Appendix AA

Integrated Water Cycle Management Strategy

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Integrated Water Cycle Management Strategy

Cudgegong Road Station Precinct South

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Cudgegong Road Station Precinct South

Client: Landcom

ABN: 79 268 260 688

Prepared by

AECOM Australia Pty Ltd
Level 21, 420 George Street, Sydney NSW 2000, PO Box Q410, QVB Post Office NSW 1230, Australia
T +61 2 8934 0000 F +61 2 8934 0001 www.aecom.com
ABN 20 093 846 925

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Executive Summary

The Cudgegong Road Station South development site comprises around 7.8 ha of government owned land within the Area 20 precinct in the North Western Growth Centre. Located between Cudgegong Road, Tallawong Road, Schofields Road and the Metro corridor, the proposal will allow for approximately 1100 apartments, 9,000m^2 of retail, commercial and community uses and 2900m^2 of public open space.

An Integrated Water Cycle Management Strategy has been prepared to support the rezoning of the site and preparations for development.

The site drains in a south eastern direction to a degraded section of Second Ponds Creek. The proposed development sits outside of the Second Ponds and First Ponds Creek riparian corridors.

The site is underlain by soils from the Blacktown Group and salinity and groundwater impacts will be avoided as infrastructure will largely avoid any infiltration of stormwater or interaction with the regional groundwater table.

The Blacktown Development Control Plan finds that there are no known groundwater dependent ecosystems within the Blacktown LGA. The proposal will not impact on downstream groundwater dependent ecosystems because stormwater will continue to recharge the regional groundwater system through local ephemeral waterways including Second Ponds Creek.

Station enabling works and existing roads include stormwater pipe drainage across Cudgegong Road in two locations. The proposed development will connect to this stormwater network. Analysis shows these drainage structures have been planned to accommodate future development including the proposed development. Some future drainage works will be required to discharge stormwater across water front lands and can be delivered in accordance with the Office of Water's criteria for stormwater outlets.

Water sensitive urban design elements are proposed as part of the treatment train that will provide an acceptable level of detention and treatment to achieve the prescribed stream stability metric and stormwater quality targets.

This strategy includes a recommendation to consolidate stormwater quality basins to the east of the proposed development site. Stormwater modelling demonstrates that the proposal location will provide enough area to comply with Council's stormwater pollution reduction targets.

1.0 Introduction

The NSW Government is currently building the Sydney Metro Northwest (SMNW) that is due to start operations in 2019. The SMNW is Stage 1 of the overall Sydney Metro project and involves the construction of eight new metro stations supporting infrastructure between Cudgegong Road and Epping and converting five existing stations between Epping and Chatswood. Stage 2 will deliver a new metro rail line from Chatswood through Sydney's CBD to Sydenham (Sydney Metro City and Southwest).

Landcom and the Sydney Metro Delivery Office (SMDO), part of Transport for NSW (TfNSW), are working in collaboration to develop walkable, attractive, mixed use places around the SMNW stations. This includes using the surplus government owned land located around the Cudgegong Road Station.

The subject site, the Cudgegong Road Station Precinct South, is located between Cudgegong Road, Tallawong Road, Schofields Road and the Metro corridor and comprises around 7.8ha of government owned land. It is within the southern part of the broader Cudgegong Road Station Precinct (Area 20) of the North West Priority Growth Area, a substantial land release area for homes and jobs in Sydney's northwest.

AECOM is engaged to carry out an Integrated Water Management Strategy to support the State Significant Development Application (SSDA) for the Station Precinct South concept proposal. The concept proposal allows for approximately 1,100 dwellings and 9,000 sqm of retail, commercial and community uses. It also includes a central park, new streets and supporting public domain.

Precinct enabling and augmentation works provided by Northwest Rapid Transit (NRT) to appropriately service the adjoining superlots are currently ongoing. Lead-in works and creation of precinct streets are expected to be completed by mid-2018. A plan of the Cudgegong Road Station Precinct South site is shown below in Figure 1.

Figure 1 Site Plan

The concept proposal generally adheres to the State Environmental Planning Policy (SEPP) (Sydney Region Growth Centres, 2006) Indicative Layout Plan (ILP) and Development Control Plan (DCP) for Area 20.

Consultation has been undertaken with each of these stakeholders as part of the Sydney Metro Northwest Urban Transformation Program project and the outcomes of this consultation are reflected in this IWCM.

Details of potable and wastewater supply, including alterative water supply arrangements is contained within the *Cudgegong Road Station Precinct South Utilities Report* (AECOM 2018). In summary:

- Potable water is supplied through the Prospect Supply System, potential ESD initiatives that could reduce potable water consumption include low flow fittings and fixtures within buildings, re-use of stormwater for irrigation and BASIX targets for residential buildings.
- Wastewater is serviced by the Rouse Hill Water Recycling Plan, some proposed ESD initiatives include the provision of a recycled water network, and community education on the methods and impacts of resource saving along with BASIX targets for residential buildings.

A Construction Soil and Water Management Plan prepared by Northwest Rapid transit (NRT) (Oct, 2015) which considers flooding within and outside site boundaries against the 100 year and PMF flooding events has also been referenced in this report.

1.1 SEARS Requirements

Table 1 below provides a summary of the SEARS requirements (SSD9063) that need to be addressed in this Integrated Water Cycle Management Strategy report.

Table 1 Response to SEARs

Item	Description	Action
12	Riparian Corridor	• Include an assessment of the proposal on the ecological values of the riparian corridors in proximity to the site
14	Flooding	• Include a detailed flood impact assessment
15	Soil and Water	• Include a description of local soils, topography, drainage and landscapes • Include a water management strategy with consideration of WSUD and the relevant provisions in BCC Engineering Guide for Development and Blacktown Development Control Plan 2015 • Assess the impacts of the proposal on groundwater resources and hydrology

2.0 Background

2.1 Existing Site Conditions

The Cudgegong Road Station Precinct South site is located within the Blacktown City Council Local Government Area (LGA) and is approximately 2km west of Rouse Hill Town Centre and 45km northwest of the Sydney CBD. The Precinct site is approximately 7.8ha in size, is bounded by Tallawong Road to the West, Cudgegong Road to the East, Schofields Road to the South and Cudgegong Metro Station to the north. The current site can be characterised as having semi-rural lots to the north and low density residential to the south. The site context is shown in Figure 2 below.

Figure 2 Site Context

The development site is located adjacent Schofields Road and 90m west of the Second Ponds Creek channel. Both waterways drain into the Hawksbury River catchment which is located to the north.

2.2 Proposed Development

The Cudgegong Road Station Precinct South development project involves the development of residential, commercial, retail and community uses. The proposal will allow for approximately 1,100 new dwellings and 9,000m^2 non-residential GFA. The development will comprise of various public facilities including a local park and new precinct streets to be constructed. The development concept plan for the site is presented below in Figure 3.

2.3 Stormwater and Integrated Water Cycle Management (IWCM) Strategy

The Cudgegong Road Station Precinct South is within the area covered by the Rouse Hill Trunk Drainage Strategy, developed by GHD on behalf of the Rouse Hill Infrastructure Consortium during the late 1990's. Sydney Water is the authority for management of the trunk drainage infrastructure incorporated within the strategy.

Stormwater quantity management for the precinct is addressed through the provision of regional detention basins, located external to the site. As such, stormwater quantity management, relating to detention basins, does not require further consideration as part of this IWCM and stormwater strategy.

In accordance with the previous approvals, streets within the development were constructed as part of the Sydney Metro Northwest works will be dedicated to Blacktown City Council.

Figure 3 - Concept Proposal

3.0 Design Standard and Approach

The following sections detail the criteria and standards that have been used to guide the development of the stormwater quality and quantity management strategy.

Note that 'pre-development' refers to conditions prior to works undertaken by Landcom on the precinct and includes works by NRT.

3.1 Area 20 Water Cycle Management Strategy Report Incorporating Water Sensitive Urban Design (2010, JWP)

The following approach, defined in the Area 20 Water Cycle Management Strategy Report Incorporating Water Sensitive Urban Design (2010, JWP) has been adopted in developing a water and stormwater management strategy for the site:

- The strategy should include water reuse and maximise potable water conservation;
- Stormwater management should be based on the objectives and principles of WSUD;
- Existing waterways and riparian zones should be conserved and enhanced where possible;
- Stormwater management strategies must considers and addresses potential salinity hazards;
- Stormwater management strategies should maximise efficient use of land and facilitate adequate allocation of land for stormwater management purposes;
- A treatment train approach should be used, incorporating structural stormwater treatment measures at the primary, secondary and tertiary levels as necessary to comply with the stormwater management targets;
- The design of stormwater management systems should be integrated with the planning of road layout and design, given the potential benefits of incorporating suitable WSUD elements into road corridors;
- Stormwater reuse, retention and detention strategies should be used to minimise changes to the hydrological (or flow) regime of receiving waterways;
- Management of stormwater should be considered on a subcatchment basis to employ source control techniques in preference to highly centralised 'end-of-pipe' treatment measures wherever practicable;
- Trunk drainage routes and dual carriageways should be aligned where possible, to allow use of centre medians for WSUD drainage systems; and
- WSUD drainage systems may be incorporated into other roads and streets, where practicable and compatible with other design issues, including safety requirements of the relevant Road Authority.

3.2 Blacktown City Council (BCC) Development Control Plan

The Blacktown City Council (BCC) Development Control Plan 2016 requires the proposed development to implement stormwater quantity controls to achieve the following:

- Manage the flow of stormwater from urban parts of the Precinct to replicate, as closely as possible pre-development flows;
- Define the flood constraints and standards applicable to urban development in the Precinct;
- Minimise the potential of flooding impacts on development;
- No residential allotments are to be located at a level lower than the 1% AEP flood level plus freeboard of 500mm;
- Pedestrian and cycle pathways and open space may extend within the 100 year ARI flood level, provided the safe access criteria contained in the NSW Floodplain Manual are met;

- Stormwater is to be managed primarily through the street network in accordance with Council's DCP;
- Roads on primary drainage lines shown on the Key elements of the water cycle management and ecology strategy figure, in the relevant Precinct Schedule, are to be constructed in the locations shown, and are to be designed in accordance with specifications of Council in relation to management of stormwater flows and quality;
- Roads are generally to be located above the 100 year ARI level;
- Management of 'minor' flows using piped systems for the 20 year ARI (residential land use) and 10 year ARI (commercial land use) shall be in accordance with Blacktown Council's Engineering Guidelines for Subdivision and Development. Management measures shall be designed to:
    - prevent damage by stormwater to the built and natural environment
    - reduce nuisance flows to a level which is acceptable to the community
    - provide a stormwater system which can be economically maintained and which uses open space in a compatible manner
    - control flooding
    - minimise urban water run-off pollutants to watercourses, and
    - meet the standards for a 100 year ARI flood level
- Management of 'major' flows using dedicated overland flow paths such as open space areas, roads and riparian corridors for all flows in excess of the pipe drainage system capacity and above the 20 year ARI shall be in accordance with Blacktown Council's Engineering Guidelines for Subdivision and Development. Management measures shall be designed to:
    - prevent both short term and long term inundation of habitable dwellings
    - manage flooding to create lots above the designated flood level with flood free access to a public road located above the 100 year ARI flood level
    - control flooding and enable access to lots, stabilise the land form and control erosion
    - provide for the orderly and safe evacuation of people away from rising floodwaters
    - stabilise the land form and control erosion
    - meet the standards for a 100 year ARI flood level
- The trunk stormwater system is to be constructed and maintained by Council in accordance with the Riparian and Water Cycle Management Strategy, and to achieve water quality targets set by the Department of Environment, Climate Change and Water (DECCW); and
- Where development on land affected by local runoff or local overland flooding – major drainage is proposed, it must be designed in accordance with Council's *Engineering Guide for Development.*

3.3 Blacktown City Council (BCC) Design Standards

During the design development stage of the Cudgegong Road Station Precinct South project, there was ongoing consultation with Blacktown City Council regarding their requirements for drainage infrastructure at the project site.

The BCC *Works Specification Civil* and *Engineering Guide for Development* provide detailed requirements addressing stormwater drainage and erosion and sediment control. BCC has also developed a design criteria memo for design of Council stormwater assets which has been referenced.

3.3.1 Design Standards

BCC design standards have generally been adopted for the Cudgegong Road Station Precinct South development, as the stormwater infrastructure that is to be delivered external to the buildings will ultimately be dedicated to council. A summary of each of the standards, codes and other additional design documents used in the design of stormwater infrastructure for the development are presented in Table 2 below.

Table 2 Stormwater Drainage reference documents and standards

Reference Number	Title
SEPP 2006	State Environmental Planning Policy (Sydney Region Growth Centres) 2006. Growth Centres Development Code 2006
DCP	Blacktown City Council Growth Centre Precincts Development Control Plan, DPE 2016.
DCP Part J	Blacktown City Council Development Control Plan 2015 including Part J and associated handbooks and guidelines.
EGFD	Blacktown City Council Engineering Guide for Development.
RMS R11	RMS Specification R11.
Works Specification Civil	Blacktown City Council Works Specification Civil, 2005
NSW FDM	New South Wales Floodplain Development Manual
-	Precinct Planning Watercycle Management Strategy reports.
-	Dams Safety Act 1978 and Dams Safety Committee Policies and Guidelines.
CPA	Concrete Pipe Association's "Concrete Pipe Selection and Installation" Guide
AR&R Vol 1	Australian Rainfall and Runoff "A Guide to Flood Estimation" Volume 1, 1987.
AR&R Vol 2	Australian Rainfall and Runoff "A Guide to Flood Estimation" Volume 2, 1987.
AR&R – Project 10	Australian Rainfall and Runoff – Revision Projects "Appropriate Safety Criteria for People"
AR&R – Project 11	Australian Rainfall and Runoff – Revision projects "Blockage of Hydraulic Structures"
AS 3500.3	Australian Standard AS3500.3: Plumbing and Drainage Code – Stormwater Drainage (2003)
AS 3725	Australian Standards AS3725: Design for Installing of Buried Concrete Pipes
Section 79C	Environmental Planning and Assessment Act 1979

3.3.2 Design Criteria

Based on the planning commitments and the requirements of the various design standards, the stormwater drainage design criteria adopted for the development are summarised below in Table 3.

Table 3 Stormwater Drainage Design Criteria

Item	Standard	Adopted	Comment
Hydrology			
Hydrological Model	BCC Engineering Guide for Development, 2005	DRAINS model	Using the Time Area method – ILSAX
Time of concentration	BCC Engineering Guide for Development, 2005	Paved: 5 minutes Grassed: 6 minutes	Kinematic Wave Equation.
Minor Design Storm	BCC Engineering Guide for	20 year Average Recurrence Interval	Commercial area with overflow to bypass to

Item	Standard	Adopted	Comment
	Development, 2005	(5% AEP)	public road
Major Design Storm	BCC Engineering Guide for Development, 2005	100 year ARI (1% AEP)	Applied to calculating flood safety criteria in streets
Design Rainfall	BCC Engineering Guide for Development, 2005	As per table or BOM values	AR&R 1987 values have been adopted
Rural Rainfall Losses		Pervious IL = 15mm Pervious CL = 2.5mm/h Imperv. IL = 1.5 mm Imperv. CL = 0 mm/h	Applied in flood modelling
Urban Rainfall Losses		Pervious IL = 5mm Pervious CL = 2.5mm/h Imperv. IL = 1.0 mm Imperv. CL = 0.0 mm/h	Applied in flood modelling
Hydraulics			
Pipe size	BCC Engineering Guide for Development, 2005	Min. 150mm diameter Min. 375mm diameter	150mm pipe diameter is the absolute minimum for pipes located in private property. 375mm pipe diameter is the minimum for pipes owned by City of Sydney.
Retardance Coefficient	BCC Engineering Guide for Development, 2005	Road/Paved Areas Only = 0.01 Medium Density Residential = 0.06 Parkland = 0.15 Open Space (Natural Bushland) = 0.3	
Pit spacing	BCC Engineering Guide for Development, 2005	Max. 80m	Maximum spacing increases with increasing pipe sizes
Pit losses	BCC Engineering Guide for Development, 2005	Missouri Charts, (Sangster et al, 1958)	
Pit blockage factors	BCC Engineering Guide for Development, 2005	Minor system (5% AEP): Sag Pit = 0 On Grade Pit = 0 Major system (1% AEP): Sag Pit = 0.5 On Grade Pit = 0.2	Applied to proposed infrastructure
Pit blockage factors for overland flow calculations	BCC design memo	Small pipes - 30% Large pipes – 50%	Applied when calculating floor levels or overland flow path capacity
Flood and Overland Flow			
Appropriate Safety Criteria for People	AR&R – Project 10	Max. Depth x Velocity = $0.4m^2s^{-1}$	
Stormwater Quality Targets			

Item	Standard	Adopted	Comment
Pollution reductions targets	Blacktown City Council Growth Centre Precinct Development Control Plan	Gross Pollutants – 90% TSS – 85% TP – 65% TN – 45%	These align with Landcom NSW 'Best Practice' standards
Stream Erosion Metrics	Growth Centres DCP and BCC DCP	Stream Erosion Index no greater than 3.5	

3.4 Flood Evacuation

The proposed development site is outside the flood extents of the Second Ponds Creek and as such there is no associated flood hazard with this watercourse in either the 1% AEP or PMF events, however there will be some localised ponding around the proposed buildings during these design storm events.

Flood Planning Levels (FPLs) are typically based on the greater of the PMF flood depths and the 1% AEP + 500mm freeboard, based on the flood results the 1% AEP + freeboard is the governing characteristic to set the Flood Planning Level. As the habitable flood levels are above the FPL level then evacuation is not required and residents can shelter safely in place. Should evacuation be required it should be noted that Conferta Avenue will have unsafe conditions for vehicle traffic in a PMF event (inc 50% blockage) and should be avoided (velocity depth product > $0.3m^2/s$), it is estimated that unsafe conditions will subside within 2 hours of the peak of the rainfall event.

In summary setting habitable floor levels 450mm above the proposed raise ground level is acceptable flood protection for the southern site, as the northern block (Site 1) is not impacted by flooding, floor levels at grade are appropriate.

