2) Precinct.

Table 6-1 – Detention Management Approach Matrix

Watercourse Order (Strahler)	Sensitive Habitat / Vegetation Downstream	Existing Stream Condition	Management Approach
1st order	Yes	Stable, bedrock foundation	No detention
		Unstable	Detention required (BAU)
	No	Stable, bedrock foundation	No detention
		Unstable	Further assessment required. Partial Detention Likely
2nd order	Yes	Stable, bedrock foundation	Further assessment required. Partial Detention Likely
		Unstable	Detention required (BAU)
	No	Stable, bedrock foundation	No detention
		Unstable	Further assessment required. Partial Detention Likely
3rd order	Yes	Stable, bedrock foundation	Further assessment required. Partial Detention Likely
		Unstable	Detention required (BAU)
	No	Stable, bedrock foundation	No detention
		Unstable	Further assessment required. Partial Detention Likely

As shown in Plate 1-1, the Appin (Part 2) Precinct comprises of two (2) portions of land, “Dunbier Land” and “Kings Land”. The Dunbier Land is bisected by a ridgeline and discharges to both Elladale Creek to the west and Ousedale Creek to the east. Kings Land discharges wholly to Ousedale Creek. Ousedale Creek is a perennial 3rd order watercourse that is considered to be a well-established riparian corridor. Preliminary investigation of the watercourse indicates that the bed and banks are likely to be susceptible to erosion caused by substantial stormwater runoff. Based on these details and the matrix shown in Table 6-1, the detention management approach for the catchments draining to Ousedale Creek includes full detention management via the provision of strategically located online and offline basins.

The western portion of the Dunbier Land discharges to environmental conservation areas which contain large gorges, and which consist of predominantly hard rock stream beds and banks. These areas are proposed to remain undetained due to this resilient environment existing downstream of the development edge. These undetained catchments will still require water quality management devices (bioretention raingardens) which will provide frequent/regular flow management in accordance with stream erosion index and mean annual runoff volume targets.

6.2. Proposed Detention

The detention requirements for the proposed site has been determined with consideration of the detention outcomes of the Appin (Part) Precinct strategy. In the Appin (Part) Precinct strategy it was determined that six (6) detention basins would be required to manage catchments in Release Area 1 which discharge to Ousedale Creek. The six (6) detention basins were sized at an average of 350 m³/ha which has been adopted for the indicative detention basins for Appin (Part 2) Precinct. Refer to Plate 6-1 for an illustration of the indicative basin locations and Table 6-2 for indicative basin sizes.

