Western Sydney Aerotropolis (Initial precincts)

Stormwater and Water Cycle Management Study

December 2021

Sydney WATER

Acknowledgement of Country

Sydney Water respects the traditional 'Caring for Country' restorative approaches practiced over tens of thousands of years by Aboriginal people and play our part to improve the health of the landscape by recognising and nurturing all values of water in our environment.

In doing so, we acknowledge the traditional custodians and their ancestors of the lands and waters in Western Sydney where we are working and learning: the D'harawal and Dharug nations, as well as their neighbours the Gundungurra. Their lore, traditions and customs nurtured and continue to nurture the sweet waters in this area, creating wellbeing for all. We also pay our respects to Elders, past and present.

We recognise the traditional name given to this region 'Wianamatta' meaning 'mother' and place of water.

Executive summary

This *Stormwater and water cycle management study* is a technical planning document that outlines how stormwater, water, wastewater, recycled water, trunk drainage and riparian zones should be managed to achieve the Western Parkland City vision within the Agribusiness, Aerotropolis Core, Badgerys Creek and Northern Gateway precincts.

These precincts account for about half of the Western Sydney Aerotropolis and primarily contain mixed use and enterprise areas as well as transport infrastructure corridors. The Aerotropolis lies mostly within the Wianamatta-South Creek catchment. Wianamatta is the Dharug name for South Creek and means ‘mother’s place’ or ‘mother’s creek.’ Wianamatta is highly significant to First Nations people who have cared for Country, including the waters of Wianamatta for thousands of years. Planning for the Aerotropolis must also respect and care for these waters ‘to the most insignificant jet.’[1]

The waterways of the Wianamatta-South Creek catchment are unique and highly vulnerable to the impacts of urbanisation. The creeks, floodplains and landscapes of Wianamatta-South Creek are valuable natural assets which underpin the future amenity and liveability of the Aerotropolis and broader Western Parkland City. This means that managing water in the Aerotropolis is a critical component of precinct planning.

The *State Environmental Planning Policy (Western Sydney Aerotropolis) 2020* requires that ‘precinct plans’ be prepared for approval by the Minister.

Section 40 (3) states that the precinct plan for each precinct must be spatially based, include performance criteria for development and identify public utility infrastructure. Importantly, the plans must contain ‘proposals for total water cycle management of the precinct.’ This report sets out the principles and systems needed to deliver an integrated water management approach for the Aerotropolis, including concepts for the infrastructure and land to be set aside..

Integrated water servicing

This study integrates supply of mains water, wastewater, stormwater and recycled water into water balances for the initial precincts and includes testing of several scenarios. Each possible servicing scenario was differentiated by levels of recycled water and stormwater harvesting. Indicative maps of trunk wastewater, drinking water, stormwater and recycled water infrastructure are provided. A final preferred scenario was identified for implementation through the Precinct Plans.

Recommendation: Water servicing for precincts is to feature total water cycle management that integrates and balances drinking water, wastewater, recycled water and harvested stormwater. All suitable open spaces, areas of landscaping, parks and streets must be developed to include irrigation infrastructure to ensure adequate demand for harvested stormwater and provide expected urban cooling benefits.

Recycled water for non-drinking end uses will be provided to the area.
The final water balance provided highlights that recycled water is a source of water that is resilient to climatic variability and helps minimise demands on drinking water supplies.

Recycled water and harvested stormwater will be provided via an integrated, distribution network. This network prioritises supply of harvested stormwater

[1] *Sydney Gazette and NSW Advertiser*, Saturday 2 September 1826 (page 4). Resolution of extraordinary meeting, Windsor Courthouse, 28 August 1826, chaired by Coleby (https://dharug.dalang.com.au/plugin_wiki/page/Colebee).
Citation provided by Dr Daniele Hromek.

to manage run off to meet waterway health outcomes, while recycled waste water provides the balance of non-drinking water supply

This integrated recycled water outcome responds to NSW Government Policy directions for the Western Parkland City including:

- creating a cool, green Parkland City in Western Sydney, with Wianamatta-South Creek as a core element and central to the amenity of the City.
- increasing tree canopy across Greater Sydney, contributing to the Government's target of 5 million additional trees, resulting in 40% canopy cover across the City.
- promoting a circular economy where waste is minimised, and resources are used sustainably to optimise economic, environmental and social benefits.
- creating a 'Smart' and resilient City which adopts the best available technology and adapts to global trends such as climate change to meet the lifestyle needs of the community.

Waterway health

Landscape led planning is being applied to orient new urban development around the network of waterways that provide the central landscape features for the region. This planning recognises the cultural, ecological and recreational values of those waterways and includes NSW Government waterway health objectives that will preserve those values. These objectives have been developed by applying the NSW Government's *Risk-Based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions* (risk-based framework).

Importantly, these objectives work towards managing waterway health within the Wianamatta-South Creek by requiring outcomes for both water quality and stormwater quantity (flow).

This Stormwater and Water Cycle Management Study adopts these objectives and demonstrates how a range of integrated approaches are required that also contribute to other government objectives regarding open space, active transport, native vegetation, riparian vegetation policy, street tree canopy targets, urban cooling, flooding and airport specific risk management.

The approach to achieving the waterway health objectives represents a shift in stormwater management that requires a combination of at-source controls, stormwater harvesting and vegetated Water Sensitive Urban Design (WSUD) elements including biofiltration street trees and wetlands, that mimic the existing hydrologic characteristics of the catchment than the approaches adopted in urban development over recent years. The integration of stormwater harvesting and recycled water will achieve cost efficiencies and reduce operational risks.

Recommendation: Development within the Western Sydney Aerotropolis is to ensure waterways, riparian corridors, selected farm dams, open water bodies and other water-dependent ecosystems are protected, restored and maintained.

Stormwater infrastructure footprints mapped as part of this study are to be set aside to deliver waterway health objectives at sub catchment and precinct scales via a regional stormwater harvesting approach. These footprints should be further explored for constraints and integrated into public open space to provide a stormwater management and amenity function. A 3D model of wetlands, flood levels, trunk drainage infrastructure and precinct earthworks should be developed to provide a coordinated basis for prescribing finished flood planning levels, drainage inverts and WSUD surface levels.

Development and public infrastructure must contribute towards the waterway health objectives developed by NSW government under the *Risk-Based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions* (OEH/EPA 2017) by maximising the reuse and retention of stormwater within the landscape.

Development is to ensure that the stormwater pollution removal and flow management requirements identified in this study are achieved through the delivery of a centralised, regional stormwater harvesting scheme that achieves the waterway health outcomes and minimises and consolidates stormwater elements in the public and private domain.

Stormwater system

Trunk drainage and preferred Water Sensitive Urban Design (WSUD) stormwater management elements have been selected in consultation with Penrith and Liverpool Councils. These WSUD elements work together to preserve the local waterways that cross the precincts and also the waterways downstream of the Aerotropolis. A coordinated approach will be required to ensure that land take and maintenance efforts are minimised to a consolidated number of strategically located stormwater assets.

Recommendation: Stormwater systems, including those on private lots, within the streetscape and trunk drainage must be designed to achieve the waterway health, urban cooling, tree canopy and open space outcomes. This shall be achieved through WSUD treatment trains developed with key stakeholders (and outlined in this report). Urban layouts, streets and drainage sysems are to utilise targets for reduced impervious surfaces to contribute towards the waterway health objectives for the catchment. Trunk drainage is to be provided through retained creek-lines or constructed open natural drainage channels to reduce the cost of drainage infrastructure, and contribute to biodiversity, public amenity and safety. The indicative layout of the regional trunk drainage network, including stormwater treatment wetlands and ponds are identified and must be allowed for in any development layout.

The ongoing ownership and management of these assets must ensure adequate and sustainable funding for maintenance is available and compliance with the waterway health objectives are met.

Stormwater detention

Stormwater detention is an industry accepted method to reduce the higher peak flowrates that are generated by urbanisation of undeveloped catchments. By attenuating the peak flowrates, the potential of flooding for downstream properties can be maintained at or below existing levels ensuring that the flood immunity afforded by flood planning controls can be maintained.

The stormwater detention strategy has been developed to manage peak flows for frequent (eg 50% Annual Exceedance Probability) and rare events to minimise the risk of impacts on stream morphology and flood impacts as a result of increased impervious surfaces associated with the initial precincts. Strategies have been developed that aim to meet these objectives using a combination of stormwater detention on private land and in open space to retard flows to meet existing case peak flows.

Recommendation: To manage local run-off and the impact that the Western Sydney Aerotropolis has on downstream areas, stormwater flows should be detained within the landscape. This study, developed in consultation with stakeholders, has shown that a combination of on-site stormwater detention (for industrial and commercial areas), on-line stormwater detention (on first and second order creeks) through natural drainage design and local stormwater assets can sufficiently manage precinct scale peak-flow run-off and should be employed throughout the Western Sydney Aerotropolis. An allocation of sufficient, suitably located land area to allow for stormwater assets must be provided. Stormwater detention assets, in the public realm, should be designed as multifunctional also contributing to waterway health, biodiversity and public amenity.

It is important to note that current and future flood planning may consider the impacts of development on overall timing and peak-flowrate of runoff flowing to the contributing tributaries of Wianamatta-South Creek. This work and any subsequent strategy derived from this work may result in changes to the precinct-scale stormwater detention strategy and may inform future refinement of the stormwater detention requirements.

Riparian land management

The protection, restoration and maintenance of waterways, riparian corridors, and water dependent ecosystems is essential in achieving the cultural, social and biodiversity aspirations as well as tree canopy targets of the Western Parkland City. Creeks within the initial precincts have been validated and mapped with associated vegetated riparian zones to support waterway health. Water-dependent ecosystems and key fish habitat have also been identified and mapped. A high level riparian revegetation strategy has been developed that recommends the areas and likely costs of riparian land that should be revegetated. Figures are provided in section 4 depicting proposed vegetated riparian zone and farm dam prioritisation.

Recommendation: Vegetated riparian zones (VRZ) adjacent to creeks and other water bodies mapped must be protected, restored and maintained. Opportunities to revegetate beyond standard VRZs should be explored to maximise biodiversity outcomes and achieve urban canopy targets, particularly within the Wianamatta Precinct. The ongoing ownership and management of these assets must ensure adequate access and sustainable funding for maintenance is available. Figures are provided in section 4 as well as in the separate Riparian Corridor Assessment (Sydney Water 2021) depicting field and desktop survey results and analysis as well as the revegetation strategy. The revegetation strategy should be further refined based on specific flood impact testing and location specific concept design development.

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1 Introduction

In September 2020, the Minister for Planning and Public Spaces approved *State Environmental Planning Policy (Western Sydney Aerotropolis) 2020* (*Aerotropolis SEPP*) to enable the rezoning of lands surrounding the proposed Western Sydney Airport, known as the Western Sydney Aerotropolis (Aerotropolis). The rezoning is for a mix of employment, residential and community uses.

The Aerotropolis lies mostly within the Wianamatta-South Creek catchment. Wianamatta is the Dharug name for South Creek and means 'mother's place' or 'mother's creek.' Wianamatta is highly significant to First Nations people who have cared for Country, including the waters of Wianamatta for thousands of years. Planning for the Aerotropolis must also respect and care for these waters 'to the most insignificant jet.'[2]

The waterways of the Wianamatta-South Creek catchment are unique and highly vulnerable to the impacts of urbanisation. The creeks, floodplains and landscapes of Wianamatta-South Creek are sensitive natural assets, which underpin the future amenity and liveability of the Aerotropolis and broader Western Parkland City. Managing water in the Aerotropolis is a critical component of precinct planning.

1.1 Total water cycle management

The *Aerotropolis SEPP* requires that precinct plans be prepared and approved by the Minister for Planning and Public Spaces. Section 40 (3) states that the precinct plan for each precinct must be spatially based, include performance criteria for development and identify public utility infrastructure. Importantly, the plans must contain 'proposals for total water cycle management of the precinct.'

This *Stormwater and water cycle management study* (the study) identifies the agreed total water cycle management proposal for each of the four initial precincts, noting that Wianamatta-South Creek corridor has been considered only where it is adjacent to these four precincts. The study integrates the water, wastewater, recycled water and stormwater servicing as well as the riparian corridor management for these initial precincts. and responds to the scope defined by the Western Sydney Planning Partnership (WSPP).

1.2 Public exhibition

An interim report documenting progress on the study was prepared and issued to the WSPP for the purposes of public consultation. The report was placed on public exhibition from 10 November 2020 to 26 February 2021.

Comprehensive review of the open space needs for the Aerotropolis was undertaken and looked at opportunities to co-locate stormwater infrastrucuture with open space and minimise impacts on productive land. An Open Space Needs Study was exhibited along with an amendment to the Aerotropolis SEPP including the identification of land proposed for acquisition from the 8th October 2021 to 5th November 2021.

The findings of the Open Space Needs Study as well as review of the issues raised in the submissions informed the preparation of this Final Report.
The roadmap for completing this work is outlined as Figure 1-1 on the next page.

[2] *Sydney Gazette and NSW Advertiser*, Saturday, 2 September 1826 (page 4). Resolution of extraordinary meeting, Windsor Courthouse, 28 August 1826, chaired by Coleby (https://dharug.dalang.com.au/plugin_wiki/page/Colebee). Citation provided by Dr Daniele Hromek.

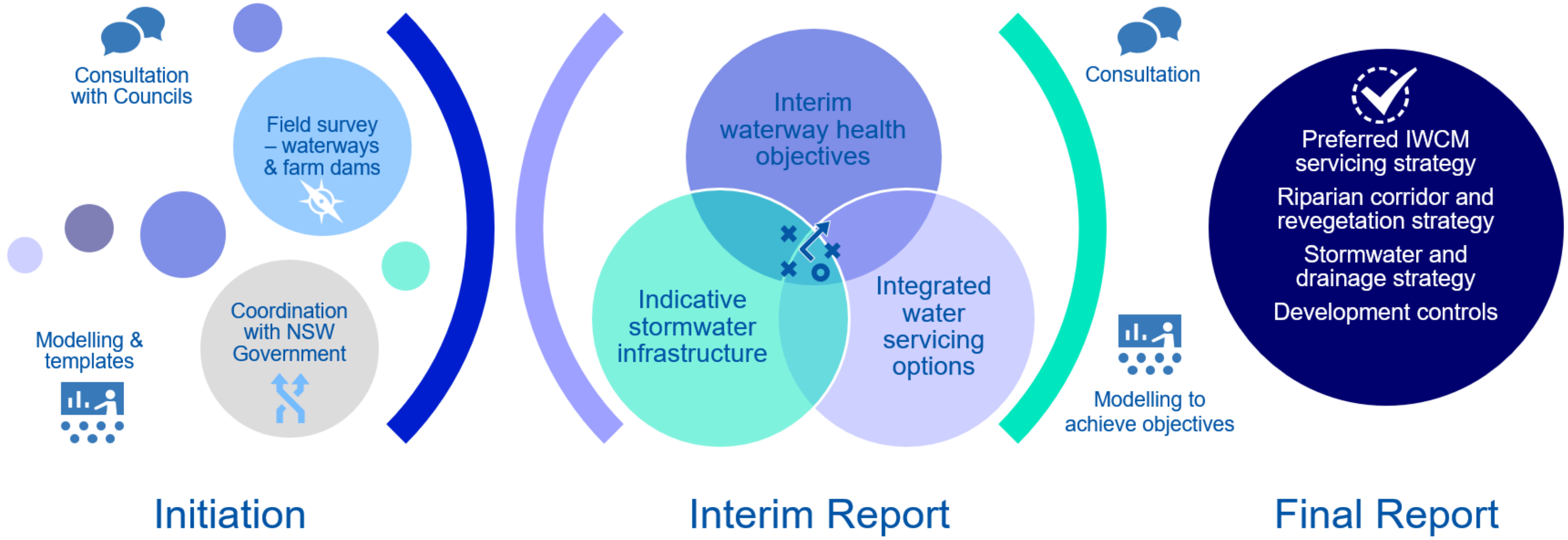


Figure 1-1 Road map to this version of the report

1.3 Initial precincts

Five precincts surrounding the proposed Western Sydney Airport in the Aerotropolis have been planned for initial release/rezoning (shown in Figure 1-2):

- Northern Gateway
- Agribusiness
- Badgerys Creek
- Aerotropolis Core
- Wianamatta-South Creek (where it adjoins the precincts above).

The initial precincts are intersected by numerous small waterways and several named waterways, including:

- Badgerys Creek
- South Creek
- Thompsons Creek
- Science Creek
- Cosgroves Creek
- Duncans Creek.

The existing character of the five precincts is summarised below (shown in Figure 1-3 and Figure 1-4):

1. **Agribusiness**: This precinct is largely dominated by an open rural landscape with sparse buildings and roads and interspersed with pockets of forested vegetation and agricultural dams.

   The rural village of Luddenham is located within this zone and the precinct is bisected by a ridgeline that forms the Wianamatta-South Creek catchment boundary. The ridge provides long distance views towards the Blue Mountains to the north, and west. Waterways follow steep and highly modified valleys that form Duncans and Mulgoa Creeks.

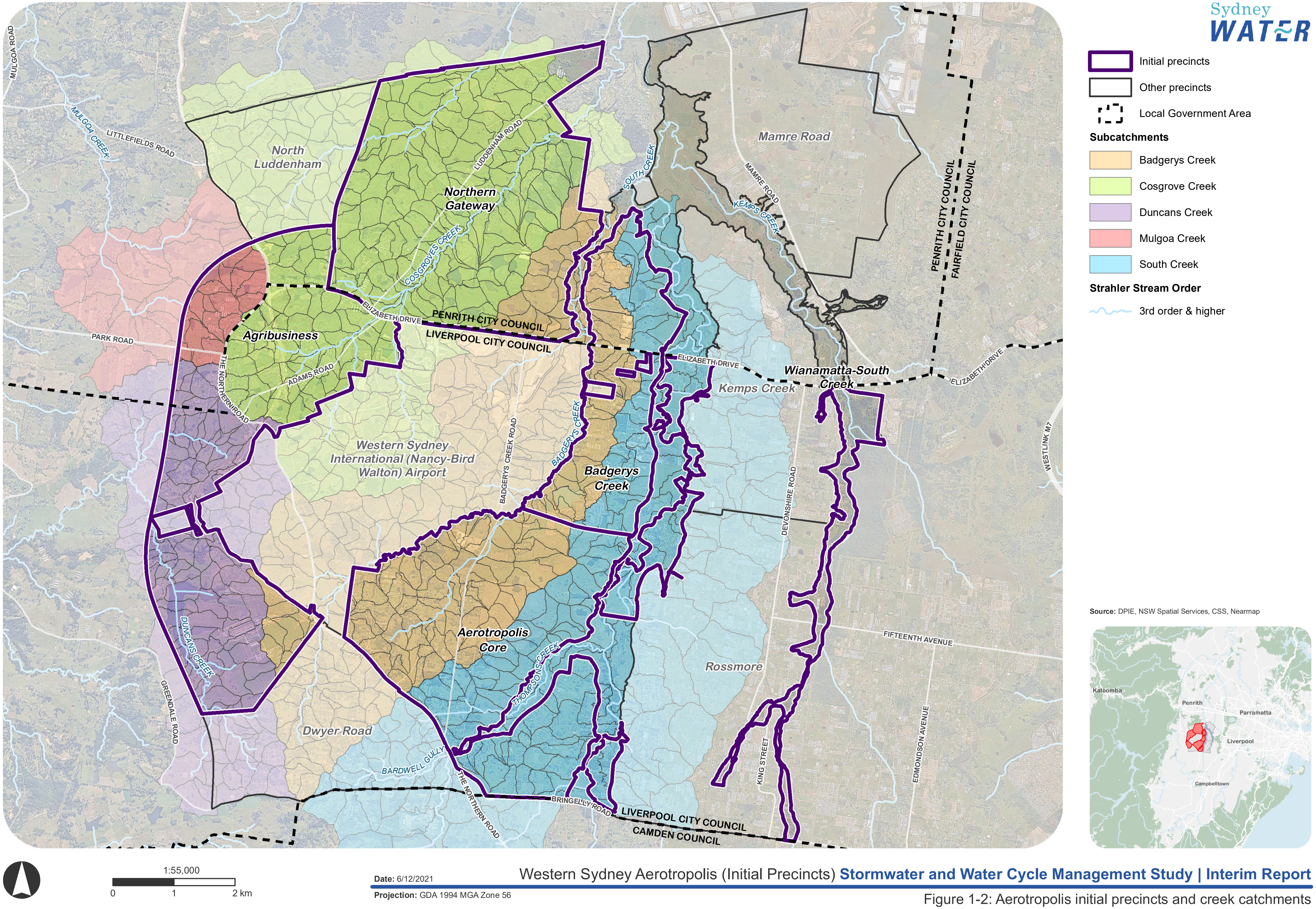
   Duncans Creek follows the western boundary of this precinct and there are significant areas of existing vegetation and existing dams associated with this corridor. Key vegetation types include Forest Red Gum and Grey Box woodland. The south western extent of the precinct is dominated by a large on-line agricultural storage known as Lake Duncan.

2. **Aerotropolis Core**: Badgerys Creek follows the northern boundary of this precinct and Thompsons Creek and Wianamatta-South Creek form the southern boundary. The precinct is largely low-lying with higher terrain located along the western boundary. The area is dominated by well vegetated small agricultural plots with frequent farm buildings and road infrastructure. Significant Cumberland Plain vegetation is found towards the west of the zone and includes primarily Grey Box woodland.

3. **Northern Gateway**: This precinct features prominent ridge lines and a range of steep and flat sloping rural lands comprising large agricultural lots as well as the Sydney Science Park development. The Cosgroves Creek corridor dissects the precinct from south-west to north-east and a second un-named creek runs along the northern boundary of the precinct and contains a number of small existing farm dams.

   The highest terrain is in the south-western corner of the precinct and a large segment of this precinct is also designed as ‘Environmentally Sensitive Land’ and follows the Cosgroves Creek corridor and the southern boundary of the precinct. Existing blocks of Cumberland Plain vegetation are scattered across the area and consist primarily of Broad-leaved Iron Bark and Grey Box woodland.

4. **Badgerys Creek**: This precinct is a low-lying area between the well-vegetated Wianamatta-South Creek and Badgery's Creek corridors. The land use consists of small agricultural plots with frequent farm buildings and road infrastructure. A strip of 'Environmentally Sensitive Land' runs through the centre of this zone and significant Cumberland Plain vegetation is focussed along the creek corridors.
5. **Wianamatta-South Creek**: This precinct is defined by the 1% AEP floodplain extents and follows the riparian corridors of Wianamatta-South Creek and Kemps Creek. The precinct features gentle grades to the north. The precinct is dominated by significant areas of Forest Red Gum woodlands, remnant native grasslands and rural pastural lands. The plots of woodland become smaller and more sparsely located as the two creeks join in the north of the precinct. The vegetated corridors are generally bordered by agricultural plots and infrastructure towards the edges of the precinct. The precinct also features significant waterbodies formed by agricultural storages on South and Kemps Creek.

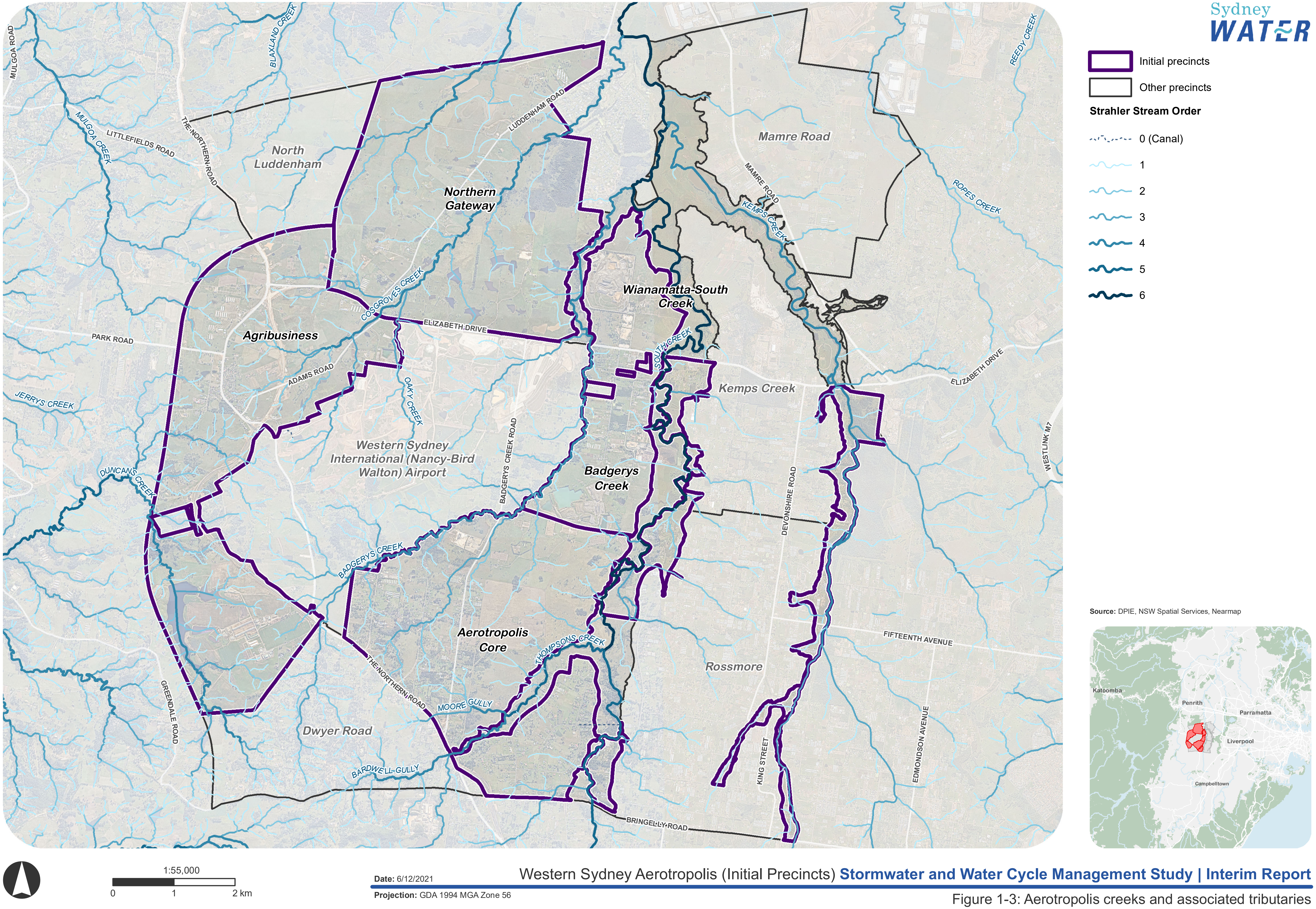


Date: 6/12/2021

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 1-2: Aerotropolis initial precincts and creek catchments



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Projection: GDA 1994 MGA Zone 56

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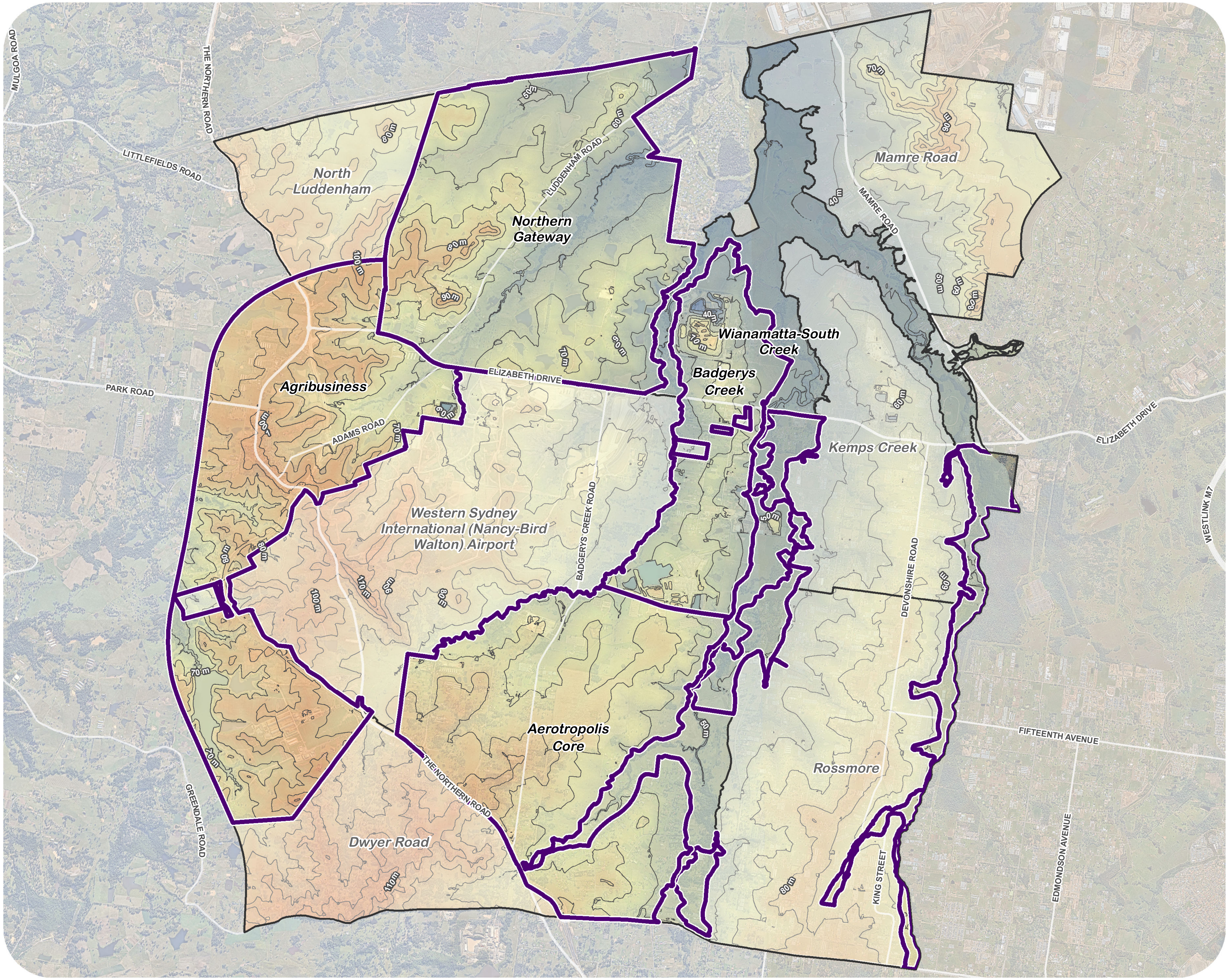
Figure 1-3: Aerotropolis creeks and associated tributaries



Sydney WATER

Initial precincts

Other precincts

Contour (m)

Elevation (mAHD)

150

20

Source: DPIE, NSW Spatial Services, Nearmap

1:55,000

0 1 2 km

Date: 6/12/2021

Projection: GDA 1994 MGA Zone 56

Figure 1-4: Aerotropolis terrain

1.4 NSW Government waterway health objectives

The Greater Sydney Commission's vision for Wianamatta-South Creek (and its tributaries) is to become a central, cool green corridor through the Western Parkland City, and be the core element of liveability and amenity for existing and future residents. This vision relies on retaining water in the landscape by encouraging green spaces with tree canopy, integrating waterways into the design of the city and residential neighbourhoods, and keeping waterways healthy so they can support the essential drainage, potential future recreation and environmental functions expected of a cool green corridor.

1.4.1 Protecting and Restoring Wianamatta-South Creek

Currently, the Wianamatta-South Creek catchment is the most degraded catchment in the Hawkesbury-Nepean River system due to historical vegetation clearing and urbanisation, but it retains regionally significant remnant terrestrial and aquatic biodiversity. Increased urbanisation will further degrade the waterways if stormwater, wastewater and flooding regimes are not managed upfront through an integrated ecosystem approach. This approach requires the waterways and hydrological cycle to be central considerations in both land use and water infrastructure planning.

To help deliver the vision, the NSW Government has developed performance criteria relevant to:

i. the protection, maintenance and/or restoration of waterways, riparian corridors, water bodies and other water dependent ecosystems that make up the 'blue' components of the Blue-Green Infrastructure Framework

ii. a landscape-led approach to integrated stormwater management and water sensitive urban design.

The performance criteria (Table 1-1, Table 1-2) are referred to as water quality and flow objectives and apply to all urban developments on land in the precinct. Compliance towards achieving the performance criteria must follow the protocol outlined in the *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions* (OEH/EPA, 2017).

Table 1-1 Ambient water quality of waterways and waterbodies in the Western Sydney Aerotropolis (DPIE, 2022b)

Water quality objectives	
*Total Nitrogen (TN, mg/L)	1.72
Dissolved Inorganic Nitrogen (DIN, mg/L)	0.74
Ammonia (NH_3-N, mg/L)	0.08
Oxidised Nitrogen (NOx, mg/L)	0.66
*Total Phosphorus (TP, mg/L)	0.14
Dissolved Inorganic Phosphorus (DIP, mg/L)	0.04
Turbidity (NTU)	50
Total Suspended Solids (TSS, mg/L)	37
Conductivity (µS/cm)	1103
pH	6.20–7.60
Dissolved Oxygen (DO, %SAT)	43–75
Dissolved Oxygen (DO, mg/L)	8

***** when showing compliance towards TN and TP through industry models, the DIN and DIP performance criteria should be instead to recognise that stormwater discharges of nutrients are mostly in dissolved form.

Table 1-2 Stream flows objectives for waterways and water-dependent ecosystems, based on averaged daily flow rates (DPIE, 2022b)

Flow objectives	Current condition	Tipping point for degradation
To be applied in Strahler ranked waterways as follows:	1^{st}-2^{nd} order streams	3^{rd} order streams or greater
Median daily flow volume (L/ha)	71.8 ± 22.0	1095.0 ± 157.3
Mean daily flow volume (L/ha) Mean annual run-off volume (ML/Ha/yr)	2351.1 ± 604.6 (0.9 ML/Ha/yr)	5542.2 ± 320.9 (2.0 ML/Ha/yr)
High spell (L/ha) ≥ 90^{th} percentile daily flow volume	2048.4 ± 739.2	10,091.7 ± 769.7
High spell - frequency (number/y) High spell - average duration (days/y)	6.9 ± 0.4 6.1 ± 0.4	19.2 ± 1.0 2.2 ± 0.2
Freshes (L/ha) ≥ 75^{th} and ≤ 90^{th} percentile daily flow volume	327.1 to 2048.4	2642.9 to 10091.7
Freshes - frequency (number/y) Freshes - average duration (days/y)	4.0 ± 0.9 38.2 ± 5.8	24.6 ± 0.7 2.5 ± 0.1
Cease to flow (proportion of time/y)	0.34 ± 0.04	0.03 ± 0.007
Cease to flow – duration (days/y)	36.8 ± 6	6 ± 1.1

The performance criteria are responsive to the protection and improvement of the condition of high ecological value waterways and water-dependent ecosystems in the Western Sydney Aerotropolis. These ecosystems include some existing native vegetation (ie groundwater dependent vegetation) that are protected under the *Biodiversity Conservation Act 2016* and *Environment Protection and Biodiversity Conservation Act 1999*, and some identified as environmentally sensitive waterways and riparian in existing Local Environment Plans. These ecosystems are mostly located in the floodplain, and are home to many threatened, critically endangered and high ecological value species of fauna and flora, including those considered iconic to the area (bass, bats and a range of birds) or are totems for the local Aboriginal communities (eg water dragons).

DPIE EES is developing background reports and a set of implementation guidelines to ensure flow and water quality objectives are met through required stormwater infrastructure. This will include specific stormwater targets that each development will need to comply with.

1.5 Study objectives

The aim of the *Stormwater and Water Cycle Management Study* (the study) is to develop a total integrated water masterplan for the four initial precincts, as part of, and in conjunction with, the precinct planning process to:

- provide the stormwater drainage strategy for the precincts, consistent with a major and minor drainage approach
- develop feasible strategies for detaining and treating post-development stormwater run-off that meets required quality and quantity criteria for the catchment
- identify and size elements of a stormwater treatment train to meet the waterway health objectives identified by DPIE EES, for the precincts
- identify stormwater re-use options and investigate the potential for a regional stormwater and wastewater reuse strategy(ies)
- determine maintenance requirements and arrangements for stormwater management assets
- ensure high value riparian corridors are retained and integrated into the precincts.

The study has been prepared to inform and support the rezoning of the Aerotropolis initial precincts. It also informed the Precinct Plan, identifying the space required to deliver the necessary stormwater infrastructure. Controls prescribed by this study will inform the Aerotropolis Phase 2 Development Control Plan (DCP) and ensure that:

- essential water servicing is provided in a timely manner
- the Western Parkland City vision can be achieved through an integrated approach to water services
- resilience (water and climate) is considered in development of integrated water approach
- stormwater detention approaches are effective across the study area
- water sensitive urban design approaches achieve waterway health targets in a flexible and cost-effective way
- sufficient land is allocated for stormwater management on private lots and in the public domain
- trunk drainage is designed in a way that protects property, improves biodiversity and is integrated into the public domain
- sustainable funding for ongoing stormwater management is coordinated across catchments.

1.5.1 Integrated water servicing strategy

Integrated water servicing approaches linking the supply of drinking water, stormwater and recycled water with wastewater services have been developed.

The ultimate water demands for the precincts have been compiled for residential and non-residential uses, irrigation, and urban cooling. These demands have been used to inform the planning, sizing and staging of water servicing infrastructure in the Aerotropolis.

The non-drinking, irrigation and urban cooling demands have been used to inform the size of stormwater harvesting elements and contribute to stormwater volume reductions.

A water balance approach identifies the practicalities of stormwater harvesting and recycled water use in the Aerotropolis and the infrastructure requirements for the initial precincts and is documented in detail later in this report. The integrated servicing approaches are based on scenarios from Sydney Water's *Re-imagining water in Western Sydney Regional Master Plan*. In this plan, the water servicing pathway delivering the greatest economic value at least cost for realising the Western Parkland City vision was the 'Water Cycle City'. The final preferred servicing pathway reflects the 'Water Cycle City' with additional elements of water sensitive urban design such as integrated stormwater management to better reflect a 'Water Sensitive City' scenario..

1.5.2 Riparian corridor management strategy

Accessible waterways across the initial precincts have been 'ground-truthed' to determine the presence and extent of riparian lands and identify those that are to be retained. A Riparian Corridor Assessment (Sydney Water 2022) has been developed for the precincts that recommends the retention of waterways based on field investigations for endorsement by key stakeholders including the NSW Natural Resources Access Regulator. This work also:

- identifies areas of key aquatic habitat
- recommends farm dams to be retained based on high ecological value
- recommends a riparian revegetation strategy.

1.5.3 Stormwater management for waterway health

This planning recognises the cultural, ecological and recreational values of waterways and contemplates how waterway management can work towards preserving those values. The Wianamatta-South Creek waterway health objectives developed by DPIE EES have informed this study for the purpose of earmarking land and funding that may be necessary to deliver the waterway outcomes.

The waterway health objectives and targets were finalised through a consultation process outlined in the NSW Government's *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions* (risk-based framework) Importantly, these objectives are based on data collected from the local waterways and work towards managing waterway health within the Wianamatta-South Creek by capping the volume of erosive stormwater flows discharged from new development and setting water quality requirements.

We acknowledge that work is still being done across various government departments and agencies to establish the best way to deliver and manage stormwater infrastructure (including riparian corridors, wetlands, basins and street trees) in the Aerotropolis. This work will also consider governance and funding structures.

1.5.4 Drainage and stormwater quantity management for precinct-scale storm events

Hydrological modelling of the existing catchments and proposed developments has been used to inform the drainage strategy for managing stormwater at a precinct scale, which includes:

- scenarios modelling the proposed developments, which have shown that the stormwater can be managed using a combination of on-site stormwater detention (OSD) on private lots (where necessary)
- pit and pipe networks within streets to convey minor drainage
- overland flow paths in streets for smaller catchments up to 15 Ha
- trunk drainage channels for catchments exceeding 15 Ha
- local stormwater detention basins adjacent to the floodplain (where necessary).

The strategy works by retaining flow from proposed developments and thereby ensuring that peak flows discharged into waterways are consistent with the existing conditions in 50% AEP event and in a 1% AEP event where necessary.

This strategy requires consistency with the Flood Risk and Impact Assessment which has a stronger focus on flood risks at a regional Wianamatta-South Creek scale.

The stormwater quantity management strategy discussed in this report is at a precinct-scale and is focussed on more frequent events (eg 50% AEP) that play a major role in stream morphology (as discussed above in the stormwater management for waterway health objectives).

It is important to note that the Flood Risk and Impact Assessment may consider the impacts of development on overall timings of flows from contributing tributaries of Wianamatta-South Creek. This work and the subsequent strategy derived from this work and/or input from local councils may result in changes to the precinct-scale stormwater quantity management strategy.

2 Land use and planning

2.1 Aerotropolis planning

The strategic planning framework for the Aerotropolis consists of:

- *Western Sydney Aerotropolis Plan* (WSAP) - establishes the strategic vision for the Aerotropolis including principles for future growth and development
- *Aerotropolis SEPP* – establishes a statutory planning framework for the Aerotropolis including identifying precincts for release, rezoning of land and high-level planning provisions and controls
- *Western Sydney Aerotropolis Plan* (WSAP) - establishes the strategic vision for the Aerotropolis including principles for future growth and development
- Aerotropolis Initial Precinct Plan

Phase 2 Stage 1 Development Control Plan (DCP) providing detailed controls to guide development proposals.This study forms of the technical inputs to the Aerotropolis planning framework and informs the Precinct plan and DCP. It also fulfils the requirements of Section 40 (3) of the Aerotropolis SEPP which states that the precinct plan for each precinct must contain 'proposals for total water cycle management of the precinct.'

2.1.1 Zoning and land use

The precincts subject of this study are zoned under the Aerotropolis SEPP into a mix of five bespoke land use zones:

1. Enterprise
2. Agribusiness
3. Environment and Recreation
4. Mixed-use
5. SP2 Infrastructure.

The land use zones are generally described as follows:

1. **Enterprise:** Aims to support the growth and establishment of business and employment related uses that supplement or complement the functions of the city core and the Western Sydney International (Nancy-Bird Walton) Airport (Airport) as a 24-hour transport hub. This zone encourages a range of commercial sectors that benefit from proximity to airport operations and services such as professional services, high technology, aviation, logistics, food production and processing, health, education and creative industries. Residential development is not permitted in this zone.
2. **Agribusiness:** Aims to establish a hub of agribusiness activities, leveraging from opportunities presented by the new Airport and Aerotropolis commercial centre. The zone is to encourage diversity in agribusiness, including related supply chain industries and food production and processing as well as agritourism. The existing Luddenham Village lies at the heart of the Agribusiness zone and is set to become a destination for local, regional and national visitors and tourists to the area.
3. **Environment and recreation:** This zone typically applies to waterways and riparian lands, areas of high environmental value or land affected by other constraints to development. The zone aims to protect, preserve and restore the ecological values of these lands and encourage appropriate recreational use of certain lands, by establishing linear parklands along the important ephemeral creeks within the precincts. Other public open spaces and parklands within urban lands and on ridgelines may also be zoned Environment and Recreation, contributing to the broader Parkland City vision. Importantly, much of the land associated with Wianamatta-South Creek and its tributaries will be zoned 'Environment and recreation'.

4. **Mixed-use**: A flexible, mixed use zone seeking to support the establishment and growth of the core centres of activity in the Aerotropolis including the Aerotropolis Core and Science Park centres. This zone allows for the broadest range of land uses, including employment and residential uses where airport operations and safety considerations are satisfied. The zone aims to encourage a mix of compatible land uses with a focus on business, retail and entertainment. The 'Mixed-use' zones are intended to encompass the highest density of development in the precincts and seek to create high-amenity urban centres serviced by high frequency public transport.
5. **Infrastructure:** This zone will be applied to new and existing road and rail corridors, transport facilities, and some land required for utilities throughout the Aerotropolis. It seeks to protect land required for infrastructure and prevent development which could detract from the delivery of necessary infrastructure.

In In addition to the zones above, overlay maps are also used to identify other considerations such as environmentally sensitive land as well as land required for stormwater infrastructure.

The Aerotropolis Precinct plan has been developed for each of the initial precincts showing the spatial distribution of land use zones, built form and density, as well as transport, water and green infrastructure. The initial precincts account for about 60% of the total Aerotropolis and development of these precincts will take place in a staged manner over a long period of time.

The Precinct plan and associated documents seek to align the sequencing of development with the provision of the necessary infrastructure to support growth to ensure orderly and efficient development and the creation of balanced, sustainable and liveable communities.

The study responds to the detailed planning presented in the Precinct Plan in terms of the likely demands and uses of water as development progresses and the potential pressures and impacts on waterways in the precincts.

Table 2-1 shows the breakdown of land use across the initial precincts as prescribed under the Aerotropolis SEPP and highlights the predominance of employment-related land uses. The Wianamatta-South Creek precinct accounts for most of the land that is constrained to development across the initial precinct areas.

Table 2-1 Breakdown of land use zones in each of the precincts (Ha) based on original data from the PPO (subject to change)

Precinct	Total area (Approx. ha)	Land-use zone					
		Enterprise zone (%) - industrial and commercial	Mixed-use (%) - integrate commercial and residential	Environment and rec (%)	Low / med density residential (%)	Agribusiness (%)	Infrastructure / transport corridors as per GSC GIS
Aerotropolis Core	1,382	54%	36%	0%	0%	0%	10%
Agribusiness	1,560	2%	0%	10%	0%	75%	14%
Badgerys Creek	634	86%	0%	5%	0%	0%	9%
Northern Gateway	1,616	43%	11%	17%	0%	0%	28%
Wianamatta-South Creek	1,330	0%	0%	95%	0%	0%	5%
Precinct	**Total area (Approx. ha)**	**Enterprise zone (Ha)**	**Mixed-use (Ha)**	**Environment and rec (Ha)**	**Low / med density residential (Ha)**	**Agribusiness (Ha)**	**Infrastructure / transport corridors as per GSC GIS**
Aerotropolis Core	1,382	746	498	0	0	0	138
Agribusiness	1,560	47	0	157	0	1164	204
Badgerys Creek	634	526	0	31	0	0	55
Northern Gateway	1,616	695	178	291	0	0	452
Wianamatta-South Creek	1,330	0	0	1322	0	0	70
Total area	6,522	2,015	675	1,801	0	1,164	920
Percentage of the precincts		31%	10%	27%	0%	18%	14%

2.1.2 The Precinct plan

The Aerotropolis Precinct plan provides an additional layer of detail in the form of structure planning for each precinct which identifies:

- spatial distribution of land use and built form (including maximum building height and floor space ratios)
- yield and density framework including projected dwellings, population and jobs for each precinct
- transport networks and nodes
- centres location and hierarchy
- environmental protection including biodiversity and waterway health
- aviation safety considerations such as wildlife attraction.

The Precinct plan, prepared by WS PPO for the Aerotropolis, establishes a Land Use and Built Form Framework informed by the land use zones established under the Aerotropolis SEPP. The framework adopts a 'landscape-led' approach which considers the 'typology' of the street and block form, the subdivision pattern and the types of open space distributed within the urban environment.

Typologies describe how different types of development can be designed in their landscape context to best achieve a variety of planning objectives including environmental, utility infrastructure, liveability and sustainability.

The typologies documented in the Aerotropolis Precinct plan excludes:

- 1% AEP flood-affected land
- regional open space and playing fields
- major infrastructure such as motorways and regional roads
- riparian areas
- areas of high biodiversity value identified for conservation.

The typologies identified for the initial Aerotropolis precincts are:

- Major centre: Mixed-use, including commercial, retail, community, cultural, tourism and high-density residential development
- Minor centre: non-residential/mixed-use allowing for some commercial, local employment, local services, medium density residential development (within mixed-use development only)
- Employment: – business and light industrial including lower density business uses with or without associated warehousing, production, smaller scale warehousing and ancillary uses
- Employment: – large footprint industrial including logistics, large scale warehouses and manufacturing.

2.2 Urban form assumptions

Urban form is an important factor in urban water demand and stormwater run-off volumes. The design and development of urban form is a critical component of contemporary water sensitive urban design and plays a significant role in integrated water management in new greenfield urban areas. The study considers the impact of urban form within the Aerotropolis precincts on integrated water management (including waterway health) and applies assumptions which reflect WSPP precinct planning to design an integrated water management strategy which optimises outcomes for water management, the environment and liveability. Key assumptions related to urban form adopted in the study are discussed below.

2.2.1 Imperviousness

Precinct planning for the Aerotropolis adopts a set range of imperviousness assumptions that inform the volumes of stormwater runoff volumes and rates generated from new development.

The Government vision for the initial precincts promotes a reduction in the extent of impervious surfaces within urban development to assist with stormwater management and provide for more landscaped areas and space for trees in the private and public domain in line with the Greater Sydney Commission's vision for the Western Parkland City and the NSW Government's tree canopy targets.

For the purpose of consistency between the stormwater modelling and the Flood Risk and Impact Assessment, Table 2-2 provides a summary of assumptions for imperviousness which were provided by the WSPP and adopted for planning purposes. The table provides assumptions for a business as usual (BAU) development scenario which reflects typical greenfield urban development in Western Sydney and for a contemporary 'Western Parkland City' scenario which aims to deliver on the Western Parkland City vision. This highlights the step change required in the design of urban form in the Aerotropolis which may drive more compact development formats, incorporating greater levels of open space for recreation and urban cooling.

Table 2-2 Imperviousness values – BAU vs those adopted for Precinct planning purposes

Impervious values (%) Post development land use zone	Typical values	New standards for waterway health
Enterprise zone – industrial and commercial (large format)	80%	65%
Mixed-use - integrated commercial and residential (high density)	85%	67%
Environment and recreation	15%	10%
SP2 - Transport corridors	85%	75%
Agribusiness	-	78%

2.2.2 Typologies

The urban typologies adopted in the Aerotropolis Precinct plan have been used to inform water balance modelling and stormwater planning in this study.

Typologies provide the opportunity to demonstrate how urban form and stormwater infrastructure can come together at a block, street and precinct scale to achieve urban design and water management objectives.

The Precinct plan defines the likely distribution of urban typologies within each land use zone which has been used to inform where the potential stormwater harvesting end uses and WSUD approaches can be deployed for each precinct. This provides the basis of water demand and wastewater load forecasts across the precincts. The precincts plans show that:

- employment typologies (including both smaller scale business and light industrial and large format warehousing) account for most of the land use in the initial precincts, having a dominant role in both the Enterprise and Agribusiness land use zones.