4.0 Previous Investigations

4.1 Soil and Water

The *Northwest Rapid Transit (NRT) Project Integrated Management System, Construction Soil and Water Management Plan* (2015) was prepared by Northwest Rapid Transit (NRT) provides details on the local soils and groundwater within the Cudgegong Road Station Precinct South site.

4.1.1 Soils

The Precinct area is underlain by the Blacktown Soil Landscape as defined by the former Department of Land and Water Conservation and shown on the 1:100,000 series Soil Landscape maps for Sydney (sheet 9130) and Penrith (sheet 9030). The Blacktown Landscape soil group occur on low undulating terrain on the Wianamatta Group shales. They are generally moderately deep (1.0 m) red and brown podsols that are moderately reactive, highly plastic and generally poorly drained.

4.1.2 Groundwater

The *Northwest Rapid Transit (NRT) Project Integrated Management System, Construction Soil and Water Management Plan* found that the regional water table is affected by the beds of low lying permanently flowing streams in the Beecroft / Castle Hill area. The water table rises away from these watercourses, following the topography but in a more subdued fashion deep between ridges, shallow and close to streams.

The level of the water table is thought to fluctuate by several metres between wet and dry seasons and is likely to be recharged by surface water along the upper, ephemeral tributaries of these streams, which includes Second Ponds creek.

The *North West Rail Link Geotechnical Data Report* prepared by AECOM (2012) installed two monitoring wells adjacent to the Precinct. Groundwater levels measured at the highest part of the site (on the Tallawong Road boundary) were measured to be between 13 m and 18 m deep. Groundwater flow is expected to be north westerly towards First Ponds Creek and Eastern Creek.

4.1.3 Salinity

Based on the salinity risk maps it is evident that if saline conditions in soil exist they may be at depth. Please refer to the acid sulphate soils report for further information.

4.2 Riparian Corridors

The *Area 20 Precinct Planning Study Riparian Assessment*, prepared by Eco Logical (2010) found that the section of Second Ponds Creek adjacent to the development site is degraded with the stream channel showing moderate erosion in sections and constriction in other areas as a result of modified flow and clearing.

4.3 Trunk Drainage

The Rouse Hill Stage 1b Area Trunk Drainage Strategy prepared by GHD (1998) prescribes flood detention basins throughout the precinct which manage flood flows from Area 20 and the Cudgegong Station Precinct.

The basins form part of a strategy that has been implemented as a component of the North West Growth Centre and is managed by Sydney Water.

The strategy does not require that any flood detention measures are implemented within the Cudgegong Station Precinct.

However, it is noted that the strategy does not provide stormwater quality measures from the Cudgegong Road Precinct and it is therefore appropriate that water quality measures be provided within the Cudgegong Road Precinct.

4.4 Water Cycle Management and Flooding

The *Water Cycle Management Strategy and Flood Study - Area 20 Precinct* was prepared by J Wyndham Prince in 2010 and prescribes the water quality basins for the Cudgegong Town Centre Precinct.

The strategy prescribes a biofiltration basin (Basin 1) to the east of the Cudgegong and Schofields Road intersection.

4.5 Flooding

A detailed assessment of surface water and hydrology issues is provided in *Stations, Rail Infrastructure and Systems – EIS 2* (October, 2012).

Results from this study indicate that flooding is generally limited to within the Second Ponds Creek corridor and do not impact on the proposed development site.

The Environmental Impact Statement (EIS) flood study considers various climate change strategies as follows:

1. Climate Change Impacts – Sydney Region, 2008 (DECC)
2. Practical Consideration of Climate Change – Flood Risk Management, 2007 (DECC)
3. Climate Change in the H-N Catchment , 2008 (CSIRO)
4. Climate Change in Australia 2007 (BoM)

Based on these strategies, the study made recommendations for the method of assessing the impact of climate change which includes the following:

- **Rainfall Intensity –** Increased by 15% for 100 year ARI storm event.
- **Trunk Channel Waterway Area –** Profile to be based on a 15% increase in rainfall intensity and must have capacity to contain runoff generated by 15% increase in 100 year ARI peak flow rates for the post-development catchment.
- **Freeboard –** applying 0.5m clearance over and above the flow depth generated by the existing 100 year ARI peak flow. This allowance is inclusive of 0.2m freeboard accommodating the impacts of climate change.

Please refer to Section 9.0 for the new Flood Impact Assessment prepared for the Cudgegong Road Station Precinct South Precinct.

5.0 Stormwater Management

The following section describes the hydrologic context of the site and the drainage design prepared to support the Site Layout, Built Form and Urban Design

5.1 Catchment Description

The project site is located within a semi-rural to low-density residential external catchment which drains towards the Second Ponds Creek low point extending from the high point north-west of the site. Stormwater from this external catchment is conveyed via overland flow paths and Blacktown City Council pipe drainage network which are currently present underneath Schofields Road to the south. Connections to existing drainage network will be made in the future, diverting stormwater to away from the site towards the Second Ponds Creek low point in the east. There are six separate sub-catchments including:

- Site 1 Catchment;
- Site 2A Catchment;
- Site 2B Catchment;
- Carpark A Catchment;
- Carpark B Catchment;
- Themeda Avenue Catchment; and
- Tallawong Road Catchment.

These are identified on Figure 4 along with the current drainage catchment plan.

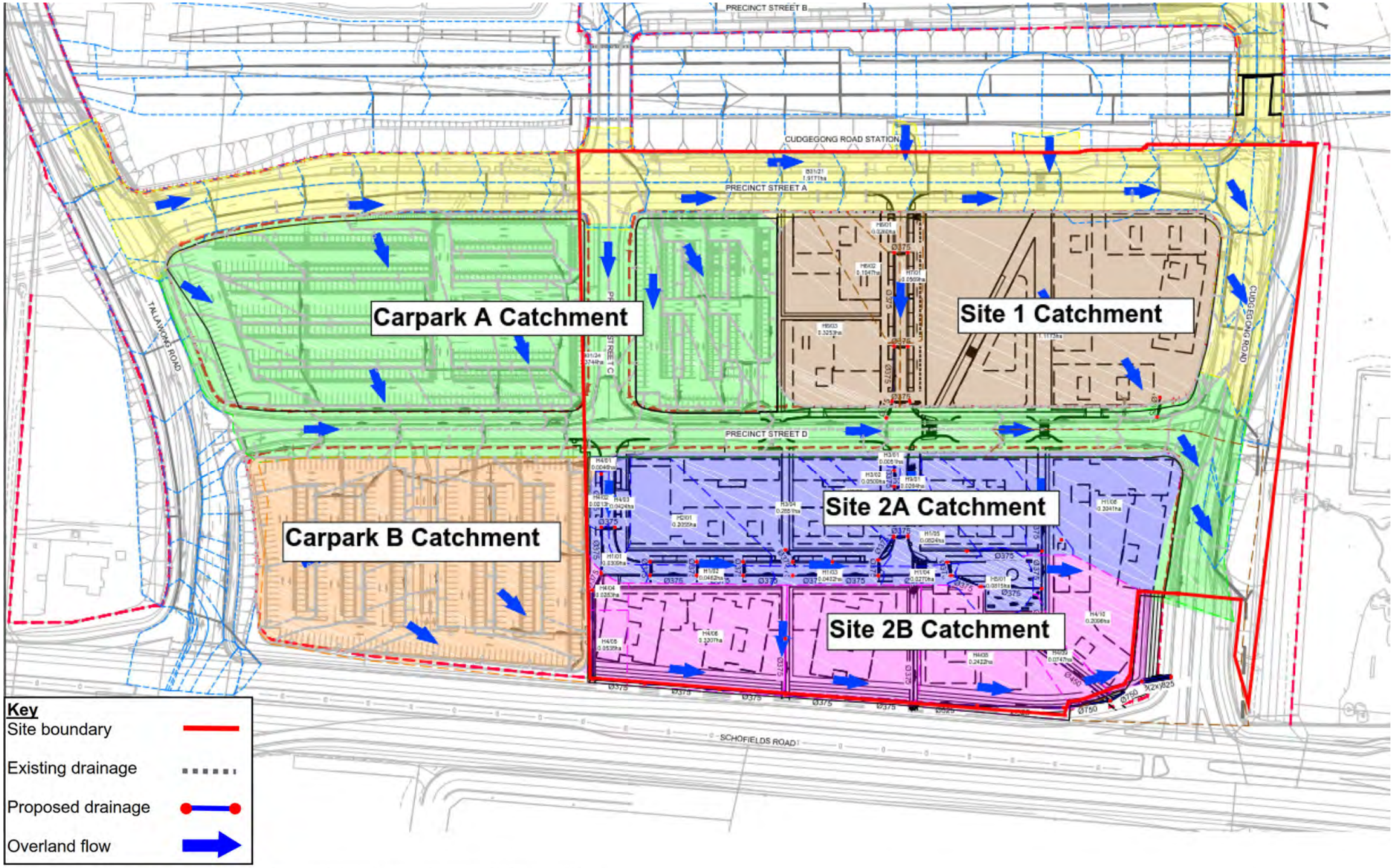


Figure 4 - Cudgegong Drainage Catchment Plan

5.2 Existing Minor Stormwater Network

An existing stormwater network has been delivered to service the Cudgegong Road station, access roads and car parks. The network consists of pit and pipe drainage networks and informal flow paths controlled by BCC and NRT.

Drainage assets owned by Council have been identified underneath Schofields Road and Cudgegong Road, which generally service the overall site catchment area and outlet towards Second Ponds Creek in the East. This includes an existing biofiltration basin to manage stormwater from Council owned roads.

A new drainage network has been constructed by NRT servicing the rail corridor and carparks located adjacent to the designated Cudgegong Road Station Precinct. Collected stormwater here converges to a DN900mm pipe underneath Conferta Avenue and outlets across Cudgegong Road through the raingarden basin immediately east of the site.

It is proposed to connect Area 1 to this drainage network.

The Roads and Maritime Services (RMS) also currently owns the drainage assets underneath the newly upgraded Schofields Road and parts of Cudgegong Road. The development site's low point in the South East corner of the site (SP2 area) is serviced by a series of pits and pipes specifically a Median Gully Pit Quadruple Grate (M.G.Q.G) and two DN825 which grade towards Second Ponds Creek underneath Schofields Road.

It is proposed to connect Area 2 to this drainage network.

5.2.1 Recent Infrastructure Upgrades

NRT has been provided stormwater drainage infrastructure as part of the precinct enabling and augmentation works as agreed in the North West Rail Link OTS Project Deed – Scope and Performance Requirements Appendix 96 – Precinct Utility Services Revision C.

RMS currently owns a network of pits and pipes underneath Schofields and Cudgegong Road which were constructed during the widening Schofields Road completed in June 2014.

5.3 Proposed Stormwater Drainage Strategy

The proposed stormwater drainage system for the Cudgegong Road Station Precinct South will comply with the design requirements identified in Section 1.1 and the previous investigations discussed in Section 4.0.

Stormwater drainage infrastructure for Site 1, 2A and 2B are as follows:

- Site 1 and the proposed park will drain to an existing stormwater pipe network in Conferta Avenue which drains to a to a DN900mm pipe that runs perpendicular underneath Cudgegong road and discharges into a bio swale filter to the east of Cudgegong Rd;
- Site 2 drains south to a drainage easement (zoned SP2) that runs along the northern edge of Schofields Rd. It is proposed to modify the drainage easement which is discussed in Section 7.0;
- The drainage easement flows in an easterly direction with base width 1.7m, depth 0.3m and batter slope 1(V):5(H) min. This will then drain under twin DN825mm pipes under Cudgegong Rd;
- Some modification to existing stormwater drainage to the east of Cudgegong Road is proposed to facilitate the formation of a regional biofiltration basin to the south of an existing basin within SP2 lands; and
- Kerb inlet pits of appropriate sizing along new the new proposed road.

Stormwater quality modelling and a concept design are provided in Section 6.3. A concept design is provided in Appendix B.

5.3.1 Demonstration of Compliance (DRAINS Modelling)

A notional pipe design has been developed using DRAINS hydraulic modelling software. The model demonstrates that the proposed site can be developed and achieve the requirements of BCC's minor and major drainage networks.

It should be noted that the final drainage network design will require inclusion of on-lot stormwater quality management through the provision of filtration as discussed further in Section 6.2. The proposed network and notional pipe diameters is provided in Figure 5.

Screenshots of the DRAINS model compiled for both minor and major storm events is presented in Appendix A.

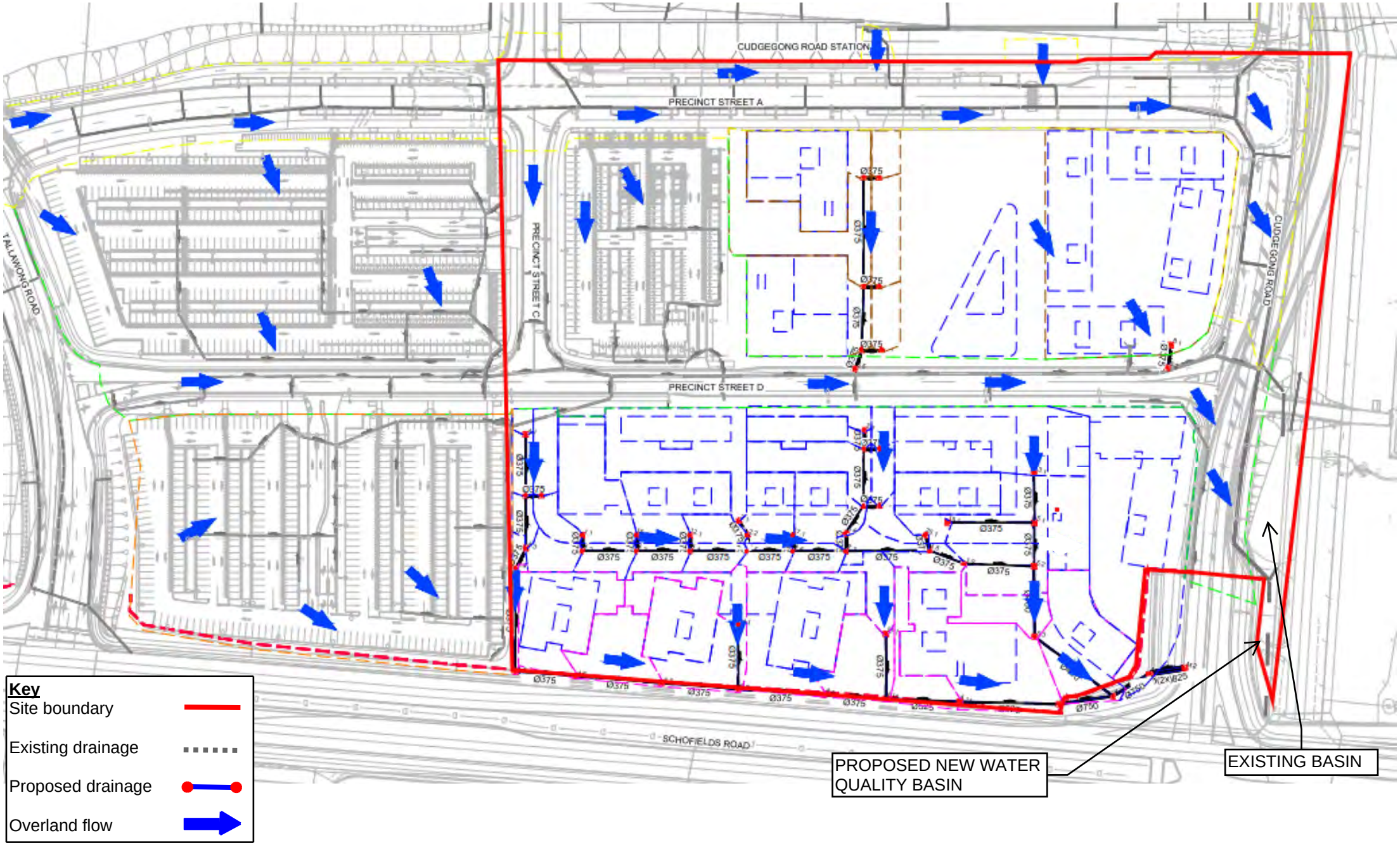


Figure 5 - Proposed Stormwater Drainage Plan

6.0 Stormwater Quality

The stormwater quality management approach incorporates WSUD (WSUD) principles and treatment train to ensure water quality targets prescribed in the Area 20 DCP and Landcom's sustainability strategy are met. The water quality targets are measured as 'mean annual pollutant load' discharged from a development site and the minimum percentage reductions are specified in Section 3.3.

It is intended that individual development lots will meet water quality requirements through at-source controls on the lot. This will be detailed as part of the development proposals for each building.

Stormwater quality management for runoff from Council roads and public open space is to be provided in regional stormwater management basins, which are to be provided on the eastern side of the Cudgegong and Schofield Road intersection. It is proposed that some stormwater quality management is also provided via biofiltration street trees in new streets located within Site 1 and Site 2.

6.1 WSUD Implementation

WSUD measures including on lot filtration, gross pollutant traps, passive irrigation and bioretention have been considered for the development. The viability of rainwater harvesting is limited due to the supply of recycled water to the precinct, which is likely to take precedence over the provision of additional rainwater tank infrastructure within buildings.

General layouts have been adopted for the current design, and further details including subsoil drainage and exact infrastructure layouts will be further developed in detailed design.

6.2 On Lot Filtration

At-source stormwater pollution control devices provide flexibility to achieve stormwater treatment targets without an associated land take at ground level. Stormwater filtration of this type is suited to densely populated sites where public open space is limited.

These treatment strategies are typically deployed to achieve stormwater pollution reduction targets prior to discharge from a super lot. These are placed in tanks beneath podium courtyards and within the upper levels of underground car parks. To remain free from tail-water impacts caused by downstream stormwater networks, tanks will be elevated at or above street level.

6.3 Regional Bioretention Systems

Two bio-retention basins are currently proposed along the eastern side of Cudgegong Road to service the precinct catchment area.

6.3.1 Existing Biofiltration Basin

An existing biofiltration basin has been provided east of the intersection of Rd Precinct Road and Cudgegong Road. This basin services stormwater runoff from Site 1 and Carpark A and achieves the stormwater management targets for Council's roads and the proposed public open space. This basin is shown in Figure 6.