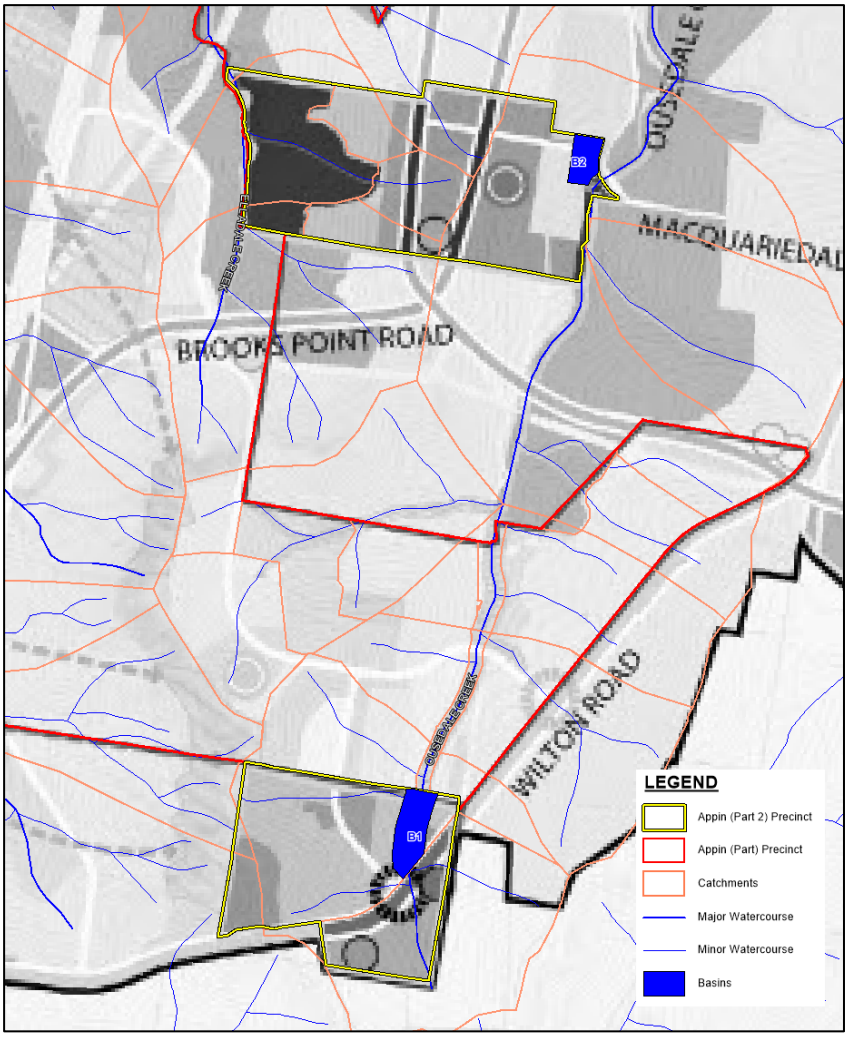


Plate 6-1 – Indicative Basin Locations

Table 6-2 – Indicative Basin Sizes

Basin	Storage Required (m^3)	Approx Footprint (m^2)
B1	19,300	34,470
B2	7,500	13,400

It is noted that as the development of the Appin (Part) Precinct Release Area 1 immediately downstream is progressed, alternative detention strategies will be explored which will aim to consolidate and reduce the number of basins required in Ousedale Creek. This will increase the efficiencies of the proposed basins while reducing future maintenance burdens for Council. It is expected that a consolidated basin approach can be achieved which removes the need for the basin “B1” which is currently situated on Kings Land. Detailed modelling will be undertaken as part of future development applications to demonstrate that a consolidated approach is achievable for the Ousedale Creek catchments.

7. FLOODING

The “Wollondilly Shire Flood Study – Broad Scale Assessment” (the Flood Study) was prepared by Advisian on behalf of Wollondilly Shire Council in October 2021 to provide understanding of the existing flood risk across the LGA. The Flood Study provides a basis from which flood planning controls can be applied to the proposed Appin (Part 2) Precinct.

The Flood Study assesses a range of flood events including the 10% AEP, 1% AEP, 1 in 500 AEP and PMF. In the vicinity of the Appin (Part 2) Precinct the flood mapping shows that the flood extents are contained in the well-defined creeks that traverse and are adjacent to the site. Wollondilly Shire Council’s flood mapping portal has been used to produce flood mapping in the vicinity of the Appin (Part 2) Precinct. The 1% AEP flood depths are shown in Plate 8-1 and the PMF flood depths are shown in Plate 8-2.