- business park and commercial typologies will account for a relatively small of the land in the initial precincts (5%).
- an equal mix of high density and medium density residential typologies are planned within Major and Minor Centres within Mixed-use zones in the Northern Gateway and Aerotropolis Core but overall, make up a relatively small proportion of land use in the Aerotropolis.

Land excluded from the defined ‘typologies’ includes ridge top parks and public open space associated with the floodplains which encompasses the entirety of the Wianamatta-South Creek precinct. These will include regionally significant vegetation, riparian corridors, farm dams, regional parks, and a mix of active and passive open space and will play an important role in water management and waterway health for all precincts.

Transport corridors reserved for the M12 and M9 are also excluded from developable land and account for a large (15%) proportion of the precincts. It is expected that the transport corridor footprints identified in the Precinct plan for will be reduced once the infrastructure is delivered and operational. Land outside of the final active corridors may support ancillary uses and/or buffer areas with surplus land being returned to other productive uses.

Table 2-3 outlines the likely split of urban typologies within each land use zone providing a representation of the scale, density and key characteristics of the development likely to occur in the Aerotropolis precincts. These splits may change as a result of post-exhibition amendments to the Precinct plan.

Table 2-3 Adopted ratio of typologies comprising each land use zone

Typology	Agribusiness	Enterprise	Mixed-use	Environment and recreation
Minor Centre - Medium density residential	-	-	25%	-
Major Centre - High density residential	-	-	25%	-
Employment - Strata business/industrial	-	50%		-
Employment - Large format industrial	80%	50%		-
Employment - Commercial (business park)	-	-	50%	-
Environment and recreation	20	-	-	100%

Table 2-3 presents the area of each typology within the initial precicnts. This data is important for sizing and costing stormwater infrastructure.

It shows that the dominant urban typology to be industrial land with very littler commercial and residential lands.

Table 2-4 Area and adopted ratio of typologies in initial precincts

Typology and land use*	Total area (Ha)	% of initial precincts
Minor Centres - Medium density residential	108	2%
Major Centres - High density residential	108	2%
Employment – Strata industrial and business park	1,155	22%
Employment - Large form industrial	2,479	48%
Employment - Commercial	216	4%
Environment and recreation	769	15%**
Infrastructure	347	7%

* Includes Wianamatta-South Creek precinct

** Adopted for stormwater planning

2.2.3 Imperviousness and stormwater run-off

Each typology can be characterised by its imperviousness and ratio of different development surfaces and the associated ability of those surfaces to infiltrate water. Table 2-5 outlines the adopted assumptions for the ratios of different development surface types within different land uses reflecting the overall imperviousness rates for different typologies.

Capping the imperviousness of new development will be important in achieving the Governments stream flow objects within tributaries of Wianamatta-South Creek. Imperviousness rates were agreed with the PPO in the early stages of the project. These have been adopted as ideal rates and the following imperviousness rates have been used to guide stormwater infrastructure planning.

Table 2-5 Adopted surface cover splits for Western Parkland City typologies

	Adopted surface cover split for modelling (%)					
Land use type	Roof	Pavements and driveways	Asphalt and footpaths	Landscaped area	Road verges	Public open space, riparian coridors
Medium density residential	30%	10%	20%	14%	11%	15%
High density residential	21%	15%	30%	11%	8%	15%
Strata industrial and business park	20%	33%	7%	24%	1%	15%
Large form industrial	34%	29%	7%	14%	1%	15%
Commercial town centre	30%	30%	7%	10%	8%	15%

* % as remnant vegetation and riparian corridor TBC.

Table 2-6 Adopted imperviousness for Aerotropolis typologies

Land use zone	Adopted imperviousness (%)	
	Including open space	Excluding open space
Medium density residential mixed-use centre	68%	71%
High density residential mixed-use centre	70%	78%
Commercial town centre	78%	84%
Employment – strata industrial and business park	68%	71%
Employment – large format industrial	78%	82%

Figure 2-1 presents mean annual run-off volumes (MARV) from new urban development adopting a mean annual rainfall depth of 691 mm/yr based on DPIE (2022e) preferred continuous modelling time series and the impervious values presented in Table 2-6. The figure illustrates that run-off rates from urban development under the current, business as usual (BAU) urban typologies is significantly higher than the interim MARV stormwater target for waterways. Notably, the figure also shows significant increases in stormwater run-off volumes post-development, which presents both a challenge and an opportunity, driving the need for a new approach to stormwater management through effective integration with broader water cycle management and land use planning processes. Emerging evidence from the Wianamatta-South Creek catchment shows a strongly negative correlation between stormwater run-off volumes and waterway health, in a non-linear relationship with a clear threshold or tipping point.

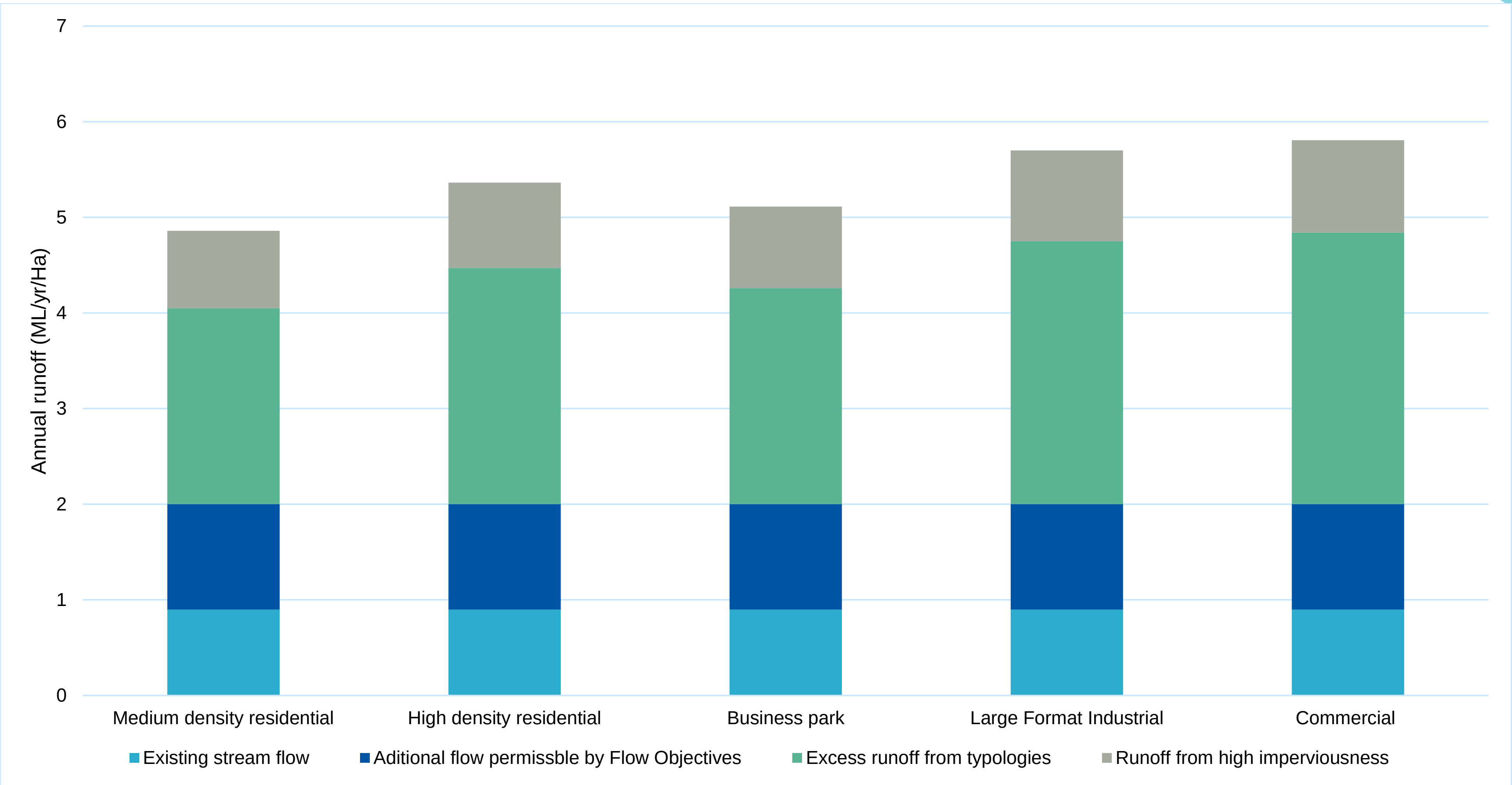


Figure 2-1 Notional stormwater discharge rates from each typology compared to waterway mean annual run-off volume (MARV) objectives

By adopting Western Parkland City typologies stormwater volumes will be reduced; however the stormwater run-off volumes from the adopted Western Parkland City typologies must be reduced to contribute to waterway health objectives which is discussed further in Chapter 6.

Table 2-7 and Figure 2-2 provide the contribution of run-off from each typology and land use to illustrate the scale of the stormwater contributions from each typology by factoring the contribution of each land use zoning.

Table 2-7 Scale of stormwater run-off contributions from different typologies and land use zones

Total areas in initial precincts	Medium density residential	High density residential	strata industrial and business park	Large Format Industrial	Commercial	Environment and recreation	Transport corridors	Total
Footprint of lots and roads excluding public open space (Ha)	108	108	1155	2479	216	769	347	5183
Pre-development stream flow (ML/yr)	97	97	1039	2231	195	692	313	4665
Post development stream flow objective (ML/yr)	216	216	2310	4958	433	1538	695	10366
Total run-off from precincts as Western Parkland City development typologies (ML/yr)	**438**	**484**	**4919**	**11775**	**1047**	**692**	**1407**	**20763**
Total run-off from precincts as Western Parkland City development typologies (ML/yr)	**526**	**580**	**5903**	**14130**	**1257**	**830**	**1689**	**24915**

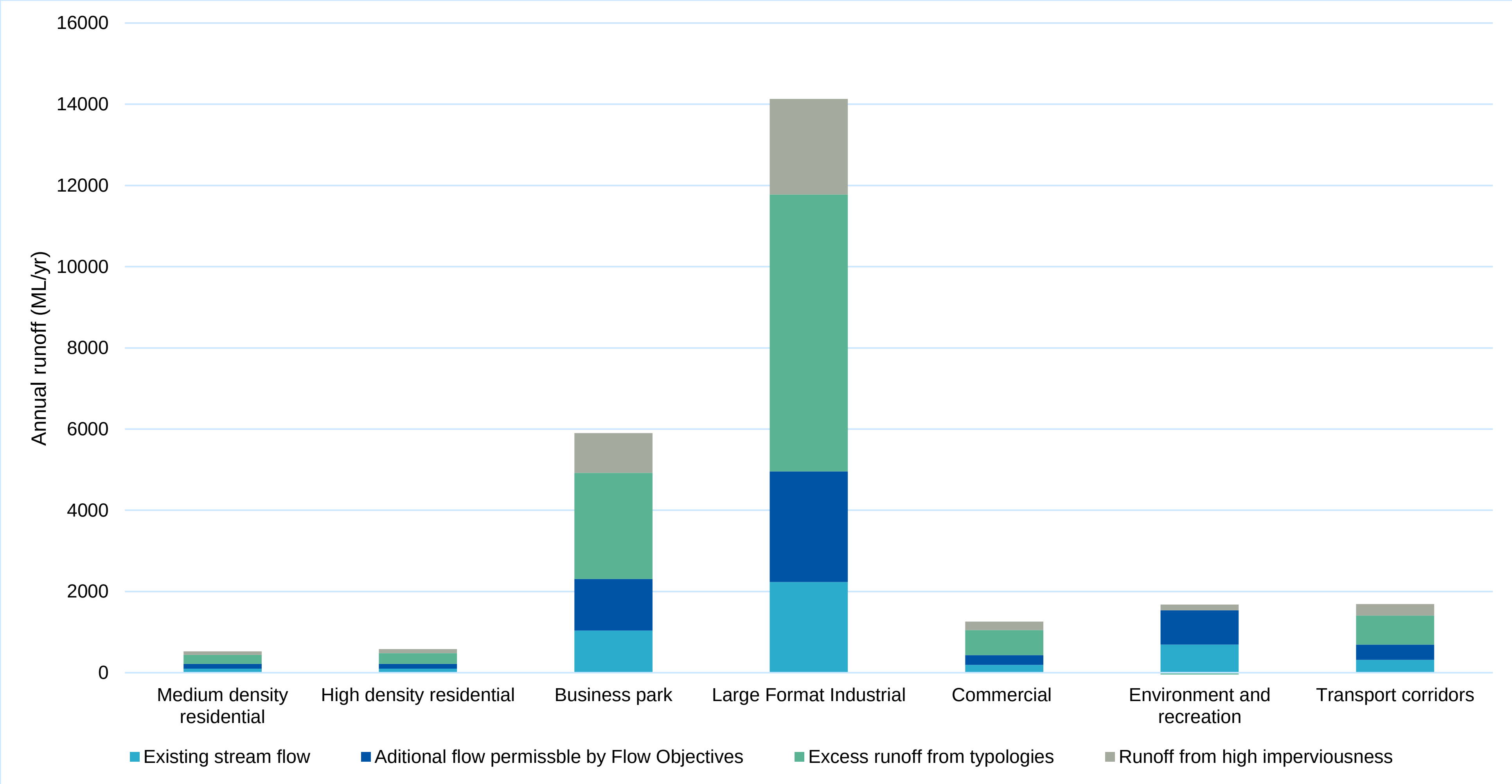


Figure 2-2 Relative contribution of stormwater run-off from land uses within the initial precincts (excludes Wianamatta-South Creek precinct)

This analysis shows the magnitude and relative change in stormwater volumes generated by new development and how that change can be limited by adopting less impervious surfaces in typologies and land uses. The scale of the stormwater volume reductions required to achieve the waterway health objectives for waterways is significant and it is shown in Chapter 6 that this cannot be achieved by conventional stormwater filtration approaches alone. While it may be possible to divert excess stormwater volumes around first and second order waterways, there is a limit to the feasibility of this on major streams such as Wianamatta-South Creek. Approaches to increase the capture, re-use, evaporation and evapotranspiration of stormwater volumes must be utilised at a range of scales to achieve the interim stormwater volume reductions.

2.3 Overview of potential water demands

Potential water demands below provide opportunities for reducing stormwater and wastewater volumes discharged to waterways. More detail on integrated water cycle management strategies is provided in Chapter 5.

The relatively low residential population associated with development means a lower baseline water demand, however there may be higher water users moving into the precincts such as industrial scale agriculture. A build-up of potential daily and annual water demands is provided below to show the potential for end water uses within the precincts to reduce the volumes of stormwater and wastewater generated within the initial precincts.

Actual water demands will potentially vary, based on the urban planning outcomes and provision of open spaces. A hierarchy of water irrigation rates that manage the salinity risk of the soils and hydrogeologic landscapes will also factor into the final water balance.

A detailed assessment of integrated water cycle management is provided in Chapter 5.

Table 2-8 Notional water demands for stormwater reuse and recycled water

Land use zone	Occupancy (EP/Ha and jobs/Ha)	Potential non potable water demands		
		Internal uses (kL/d/Ha)	Gardens and landscaping (ML/Ha/yr)*	Public open space (ML/Ha/yr)*
Medium density residential	87.5	4.2	2.5	3.2
High density residential	175	8.3	2.5	3.2
Strata industrial	107	3.23	2.5	3.2
Large form industrial	44	3.23	2.5	3.2
Commercial and business park	113 to 235	3.23	2.5	3.2
Environment and recreation	0	0	0 for native vegetation 3.2 passive open space 4.5 for active open space	
Transport corridors	0	0	0	0

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3 Key issues

The following chapter provides an overview of the planning and environmental context within which the *Stormwater and water cycle management study* has been developed, highlighting key issues which were central to shaping the integrated water management strategy.

3.1 Waterway health

The NSW Government is developing waterway health management objectives, using the *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions*. These objectives will provide appropriate water quality and flow measures to achieve the vision and community environmental values and uses for waterways within the Aerotropolis and downstream catchment.

New stormwater objectives will cap mean annual run-off volumes and low flow rates to match existing low flow characteristics. Targets will be differentiated based on category of stream order. These will be different to the Stream Erosion Index, but will address the impacts of frequent flow events on channel form, geomorphology and ecological processes that are commonplace within the existing urban areas of the lower Wianamatta-South Creek catchment. Interim waterway health objectives have been reflected in the initial Pprecinct plans and finalised objectives will be embedded into the final precinct plans to ensure statutory compliance. Precinct specific waterway health targets will also be incorporated into the Phase 2 DCP, along with performance outcomes and benchmark solutions.

3.2 Stormwater detention management

Stormwater detention is an accepted method to control peak flowrates in urban development and its principles are adopted in peak flow management by Penrith and Liverpool Councils. This strategy follows these principles and forms a key component of the broader water cycle management strategy for the Aerotropolis.

The strategy has been based on the catchments within the Aerotropolis and it is acknowledged that refinement of this strategy is beyond the scope given to this study. The performance outcomes may possibly be improved based on Wianamatta-South Creek catchment wide modelling and a coordinated approach to managing floods. This approach has the potential to reduce the cost of stormwater infrastructure delivery and number of stormwater assets under management in the private and public domain.

Appropriate flow management objectives and stormwater detention targets will inform the size, function and distribution of on-site stormwater detention and stormwater flow management basins across the Aerotropolis and is therefore a key reference for the Stormwater and Water Cycle Management Study.

3.3 Riparian corridors

Freshwater waterways are important features of Western Sydney, and riparian areas are the interface between land-based and waterway ecosystems. NSW Office of Water (now DPIE) defines a riparian corridor as ‘a transition zone between the land, also known as the terrestrial environment, and the river or watercourse or aquatic environment’.

Riparian corridors provide a variety of functions within urban landscapes. They play a major role in bank stabilisation, reducing erosion scour and sedimentation problems within rivers and creeks. Vegetated areas along the creek lines function as ‘buffer zones’ to surrounding land and help filter nutrients, pollutants and sediments before they reach the creek itself and degrade the quality of water flowing throughout the Aerotropolis.

A riparian corridor strategy has been completed that includes top of bank mapping and the designation of vegetated riparian zones that informs setbacks for development and stormwater assets.

3.4 Salinity

Salinity within the Aerotropolis has been exacerbated where groundwater has mobilised naturally occurring salts and caused concentration of salt at the ground surface. Such movements are caused by changes in the natural water cycle. In these areas, activities, infrastructure and resources on and above the soil surface may be affected. In urban areas, the processes which cause salinity are intensified by the increased volumes of water added to the natural system in urban areas.

The *Stormwater and water cycle management study* proposes careful management of irrigation and infiltration to ensure no significant increase in groundwater recharge or mobilisation of salts. This is a significant constraint to balance against the objective of a green and cool Western Parkland City.

Consultation with DPIE EES on salt risks has identified the need for appropriate shallow groundwater management according to the Hydrologic Landscapes Mapping. This includes using vegetation and trees as a mitigation measure against the generation of shallow groundwater flows that would increase the salt budget to the downstream waterways. This mitigation is to be implemented as biofiltration street trees and riparian corridor plantings.

Controls are required to prevent excessive additional water in the from the irrigation of gardens, lawns and parks, and concentrated infiltration of stormwater from adding to existing salinity issues. These issues are best addressed at a precinct scale, with integrated water cycle management provisions being included in the Phase 2 DCP for the Aerotropolis.

3.5 Farm dams and water bodies

Farm dams are an important hydrologic feature of the Western Parkland City that reduce run-off volumes in waterways while recharging the local and regional groundwater table. They can also provide significant aesthetic benefits and ecological habitat.

A key part of the landscape-led design approach for the Western Parkland City is to, where appropriate, repurpose or rebuild farm dams as water in the landscape features. Retaining or replacing farm dams is an important approach to preserve hydrologic characteristics of the local waterways. A large number of stormwater wetlands will be required as part of the regional approach to meeting waterway objectives. These wetlands will provide significant water in the landscape will will offset the removal of many existing farm dams.

As most farm dams have not been designed for amenity functions or to be located near development, many will need to be removed or rebuilt to ensure efficient infrastructure planning and address issues such as dam stability, safe access, water quality, algal bloom risk, water level fluctuations and wildlife attraction.

Planning will also need to address ownership, responsibility and funding arrangements for retained artificial water bodies. High value ecology in existing dams will need to be carefully managed.

3.6 Wildlife strike risk

The Western Sydney Aerotropolis Draft Wildlife Management Assessment Report (Avisure 2020) identifies drainage assets as well as detention and retaintion basins as having the potential to attract wildlife (mainly birds). The report also notes that the initial precincts currently includes a complex network of farm dams and ponds that support large populations of water birds. Construction of the airport and changes to land use within the Aerotropolis will alter many of these habitat sources. The vast majority of existing farm dams will be removed, whilst a series of natural drainage channels and stormwater wetlands will be required to service development. The report outlines the Aerotropolis Aviation Wildlife Safeguarding Framework to mitigate wildlife strike risks for aircraft operating at Western Sydney Airport once the airport is operational.

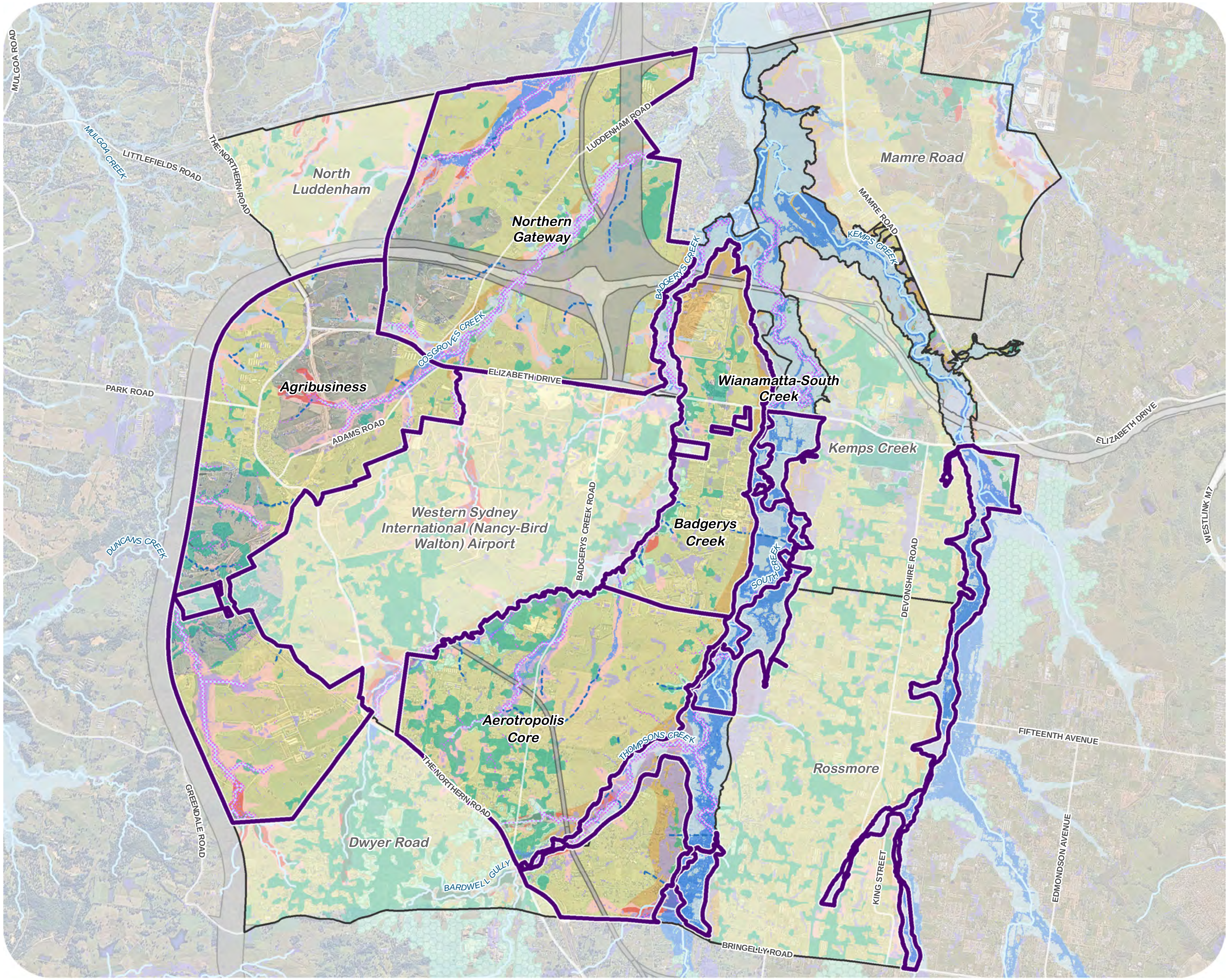
Controls will be required to manage the wildlife strike risk that elements of essential stormwater infrastrucure along with the revitalisation of natural water courses may have. The Aerotropolis Aviation Wildlife Safeguarding Framework will need to be followed and the wildlife hazard assessment process (Avisure 2020) used to ensure risks for infrastructure design and management are managed effectively.

3.7 Heat and climate

Variable rainfall and climate conditions are a significant consideration for water management in Western Sydney. Urban heat causes major liveability and resilience problems with critical impacts for human health, infrastructure, emergency services and the natural environment. These impacts are expected to increase in severity into the future as a result of climate change and the continued urbanisation of the area. Water plays an important role in mitigating urban heat and providing respite from extreme heat conditions.

Planning must ensure that reliable and cost-effective water supplies are available to support urban green cover and mitigate extreme heat.

Planning must also ensure that the level of service provided by stormwater assets is not compromised by the potential impacts of climate change on rainfall intensity.



Initial precincts
Other precincts
Riparian corridors
HEV protect
1% AEP
50% AEP
Blacktown Soil Landscape
South Creek Soil Landscape
Cumberland Plain West Vegetation
Grade <2%
Future Western Sydney Transport Corridors
Proposed M12 Corridor

Salinity Potential Risk

Known Salinity
High

All other areas within precincts moderate salinity risk

Strahler Stream Order

3rd order & higher
Trunk drainage channels without VRZs

*Infiltration permissible where groundwater is greater than 2m below ground surface beneath South Creek & alluvial soils

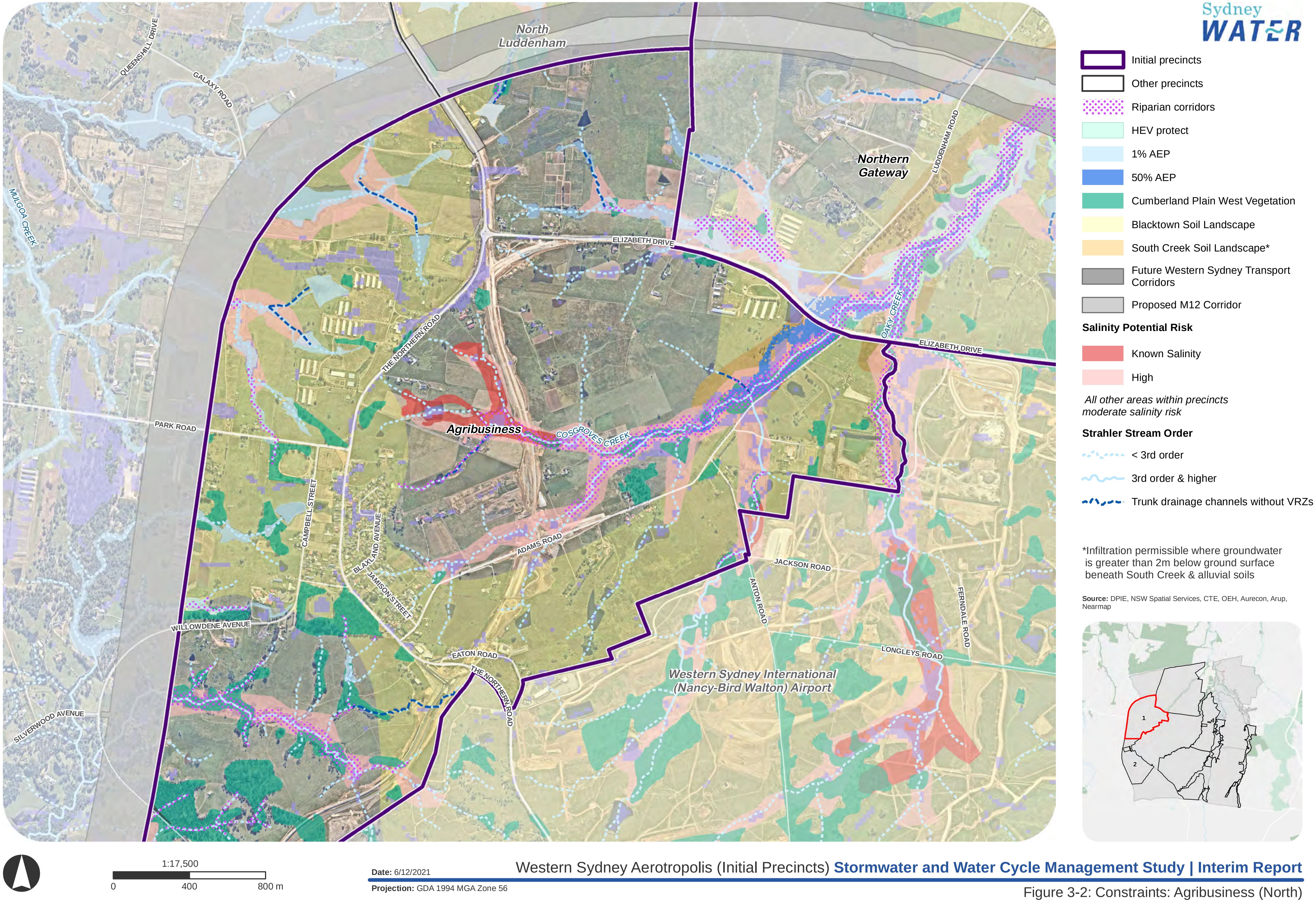
Source: DPIE, NSW Spatial Services, CTE, OEH, Aurecon, Arup, Nearmap

1:55,000
0 1 2 km

Date: 6/12/2021
Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 3-1: Constraints: whole of study area

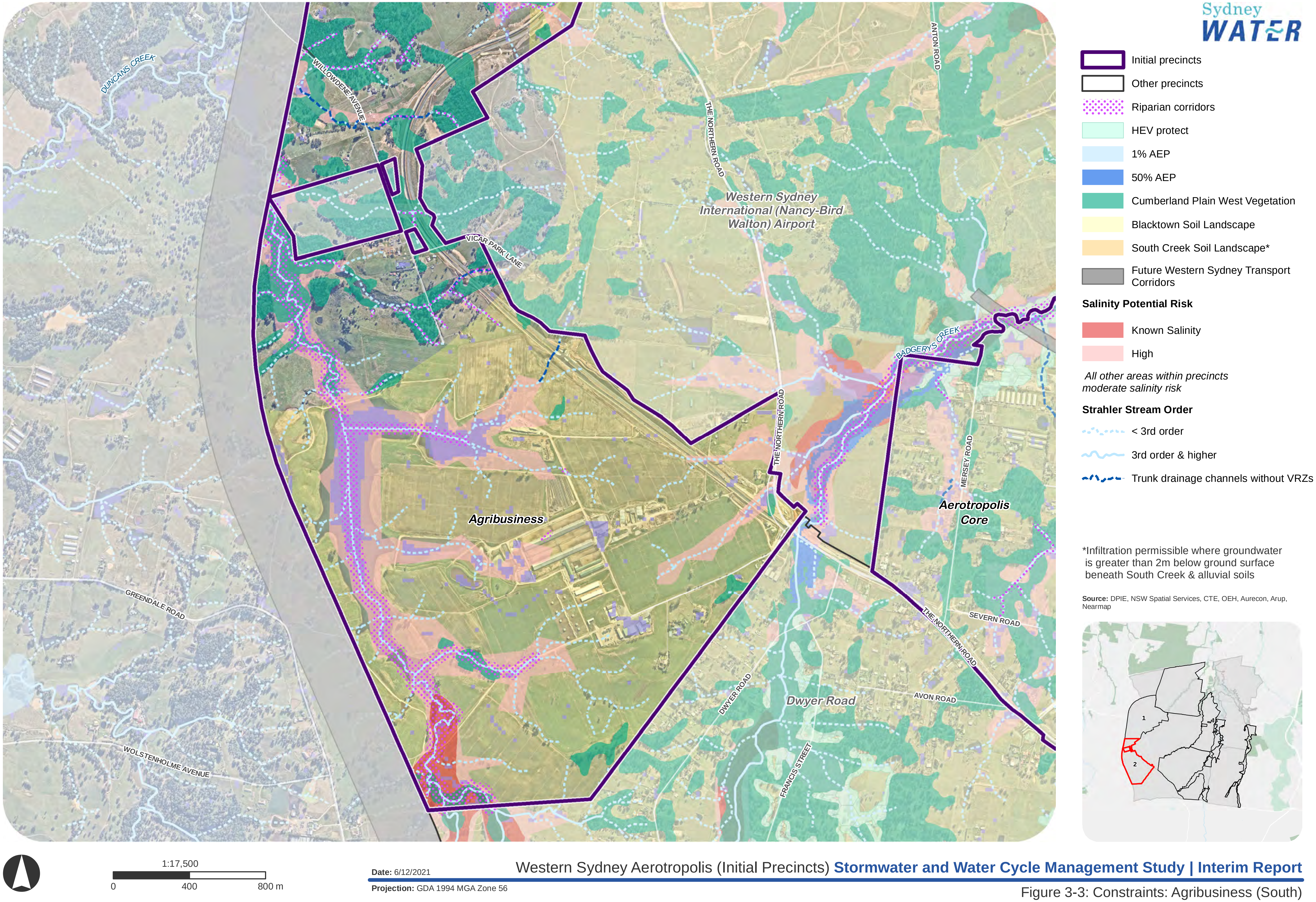


Date: 6/12/2021

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 3-2: Constraints: Agribusiness (North)



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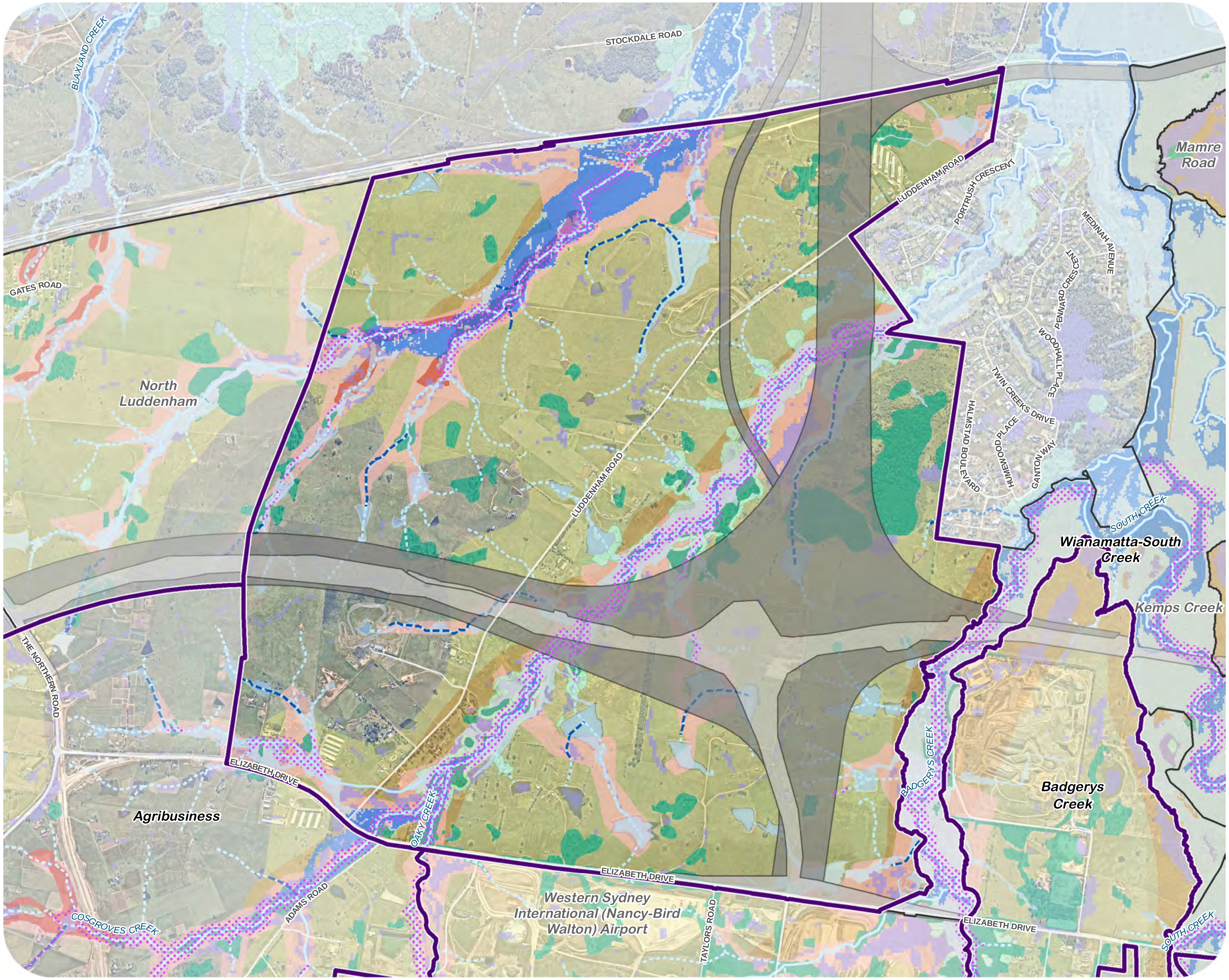
Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 3-3: Constraints: Agribusiness (South)

Sydney WATER



	Initial precincts
	Other precincts
	Riparian corridors
	HEV protect
	1% AEP
	50% AEP
	Cumberland Plain West Vegetation
	Blacktown Soil Landscape
	South Creek Soil Landscape*
	Future Western Sydney Transport Corridors
	Proposed M12 Corridor

Salinity Potential Risk

	Known Salinity
	High

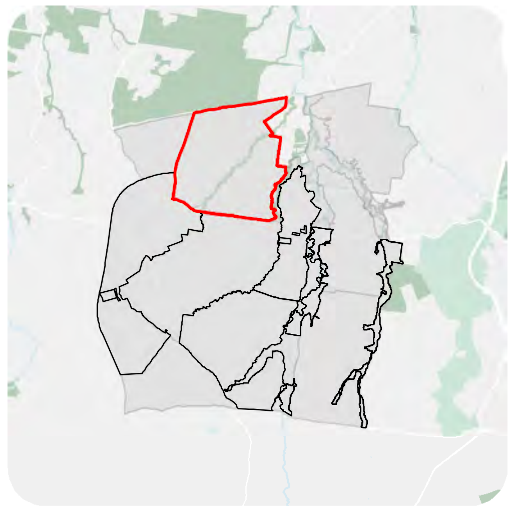
All other areas within precincts moderate salinity risk

Strahler Stream Order

	< 3rd order
	3rd order & higher
	Trunk drainage channels without VRZs

*Infiltration permissible where groundwater is greater than 2m below ground surface beneath South Creek & alluvial soils

Source: DPIE, NSW Spatial Services, CTE, OEH, Aurecon, Arup, Nearmap



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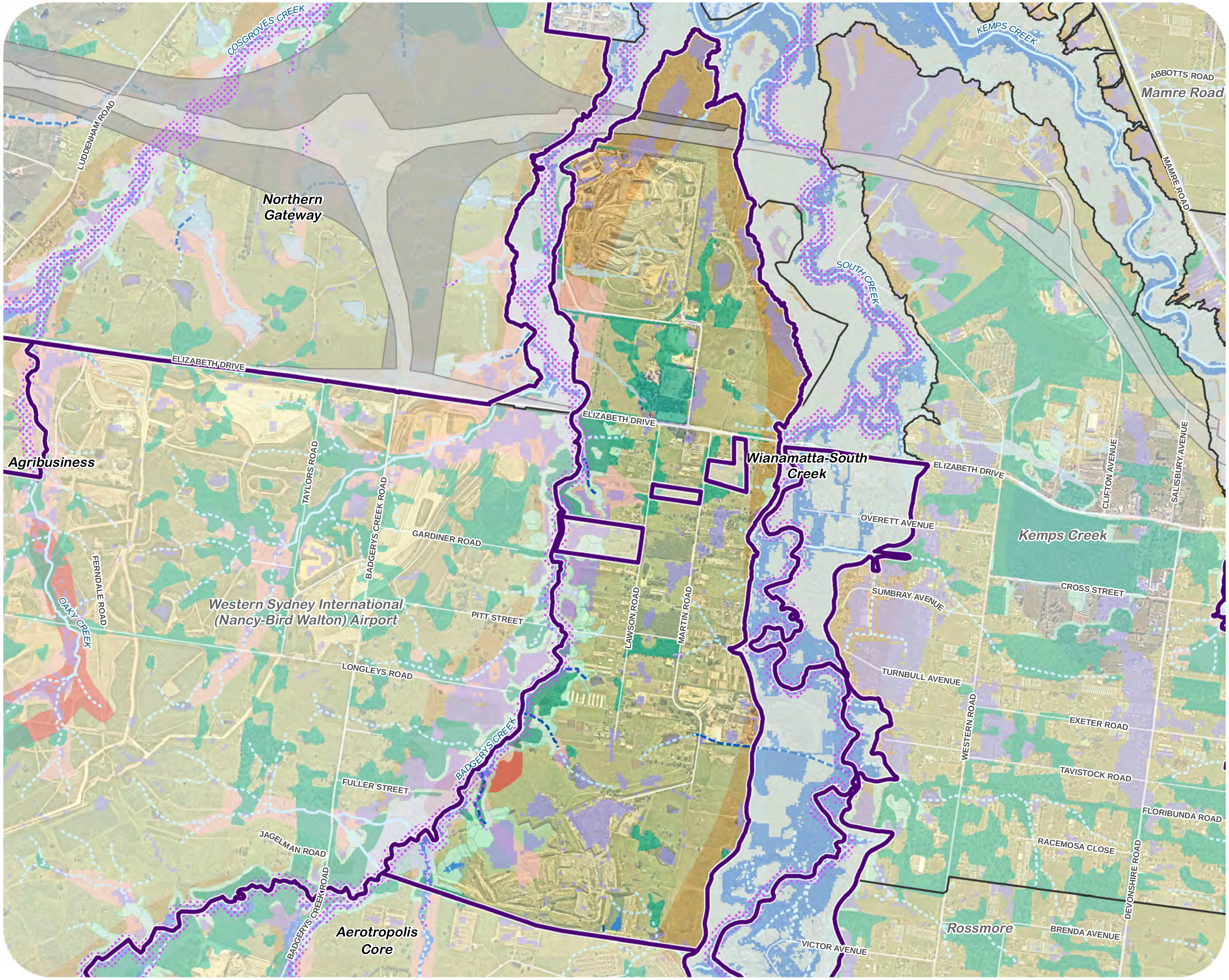
Projection: GDA 1994 MGA Zone 56

Figure 3-4: Constraints: Northern Gateway



Sydney WATER

- Initial precincts
- Other precincts
- Riparian corridors
- HEV protect
- 1% AEP
- 50% AEP
- Cumberland Plain West Vegetation
- Blacktown Soil Landscape
- South Creek Soil Landscape*
- Future Western Sydney Transport Corridors
- Proposed M12 Corridor

Salinity Potential Risk

- Known Salinity
- High

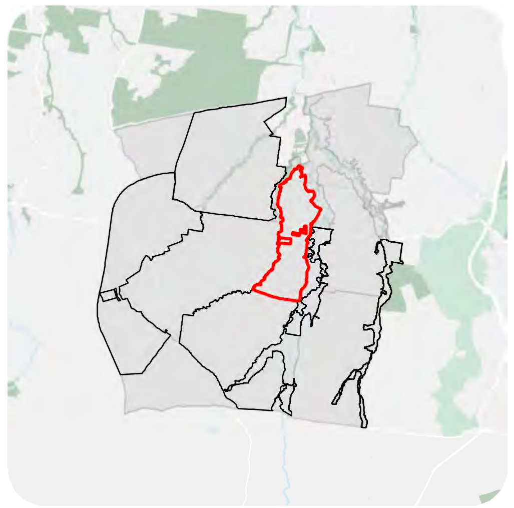
All other areas within precincts moderate salinity risk

Strahler Stream Order

- < 3rd order
- 3rd order & higher
- Trunk drainage channels without VRZs

*Infiltration permissible where groundwater is greater than 2m below ground surface beneath South Creek & alluvial soils

Source: DPIE, NSW Spatial Services, CTE, OEH, Aurecon, Arup, Nearmap



1:22,500

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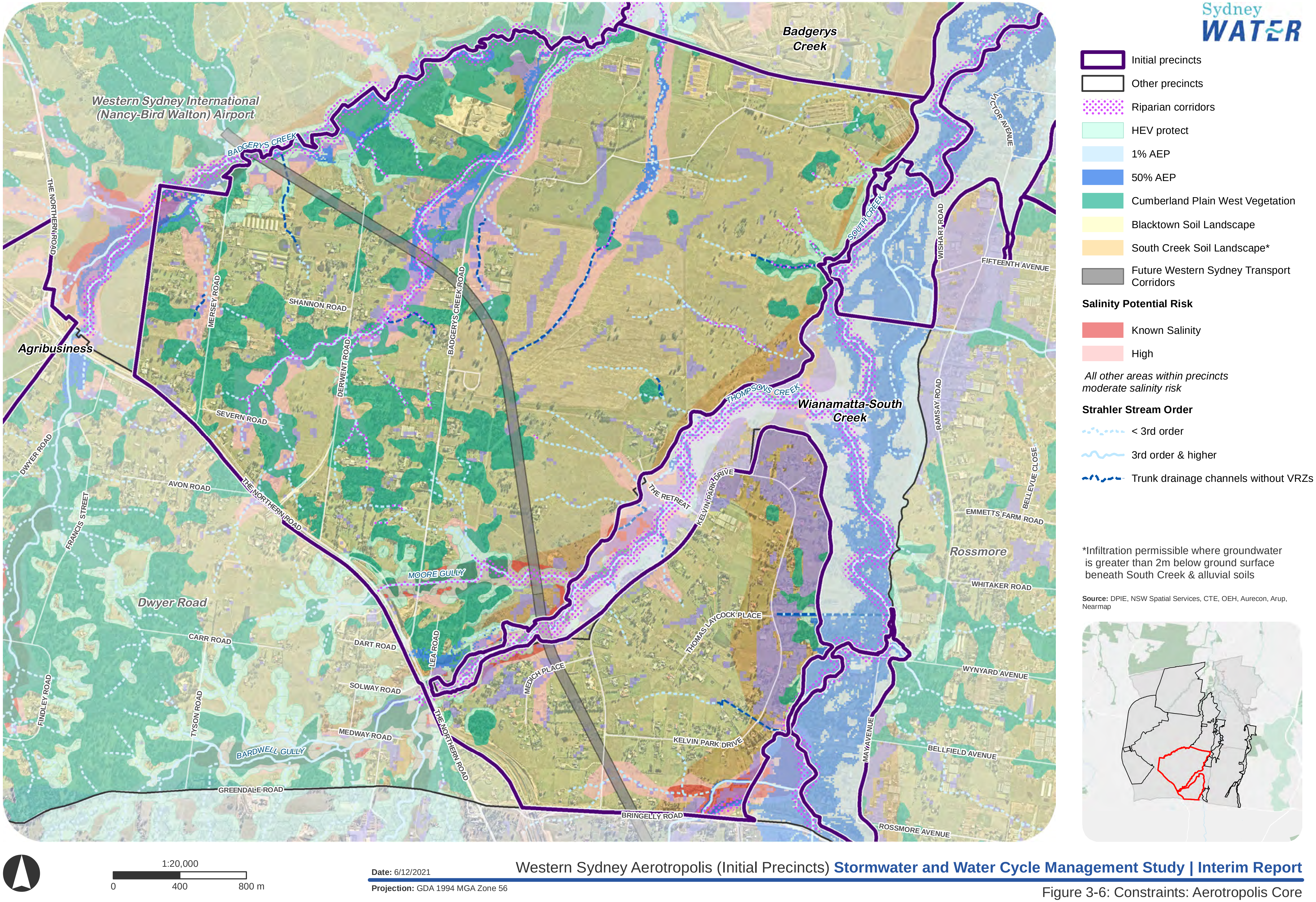
Date: 6/12/2021

Projection: GDA 1994 MGA Zone 56

Figure 3-5: Constraints: Badgerys Creek



Date: 6/12/2021

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 3-6: Constraints: Aerotropolis Core

4 Riparian corridor strategy

The landscape-led approach to developing the Aerotropolis precincts requires the protection, restoration and incorporation of key natural features into planning. Creeks, riparian corridors, groundwater-dependent ecosystems and farm dams have particular significance as waterway features. They require protection to preserve the unique ecology of the Cumberland Plain, as well as enhancing the liveability of the area through amenity and urban cooling. To advise precinct planning a Riparian Corridor Assessment (Sydney Water 2022) has been undertaken. In summary this work included:

- validating waterways and mapping of riparian zones to be protected
- identifying groundwater-dependent ecosystems and key aquatic habitat
- assessing the ecological value of selected farm dams
- developing a riparian revegetation strategy.

4.1 Waterway validation

The primary objective of the *Water Management Act 2000* (WM Act) is to manage NSW water in a sustainable and integrated manner that will benefit current generations without compromising future generations' ability to meet their needs.

Since 2018, the *Water Management Act* has been administered by the Natural Resources Access Regulator (NRAR) and establishes an approval framework for activities within waterfront land which is defined as land 40 m from the highest bank of a river, lake, wetland or estuary.

The definition of a 'river' as per the *Water Management Act* is:

a. any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved

b. any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows

c. anything declared by the regulations to be a river.

In relation to point (c) of the definition of 'river' in the dictionary to the Act, the following are declared to be a river as per the *Water Management (General) Regulation 2018* (WM Regulation):

- any watercourse, whether perennial or intermittent, comprising an artificial channel that has changed the course of the watercourse
- any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows.