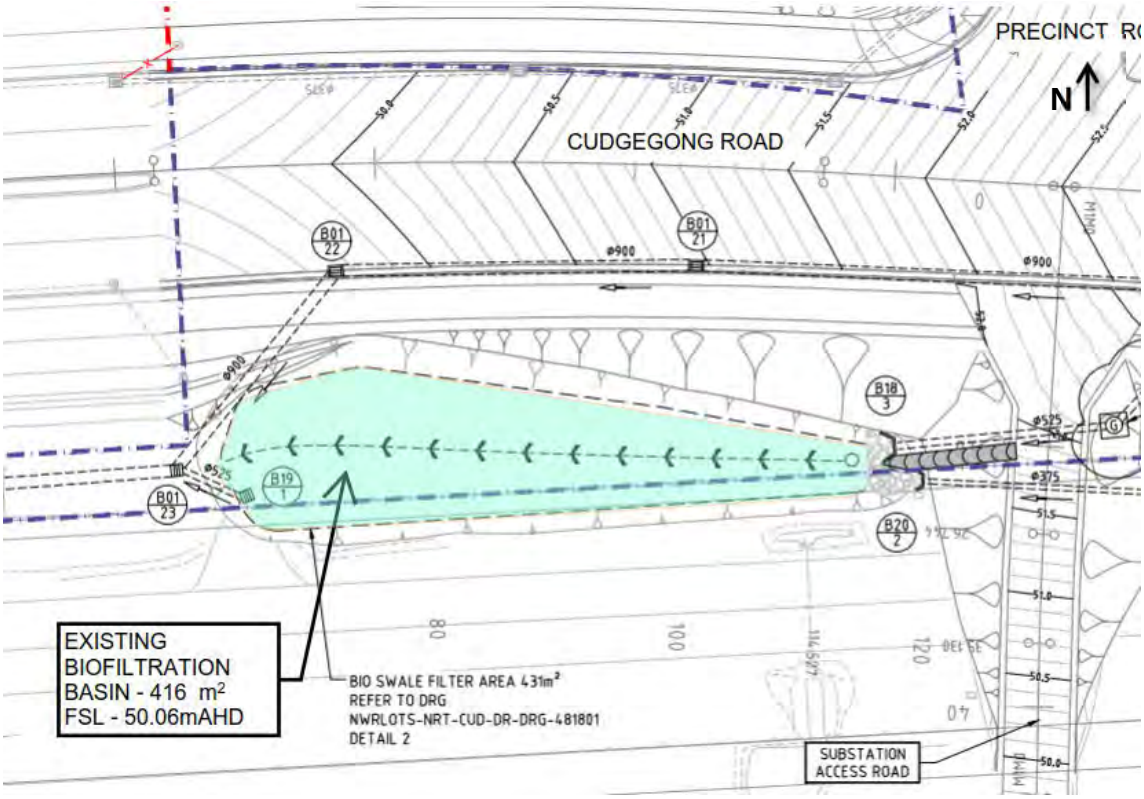


Figure 6 Existing biofiltration basin for Site 1

6.3.2 Proposed Biofiltration Basin

It is proposed to relocate a bioretention basin to the east of Cudgegong Rd to another area of SP2 zoned land, adjacent to the existing biofiltration basin shown in Figure 11. This will consolidate the basins for Site 1 and Site 2 onto one parcel of SP2 land with no real development potential and will unburden 410 m^2 of potential developable land within Site 2.

The proposed basin site is crossed by an existing DN900 stormwater pipe that drains Site 1 and the existing biofiltration basin described above. This will require rebuilding the pipe to avoid the new basin and reconnect the DN900 pipe to an existing stormwater pit 80m downstream. It is proposed to rebuild the lower section of pipe as a DN525 and surcharge excess flows into the SP2 overland flow path. This pipe will be required to cross existing high voltage cables but there is reasonable flexibility in the vertical alignment of the pipe to avoid clashes.

A schematic of the proposal is provided in Appendix B and below in Figure 7.

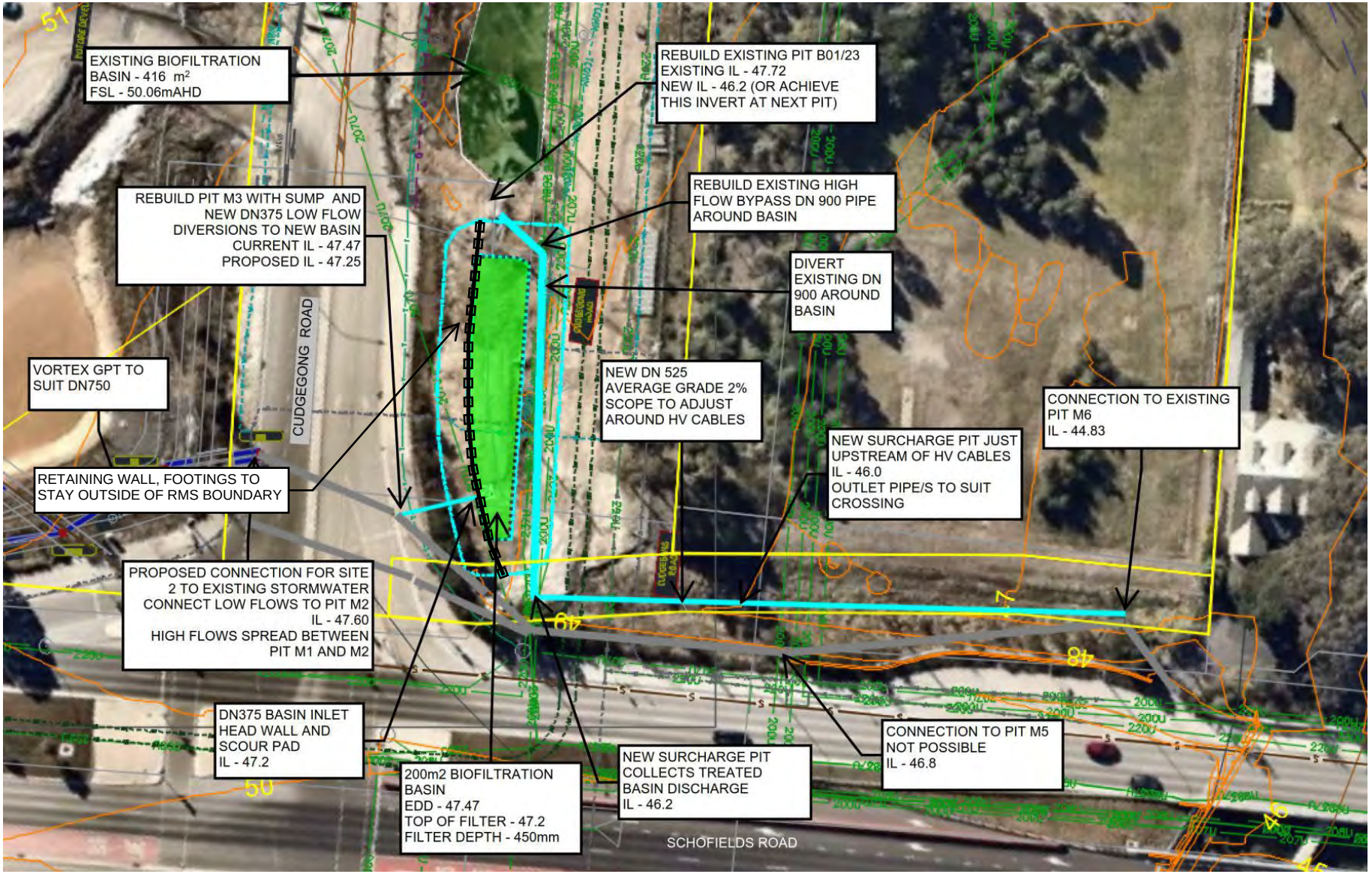


Figure 7 Proposed regional basin

The concept design shows that basin will generally satisfy BCC's criteria as follows:

- Basin holds a 246 m^2 filter area that is no wider than 7.5m for maintenance;
- A 300mm extended detention depth and 450mm deep filter media layer is proposed;
- A GPT with 0.35 m^3/s treatment capacity is proposed on the western side of Schofields Road to pre-treat the majority stormwater prior to discharge to the basin;
- A high flow bypass is proposed upstream of the basin. TUFLOW hydraulic modelling shows velocities in the basin are no higher than 0.8 m/s in the basin in a 1% AEP event. This is reasonable for a rare flood event and would be less than 5 m/s in more frequent events;
- The basin is free draining and free of tail water effects in events up to and including a 50%AEP event;
- The basin is to be drained by a new pipe that will run parallel to the existing pipes that drain the Precinct to Second Ponds Creek;
- Maintenance access is provided from the old Cudgegong Road which also serves as maintenance access for the existing bioretention basin to the north.

  A retaining wall is required at the western end of the basin to ensure that the basin footprint is kept off the RMS Land.

6.3.3 Biofiltration Street Trees

Consultation with Blacktown Council indicates that street tree biofiltration is not supported where it would reduce on street parking. Biofiltration street trees are not proposed along existing Themeda and Conferta Avenues but are proposed along new Council roads shown in Figure 8.

The strategy is reliant on these trees to provide additional stormwater quality reductions as the regional biofiltration basins discussed above cannot get any larger due to site constraints.

The subject streets are graded at 3 to 4% which will not be associated with adverse level changes or trip hazards. Each street tree is designated to have 100mm of ponding over a 2.5 m^2 area above the tree pit. TUFLOW modelling indicates flood velocities from along the proposed roads will vary between 0.7 and 1.2 m/s in a 1% AEP event which suggests some erosion control measures may be required, but overall velocities are not unsuitable.

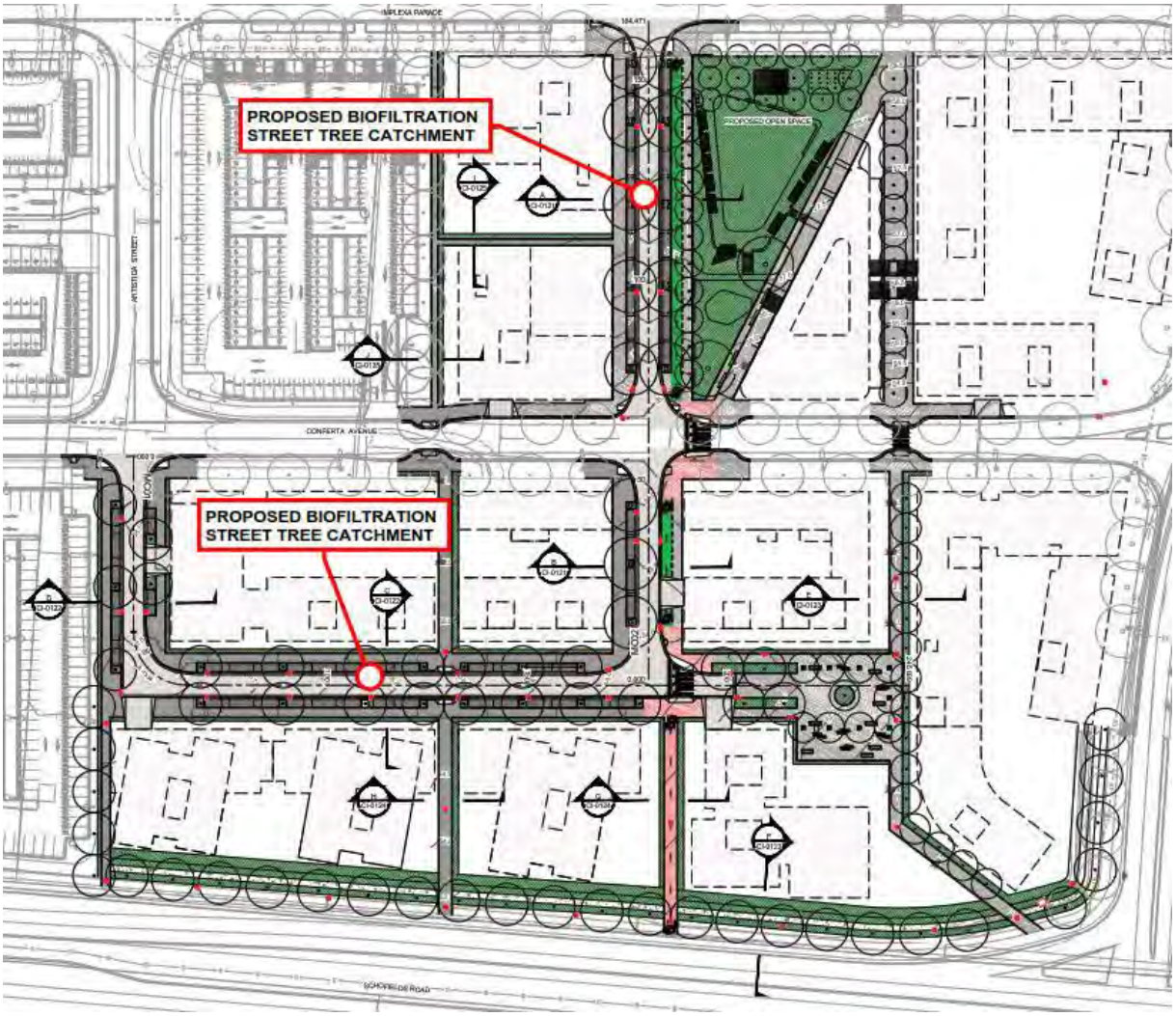


Figure 8 – Proposed biofiltration street trees

6.4 Demonstration of Compliance (MUSIC Modelling)

MUSIC modelling is being undertaken to assess the quality of stormwater runoff discharged from the proposed development site to ensure water quality requirements are met. MUSIC modelling results for the entire Area 20 zone demonstrate that integrating proposed WSUD techniques allow the pollutant reduction targets as outlined in Section 3.6 to be met.

A land use schedule is presented in Table 3 and MUSIC model structure is shown in Figure 9.

Table 4 Land Use Schedule

Future Development (currently car parks and not part of this proposal)	Area (Ha)
Roof areas	1.93
Courtyards/ ground floor lands within super lots	1.14
Private Roads* (& public easement or drainage easement)	0.31
Council Open Space	-
Council Roads - To be dedicated	-
Council Roads - Existing	-
Existing Biofiltration Basin	**Area (Ha)**
Roof areas	0.72
Courtyards/ ground floor lands within super lots	0.36
Private Roads* (& public easement or drainage easement)	0.16
Council Open Space	0.20
Council Roads - To be dedicated	0.17
Council Roads - Existing	3.42
Proposed Basin (South)	**Area (Ha)**
Roof areas	1.16
Courtyards/ ground floor lands within super lots	0.69
Private Roads* (& public easement or drainage easement)	0.19
Swale	0.19
Council Roads - To be dedicated	0.47
Council Roads - Existing	0.71

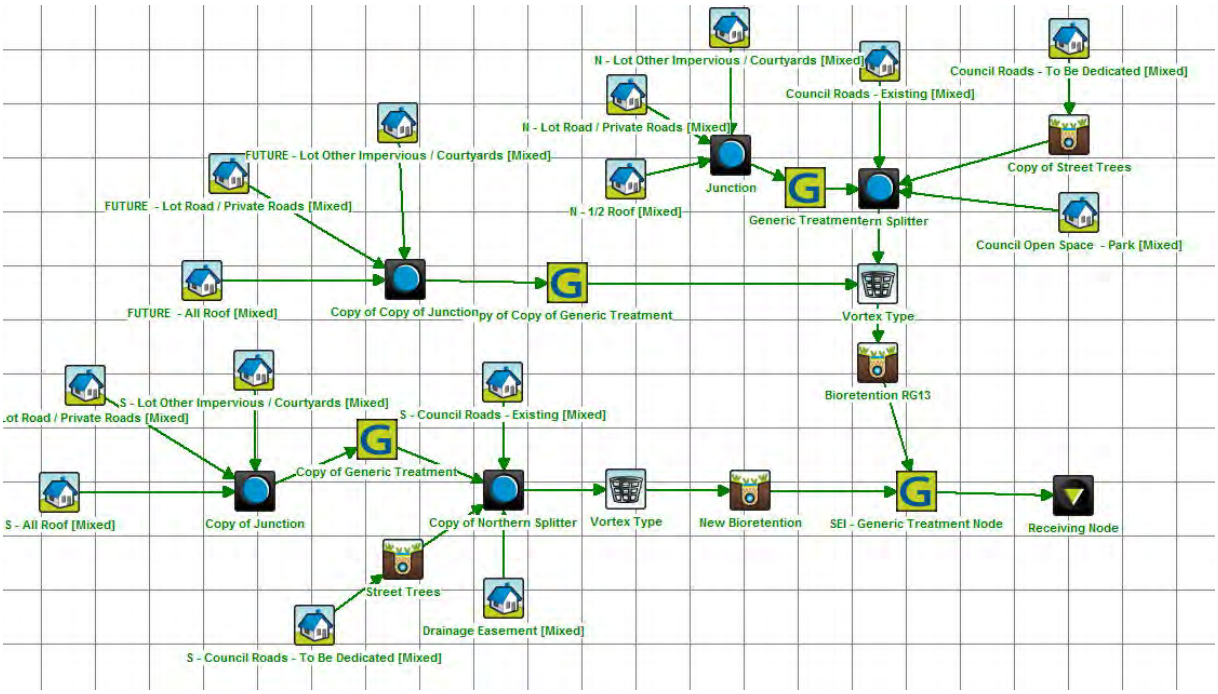


Figure 9 – MUSIC model structure (file ref : *CRTS - Landcom - STRATEGY 1 - trees.sqz*)

Results of the MUSIC modelling are provided in Table 4.

Table 5 – MUSIC Modelling

Pollutants	Sources (kg/yr)	Residual Load (kg/yr)	% Reduction	Compliance
Total Suspended Solids	17,500	2,320	87%	Yes
Total Phosphorus	32.3	11.3	65%	Yes
Total Nitrogen	192	105	45%	Yes
Gross Pollutants	2,200	4	100%	Yes

The stream erosion index was calculated for the reach of creek immediately to the east of Site 1 and Site 2. The critical flow rate was adopted as 25% of the 50% AEP flow rate from a rural catchment with 0% imperviousness. This was determined from DRAINS modelling using a kinematic wave calculation to determine the time of concentration for three sub catchments. This method produced a flow estimate that is similar to the prescribed method in BCC's MUSIC modelling guideline.