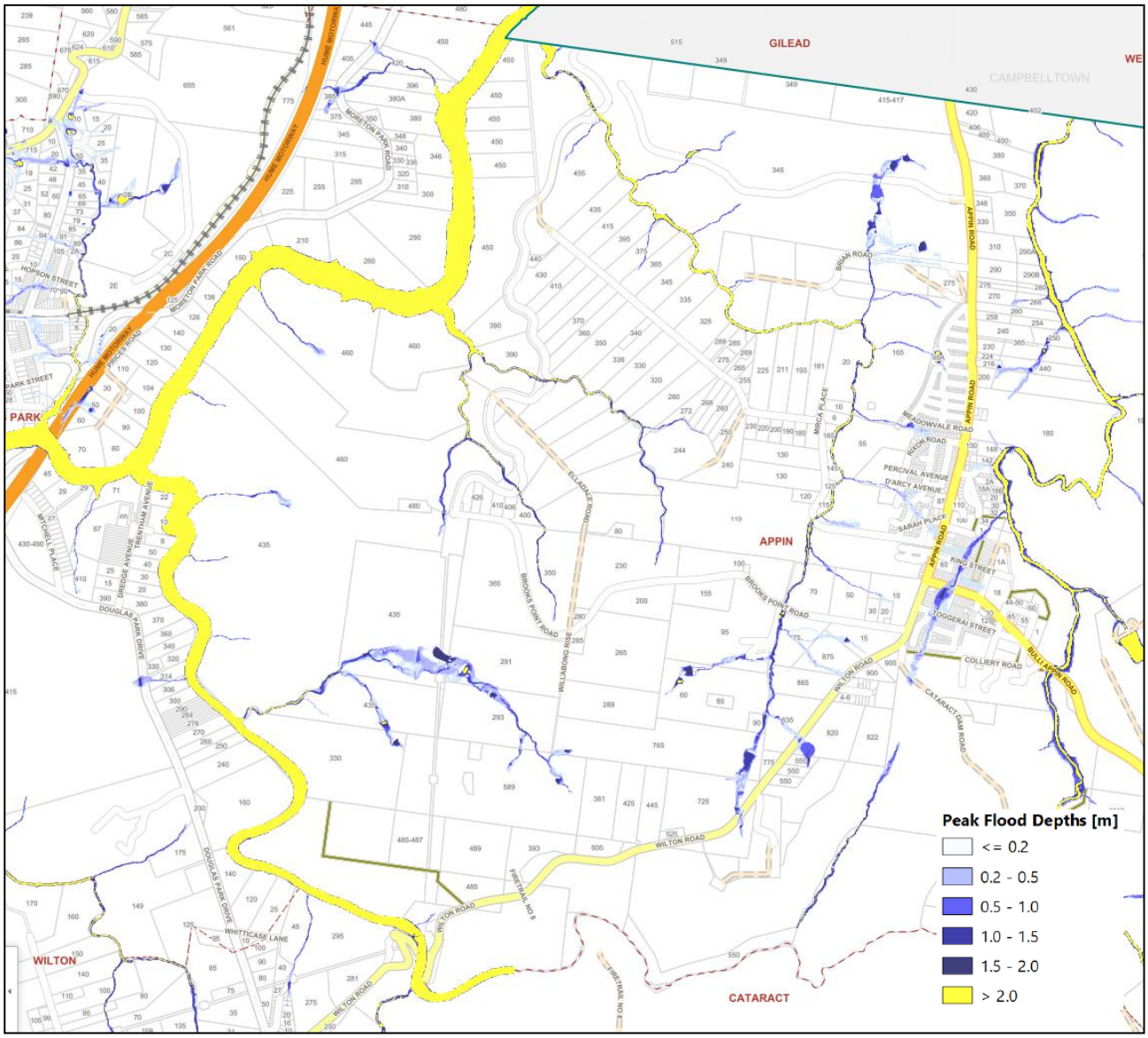


Plate 7-1 – 1% AEP Flood Depth Mapping (Wollondilly Online Mapping System)