The *Guidelines for Controlled Activities on waterfront land—Riparian corridors* (NRAR 2018) provides guidance to establish Vegetated Riparian Zones (VRZ) along watercourses, based on the Strahler stream ordering system. The VRZ is measured from the top of the creek bank and includes the creek channel. The minimum required VRZ width for a first order stream is 10 m either side of the creek (measured from top of bank) plus the width of the creek channel. The maximum required VRZ is 40 m either side of the creek (measured from top of bank) plus the channel width and this is applied to 4th order and greater streams, wetlands, estuaries and tidal influenced waters.

Waterways in the Aerotropolis initial precincts and adjoining areas of the Wianamatta South Creek precinct were assessed via a mix of aerial photography, drone photography and ground survey. Following field assessment vegetated riparian zones (VRZ) were assigned to waterways according to those required by *NSW Water Management Act 2000*. Figure 4-1 shows results of the waterway validation and assessment, including VRZs.

4.2 Key fish habitat

Key fish habitat (KFH) was identified using datasets including, KFH mapping of LGA’s in the Sydney area and ‘threatened species habitat mapping datasets (NSW Department of Primary Industries 2007), the DPIE Fisheries key fish habitat (KFH) and threatened species habitat mapping and the DPIE *Fisheries policy and guidelines for fish habitat conservation and management* (update 2013).

Field validation to verify key fish habitat (KFH) were conducted across waterways that were identified as mapped key fish habitat by the desktop review. The field validations sought to:

- identify existing aquatic habitat occurring across the precincts
- identify any species, populations or ecological communities listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*, the *NSW Biodiversity Conservation Act 2016* and the *Fisheries Management Act 1994*
- identify any requirements for further work under the relevant legislation
- identify any noxious aquatic weed species listed under the *Biosecurity Act 2015*
- Ground-truth and validate habitats and identify threatened species (aquatic and groundwater dependent) through field surveys.

This information was then used to develop precinct mapping and inform revegetation strategies. Field assessments of KFH were carried out following the framework outlined by DPIE *Fisheries policy and guidelines for fish habitat conservation and management* (update 2013).The presence/absence of significant in-stream habitat such as rocks, woody debris and snags were assessed, which enabled the KFH type and class to be assigned according to the DPIE Fisheries policy and guidelines for fish habitat conservation and management (update 2013).

Figure 4-2 shows mapped KFH as per DPIE 2007. For more information on KFH types and class see the Riparian Corridor Assessment (Sydney Water 2021).

4.3 Groundwater-dependent ecosystems

Groundwater-dependent ecosystems (GDEs) need access to groundwater to maintain their communities of plants and animals, ecological processes and ecosystem services. They are very susceptible to changes in water quality and water quantity. A desktop review of GDE mapping was conducted to gain insight into the extent of both terrestrial GDE and aquatic GDE classified areas across the four study precincts. This information was used to inform the desktop selection of streams for validation, identification of significant vegetation communities and in RRS development. The review of terrestrial and aquatic GDE indicated that many areas of terrestrial vegetation across the four study precincts are classified as high potential GDE (see Figure 4-3).

4.4 High ecological value ecosystems

Prepared by the Science Division of the NSW Department of Planning, Industry and Environment (DPIE, 2022a), LGA and region-wide HEV (High Ecological Value) mapping aims to inform local and regional strategic assessment and planning of cool blue-green corridors and the protection and improvement of high value waterways. State and federal biodiversity and water legislation, including the *EPBC Act 1999* (Cth), *Biodiversity Conservation Act 2016* (NSW) and the *Water Management Act 2000* (NSW) form the basis for defining what constitutes HEV mapped areas. Indicators not limited to Strahler stream order, GDE, threatened fish species distribution and River Condition Index define HEV. Figure 4-4 shows areas of HEV (protect and improve) associated with waterways within the waterway corridors of the Aerotropolis.

4.5 Farm dam assessment

Farm dams as they currently exist in the Wianamatta-South Creek catchment primarily provide water for stock and domestic uses in agricultural areas, and as a secondary consequence, provide aesthetic and ecological habitat functions. They have typically been constructed as private works to store supplementary water for use on properties. This storage function results in significant areas of water in the landscape which can be highly beneficial for the Aerotropolis.

The location, size and operation of existing farm dams must be considered and where appropriate, dams should be retained and enhanced to provide water in the landscape functions for the future urbanised landscape. Critical to the success of retaining farm dams is to understand how they can best operate in a future urban environment.

Key benefits of retained farm dams could be:

- storage and evaporation of stormwater run-off
- control of the release of stormwater to minimise hydrologic impacts
- retention/provision of key ecological habitat features (eg chain of ponds, open water bodies and wetting of native vegetation communities)
- provision of alternative sources of water for re-use opportunities and irrigation
- water quality treatment (if properly configured)
- aesthetic features of water in the landscape
- recreational opportunities (walking trails etc)
- reduction in urban heat island impacts due to water presence in the landscape enhancing evaporative cooling.

INSW developed a decision framework applied to farm dams across Wianamatta-South Creek catchment to help determine whether a farm dam should be retained in the landscape or removed. This framework considers the following metrics:

- Size (surface area and likely depth), including a water balance of typical farm dams to determine appropriate sizing.
- Contributing catchment area.
- Ecological condition or if the farm dam provides ecological services.
- Amenity provisions.
- Land use and zoning, such as development areas, EECs, riparian zones.

Application of the framework provides an informed approach to the decision-making process regarding future management of farm dams across the catchment.

In order to recommend dams to be retained due to ecological condition, a combination of desktop and field assessment was completed. The results of this assessment are intended to feed into the decision framework as a component of the 'retain or remove' process to be done as part of the broader precinct planning or during the development application stage.

A four-stage process was used for the ecological assessment of farm dams:

Stage 1: Desktop assessment to identify eligible dams for assessment

We used spatial data sets and aerial photography to determine which farm dams would be considered for field assessment.

Criteria applied included:

- dam surface area of 0.2 – 3% of the upstream catchment
- located on a 1st, 2nd or 3rd order stream
- located within the DPIE HEV mapped areas (DPIE, 2022a).

Stage 2: Development of rapid ecological assessment method for farm dams

We developed an assessment method to enable a rapid qualitative assessment of the ecological value of farm dams. Metrics considered include:

- distance of dam to native vegetation
- connectivity to creek
- presence/extent of native macrophytes
- presence of native water dependent fauna (mapped on BIONET and observed)
- on or adjacent to mapped key aquatic habitat
- presence/extent of fringing wetland ecosystem.

A ranking system has been developed which scores farm dams according to their ecological value, which will be applied during the field assessment stage.

Stage 3: Field assessment to assess ecological value of farm dams

A total of 70 farm dams identified for assessment by Stage 1 were assessed in the field using the method developed in Stage 2. Each dam was visited on foot, or where access was restricted or time constrained, a drone fly over was used to capture up close aerial photos and the assessment performed remotely.

Stage 4: Mapping of assessment and recommendation for retention or removal based on ecological value

Following field assessment, the dams with significant ecological value have been recommended to be retained (see Figure 4-5). For precinct specific mapping see the Riparian Corridor Assessment (Sydney Water 2021). The dams are unlikely to provide any meaningful retardation of flows, as it would be valid to assume that the dams would be full at the start of a storm event. This is even more likely if the dams are required for visual appeal.

Regarding dam safety, most farm dams are privately constructed with no regulation of the construction material and techniques, and no on-going monitoring, so the geotechnical stability of the dam embankment walls is unknown. If identified for retention, the potential impact in case of failure will need to be assessed through hydraulic modelling according to Dam Safety NSW requirements. Since these dams will be in an urban environment, some of the retained dams could create a safety hazard if they failed. This may influence their viability where potential risks posed to future development are not acceptable. If assessed as having failure consequences, the dams would need to be registered with Dam Safety NSW, remediated structurally, and require ongoing asset management and reporting. Dams to be retained will need to be integrated with the urban fabric and public safety will need to be ensured.

4.6 Riparian revegetation strategy

Native revegetation of the VRZs is required to protect and restore these areas and help achieve the waterway outcomes identified for the aerotropolis. Revegetation of additional land outside the standard VRZs could provide significant additional benefits (such as habitat and canopy cover). A Riparian Revegetation Strategy (RRS) for the four initial precincts as well as adjoining areas of the Wianamatta-South Creek Precinct has been developed by Sydney Water in collaboration with DPIE to provide high level guidance on the extent and cost of riparian management actions and potential biodiversity credit generation.

The RRS looks to maximise the opportunity for native revegetation while being cognisant of the need to avoid impacts on flooding. The main spatial elements used to develop the RRS were:

- vegetated riparian zones
- HEV ‘Protect’ areas
- HEV ‘Improve’ areas
- the 1% AEP floodway and flood extent.

These spacial elements were overlayed to form the following four management zones. Each zone represents a different desired outcome, management effort (and associated cost):

Management Zone 1 - HEV Protect

Incorporates land mapped as HEV 'Protect' between creek channel to the outer edge of the 1% AEP extent. The primary function of this zone is to protect remnant biodiversity. Management of this zone seeks to protect existing native vegetation patches and restore a fully structured river flat forest plant community (canopy, understory and ground cover).

Management Zone 2 - HEV Improve

Incorporates land mapped as HEV 'Improve' between the creek channel to the outer edge of the 1% AEP Flood extent. The primary function of this zone is to improve the connectivity of remnant biodiversity and provide buffers to HEV 'Protect'. Management of this zone seeks to either revegetate a fully structured river flat forest plant community within the vegetated riparian zone (VRZ) or create a near continuous tree canopy while maintaining flood conveyance in areas outside the VRZ. This zone may include WSUD elements (outside the VRZ) if desired flood planning levels are not affected.

Management Zone 3 - Floodway

Incorporates land mapped as the 1% AEP Floodway that excludes areas mapped as HEV and VRZ. The primary function of this zone is flood conveyance. Management of this zone aims to create a mosaic of native tree canopy cover with native groundcover (ie native grasses, forbs and herbs). This zone may include WSUD elements if desired, flood planning levels are not affected. Any alterations within the flood planning area will be tested against the adopted floodplain management plan.

Management Zone 4a – Vegetated riparian zones (outside HEV)

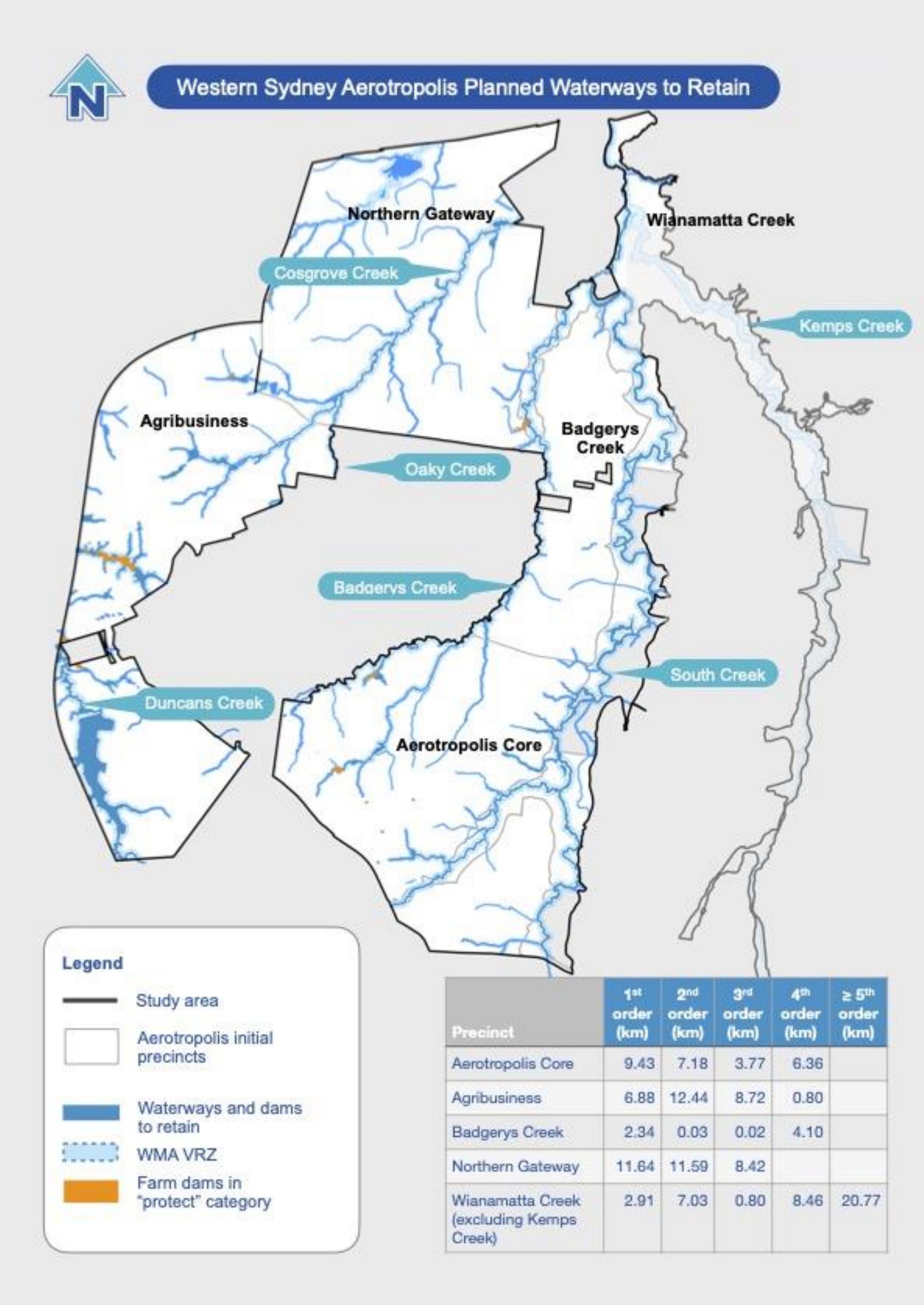
Incorporates areas of VRZ that are not mapped as HEV. The primary function of this zone is to protect and enhance the riparian zone along creek lines. The management of this zone seeks to reinstate a fully structured river flat forest plant community (canopy, understory and ground cover) on to land that contains little existing ecological value (similar to zone 4b).

Management Zone 4b – Opportunities for more habitat and tree canopy

Incorporates public open space between the 1% AEP floodway and 1% AEP flood extent that are not mapped as HEV. The primary function of this zone is to expand habitat and tree canopy outside of remnant native vegetation patches and into zones that are less critical for flood conveyance. The management of this zone seeks to reinstate a fully structured river flat forest plant community (canopy, understory and groundcover) on to land that contains little existing ecological value (similar to zone 4a). This zone may include WSUD elements if desired flood planning levels are not affected.

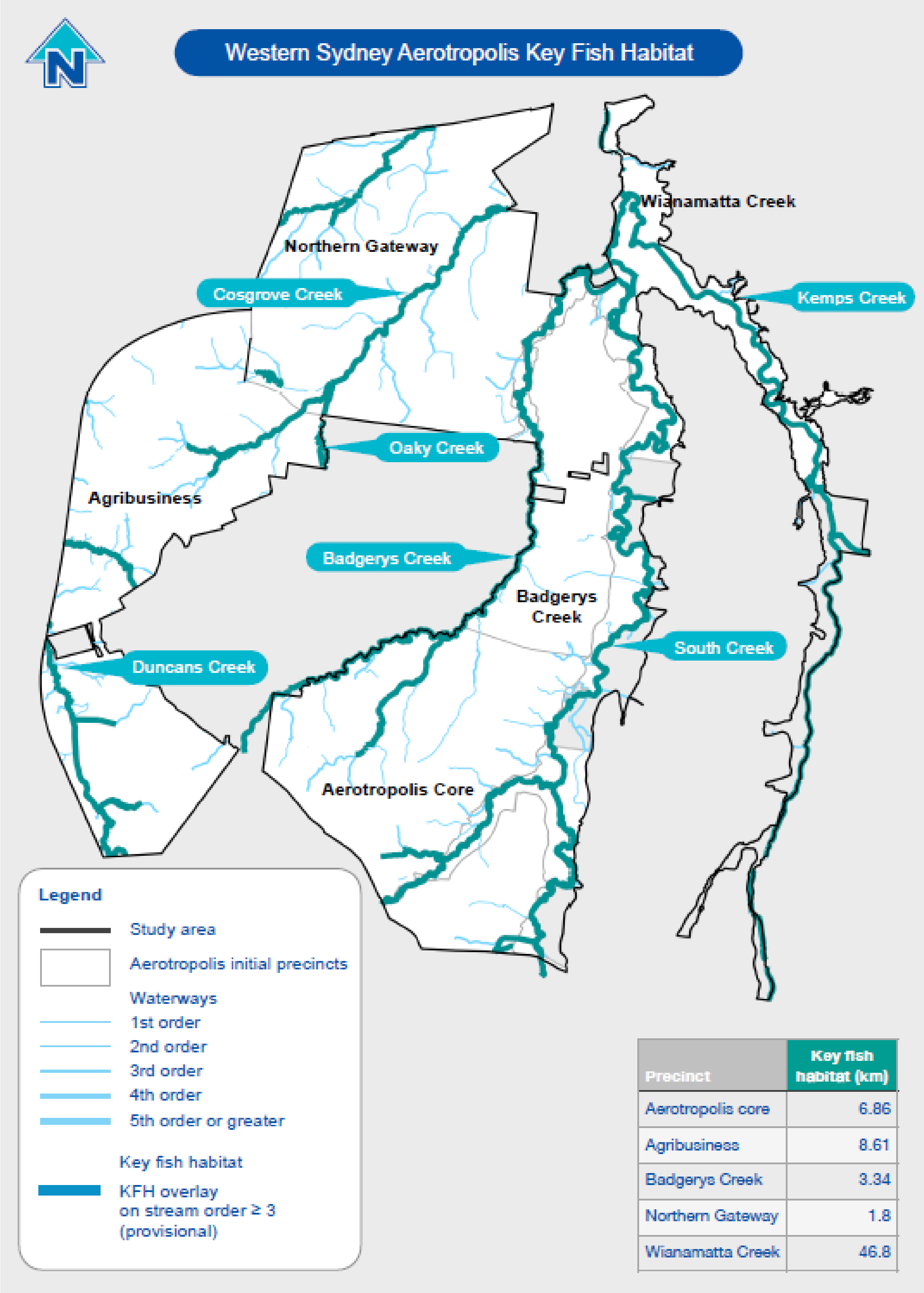
Figure 4-6 shows the distribution of the different management zones across the study area as part of the RRS. Costs for implementing the RRS were developed with input from key stakeholders as well as field data on the current condition of bushland areas (weed coverage) and the current level of erosion in the creeks. For more detail refer to Riparian Corridor Assessment (Sydney Water 2021).

The RRS in its current form represents a strategic approach and high-level opportunity for revegetation. Further work is required to test and refine the RRS based on any flood impacts. Infrastructure such as road crossings, sports fields, cycleways and other assets that are required would need to be excised from the proposed areas for revegetation and the costs adjusted accordingly.



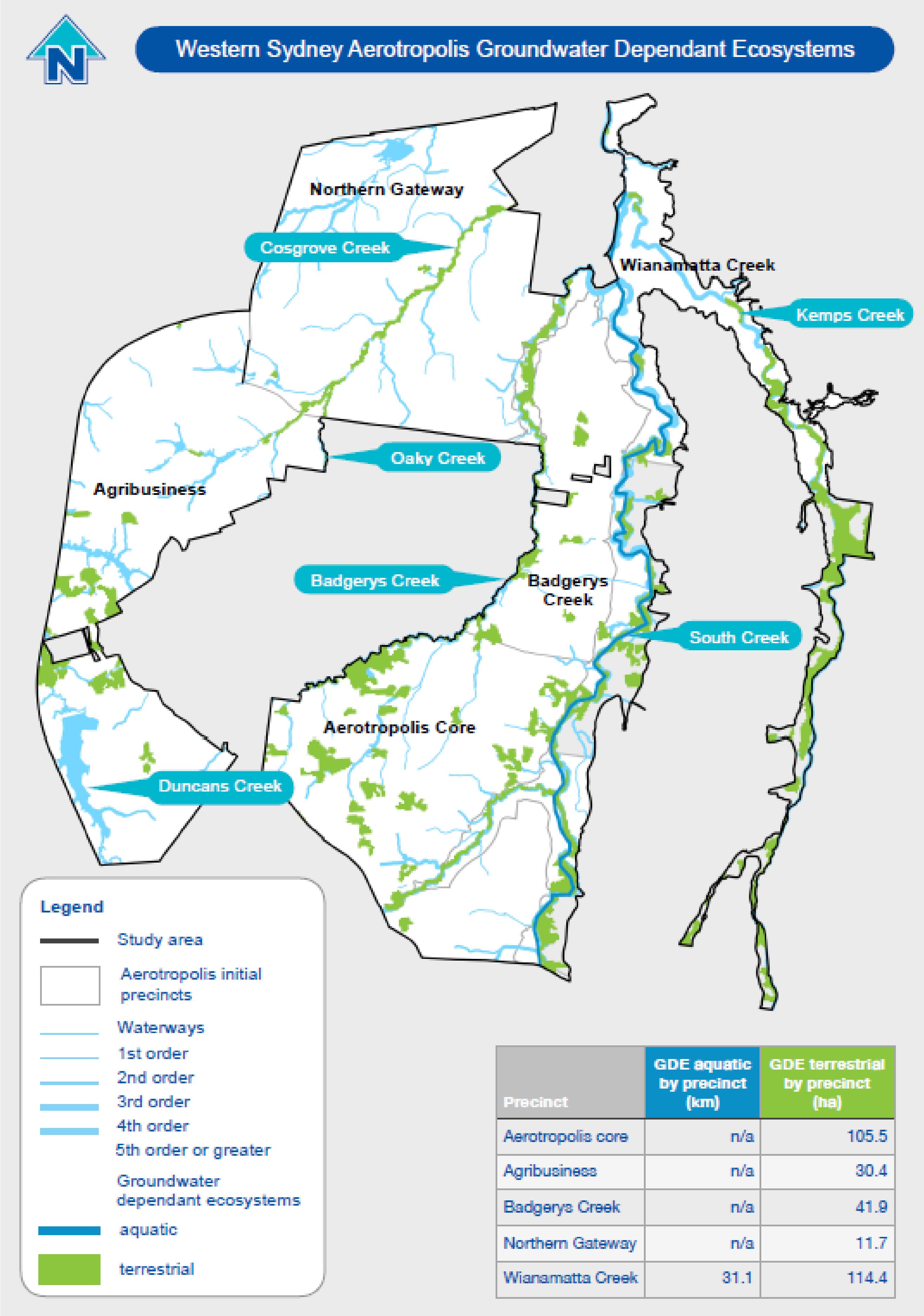
Precinct	1st order (km)	2nd order (km)	3rd order (km)	4th order (km)	≥ 5th order (km)
Aerotropolis Core	9.43	7.18	3.77	6.36	
Agribusiness	6.88	12.44	8.72	0.80	
Badgerys Creek	2.34	0.03	0.02	4.10	
Northern Gateway	11.64	11.59	8.42		
Wianamatta Creek (excluding Kemps Creek)	2.91	7.03	0.80	8.46	20.77

Figure 4-1 Waterways and vegetated riparian zones to be retained within the study area



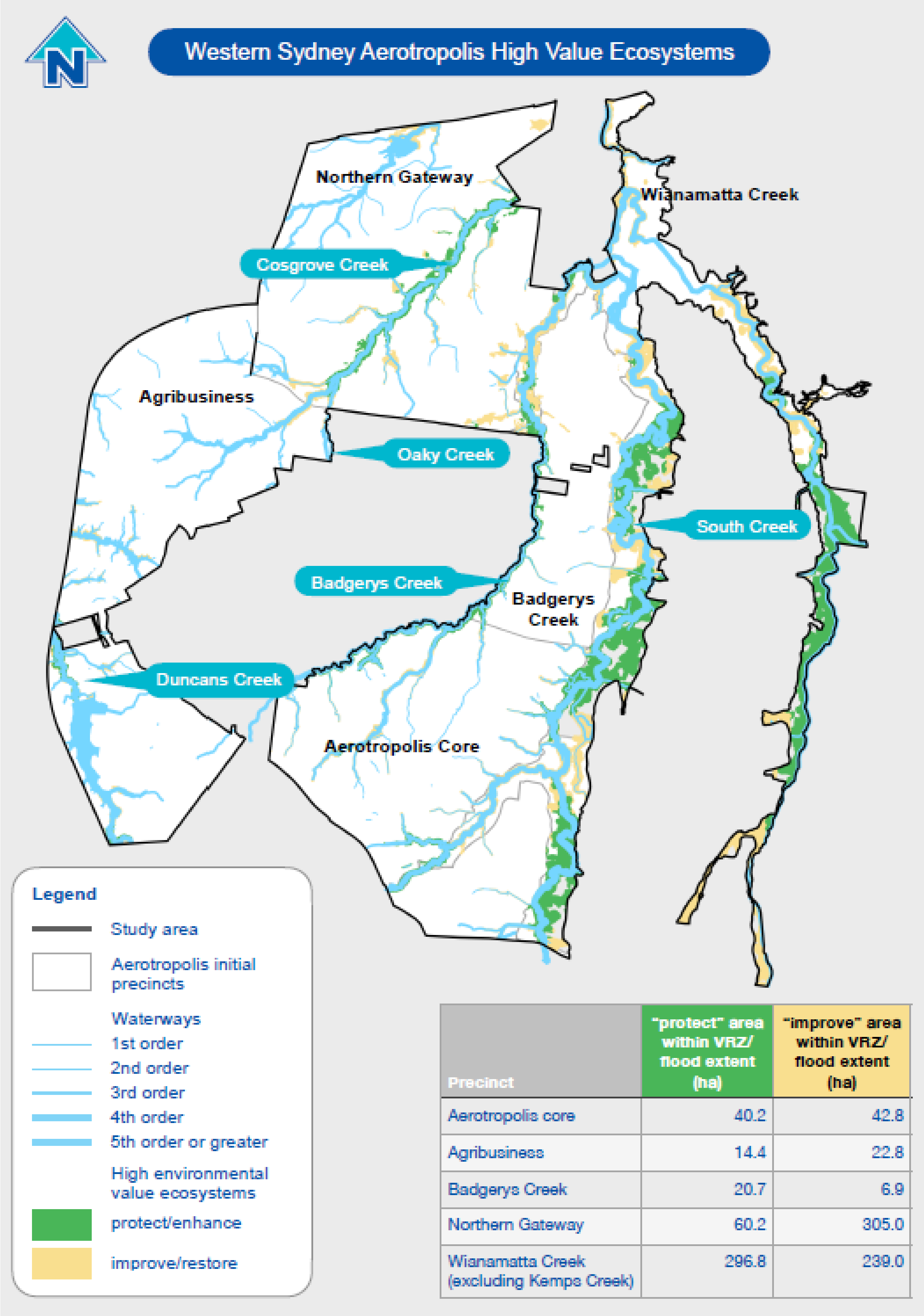
Precinct	Key fish habitat (km)
Aerotropolis core	6.86
Agribusiness	8.61
Badgerys Creek	3.34
Northern Gateway	1.8
Wianamatta Creek	46.8

Figure 4-2 Mapped key fish habitat within the study area



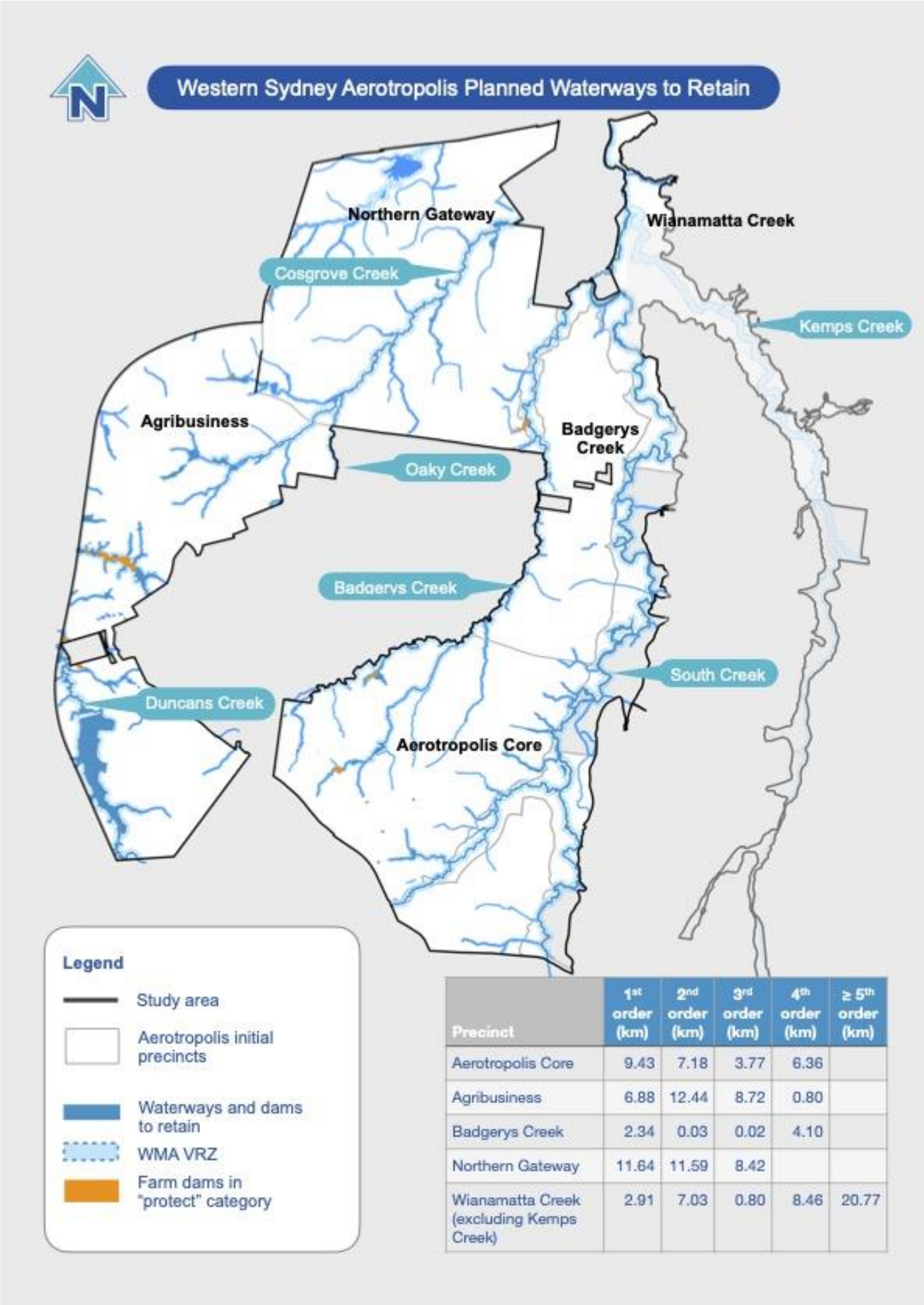
Precinct	GDE aquatic by precinct (km)	GDE terrestrial by precinct (ha)
Aerotropolis core	n/a	105.5
Agribusiness	n/a	30.4
Badgerys Creek	n/a	41.9
Northern Gateway	n/a	11.7
Wianamatta Creek	31.1	114.4

Figure 4-3 Groundwater-dependent ecosystems within the study area



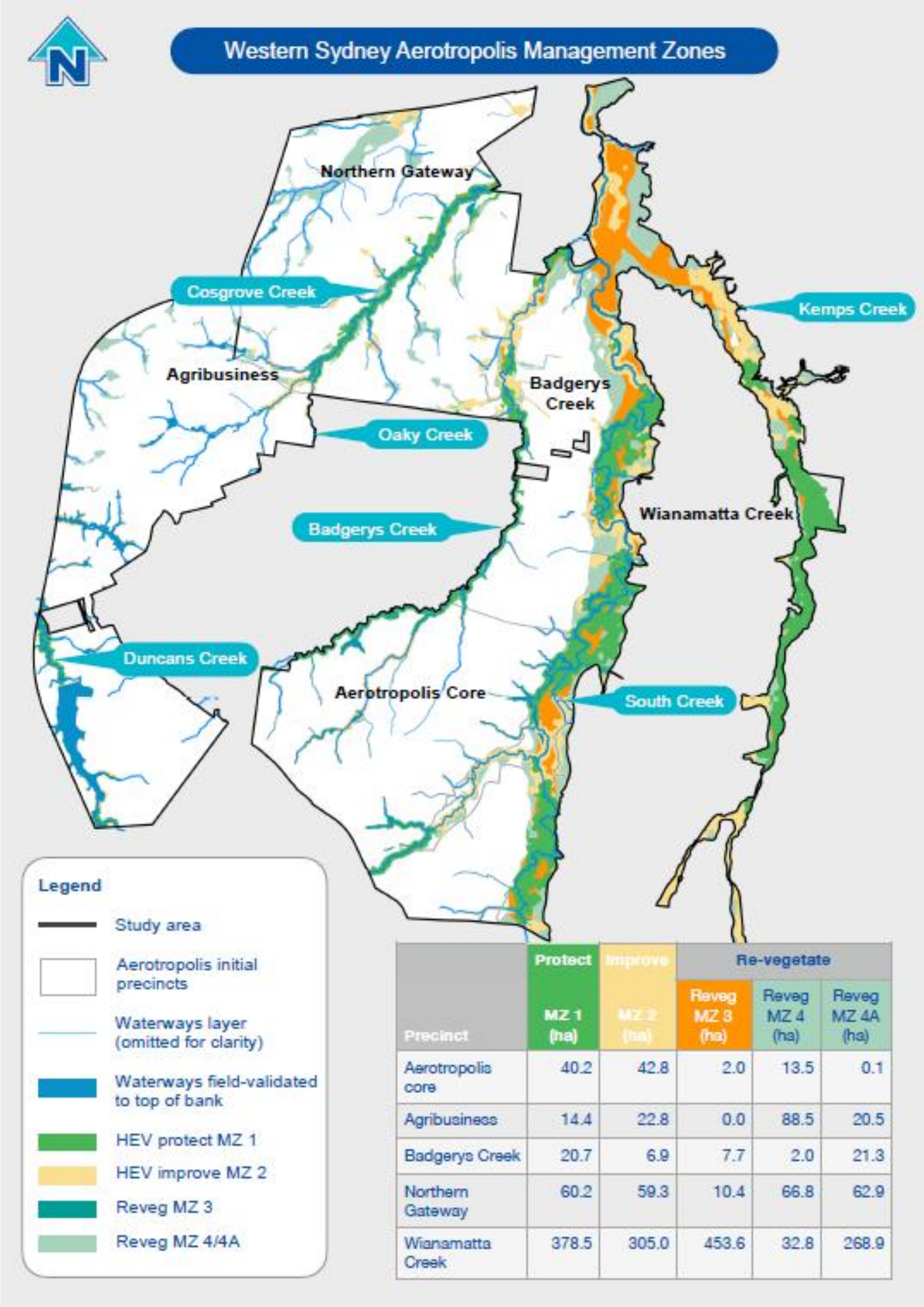
Precinct	"protect" area within VRZ/ flood extent (ha)	"improve" area within VRZ/ flood extent (ha)
Aerotropolis core	40.2	42.8
Agribusiness	14.4	22.8
Badgerys Creek	20.7	6.9
Northern Gateway	60.2	305.0
Wianamatta Creek (excluding Kemps Creek)	296.8	239.0

Figure 4-4 High ecological value areas associated with waterways within the study area



Precinct	1st order (km)	2nd order (km)	3rd order (km)	4th order (km)	≥ 5th order (km)
Aerotropolis Core	9.43	7.18	3.77	6.36	
Agribusiness	6.88	12.44	8.72	0.80	
Badgerys Creek	2.34	0.03	0.02	4.10	
Northern Gateway	11.64	11.59	8.42		
Wianamatta Creek (excluding Kemps Creek)	2.91	7.03	0.80	8.46	20.77

Figure 4-5 Farm dams with high ecological value that have been recommended to be retained.



Precinct	Protect MZ 1 (ha)	Improve MZ 2 (ha)	Re-vegetate Reveg MZ 3 (ha)	Reveg MZ 4 (ha)	Reveg MZ 4A (ha)
Aerotropolis core	40.2	42.8	2.0	13.5	0.1
Agribusiness	14.4	22.8	0.0	88.5	20.5
Badgerys Creek	20.7	6.9	7.7	2.0	21.3
Northern Gateway	60.2	59.3	10.4	66.8	62.9
Wianamatta Creek	378.5	305.0	453.6	32.8	268.9

Figure 4-6 Riparian revegetation and management zones

5 Total water cycle management

This chapter details the process used to identify the preferred total water cycle servicing outcome for the initial precincts. It is consistent with the Government's total water cycle position identified in the District Plan, the Western Sydney Aerotropolis Plan and the SEPP as well as accommodating the outcomes of the other sections of this report.

The information provided is high level in nature and provides as a clear indication of locations and land requirements for key integrated water servicing infrastructure. Sydney Water will continue to further detail planning at the precinct level in collaboration with stakeholders. The total demands and water balances presented in this section are based on the DPIE's growth precinct ultimate and annual growth projections for the Aerotropolis precincts as detailed in Chapter 5.1.

5.1 Population and growth basis

The forecasts in Table 5-1 reflect the current adopted ultimate growth basis at 2056 for planning in the Aerotropolis initial precincts.[3]

Table 5-1 Aerotropolis initial precincts - ultimate growth forecasts Source: DPIE data issued March 2020

Precinct	Single dwellings	Multi dwellings	Jobs
Aerotropolis Core	-	8,000	60,000
Agribusiness	550	-	10,000
Badgerys Creek	-	-	11,000
Northern Gateway	-	3,598	
Wianamatta-South Creek			

[3] These growth projections are those currently adopted in Sydney Water's infrastructure planning and include commercial projections.

Sydney Water's UGI (Urban Growth Intelligence layer) reviews and updates the annual DPIE HSFM data that provides a 20-year growth forecast at the local government area (LGA) level, as well as ultimate and annual growth projections provided by DPIE and the WSPP for all growth precincts. Council data is also updated in the UGI based on Local Housing Strategy forecasts (1–5 and 6–10 year forecasts) and planning proposal updates.

Developer information is overlaid on top of this intelligence to build up confidence in forecast and demonstrated demand. As the area is a new growth precinct, the DPIE and the WSPP precinct projections are deemed the most detailed forecast intelligence at this time, based on the recent precinct planning for the Aerotropolis. These are subject to change and may be revised as part of any future water management planning.

5.2 Water demands

Average Daily Demands (ADD) of water for different uses adopted in the integrated water balance modelling are summarised in Table 5-2. Evidence-based demands indicate that average daily demands are higher but conservative values have been adopted for the purpose of sizing stormwater harvesting infrastructure as outlined in Chapter 6.

Evidence-based water demands can continue to be assessed based on the usage and typologies as more data become available. Staged delivery of assets allows flexibility to continually assess demands and servicing requirements.

Table 5-2 Water demand unit rates (ADD)

Internal water demand unit rates (ADD) for stormwater harvesting calculations	Water demand unit rates (ADD) for water servicing calculations	Proportion of demand that could be met by a non-drinking supply[4]
Medium density – 10.8 kL/NHa/day High density – 29.6 kL/NHa/day*	200 L/EP/day	50%
Large format industrial – 4.6 kL/NHa/day Strata industrial – 11.2 kL/NHa/day Commercial and business park – 24.4 kL/NHa/day	10 kL/NHa/day	50%
~2.5 ML/yr/Ha of private gardens irrigated ~3.2 ML/yr/Ha of public open space and formal parks ~4.5 ML/yr/Ha of playing fields irrigated	100%	

Note that water demands expressed in terms of NHa refer to gross water demand across net hectares of development.

[4] Non-drinking supply sources include stormwater, rainwater or recycled water

5.2.1 Residential and non-residential demands

The residential usage demand of 200 L/EP/day includes all internal residential uses along with irrigation of private open spaces. Up to 50% of this demand can be met by non-drinking water sources if connected for toilet flushing, washing machine use and irrigation. For non-residential demands, an evidence-based average day demand rate of 10 kL/NHa/day was applied across all precincts. Up to 50% of this total demand can be met by non-drinking water sources. The assumptions above have been derived from evidence-based demands as observed for the different land type uses across Sydney. These are based on current BASIX requirements and may change with updated requirements.

For the purpose of stormwater harvesting calculations, it is prudent to apply a more conservative estimate to ensure that stormwater volume reductions are not over estimated and that there is a level of redundancy in the stormwater treatment train to allow for variations in water demands and conditions across the typologies and precincts. Internal water demands in Table 5-2 do not include irrigation rates. Up to 50% of this total demand can be met by non-drinking water sources.

5.2.2 Irrigation

Irrigation demands associated with landscaping and vegetated set back areas on the lot will be higher for Western Parkland City than the Eastern and Central City where 2.5 ML/Ha/yr is commonly adopted[5]. It should be noted that this unit refers to the extent of the area irrigated. Again, conservative estimates for irrigation rates are adopted to ensure that there is redundancy in the stormwater treatment train to account for normal variations in irrigation demand. Irrigation water will be sourced from a mix of water sources.

Active open space and public open space can feasibly be irrigated at 4.5 ML/Ha/yr and as high as 8 ML/Ha/yr subject to suitable hydrologic landscapes. Some areas in the Aerotropolis may be less suitable for irrigation due to soil salinity risks and other soil properties without additional measures. Reduced irrigation rates of 2.5 and 3.2 ML/Ha/yr have been adopted for residential and public open space respectively.

5.2.3 Urban cooling

Evaporative cooling of buildings is an emerging method for reducing ambient temperatures inside and outside of buildings which is promoted by the Low Carbon Living CRC (2017) as an urban cooling strategy to reduce the impacts of extreme heat.

The notion of irrigating rooftops for evaporative cooling is promoted as a potential means of reducing stormwater run-off volumes (especially in building types with large roof areas) where there is no regional stormwater harvesting strategy in place. This practice requires consideration of public health and the seasonality of demands (notionally 4.5 ML/yr/Ha of roof).

It is important that the quality of the source of water is considered where there is a risk of human contact and ingestion. Rainwater could be used through a large-droplet sprinkler system on roofs. The use of recycled water for roof sprinkler systems is not recommended if roof run-off is being captured in a rainwater tank. It is recommended that drinking water be used for misting.

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[5] Irrigation rates are adopted from Table 2 of Sydney Water's *Best practice guidelines for holistic open space turf management in Sydney (2011)*.

5.3 Integrated water servicing

Sydney Water has completed daily time-step water balance modelling on a sub-regional level for the Aerotropolis and for each of the precincts to understand the ultimate system and infrastructure requirements under various approaches to integrated water servicing. Each servicing scenario is differentiated with key concepts relating to urban form outcomes and levels of recycled water and stormwater servicing in the Aerotropolis, as shown in Figure 5-1.

Individual precincts may be more suited to certain servicing approaches due to land uses, locations, council preferences and timing.

This report highlights the preferred integrated servicing approach for all products. An adaptive planning approach has been considered for flexibility and staging to help address uncertainty in the future and potential changes to achieve the best outcomes for customers. Further analysis including economic and regulatory approvals will be considered in the next stages of planning.

An overview of a sub-set of the integrated water servicing approaches analysed is presented here, with the results shown assuming the servicing approach is consistent across all the Aerotropolis initial precincts.

The volume of each water product that would be supplied under each of the integrated water servicing approach at 2056 is shown in Figure 5-2. All volumes are indicated in megalitres per year (ML/yr).

Outcomes from integrated water balance modelling will continue to inform Sydney Water's planning for servicing the Aerotropolis.

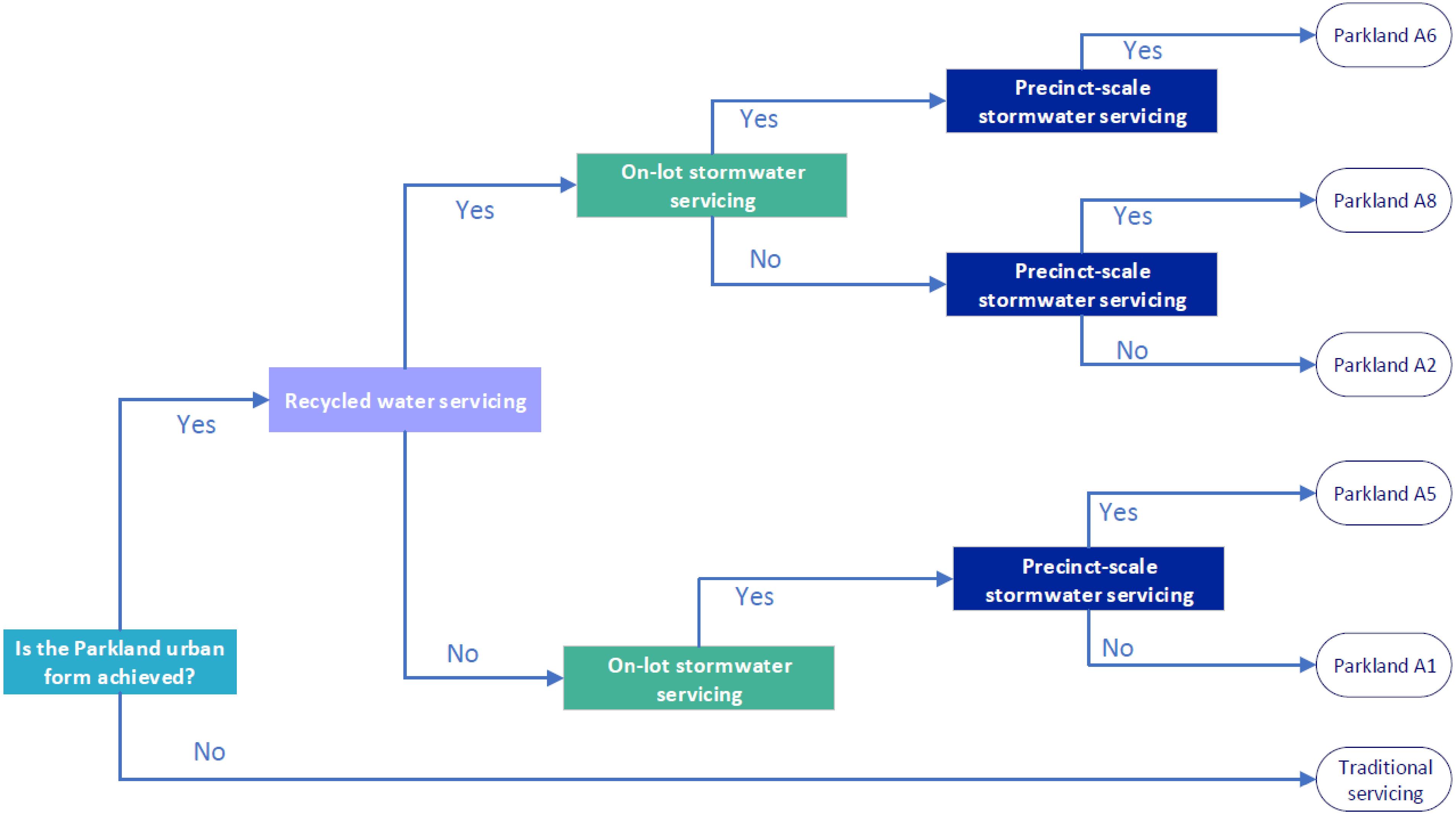


Figure 5-1 Integrated water servicing scenarios

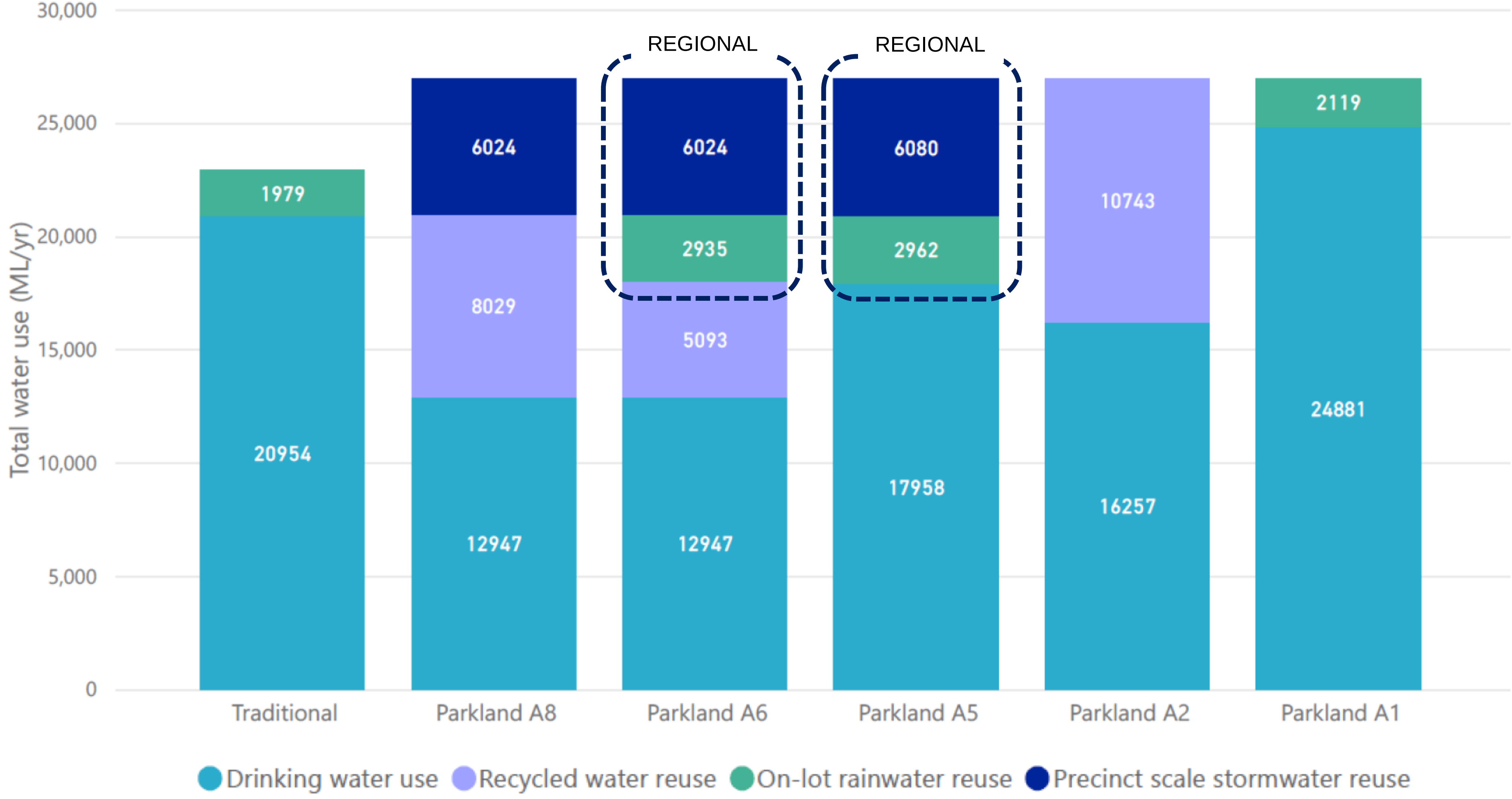


Figure 5-2 Water supply mix under various integrated water servicing approaches for the initial precincts

5.4 Drinking water servicing

5.4.1 Existing drinking water servicing

Each of the initial precincts fall in Cecil Park Water Supply Zone within the Prospect South Delivery System and currently have limited or no water services available.