The stream erosion index for the proposed stormwater strategy is 3.4 and therefore complies with BCC's target (less than 3.5).

Conclusion

The proposed WSUD strategy will meet the water quality targets prescribed by BCC for stream health and stability. The proposed development will therefore have an acceptable impact on Second Ponds Creek.

The WSUD strategy does not reduce existing stream flow rates within the recharge zones of the regional aquifer, and the development will therefore have no impact on groundwater dependent ecosystems.

The proposed WSUD strategy does not propose any water extraction and will not require any licensing under the Water Act 1912 or Water Management Act 2010. At the time that the proposed basin works are undertaken, an application for approval for works on waterfront lands will be lodged with the Water NSW.

7.0 Trunk Drainage and SP2 Infrastructure (Local Drainage) Zoned Lands

The existing SP2 zone located at the corner of Cudgegong Road and Schofields Road is a triangular area measuring 13m in height by 42m in width, and is approximately 380m^2 in total area, shown within Figure 10. By expanding the size of the existing bioretention basin to the east of Cudgegong Road, this allows for this existing SP2 zone at the corner of Cudgegong Road and Schofields Road to be used for an increase in the residential development footprint, as shown in Figure 10 also.

It is noted that a bioretention basin has been formed to the east of Conferta Avenue to manage stormwater quality from the Council road network. This basin is located between the old and new alignments of Cudgegong Road. A 16m wide overland flow path is provided at the western end for management of flood water from the south of Conferta Ave which includes Site 2 and the Car Park B. The eastern extent is intended as a stormwater quality basin to manage runoff from Council Roads. A section of the land is occupied by the Cudgegong and Schofields Rd intersection. The intended trunk drainage function for the precinct is shown in Figure 11. Additional information regarding the existing and proposed stormwater strategy has been provided in Sections 5.2 and 5.3 respectively.

In keeping with the existing biofiltration basin partially shown in Figure 10, it is proposed to consolidate the stormwater quality basins into the same strip of land between the old and upgraded Cudgegong Road alignment. Preliminary discussions with Blacktown Council indicate that relocating the proposed biofiltration basin from the west of Cudgegong Road to the eastern side is reasonable, pending demonstration of the concept and its merits.

Modelling has demonstrated that consolidation of the biofiltration basins satisfies Part J of the *Blacktown Development Control Plan (2015)* which stipulates water quality requirements for new developments. Additionally, in line with Section 9.4 of the *Blacktown City Council Engineering Guide for Development (2005)* the biofiltration basins primary use is for water quality improvements rather than stormwater quantity and flow retardation. Further detail on the existing and proposed basin arrangement is also provided in Section 6.3.

Preliminary discussions proposed expanding the existing bioretention basin however level constraints dictate that stormwater Council dedicated roads within Site 2 cannot be drained to the existing basin. As such, it is necessary to construct the second biofiltration basin at a lower level. Blacktown City Council has been contacted regarding the expansion of the biofiltration basin and they have expressed support regarding its development.

These proposed works will consolidate the basins for the site onto one parcel of land. The SP2 local drainage land requirements are then reduced, providing an opportunity for this land to be used for residential purposes. The required SP2 Local Drainage land is shown in Figure 11, and is 430m^2 in total area with a filter footprint of 200m^2.

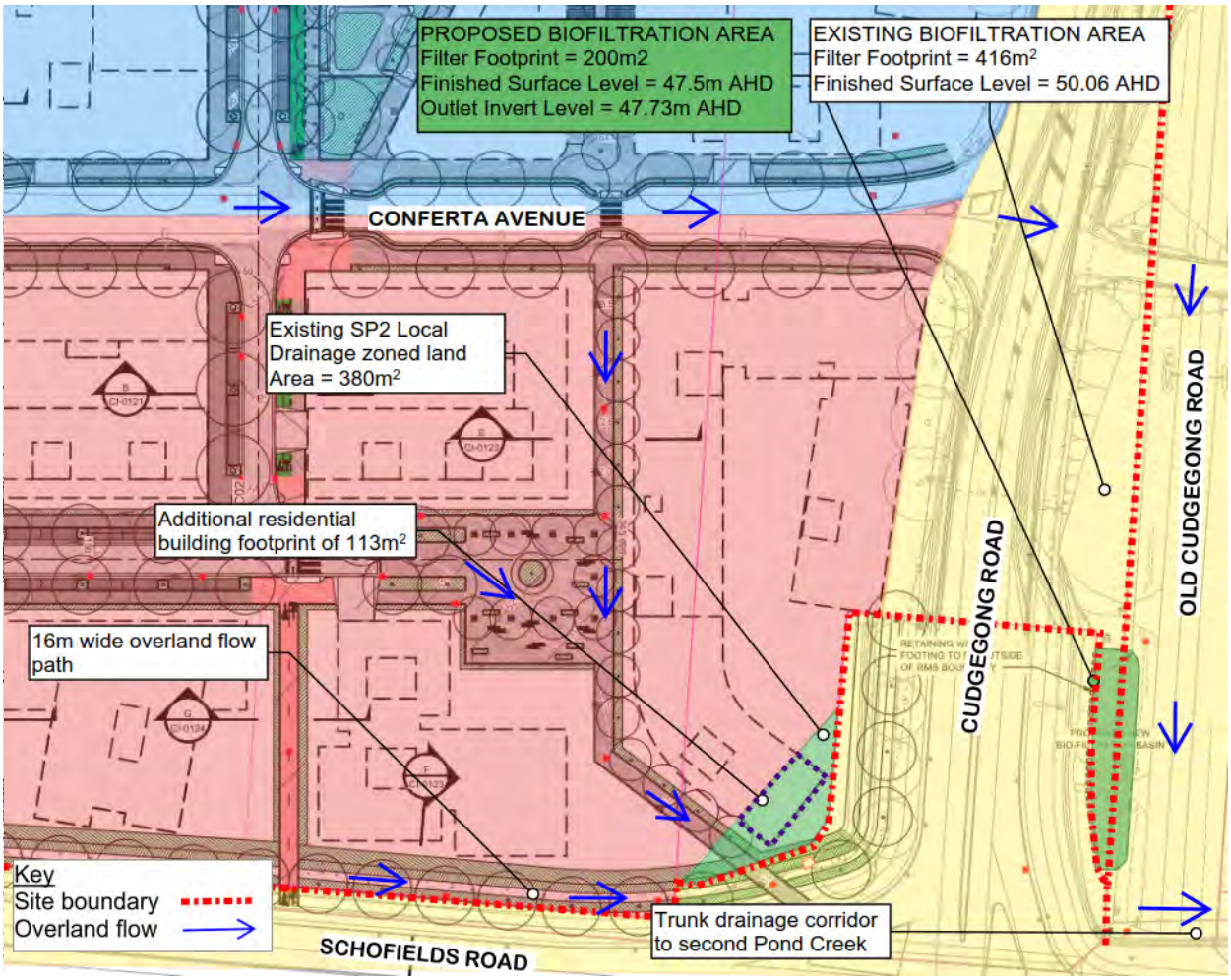


Figure 10 Zoning and intended drainage function and proposed adjustment to SP2 land

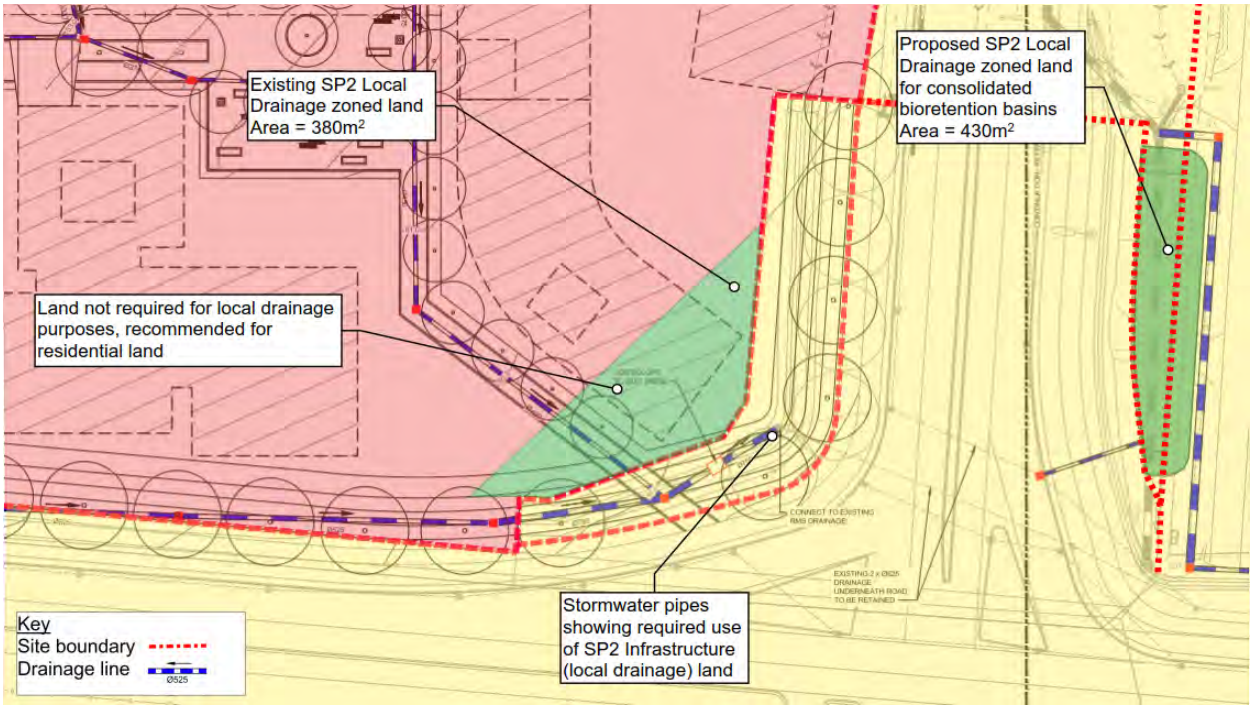


Figure 11 Utilisation of SP2 land

8.0 Water Cycle Management

The proposed development comprises a mix of retail and commercial uses with public open space and residential towers. The area is within the Rouse Hill recycled water network area and supply of recycled water is expected for non-potable residential (laundry, toilet flushing and irrigation) and public open space irrigation demands.

8.1 Population

The target dwelling yield within Site 1 and Site is 1,103 apartments. Based on approximate occupancy rates for multi residential development in Blacktown (1.4), the future population is expected to be 1,632 residents within the subject area.

8.2 Residential Demands

The City of Sydney Decentralised Water Master Plan provides a basis for determining the split of potable and non-potable water use in multi dwelling apartments. This study found that multi-unit dwellings consume approximately 156 kL/dwelling/year and approximately 42% of these demands could be supplied by non-potable water. Applying these water usage rates to the proposed dwelling yield gives an indicative water usage volume for the proposed development. A breakdown of potable and non-potable water demands is provided in Table 6.

Table 6 – Water usage

Water Uses (kL/dwelling/yr)		Residential Water Split	BASIX Bench-mark for Potable Water Use	Adopted Water Demand	Recycled Water	Potable Water	Waste Water
Non Potable	Toilet	18%	24.0	28.1	28.1	0.0	25.3
	Washing	15%	20.0	23.4	23.4	0.0	21.1
	Irrigation	4%	5.3	6.2	6.2	0.0	5.6
	Outdoor	5%	6.7	7.8	7.8	0.0	7.0
	Total	42%	**56.0**	**65.5**	**65.5**	**0.0**	**59.0**
Potable	Basin	5%	6.7	7.8	0.0	6.7	6.0
	Kitchen	5%	6.7	7.8	0.0	6.7	6.0
	Leaks	5%	6.7	7.8	0.0	6.7	6.0
	Shower	37%	49.4	57.7	0.0	37.0*	33.3
	Bath	4%	5.3	6.2	0.0	5.3	4.8
	Dishwasher	2%	2.7	3.1	0.0	2.7	2.4
	Total	**58%**	**77.4**	**90.5**	**0.0**	**65.0**	**58.5**
Total Usage / Dwelling (kL/yr)			**133.4**	**156.0**	**65.5**	**65.0**	**117.5**

The water usage figures above show that the use of recycled water for all non-potable water demands and use of efficient shower heads will provide a reduction in potable water use of 51% against the BASIX benchmark.

8.3 External Water Use and Irrigation

The private domain features extensive courtyards (1.05 ha in total) which are intended to have high amenity. The irrigation rate for these areas is expected to be moderate (2.5 ML/Ha) as they will comprise a mix of pavements and planted areas.

A 2,000 m^2 public park is proposed which is intended to provide high amenity to local residents. Due to the relatively low rate of public open space provided within the town centre, it is expected that the park will be well patronised and will require a high rate of irrigation (4 ML/Ha).

Passive irrigation is proposed for street trees and no further water usage is associated with this landscape. It is noted, however, that if passive irrigation is not pursued as a strategy for irrigating street trees, the stormwater management strategy will need to be adjusted to reflect a slight reduction in stormwater pollution removal and this can be explored through the use of rainwater tanks on buildings.

8.4 Water Balance

An annual water balance for the proposed development is provided in Figure 12 to indicate the associated quantum of potable and recycled water demands and the waste water and stormwater volumes discharged.

MUSIC modelling shows that there is insufficient roof water available to satisfy all non-potable demands within the development site. Daily rainwater tank modelling using MUSIC software shows that small rainwater tanks (0.2 kL/dwelling) within basements will provide up to 12 to 15% of non-potable demands. It is therefore necessary to provide recycled water to dwellings to make up the shortfall in supply.

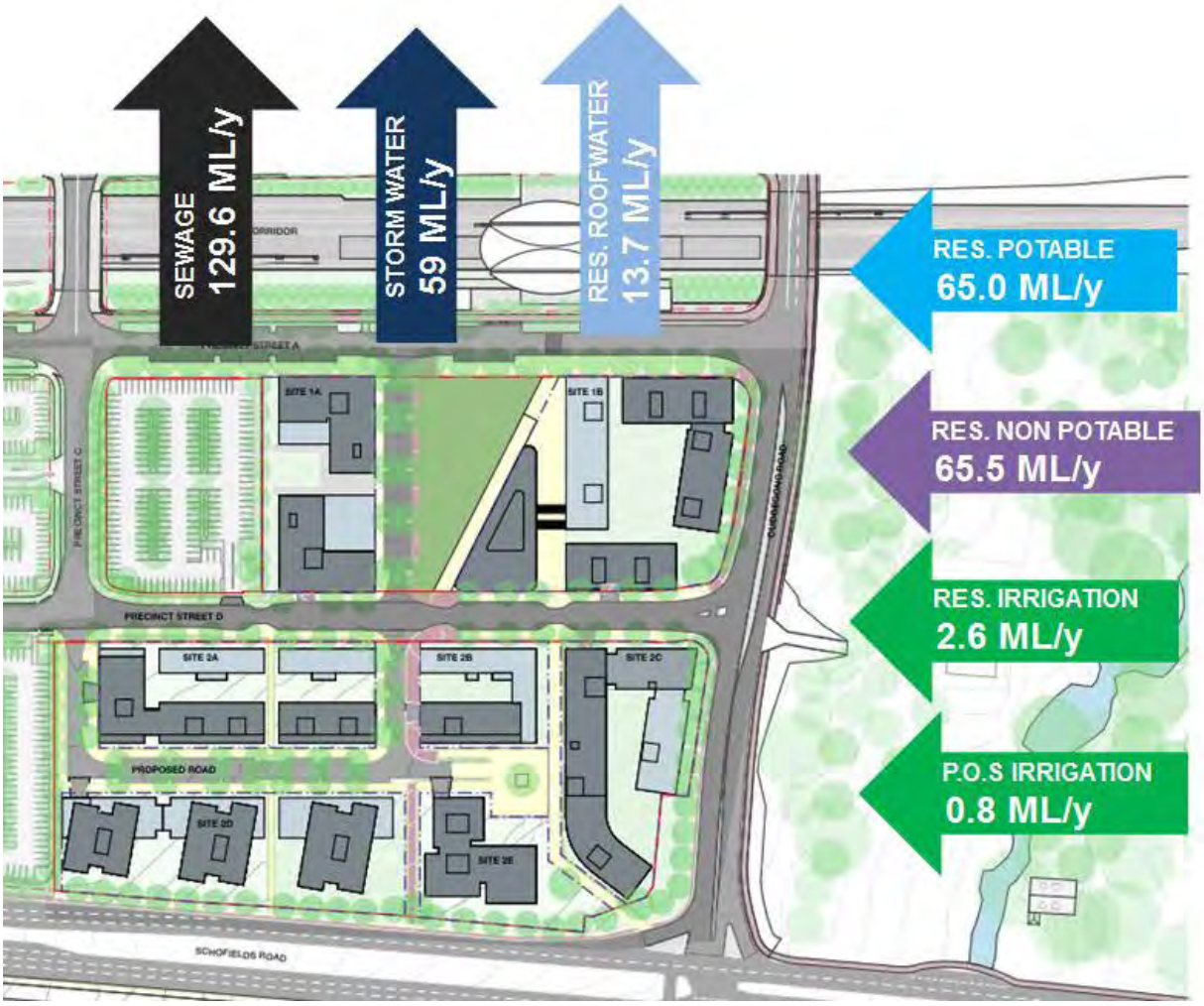


Figure 12 Site water balance

9.0 Flooding

The site is located outside the 1% and PMF flood extent of Second Ponds Creek to the East.

Flood modelling of the local overland flow paths has been undertaken by AECOM and forms the basis of a separate memo. This work has been carried out to identify the 1% AEP flood level with 50% blockage of stormwater pipe network and a 15% increase in rainfall intensity to reflect possible climate change impacts.

The Cudgegong Flood Impact Assessment has been conducted under the assumption that there is no development north of the station rail line currently. In the existing condition 1% AEP flood hazards were found to be low, except at the intersection of Conferta Avenue and Cudgegong Road. At this intersection, unsafe conditions were limited to the low point of the road kerb and did not extend across the road corridor. The assessment also informed proposed conditions. Conclusively, the 1% AEP flood impacts to the development site are limited to Council road, current drainage lands (SP2) and the car park area west of Area 2. Refer to Appendix C for the full version of the Cudgegong Flood Impact Assessment prepared by AECOM.