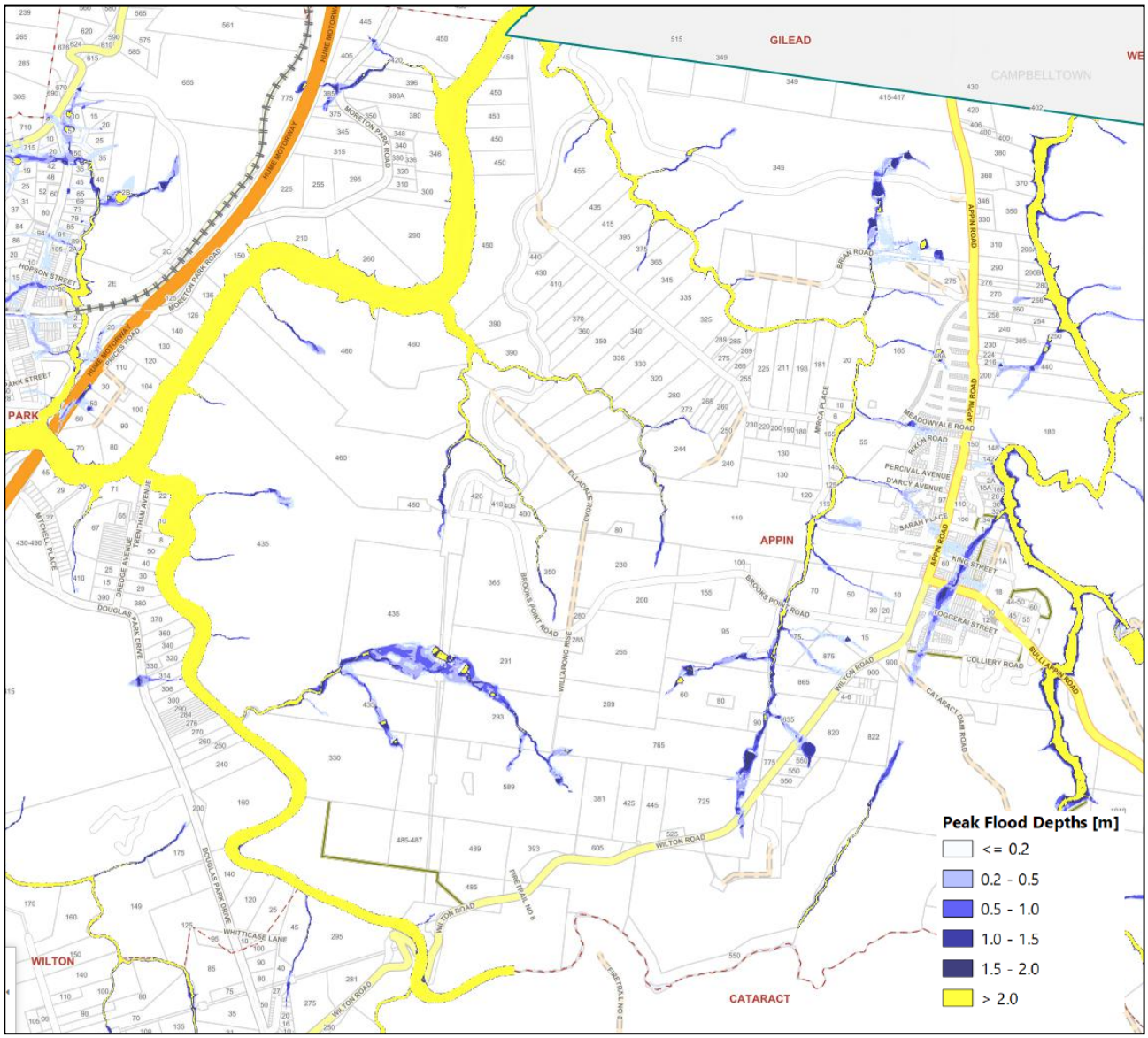


Plate 7-2 – PMF Flood Depth Mapping (Wollondilly Online Mapping System)

The nature of the site is such that the development catchments will drain directly to Elladale Creek and Ousedale Creek. The Flood Study mapping shows that flooding within these creeks is well contained within the riparian corridors suggesting that the development of Appin (Part 2) Precinct will not be impacted during a major flooding event. As such, it was considered that detailed post development hydraulic flood assessment is not required at this stage.

8. REFERENCES

1. DCP 2021. Wilton Growth Area Development Control Plan, Wollondilly Shire Council

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9. Wollondilly Shire Council (2020), Integrated Water Management Strategy, prepared by Wave Consulting

10. Wollondilly Shire Council (2020), Memo: MUSIC Template, prepared by Wave Consulting

11. Wollondilly Shire Council (2020), Integrated Water Management Policy

12. J. Wyndham Prince (2021), Appin (Part) Precinct Water Cycle Management Strategy

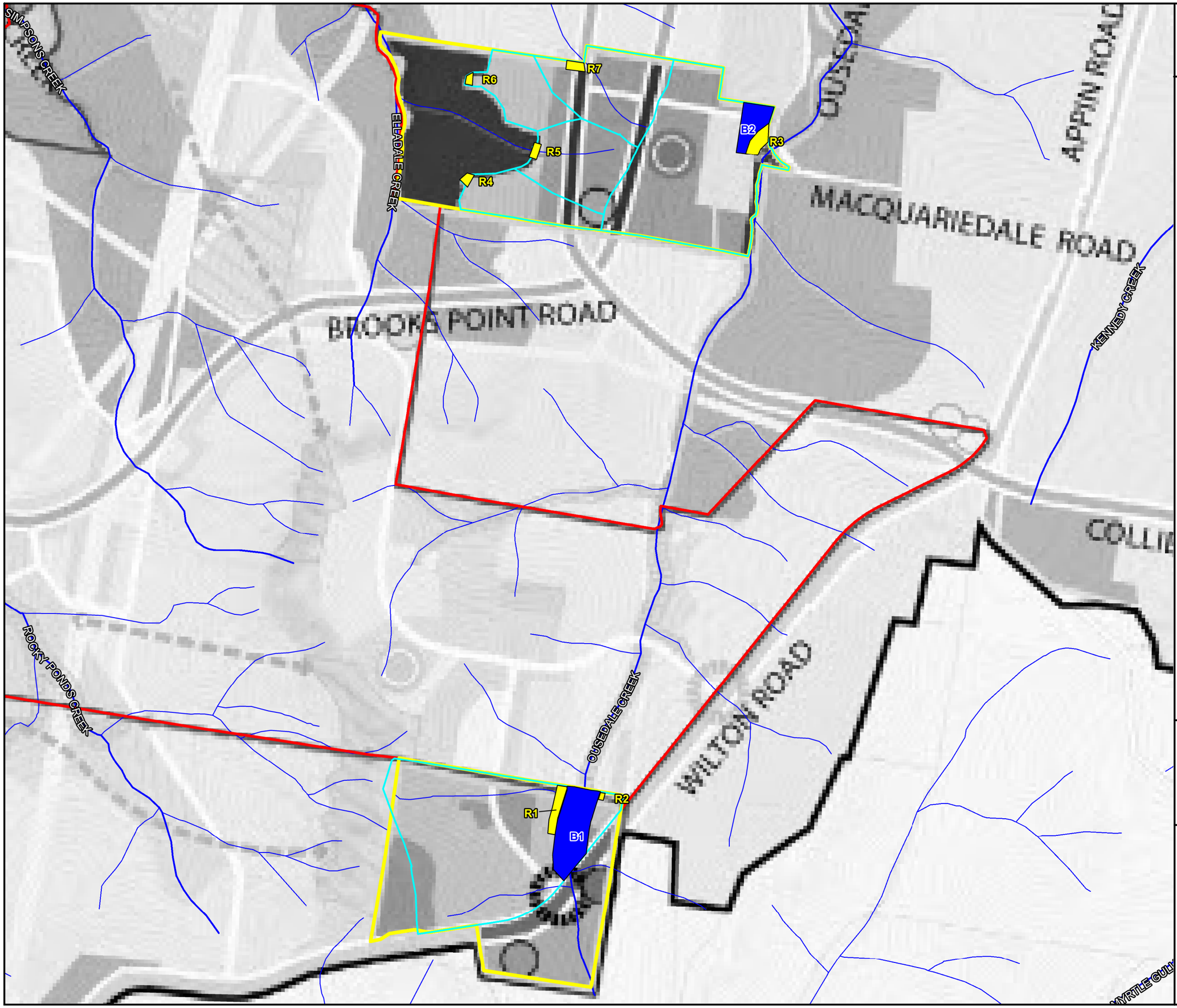
13. Natural Resources Access Regulator (2018), Guidelines for controlled activities on waterfront land - Riparian corridors