Cecil Park Reservoirs are currently at capacity and cannot accommodate demands from new developments without the additional proposed amplification work to transfer flow from Liverpool and trunk infrastructure proposed within Cecil Park Water Supply Zone (WSZ).

Drinking water in the Cecil Park WSZ is supplied from Prospect Water Filtration Plant, which gets its source water from Warragamba Dam and Prospect Reservoir.

5.4.2 Staged drinking water servicing for initial developments

Sydney Water will provide services to early developments via the following trunk drinking water infrastructure to increase supply to the area:

- Amplification of WP0184 at Prospect.
- Rising Main (DN900) and pump WP0432 at Liverpool, 60ML reservoir at Liverpool.
- DN1200/DN1050 from Cecil Park reservoir up to Western Rd, with offtakes at Range Rd and Western Rd connecting existing mains in Elizabeth Drive.
- DN900/750 along Elizabeth Drive to Luddenham Road.
- DN450 along Luddenham Road from Elizabeth Drive intersection.
- DN450/150 along Badgerys Creek Road from intersection with The Northern Road.

This work is in delivery and proposed to be operational in 2022.

Sydney Water is also planning to deliver trunk infrastructure to support growth and major projects along Elizabeth Drive and Luddenham Road.

Interim servicing for Aerotropolis Core precinct would be through proposed Oran Park Reservoir via Northern Road trunk mains.

5.4.3 Ultimate drinking water servicing

Drinking water servicing for the Aerotropolis initial precincts is linked to the *Western Sydney Regional Master Plan* and draft *Western Sydney Aerotropolis Sub Regional Plan*. The current ultimate drinking water supply strategy for these precincts is to supply from Prospect South delivery system via the Cecil Park water supply zone and a proposed new water supply zone. A new reservoir (60ML) is proposed in the west at the end of Elizabeth Drive within the Agribusiness precinct. Detailed planning for options assessment and staging requirements has recently been completed.

Trunk drinking water infrastructure is planned to be delivered in stages to meet DPIE growth forecasts. New drinking water reservoirs, pumping stations and trunk mains are required to fully service the precincts. The trunk infrastructure identified is the skeleton trunk infrastructure and additional precinct trunk infrastructure and reticulation mains will be identified based on the Precinct Plan road layouts when they are approved. Refer to Figure 5-7Figure 5-9 for a map of the ultimate drinking water trunk infrastructure network.

5.4.4 Integrated servicing infrastructure impacts

Table 5-2 highlights how drinking water infrastructure requirements to service the Aerotropolis may be impacted by the different integrated servicing approaches.

Table 5-2 Integrated servicing impacts on drinking water infrastructure

Integrated servicing scenario	Effect on drinking water infrastructure requirements
Traditional servicing	No changes
Parkland A1	The increased overall water demand requires additional consideration of the requirements to meet the Western Parkland City greening requirements which will increase trunk sizing and impact the water supply for Greater Sydney.
Parkland A2	If recycled water is supplied, there is the opportunity to reduce the sizing of some trunk infrastructure. Additional top-up infrastructure requirements with potential co-location of recycled water and drinking water reservoirs
Parkland A5	There may be an opportunity to reduce sizing of some trunk infrastructure with optimised stormwater harvesting for irrigation uses, however the reliability of stormwater harvesting may mean that full drinking water infrastructure is required.
Parkland A6	Opportunity to reduce sizing of trunk infrastructure with recycled water supply and optimised stormwater harvesting. Additional top-up requirements with potential co-location of recycled water and drinking water reservoirs.
Parkland A8	Opportunity to reduce sizing of trunk infrastructure with recycled water supply and optimised stormwater harvesting. Additional top-up requirements with potential co-location of recycled water and drinking water reservoirs.

5.5 Wastewater servicing

5.5.1 Residential and non-residential flows

For residential flows 150 L/EP/day average dry weather flow (ADWF) rate has been applied. For non-residential flows, an evidence-based average dry weather flow (ADWF) rate of 30EP/NHa for expected flows and typology has been applied across all precincts.

Evidence based demands will continue to be assessed based on flows and typology as it becomes known. Staged delivery of assets allows flexibility to continually assess demands and servicing requirements.

5.5.2 Existing wastewater servicing

Each of the initial precincts currently have no wastewater servicing available, with most areas currently relying on septic tanks for wastewater disposal.

5.5.3 Interim wastewater servicing

Before delivering the Upper South Creek Advanced Water Recycling Centre (AWRC), Sydney Water is committed to working with developers for interim servicing for early developments (before 2025–26 when the AWRC is expected to be operational). Interim servicing may include decentralised wastewater treatment, tankering or interim pumped transfer. Interim servicing would be designed for transition to long term servicing, subject to meeting operational and environmental requirements and the timing of transition to be assessed on a case-by-case basis.

5.5.4 Staged and ultimate wastewater servicing

Wastewater servicing for the Aerotropolis initial precincts is linked to the Western Sydney Regional Master Plan and Western Sydney Aerotropolis Sub-Regional Plan. To fully service the region requires several wastewater pumping stations (WWPS) and deep gravity trunk mains. Several new pressure mains will transfer flows to the proposed Upper South Creek Advanced Water Recycling Centre (USC AWRC).

The USC AWRC first stage completion is targeted for 2025–26.
Trunk wastewater infrastructure is planned to be delivered in stages based on DPIE growth forecasts.

The first stages are planned to be delivered in line with operation of the USC AWRC. Detailed planning for options assessment and staging requirements is nearing completion. Refer to Figure 5-9 showing indicative location for ultimate trunk wastewater infrastructure for each of the four initial precincts.

5.5.5 Integrated servicing infrastructure impacts

Table 5-3 highlights how wastewater infrastructure requirements to service the Aerotropolis may be impacted by the different integrated servicing approaches.

Table 5-3 Integrated servicing impacts on wastewater infrastructure

Integrated servicing scenario	Effect on wastewater infrastructure requirements
Traditional servicing	No changes
Parkland A1	Some potential (still to be assessed) for the reduction in hydraulic capacity of the wastewater system and plant through reduction of infiltration to sewer.
Parkland A2	As for Parkland A1
Parkland A5	As for Parkland A1
Parkland A6	As for Parkland A1
Parkland A8	As for Parkland A1

5.6 Stormwater servicing

Stormwater generated within the precincts will be managed through a range of on-lot, street scape and end of pipe stormwater management elements to deliver the proposed controls outlined in Chapter 6.

Of significance to this *Stormwater and water cycle management study* is the consideration of waterway health objectives (Table 6-2) that seek to cap the average daily (or mean annual) contribution of stormwater run-off from the Aerotropolis to 2.0 ML/NHa/yr. Chapter 6 provides further detail on how this can only be achieved by maximising stormwater harvesting and by prioritising rainwater and stormwater harvesting above the use of recycled water to satisfy internal non-potable and irrigation demands.

5.6.1 Rainwater and stormwater harvesting

For the purpose of testing on-lot stormwater management scenarios, rainwater tanks are adopted in all scenarios except for Parkland A2 and A8 (the regional approach). Rainwater tanks are utilised to provide non potable water demands on the lot. Under these scenarios each business and residence is fitted with a rainwater tank that is plumbed into the building.

For all scenarios except A8, precinct scale stormwater harvesting entails the filtration of stormwater and storage within open water bodes to be used for the irrigation of the local green grid within each local sub catchment.

Scenario A8 utilises harvested stormwater delivered by a reticulation network to private lots and open space irrigation demands. This allows for flexibility in servicing both high and low water demands and realises greater benefits in terms of stormwater volume reductions.

5.6.2 Integrated servicing infrastructure impacts

Scenario A8 consolidates several stormwater management elements into a single network of centralised stormwater management and removes the reliance on private rainwater tanks.

Table 5-4 Integrated servicing impacts on stormwater infrastructure

Integrated servicing scenario	Effect on stormwater infrastructure requirements
Traditional servicing	Investment in stormwater infrastructure continues as it has for previous decade with rainwater tanks in the private domain and ad-hoc investment in stormwater harvesting for larger playing field facilities. Waterway health objectives are not met, requiring long-term expenditure on creek stabilisation works (eg rock rip rap) to protect remnant vegetation and infrastructure in the floodplain (e.g. WaterNSW pipeline).
Parkland A1	Investment in stormwater increases to provide water in the landscape through wetlands, ponds in the public domain. Waterway health objectives are not met, requiring long-term expenditure on creek stabilisation works (eg rock rip rap) to protect remnant vegetation and infrastructure in the floodplain (e.g. WaterNSW pipeline).
Parkland A2	Investment in stormwater infrastructure reduces. Waterway health objectives are not met, requiring long-term expenditure on creek stabilisation works (eg rock rip rap) to protect remnant vegetation and infrastructure in the floodplain (e.g. WaterNSW pipeline). Expenditure on waterway stabilisation is high.
Parkland A5	Investment in stormwater increases to provide larger rainwater tanks and water in the landscape through wetlands, ponds in the public domain. Investment in stormwater harvesting increases to provide a network playing fields and open spaces irrigated by stormwater from open water storages when stormwater is available. Waterway health objectives are achieved. Expenditure on waterway stabilisation is about half, compared to traditional servicing.
Parkland A6	Same stormwater infrastructure requirements as scenario A5 above.
Parkland A8	Investment in stormwater harvesting increases to provide a network of playing fields and open spaces irrigated by stormwater from open water storages when water is available. Significantly reduced investment in on-lot rainwater tanks in the private domain through use of the recycled water reticulation network. Waterway health objectives are achieved. Expenditure on waterway stabilisation is about half, compared to traditional servicing.

5.7 Recycled water servicing

Sydney Water is committed to providing recycled water in the Western Parkland City and/or other beneficial re-use from the USC AWRC. Recycled water servicing for the initial precincts is linked to Sydney Water's *Western Sydney Regional Master Plan* and draft *Western Sydney Aerotropolis Sub Regional Plan*:

- *The Western Sydney Regional Master Plan* included an economic assessment confirming the value of water supply in supporting urban greening and cooling objectives as part of the GSC's Parkland vision.
- The sub regional planning work has developed adaptive pathways for integrated product servicing (including consideration of recycled water use).

This chapter includes a feasibility assessment of potential recycled water options as an alternative or complementary source of water (ie in addition to rainwater/stormwater) in serving customer's non-drinking water needs.

Sydney Water has developed a proposed recycled water supply network from USC AWRC at the sub regional planning level to service non-drinking uses across the Aerotropolis. In the proposed configuration, recycled water storages within the network would be topped-up from the drinking water network when recycled water supply cannot meet demand.

Sydney Water is also assessing alternate uses for highly purified recycled water such as environmental flows and augmentation of the drinking water supply. These potential uses are not reflected as recycled water re-use in this analysis.

Sydney Water's adaptive planning and servicing approach will allow for flexibility to provide recycled water servicing in the Aerotropolis that provides the greatest economic value.

5.7.1 Recycled water option study

To determine Sydney Water's position on recycled water for these precincts, a recycled water feasibility study was done. This consisted of a basis of planning, basis of modelling, water balance, infrastructure sizing, infrastructure costing, and risk assessments.

Two main concepts were developed, Base Case and Recycled Water. The Base Case concept corresponds to the Parkland A5 servicing approach, with the use of stormwater, rainwater and drinking water only. The Recycled Water concept corresponds to the Parkland A6, which is the same as the Base Case, with the addition of recycled water servicing. Within the Recycled Water concept, there were five options (Figure 5-3) developed to identify if servicing all precincts or only individual precincts would provide the best outcome for the area.

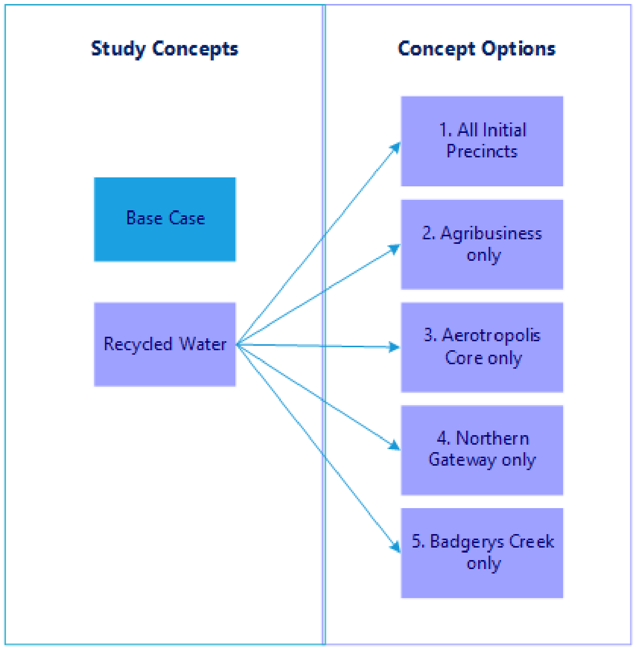


Figure 5-3 Concepts and options used in the recycled water study

The seasonal water balance developed for this study was based on the water demands in Chapter 5.2 and up-to-date land use data. By having each water demand and end use captured, it allowed for prioritisation of water product. Available rainwater and stormwater were prioritised to meet mean daily flow (or annual average flow volumes) in line with waterway health objectives.

Demands that are impacted by seasonal variability had a daily seasonal factor applied to ensure accurate demand values. In addition to the seasonal factor, each concept was modelled under different rainfall profiles, acknowledging the seasonal variation in rainfall and the impact on rainwater/stormwater source availability.

The yearly averages for water usage, wastewater load and stormwater discharge to waterways are presented in Table 5-5, with all values in megalitres per year (ML/yr).

Drinking water for potable end uses, harvested rainwater or stormwater, wastewater load and discharge to waterways remained the same for both scenarios. The stormwater run-off values met the MARV target of 2 ML/ha/yr.

The addition of recycled water resulted in a reduction in overall drinking water demand, saving 4,612 ML/yr for the All Initial Precincts option. This value includes the necessary drinking water top-up of the recycled water system for high demand peaks.

The values in Table 5-5 differ slightly to those presented in Figure 5-2, as the seasonal water balance in this study took into account updated land use and growth information. This information was not available at the time for the initial comparison of the sub-set of the integrated water servicing approaches.

Table 5-5 Seasonal water balance output summary.

Product	Base Case	Recycled water	Agri business	Aero Core	Northern Gateway	Badgerys Creek
	All precincts			Individual precincts with recycled water		
Drinking water for drinking water end use	7,662					
Drinking water (for non-potable end use)	9,480	4,868	8,231	6,982	8,589	7,78
Reticulated rainwater	3,080	3,080	2,980	3,080	3,180	2,980
Harvested stormwater	6,830					
Recycled water	-	4,862	1,118	1,487	1,193	521
Wastewater Load	9,657					
Stormwater discharge to waterways	5,669					

Values are yearly averages (ML/yr). Base Case (BC) concept and Recycled Water (RW) concept are shown for the combined and individual precincts.

Risk assessments identified several very high risks for the Base Case *concept*, mainly not contributing to a climate independent water resilient city in the local context and meaning that the Parkland objectives are met through stormwater re-use supplemented by drinking water. Another concern was limiting recycled water expansion to surrounding areas (eg the loss of opportunity to enable broader agricultural re-use at the fringe of the growth centre - particularly of value during extended dry periods).

The Recycled Water scenario's risks were a lower risk rating of high. These included overestimating recycled water demand and the potential for ongoing financial loss because of this. The intention to use a staged approach to deliver services reduces this risk.

5.7.2 Staged and ultimate recycled water servicing

The drinking water and wastewater servicing assets for Base Case concept represent essential and minimal (traditional) servicing requirements without any recycled water assets. The detail on these assets are discussed in Chapters 5.4 and 5.5. Additionally, rainwater and stormwater assets and controls including re-use are assumed to meet mean annual run-off volume (MARV) targets in the order of 2.0ML/ha/year.

The Recycled Water concept also uses the same drinking water and wastewater assets as the Base Case concept, acknowledging the need for top-up and back up supply from the drinking water system and that the wastewater network assets are required to transfer wastewater to the centralised USC AWRC plant where recycled water would be sourced from. Additionally, rainwater and stormwater servicing assumptions are the same as for the base case with prioritised use of rainwater / stormwater for viable end uses when available. This concept contains five options, outlined in Figure 5-3.

The recycled water produced at the AWRC would be transferred to a 13 ML reservoir in the Agribusiness precinct and an 8 ML reservoir in the Dwyer Road precinct via two transfer pump stations at the AWRC (Figure 5-8). From these reservoirs, recycled water would be distributed to all initial precincts via network of recycled water trunk mains and reticulation. A booster pump station will be required in Agribusiness to supply high elevation area in Agribusiness precinct.

Drinking water top-up for the reservoir in Agribusiness precinct would be sourced from a new 60 ML drinking water reservoir to the east of the airport and Dwyer Road reservoir would be from Cecil Park WSZ. The servicing maps for other options are shown in Chapter 5.8.

Within the Recycled Water concept there are two sub-options, recycled water with distributed storage and recycled water without distributed storage. Distributed storage refers to on-lot tanks anticipated to be required to meet run off targets (ie partially through appropriate re-use).

Distributed or on-lot storages could be used to buffer peak demands and allow a lower capacity and lower cost recycled water system to provide an equivalent level of service to end users (subject to appropriate hydraulic and water quality controls). The option without distributed storage includes supplying recycled water to the lot directly from street reticulation that will have direct exposure to peak demands. A public health and environmental risk assessment is required to determine the water quality risks and exposure pathways of implementing distributed storages.

5.7.3 Integrated servicing infrastructure impacts

The recycled water infrastructure requirements to service the Aerotropolis may be impacted by changes in other product servicing approaches for each precinct. These are highlighted in Figure 5-4.

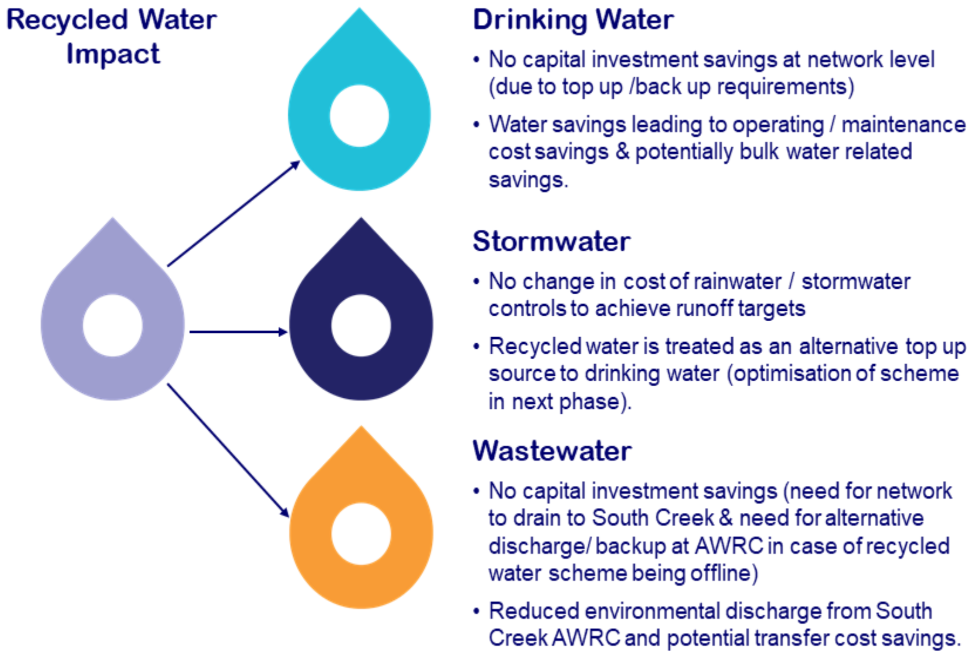


Figure 5-4 Impact of recycled water infrastructure on other product servicing

5.7.4 Recommendation

A combined stormwater harvesting and recycled water servicing strategy for all initial precincts is currently recommended as it is a reliable climate-independent source of water which plays an important role in substituting drinking water while providing a lower risk approach to meeting the waterway health objectives for Wianamatta-South Creek.

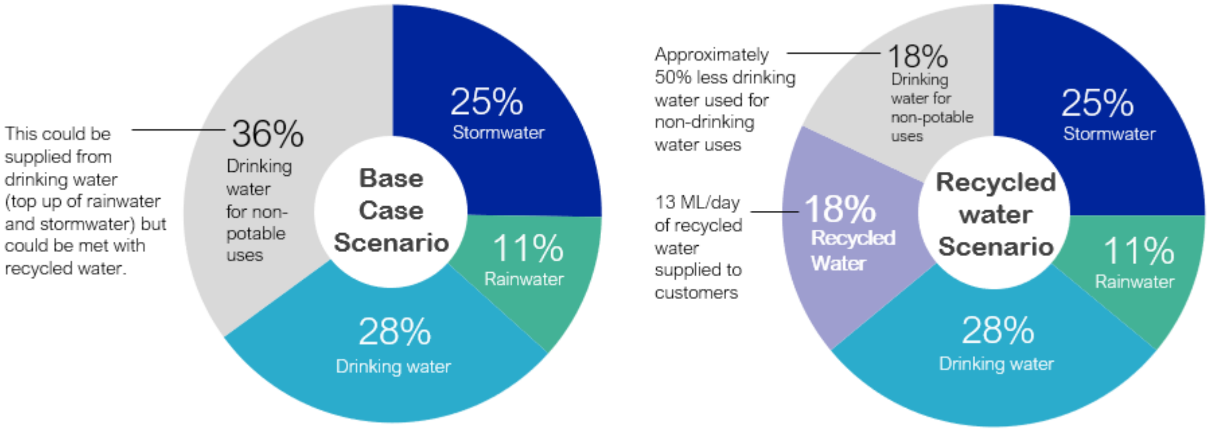
Seasonal water balance modelling highlights even with rainwater and stormwater harvesting, recycled water in the initial Aerotropolis precincts replaces 13ML/day of drinking water on an annual average and up to 24ML/day daily max.

This approach is in alignment with the Western Sydney Aerotropolis Plan's Parkland City objectives and to ensure these objectives are met, the above position should be reflected in planning instruments including the *Precinct Plan, Development Control Plan* (DCP) and the *State Environment Planning Policy* (SEPP).

Water products and usage

Recycled water has been integrated with stormwater providing a climate independent source of water which contributes to tackling the issue of drinking water security and resilience during hot, dry spells. The following graphs illustrate scenario comparison, with and without recycled water and represent water usage in the initial precincts.

Average water uses



Recycled Water Scenario

Modelling shows recycled water for the initial precincts replaces 13 ML/day of drinking water on an annual average and up to 24 ML/day daily max. There is opportunity to increase recycled water supplied through scheme optimisation and reducing potable top-up.

Product priority

To meet stormwater runoff targets, water products are prioritised in the following order:

Top priority

1. Stormwater is used for on-lot irrigation, streetscapes, parklands and local urban cooling

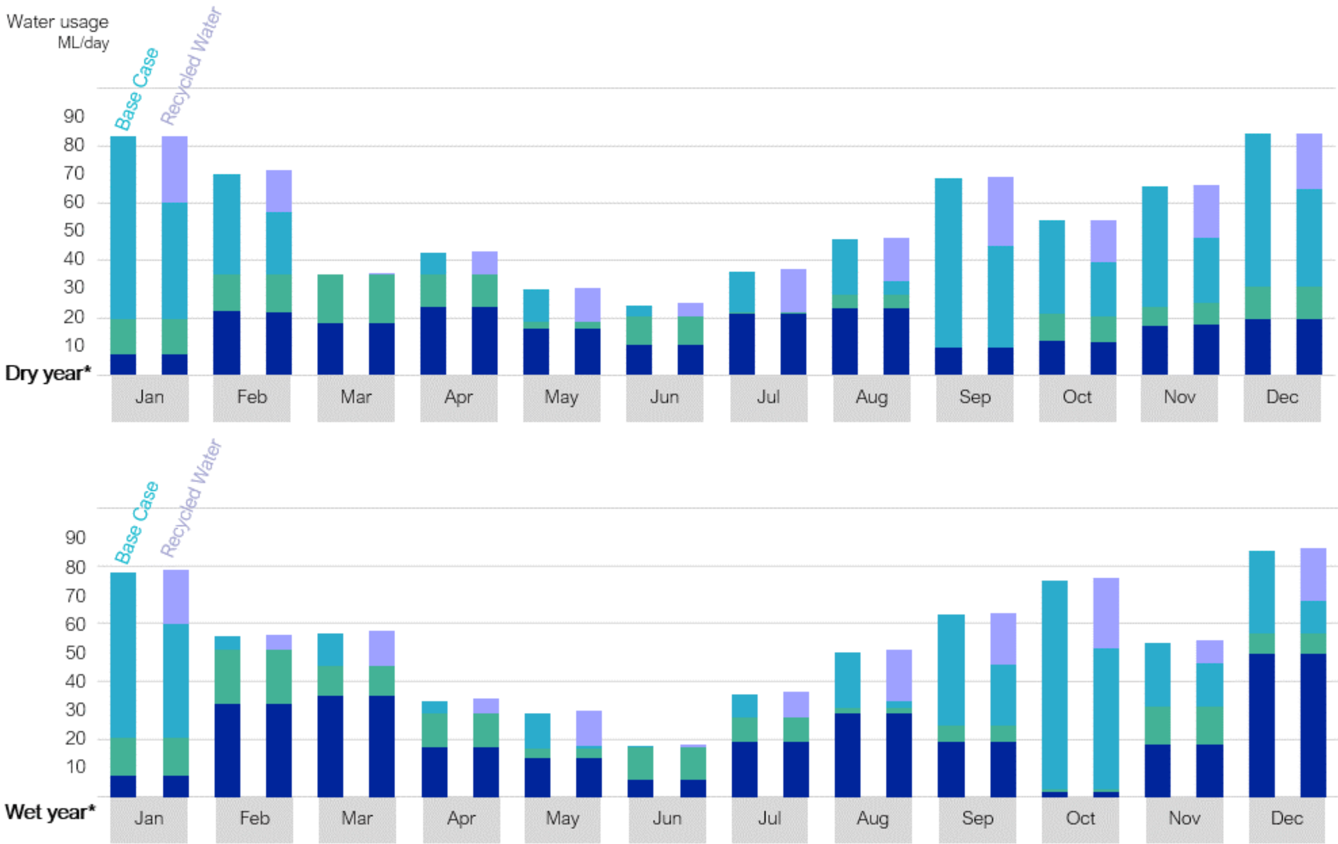
Regional harvesting

2. Where there is no regional stormwater harvesting scheme, rainwater is used for toilet flushing, on-lot irrigation, and streetscapes
3. Recycled is used for internal non-drinking water use, outdoor/ irrigation, and streetscape
4. Drinking water is used for internal uses (e.g. cooking, showering) and to top up rainwater and stormwater

Figure 5-5 Base Case and Recycled Water concepts compared

Seasonal supply for non-potable uses

Seasonal water balance confirms that even if broad-scale stormwater harvesting is in place, there remains an important role for recycled wastewater to ensure the reliability of supply in hotter, drier months.



Monthly water balance modelling highlights the seasonal variability in stormwater/ rainwater and when recycled water can be used to top up stormwater supplies.

Note that rainwater tanks are only required if no regional stormwater harvesting scheme is available.

A regional stormwater harvesting scheme provides the same volume of water as the combined stormwater and rainwater volumes.

* Historical rainfall data was used in the water balance model, with 2013 representing a recent dry year and 2017 representing a recent wet year.

Figure 5-6 Base Case and Recycled Water concepts compared, part 2

5.8 Proposed Infrastructure maps

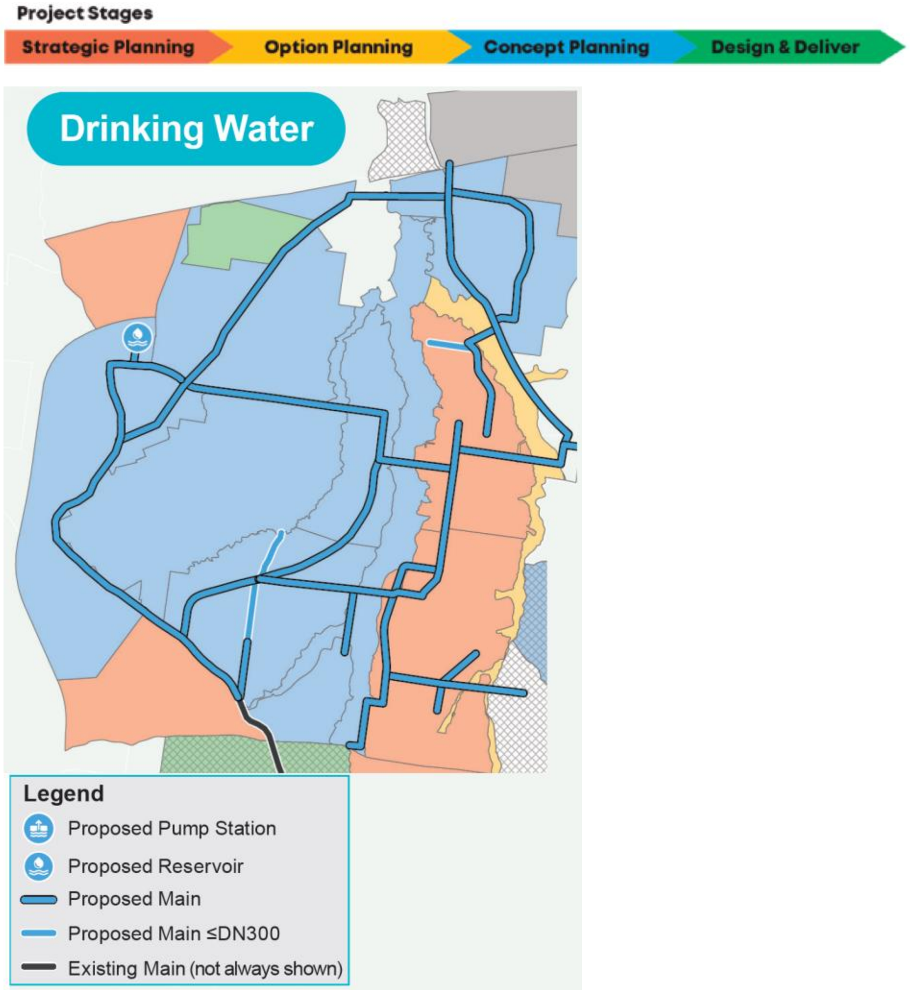


Figure 5-7 Proposed drinking water infrastructure

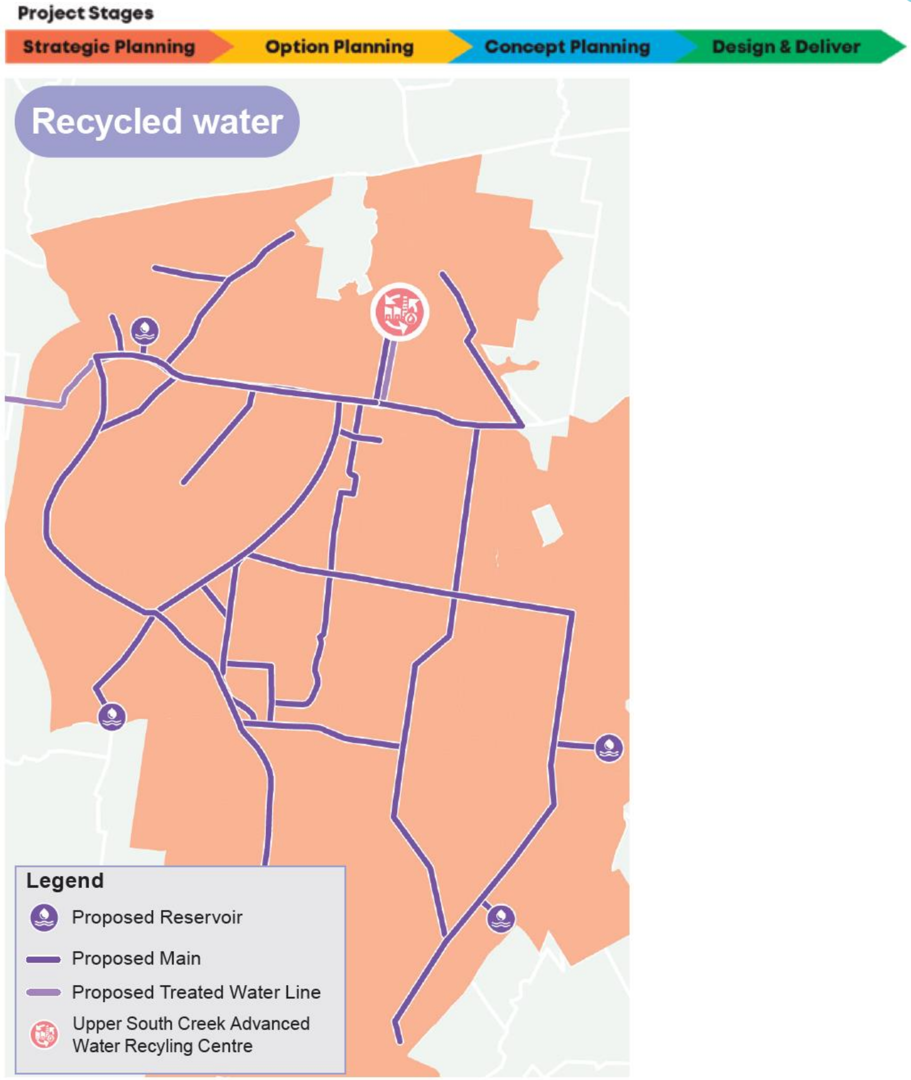


Figure 5-8 Proposed recycled water infrastructure

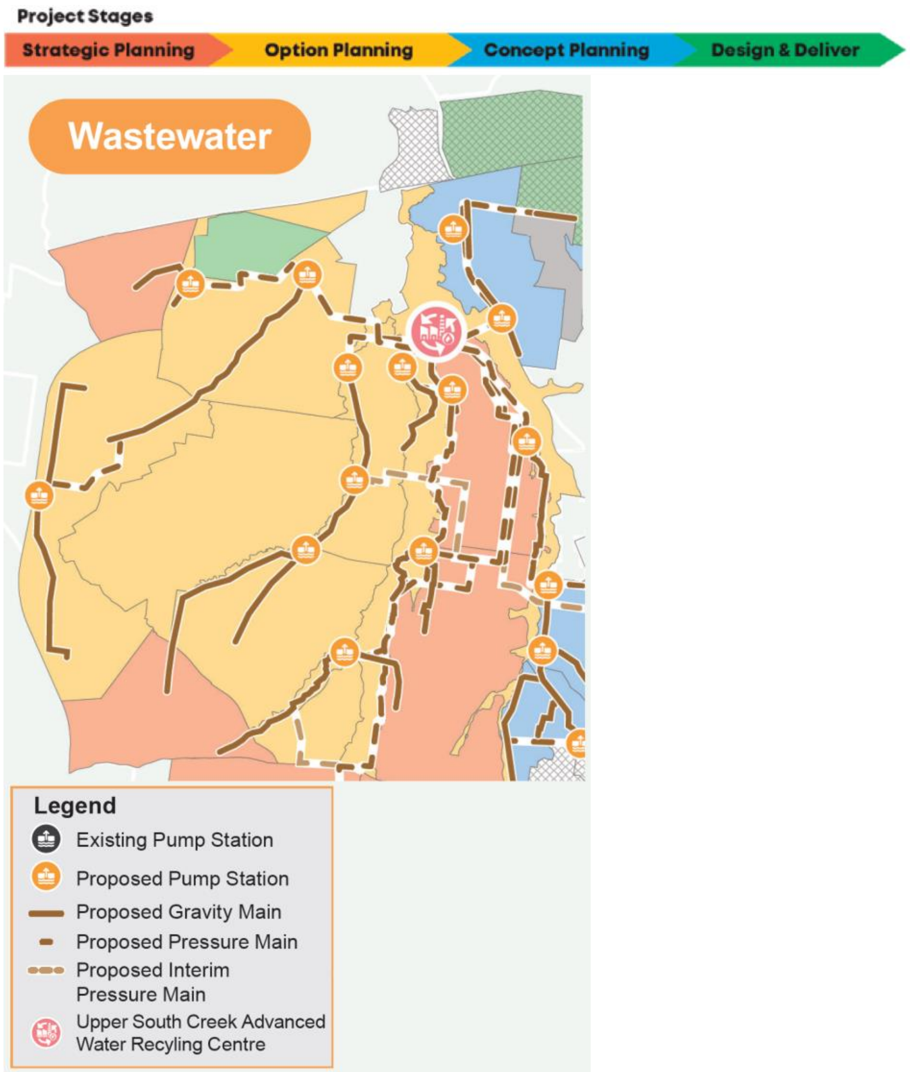


Figure 5-9 Proposed wastewater infrastructure

6 Stormwater management for waterway health

6.1 Overview

DPIE (2022c) has prepared guidance material on stormwater quality and frequent, low-flow controls for the Aerotropolis. This guidance material is to assist catchment managers to design stormwater infrastructure that will deliver the numerical waterway health objectives for both ambient water quality concentrations in waterways and frequent, low flow conditions (Table 1-1, Table 1-2).

The stormwater management objectives and targets developed by DPIE (2022b and 2022c) inform the size, distribution and function of water sensitive urban design (WSUD) and stormwater management asets across the precincts. This study demonstrates how stormwater management assets work towards achieving the stormwater management targets outlined above.

The stormwater management strategy outlined in this document is at a precinct-scale and is intended to work with DPIE (2022c) guidance material on stormwater quality and frequent, low-flow controls.

This strategy seeks to ensure that ample land is provided to facilitate regional stormwater management devices required under the detailed planning that follows rezoning. The land that is earmarked for future stormwater infrastructure must do so in a flexible way that accommodates constraints that are not yet defined (e.g. heritage, soils, detailed waterway bathymetry).

This chapter discusses the development of strategies to:

- Achieve those targets and avoid or minimise adverse impacts of urban stormwater flows on land, native vegetation, waterways, groundwater dependent ecosystems and groundwater systems
- protect and enhance water quality, by improving the quality of stormwater run-off from urban catchments to help achieve local water quality and health objectives
- integrate stormwater management systems into the landscape in a manner that reduces land-take on developable areas while providing multiple benefits, including public open space, habitat improvement and recreational and visual amenity.

6.2 Waterway health

6.2.1 Wianamatta-South Creek objectives

The NSW Government has developed numerical waterway health objectives for Wianamatta-South Creek by applying the *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions* (OEH/EPA, 2017). The waterway health objectives aim to achieve:

i. the protection, maintenance and/or restoration of waterways, riparian corridors, water bodies and other water dependent ecosystems that make up the 'blue' components of the Blue-Green Infrastructure Framework

ii. a landscape-led approach to integrated stormwater management and water sensitive urban design if followed.

The numerical criteria (Table 6-1and Table 6-2) are referred to as water quality and flow objectives and apply to all urban development on land in the Aerotropolis.

The objectives are responsive to the protection and improvement of the condition of high ecological value waterways and water-dependent ecosystems in the Western Sydney Aerotropolis. These ecosystems include some existing native vegetation (ie groundwater dependent vegetation) that are protected under the *Biodiversity Conservation Act 2016* and *Environment Protection and Biodiversity Conservation Act 1999*, and some identified as environmentally sensitive waterways and riparian in existing Local

Environment Plans. These ecosystems are mostly located in the floodplain, and are home to many threatened, critically endangered, and high ecological value species of fauna and flora, including those considered iconic to the area and significant for the local Aboriginal communities.

Table 6-1 Ambient water quality of waterways and waterbodies in the Western Sydney Aerotropolis

Water quality objectives	
*Total Nitrogen (TN, mg/L)	1.72
Dissolved Inorganic Nitrogen (DIN, mg/L)	0.74
Ammonia (NH_3-N, mg/L)	0.08
Oxidised Nitrogen (NOx, mg/L)	0.66
*Total Phosphorus (TP, mg/L)	0.14
Dissolved Inorganic Phosphorus (DIP, mg/L)	0.04
Turbidity (NTU)	50
Total Suspended Solids (TSS, mg/L)	37
Conductivity (µS/cm)	1103
pH	6.20–7.60
Dissolved Oxygen (DO, %SAT)	43–75
Dissolved Oxygen (DO, mg/L)	8

***** DIN and DIP performance criteria should be adopted when modelling using MUSIC software

Table 6-2 Stream flows objectives for waterways and water-dependent ecosystems based on averaged daily flow rates

Flow Objectives	Current condition	Tipping point for degradation
To be applied in Strahler ranked waterways as follows	1^{st}-2^{nd} order streams	3^{rd} order streams or greater
Mean daily flow volume (L/ha) Implied mean annual run-off volume (ML/Ha/yr)	2351.1 ± 604.6 (0.9 ML/Ha/yr)	5542.2 ± 320.9 (2.0 ML/Ha/yr)
Median daily flow volume (L/ha)	71.8 ± 22.0	1095.0 ± 157.3
High spell (L/ha) ≥ 90^{th} percentile daily flow volume	2048.4 ± 739.2	10,091.7 ± 769.7
High spell - frequency (number/y) High spell - average duration (days/y)	6.9 ± 0.4 6.1 ± 0.4	19.2 ± 1.0 2.2 ± 0.2
Freshes (L/ha) ≥ 75^{th} and ≤ 90^{th} percentile daily flow volume	327.1 to 2048.4	2642.9 to 10091.7
Freshes - frequency (number/y) Freshes - average duration (days/y)	4.0 ± 0.9 38.2 ± 5.8	24.6 ± 0.7 2.5 ± 0.1
Cease to flow (proportion of time/y)	0.34 ± 0.04	0.03 ± 0.007
Cease to flow – duration (days/y)	36.8 ± 6	6 ± 1.1

6.2.2 Stormwater Management Compliance Targets

The NSW Government has also developed the following stormwater quality and frequent, low-flow targets to ensure stormwater management contributes to the waterway health objectives being achieved in the Aerotropolis. New development must adopt these targets in designing stormwater and WSUD infrastructure.

Table 6-3 Pollution reduction targets to achieve waterway health objectives

Stormwater quality targets	Operational Phase
Gross Pollutants (anthropogenic litter >5mm and coarse sediment >1mm)	90% reduction (minimum) in mean annual load from unmitigated development
Total Suspended Solids (TSS)	90% reduction in mean annual load from unmitigated development
Total Phosphorus (TP)	80% reduction in mean annual load from unmitigated development
Total Nitrogen (TN)	65% reduction in mean annual load from unmitigated development

Table 6-4 Frequent, low flow targets to achieve waterway health objectives

Option 1: Mean Annual Runoff	Stormwater Flow Target
Mean Annual Runoff Volume (MARV)	2 ML/ha/year at the point of discharge to the local waterway
90%ile flow	1000 to 5000 L/ha/day at the point of discharge to the local waterway
50%ile flow	5 to 100 L/ha/day at the point of discharge to the local waterway
10%ile flow	0 L/ha/day at the point of discharge to the local waterway
Option 2: Flow Duration Curve Approach	**Stormwater Flow Target**
95%ile flow	3000 to 15000 L/ha/day at the point of discharge to the local waterway
90%ile flow	1000 to 5000 L/ha/day at the point of discharge to the local waterway
75%ile flow	100 to 1000 L/ha/day at the point of discharge to the local waterway
50%ile flow	5 to 100 L/ha/day at the point of discharge to the local waterway
Cease to flow	Cease to flow to be between 10% to 30% of the time

6.3 Approach to meeting waterway objectives

Options analysis undertaken in the *Mamre Road Flood, Riparian Corridor and Integrated Water Cycle Management Strategy* (Sydney Water 2020) and *Review of Water Sensitive Urban Design Options for Wianamatta-South Creek* (DPIE, 2022d) determined that the most efficient and effective way to achieve Wianamatta South Creekwaterway health objectives and stormwater targets (DPIE, 2022b) was through a regional approach to stormwater management, including precinct-scale stormwater harvesting and reticulation.

This finding was also documented by DPIE (2022d) who prepared a Which also found that a regional approach to stormwater management is the most cost effective approach to achieving

This approach is shown to provide efficiencies of land use, land take and in asset management while reducing the overall burden of stormwater management on development and the risk of non-compliance. This approach, while removing many of the stormwater infrastructure treatment train off private alotments, still relies on controls on private land that limit the total imperviousness of new development and gross pollutant loads.

WSUD strategies in the following sections compare the infrastructure requirements of on-lot and regional stormwater management approaches for large format industrial typologies.

6.3.1 On-lot stormwater management approach

A workshop was held on 6 August 2020 with Sydney Water, Penrith and Liverpool Councils (and other government agencies including DPIE, INSW and PPO) to understand Councils' preferences for stormwater management infrastructure in their local government areas.The following approaches have been adopted in developing the treatment trains:

- There is a preference for precinct scale biofiltration and wetlands to be well integrated into the landscape and co-located within stormwater detention basins as appropriate.
- For industrial and commercial development, on-lot measures may include a combination of robust and low maintenance elements including use of rainwater tanks, biofiltration basins and proprietary filtration devices. While regional detention basins are not supported, it is likely that wetlands and open water bodies would be better managed as centralised facilities with appropriate funding.
- Street scale rain gardens should be avoided but biofiltration street trees may be incorporated into the streetscape. Subsequent discussions with DPIE's soils teams have identified the benefits of rows of trees to managing shallow, saline groundwater. As well as achieving the NSW Government canopy targets, rows of street trees may play an important role in managing salinity risk associated with irrigation across the landscape, especially on private lands.

An on-lot approach prioritises the use of private rainwater tanks and/or wetlands to maximise the retention and reuse of stormwater on the on-lot. A schematic for this on-lot approach is presented in Figure 6-1, and a cross section is presented in Figure 6-3.

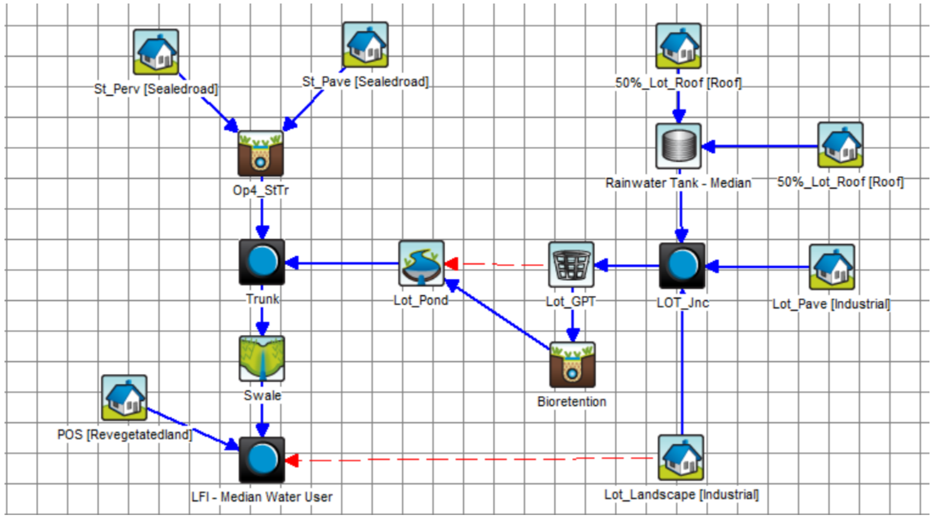
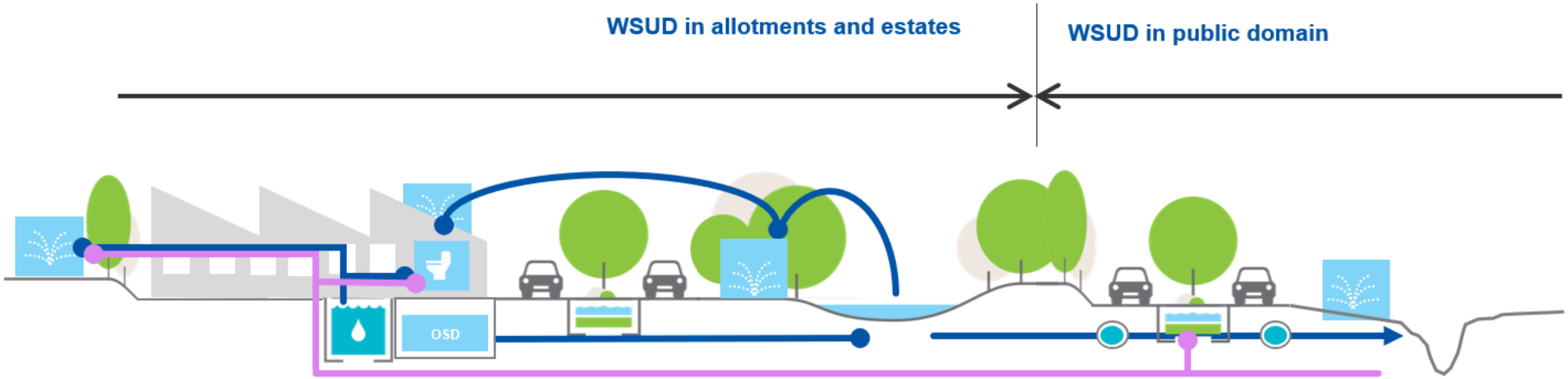


Figure 6-1 Treatment train structure showing on-lot measures

In MUSIC software, the mean daily flow volumes are calculated and expressed as mean annual run-off volume (MARV) in megalitres of run-off per year (ML/year/NHa). This includes allowance for 15% of the precinct to remain as RE1, RE2, E2 and trunk drainage.

The MARV generated by each hectare of Precinct is presented as the stacked column graph on the left side of each graph. The volume of annual stormwater that 1st-2nd order and 3rd-4th order waterways receive is presented as the dark and pale green bars on the left-hand side. The grey bar above this represents the volume of run-off generated that exceeds the waterway flow objectives. The potential stormwater volume reductions associated with the range of IWCM and WSUD approaches are presented as floating bars and the size of each bar represents the effectiveness (magnitude of flow reduction) of each measure.