10.0 Conclusion

Responses to design standards and approaches taken to fulfil the requirements are summarised below.

Growth Centres Development Code (Growth Centres Commission 2006)

This Integrated Water Cycle Management Strategy the Cudgegong Road Station Precinct South project adopts a WSUD approach to water management and is consistent with the Growth Centres Development Code in:

- Use of recycled water will reduce potable water use up to 50% when measured against the BASIX benchmark
- Achieving the stormwater quality targets stipulated by BCC, and on this basis will not worsen flood
- Achieving the target stream erosion index criteria, and on this basis will not worsen erosion in Second Ponds Creek
- Avoiding potential salinity hazards by prescribing stormwater filtration basins that do not promote infiltration of stormwater or interact with groundwater
- Maximising efficient use of land by proposing to relocate a regional basin to the same parcel of SP2 land as an existing basin, thereby consolidating Council stormwater drainage assets adjacent to an existing Council road which can function as maintenance access
- Utilising a treatment train approach through use of GPTs, on-lot filtration and regional stormwater filtration basins
- Integrating passive irrigation and street tree biofiltration amongst parking bays for improved amenity, street tree health and canopy cover
- Managed low flows through bioretention to achieve the target stream erosion index
- Proposing a mix of on-lot, street scape and ‘end-of-pipe’ treatment measures in a practical way
- Aligning trunk drainage routes with local roads and drainage easements overland flow paths where possible.
- Avoiding safety issues associated with biofiltration street trees in collector roads.

Adherence to Blacktown City Council Engineering Guidelines for Development (2005)

The stormwater quality management strategy demonstrates that minor and major drainage can be provided without risk of property damage or public safety. The concept stormwater drainage design

demonstrates that the appropriate freeboard between hydraulic grade lines and street levels and habitable floor levels in design minor and major storm events respectively.

Adherence to Blacktown City Council WSUD Design Criteria (2017)

The development proposes a modification to the zoned stormwater assets by relocating a biofiltration basin intended to the east of the Cudgegong and Schofields Rd intersection as described in Section 7.0. This will consolidate the basins for the site onto one parcel of land and provide the opportunity to use that land not required for drainage purposes for residential development. This strategy allows for approximately 380 m^2 of potential developable land within Site 2. This has allowed extension of the building footprint by 113m^2.

The basin is constrained by services to the west and east. To accommodate these, the batter slope between the basin and Cudgegong Rd is proposed to be vegetated with a 1(V):3(H) slope ending in a with a 500mm high sandstone block wall. It will be necessary to realign an existing DN900mm pipe to provide space for the filter. The concept design (Appendix B) shows that basin will generally satisfy BCC's criteria as follows:

- Basin holds a 246 m2 filter area that is no wider than 7.5m for maintenance;
- A 300mm extended detention depth and 450mm deep filter media layer is proposed;
- A GPT with 0.35 m3/s treatment capacity is proposed on the western side of Schofields Road to pre-treat the majority stormwater prior to discharge to the basin;
- A high flow bypass is proposed upstream of the basin. TUFLOW hydraulic modelling shows velocities in the basin are no higher than 0.8 m/s in the basin in a 1% AEP event. This is reasonable for a rare flood event and would be less than 5 m/s in more frequent events;
- The basin is free draining and free of tail water effects in events up to and including a 50%AEP event;
- The basin is to be drained by a new pipe that will run parallel to the existing pipes that drain the Precinct to Second Ponds Creek; and
- Maintenance access is provided from the old Cudgegong Road which also serves as maintenance access for the existing bioretention basin to the north.

An overland flow path is also proposed along the southern boundary of the site, as intended in the zoning. It is shown that a shallow drainage path can accommodate overland flows in a 1%AEP event, with 50% blockage of local pipe network. The overland flow path design incorporates 2.5m berms on both sides, 1(V):5(H) internal batters and a 300mm of depth. Access to the channel would be via Schofields Road.

The proposed drainage arrangement results in less land on the site being required for drainage purposes, the SP2 Local Drainage zone, and proposed acquisition. This allows for some of the SP2 land to be used for residential purposes. As demonstrated by modelling, this residential use is compatible with and does not detract from the provision of local drainage.

Summary of Responses to SEARs

Table 7 provides a summary of how each of the project SEARS requirements (SSD9063) are addressed in this management plan.

Table 7 Response to SEARs

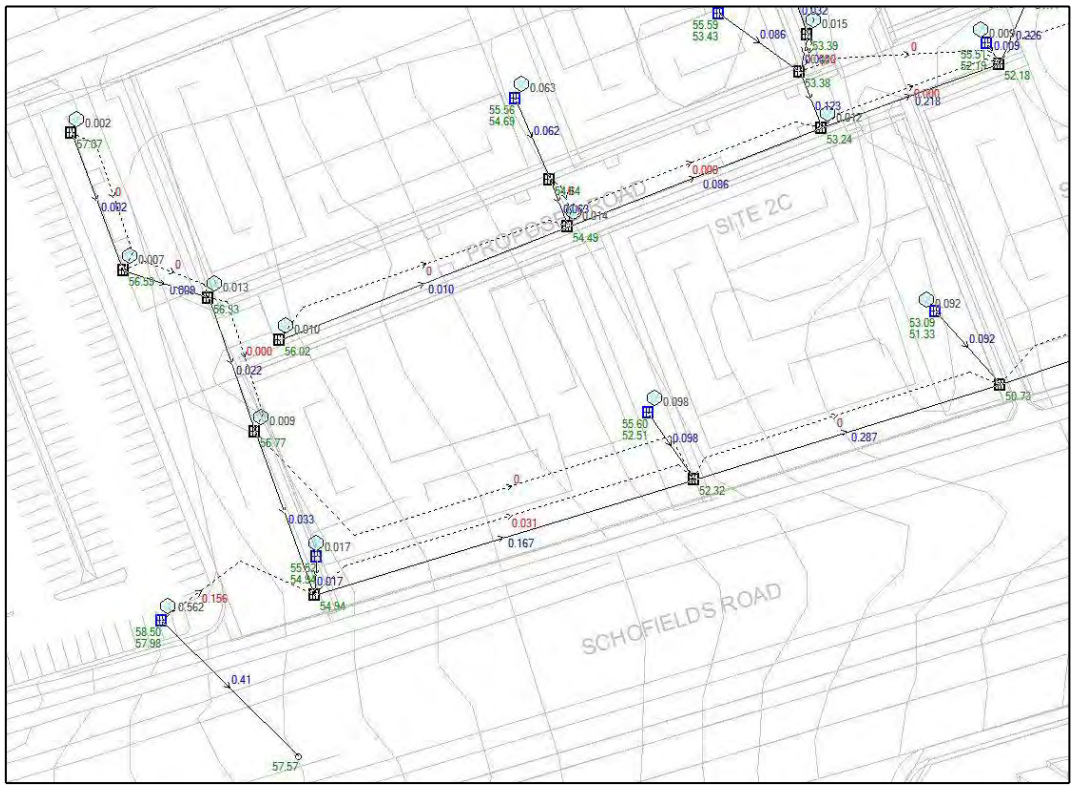
Item	Description	Action	Response
14	Flooding	Include a detailed flood impact assessment	A detailed flood modelling exercise has been carried out and is documented in *Cudgegong Road Station Precinct South Flood Impact Assessment*. Refer to Section 9.0 for a summary of the flooding impacts, and Appendix C for the full report

			prepared by AECOM.

Item	Description	Action	Response
15	Soil and Water	Include a description of local soils, topography, drainage and landscapes	A description of drainage is provided in Section 4.2
		Include a water management strategy with consideration of WSUD and the relevant provisions in BCC Engineering Guide for Development and Blacktown Development Control Plan 2015	The stormwater management plan for the development has been formulated and demonstrates using industry standard software (DRAINS and MUSIC) that the proposed measures meet: Minor and major drainage performance criteria prescribed in the BCC Engineering Guide for Development (Section 5.4) Stormwater pollution reduction targets are satisfied as prescribed in BCC *Development Control Plan - Section J* (Section 6.4) Stream erosion index target (waterway stability metric) is achieved (Section 6.4) as prescribed in BCC *Development Control Plan - Section J*
		Assess the impacts of the proposal on groundwater resources and hydrology	The proposed stormwater management elements will not interact with local groundwater and the stormwater management plan will continue to supply stormwater to the ephemeral waterways that recharge the regional groundwater system. More detail is provided in Section 6.4,

AECOM
AECOM Australia Pty Ltd
Level 21, 420 George Street
Sydney NSW 2000
PO Box Q410
QVB Post Office NSW 1230
Australia
T +61 2 8934 0000
F +61 2 8934 0001
www.aecom.com
ABN 20 093 846 925

Appendix A – Stormwater Design



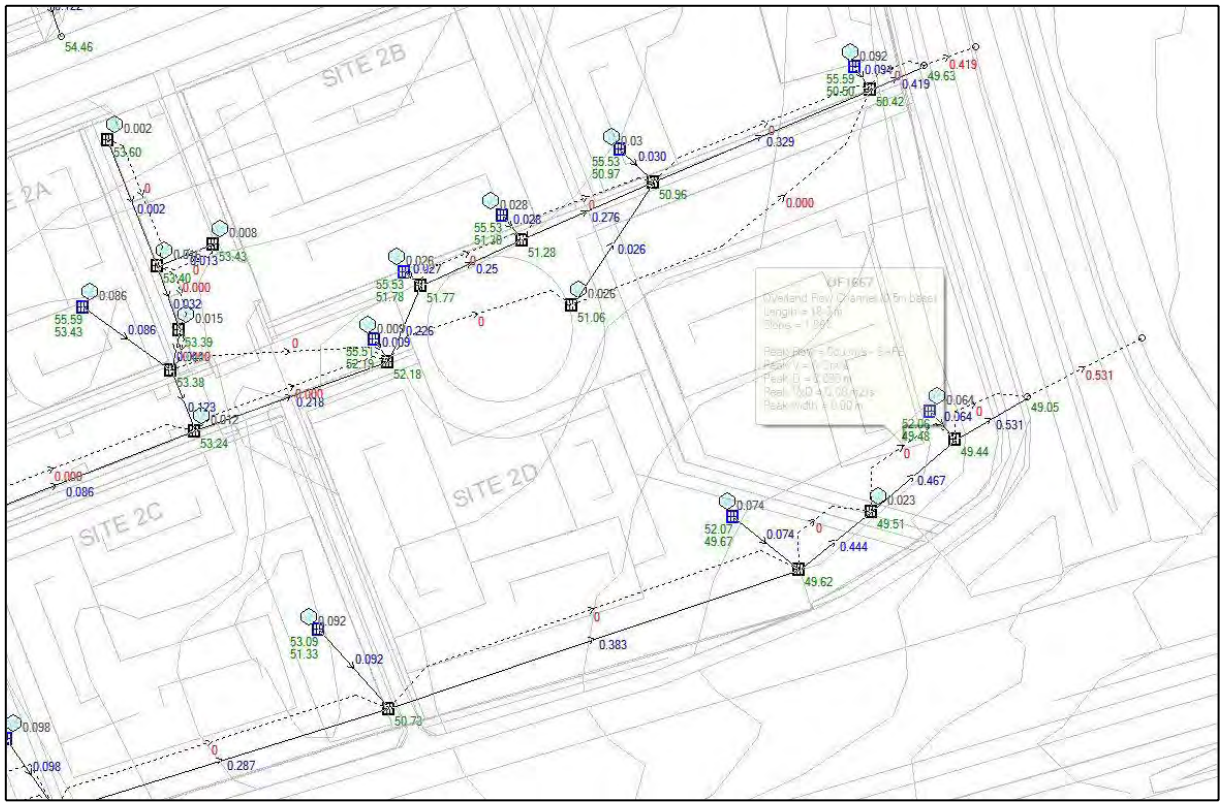


Figure 13 A - DRAINS Results (Minor Storm 20yr ARI)

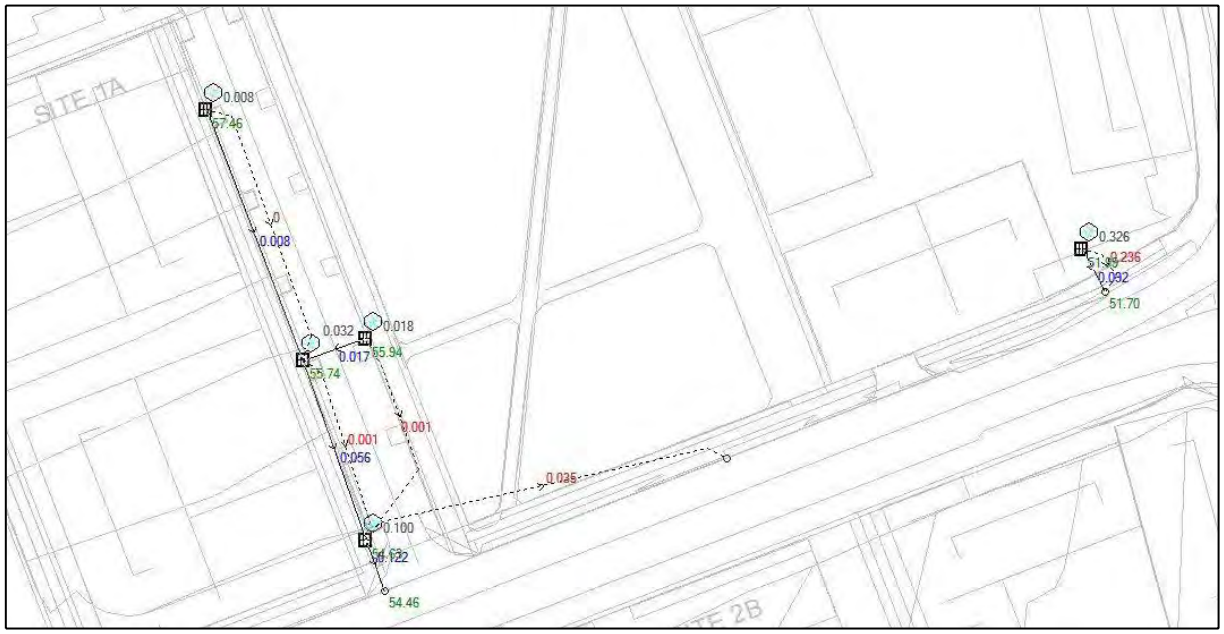


Figure 14 B - DRAINS Results (Minor Storm 20yr ARI)

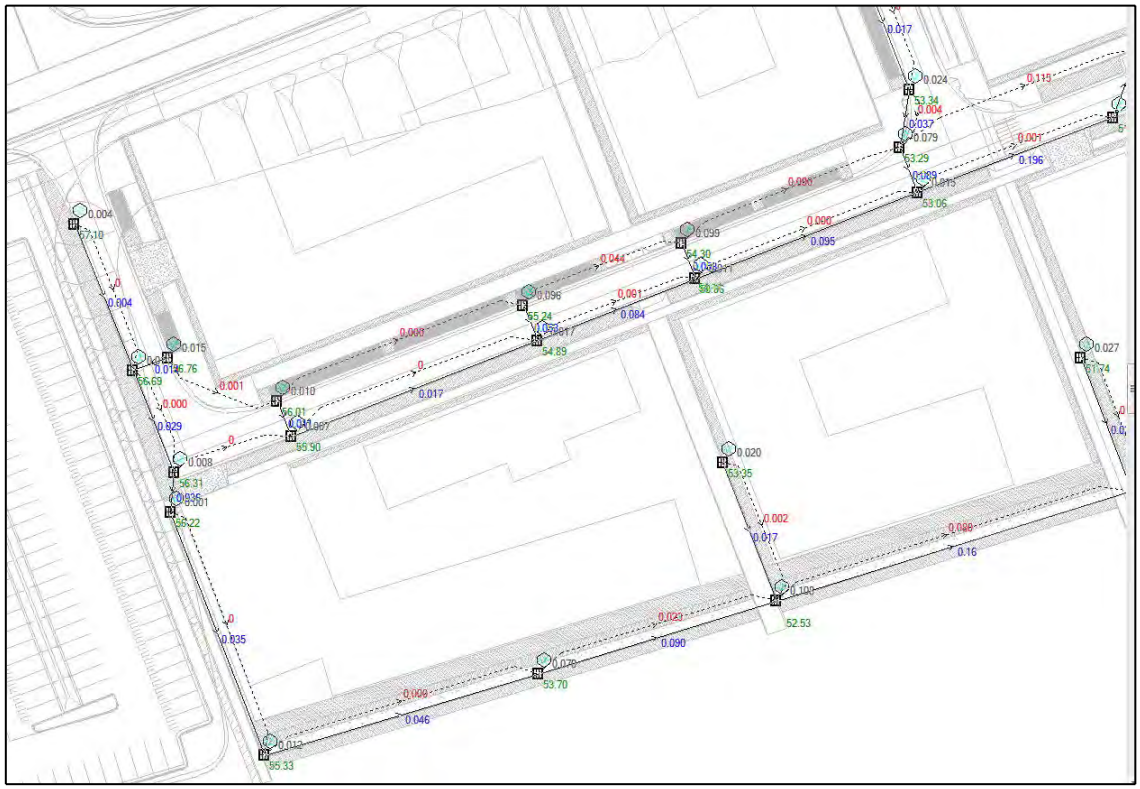


Figure 15 A DRAINS Results (Major Storm 100yr ARI)