9. GLOSSARY

Term	Definition
Annual Exceedance Probability (AEP)	The chance or probability of a natural hazard event (usually a rainfall or flooding event) occurring annually. Normally expressed as a percentage.
Australian Rainfall and Runoff (AR&R)	Refers to the current edition of Australian Rainfall and Runoff published by the Institution of Engineers, Australia.
Exceedances per Year (EY)	The number of times a year that statistically a storm flow is exceeded.
Floodplain Planning Level (FPL)	The FPL is a height used to set floor levels for property development in flood-prone areas. It is generally defined as the 1% AEP flood level plus 0.5m freeboard.
Floodplain Development Manual (FDM) and Guidelines (April 2005)	The FDM is a document issued by the Department of Environment Climate Change and Water (DECCW) that provides a strategic approach to floodplain management. The guidelines have been issued by the NSW Department of Planning (DoP) to clarify issues regarding the setting of FPL's. This document is also the framework for the development of Floodplain Risk Management Studies and Plans.
Hydrograph	Is a graph that shows how the stormwater discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
J. Wyndham Prince Pty Ltd (JWP)	Consulting Civil Infrastructure Engineers and Project Managers undertaking these investigations
MUSIC	A modelling package designed to help urban stormwater professionals visualise possible strategies to tackle urban stormwater hydrology and pollution impacts. MUSIC stands for Model for Urban Stormwater Improvement Conceptualisation and has been developed by the Cooperative Research Centre (CRC),
Peak Discharge	Is the maximum stormwater runoff that occurs during a flood event
Probable Maximum Flood (PMF)	The greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends.

Term	Definition
TUFLOW	A computer program that provides two-dimensional (2D) and one dimensional (1D) solutions of the free surface flow equations to simulate flood and tidal wave propagation. It is specifically beneficial where the hydrodynamic behaviour, estuaries, rivers, floodplains and urban drainage environments have complex 2D flow patterns that would be awkward to represent using traditional 1D network models.
XP-RAFTS	Is a runoff routing model that uses the Laurenson non-linear runoff routing procedure to develop a sub catchment stormwater runoff hydrograph from either an actual event (recorded rainfall time series) or a design storm utilising Intensity-Frequency-Duration data together with dimensionless storm temporal patterns as well as standard AR&R 1987 data.

APPENDIX A – FIGURES



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LEGEND

- Appin (Part 2) Precinct
- Appin (Part) Precinct
- Appin & North Appin Precinct
- Catchments
- Major Watercourse
- Minor Watercourse
- Raingardens
- Basins