Large Format Industrial land use, , is expected to be the dominant typology in the Precinct.



1. On the Lot

Rainwater tanks to supply toilets and as many non-potable water demands as possible. Recycled water to top up tank water supply.
Ponds or wetlands to irrigated as much of the site as possible including roofs, landscaping and all vegetated set backs. Recycled water to top up irrigation of gardens and verges.
Filtration and retention to achieve waterway health targets.
On-site stormwater detention (OSD) to ensure no increase in peak flow rate for critical storms. OSD to over attenuate site drainage to accommodate road runoff.
Wetlands and water storages reduce stormwater volumes through evaporative losses and provide cost effective stormwater harvesting opportunities.

2. In the street

Passive irrigation to support urban canopy and achieve stormwater pollution reduction targets for road runoff.

3. Trunk drainage

Where catchments exceed 15Ha, flood conveyance is provided along vegetated constructed channels and existing waterways.

Figure 6-2 Schematic section for on-lot approach

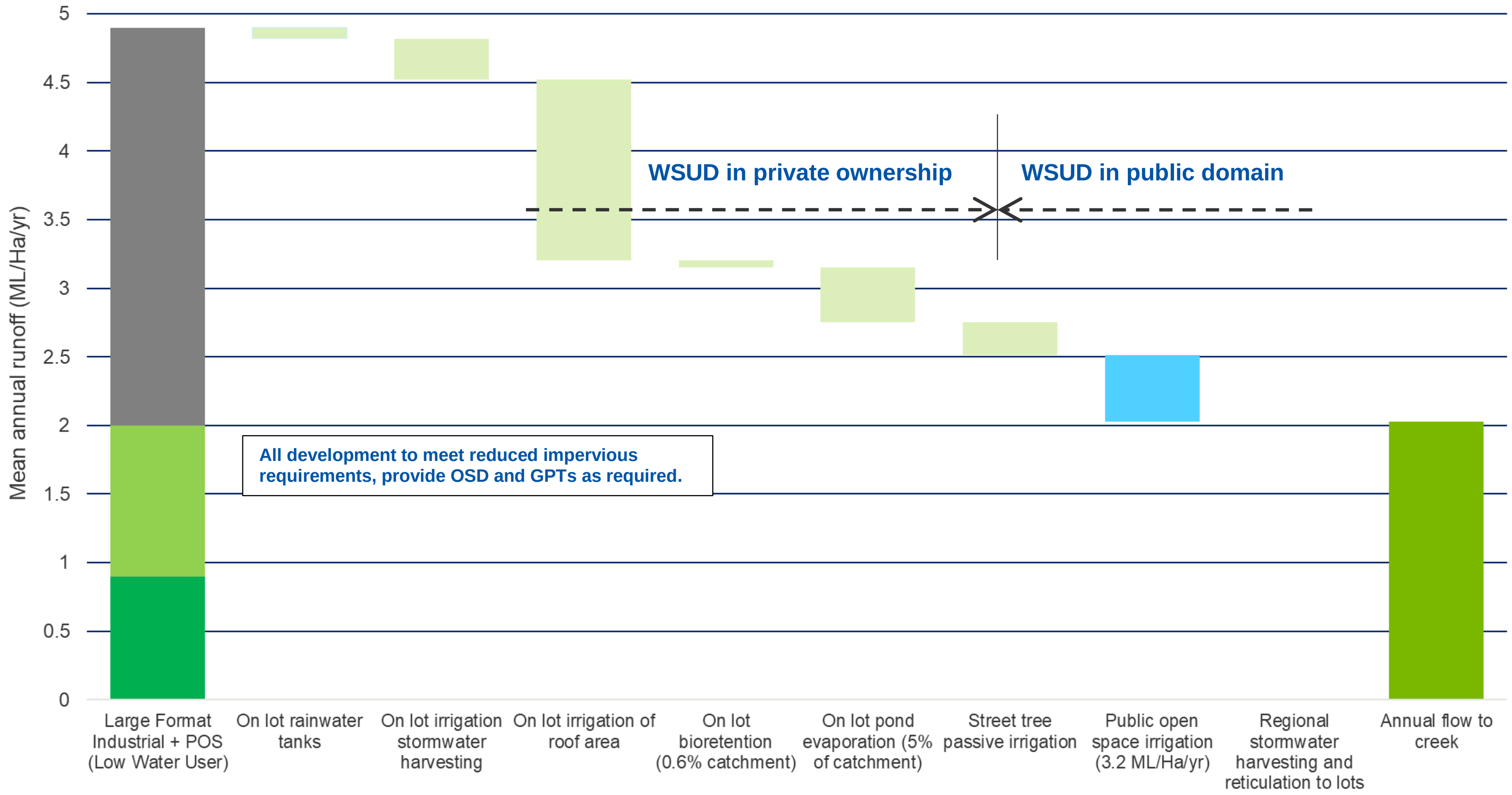


Figure 6-3 Effectiveness of on-lot approach on Large Format Industrial lots with low water use

Figure 6-3shows that rainwater tanks have limited effectiveness on typical, low water use sites. Irrigation of roof, gardens, verges and public open space contributes to achieving the mean daily or annual flow objectives. Under this scenario, additional stormwater harvesting for irrigation of public open space is required to achieve the objectives, which requires an additional level of governance and catchment coordination through Councils or a trunk drainage manager.

While no single measure will deliver the required flow reductions, the combined effect of all measures can deliver the mean daily or annual flow objectives for the Precinct. However, this would require significant on lot investment, maintenance and land take.

Residual Risk

Achieving the flow objectives through on-lot measures is highly dependent on imperviousness and water demands on the lot.

While the water balance shows that it is possible to achieve the flow objectives on median and low water use sites, there is a risk of failure if on-lot measures are not designed or constructed correctly are abandoned or inadequately maintained. To manage this risk, arrangements such as compliance officers to ensure or enforce compliance for on-lot WSUD and IWCM measures would be required. There is also a risk that the significant land take required for an on-lot approach is deemed unfeasible by developers who would need to forgo large areas of developbale land to allow for on lot stormwater assets.

A regional approach to stormwater harvesting mitigates these risks.

6.3.2 Regional stormwater management approach

The preferred stormwater management approach is for a series of consolidated regional wetlands and storages to be delivered in optimal locations to capture and treat stormwater runoff. Following capture and storage, stormwater would be conveyed via pipeline to strategically located pumping facilities where it will be transferred to reservoir sites for final treatment and mixing with recycled wastewater from the AWRC. The combined stormwater/recycled water will then be stored and distributed via the third (purple) pipe network. Whilst development will still need to allow for a level of on-site permeability, stormwater detention and GPT's, the footprint for stormwater management within development sites is significantly reduced. This approach does however require sufficient, suitably located land is allocated for regional stormwater assets to be provided.

Land required for stormwater assets is identified in maps is presented in Section 9.

The ongoing management and maintenance of regional stormwater infrastructure requires a coordinated, consistent and catchment-based approach which can readily cross precinct and local government boundaries.

The regional approach removes reliance on private rainwater tanks and stormwater harvesting on the lot and utilises a centralised stormwater harvesting network to capture, filter and reticulate stormwater to lots and public open space across the precincts. This approach consolidates all stormwater and IWCM measures into a regional strategy that takes advantage of the third pipe (purple pipe) reticulation network. It also overcomes the risk of low water users occupying the precinct as a regional stormwater harvesting approach can buffer the difference between low and high median water demands more effectively than on-lot tanks and ponds.

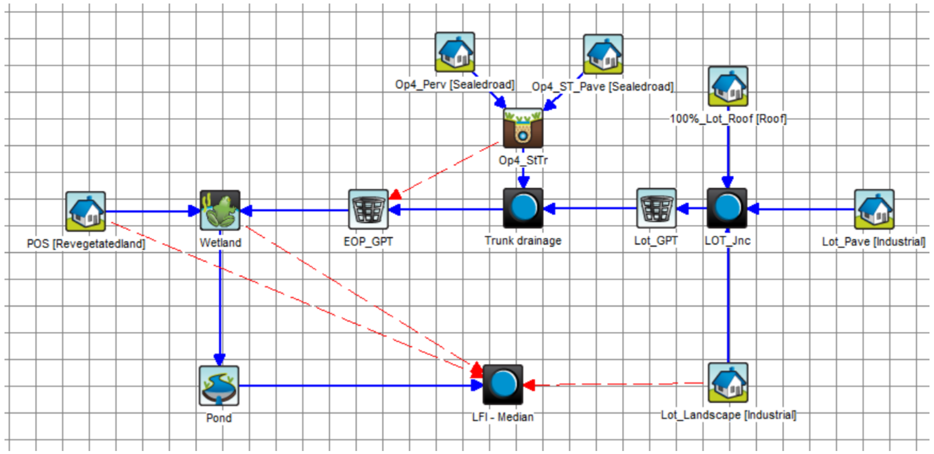
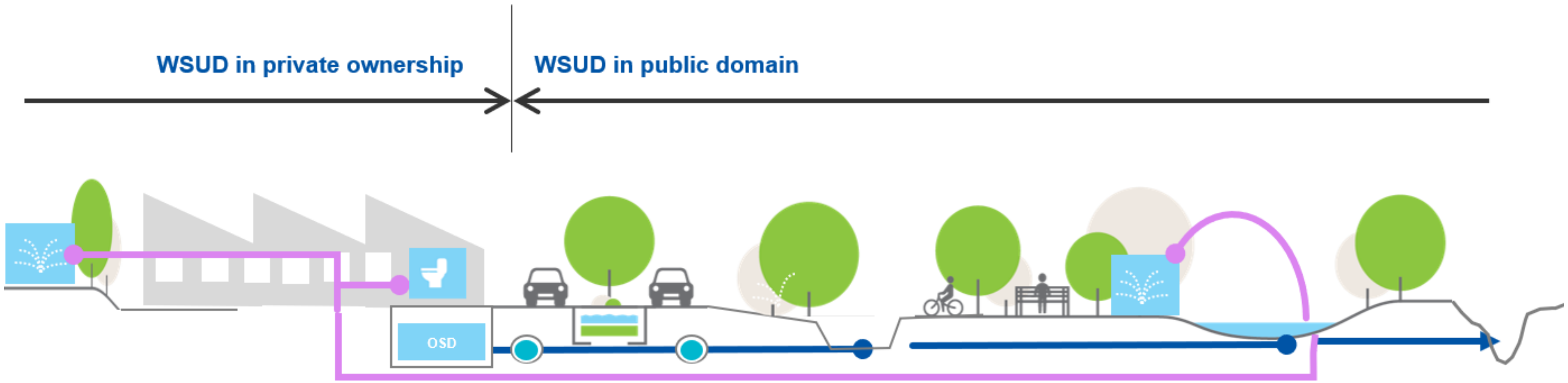


Figure 6-4 Regional approach treatment train structure

A schematic for the regional approach is presented inFigure 6-5 and a cross section is presented in Figure 6-5. MUSIC modelling results for the regional stormwater strategy is shown in Figure 6-6.



1. On the Lot
GPTs provide filtration to manage nuisance litter and sediment.
On-site stormwater detention (OSD) to ensure no increase in peak flow rate for critical storms. OSD to over attenuate site drainage to accommodate road runoff.

2. In the street
Passive irrigation to support urban canopy and achieve stormwater pollution reduction targets for road runoff.

3. Trunk drainage
Where catchments exceed 15 Ha, flood conveyance is provided along vegetated constructed channels and existing waterways. Constructed wetlands, ponds and water storages capture stormwater for harvesting and reuse in the private domain and for irrigation of gardens, verges and public open space.

Figure 6-5 Schematic section for regional approach

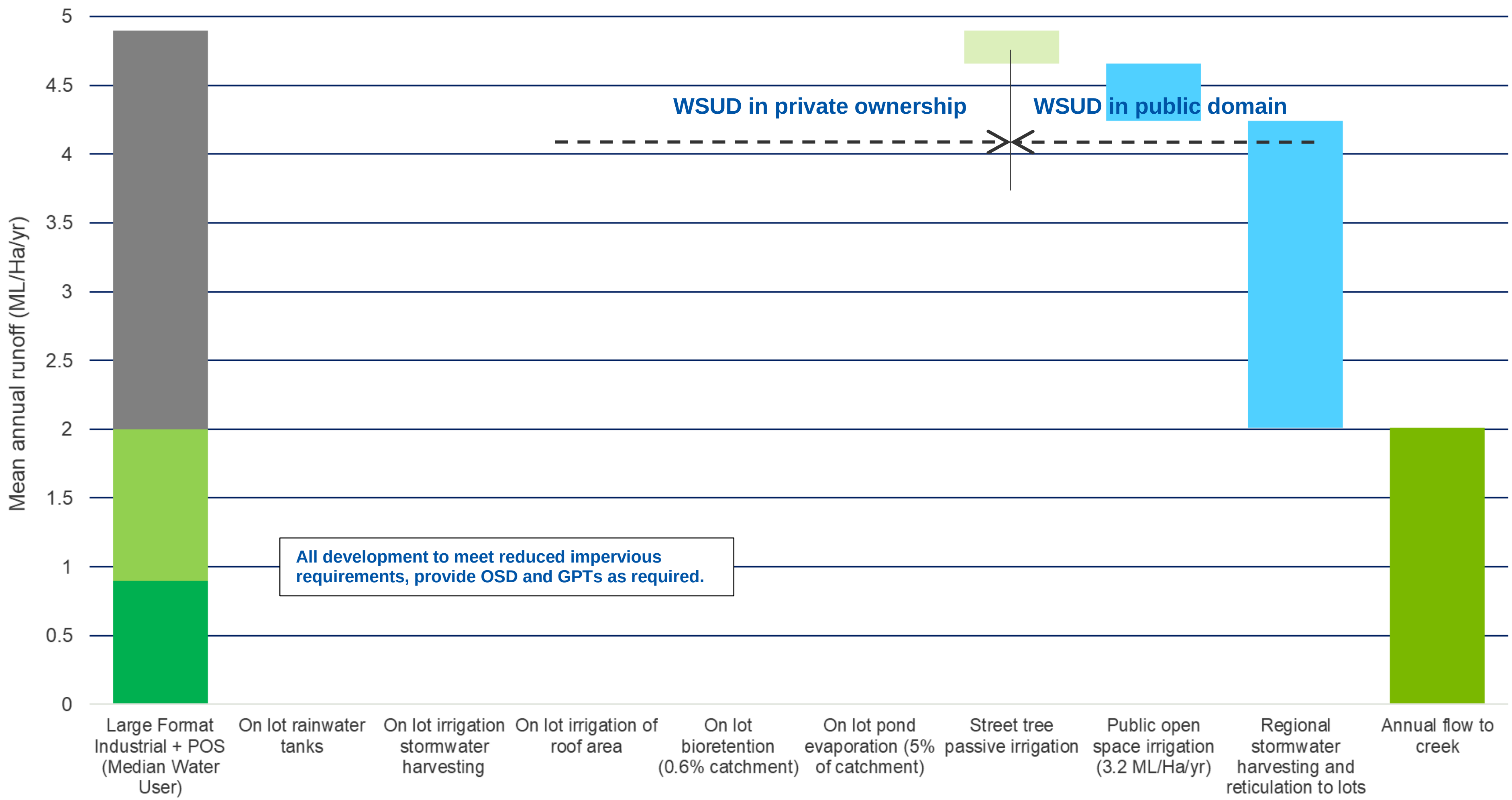


Figure 6-6 Effectiveness of regional stormwater harvesting with median water use on Large Format Industrial typologies

Figure 6-6 shows that regional stormwater harvesting on large format industrial lots combined with irrigation of public open space and passively irrigated street trees achieves the mean daily or annual flow objectives.

Residual Risk

The water balance for regional harvesting overcomes the risk that low water users in the Precinct do not result in sufficient reduction of stormwater volumes to achieve the mean daily and annual flow objectives. This is achieved by combining high and low water users into the same harvesting and reticulation system, and using a stormwater harvesting network that has capacity to buffer the high and low water demands.

Regional harvesting is also shown to achieve the flow objectives by consolidating stormwater management elements and removing reliance on privately owned and maintained infrastructure.

This centralised management of water also provides a scale of WSUD assets that is more cost-effective for maintenance and management and allows integration with the recycled water network.

The regional harvesting requires the introduction of centralised and coordinated stormwater harvesting management on a scale that is not currently provided. To maximise economic benefits, flood fringe land within the adjacent Wianamatta Precinct should be the preference to locate regional wetlands and water storages.

6.4 Flow Duration Curves

Flow duration analysis as per DPIE (2022c) guidelines has been undertaken using the mean annual runoff approach for initial precicnts by modelling utilises the MUSIC modelling template developed by DPIE (2022c) having a mean annual rainfall depth of 691mm and potential evapo-transpiration of 1338 mm.

Stormwater models have been developed for the following typologies as outlined in Table 2-5 above. Modelling results for the following typologies are are summarised below:

- Large format industrial (LFI) plotted in Figure 6-7
- Business campuses (BC) plotted in Figure 6-8
- High density residential (HDR) plotted in Figure 6-9
- Medium density residential (MDR) plotted in Figure 6-10
- Commercial (COM)

Results of modelleing each typology using the DPIE modelling toolkit (DPIE, 2022e) is summarised in Table 6-5 below showing compliance with the targets can be achieved using the treatment train outlined above in Figure 6-4. Further detail on the size of each element in the treatment train is provided in Section 9.

Table 6-5 Stormwater flow targets (Alternative 2)

Indice	Target	LFI	BC	COM	MDR	HDR
MARV (ML/ha/yr)	< 2	2.0	2.0	2.0	2.0	1.5
90%ile	1000 to 5000 L/ha/day	2563	4520	2535	2648	1745
50%ile	5 to 100 L/ha/day	30	39	29	93	93
10%ile	0 L/ha/day	0	0	0	0	0

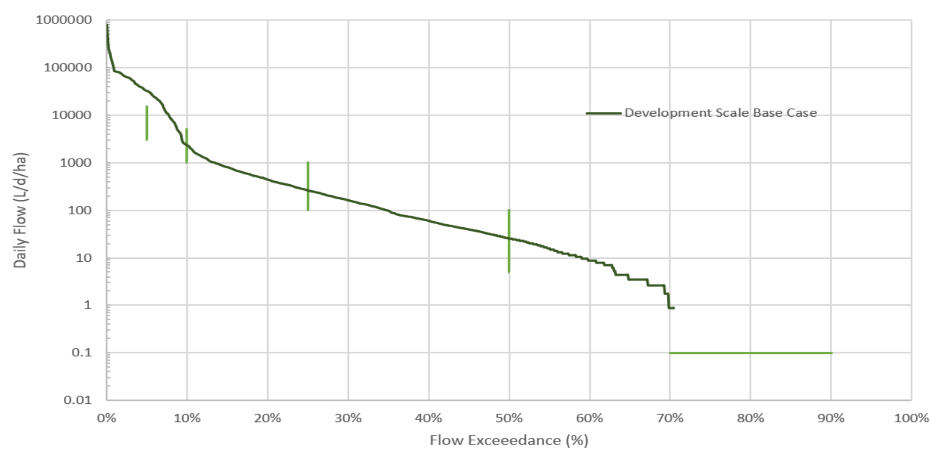


Figure 6-7 Flow duration curve for **large format industrial** typology and regional stormwater harvesting treatment train

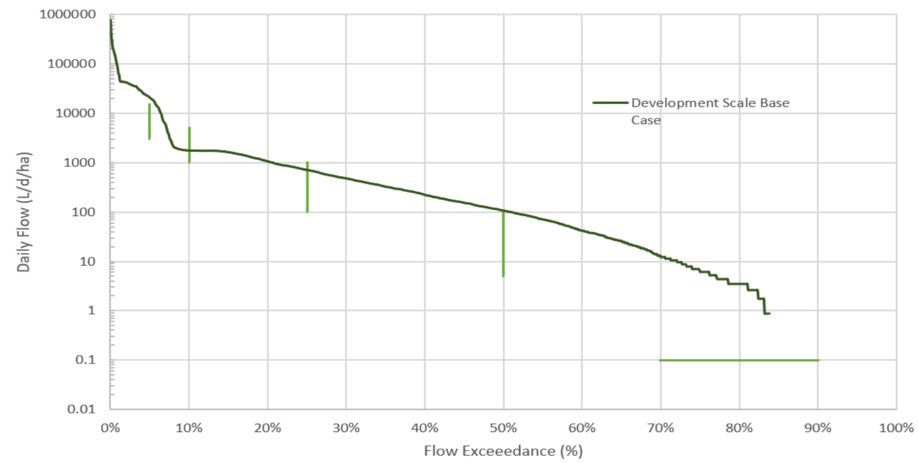


Figure 6-9 Flow duration curve for **high density residential** typology and regional stormwater harvesting treatment train

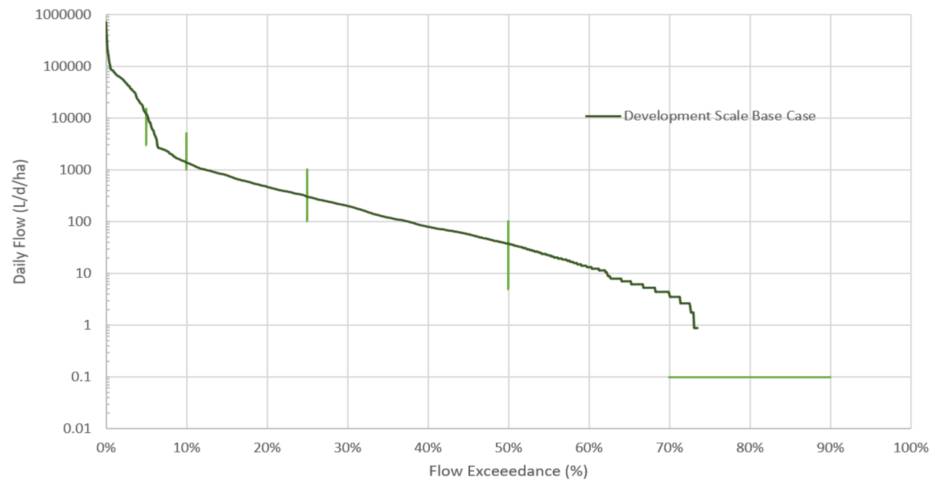


Figure 6-8 Flow duration curve for **business campus** typology and regional stormwater harvesting treatment train

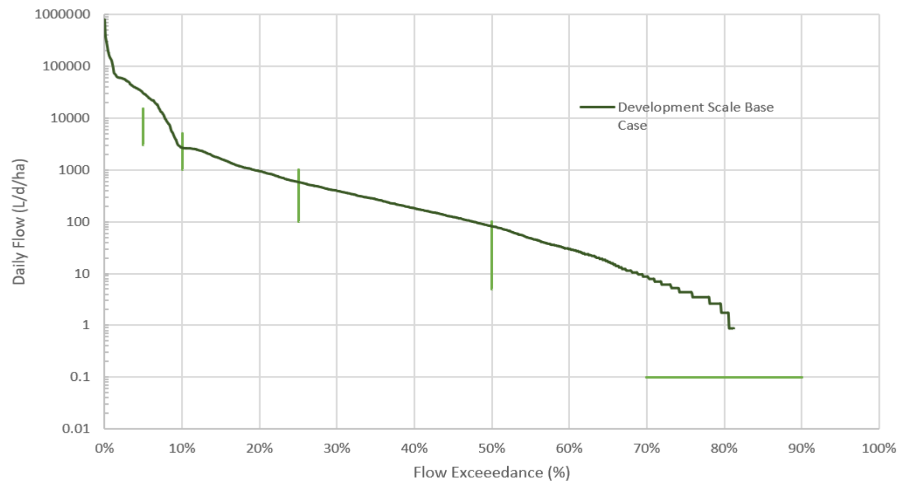


Figure 6-10 Flow duration curve for **medium density residential** typology and regional stormwater harvesting treatment train

6.5 Stormwater Pollution Load Reductions

Stormwater pollution reductions for the proposed treatment train have been determined using the recommended MUSIC template from DPIE (2022c).

Pollutant load reductions for the regional stormwater management approach is provided in Table 6-6. demonstrating that strategies for each typology will achieve the required pollution reduction targets.

6.6 Regional Stormwater Harvesting Schematic

The lowest risk approach to achieving stormwater flow objectives is via centralised open water bodies and wetlands connected to a precinct wide reticulation network. This approach utilises the highest water demands across the precicnts and thereby reduces the size of stormwater infrastructure storages.

Aplan indicating required land forregional stormwater assets is provided in Section 9.

Table 6-6 Stormwater pollution reductions for regional and on-lot approaches for each typology

Indice	Target*	Reduction in Mean Annual Loads				
		LFI	BC	COM	MDR	HDR
Gross Pollutants **	90% reduction	99.9	99.8	99.9	99.9	99.9
Total Suspended Solids (TSS)	90% reduction	94.8	94.3	94.8	94.5	97
Total Phosphorus (TP)	80% reduction	83.6	82.1	83.9	83.1	90.1
Total Nitrogen (TN)	65% reduction	74.3	69.1	74.5	68.1	78.6

* reduction in mean annual load from unmitigated development
** anthropogenic litter >5mm and coarse sediment >1mm

7 Stormwater detention

7.1 Overview

The *Stormwater and Water Cycle Management Study* aims to identify a suitable strategy that would maintain peak flow rates at the precinct boundary to minimise the risk of downstream impacts on stream morphology and preserve peak flow rates. By attenuating the peak flowrates, the potential of flooding for downstream properties can be maintained at or below existing levels ensuring that the flood immunity afforded by flood planning controls can be maintained. Stormwater detention is an industry accepted method to reduce the higher peak flowrates that are generated by urbanisation of undeveloped catchments.

It is important to note that current and future flood planning may consider the impacts of development on overall timings of flows from contributing tributaries of Wianamatta-South Creek. This work and any subsequent strategy derived from this work may result in changes to the precinct-scale stormwater detention strategy and may inform future refinement of the stormwater detention requirements.

This chapter discusses the development of:

- Strategies that aim to meet broad but preliminary objectives of peak flow management.
- Stormwater detention basins sizes at suitable locations to retard flows to meet existing case peak flows for a range of events up to the 1% AEP.

7.2 Hydrologic model development

7.2.1 Catchments modelled in XP-RAFTS

Hydrologic models (XP-RAFTS) have been developed for this study for:

- Badgerys Creek
- Cosgrove Creek
- Duncans Creek
- Mulgoa Creek
- A portion of Wianamatta-South Creek (downstream of Bringelly Road to Twin Creeks estate)
- Unnamed Creek in Science Park.

These models have been created to simulate the distribution and volume of stormwater run-off generated at key locations within the precincts under existing (ie mainly rural) and post development conditions.

The models will be used to simulate changes in 50% AEP, 10% AEP and 1% AEP hydrographs at the precinct boundaries.

7.2.2 Rainfall data

The *Australian Rainfall and Run-off* (ARR) 1987 (ARR87) was adopted for water quantity and stormwater management. This is consistent with planning in the Penrith LGA and has been adopted in this study for consistency and through consultation with the Western Sydney Planning Partnership Flood and Stormwater Management Technical Working Group.

Examples of the intensity frequency duration data adopted for the precincts is shown in Figure 7-1.

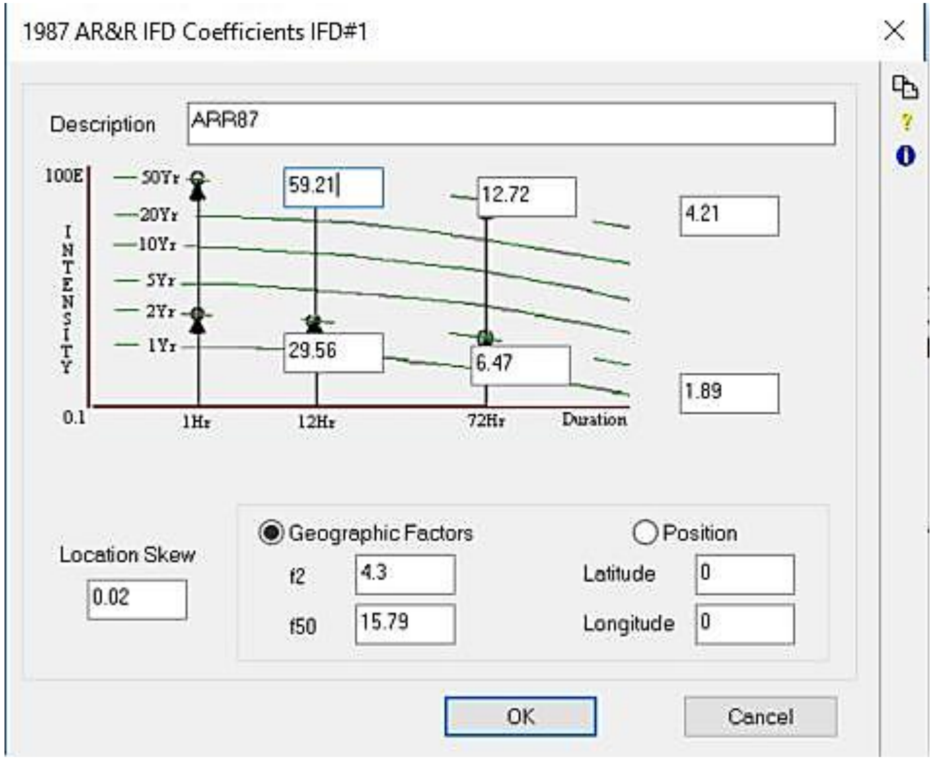


Figure 7-1 Typical IFD parameters adopted in RAFTS modelling

7.2.3 Sub-catchment areas

Catchment boundaries were discretised using LiDAR survey of the precinct catchments. Catchment mapping is shown in Figure 1-2.

Changes in local sub-catchment boundaries are likely following regrading of the precincts for industrial land uses. However, changes to the total creek catchment areas will not be significant due to an expected match of gains and losses.

Approximate sub-catchment areas of 15ha were adopted to reflect the notional catchment size at which stormwater networks would generally be considered as trunk drainage systems.

7.2.4 Assumed catchment parameters

Rainfall losses account for the rainfall that does not directly contribute to run-off and some rainfall is soaked into the ground, intercepted by plants or stored in small depressions on the surface.

Losses adopted for rainfall in the models were based on guidelines in ARR2019. In accordance with this, existing case losses for the pervious land surface were to be based on an average of model calibrations. Models were calibrated to 1986, 1988 and 2015 rainfall data. The adopted rainfall losses following calibrations are summarised in Table 7-1.

Table 7-1 Adopted rainfall losses within hydrological models

Land Surface	Initial Loss (mm)	Continuing Loss (mm/h)
Pervious	23	0.94
Impervious	1	0

Post development catchment conditions will be modelled using the imperviousness rates shown in Table 2-2. Rainfall losses were adopted across the whole developed catchment, even with imperviousness rates less than 100%. This results in more conservative flows, however sensitivity tests, showed that the difference is minimal, as discussed in Chapter 7.9.

7.3 Overall strategy for stormwater quantity management

The overall stormwater strategy adopted is comprised of two components:

- onsite stormwater detention
- detention basins with staged outlet flows.

Preliminary modelling results demonstrated that detention basins alone would be insufficient in mitigating the increased flow effects due to development of the region. To meet the flow and timing requirements then, onsite stormwater detention (OSD) was provided on each development. The details of the design of the OSD structures is outlined in 7.4.

OSD mitigates up to one-third of the developed case flows, therefore key locations were chosen where detention basins were placed, within open spaces, to further reduce flows. Detention basins were placed at locations with controls as discussed in 7.5.2.

There are other elements that have not been quantified as a part of the stormwater strategy but would provide additional attenuation performance. The first is storage in wetlands gained through stormwater reuse, as discussed in Chapter 4.1. This additional storage would be available in the smaller, more frequent events.

Secondly, there are opportunities to increase vegetation in channels within open spaces. It has been demonstrated that the vegetation of the channels further reduced the flows within the main streams, resulting in improved flow attenuation.

Hence the assessments documented in this chapter represent a lower-bound of the likely performance possible.

7.4 On-site stormwater detention strategy

The urbanised model was developed to a much higher level of detail to enable modelling of individual lots with individual OSD elements modelled as detention basins. Storage rates were based at a water level of 1.5m and vary with land-use type:

- 337.5m^3/ha at 1.5m height for land uses classified as Mixed-use
- 450m^3/ha at 1.5m height for all other land uses.

The OSD outflows are adopted from accepted Western Sydney design standards. The standard curve used for the outflow is shown in Figure 7-2. The curve specifies an outflow per hectare of developable area for stages up to 2m in the OSD.

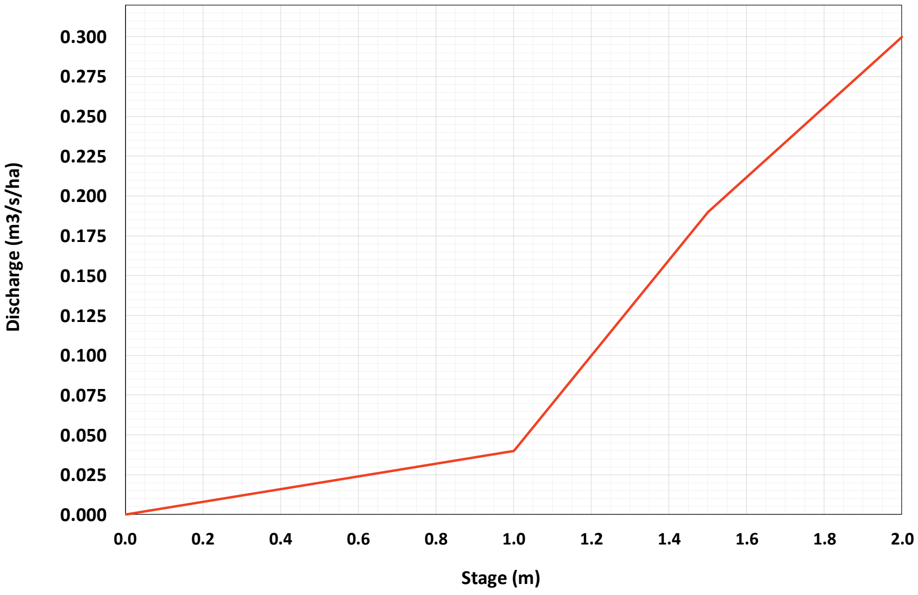


Figure 7-2 Typical OSD Outflow curve per ha of development

Addition of the OSD features on development lots demonstrated an average of about 20% to 30% reduction in flows at key reporting locations. A set of 12 arbitrary development lots were chosen within Cosgrove Creek. The efficiency of these OSD basins is shown in Figure 7-3.

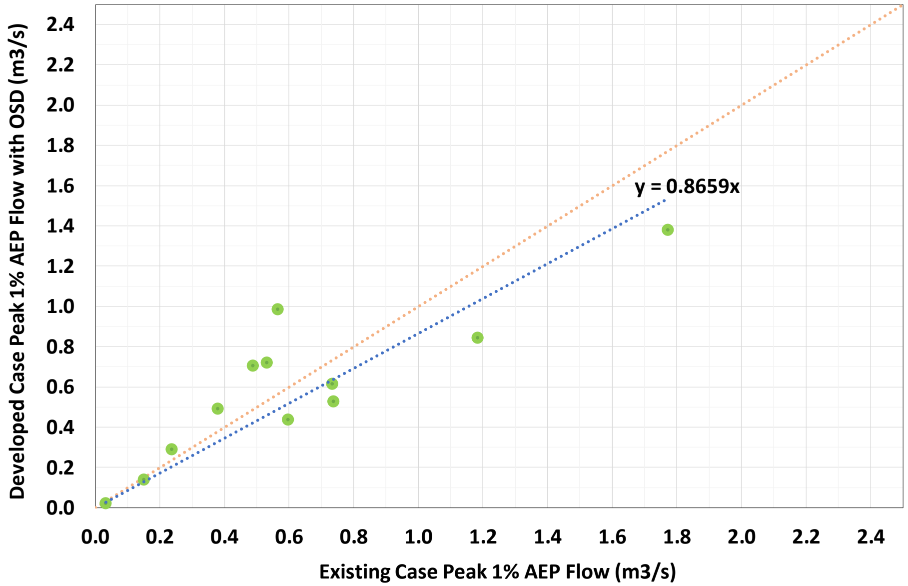


Figure 7-3 OSD Performance in Cosgrove Creek

Where the developed case flow is greater than the existing case flows, the OSD basins are deemed inefficient. The figure above demonstrates an efficacy of about 50%, due to longer storm durations. In longer events, OSDs reach capacity before the peak of the storm and so are less effective at further flood detention.

In addition to the effect of storm durations, the OSD strategy does not detain water from all developments, particularly roads, which have a high degree of imperviousness. For these reasons, OSD infrastructure alone is insufficient as the complete stormwater management strategy.

7.5 Detention basin development

7.5.1 Design assumptions

Preliminary basin sizes were taken to be 5% of the contributing catchment area. XP-RAFTS modelling of the flows for the 1%, 10% and 50% AEP events with these basins allowed for the refinement of basin sizes.

To inform the refined sizing of the detention basins across all catchments, it was assumed that the existing terrain would remain the same at the chosen locations. Following this assumption, the volume within the basin with respect to increasing flood height was taken from the existing terrain. Basin embankments were placed with consideration of the natural contours of the terrain, placing them where it was possible to optimise the storage of the basin.

An example of the stage storage curves adopted is shown in Figure 7-4.

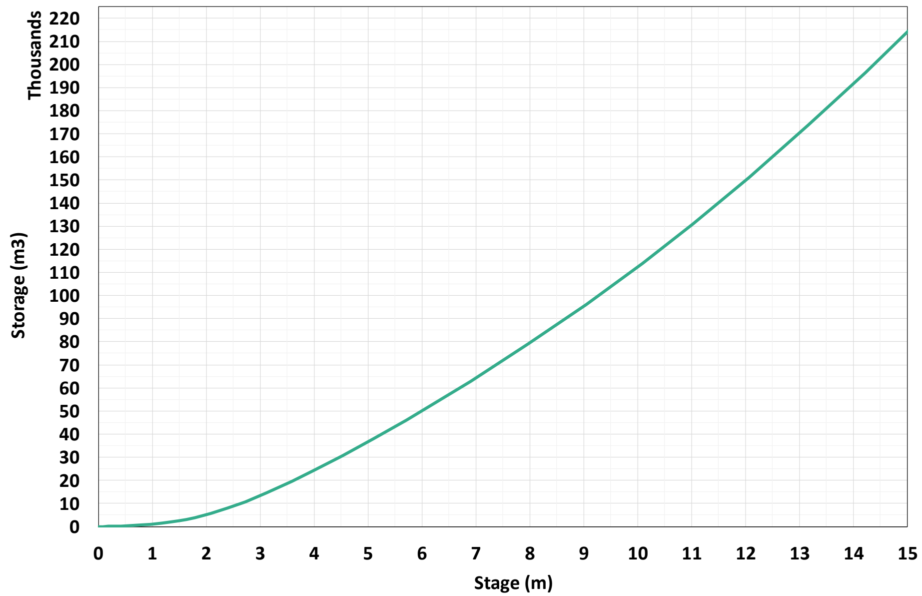


Figure 7-4 Example detention basin stage storage curve

The typical basin arrangement included the following features:

- 1V:6H batter slopes
- natural longitudinal slopes on bed of basin (0.5–1% slopes to allow for suitable drainage)
- two-stage outlet with:
  - a low-level outlet at the bed of the basin with a 0.6m high RCBC (variable width) to discharge all flows up to about the 50% AEP local run-off event
  - a high-level outlet that engages at a depth of 1m via a drop inlet structure with two additional 0.6m high RCBC (variable width but assumed to be same dimension as low level culvert) to discharge all flows up to the 1% AEP local run-off event in conjunction with the low-level culvert.

The stage-discharge curves were then developed for this outlet arrangement assuming inlet control. An example stage-discharge curve is presented below for a 1.0m wide RCBC.

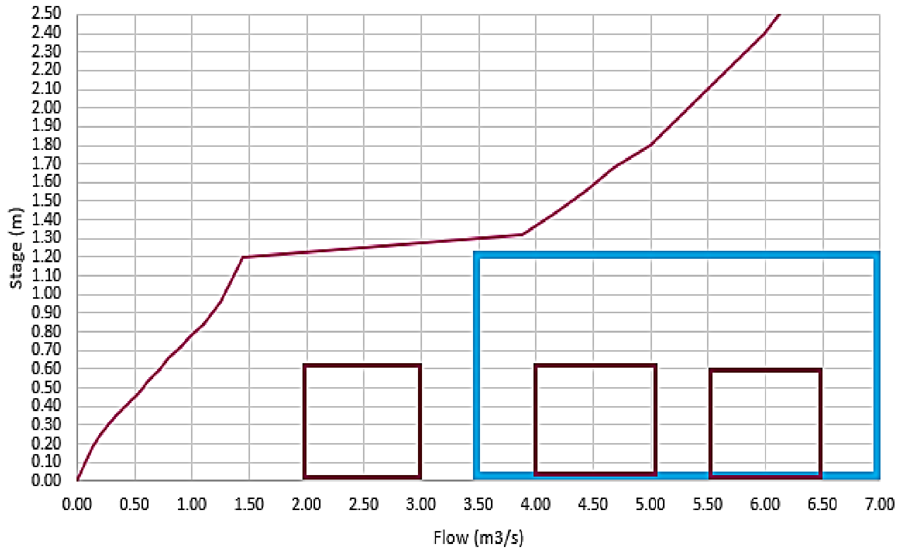


Figure 7-5 Typical stage storage curve used in XP-RAFTS modelling

7.5.2 Detention basin sizing process

A set of guiding principles and rules were used in this sizing exercise.

1) Co-locate detention basins with WSUD elements where possible with a recognition that some WSUD elements may reduce the efficacy of detention basins.
2) Locate basins on existing trunk drainage lines\creeks and outlets to the main creek. Assume open drainage for catchments greater than 15ha.
3) Identify opportunities and constraints including:
   a) Precinct layouts (preliminary)
   b) Regional roads
   c) New proposed roads (regional, motorways etc)
   d) New and existing railway lines
   e) Major services
   f) Flood extents for 1% AEP for the major watercourse floodplains (eg Wianamatta-South Creek, Cosgrove Creek etc). Keep basins out of the floodway and flood fringe unless they are online in 2nd order waterways
   g) Environmental lands – high ecological value vegetation
   h) Proximity to airport
   i) Proposed parkland spaces – integrate basins within open parkland areas
   j) Existing bodies of water and dams to be protected/retained
   k) Contaminated sites
   l) Aboriginal heritage
   m) Riparian corridors
4) General rules for basin siting:
   a) Fewer and larger basins for maintenance purposes.
   b) Small catchments discharging directly into major creeks (e.g. Cosgrove Creek, Wianamatta-South Creek) will not be viable. Use a feasible catchment range of 2ha to 100ha for locating basins.
   c) Larger basins may be needed to offset smaller catchment areas where flows would not pass through any detention basin. This can be considered at a later stage of IWM strategy development when more detail is available.
   d) Consider off-line basins that can be integrated into active open spaces and corridors. These should be placed where grades are greater than 2%, outside of the 1% AEP floodway and upstream of farm dams.
   e) Consider on-line basins that follow natural riparian paths (eg a series of weirs along a meandering creek). These should be placed at the start of Strahler 3rd order streams, and at road crossings where grades are less than 2%.
5) Riparian corridor requirements:
   a) Place basins in suitable locations based on vegetated riparian zone (VRZ) requirements of 10m for Strahler 1st order streams and 20m for Strahler 2nd order streams.
   b) Preference is for placing basins within designated green space areas and in visible locations (e.g. not at the back of developments).
6) Add additional basins or consolidate as needed depending on site constraints.

7.5.3 Detention basin sizes and locations

A total of 38 stormwater detention basins (not including WSUD only features) have been sized and located across the four initial precincts. Figure 7-14 to Figure 7-18 show the basin footprints, for the 1% AEP event, across the four individual precincts.

More detailed investigations and design resolution of basins will be required at the development stage, with consideration to changes in terrain resulting from construction and changes to catchment boundaries.

7.5.4 Issues with detention basin sizes and locations

There are some issues with locating basins where there are existing farm dams. Extracting stage-volume relationships from these locations would not have provided a realistic result on basin performance. Surrounding terrain was analysed to provide more appropriate basin volumes.

As well, the size of basins required to comprise the detention strategy alone would be great due to steep slopes in the terrain. Batter slopes of 1V:6H would also add considerably to the footprint of the basins and is likely to lead to more open space than originally planned.

Hence, it is considered that a reliance upon end-of-pipe detention basins alone is unlikely to yield a suitable balance between flow management performance and viable land yield and economical development.

So, a focus on a mix of detention strategies including on-line detention basins and OSD has been assessed. The siting and number of OSD elements and detention basins has been revised following the assessment of the impacts of development on the overall impact on hydrograph timings in the broader Wianamatta-South Creek system.

7.6 Hydrological modelling of detention elements

The post development hydrological models were developed to a high level of complexity. In accordance with the overall strategy, each catchment was divided into three nodes:

- Existing area (EX)
- Developed area (DA)
- Parks and roads (PR).

Existing areas are areas of catchment that are outside of the Precinct plan and remain undeveloped.

Developed areas were isolated to model as OSD. To achieve an understanding of the OSD performance it was treated as a detention basin in the program XP-RAFTS.

Parks and roads were modelled using the first and second sub-catchment method in XP-RAFTS. Figure 7-6 shows an example of the model layout at a sub-catchment level.

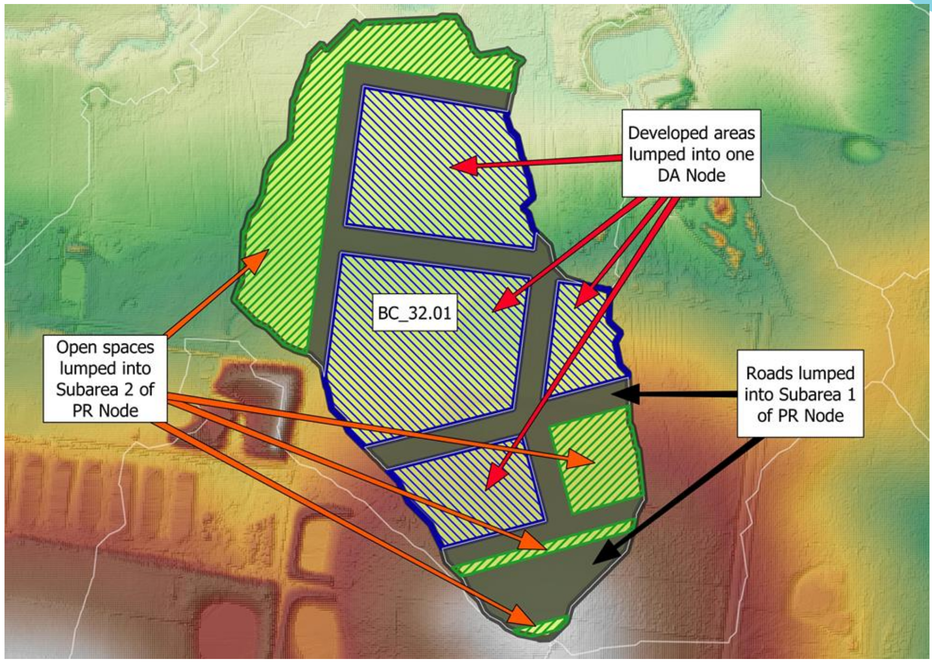


Figure 7-6 Model layout

7.7 Changes to flood flows and timings with OSD and detention basins

This model was used to derive flows for a range of 1%, 10% and 50% AEP storms for the existing case and three developed cases:

- developed with no detention
- developed with only OSD
- developed with both OSD and detention basins.

The catchment outcomes for all the AEP events are shown from Table 7-2 to Table 7-7.

The ratio between the flows of the existing case and the final solution (with basins and OSD) is also shown in the tables. Where the ratio of the flows is:

- below 100% – the ratio is shown as green.
- between 100% to 110% – the ratio is shown as yellow.
- greater than 110% – the ratio is shown as red.

Based on the modelling results, it was observed that the OSD alone would contribute to a flow reduction of about 20% to 40% in the upper reaches of the catchment, and about 2% to 5% further downstream.

Figure 7-14 to Figure 7-23 show the changes in peak flows at critical locations of development and at locations in the main creek channels for both the 1% AEP and 50% AEP storm events. Peak flows within the main creeks would be reduced to below existing case levels following the introduction of detention basins.

Changes in development affected both the timings of the flow as well as peak flows, resulting in earlier peaks and reduced critical storm durations. This occurs due to the increased imperviousness of the development, causing flows to run off faster and increase in magnitude as well. Detention basins were therefore placed in the upper reaches of the catchments to counter this effect.

The difference in flows timing is demonstrated in Figure 7-7 to Figure 7-12. The figures demonstrate that post development, the peak flows are changed by less than 0.5 hours. This reduction in time to peak is further reduced to less than 0.25 hours after the addition of the detention basins in the developments.