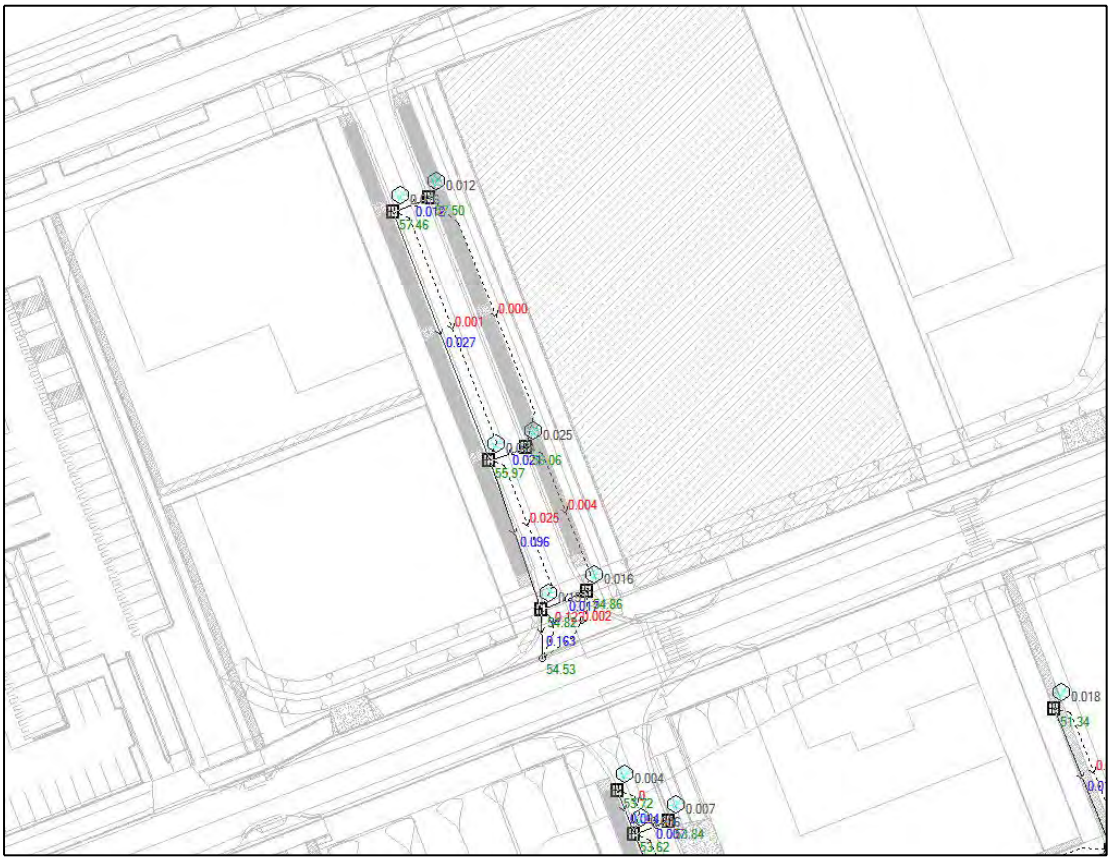
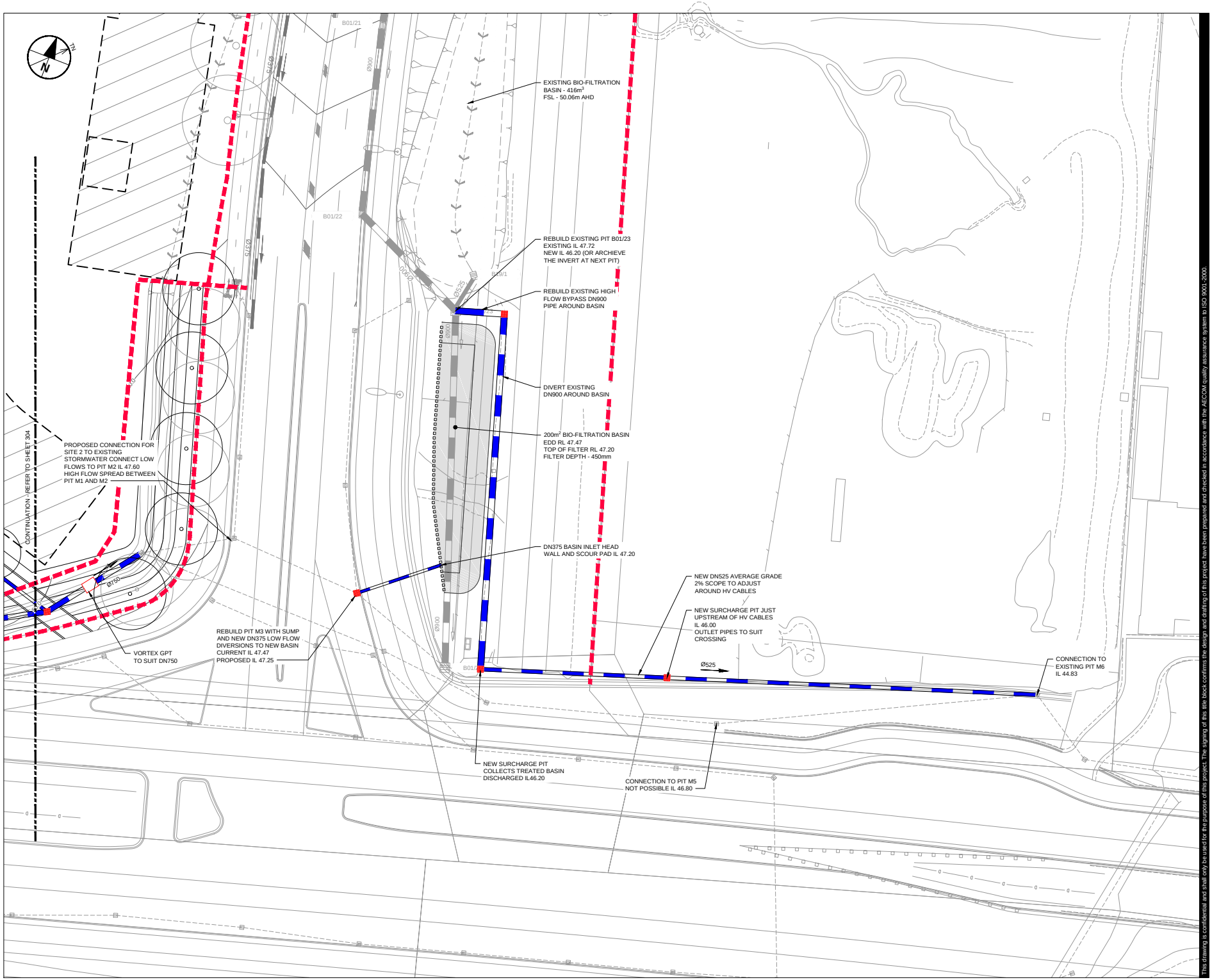


Figure 16 B DRAINS Results (Major Storm 100yr ARI)

Appendix B – Basin Concept Design



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AECOM

PROJECT

CUDGEGONG ROAD STATION PRECINCT
TOWN CENTRE SOUTH
CIVIL PACKAGE

CLIENT

LANDCOM

CONSULTANT

AECOM Australia Pty Ltd
A.B.N 20 093 846 925
www.aecom.com

LEGEND

- 56.5 — MAJOR COUNTOURS
- Ø525 — DRAINAGE LINE, SIZES AND FLOW DIRECTION
- 2.03 — DRAINAGE PITS (REFER DRAINAGE DRAWINGS FOR DETAILS)
- EXISTING DRAINAGE LINE
- EXISTING RMS DRAINAGE

SCALE BAR

0 6.25 12.5 m
1:250

PRELIMINARY

PROJECT MANAGEMENT INITIALS

J. CHAN	D. FETTELL	D. FETTELL
DESIGNER	CHECKED	APPROVED

ISSUE/REVISION

I/R	DATE	DESCRIPTION
A	18/05/2018	ISSUED FOR PRELIMINARY

KEY PLAN

PROJECT NUMBER

60558549

SHEET TITLE

DRAINAGE
PLAN
SHEET 05

SHEET NUMBER

60558549-SHT-00-0000-CI-0305

Appendix C – Flood Impact Assessment

Flood Impact Assessment

Cudgegong Road Station Precinct South

Flood Impact Assessment

Cudgegong Road Station Precinct South

Client: Landcom

ABN: 79 268 260 688

Prepared by

AECOM Australia Pty Ltd
Level 21, 420 George Street, Sydney NSW 2000, PO Box Q410, QVB Post Office NSW 1230, Australia
T +61 2 8934 0000 F +61 2 8934 0001 www.aecom.com
ABN 20 093 846 925

27 March 2018

Job No.: 60558549

AECOM in Australia and New Zealand is certified to ISO9001, ISO14001 AS/NZS4801 and OHSAS18001.

Quality Information

Document Flood Impact Assessment

Ref 60558549

Date 27-Mar 2018

Prepared by Prawi Woods / Peter Gillam

Reviewed by Nick Bartho

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
001	15-Mar-2018	For Submission	Peter Gillam Principal Engineer	
002	23 Mar- 2018	For Submission	Peter Gillam Principal Engineer	
003	27-Mar-2018	For Submission	Peter Gillam Principal Engineer	

Table of Contents

1.0 Introduction

1.1 Background and Purpose

The Cudgegong Road Station Precinct South development site comprises around 7.8 ha of government owned land within the Area 20 precinct in the North Western Growth Centre. Located between Cudgegong Road, Tallawong Road, Schofields Road and the Metro corridor, the development (Area 1 and Area 2) will deliver up to 1,107 apartments, 9,155 m^2 of retail, commercial and community uses and 2000 m^2 of public open space.

This report is prepared to address the Secretary's Environmental Assessment Requirements (SSD9063) for flooding, specifically to:

- Provide a detailed flood impact assessment in accordance with the NSW Floodplain Development Manual (2005) and consistent with the finding of the flood assessment undertaken as part of the SSI-5415
- Identify minimum floor levels for buildings and flood evacuation strategies where necessary.

A Water Cycle Management Strategy (AECOM, 2018) (WCMS) has been prepared to support the rezoning of the site and preparations for development and should be read in conjunction with this report. The WCMS provides detail on the proposed drainage network through the development site and connections to the existing stormwater network.

2.0 Flood Model Development

2.1 Software

The adopted software for this model is TUFLOW.

TUFLOW simulates depth-averaged, one and two-dimensional free-surface flows over a regular grid of square elements.

TUFLOW is very flexible in that it can readily input information and output results in a variety of different formats (data files are easily transferable). This allows models to be readily updated with new information such as survey, stormwater infrastructure or building developments/demolitions to keep the model updated. It also makes it easy to adjust the model for future developments and undertake relative impact assessments for different scenarios.

Version 2017-09-AC (Single Precision) of TUFLOW was used for this project.

2.2 Rainfall Data and Losses

Rainfall hyetographs are presented in Figure 8. Initial and continuing loss values were adopted in line with Blacktown City Council's design criteria and are summarised in Table 1.

Pervious land uses were delineated according to observed land use in aerial imagery for the existing scenario with adjustments based on land zoning data for the developed scenario. Rainfall data from ARR1987 has been adopted and hyetographs are provided at the end of this report.

Table 1 Adopted rainfall losses

Surface type	Initial Loss (mm)	Continuing Loss (mm/hr)
Rural and riparian corridor	15.0	2.5
Roads and development lots	1.0	0.0
Urban parkland	5.0	2.5

To minimise the volume of runoff trapped within building footprints due to high roughness and uneven terrain, these footprints were excluded from the direct rainfall application polygon. To account for the excluded areas, the rainfall depth for the rest of the direct rainfall application polygon has been proportionally increased in the localised areas where roof drainage is expected to discharge to.

2.3 Extent and Grid Size

A cell size of 1 m by 1 m was adopted for this study. The extent of the model is shown in Figure 1 and Figure 2.

2.4 Terrain

The terrain adopted in the TUFLOW model was created using a layered approach to add detail where required from the sources of terrain made available during the model development process. Land and Property Information (LPI) NSW LiDAR dataset flown on 13-14/05/2011 formed the basis for the overall model topography.

Client supplied design TINs from NRT were used to define the Cudgegong Station enabling works, precinct roads and earthworks.

The design TINs were also used to represent the proposed development site.

Several terrain modifications were made to represent current site conditions in the model. These included:

- Various road crests and kerbs were enforced in the terrain to ensure their potential hydraulic impact is captured
- The centreline of selected gullies and other small channels were enforced in the model topography to ensure appropriate representation of overland flow paths along the southern boundary of Area 2
- The interface between different TINs was smoothed where necessary to allow for unobstructed flow paths and more stable transitions
- Runoff from within the proposed station and rail line was precluded from entering Council's networks which is consistent with the NRT drainage approach.

2.5 1D Network

The pit and pipe network includes all existing and proposed pits in precinct roads, station enabling works and the development site. These details were taken from as-built surveys or design plans from RMS/NRT or from digital designs in 12d software.

Standard entry and exit loss values were assigned to the pipe network as shown in Table 2. A blockage of 50% was applied to the piped drainage for all scenarios.

Table 2 Adopted entry and exit losses

Variable	Circular Pipe
Entry loss	0.5
Exit loss	1
Width contraction coefficient	1

2.6 Surface Roughness and Building Representation

The area of assessment is dominated by roads, car parks, grassed areas and public open space. Downstream areas of the site include grassed areas and floodplain.

Hydraulic roughness in the 2D model domain is applied using GIS layers which define the extent of unique land uses. In the 1D model domain the adopted roughness value is applied to each pipe as one of its attributes. The Manning's "n" values adopted for the study area, including flow paths (overland, pipe and in-channel) are shown in Table 3. The spatially-varying roughness values for the model are shown in Figure 1 and Figure 2.

Note that the modelling approach has been to block out the proposed building footprints to ensure that no flood storage is modelled within buildings which are intended to remain flood free.

Table 3 Adopted hydraulic roughness coefficients

Surface type	Adopted roughness value
Concrete pipes	0.015
Road and car parks	0.02
Grassed, landscaped areas	0.03
Public open space parkland	0.045
Floodplain vegetation	0.065 – 0.10
Trees and shrubs	0.06
Commercial	0.025
Fenced properties	0.1

2.7 Boundary Conditions

Tail water levels in Second Ponds Creek were modelled as a static water level adopted from modelling carried out as part of the station enabling works assessment. These were taken from NRT flood maps prepared during the enabling works design.

Peak water levels were adopted for the 1% Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF) under existing and climate change scenarios.

Event	Adopted tailwater level (m AHD)
1% AEP	46.8
PMF	48.4

Modelling shows that the development is not sensitive to these levels, and adopting a static water level provides a reasonable boundary.

2.8 Design Flood Estimation

To determine the critical storm duration across the entire site, modelling of the 1% AEP and PMF event was undertaken for design storm durations ranging from 15 minutes to 360 minutes.

A critical duration of 90 minutes and 15 minutes were found for the 1% AEP and PMF respectively. Being a small catchment, different durations yield very similar maximum flood levels.

2.9 Scenarios

Flood Planning Levels

For the purposes of defining flood planning levels, the post development catchment condition includes the development of the Town Centre North, which has the potential to contribute runoff to Area 1 and Area 2 in large storm events.

Flood planning levels are provided for the PMF event and for the 1% annual exceedance probability (AEP) event with 15% increase in rainfall intensity and 50% blockage of all stormwater pipes.

Flood Impact

For the purposes of carrying out flood impacts, the existing development catchment condition includes the Cudgegong Station enabling works, Conferta Ave and Themeda Ave and upgraded Cudgegong and Tallawong Roads.

The post development catchment condition excludes the development of the Town Centre North, which has the potential to contribute runoff to Area 1.

Flood impacts are determined for the critical 1% AEP event assuming ARR1987 rainfall and 50% blockage of all stormwater pipes.

3.0 Flood Model Results and Mapping

3.1 Validation of Rainfall on Grid Results

A stand-alone hydrologic model (DRAINS) has been developed to validate the runoff generation in the TUFLOW.

The DRAINS model predicts a peak flow rate of 4.7 m^3/s east of Cudgegong Road under developed conditions

The TUFLOW model, which includes more rigorous hydraulic calculations and storage properties, predicts a peak flow rate of 4.9 m^3/s across Cudgegong Road.

Given the differences in model structure, a difference of 5% is good agreeance between models. Therefore the TUFLOW model is considered suitable for flood assessment purposes and for setting habitable floor levels.

3.2 Flood Planning Levels

The flood planning levels for the site were determined under the following conditions:

- 50% blockage of stormwater pipes
- Buildings blocked-out of the floodplain
- Car parking in western areas of the site
- Developed catchment conditions north of the station
- No runoff from the station entering Council's stormwater network
- Urban losses for parkland
- 15% increase in 1% AEP rainfall depths to allow for future climate change, per council requirements.
- Proposed drainage swale and overland flow path along the southern boundary of Site 2.

1% AEP flood depths and flood planning levels are shown in Figure 3.

PMF flood levels and depths are shown in Figure 4.

3.3 Flood Impacts

The flood impacts for the post development site were determined under a 50% blockage condition of all pipes.

Both pre and post development conditions assume no development north of the station and rail line, which has the potential to contribute some flows south of the rail line and along Cudgegong Road.

The 1% AEP flood impacts on lands external to the development site are confined to Council roads, current drainage lands (zoned SP2) and on the car park area west of Area 2 as shown in Figure 5. A discussion of these impacts is provided below.

Area 1 – Car Park 2

Under existing 1% AEP flood conditions, overland flow from Car Park 2 is shown to discharge into the south western corner of the proposed development. This results in sheet flow across the development site.

Under developed 1% AEP conditions, the proposed development will diverted this overland flow south to the proposed drainage swale along Schofields Road. This will result in 250mm of flooding at the edge of the car park and low hydraulic hazard conditions on the NRT metro lands. This impact does not pose a safety risk to cars or pedestrians or private property.

In the future, and as a requirement of the re development of the car park, stormwater drainage will be provided to prevent discharge onto the development site. This impact does not affect the future development potential of the car park lands.

On these grounds, the impact is considered to be acceptable.

Area 2—Conferta Avenue and Cudgegong Road

Under existing 1% AEP flood conditions, overland flow from Area 1 enters Conferta Ave in a controlled manner via swales and sediment basins.

Under developed 1% AEP conditions, the volume and flow rate of overland flow entering Conferta Ave will increase but will be controlled via trunk drainage lines. This results in a minor increase in flow depths (up to 100mm), a maximum depth of 250mm within the gutter and low hydraulic hazard conditions along Conferta Ave.

On these grounds, the impact is considered to be acceptable.

Area 3—Conferta Avenue and Cudgegong Road Intersection

The modelled 50% blockage scenario shows that additional discharge to Conferta Ave may cause localised high hydraulic hazard conditions in the very invert of the southern kerb return. This flooding is isolated and surrounded by areas of low hazard which mitigates the risk of cars potentially being washed into buildings or waterways. This also demonstrates that the majority of the street would be trafficable in a 1% AEP event, even with 50% blockage of local pipes.