Note:
Device footprints are indicative and subj to future detailed design

N

0 440
metres
Scale 1:11,000 @ A3

Projection: GDA 1994 MGA Zone 56

Figure 1-1

Appin (Part 2) Precinct: Water Cycle Management Strategy

Water Cycle Management Plan

Date: 8/10/2024 Issue: C

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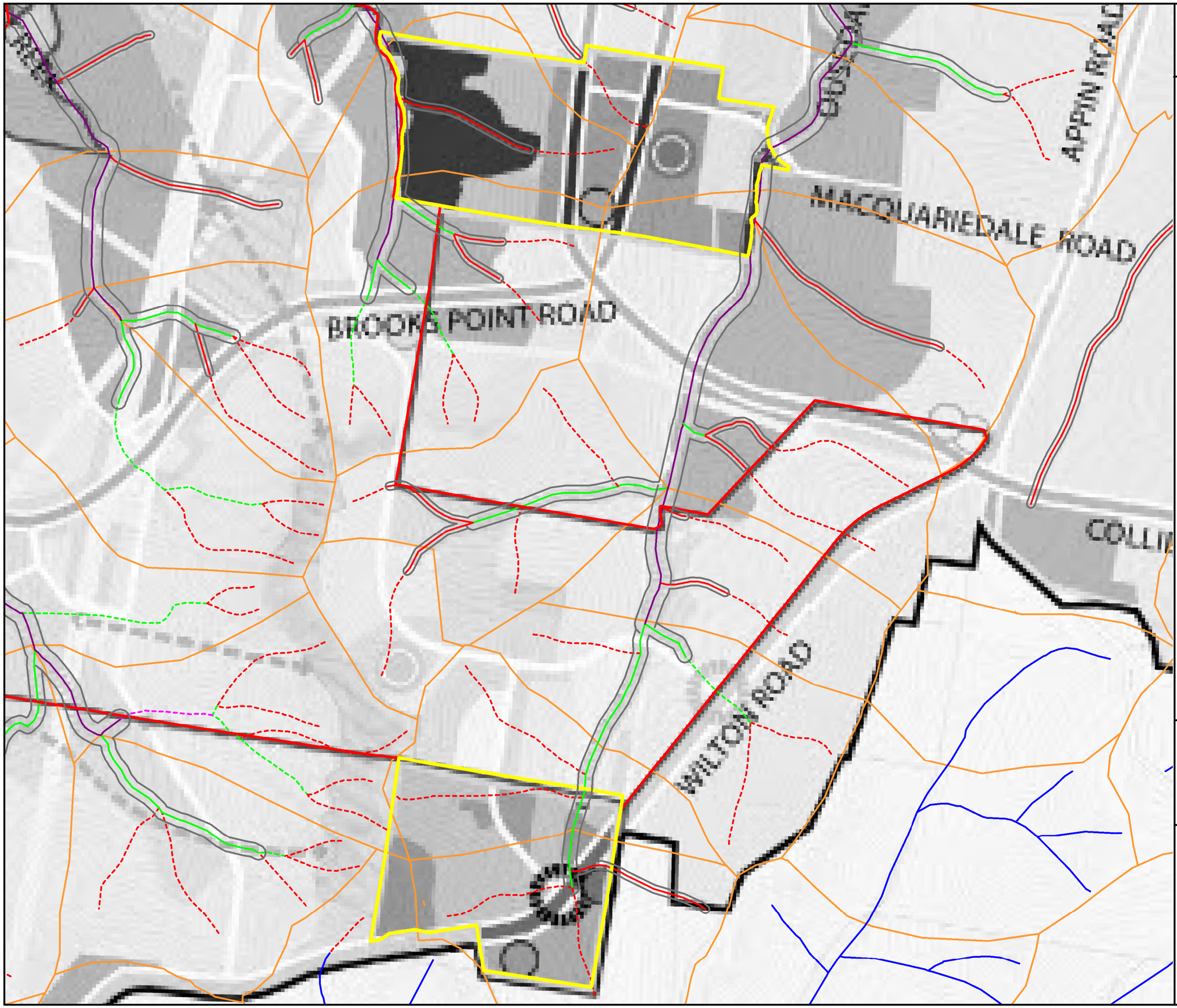

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LEGEND

- Appin (Part 2) Precinct
- Appin (Part) Precinct
- Appin & North Appin Precinct
- External Watercourse
- Existing Catchments
- Vegetated Riparian Zone (VRZ)

STRAHLER STREAM ORDER

- 1st Order Watercourse (10m VRZ Buffer)
- 2nd Order Watercourse (20m VRZ Buffer)
- 3rd Order Watercourse (30m VRZ Buffer)
- 4th Order Watercourse (40m VRZ Buffer)

PROPOSED FOR REMOVAL

- 1st Order Watercourse (10m VRZ Buffer)
- 2nd Order Watercourse (20m VRZ Buffer)
- 3rd Order Watercourse (30m VRZ Buffer)

NOTES

- Creek beds assumed to be 5 metres in width for the purpose of VRZ buffer calculations

N

0 440
metres
Scale 1:11,000 @ A3

Projection: GDA 1994 MGA Zone 56

Figure 4-1

Appin (Part 2) Precinct: Water Cycle Management Strategy

Riparian Assessment Plan

Date: 8/10/2024 Issue: C

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APPENDIX B - MUSIC MODEL DATA

Modelling Inputs and Assumptions

The proposed rezoning area of the West Appin Precinct is intersected by a series of existing watercourses, many of which are located within environmental conservation areas within the site. In accordance with the Guidelines for controlled activities on waterfront land (NRAR, 2018), the watercourses have each been identified to range between 1st to 4th order riparian corridors based on the Strahler classification system using available 1:25,000 topographic maps. The guidelines state that where a watercourse does not exhibit the features of a defined channel with bed and banks, the NRAR may determine that the watercourse is not waterfront land for the purposes of the Water Management Act (2000) (WM Act).