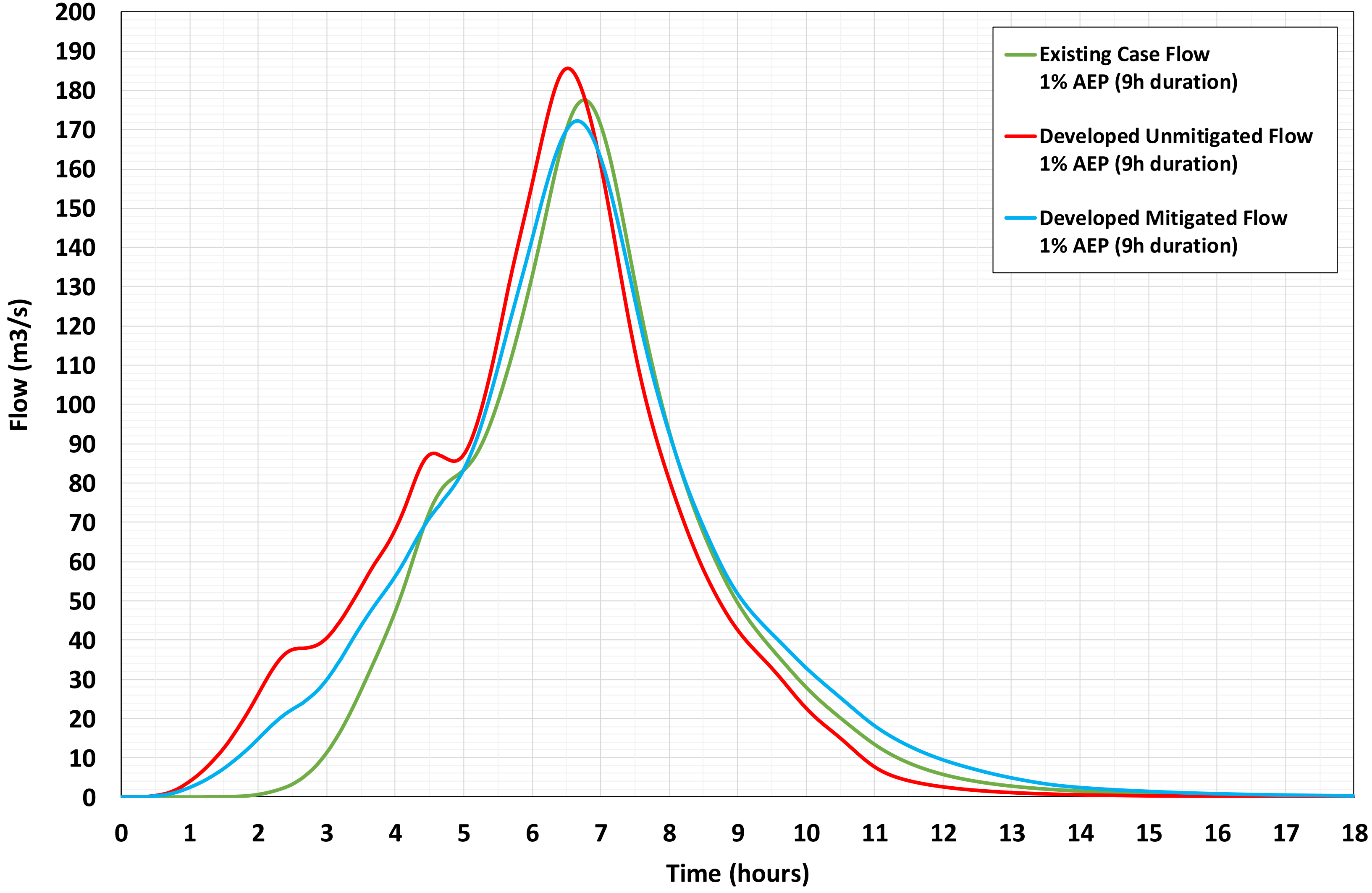


Figure 7-7 Flow comparison pre-development and post-development at downstream node in Cosgrove Creek

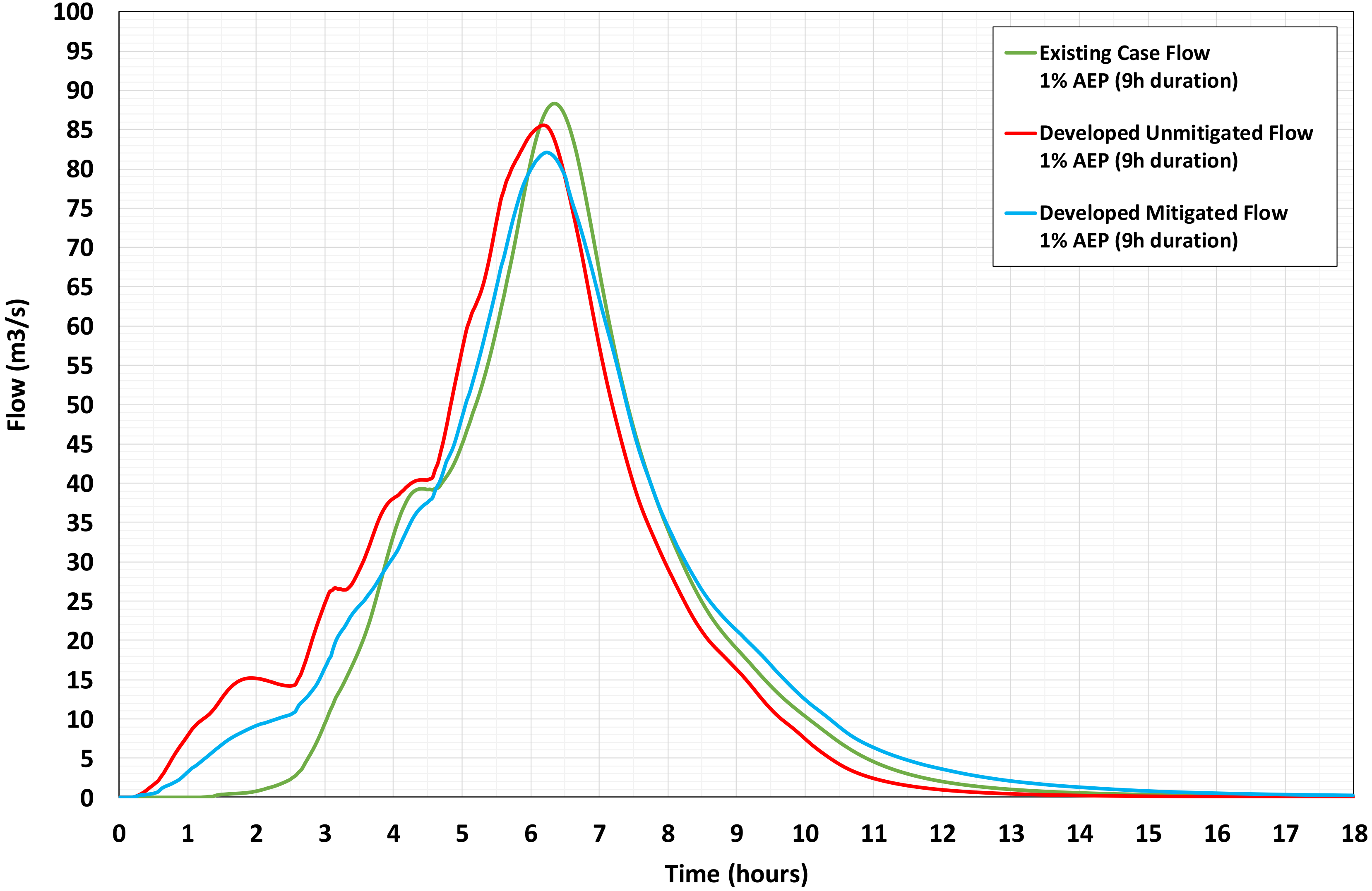


Figure 7-8 Flow comparison pre-development and post-development at downstream node in Science Park

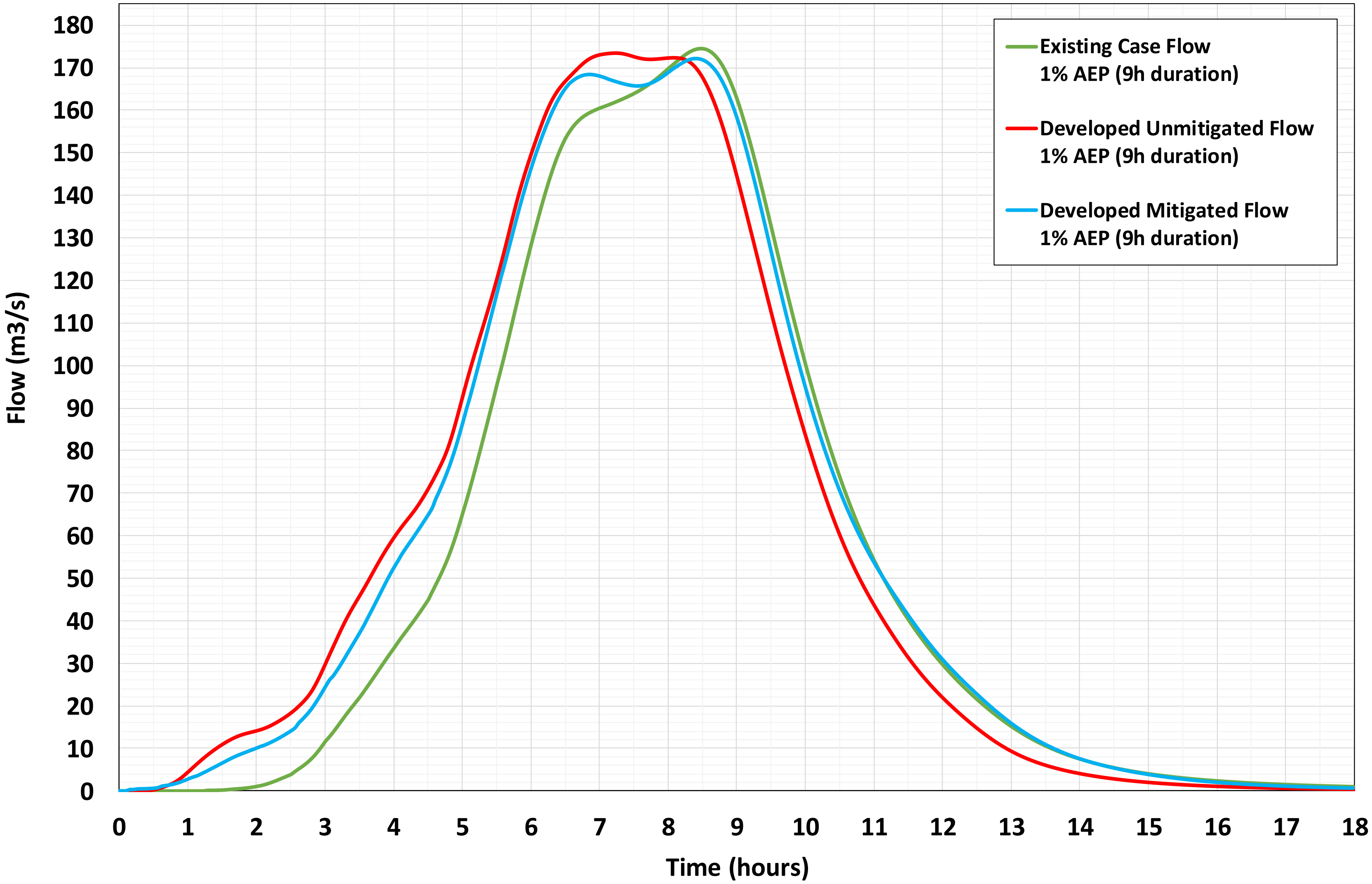


Figure 7-9 Flow comparison pre-development and post-development at downstream node in Badgerys Creek

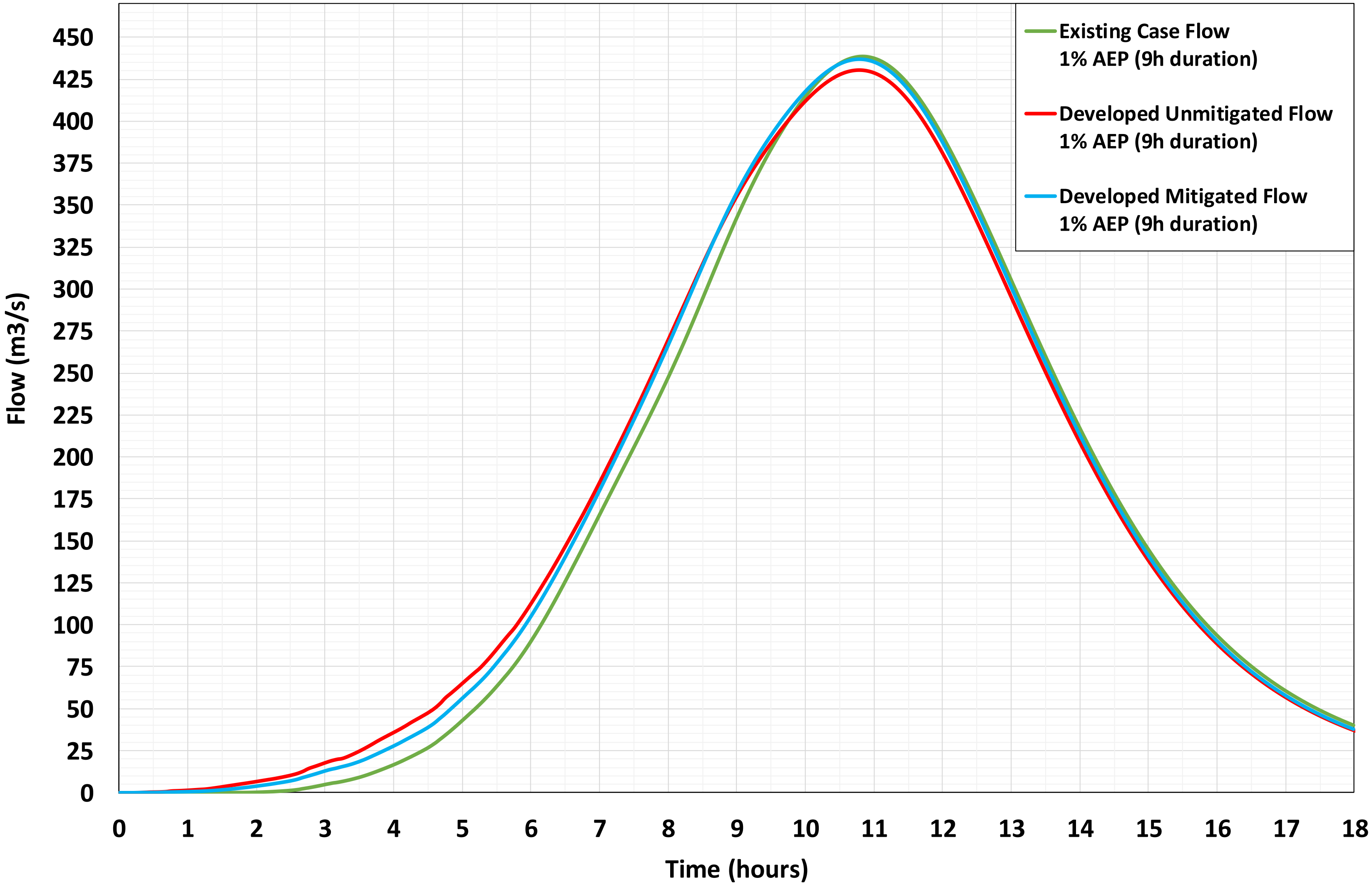


Figure 7-10 Flow comparison pre-development and post-development at downstream node in South Creek

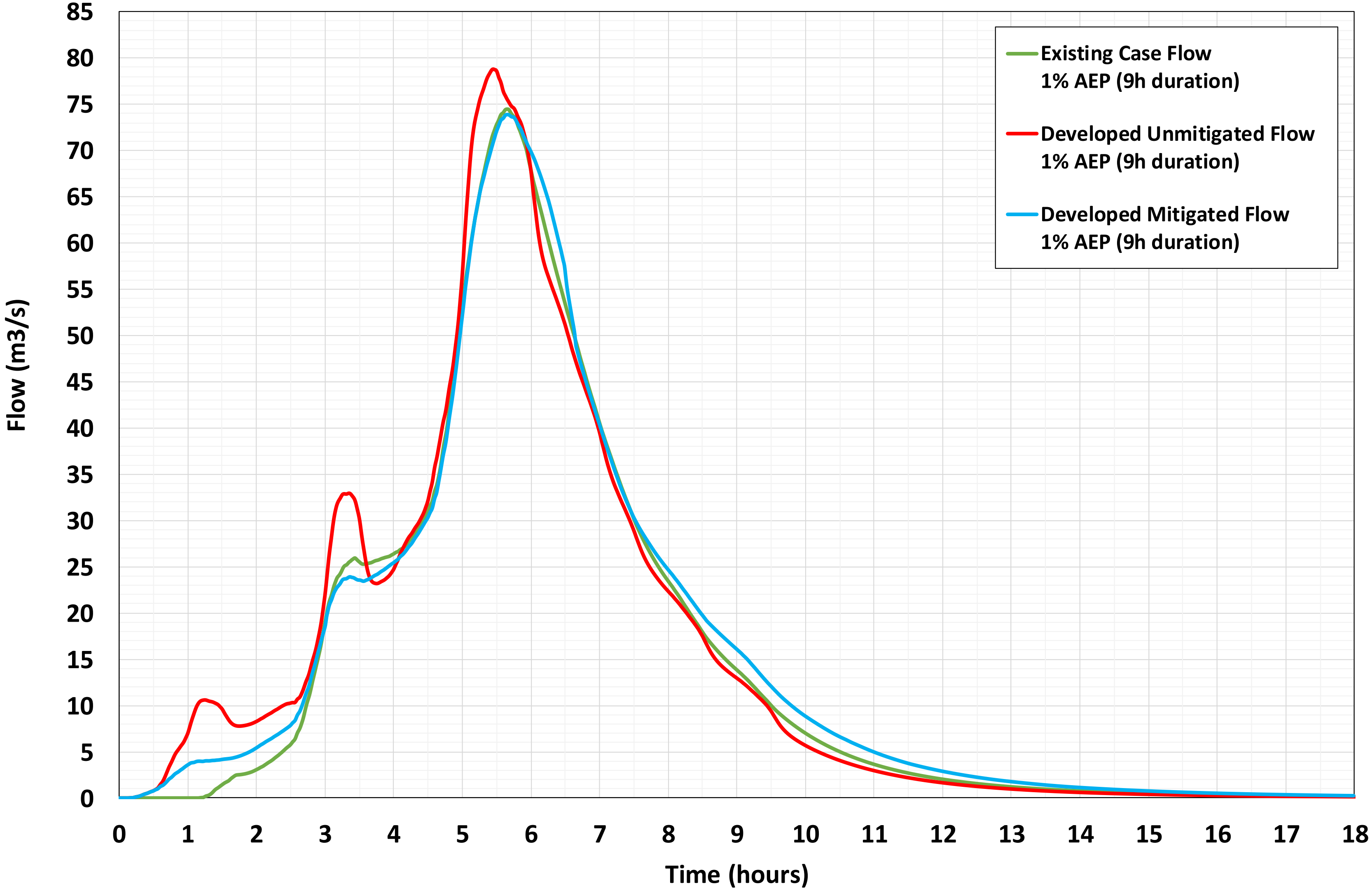


Figure 7-11 Flow comparison pre-development and post-development at downstream node in Mulgoa Creek

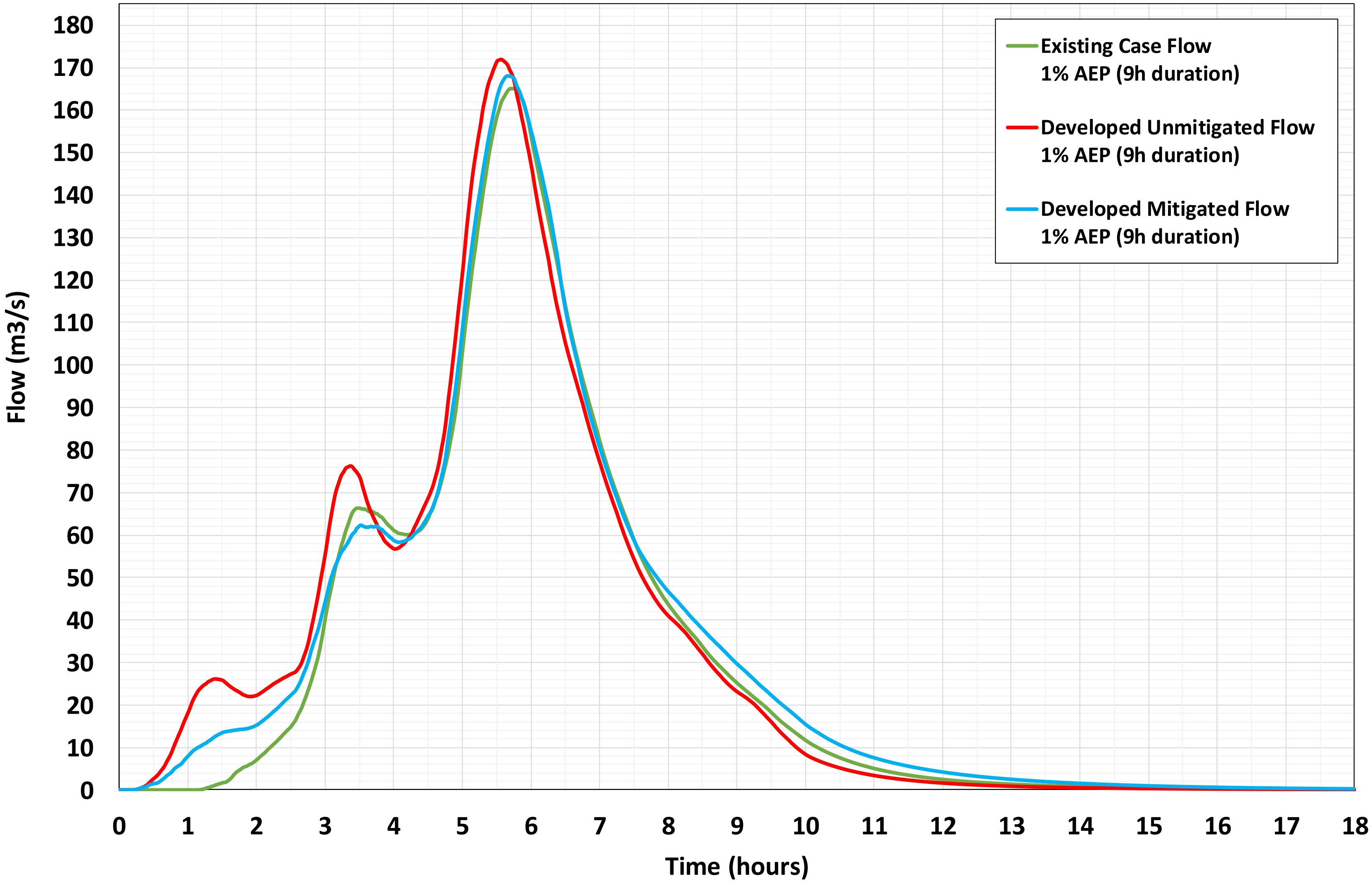


Figure 7-12 Flow comparison pre-development and post-development at downstream node in Duncans Creek

Table 7-2 Flow outcomes for existing case and all design scenarios (Badgerys Creek)

	1% AEP				10% AEP				50% AEP			
Reporting points	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case
Node	Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)	-	Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)	-	Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)	-
BC_16.04	5.8	15.3	6.3	1.09	3.6	10.1	4.2	1.17	2.3	6.5	1.8	0.78
BC_37.07	12.1	16.7	11.1	0.92	8	10.3	7.8	0.98	4.9	6.5	4.8	0.98
BC_37.11	23.1	38.5	24.6	1.06	15.2	25.1	16.3	1.07	9.1	16.5	9.2	1.01
BC_48.04	4.6	13.7	4.5	0.98	2.9	9.1	3.5	1.21	1.6	5.9	1.3	0.81
BC_32.04	5	11.8	4.9	0.98	3.3	7	2.7	0.82	1.9	4.2	1.7	0.89
BC_53.08	9.7	21.6	8	0.82	6.4	14.1	6.8	1.06	3.8	9.3	4	1.05
BC_1.30	142.2	140.4	141.3	0.99	93	92.9	91.8	0.99	55.8	57.4	54.5	0.98
BC_1.34	154.5	151.1	151.1	0.98	100.8	99.6	98.7	0.98	60.5	61.7	58.9	0.97
BC_1.36	157.9	154	154.4	0.98	102.9	101.4	101.1	0.98	61.9	62.9	60.6	0.98
BC_1.44 (outlet)	180.3	178.3	181.9	1.00	117.3	117.7	116.9	1.00	70.7	73.9	72	1.02

Table 7-3 Flow outcomes for existing case and all design scenarios (Mulgoa Creek)

	1% AEP				10% AEP				50% AEP			
Reporting points	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case
Node	Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)		Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)		Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)	
MC_1.05	10.9	27.5	10.2	0.94	7.1	17.9	7	0.99	4.5	11.4	2.9	0.64
MC_7.03	11.2	29.3	11.1	0.99	7.4	31.1	7.2	0.97	4.5	15.7	4	0.89
MC_9.02	2.7	6	2.5	0.93	1.6	3.8	1.5	0.94	0.9	2.4	0.8	0.89
MC_1.08	74.5	92.4	73.9	0.99	47.1	52.6	47	1.00	26.7	29.3	24.6	0.92
MC_11.01	0.9	2.6	0.9	1.00	0.5	1.7	0.6	1.20	0.3	1.1	0.4	1.33
MC_7.06 (outlet)	27.8	42.4	27.7	1.00	17.7	25.4	17.6	0.99	10.2	15	9.5	0.93

Table 7-4 Flow outcomes for existing case and all design scenarios (Duncans Creek)

	1% AEP				10% AEP				50% AEP			
Reporting points	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case
Node	Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)		Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)		Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)	
DC_16.03	5.9	13.3	5.9	1.00	3.9	8.7	3.8	0.97	2.4	5.8	2.1	0.88
DC_24.13	32.6	35.9	33.5	1.03	21.4	22	21.4	1.00	13.3	13.7	12.8	0.96
DC_34.05	9.3	16.8	9.3	1.00	5.7	10.7	5.7	1.00	3.2	6.9	2.7	0.84
DC_37.07	8.3	12.1	10.5	1.27	5.5	6.3	5.9	1.07	3.4	4	3.7	1.09
DC_10.04	10.3	25.8	9.5	0.92	6.3	16.9	5.6	0.89	3.9	11.2	2.8	0.72
DC_1.16	64.1	78.4	65.8	1.03	42.1	46.3	42.8	1.02	25.5	27.7	24.5	0.96
DC_1.21	81.8	98.1	84.1	1.03	53.9	58	54.4	1.01	32.7	36	30.6	0.94
DC_1.27 (outlet)	165.2	185.4	168.1	1.02	108.4	114.4	107.9	1.00	66	70.9	60.5	0.92

Table 7-5 Flow outcomes for existing case and all design scenarios (Cosgrove Creek)

	1% AEP				10% AEP				50% AEP			
Reporting points	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case
Node	Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)		Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)		Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)	
CC_26.03	11.9	31.5	9.3	0.78	7.4	20.9	6.4	0.86	4.7	13.5	3.5	0.74
CC_21.03	8.2	17	5.8	0.71	5	10.4	4.2	0.84	3.2	6.3	1.7	0.53
CC_21.08	38.7	76.7	30.9	0.80	24.4	49.1	19.3	0.79	15.7	31.9	10.4	0.66
CC_16.13	60.1	92.7	53.3	0.89	39.2	56.9	34	0.87	24.8	36.5	19.2	0.77
CC_33.06	21.8	50	24.3	1.11	14.1	30.7	15	1.06	9	18.7	7.3	0.81
CC_45.06	9.6	23.9	6.3	0.66	6.4	15.6	5	0.78	4	10.1	2.1	0.53
CC_1.25	151.1	180.2	146.4	0.97	100.3	108.5	94.6	0.94	62.3	65.1	53.5	0.86
CC_1.33	170.3	197	164.8	0.97	113	117.2	106.7	0.94	70.3	69.4	62	0.88
CC_1.36 (outlet)	177.5	200.3	172.3	0.97	117.8	118.2	111.3	0.94	73.2	68.7	65.3	0.89

Table 7-6 Flow outcomes for existing case and all design scenarios (Science Park)

	1% AEP				10% AEP				50% AEP			
Reporting points	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case
Node	Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)		Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)		Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)	
SP_65.11	31.7	33.1	31.8	1.00	20.7	20.9	20.7	1.00	13	13	12.8	0.98
SP_82.04	13.1	24.1	9.7	0.74	8.6	15.1	6	0.70	5.4	9.6	2.7	0.50
SP_65.15	67.1	68.3	60.2	0.90	44.1	44.4	40.4	0.92	27.6	28.4	23.4	0.85
SP_93.04	6.6	17.4	6.7	1.02	4.4	11.4	4.3	0.98	2.7	7.4	2.7	1.00
SP_93.06	11.6	28.3	10.7	0.92	7.6	18.5	7.9	1.04	4.6	12.1	3.9	0.85
SP_65.17	76.5	75.3	69.3	0.91	50.7	50.6	46.7	0.92	31.7	32.4	27	0.85
SP_65.18 (outlet)	88.3	85.6	82.1	0.93	58.6	57.5	53.4	0.91	36.5	36.7	31.6	0.87

Table 7-7 Flow outcomes for existing case and all design scenarios (South Creek)

	1% AEP				10% AEP				50% AEP			
Reporting points	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case	EXG case	Post dev	Post dev OSD + basins	Ratio to Exg case
Node	Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)		Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)		Flows (m^3/s)	Flows (m^3/s)	Flows (m^3/s)	
SC_1.09	53.3	51.6	52.6	0.99	34.2	33.1	33.5	0.98	19.5	19	19.4	0.99
SC_38.07	23.9	23	23.1	0.97	14.5	13.8	14	0.97	7.9	7.7	7.8	0.99
SC_1.12	80.4	76.8	78.2	0.97	51.8	49.4	49.4	0.95	30.2	28.7	29.2	0.97
SC_1.13	81.1	77.8	79.3	0.98	52.2	50	50	0.96	30.4	29	29.6	0.97
SC_62.03	7.1	15.8	6.7	0.94	4.7	9.3	4.2	0.89	2.9	5.6	2.2	0.76
SC_1.21	441.3	441.6	444.6	1.01	268.9	267.6	272	1.01	153.2	152.4	156.3	1.02
SC_1.28 (outlet)	444.5	443.2	446.8	1.01	271.7	270.8	274.1	1.01	155.6	157	158.8	1.02

7.8 Downstream impacts of precincts on South Creek flows

Flows were compared at the most downstream location of South Creek, along the Warragamba Dam pipeline. Figure 7-13 shows the difference in peak flows from the existing case and the developed case with basins. The flows at this location are a summation of the flows from the contributing catchments:

- South Creek
- Badgerys Creek
- Cosgrove Creek
- Science Park
- Kemps Creek.

The flows coming in from Kemps Creek and South Creek upstream of Bringelly Road are unchanged in the developed and the undeveloped scenarios as the Precinct plan does not cover this region.

The difference in flow peaks was calculated to be 0.2%, with peaks within 15 minutes of each other. This demonstrates the overall effectiveness in using the combined detention basin and OSD strategy for stormwater detention.

The increase in volume and flow that arises from the developments occurs earlier in the storm, before the storm peak. On the receding limb, both flows collapse onto the same line, further highlighting the need for basins only on the upper reaches of the catchments. This means that retaining flows in the upper reaches allows flows downstream to flow through the channels, after which the retained water is slowly released, resulting in minimal changes to the peak flows.

Similar assessments were carried out for the 2-hour, 6-hour and 36-hour flood events. These assessments also showed that the proposed development of the precincts and use of detention basins and on-site stormwater detention would have minimal impact on the timing of flood events at key locations on South Creek.

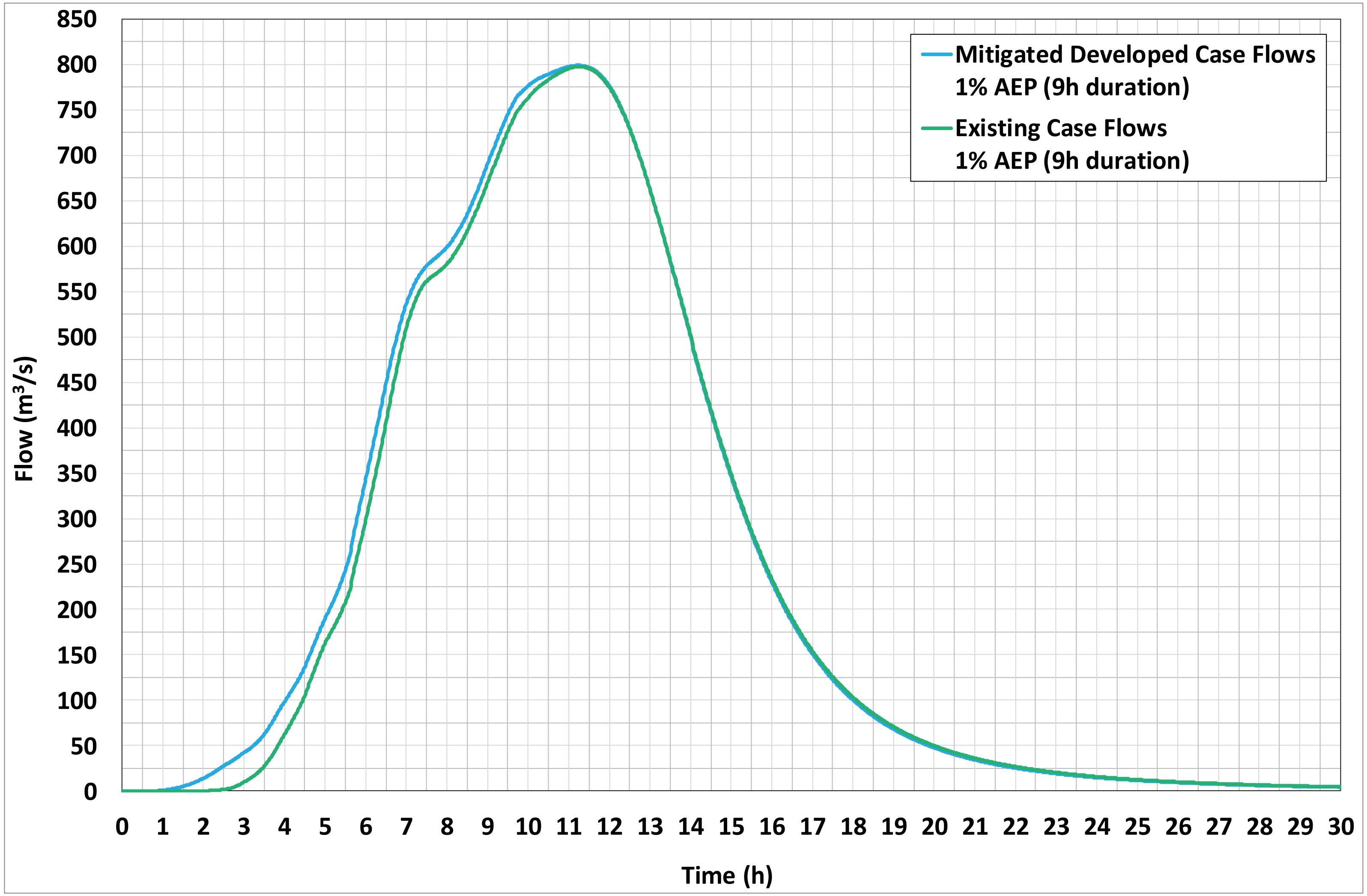


Figure 7-13 Flow comparison downstream of precincts

7.9 Sensitivity analyses

7.9.1 Impacts of initial losses

As discussed in Chapter 7.2.4, a sensitivity analysis was conducted, whereby the rainfall losses were scaled down to match the imperviousness of the catchments.

This analysis was conducted for development lots of low imperviousness, such as Agribusiness, where the effects would be more profound. This test was, therefore, conducted in Cosgrove Creek, where the primary urban typology is planned to be Agribusiness, which has a lower impervious fraction of 60%. The test was not conducted on other precincts as their impervious fractions were much higher, 80% or greater, which meant the impact of the rainfall losses would be less significant. Results from the analysis showed an average difference of 4% across the creek catchment, as shown in Table 7-8.

Table 7-8 Sensitivity analysis of flow impacts from initial losses (Cosgrove Creek)

Node ID	Design flow (IL=1, CL=0) (m^3/s)	Sens. flow (IL=9.2, CL=0.4) (m^3/s)	Flow change (% decrease)
CC_26.03	9.3	8.9	3.6
CC_21.03	5.8	5.8	0.4
CC_21.08	30.9	30.3	2.0
CC_16.13	53.3	52.7	1.2
CC_33.06	24.3	22.8	6.5
CC_45.06	6.3	6.2	2.4
CC_1.25	146.4	145.2	0.8
CC_1.33	164.8	163.5	0.8
CC_1.36	172.3	170.9	0.8

7.9.2 Impacts of reduced basin storage

A sensitivity analysis was also conducted on the impacts of reduced flood storage capacity within the detention basins. It is possible that basin storage could be reduced due to the co-location of WSUD features (such as wetlands) with the stormwater detention basins. This test was conducted to understand the effect of such a reduction.

Sensitivity testing of the basins involved:

- basin storage volume reduced by 30%
- increased outlet culvert capacity by 30%.

Tests were conducted in Cosgrove and Badgerys Creek, due to the size of the catchments and the greater number of basins sized within.

The resulting average increase in flows would be about 10%. Due to the stormwater detention strategy generally overperforming for peak flow reduction, flows within the main streams would not be increased beyond those for the existing case.

7.10 Stormwater conveyance

7.10.1 Trunk drainage

Naturalised trunk drainage has increasingly become a part of greenfield development. It is often adopted when considering the safe and economic conveyance of overland flows (often referred to as pluvial flows).

In part of the Aerotropolis precincts, it will be necessary in some locations to use designated trunk drainage channels to safely convey stormwater from upstream catchments through land that would be zoned as developed land (e.g. enterprise, industrial, mixed-use).

Assessments of conveying flows through a trunk drainage network comprising of open channels needs to consider the costs and the safety elements as well as ecological and social benefits.

The issues defining the upstream limit of these trunk drainage systems are varied. However, a maximum contributing catchment area of 15ha has been found to be typically the point at which the velocity-depth product in the street drainage becomes hazardous. This is on the assumption that the street drainage system is designed to convey the 5% AEP flow. This drops to 12ha of contributing catchment where the street drainage system is designed for a 10% AEP peak flowrate.

Application of this principle to the proposed land-use designations for the Aerotropolis precincts has indicated that there are very few locations where the catchment area exceeds 15ha prior to the transition from developed land (e.g. enterprise, industrial, mixed use) to open space. In most of these locations, the water course is designated to be retained for Vegetated Riparian Zones (VRZ) and, hence, these watercourses will be retained.

Only one location has been identified where an open channel will be required for trunk drainage. Preliminary sizing has demonstrated that a 20m wide corridor is required. This is shown in Figure 7-14.

7.10.2 Road network transverse drainage requirements

The transverse drainage requirements (ie culverts and bridges) for all four precincts have been sized for both major and minor roads. This sizing exercise provides preliminary sizing for the purposes of cost estimation at this stage of the project.

The flood immunity requirements of both the Penrith and Liverpool City Councils as shown in Table 7-9.

Table 7-9 Transverse drainage requirements defined by locality

Council	Road	Road immunity
Penrith	Major	1% AEP
Liverpool	Sub-arterial	5% AEP
Penrith	Minor Roads (local	10% AEP

However, at this stage of the Precinct plan the available information of road hierarchy is limited to major and minor roadways only. Hence, the transverse drainage was designed to provide immunity for the 1% AEP for structures under major roads, and 10% AEP for all other roads.

A total of 106 culverts and bridges were identified and sized. Flows within each sub-catchment at identified road crossings were derived from the hydrological models for the mitigated design case with on-site stormwater detention and detention basins.

Conservative structure flow velocities were adopted based on general catchment slopes, with the following:

- 1m/s for catchment slopes <2%
- 2m/s for slopes >2%.

The flows and velocities were used to define a structure cross-sectional area. Nominal sizes were adopted for culvert dimensions, with a standard height of 1500mm for RCBC's adopted for all culverts and widths varying based on flows passed through the structure. Results of the transverse drainage structure sizing are shown in Table 7-10 with the locations of each structure shown in Figure 7-24 to Figure 7-28.

For road crossings with 1% AEP peak flows greater than 50m^3/s passing through the structure, bridges are proposed instead of culverts. All bridges were provided with an immunity for the 1% AEP event, with bridge extents based on a combination of LiDAR data and flood extent mapping. Bridge sizes are defined in Table 7-10 with the locations of each structure shown in Figure **7-24** to Figure 7-28.

Table 7-10 Details of preliminary transverse drainage requirements

Culvert name	Flow	Slope	Velocity	Immunity	Area	Precinct	Structure size	Structure length
BC_10	2.3	1.18	1	1%	2.3	AC	1/ 1800x1500	57
BC_100	10.7	3.45	2	1%	5.3	AC	3/RCBC 1670x600	34
BC_110	11.2	1.67	1	1%	11.2	AC	5/RCBC 1500x1500	72
BC_120	10.6	1.88	1	10%	10.6	AC	3/RCBC 2400x1500	30
BC_130	150.6	1.65	1	1%	150.6	BG	1/135 m span	N/A
BC_140	5.7	1.07	1	1%	5.7	BG	2/RCBC 2100 x 1500	55
BC_150	6.1	3.45	2	1%	3	BG	3/RCBC 1670x600	35
BC_150	34.4	1.9	1	1%	34.4	BG	11/RCBC 2100 x 1500	141
BC_160	154.4	1.84	1	1%	154.4	BG	1/93 m span	N/A
BC_170	3.1	3.72	2	10%	1.5	BG	1/RCBC 1500x1500	45
BC_180	110.7	1	1	10%	110.7	BG	1/71 m span	N/A
BC_190	2.3	4.33	2	10%	1.1	BG	1/RCBC 1500x1500	50
BC_20	7.2	1.42	1	1%	7.2	AC	3/RCBC 1800x1500	61
BC_200	115	1	1	10%	115	BG	1/60 m span	N/A
BC_30	8.5	1.5	1	10%	8.5	AC	4/RCBC 1500x1500	28
BC_40	13.9	1.24	1	10%	13.9	AC	4/RCBC 2400x1500	40
BC_50	25.7	1.71	1	1%	25.7	AC	10/RCBC 1800x1500	120
BC_60	5.4	1.24	1	1%	5.4	AC	2/RCBC 1800x1500	142
BC_70	23.2	1.86	1	10%	23.2	AC	9/RCBC 1800x1500	52
BC_80	92.6	1.35	1	1%	92.6	AC	1/80 m span	N/A
BC_90	7.5	1.38	1	10%	7.5	AC	3/RCBC 1800x1500	54
CC_10	4	3.05	2	10%	2	AB	1/RCBC 1500x1500	42
CC_100	25	2.1	2	1%	12.5	AB	4/RCBC 2100 x 1500	48
CC_110	7.3	1.8	1	1%	7.3	AB	3/RCBC 1800x1500	50
CC_120	11.9	1.91	1	10%	11.9	AB	4/RCBC 2100 x 1500	39
CC_130	12.8	2.23	2	10%	6.4	AB	3/RCBC 1500x1500	57
CC_140	13.9	1.39	1	10%	13.9	AB	4/RCBC 2400x1500	34
CC_150	19.3	1.38	1	10%	19.3	AB	9/RCBC 1500x1500	34
CC_160	5.7	1	1	1%	5.7	AB	2/RCBC 2100 x 1500	96
CC_170	35.1	1.76	1	1%	35.1	AB	13/RCBC 1800x1500	108
CC_180	3.6	2.45	2	10%	1.8	AB	1/RCBC 1500x1500	38
CC_190	7.6	2.94	2	1%	3.8	AB	2/RCBC 1500x1500	76
CC_20	7.8	3.05	2	1%	3.9	AB	3/RCBC 1270x600	57
CC_200	5.9	2.94	2	1%	2.9	AB	1/RCBC 2100 x1500	123
CC_210	11	2.31	2	1%	5.5	AB	3/RCBC 1835x600	58
CC_220	9.7	1.29	1	10%	9.7	AB	3/RCBC 2400x1500	58
CC_230	15	1	1	10%	15	AB	5/RCBC 2100 x 1500	54
CC_240	2.9	1.4	1	10%	2.9	AB	1/RCBC 2100 x 1500	81
CC_250	4.6	1.4	1	1%	4.6	AB	2/RCBC 1800x1500	54
CC_260	2.9	1.4	1	10%	2.9	AB	1/RCBC 2100 x 1500	51
CC_270	51.7	1	1	10%	51.7	AB	2/20 m spans	N/A
CC_280	27.6	2.06	2	10%	13.8	AB	4/RCBC 2400x1500	61
CC_290	83.3	2.22	2	10%	41.6	AB	1/50 m span	N/A
CC_30	6.9	2.17	2	1%	3.5	AB	3/RCBC 1270x600	111
CC_300	84.2	1.97	1	10%	84.2	AB	1/32 m span	N/A

Culvert name	Flow	Slope	Velocity	Immunity	Area	Precinct	Structure size	Structure length
CC_310	1.1	2.06	2	10%	0.6	AB	1/RCBC 1500x1500	36
CC_320	2.7	1.08	1	10%	2.7	AB	1/RCBC 1800x1500	81
CC_330	4.3	1.82	1	10%	4.3	AB	2/RCBC 1500x1500	52
CC_340	5.3	1	1	10%	5.3	AB	2/RCBC 1800x1500	97
CC_350	10.7	2.86	2	1%	5.3	AB	3/RCBS 1370x600	61
CC_360	94.6	2.19	2	10%	47.3	NG	1/20 m span	N/A
CC_370	3.8	2.66	2	10%	1.9	NG	1/RCBC 1500x1500	37
CC_380	4.6	1.59	1	10%	4.6	NG	2/RCBC 1800x1500	36
CC_390	4.9	1	1	10%	4.9	NG	2/RCBC 1800x1500	35
CC_40	5.9	3.06	2	10%	3	AB	1/RCBC 2100 x 1500	38
CC_400	2.8	2.25	2	10%	1.4	NG	1/RCBC 1500x1500	40
CC_410	6	1.01	1	10%	6	NG	2/RCBC 2100 x 1500	59
CC_420	11.8	2.32	2	1%	5.9	NG	2/RCBC 2100 x 1500	70
CC_430	58.5	1	1	1%	58.5	NG	1/93 m span	N/A
CC_430	7.5	1.55	1	10%	7.5	NG	3/RCBC 1800x1500	54
CC_440	30.9	1	1	10%	30.9	NG	10/RCBC 2100 x 1500	88
CC_440	40.4	1	1	10%	40.4	NG	15/RCBC 1800x1500	66
CC_450	2	1.67	1	10%	2	NG	1/RCBC 1500x1500	38
CC_460	4.3	1.51	1	10%	4.3	NG	2/RCBC 1500x1500	35
CC_470	4.3	1.51	1	10%	4.3	NG	2/RCBC 1500x1500	51
CC_480	11.2	1	1	1%	11.2	NG	3/RCBC 1670x600	65
CC_50	2.3	2.29	2	10%	1.1	AB	1/RCBC 1500x1500	40
CC_60	3.8	1.6	1	10%	3.8	AB	2/RCBC 1500x1500	56

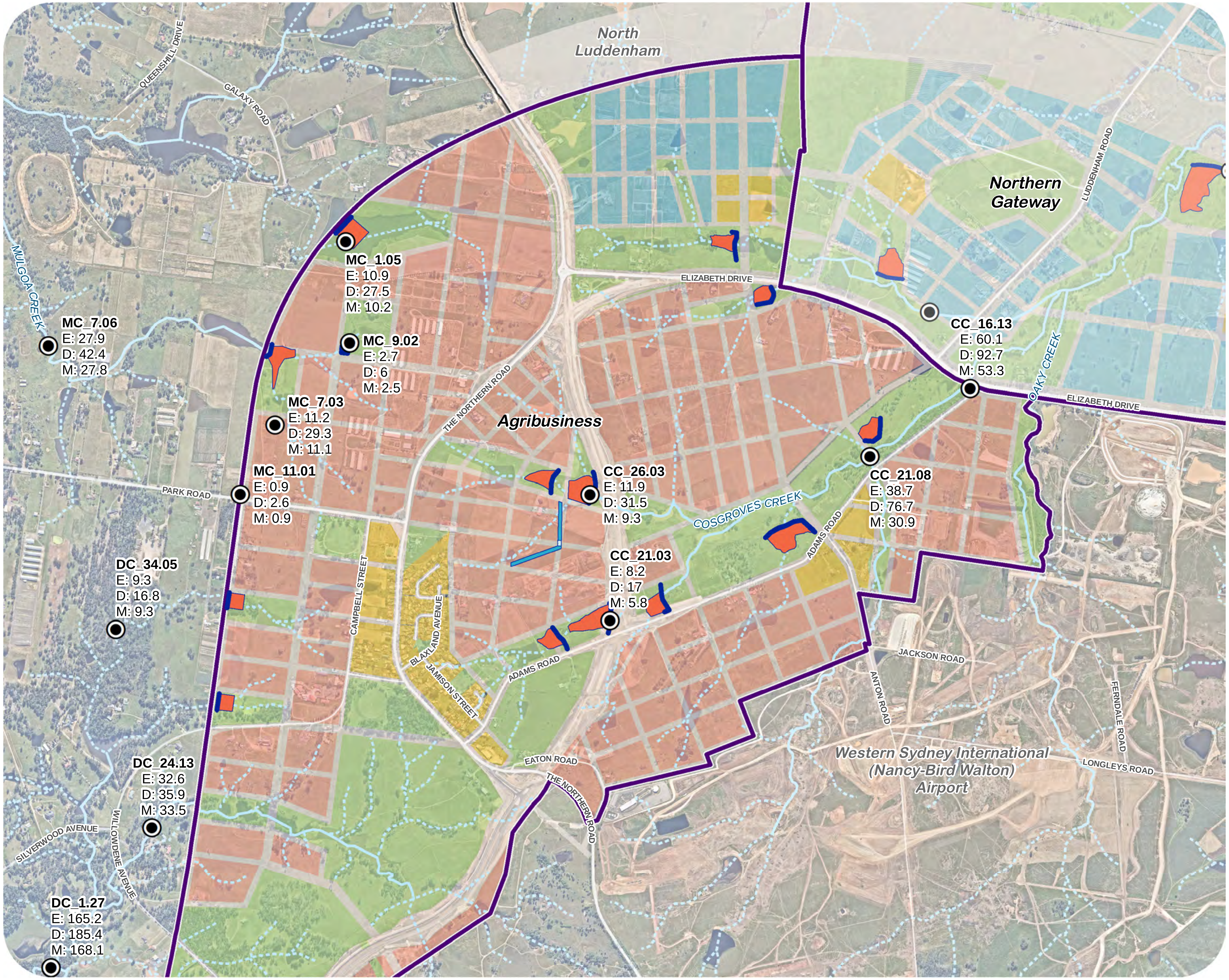
Culvert name	Flow	Slope	Velocity	Immunity	Area	Precinct	Structure size	Structure length
CC_70	4.6	3.19	2	1%	2.3	AB	1/RCBC 1800x1500	34
CC_80	10.9	2.5	2	1%	5.5	AB	2/RCBC 2100 x 1500	94
CC_90	9.4	1.93	1	10%	9.4	AB	3/RCBC 2100 x 1500	35
DC_10	25	1	1	10%	25	AB	7/RCBC 2400x1500	34
DC_100	3.1	3.07	2	1%	1.5	AB	1/RCBC 1500x1500	110
DC_110	3.5	5.17	2	10%	1.7	AB	1/RCBC 1500x1500	54
DC_120	4.9	3.96	2	10%	2.5	AB	1/RCBC 1800x1500	35
DC_130	3.8	7.57	2	1%	1.9	AB	1/RCBC 1500x1500	87
DC_140	3.5	5.53	2	10%	1.8	AB	1/RCBC 1500x1500	34
DC_150	3.1	2.82	2	1%	1.6	AB	1/RCBC 1500x1500	83
DC_160	6.3	5.36	2	1%	3.2	AB	1/RCBC 2400x1500	93
DC_170	8.3	5.46	2	1%	4.1	AB	2/RCBC 1500x1500	83
DC_180	18	4.74	2	10%	9	AB	3/RCBC 2100 x 1500	57
DC_20	1.2	4.39	2	10%	0.6	AB	1/RCBC 1500x1500	40
DC_30	4.6	2.66	2	10%	2.3	AB	1/RCBC 1800x1500	63
DC_40	6.2	2.87	2	10%	3.1	AB	1/RCBC 2100 x 1500	35
DC_50	4.1	2.43	2	10%	2.1	AB	1/RCBC 1500x1500	57
DC_60	1.4	2.71	2	10%	0.7	AB	1/RCBC 1500x1500	57
DC_70	3.9	1.81	1	10%	3.9	AB	2/RCBC 1500x1500	34
DC_80	52.7	1	1	10%	52.7	AB	17/RCBC 2100 x 1500	59
DC_90	84.1	4.25	2	1%	42	AB	1/23 m span	N/A
MC_10	2.7	1.69	1	10%	2.7	AB	1/RCBC 2100 x 1500	43
MC_20	3.7	3.08	2	10%	1.9	AB	1/RCBC 1500x1500	32

Culvert name	Flow	Slope	Velocity	Immunity	Area	Precinct	Structure size	Structure length
SC_10	1.3	2.43	2	10%	0.7	AC	1/RCBC 1500x1500	54
SC_100	69.3	1	1	1%	69.3	AC	1/67 m span	N/A
SC_110	75.5	1	1	1%	75.5	AC	1/30 m span	N/A
SC_120	14	1.21	1	10%	14	AC	4/RCBC 2400x1500	36
SC_130	3.6	1.78	1	10%	3.6	AC	2/RCBC 1500x1500	17
SC_140	4.4	1.36	1	10%	4.4	AC	2/RCBC 1500x1500	20
SC_20	1.3	2.19	2	10%	0.6	AC	1/RCBC 1500x1500	57
SC_30	6.9	1.92	1	1%	6.9	AC	3/RCBC 830x600	42
SC_40	8.4	2.07	2	1%	4.2	AC	2/RCBC 1500x1500	69
SC_50	6.2	1.19	1	10%	6.2	AC	2/RCBC 2100 x 1500	38
SC_60	8.3	1.02	1	10%	8.3	AC	4/RCBC 1500x1500	31
SC_70	29.3	1.24	1	10%	29.3	AC	11/RCBC 1800x1500	35
SC_80	33.5	1	1	10%	33.5	AC	15/RCBC 1500x1500	47
SC_90	43.7	1	1	10%	43.7	AC	14/RCBC 2100 x 1500	34

7.11 Coordination with flood risk and impact assessment

There was an intent for significant coordination between this study and the FRIA. The required coordination between the FRIA and this study was for the FRIA to provide flow data to enable this study to utilise for the stormwater infrastructure planning, and for the FRIA to assess the performance and impacts of the proposed stormwater detention strategy identified by this study.