Given that this is a conservative scenario, the impact is considered to be acceptable.

Area 4—Schofields Road

Under existing 1% AEP flood conditions, overland flow from Schofields Rd will enter the development site across the southern boundary.

The proposed development will include a swale to prevent overland flow entering the site, and is shown to result in a 30mm increase in flow depth within the Schofields Rd kerb. Flow depths in Schofields Rd (under a 50% blockage condition) are less than 250mm and associate with a low hazard.

On these grounds, the impact is considered to be acceptable.

Area 5—Council Owned SP2 Lands

The proposed development will discharge more runoff to the drainage easement east of Cudgegong Road, resulting in slightly elevated flood levels (30mm increase) when compared to existing conditions. This is associated with a low hydraulic hazard and it is contained within SP2 drainage lands which are designated for a flood and drainage management purpose.

On these grounds, the impact the impact is considered to be acceptable.

3.4 Flood Evacuation

The proposed development site sits outside the mainstream flood extents of Second Ponds Creek and there is no associated flood hazard to residents in either 1% or PMF events. Localised flooding will create relatively shallow flooding around proposed buildings in both 1% AEP and PMF events.

PMF flooding around buildings is shown to be within 500 mm of the 1% AEP peak flood level with allowance for 1% AEP climate change. This means that the habitable floor level should also be above the PMF level and evacuation will not be required. Residents can safely shelter in place. It should be noted that evacuation via Cudgegong Road and Conferta Avenue will be unsafe for passenger vehicles during PMF conditions. As such habitable floor levels 450mm above the proposed raised ground level are acceptable flood protection for the buildings in the south of the site. As the northern block (Site 1) is not impacted by flooding, floor levels at grade with the proposed ground level are appropriate.

3.5 Flood Hazard

The flood hazards based on preliminary hazard as defined in Figure L2 of the Floodplain Development Manual (2005) for the 1% AEP and PMF event were modelled across the existing roads and proposed development under 50% blockage criteria for the stormwater drainage network.

With the exception of the intersection of Conferta Ave and Cudgegong Road, 1% AEP flood hazards are shown to be low.

Flood depths at the intersection of Conferta Ave and Cudgegong Road imply unsafe conditions are limited to the very low point of the kerb, but these conditions do not extend across the entire road corridor.

4.0 References

AECOM 2018, *Integrated Water Cycle Management Strategy*

Department of Infrastructure, *Planning and Natural Resources 2005, Floodplain Development Manual, the management of flood liable land*

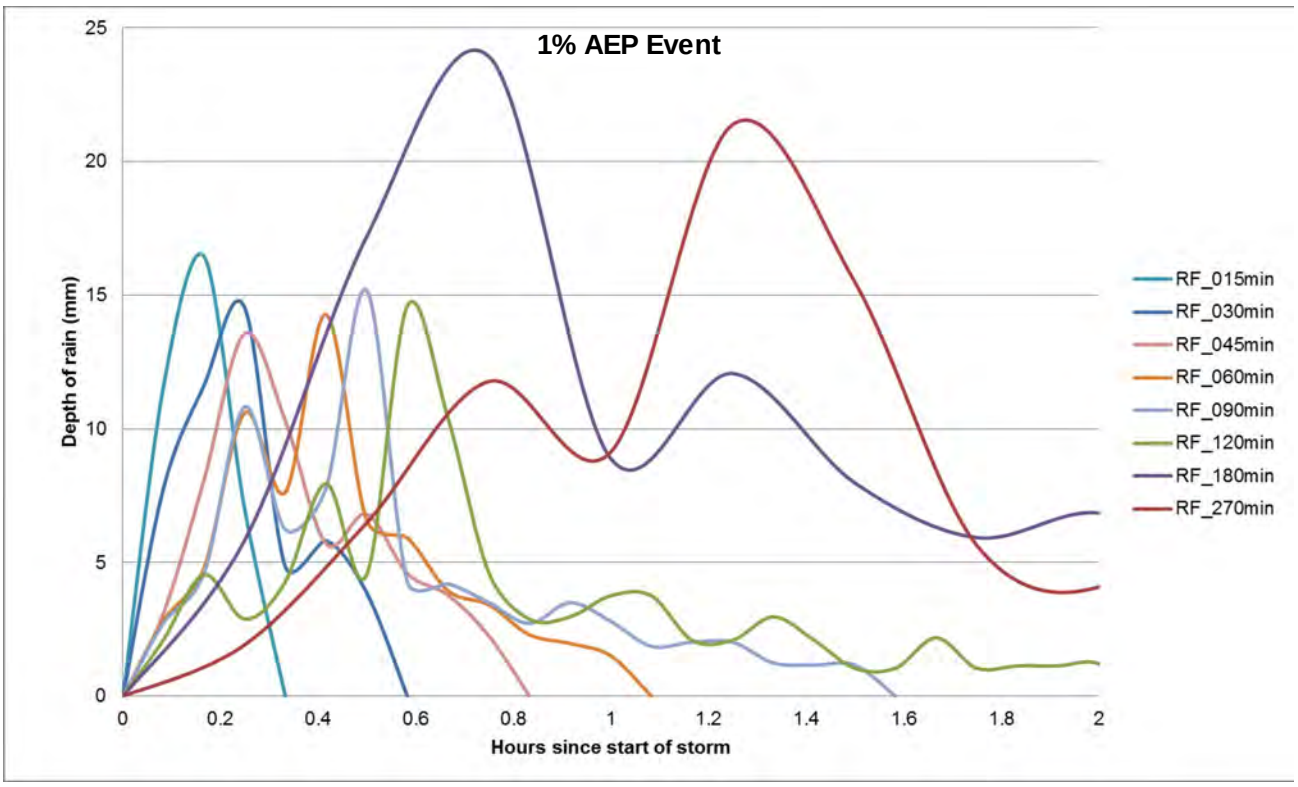

Figure 8 - 1% AEP hyetographs (ARR1987)

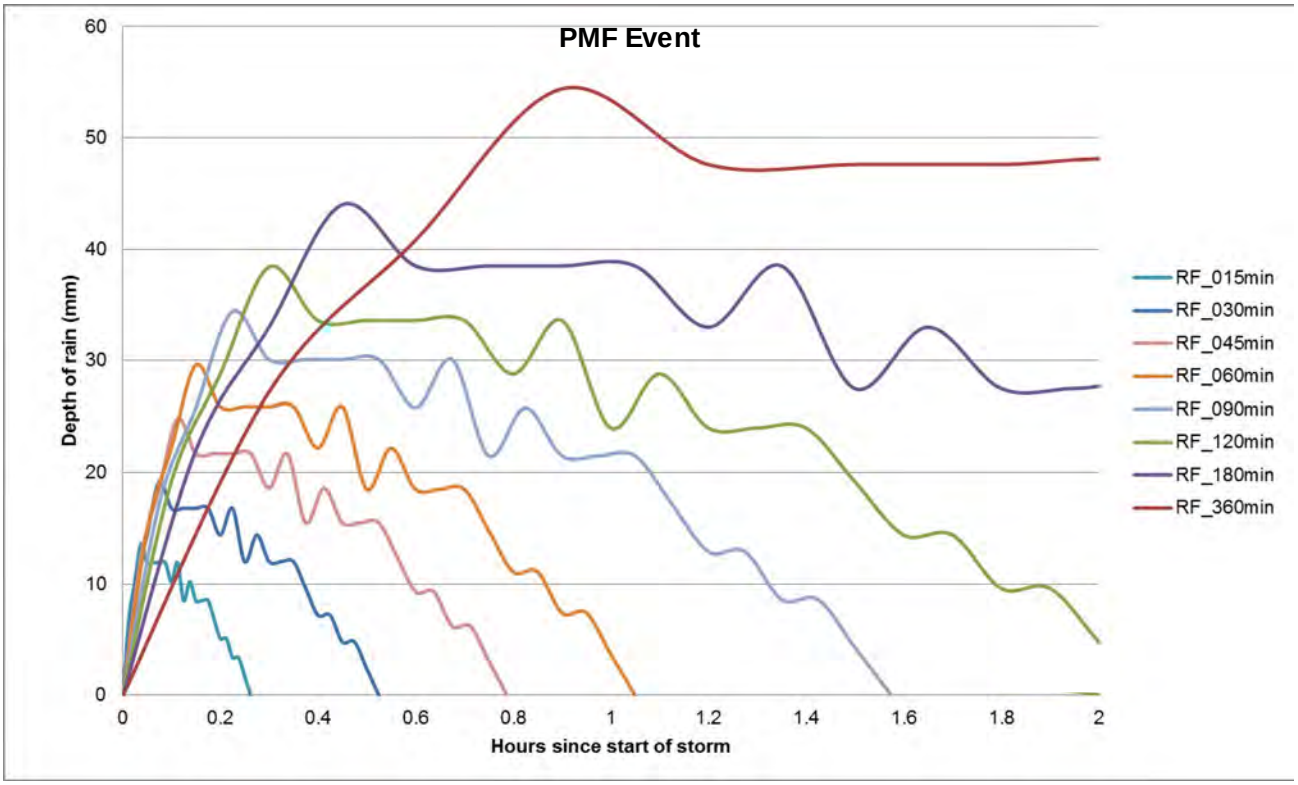

Figure 9 – Design Rainfall hyetographs (ARR1987)

Appendix A

Figures

Lable	Mannings	Initial Loss (mm)	Continuing Loss (mm/hr)	Land Type
1	0.02	1	0	Asphalt (i.e. roads)
2	0.03	5	2.5	Urban well Maintained Grassed Cove
3	0.045	15	2.5	Rural non maintained grass
4	0.06	15	2.5	Trees
5	0.035	0	0	Wetland Area
6	0.015	5	2.5	Sand
7	0.1	15	2.5	Medium Density Vegetation
8	0.065	15	2.5	Mildly Dense Vegetation
9	10	1	0	Fenced Properties (ie allotments)
10	10	1	0	Buildings
12	0.05	5	2.5	Urban Public Open Space / Water
14	0.025	1	0	Commercial

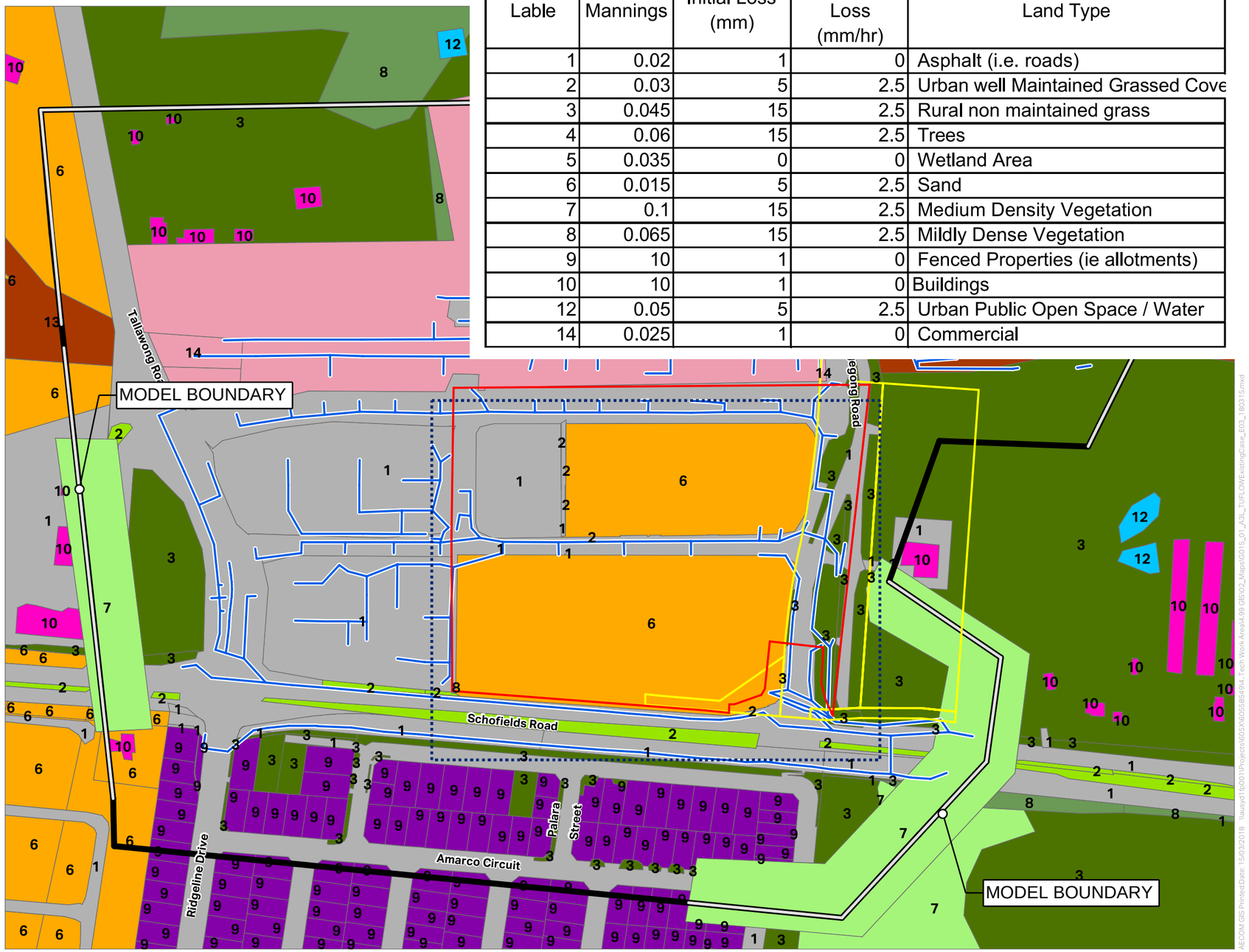

FIGURE 1
TUFLOW MODEL EXISTING CASE

KEY

- Site Boundary
- Limit of mapping
- SP2 zoned land
- Existing stormwater pipe
- 1 Asphalt
- 2 Well Maintained Grass Cover
- 3 Non Maintained Grass Cover
- 6 Sand
- 7 Medium Density Vegetation
- 8 Mildly Dense Vegetation
- 9 Fenced Properties
- 10 Buildings
- 12 Water
- 13 Rails
- 14 Commercial

AECOM

0 50 100 m

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Lable	Mannings	Initial Loss (mm)	Continuing Loss (mm/hr)	Land Type
1	0.02	1	0	Asphalt (i.e. roads)
2	0.03	5	2.5	Urban well Maintained Grassed Cove
3	0.045	15	2.5	Rural non maintained grass
4	0.06	15	2.5	Trees
5	0.035	0	0	Wetland Area
6	0.015	5	2.5	Sand
7	0.1	15	2.5	Medium Density Vegetation
8	0.065	15	2.5	Mildly Dense Vegetation
9	10	1	0	Fenced Properties (ie allotments)
10	10	1	0	Buildings
12	0.05	5	2.5	Urban Public Open Space / Water
14	0.025	1	0	Commercial

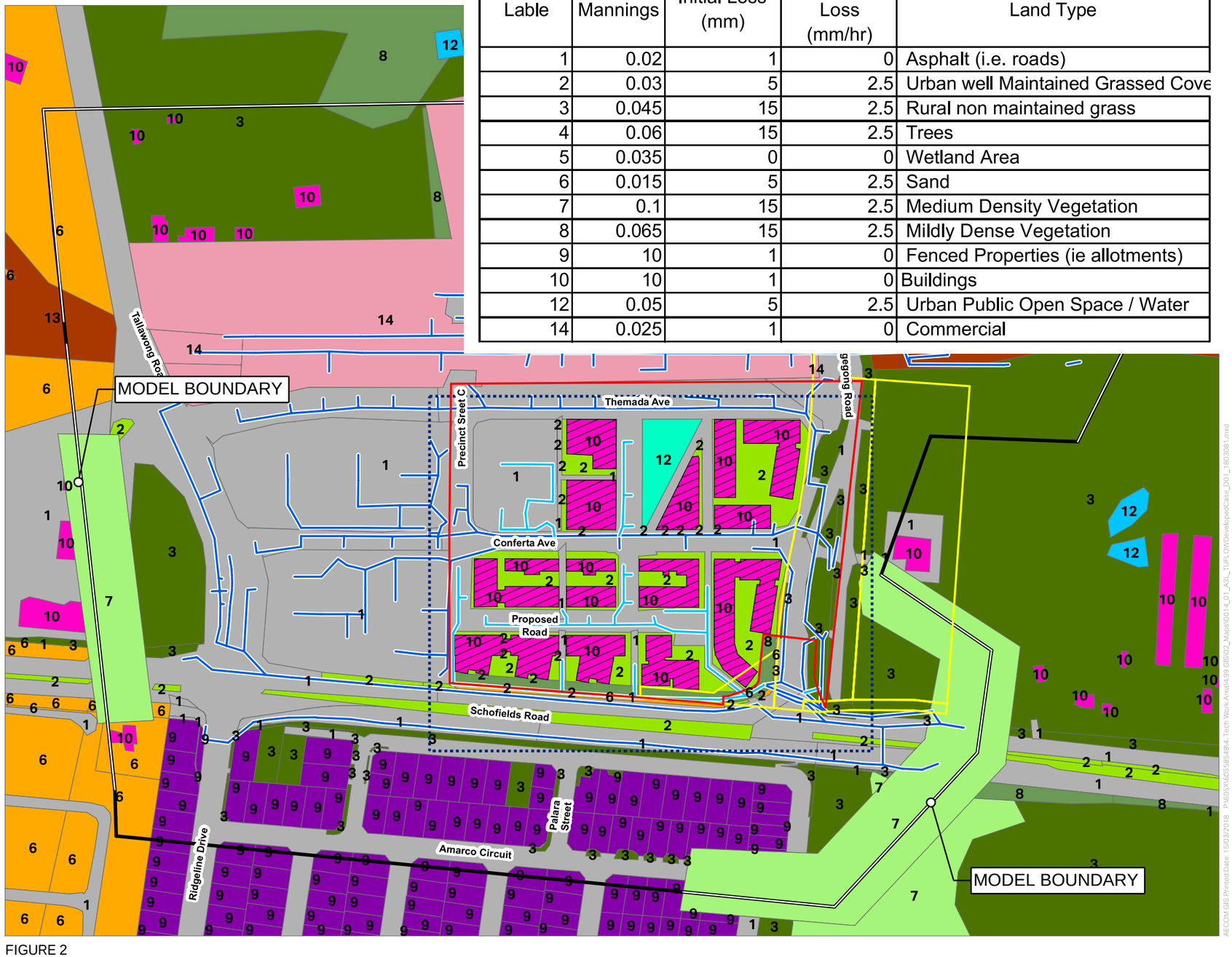

FIGURE 2
TUFLOW MODEL DEVELOPED CASE

KEY

- Site Boundary
- Limit of mapping
- SP2 zoned land
- Buildings outline
- Proposed stormwater pipe
- Existing stormwater pipe
- 1 Asphalt
- 2 Well Maintained Grass Cover
- 3 Non Maintained Grass Cover
- 6 Sand
- 7 Medium Density Vegetation
- 8 Mildly Dense Vegetation
- 9 Fenced Properties
- 10 Buildings
- 12 Water
- 13 Rails
- 14 Commercial