The MUSIC Modelling has used a series of default assumptions and parameters consistent with NSW MUSIC Modelling Guidelines (WBM BMT, 2015). Details are provided below.

- Commercial areas are assumed to provide on-lot stormwater quality treatment measures that achieve statutory pollutant removal targets prior to discharge to the regional system;
- The MUSIC model catchments have been split into the roof, driveways, road, urban previous and urban impervious;
- The soil / groundwater parameters and pollutant loading rates adopted for all “source nodes” in the modelling are based on the recommended parameters in the NSW MUSIC Modelling Guidelines (2015). 'Light Clay' parameters have been adopted from the guidelines which is consistent with the desktop geotechnical study undertaken by Douglas Partners for the wider Wilton Junction site which is adjacent to the West Appin Precinct.

Rainfall & Evapotranspiration Data

The MUSIC model is able to utilise rainfall data based on 6 minute, hourly, 6 hourly and daily time steps. In accordance with the recommendations from the Memo: MUSIC Template prepared by Wave Consulting on behalf of Wollondilly Shire Council (2020), a 6 minute rainfall data set has been selected from the Rookwood Station (no. 066164).

The 6 minute data obtained for Rookwood Station between the years 1975 – 1984 was analysed and found to be a fair representation of the long term statistical data for the mean annual rainfall within Wollondilly Shire and was therefore adopted in this study.

The evapotranspiration data used in the mode was also source from those suggested in Councils MUSIC Template. The evapotranspiration data used in the modelling is summarised in Table C-1 below.

The rainfall and evapo-transpiration data for the period analysed is shown on the graph which is provided in Plate C-1 below.

Table C-1 – Daily mean PET data

Month	Daily Mean PET (mm)
January	5.35
February	4.63
March	3.85
April	2.55
May	1.58
June	1.27
July	1.28
August	1.83
September	2.68
October	4.00
November	4.78
December	5.18