At the time of publishing the FRIA was not yet available. Given that co-ordination may provide efficiencies in stormwater detention infrastructure it is suggested that further studies and analysis on stormwater detention be undertaken in consultation with local councils.



Sydney WATER

Initial precincts

Other precincts

Reporting locations*

Bunds

1% AEP inundation extent

Trunk drainage open channel

Trunk drainage channel beneath road

Strahler Stream Order

< 3rd order

3rd order & higher

Proposed land use

Transport

Agribusiness

Enterprise

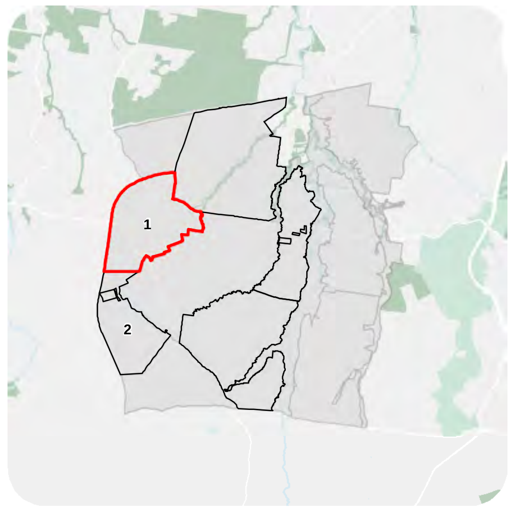
Environment and recreation

Mixed-use

*Values are displayed as m^3/s

CC_16.13 ← *Node ID*
E: 60.1 ← *Existing case flows*
D: 92.7 ← *Developed flows*
M: 53.34 ← *Mitigated flows*

Source: DPIE, WSPP, NSW Spatial Services, Aurecon, Arup, Nearmap



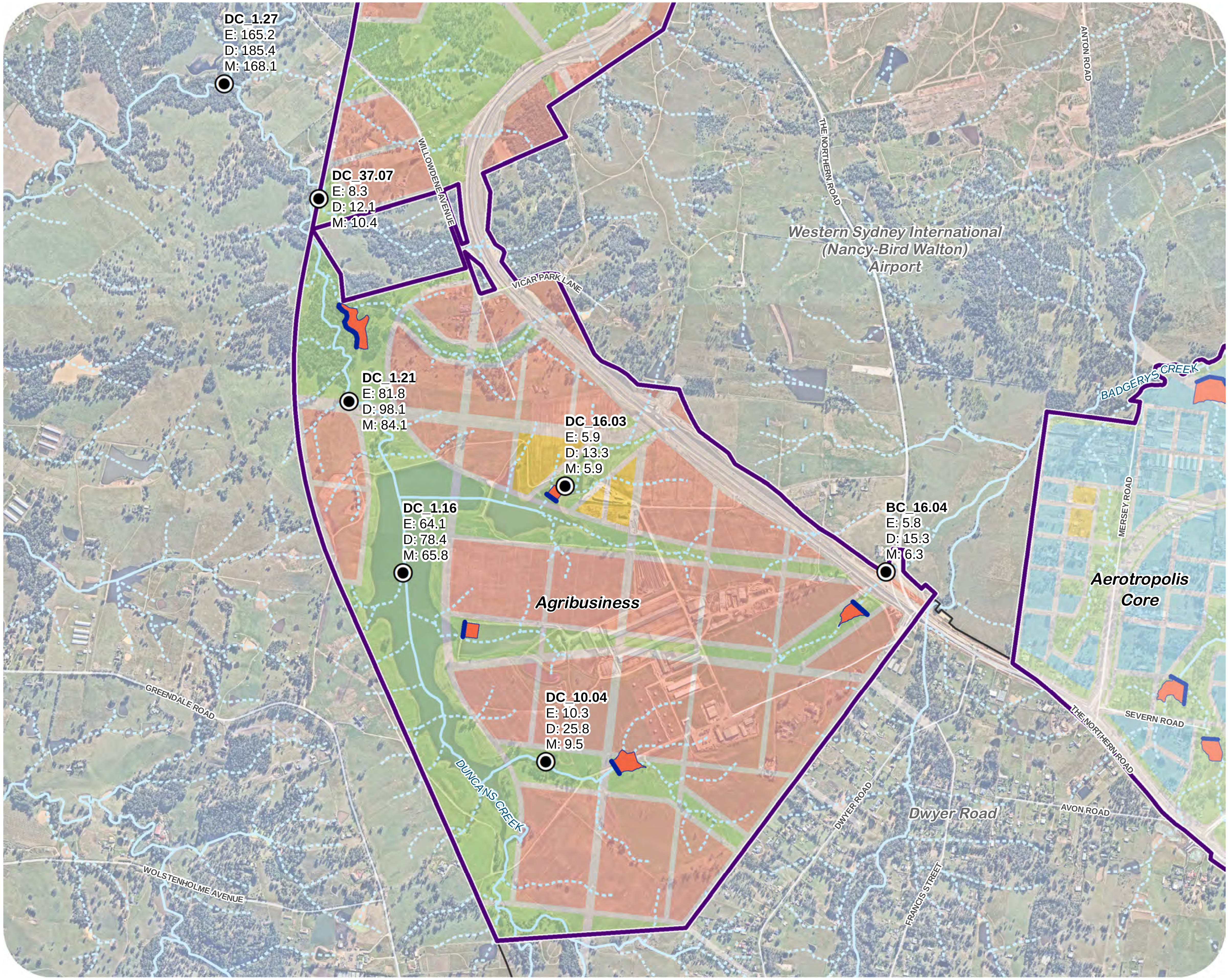
1:17,500

0 400 800 m

Date: 18/02/2021

Projection: GDA 1994 MGA Zone 56

Figure 7 - 14: Basin locations (indicative), 1% AEP inundation extent: Agribusiness (North)



Sydney WATER

Initial precincts

Other precincts

Reporting locations*

Bunds

1% AEP innundation extent

Strahler Stream Order

< 3rd order

3rd order & higher

Proposed land use

Transport

Agribusiness

Enterprise

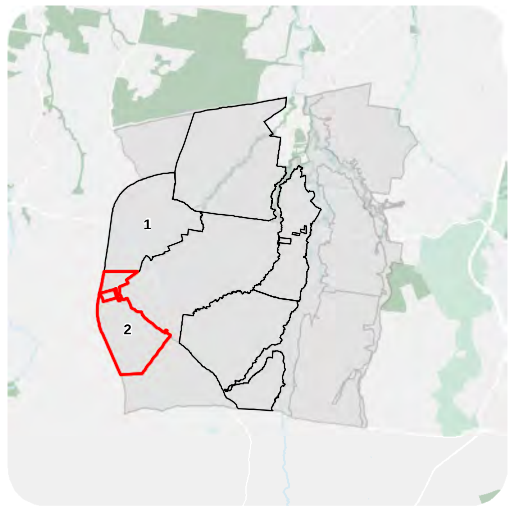
Environment and recreation

Mixed-use

*Values are displayed as m^3/s

CC_16.13 ← Node ID
E: 60.1 ← Existing case flows
D: 92.7 ← Developed flows
M: 53.34 ← Mitigated flows

Source: DPIE, WSPP, NSW Spatial Services, Aurecon, Arup, Nearmap



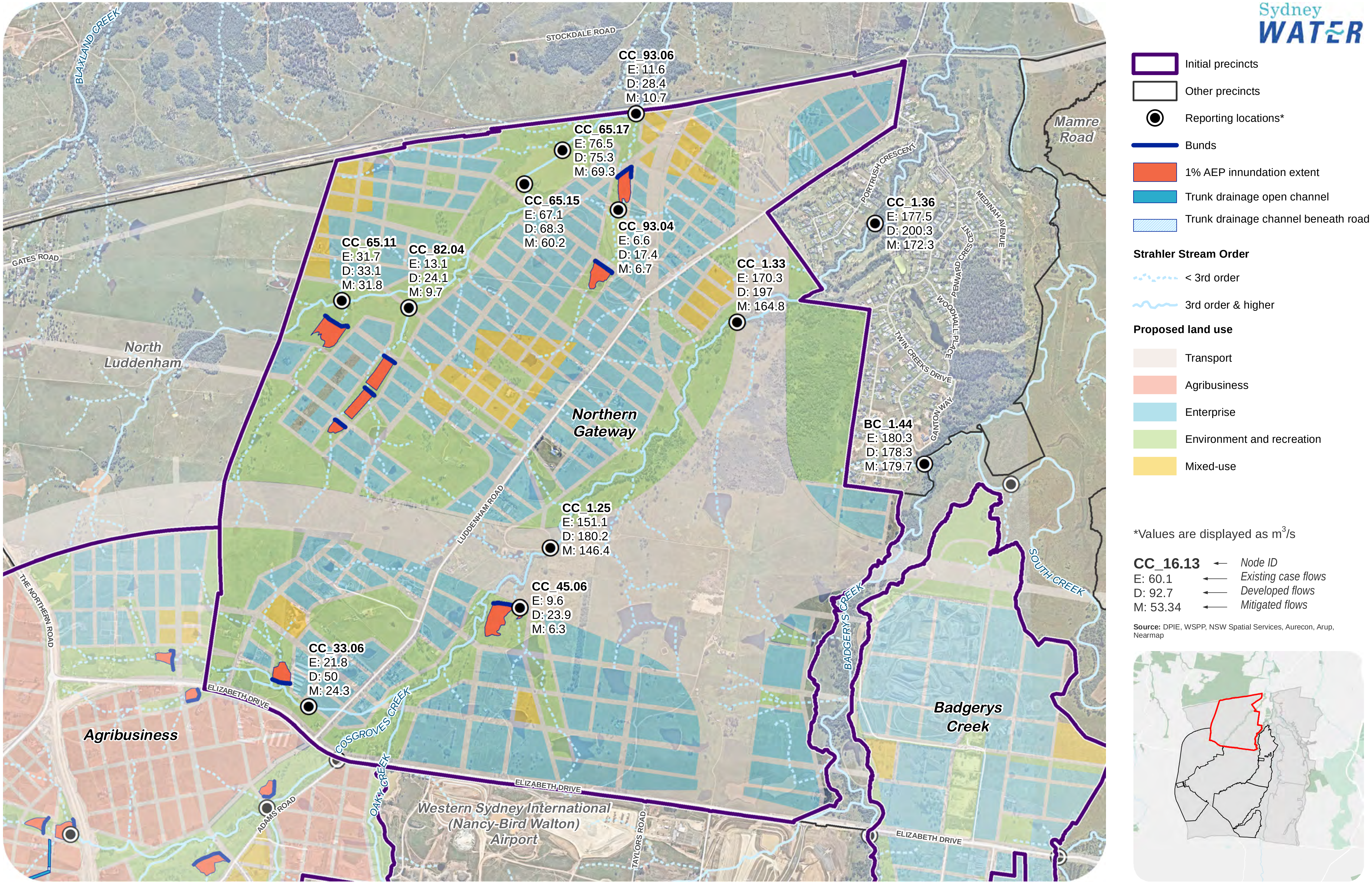
1:17,500

0 400 800 m

Date: 18/02/2021

Projection: GDA 1994 MGA Zone 56

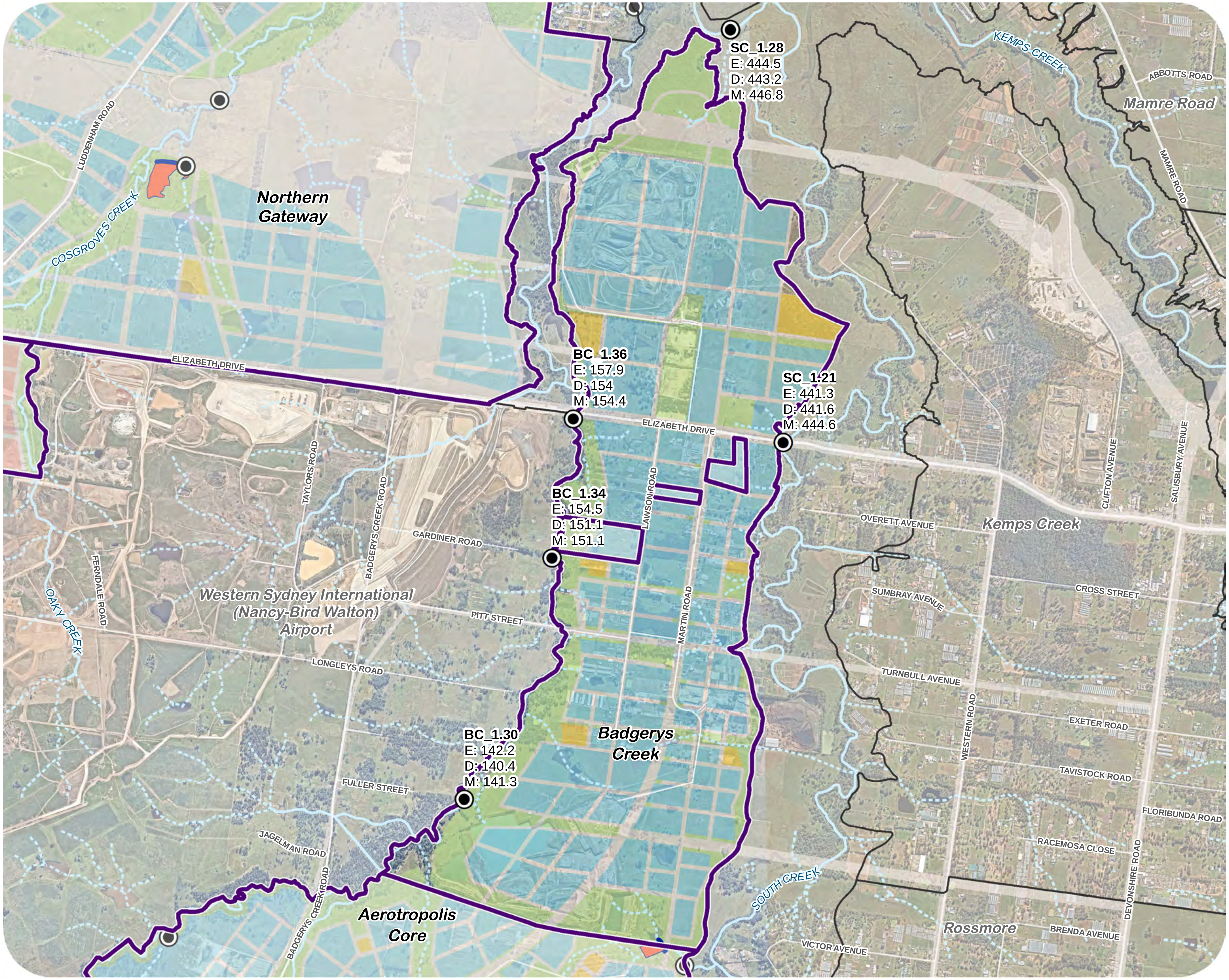
Figure 7 - 15: Basin locations (indicative), 1% AEP inundation extent: Agribusiness (South)



Date: 18/02/2021

Projection: GDA 1994 MGA Zone 56

Figure 7 -16: Basin locations (indicative), 1% AEP inundation extent: Northern Gateway



Sydney WATER

Initial precincts

Other precincts

Reporting locations*

Strahler Stream Order

< 3rd order

3rd order & higher

Proposed land use

Transport

Agribusiness

Enterprise

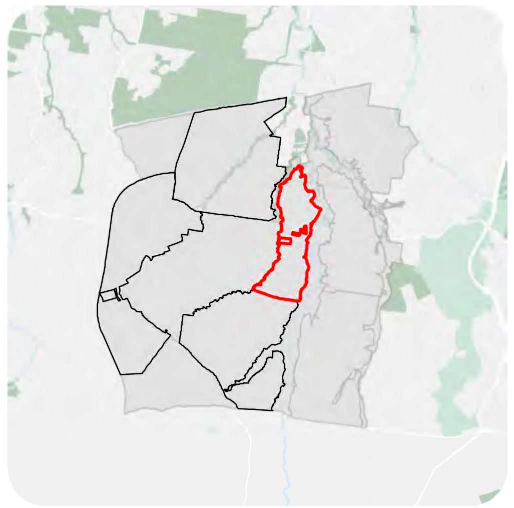
Environment and recreation

Mixed-use

*Values are displayed as m^3/s

CC_16.13 ← *Node ID*
E: 60.1 ← *Existing case flows*
D: 92.7 ← *Developed flows*
M: 53.34 ← *Mitigated flows*

Source: DPIE, WSPP, NSW Spatial Services, Aurecon, Arup, Nearmap



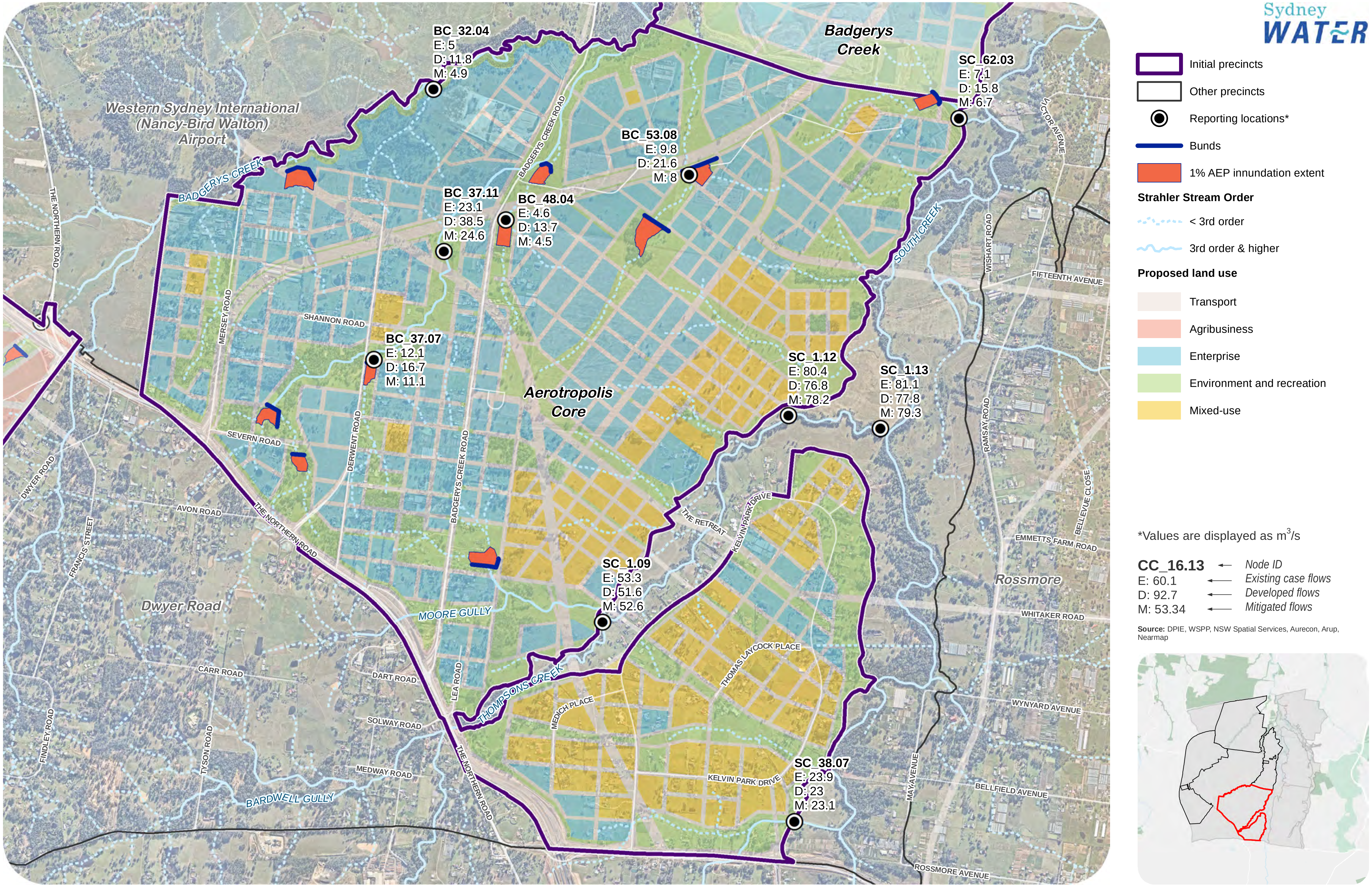
1:22,500

0 400 800 m

Date: 18/02/2021

Projection: GDA 1994 MGA Zone 56

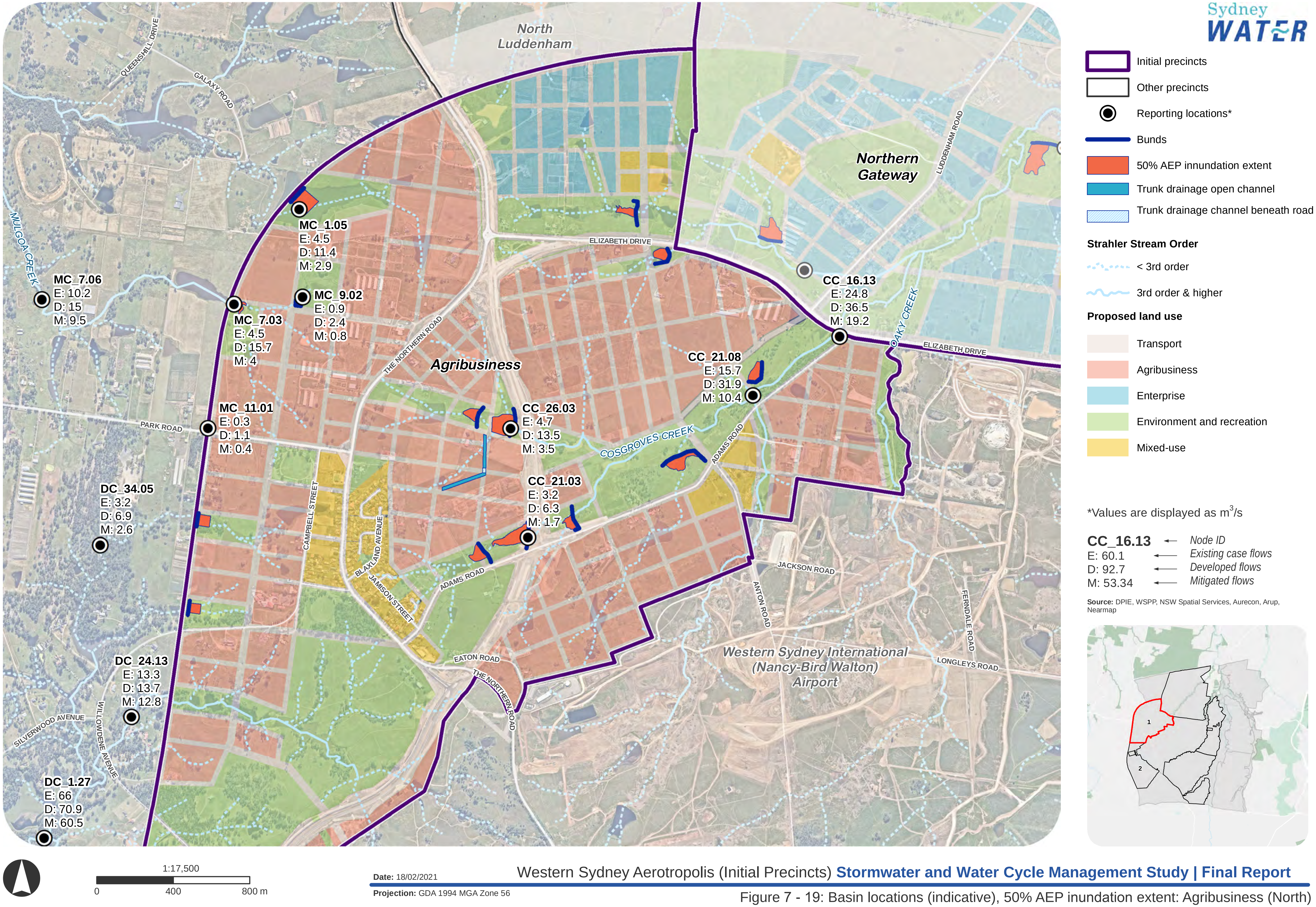
Figure 7 - 17: Basin locations (indicative), 1% AEP inundation extent: Badgerys Creek



1:20,000
0 400 800 m

Date: 18/02/2021
Projection: GDA 1994 MGA Zone 56

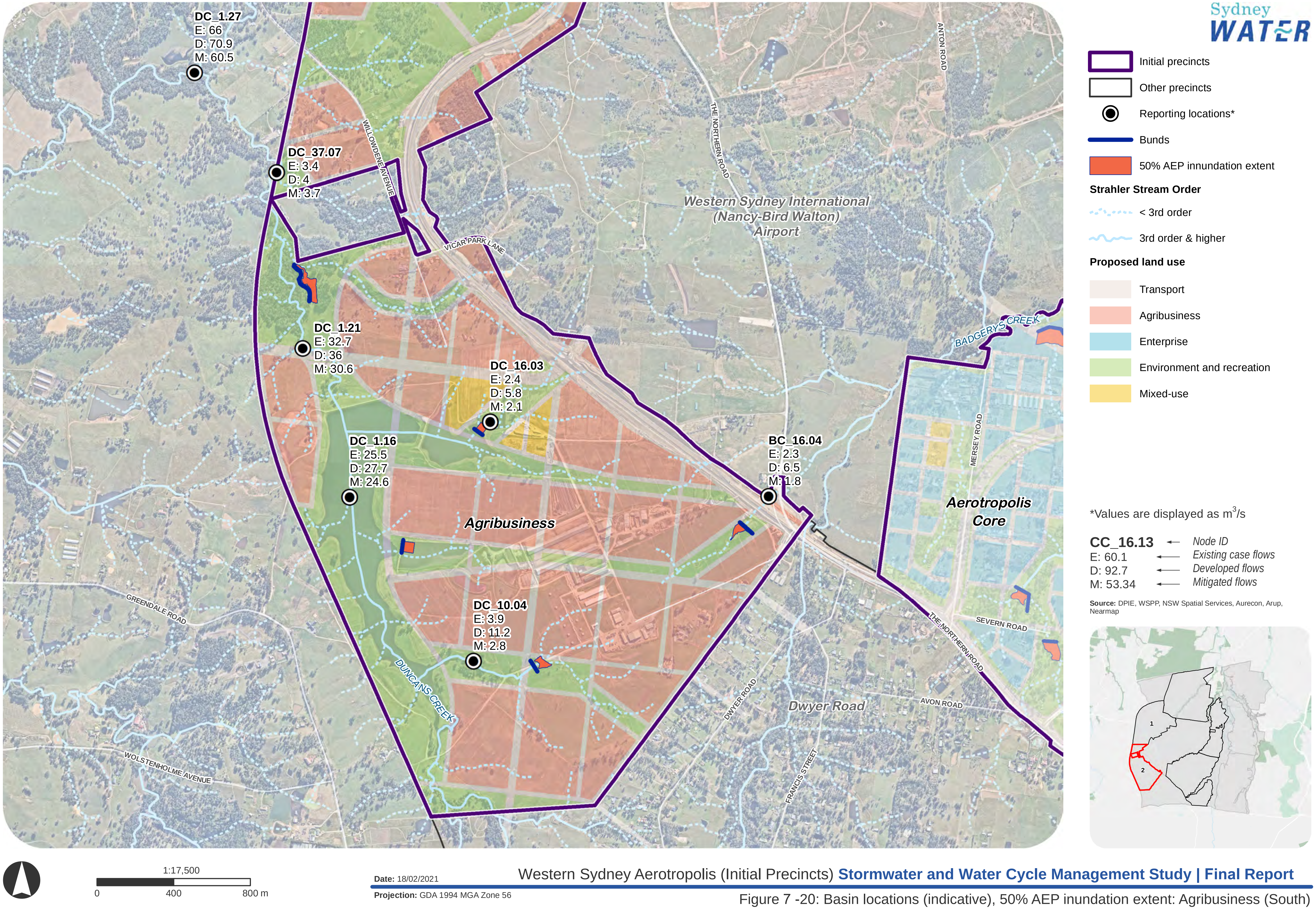
Figure 7 - 18: Basin locations (indicative), 1% AEP inundation extent: Aerotropolis Core



Date: 18/02/2021

Projection: GDA 1994 MGA Zone 56

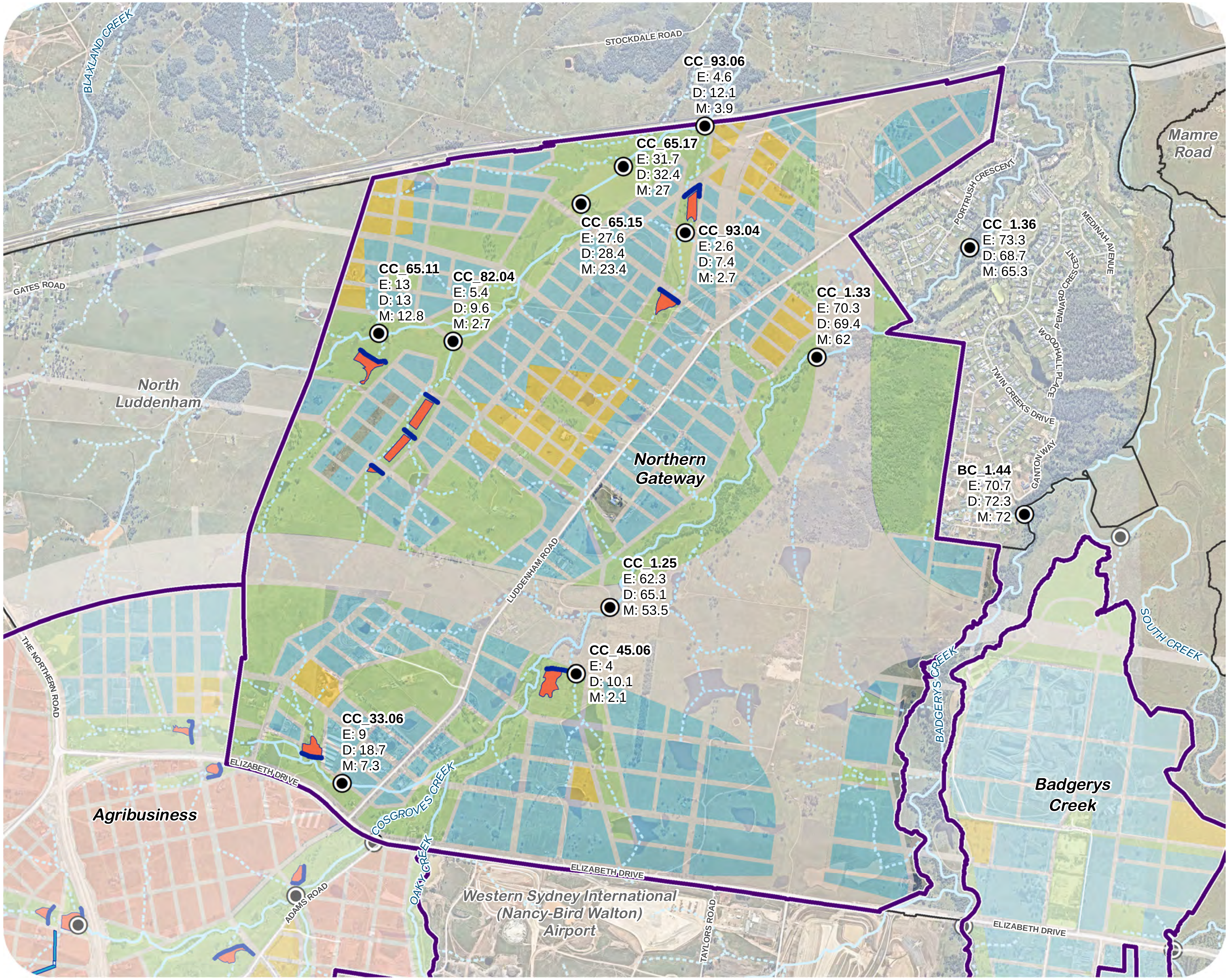
Figure 7 - 19: Basin locations (indicative), 50% AEP inundation extent: Agribusiness (North)



Date: 18/02/2021

Projection: GDA 1994 MGA Zone 56

Figure 7 -20: Basin locations (indicative), 50% AEP inundation extent: Agribusiness (South)



Sydney WATER

Initial precincts
Other precincts
Reporting locations*
Bunds
50% AEP innundation extent
Trunk drainage open channel
Trunk drainage channel beneath road

Strahler Stream Order

< 3rd order
3rd order & higher

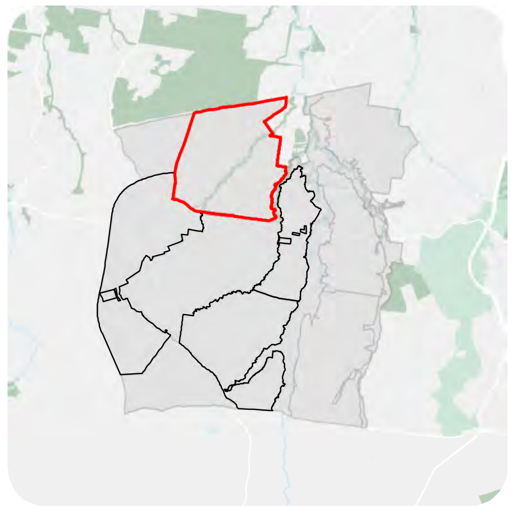
Proposed land use

Transport
Agribusiness
Enterprise
Environment and recreation
Mixed-use

*Values are displayed as m^3/s

CC_16.13 ← *Node ID*
E: 60.1 ← *Existing case flows*
D: 92.7 ← *Developed flows*
M: 53.34 ← *Mitigated flows*

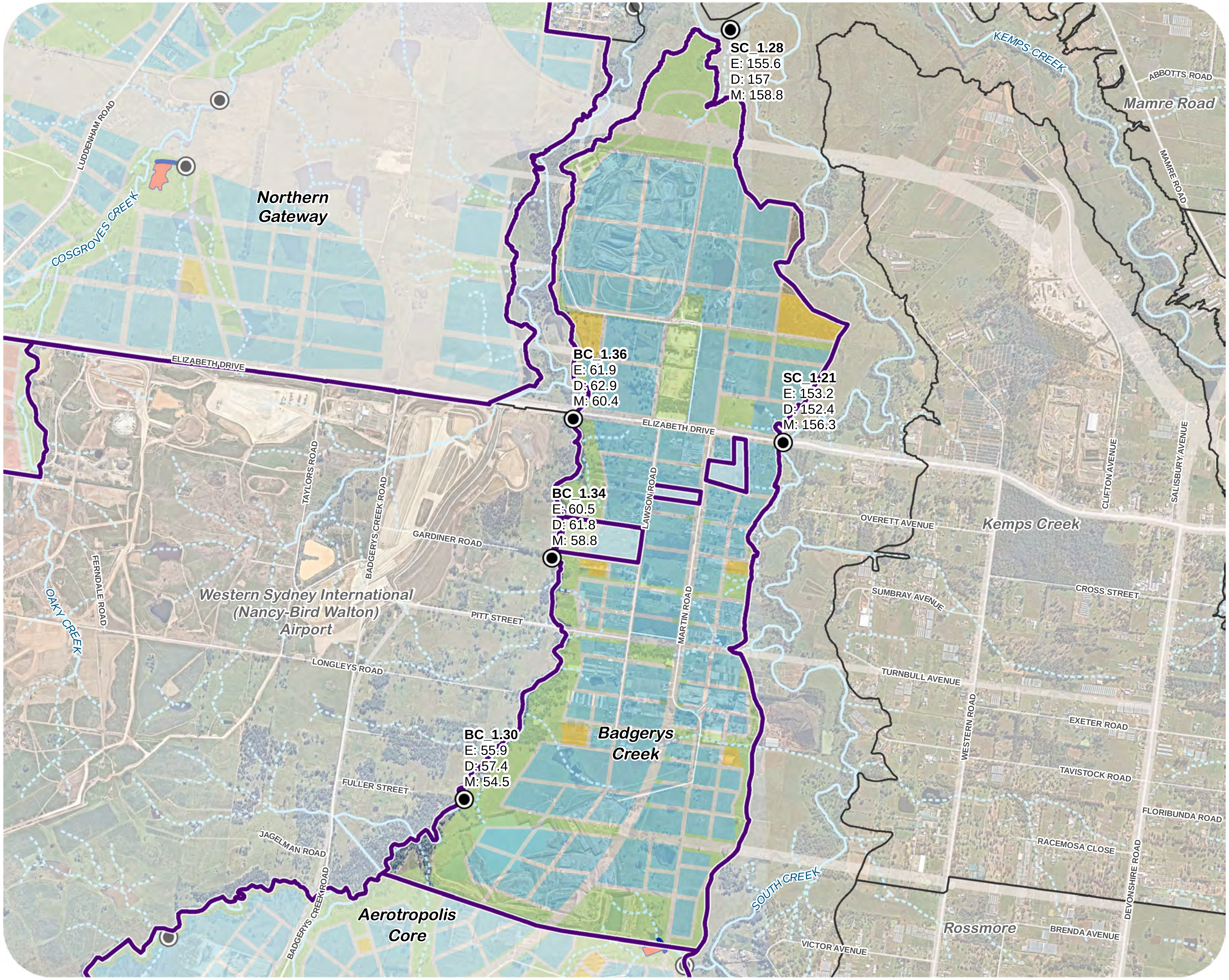
Source: DPIE, WSPP, NSW Spatial Services, Aurecon, Arup, Nearmap



1:22,500
0 400 800 m

Date: 18/02/2021
Projection: GDA 1994 MGA Zone 56

Figure 7 -21: Basin locations (indicative), 50% AEP inundation extent: Northern Gateway



Sydney WATER

Initial precincts
Other precincts
Reporting locations*

Strahler Stream Order

< 3rd order
3rd order & higher

Proposed land use

Transport
Agribusiness
Enterprise
Environment and recreation
Mixed-use

*Values are displayed as m^3/s

CC_16.13 ← *Node ID*
E: 60.1 ← *Existing case flows*
D: 92.7 ← *Developed flows*
M: 53.34 ← *Mitigated flows*

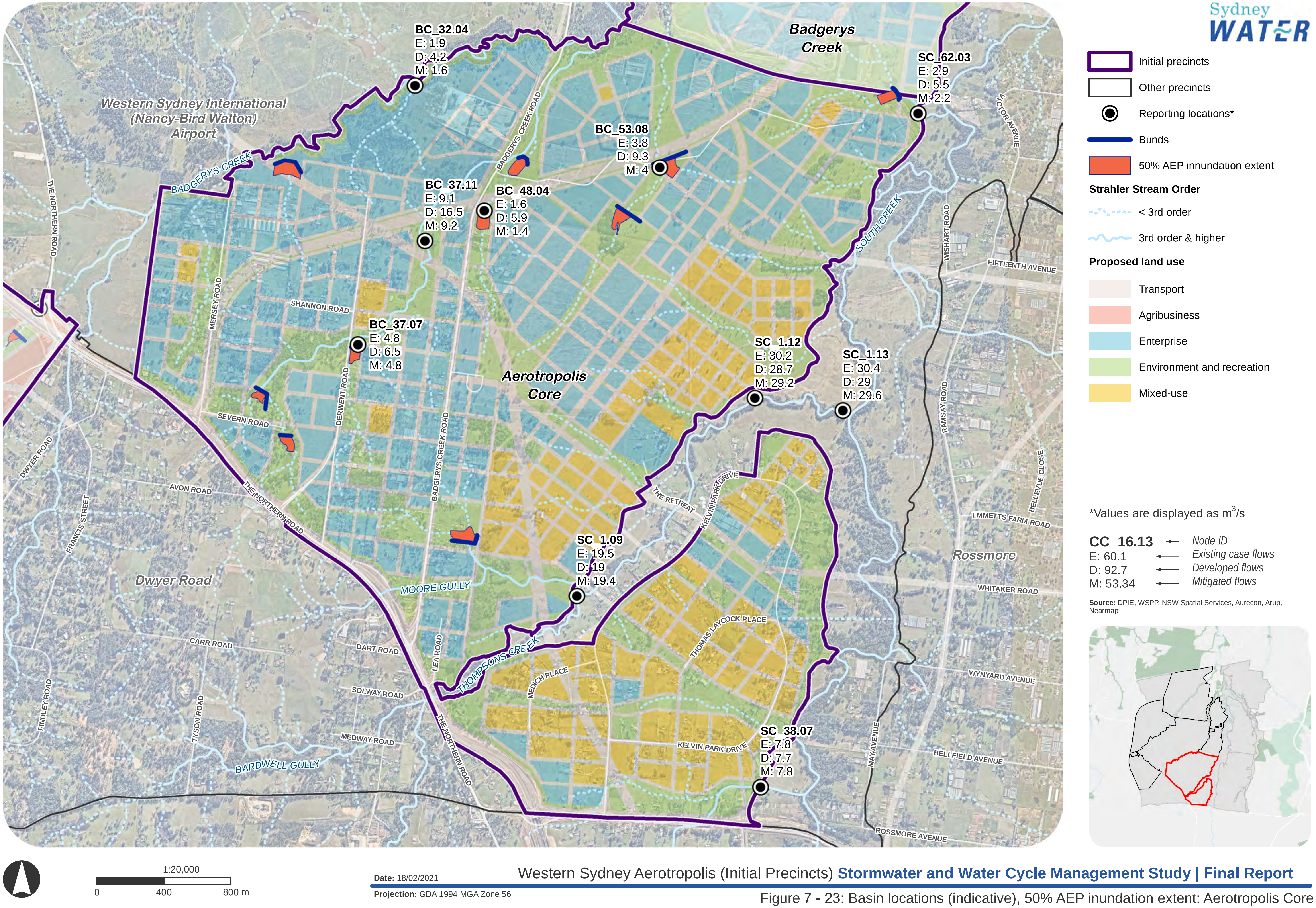
Source: DPIE, WSPP, NSW Spatial Services, Aurecon, Arup, Nearmap

1:22,500
0 400 800 m

Date: 18/02/2021
Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Final Report**

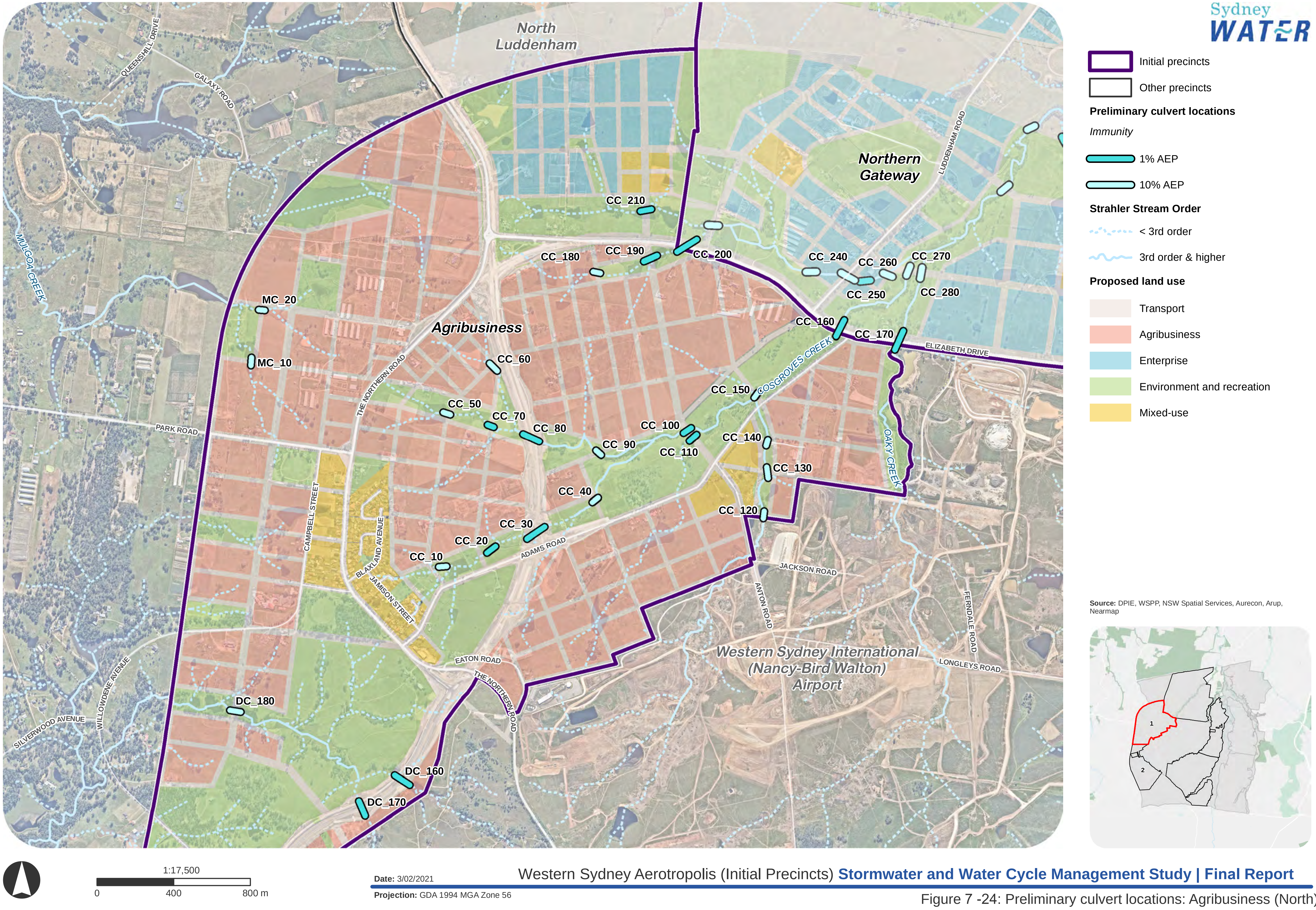
Figure 7 - 22: Basin locations (indicative), 50% AEP inundation extent: Badgerys Creek



Date: 18/02/2021

Projection: GDA 1994 MGA Zone 56

Figure 7 - 23: Basin locations (indicative), 50% AEP inundation extent: Aerotropolis Core