AECOM

0 50 100 m

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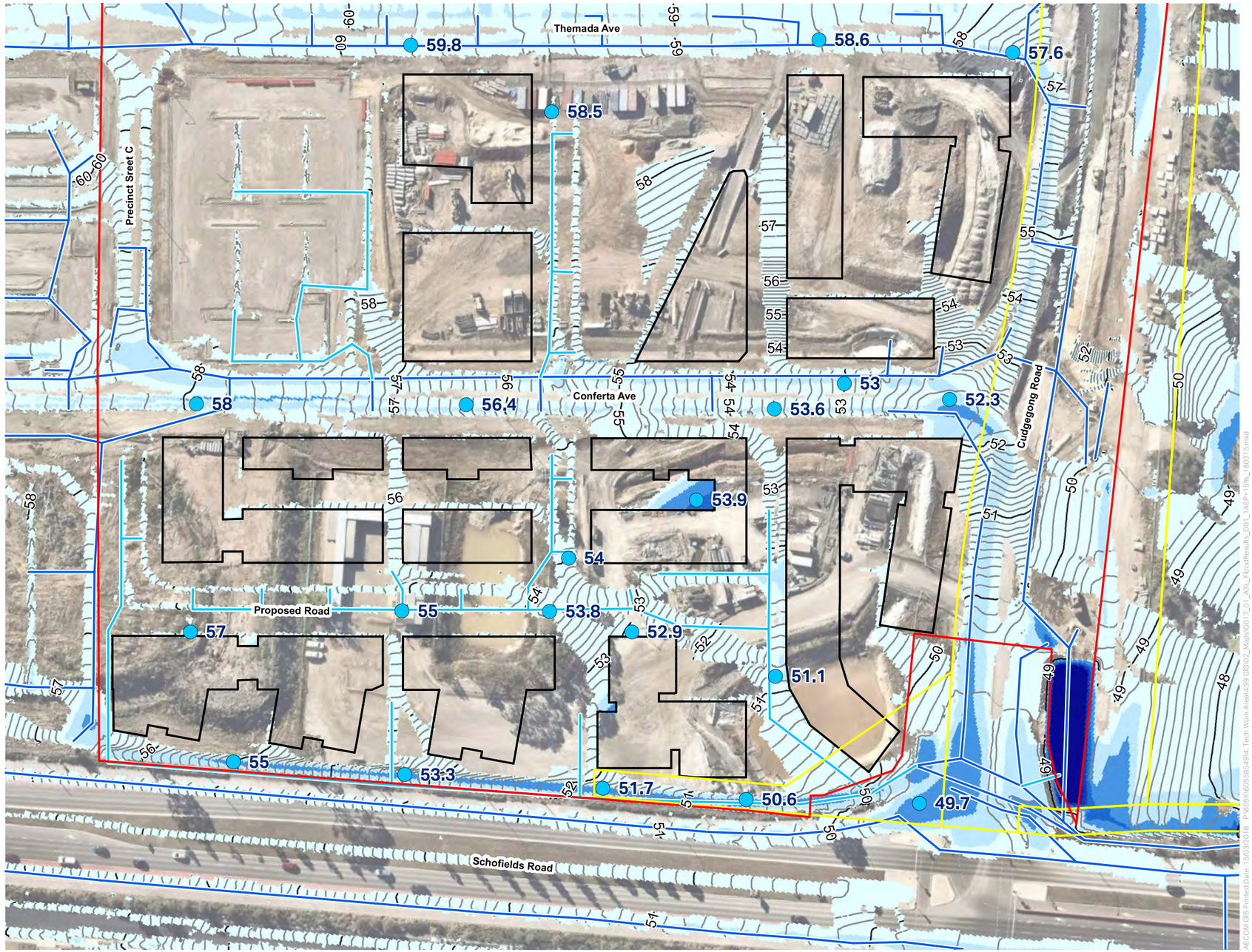

FIGURE 3

FLOOD RESULTS DEVELOPED CASE – 1AEP+15%

KEY

Flood Level 1m Contour	**Depth (m)**
Spot Height	< 0.1
Site boundary	0.1 - 0.25
SP2 zoned land	0.25 - 0.5
Proposed stormwater pipe	0.5 - 0.75
Existing stormwater pipe	0.75 - 1
	1 -

AECOM

0 25 50 m

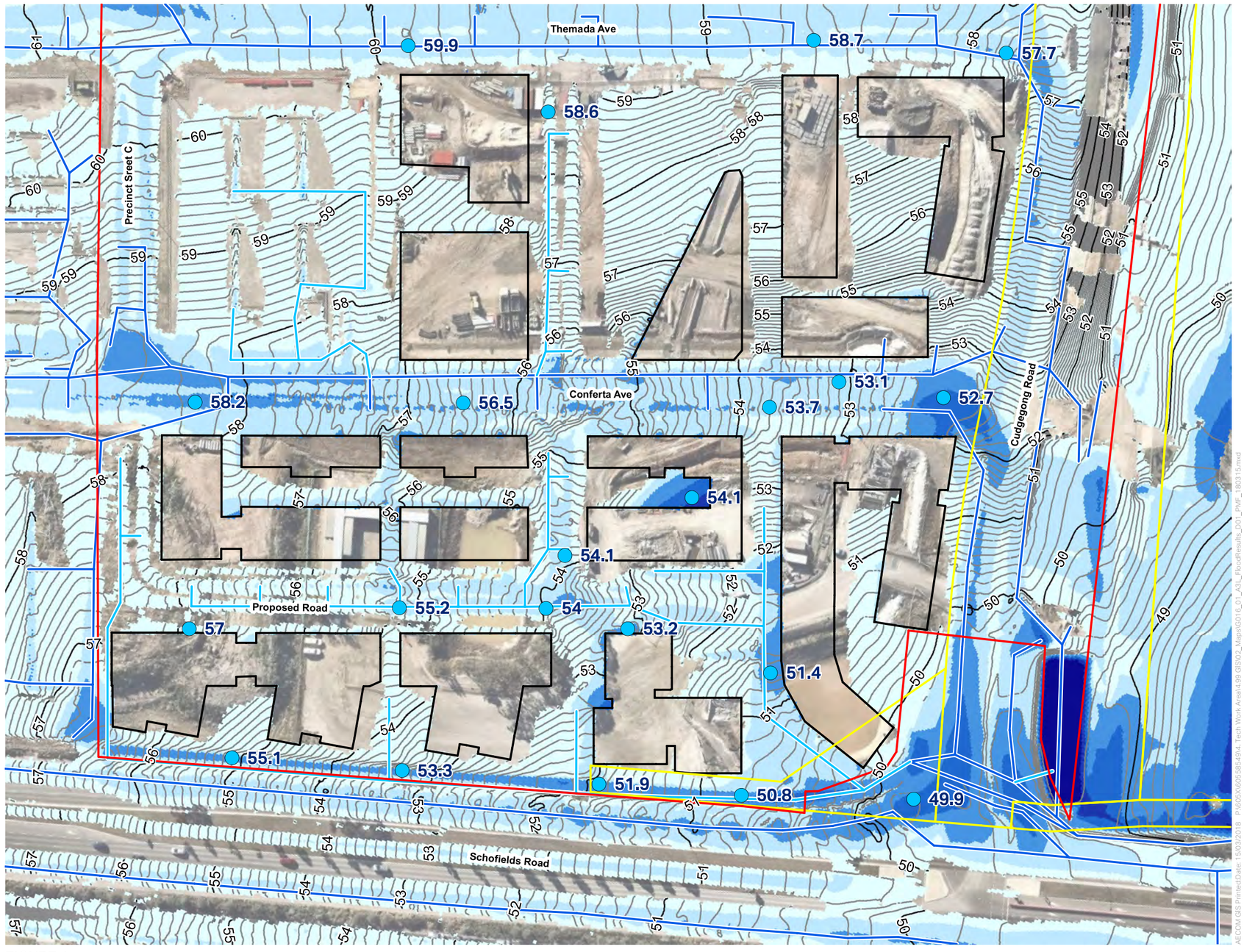

FIGURE 4

FLOOD RESULTS DEVELOPED CASE – PMF

KEY

- Flood Level 1m Contour
- Spot Height
- Site boundary
- SP2 zoned land
- Proposed stormwater pipe
- Existing stormwater pipe

Depth (m)

- < 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 -

AECOM

0 25 50 m

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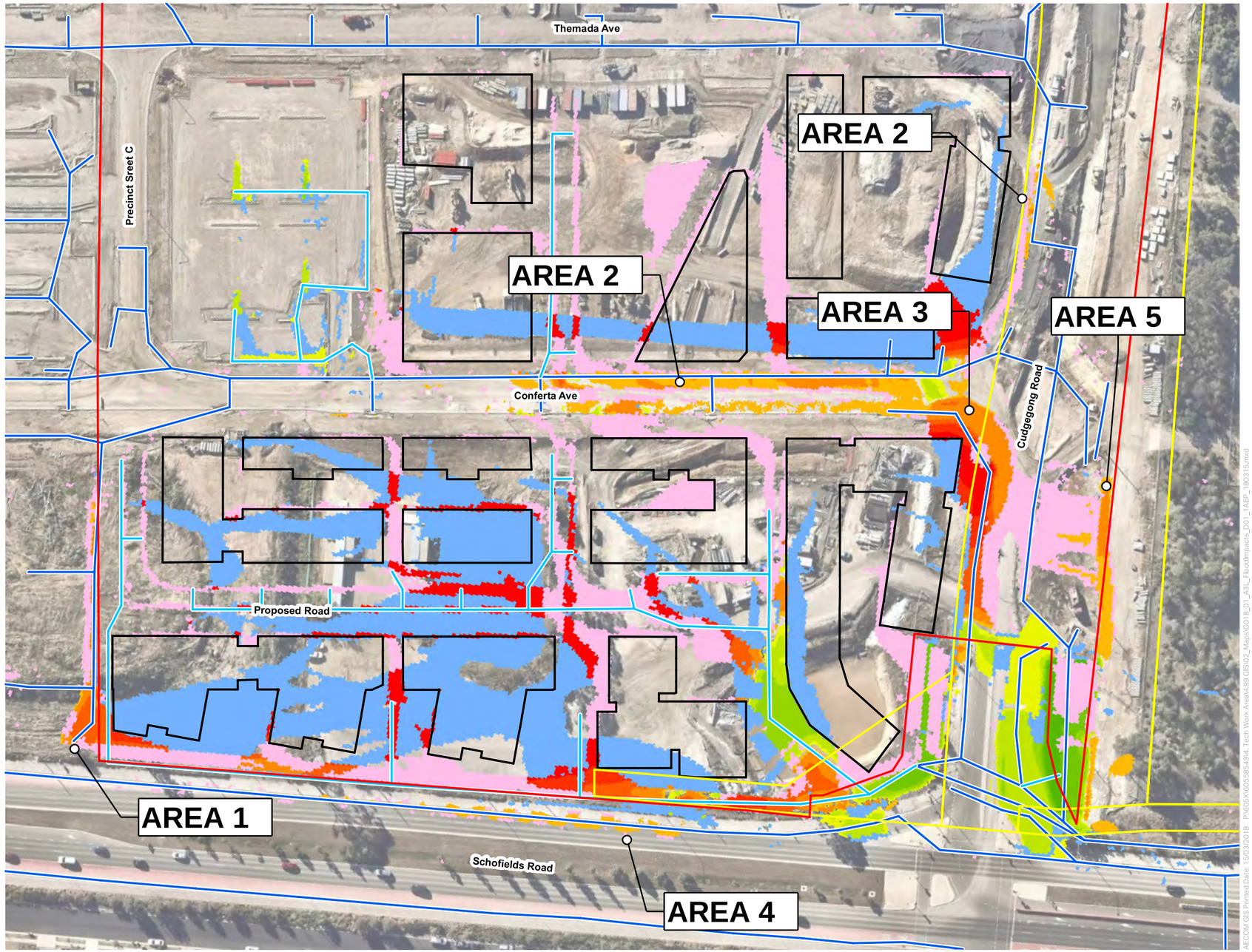

FIGURE 5

FLOOD RESULTS DEVELOPED CASE – 1AEP

KEY

- Site_Boundary_R_002
- SP2 zoned land
- Proposed stormwater pipe
- Existing stormwater pipe

Impacts (m)	
-2.8 - -2.3	0.01 - 0.03
-2.3 - -0.5	0.03 - 0.1
-0.5 - -0.25	0.1 - 0.25
-0.25 - -0.1	0.25 - 0.5
-0.1 - -0.03	0.5 - 1.2
-0.03 - -0.01	**Wet Dry**
-0.01 - 0.01	Was wet, now dry
	Was dry, now wet

AECOM

0 25 50 m

imagery © nearmap (2017)

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FIGURE 6

FLOOD HAZARDS DEVELOPED CASE – PMF

KEY

Site_Boundary_R_002	**Flood Hazard Category**
SP2 zoned land	Low Hazard
Proposed stormwater pipe	Intermediate Hazard
Existing stormwater pipe	High Hazard

0 25 50 m

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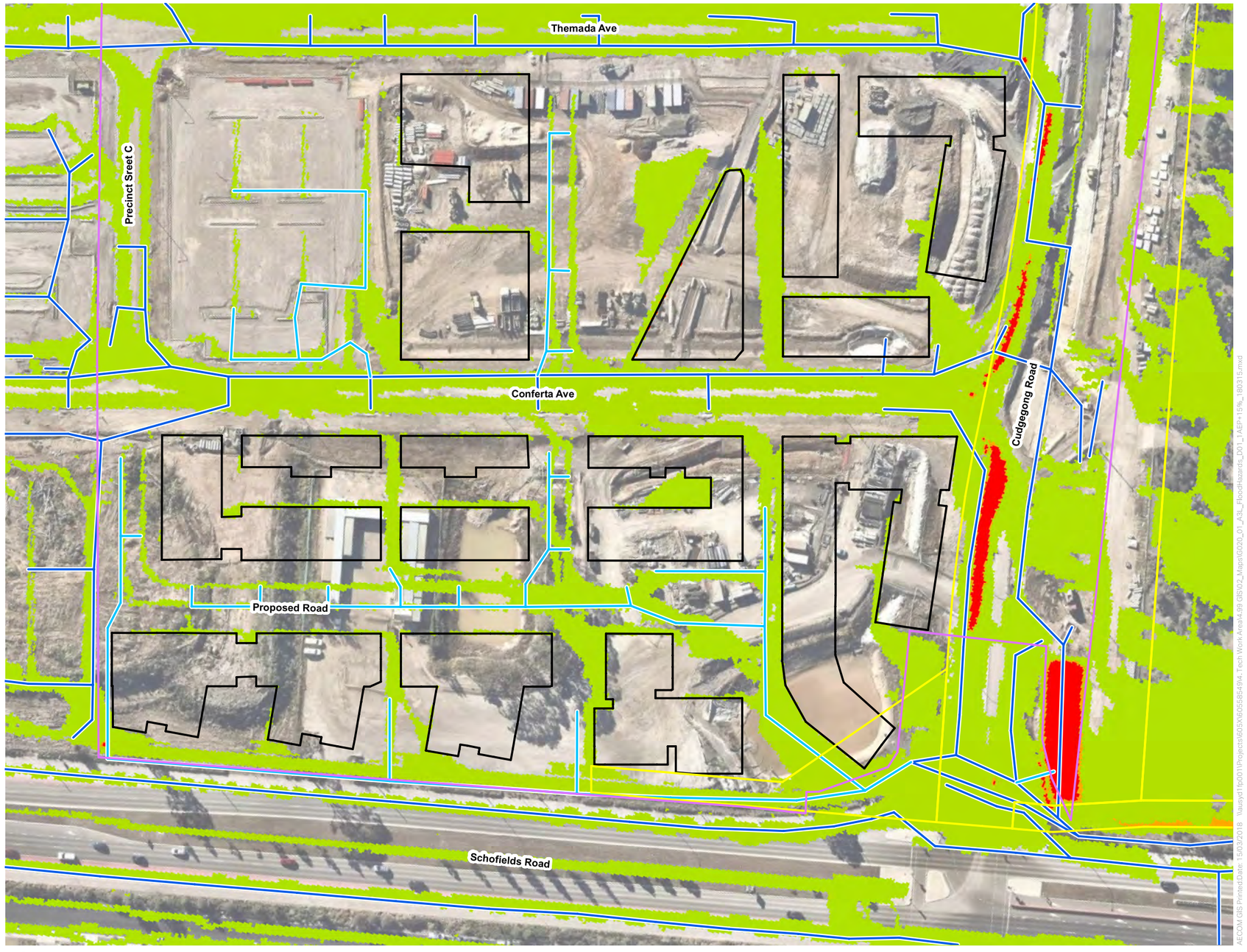

FIGURE 7

FLOOD HAZARDS DEVELOPED CASE – 1AEP+15%

KEY

- Site Boundary
- SP2 zoned land
- Proposed stormwater pipe
- Existing stormwater pipe

Flood Hazard Category

- Low Hazard
- Intermediate Hazard
- High Hazard

AECOM

0 25 50 m

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