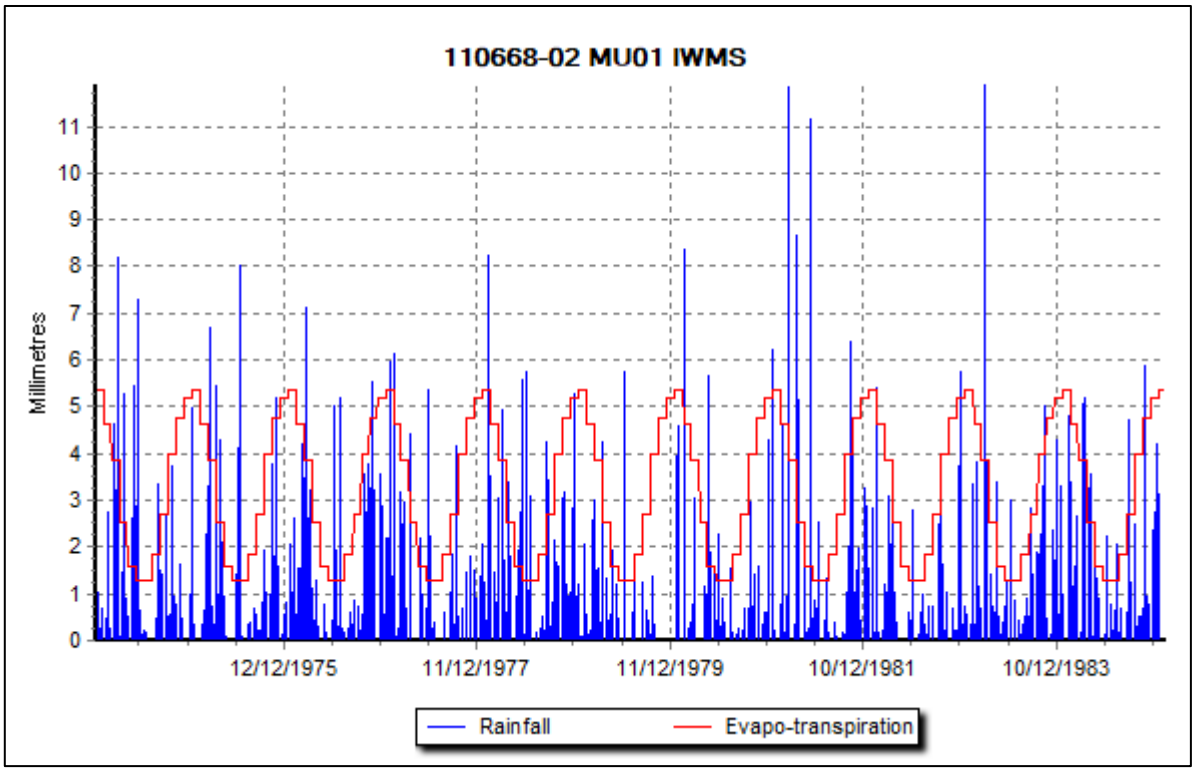

Plate C-1 – Rainfall and Evapo-transpiration Data for Rookwood Station

MUSIC MODELLING WORKSHEET Input
West Appin - IWMS WQ Assessment MUSIC Input
110668-02 MU02 IWMS.sqz

	Catchment Division						Node Inputs Catchment Split for MUSIC							
Catchment	**Total Catchment Area (ha)**	**Lot Area (ha)**	**R2 No. of Lots**	**Avg Lot Size (m²)**	**Road Reserve Area (ha)**	**Active Open Space**	**Road Impervious (ha)**	**Driveways (ha)**	**Roof to Tank (ha)**	**Roof bypass (ha)**	**Other Impervious (ha)**	**Pervious (ha)**	**Road Pervious (ha)**	**Effective % Impervious**
Typical 10 ha Low-Density	10.000	6.500	217	300	3.000	0.500	2.100	0.325	3.250		0.375	3.950	--	61%

	Node Inputs Rainwater Tanks					
Catchment	**Hi Flow Bypass**	**Equivalent Pipe dia (mm)**	**Daily Demand (kL)**	**Annual Demand (kL/yr)**	**Total Tank Volume (m^3)**	**Tank Surface Area (m^2)**
Low Density Residential	1.679	737	195.3	0	868.0	368.9

	Cat. Area (ha)	**Treatable Flow Calculation**				
		Flow Path Length (m)	**Tc* (min)**	**%Imperv.**	**1yr Flow (m^3/s)**	**3mth Flow (m^3/s)**
GPT Treatable flow (low density)	10.000	300	6	61%	1.231	0.640

*Tc calculated based on Kinematic wave equation for a typical lot plus flowpath travel time @ 2 m/s

	RWT	
Overflow Pipe Diameter	50	mm
PET - Rain for landscape area		L/m²/day
Assumed daily demand	900	L/day
Adopted tank size	5	kL
Assumed 80% is usable (w/o topups)	80	%
Useable tank	4	kL
Tank surface area per dwelling	1.7	m2
I5min/10yr	186	mm/hr

%Impervious	
R2 Lots	60%
Commercial	90%
Road Reserve	70%
Active Open Space	10%

% Breakdown Low Density		**% Breakdown Commercial**	
Roof	50%	Roof	60%
Driveways	5%	Driveways	20%
Other Impervious	5%	Other Impervious	10%
Pervious Areas	40%	Pervious Areas	10%

Water Quality Management Measures

Details as to the Gross Pollutant Traps and Bioretention Raingarden are provided below.

Gross Pollutant Traps

Gross Pollutant Traps (GPTs) have been provided to filter stormwater prior to discharge into the bioretention raingardens. A generic GPT has been adopted with the pollutant removal rates as specified in Table C-2.

Table C-2 – GPT Input Parameters

Pollutant	Input	Output
TSS (mg/L)	0	0
	100	100
TP (mg/L)	0	0
	100	100
TN (mg/L)	0	0
	50	50
GP (kg/ML)	0	0
	100	2

A 4 EY (3-month ARI) treatable flow rate has been adopted. A high flow bypass link within the MUSIC model reflects flows in excess of the treatable flow bypassing both the bio-retention raingarden and GPT. The final hydraulic arrangement for each device will be subject to a detailed design process to support the future development application.

Bioretention Raingarden

The design parameters adopted for the bioretention raingarden are shown in Table C-3. The filter media receives flow having firstly being treated by the GPT at each outlet.

Table C-3 – Raingarden Input Parameters

Raingarden Parameter	10 ha Residential Catchment
High Flow Bypass (m^3/s)	100
Extended Detention Basin (m)	0.3
Surface Area (m^2)	1580
Filter Area (m^2)	1580
Filter Depth	0.5
Unlined Filter Media Perimeter (m)	0.01
Saturated Hydraulic Conductivity (mm/h)	100
TN Content of Filter Media (mg/kg)	400
Orthophosphate Content of Filter Media (mg/kg)	40
Exfiltration Rate (mm/hr)	0.36
Overflow Weir Width (m)	6.50
Base Lined	No
Vegetated with effective Nutrient removal Plants	Yes
Underdrain Present	Yes
Submerged Zone with Carbon Present	No