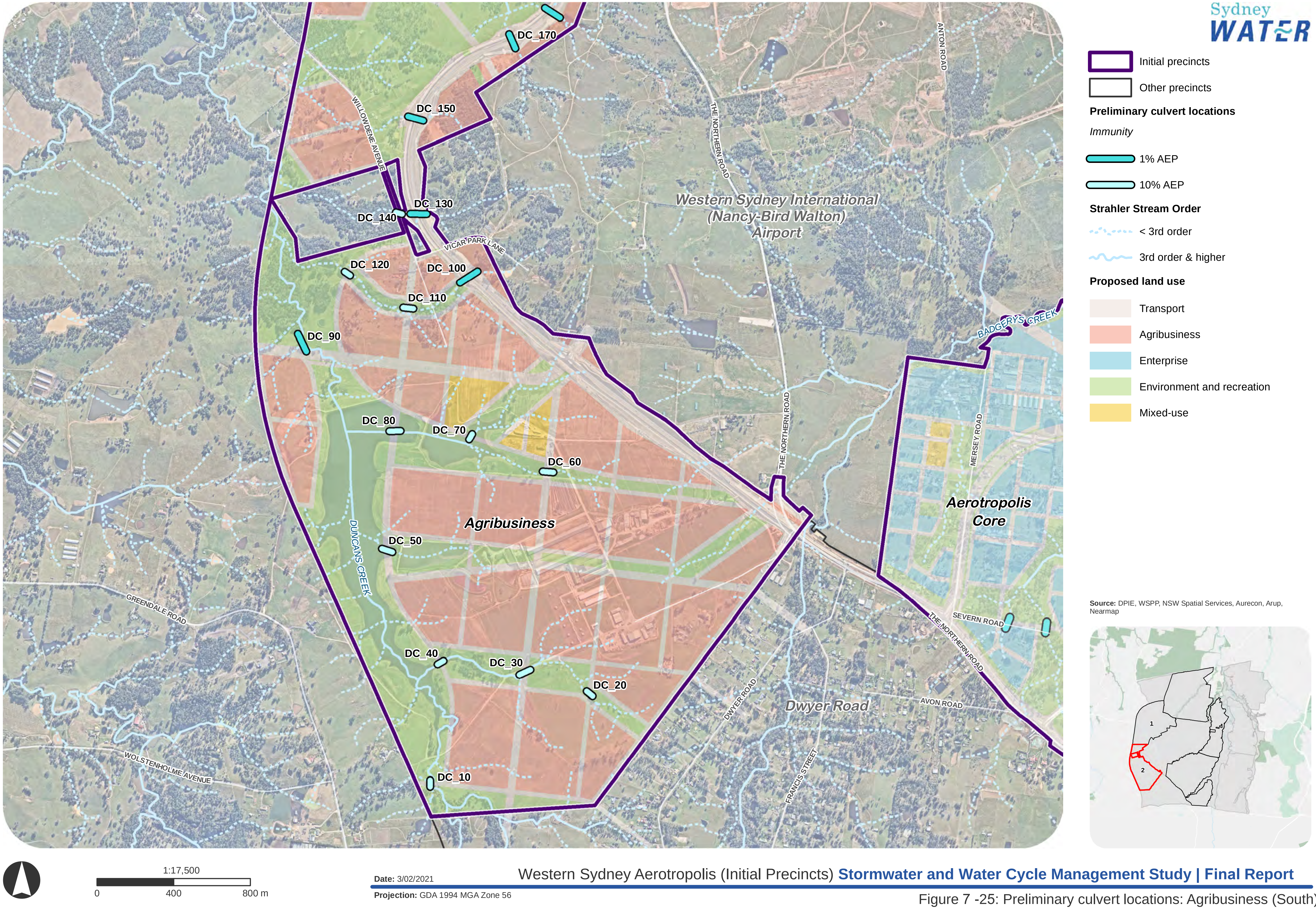


Date: 3/02/2021

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Final Report**

Figure 7 -24: Preliminary culvert locations: Agribusiness (North)

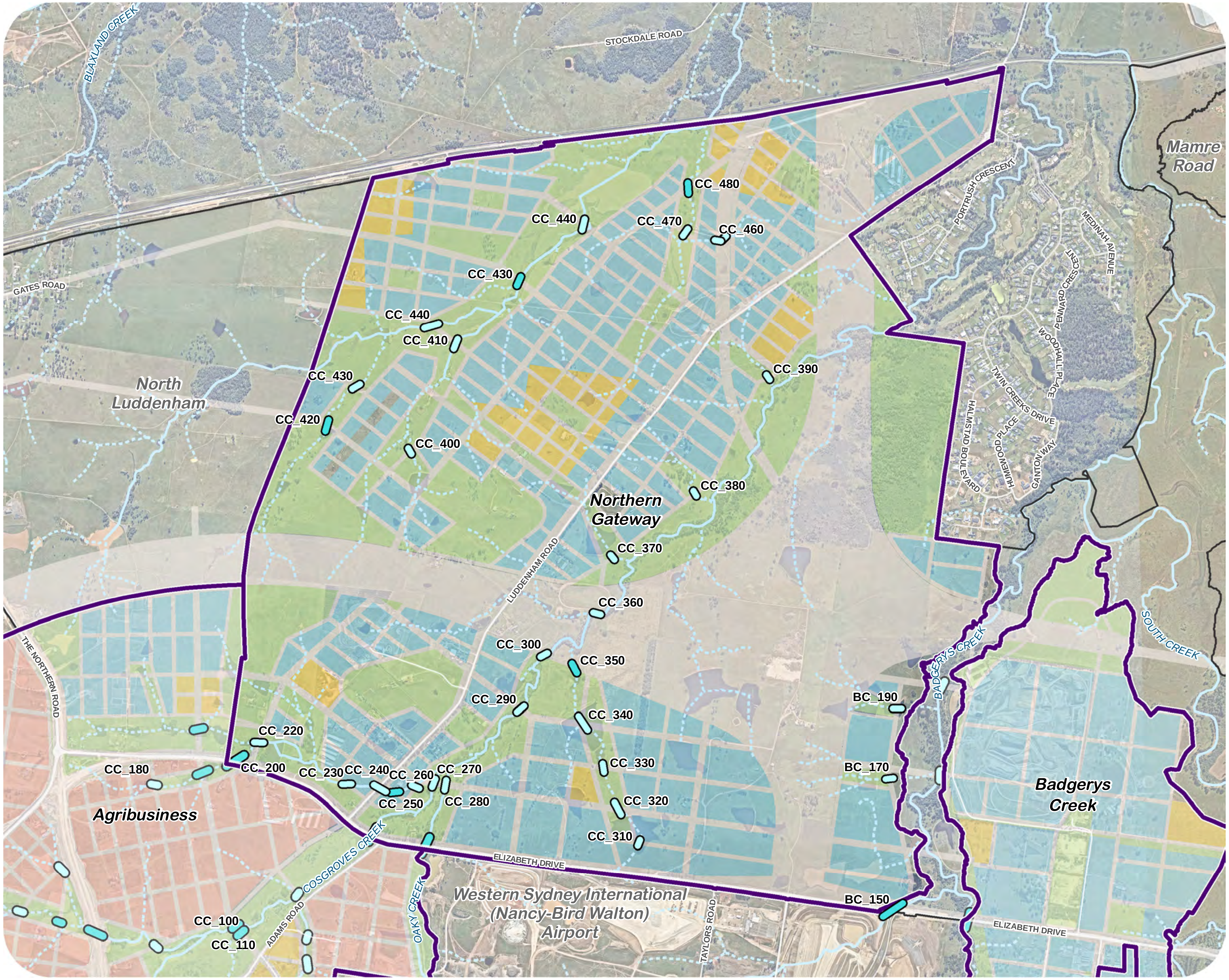


Date: 3/02/2021

Projection: GDA 1994 MGA Zone 56

Figure 7 -25: Preliminary culvert locations: Agribusiness (South)

Sydney WATER



Initial precincts

Other precincts

Preliminary culvert locations

Immunity

1% AEP

10% AEP

Strahler Stream Order

< 3rd order

3rd order & higher

Proposed land use

Transport

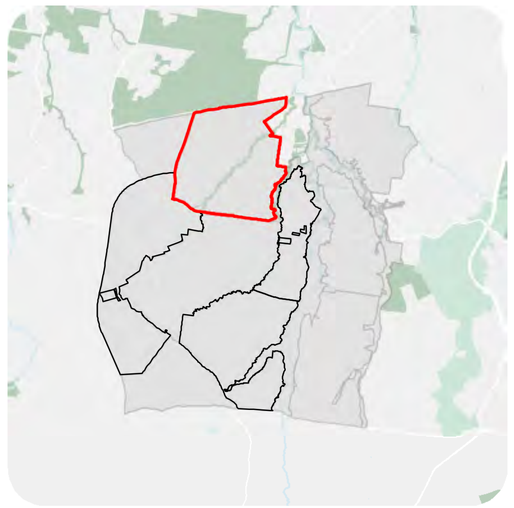
Agribusiness

Enterprise

Environment and recreation

Mixed-use

Source: DPIE, WSPP, NSW Spatial Services, Aurecon, Arup, Nearmap



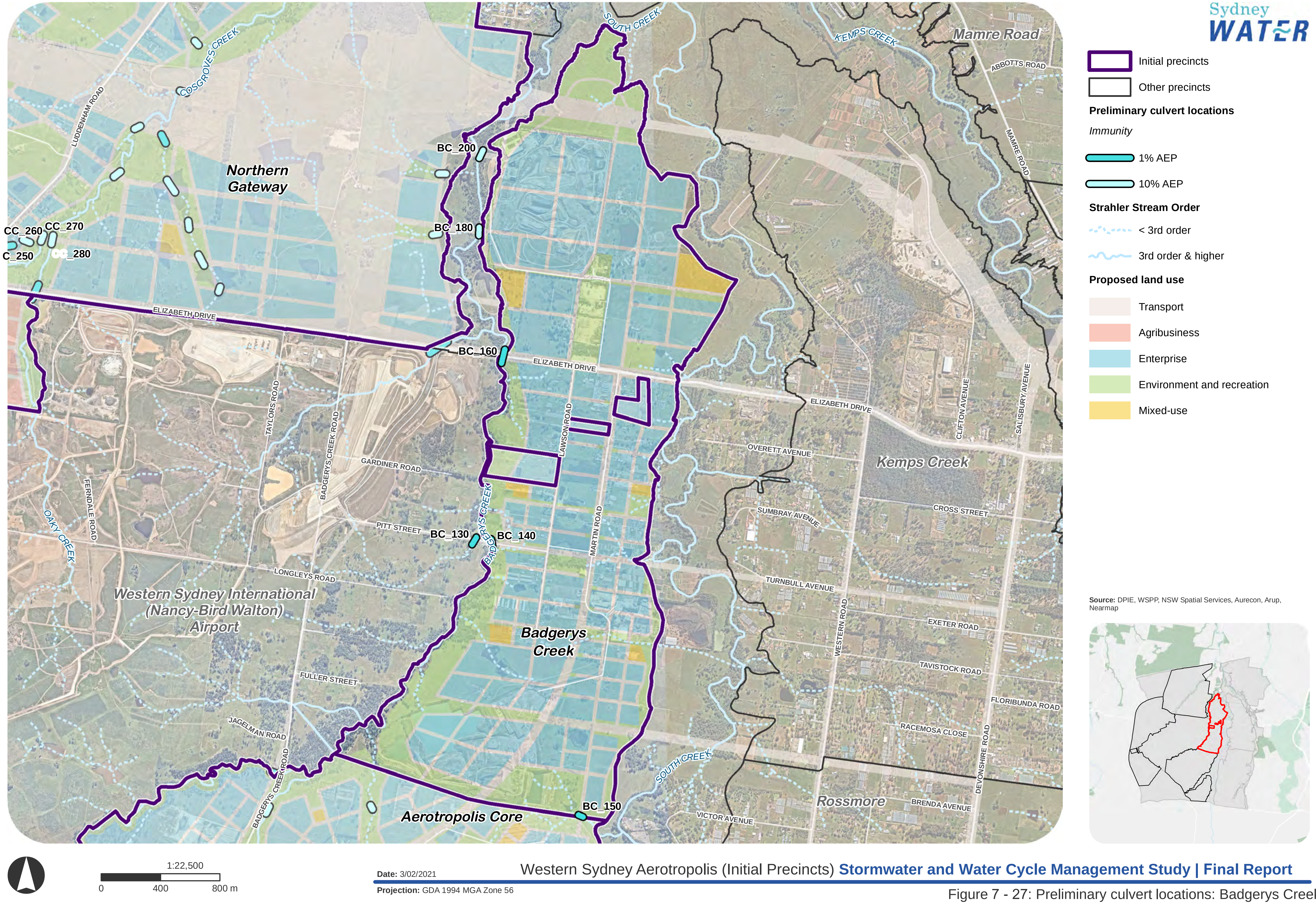
1:22,500

0 400 800 m

Date: 3/02/2021

Projection: GDA 1994 MGA Zone 56

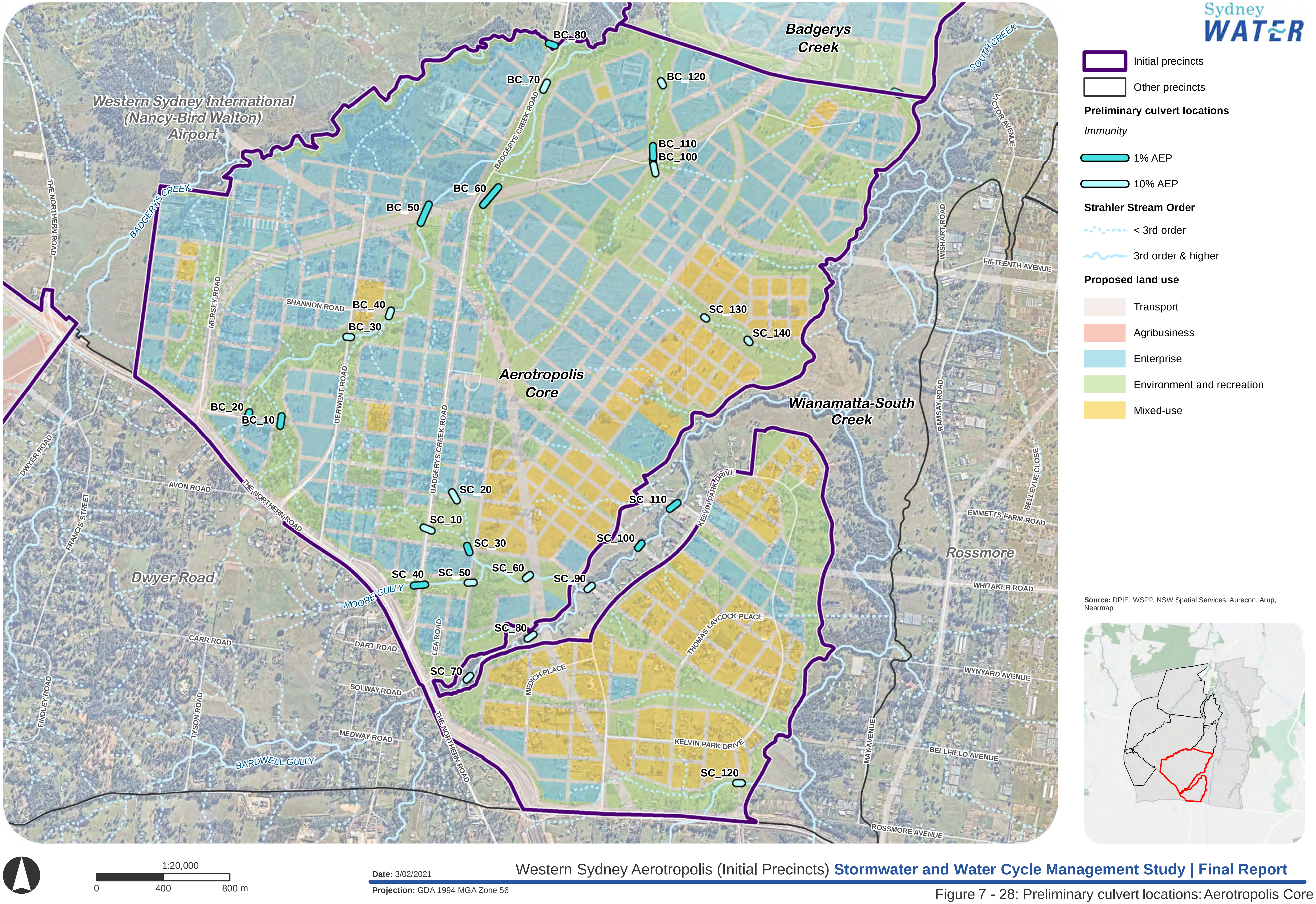
Figure 7 -26: Preliminary culvert locations: Northern Gateway



Date: 3/02/2021

Projection: GDA 1994 MGA Zone 56

Figure 7 - 27: Preliminary culvert locations: Badgerys Creek



Date: 3/02/2021

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Final Report**

Figure 7 - 28: Preliminary culvert locations: Aerotropolis Core

8 Landscape integration

This *Stormwater and water cycle management study* demonstrates stormwater management strategies for the purpose of identifying the land requirements for stormwater management infrastructure across the initial four precincts (Northern Gateway, Agribusiness, Badgerys Creek, and Aerotropolis Core) and the Wianamatta-South Creek precinct where it is adjacent to those precincts. Consideration is also given to stormwater management assets for Mamre Road.

As Chapter 6 and 7 indicate, new stormwater management objectives for the protection and improvement of Wianamatta South Creek call for more infrastructure than has been understood to be necessary in greenfield development within the Wianamatta-South Creek catchment. While this additional infrastructure places a greater demand on already constrained lands, this chapter sets out to demonstrate how the stormwater infrastructure can be optimised to become functional in place making for Western Sydney.

As well as ensuring that water servicing minimises demands on potable water supplies, the study strives to enhance the cultural, ecological and recreational values of the precinct waterways and downstream network of regional water bodies. This chapter provides the principles that have been used to integrate water sensitive urban design and stormwater retention into the multifunctional design of open space while preserving the sensitive Wianamatta-South Creek riparian landscape and ensuring public safety and airport specific risk management.

8.1 Landscape-led principles

The Wianamatta-South Creek precinct and its tributary waterways are the dominant landscape feature of the Aerotropolis and will play multiple roles to the existing and future community.

A key objective of this *Stormwater and water cycle management study* is to achieve stormwater discharges that work towards the NSW Government's waterway health objectives by mimicking the existing hydrological characteristics of waterways to maintain an acceptable condition of health and structure.

As detailed in the preceding chapters this requires a combination of at-source controls, stormwater harvesting and WSUD. The elements in the treatment train have been deliberately selected to complement the Parkland vision for the Aerotropolis and the Western Parkland City and provide multiple benefits besides stormwater management. These include dense street trees, wetlands, stomwater storages and irrigation networks. By playing a role in stormwater management, these elements become stormwater assets, but they play an equally, if not more important role, in making the Aerotropolis a liveable and competitive city in the face of an increasingly harsh climate. To play both roles, these elements need to be successfully integrated into the land use planning of these precincts.

By adopting a landscape-led approach in the design of all the future WSUD features we can ensure that the integration of the future stormwater infrastructure is appropriate to local context and maximises benefits for the local economy, environment and population.

The Aerotropolis Initial Precinct Plan (DPIE, 2021) establish overarching objectives for the design and development of precincts in the Aerotropolis. The following objectives from the Precinct Plan has been used to guide the integration of the WSUD stormwater assets:

i) 'Start with Country' by promoting access to Country and designing the Aerotropolis through a process that includes Aboriginal people.
ii) Integrate development and the delivery of infrastructure to maintain a supply of developable land and to maximise the efficiency of infrastructure investment;
iii) Protect Airport operations, including 24-hour operations, and protect future communities from aircraft noise;
iv) Create a distinctive Aerotropolis city character with a public domain of outstanding urban design, and architectural and landscape merit that responds to site topography and landscape;
v) Implement a landscape-led approach to designing the Aerotropolis, utilising the blue-green grid and natural topopgraphy of the Aerotorpolis as the defining elements;
vi) Design an urban environment that responds to the climate extremes of Western Sydney and which mitigates and adapts to urban heat;
vii) Manage water in the landscape to faclitate urban cooling, improve waterway health and biodiversity and promote sustainable water use;
viii) Plan for a resilient city through the implementation of a risk based approach to management of natural hazards including flooding, bushfire, drought and heat;
ix) Reinstate and rehabilitate natural landscape connections and systemss to sustain biodiversity and allow natural systems to function sustainability.

8.2 Designing with vegetation

All trees and vegetation in an urban context play an important dual role in increasing the capture, re-use, evaporation, and evapotranspiration of stormwater. Maximising the areas of soft landscaping around urban form will contribute significantly to stormwater management at a lot, street and precinct scales.

Providing generous setbacks around industrial development and in providing compact forms works towards achieving the waterway health objectives by reducing the total volume of stormwater runoff generated in the catchment. This requires the efficient use of impervious areas. Where space for planting is limited, green roofs and walls can also play a role in water capture. These all provide an important opportunity to retain additional stormwater through irrigation of stored water.

8.2.1 Tree canopy targets

In 2019, the NSW Government announced a grant program with the goal of planting 5 million additional trees across Greater Sydney. The program aims to achieve an average 40% canopy cover across the City to create greener places, cleaner air and mitigate increasing urban heat. The success of this program will rely upon sufficient space within the urban environment for trees to be planted and established and a sustainable, climate independent source of water for irrigation to ensure the health and longevity of the trees planted. Stormwater infrastructure can play an important role in supporting street trees and canopy cover in the new urban areas of the Aerotropolis, where an increasingly hot and dry climate presents a significant challenge to tree health.

Passive irrigation of trees within the private domain, streetscape and open spaces through the stormwater system can improve tree growth and canopy cover and can improve the cooling benefits of trees and vegetation. When integrated with the recycled water network to supplement stormwater during dry periods, trees and open spaces can remain 'green and cool' all year round, providing important respite from extreme heat. Large species trees (a tree that can attain a hight of 15+ m when mature) are preferred in urban landscapes to maximise stormwater management capture as well as achieving urban canopy targets aimed at providing greater social, economic and ecological benefits.

Increased tree canopy also plays any important role in mitigating the movement of salt across precincts by intercepting shallow groundwater.

Generally, street trees will be placed at variable densities and on one of both sides of the road depending on land use and streetscape typologies. The tree pit and raingarden details can be configured to ensure that planting is passively irrigated with stormwater on even very steep grades. Soil depths will be maximised, and the structure, fertility and moisture retention of the soil mediums will be tailored to site conditions and tree species.

Drainage layers will ensure that the tree roots are not sitting in water logger conditions and gain the best chance of developing a healthy root mass to support an equivalent leafy crown.

8.2.2 Groundwater dependent vegetation

The function of WSUD elements can significantly impact on regional groundwater tables and groundwater quality on which local flora and groundwater dependent ecosystems. WSUD elements will be designed to:

- accommodate regional groundwater that has been mapped as shallow as 2 m below ground surface. This has implications for construction and ongoing maintenance
- avoid infiltration or over irrigation unless it is deemed appropriate by the relevant hydrogeologic landscape guidance
- encourage infiltration in an appropriate way where it is necessary to the preservation of existing stands of Cumberland Plain species and groundwater dependent ecosystems
- match baseflow contributions or provide equivalent opportunities for groundwater expressed flows in waterways through appropriate means (infiltration or direct discharge as trickle flows)
- contribute to rows of trees within streets, reserves and riparian corridors to intercept shallow lateral groundwater and mitigate the potential migration of salt from hill slopes into the groundwater table and baseflow.

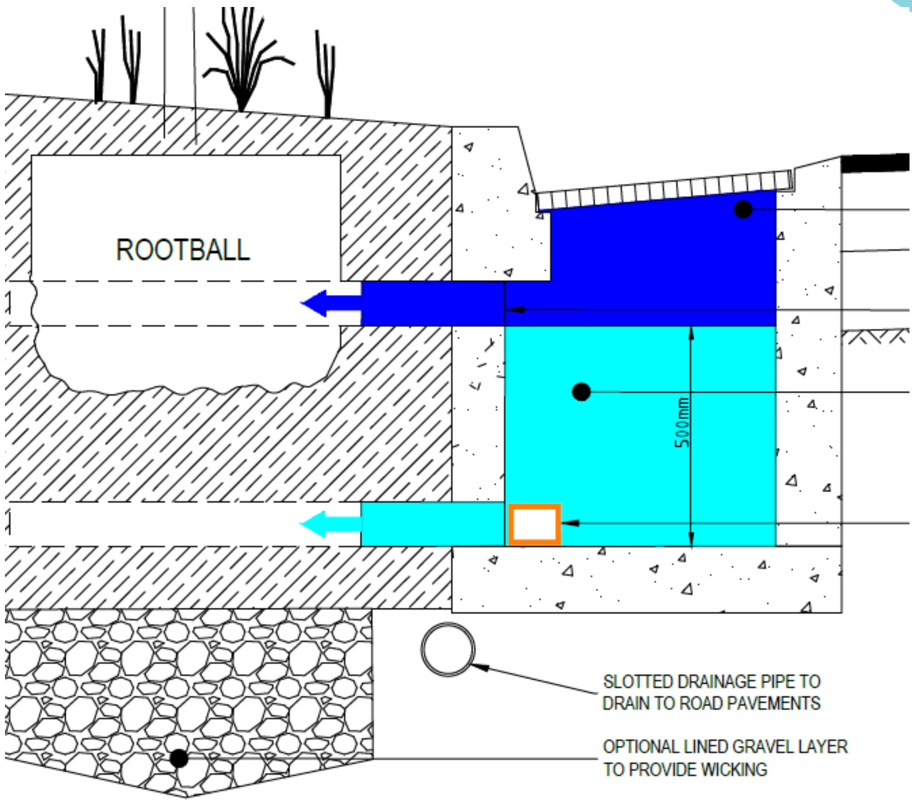


Figure 8-1 Typical passively irrigated street tree (refer to Appendix B for all details)

8.3 Wildlife strike risk management

The Western Sydney Aerotropolis Draft Wildlife Management Assessment Report (Avisure 2020) identifies drainage assets as well as detention and retention basins as having the potential to attract wildlife (mainly birds). Sydney Water has considered both the Draft Wildlife Management Assessment Report as well as the Sydney Water Wildlife Hazard Assessment (Avisure 2020a) in developing this Stormwater and Water Cycle Management Study. Both note that the initial precincts currently include a complex network of farm dams and ponds that support large populations of water birds. Construction of the airport and changes to land use within the Aerotropolis will alter many of these habitat sources. The vast majority of existing farm dams will be removed, whilst a series of natural drainage channels and stormwater wetlands will be required to service development. The Draft Wildlife Management Assessment Report outlines the Aerotropolis Aviation Wildlife Safeguarding Framework to mitigate wildlife strike risks for aircraft operating at Western Sydney Airport once the airport is operational.

The framework identifies stormwater assets such as wetlands and water storages as having a high wildlife attraction risk and waterways a moderate wildlife attraction risk. Neither are listed as incompatible land uses. The level of risk and required management response varies depending on the proximity to the airport. These types of assets will need to be planned, designed, constructed and operated in line with the wildlife hazard assessment process (Avisure 2020) with input from suitably qualified experts. The stormwater system (or scheme) as well as each individual stormwater asset will likely require a wildlife management plan that documents how wildlife strike will be managed and monitored. Some of the wildlife strike management controls that will likely be required include:

- Use of suitably qualified aviation ecologists in the scheme and concept design for stormwater assets
- Develop and implement ongoing Wildlife Management Plan/s
- Assets owned and managed by trunk drainage manager
- consider use of bioretention systems and sub surface wetlands
- Water edge treatments that exclude foraging zones and water access
- Specific water depths that discourage wildlife attraction
- Plant and manage vegetation to minimise wildlife strike (as per approved guidelines for species etc.)
- Avoid islands or perching structures
- Include interpretive signage and/or enforcement discouraging bird feeding
- Adaptive management to respond to issues as they arise or seasonal risks
- Overhead wires or netting over water bodies as required
- In extreme cases water storages could be buried/covered (at significant additional cost)

8.4 Designing for maintenance

To sustain high amenity values,WSUD elements and green infrastructure must be robust enough to withstand the wear and tear of frequent and rare storm events. Stormwater management elements will be designed to minimise maintenance and lifecycle costs whilst still achieving their intended benefits and functionality.

WSUD elements will be designed to:

- have appropriate flood immunity without sterilising developable or otherwise functional land
- be elevated above frequent water levels in adjacent waterways to ensure that WSUD devices do not go into flow bypass in frequent events up to the six month or (2 EY) event

- be bypassed by flows exceeding the six-month flow and up to the one-year flow
- minimise algal bloom risks in open water bodies through nutrient management on inflows, appropriate residence times and depth profiles, and management of the water column through macrophyte planning
- allow for wet weather access to the top of any extended detention zone using a 9m long rigid vehicle
- consolidate maintenance activities into areas of easy and safe access and work with prevailing conditions
- to be drained without the use of pumps (where practicable) or physical attendance of maintenance staff at site
- allow staged maintenance without taking an entire WSUD element offline
- avoid materials that can be vandalised or broken, or provide protection of vulnerable elements (eg wetland outlet risers).

8.5 Public safety

Public safety is essential for proper integration of WSUD infrastructure into the landscape. Interaction with waterways and blue green infrastructure is an ideal aspiration for WSUD elements but must minimise the chance of harm occurring through reasonable safeguards. WSUD elements will be designed to:

- ensure inundation free pedestrian/bicycle routes and playground facilities up to the 10% AEP (1 in 10-year) flood level
- ensure no more than 1.2 m deep stormwater over pedestrian/bicycle routes, active open space and playground facilities up to the 1% AEP (1 in 100-year) flood level
- ensure pedestrian egress paths lead away from high flood hazards, along grades no steeper than 1(V):6(H)
- minimise risk of drowning and fall injury with appropriate level changes, internal batter slopes for egress and include balustrades where necessary
- have regard for human exposure risk and mitigate ingestion of pathogens through appropriately timed irrigation periods and include disinfection where necessary
- manage algal risk by reducing incoming nutrient loads and providing oppertunitiy to management poor water quality during periods of algal blooms or eutrofication.

8.6 Preserving floodplain function

To preserve flood conditions and hydraulic function of the floodplain, stormwater management elements will be designed, constructed and maintained to manage impacts on flooding. Stormwater assets will be designed to:

- preserve floodplain conveyance for critical flood events
- not worsen flood risk and flow patterns on existing development by generally avoiding the 1% AEP floodway
- preserve floodplain storage up to critical flood event (eg.1% AEP event) as determined by floodplain management studies

To achieve these broad principles, a typical design process shall include:

- Source suitable baseline flood information
- Determine the type (wetland, detention zone, trunk drainage channel etc.) combination and required sizing of stormwater elements at each site
- Assessment of opportunity to adjust or relocate footprint of less compatible structures outside of core floodway corridor
- Identification of specified height of bunds or local changes in the floodplain topography that will be required to construct each structure
- Determination of floodwater depths at location of each bund or local changes in the floodplain topography for the 5% and 1% AEP floods
- Comparison of flood levels due to height of bund or local changes in the floodplain topography with predicted floodwater levels
- Flood engineering assessment to determine the potential for the bunds / structures to impact on peak flood levels and/or flow conveyance and determine whether the design principles are being met.

8.7 Templates for integrated water management infrastructure

The following chapter presents ten typical WSUD elements and how they can be configured and integrated into the landscape while contributing to the delivery of stormwater management and waterway health objectives outlined in Chapters 6 and 7. In this way, the stormwater assets provide value to the landscape and minimise the amount of land required for stormwater management.

A key feature of the templates has been the provision of adequate extra space around the WSUD elements to respond to the objectives and design principles defined above. This extra space refers to the ancillary land surrounding the functional areas of the WSUD basins (eg macrophytes, sediment basins, open water zones or biofiltration media) that accommodate maintenance tracks and safe, natural batter slopes. This to avoid insufficient space giving the appearance that WSUD elements are ‘forced’ onto the landscape resulting in poor operational, social and aesthetic outcomes.

Templates have been developed through a combination of terrain modelling, civil design, and landscape architecture. Terrain models of several specific sites across the precincts has informed the total land take for WSUD elements, access tracks and batter slopes. This has been done on a range of grades representative of the floodplains that WSUD elements will occupy.

The provision of extra space around the WSUD elements also ensures flexibility to configure the various parts once all catchment land use, road network patterns and site constraints (especially Aboriginal heritage) that inform each basin are understood completely.

The templates include landscape and civil design considerations. These are not detailed designs, for the sheer number of basins required at this time does not allow for conceptual design of every basin. The templates are illustrative in nature and are intended to provide guidance and inspiration for WSUD practitioners who will ultimately develop the designs of the precinct WSUD elements.

Appendix B should be read in conjunction with this chapter and provides illustrations of each scenario with precedent images. Sections and sketch templates based on indicative locations within the precincts and to represent the widest range of land uses.

Template 1: Typical bio-retention and wetland/pond treatment

Template 1 provides a typical configuration of bio-retention basins and wetlands to treat storm water before discharge into adjacent existing creeks.

Whether located on the edge of a recreational playing field or within a public open space or business park landscape the design of the basins will aim to:

- maximise connectivity to the wider active transport network
- integrate maintenance access into the landscape design of the asset
- provide recreational facilities
- improve landscape integration through sensitive terrain grading and planting strategy.

Figure 8-2 Typical bio-retention and wetland/pond treatment at end of pipe

Template 2: Space restricted bio-retention and wetland/pond treatment

Open space in and around building plots within the precincts is likely to be constrained and therefore this template presents a typical linear configuration of bio-retention features within a restricted /narrow infrastructure corridor. The features are located close together and following contours to reduce need for large batters and earth works.

Set within an agri-business land use the design of the basins will aim to:

- maximise the integration of the WSUD into road and infrastructure network
- provide walking trails and increased canopy cover for use by office workers and visitors
- accommodate narrow land through the use of retaining walls as necessary
- utilise the stormwater treatment functionality of the wetland which can accommodate a shallower level change between the creek and adjacent road corridor.

Figure 8-3 Typical bio-retention and wetland treatment

Template 3: Steep terrain profile bio-retention and wetland/pond treatment

This template has been selected to demonstrate design considerations in areas where gradients exceed slopes of 1 in 4 or greater. As with template 2 the features follow site contours to reduce the need for large batters.

Although space is less of a limiting factor, careful orientation is needed to allow for optimal flow rates between basins. The design of the WSUD features will aim to:

- utilise the changes in topography to create look out features that enhance viewing corridors and views
- connect habitats and utilise linear assets to strengthen biodiversity
- incorporate a matrix of aquatic, marginal and terrestrial native planting within and around the water treatment areas for visual appeal, biodiversity value as well as enhanced water treatment potential
- locate bioretention at levels that can drain freely while utilising low lying floodplain zones for wetland/open water that require less level change to function
- utilise stormwater diversions to distribute stormwater between biofiltration and wetlands to derive more land use benefit.

Figure 8-4 Steep terrain profile bio-retention and wetland treatment

Template 4: Tree pit detail

As discussed in the 'designing with vegetation' section above, street trees provide multiple urban benefits and management of salt in Western Sydney. The delivery of healthy tree canopy is recognised in the Premier's Priority for 5 million trees across Greater Sydney, as an important way of increasing the resilience of Western Sydney in the face of climate change and increased annual days exceeding 40 degrees.

The role of street trees in stormwater management is not new but has received increasing focus in recent years. Literature provides guidance on the volume of soil that a tree root ball requires to support its ideal height and canopy diameter. Delivery of water and oxygen to the root ball is also essential for creating a viable volume of soil that the tree can utilise. It follows that trees need to be well provided for during the boxing out of local streets to ensure that services are protected, and root balls are accommodated. For some tree species this will also require amelioration of the Western Sydney soils.

The sheer number and scale of investment in street trees provides an ideal opportunity to incorporate stormwater management that supports the trees and achieves a downstream waterway benefit by acting as a de-facto bioretention system. Delivery of stormwater run-off to the tree rootball enables the tree to be passively irrigated during every rain event and facilitates easy irrigation during dry spells.

There are many examples and potential configurations of tree designs, two are presented in Template 4 represent the book-ends of low- and high-tech street trees and overcome a range of issues encountered on both flat and steep streets alike.

The design of passively irrigated the biofiltration street trees will:

- integrate with utilities and infrastructure to maximise the tree canopy cover on streets
- include diverse variety of tree and planting native species to improve seasonal interest and biodiversity value
- utilise tree species that will be viable in climate forecasts
- incorporate a means of capturing run-off during each rain event and effectively deliver that water to the root ball
- include a means of capturing sediment and facilitating sediment removal while remaining functional between maintenance events
- prevent excessive groundwater recharge, while allowing shallow lateral groundwater ingress to reach the root ball. This may require lining only the base and any wicking bed features
- discharge excess stormwater to the stormwater networks to prevent waterlogging and damage to pavements.

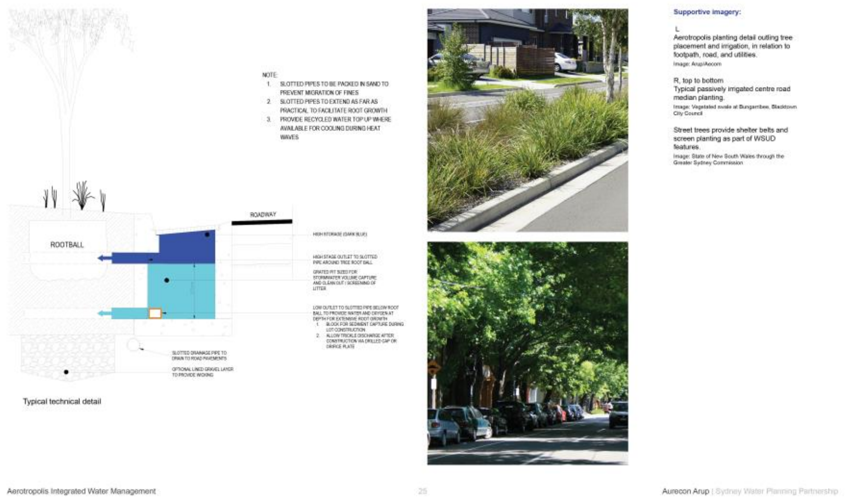


Figure 8-5 Typical streetscape section (courtesy of Bligh Tanner)

Template 5: Online detention on 1st/2nd order creek (outside VRZ and HEV)

Chapter 7 demonstrates how a combination of on-site stormwater detention and regional facilities can manage run-off to ensure no increase in peak discharge conditions at the precinct boundaries.

Template 5 illustrates how a regional stormwater detention facility can be delivered as an online stormwater detention basin incorporated into 1st and 2nd order watercourses. This approach has merits for inclusion on 3rd and 4th order waterways but is not endorsed by the guidelines for controlled activities on waterfront lands at this time.

This approach relies on achieving waterway health objectives for all flows entering the detention basin to ensure that waterway integrity is protected against erosion.

It provides a benefit in utilising the flood plain as additional active detention storage without requiring additional land for creating stormwater detention basins.

The configuration below shows how an elevated active transport route provides the detention embankment with a culvert underneath, sized to provide the design discharge rates. Failure of the culverts would result in overtopping of the active transport route, as opposed to overtopping a roadway and potential evacuation route.

It is feasible that the same approach could be utilised for road embankments on 3rd and 4th order if appropriate blockage controls (e.g. bollards spaced regularly across the at the upstream culvert) are provided that prevent the basin from functioning as designed.

Figure 8-6 Online detention on 1st or 2nd order creek

Template 6: Riparian revegetation

The network of creeks and tributary waterways contain remnant biodiversity that should be fortified with complementary re-vegetation works to restore continuous habitat corridors. Revegetation and corridor management must be compatible with fire and flood planning and ensure no worsening of risk on existing development. On a merits basis, new development may accommodate altered flood levels but the flood immunity of existing development must be protected.

This template illustrates how different zones within the floodplain and blue-green grid will require different revegetation and management strategies to balance the various objectives for floodplains. This approach would not apply active open space or formal parks.

- **Management Zone 1 HEV Protect** - Incorporates land mapped as HEV 'Protect' between creek channel to the outer edge of the 1% AEP extent. The primary function of this zone is to protect remnant biodiversity. Management of this zone seeks to protect existing native vegetation patches and restore a fully structured river flat forest plant community (canopy, understory and ground cover).
- **Management Zone 2 HEV** Improve - Incorporates land mapped as HEV 'Improve' between the creek channel to the outer edge of the 1% AEP Flood extent. The primary function of this zone is to improve the connectivity of remnant biodiversity and provide buffers to HEV 'Protect'. Management of this zone seeks to either:
  - revegetate a fully structured river flat forest plant community within the vegetated riparian zone (VRZ) or
  - create a near continuous tree canopy while maintaining flood conveyance in areas outside the VRZ. This zone may include WSUD elements if existing flood planning levels are not affected.
- **Management Zone 3 Floodway** - Incorporates land mapped as the 1% AEP Floodway that excludes areas mapped as HEV and VRZ. The primary function of this zone is flood conveyance. Management of this zone aims to create a mosaic of native tree canopy cover with native groundcover (ie native grasses, forbs and herbs).
- **Management Zone 4a vegetated riparian zones outside of HEV** - Incorporates areas of VRZ that are not mapped as HEV. The primary function of this zone is to protect and enhance the riparian zone along creek lines. The management of this zone seeks to reinstate a fully structured river flat forest plant community (canopy, understory and groundcover) on to land that contains little existing ecological value (similar to zone 4b).
- **Management Zone 4b Opportunities for more habitat and tree canopy** - Incorporates public open space between the 1% AEP floodway and 1% AEP flood extent as that are not mapped as HEV. The primary function of this zone is to expand habitat and tree canopy outside of remnant native vegetation patches and into zones that are less critical for flood conveyance. The management of this zone seeks to reinstate a fully structured river flat forest plant community (canopy, understory and groundcover on to land that contains little existing ecological value (similar to zone 4a). This zone may include WSUD elements if existing flood planning levels are not affected.

Template 7: Trunk drainage channel outside HEV

Analysis of Western Sydney street typologies shows that trunk drainage should commence when roughly 15 to 16 Ha of catchment contribute flows to the major and minor drainage network. The provision of open trunk drainage channels will assist in providing safe conveyance of pluvial flows through urban areas, avoiding the need for box culverts to maintain safe overland flow conditions within roadways.

Template 7 illustrates the creation of a natural stormwater channel and drainage easement where peak flows would require costly stormwater culverts to avoid unsafe conditions forming within roadways and private land. The channels are intended to provide a trunk drainage function while extending active transport links and habitat corridors.

The key design objectives of this template include:

- waterway health objectives being achieved before discharging to waterways
- channel access being provided to at least one side for maintenance and may serve a dual function as an active transport route.

Template 8: Retained farm dams for ecology

Selected existing farm dams of ecological value and located within an HEV protected area will be safeguarded. A new engineered dam and bioretention basin/wetlands will be designed into the existing dam landscape to protect endangered ecological communities. Revegetation along the new dam wall will also help restore native habitat and connect to existing vegetation associated with the retained farm dam.

These retained dams will not only function as places for ecology but also focal areas for learning and for the community. In this example the selected dam is located within an industrial area land use and in addition to the reconstructed dam wall a new community education facility is proposed to engage with First Nations traditional land, water and agricultural management practices associated with the Wianamatta landscape.

WSUD elements around farm dams will be designed to:

- meet water quality objectives before discharge to farm dams
- utilise farm dam footprints where feasible
- ensure integration with surrounding land use and public safety is protected
- divert high flows around farm dams.

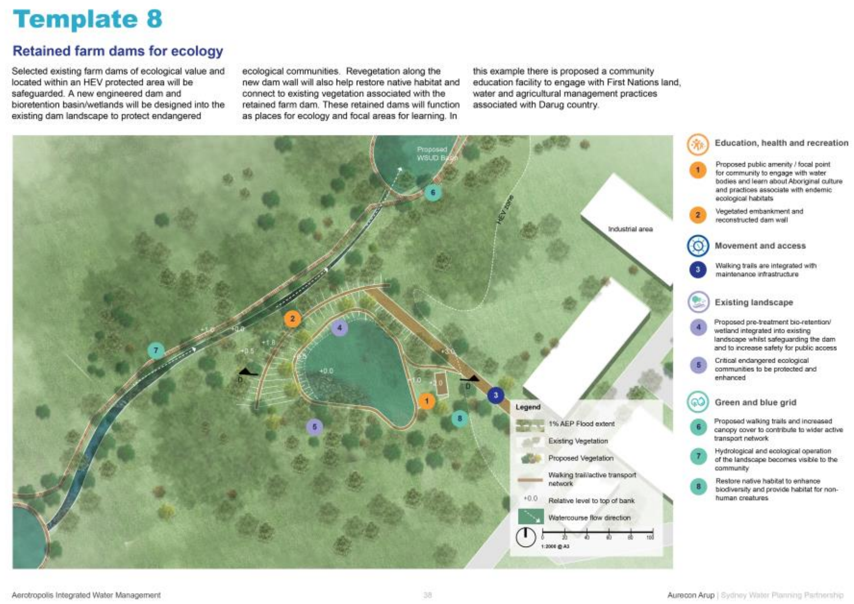


Figure 8-7 Retained farm dams for ecology

Template 9: Reprofiled farm dams for recreation

This template illustrates how existing farm dams can be relocated and rebuilt to continue their habitat and amenity for the surrounding community.

Online farm dams will require rebuilding to be offline. By re-engineering the dam walls to meet engineering standards recreational and biodiversity values can be preserved. In this example the basins incorporate walking trails and gathering spaces together with boardwalks, stepping stones and seating.

New planting could also be provided to help connect creek-side vegetation with new parklands.

Figure 8-8 Reprofiled farm dams for recreation

Template 10: Bypass pipelines for 1st-2nd order waterways

Chapter 6 has demonstrated that the hydrology from the proposed treatment train is suitable for 3rd and 4th order waterways but is still too much discharge for 1st and 2nd order waterways. Chapter 5 also documents the responses from Councils that regional WSUD facilities should be consolidated to reduce the number of stormwater management assets across the precincts. This template demonstrates the principle of consolidating WSUD basins via a diversion pipeline that runs parallel to creeks and carries the treatable flow rate to centralised wetlands and open water bodies.

WSUD elements can often dictate the earthworks design for new development, particularly where the use of bioretention basins requires that adjacent roads are some +3m above the adjacent creek invert. Ideally, the entire network of bypass pipelines should be designed in total for each precinct once the flood characteristics of all tributaries are known. This would greatly streamline the design and approvals process at the boundary of developments allowing development assessors and proponents to agree to a set elevation before design begins.

The bypass system will be designed to:

- work with principles of minor and major drainage
- deliver flows to 1st and 2nd order waterways in a way that achieves the flow objectives defined in Chapter 6 (eg deliver an average flow rate of $2.3m^3$/day/Ha of development)
- divert flows exceeding the 1st-2nd order flow objectives around the 1st-2nd order waterways and are discharged to centralised WSUD elements (bioretention or wetlands/ponds) or a 3rd and 4th order waterway
- discharge high flows to waterways when the capacity of the WSUD elements is exceeded
- be self-cleansing in frequent events.

9 Implementation

The ultimate aims of the study are demonstrating how the stormwater and integrated water cycle management approach facilitates the development of the initial precincts while achieving the waterway health objectives and stormwater management criteria for the Aerotropolis.

The stormwater management strategy documented in Chapters 5, 6 and 7 above has been tailored in a flexible way to accommodate either:

- existing governance arrangements where Penrith and Liverpool Council are stormwater managers and waterway health objectives and stormwater drainage are delivered via a mix of privately owned and public stormwater infrastructure; or
- centralised catchment management where a waterway manager delivers, owns and operates trunk drainage infrastructure, regional stormwater infrastructure and water servicing assets.

This chapter contemplates both options and identifies how the stormwater management elements can be implemented in the public and private lands, the land take associated with stormwater infrastructure, maintenance requirements and the funding required to ensure the study outcomes are sustained into the future.

9.1 Stormwater management under a centralised trunk drainage management

To mitigate the risk of not achieving the waterway health objectives due to partial delivery or failure of any elements in the WSUD the treatment train, it is ideal to provide a reticulated stormwater harvesting scheme that delivers recycled stormwater to lots, open space and playing fields via a third pipe network and consolidates various elements in the treatment train into centraly managed stormwater assets. The same third pipe network can be utilised that is intended for the provision of recycled water described under in Scenario A8 in Chapter 5.3.

This approach has significant merits as follows:

- reduces the reliance on rainwater tanks and pump infrastructure duplicated across every property in the Aerotropolis and reduces reliance on the private management and upkeep of these assets.
- can supply greater volumes of stormwater than tanks if optimised and overcomes the risk of low rainwater usage across a catchment.
- centralises the control of stormwater treatment, storage and polishing for re-use and reduces the duplication of stormwater irrigation.
- consolidates various elements in the treatment train.

This significant change of approach will require a shift in the governance arrangement to allow Sydney Water to fund and manage the delivery of stormwater harvesting services under its existing charter.

Stormwater assets required under this scheme are outlined below and quantified in Table 9-1:

- on-lot stormwater detention (OSD) basins or underground tanks on private domain
- passively irrigated street trees in private and public roads
- stormwater detention storages in the public land to retard runoff from public roads and open space
- low flow diversions and channel works to make stormwater assets offline
- high flow bypasses and trunk drainage channels to convey high flows around stormwater assets
- gross pollutant traps on private land and immediately upstream of regional WSUD wetlands

- combined WSUD wetlands and ponds to treat and store stormwater for harvesting and manage algal risk
- a stormwater collection network that extracts water from storages in a controlled way and collects water in a centralized location for final treatment and distribution
- post-storage treatment train comprising screening, UV and chlorine dosing
- reservoirs for combined treated stormwater and recycled waste water
- third pipe recycled water pipelines that reticulate recycled stormwater (when available) and recycled wastewater to private land for non-potable reuse and public open space
- irrigation infrastructure that applies treated stormwater and recycled wasterwater to recreational areas and street trees.

It should be noted that the remaining elements of the treatment train are likely to be required and may be optimised pending detailed modelling. Until this is demonstrated through a proof of concept, it is recommended that the same footprints are adopted in Table 9-1.

Table 9-1 Stormwater infrastructure required to meet Wianamatta South Creek stormwater management targets (DPIE, 2022c) using a centralised trunk drainage approach

WSUD element	Unit	Medium density residential	High density residential	Business Campas	Large format industrial	Commercial
Adopted imperviousness for waterway health calculations Imperviousness of alotments and roads	%	71%	78%	71%	82%	84%
Imperviousness of alotments, roads public open space and stormwater infrastructure	%	64%	70%	68%	70%	78%
Passively irrigated street trees or biofiltration street trees	Trees/NHa	16	16	14	14	14
Wetland surface area delivered at the end-of-pipe	m2/NHa	200	200	200	300	200
Stormwater storage pond surface area	m2/NHa	200	200	250	400	200
Extended detention on wetlands and ponds	mm	300	300	300	300	300
Stormwater reticulation network capacity (Daily demand extracted from ponds for non potable internal daily demands)	kL/NHa/d	4.2	8.3	3.23	3.23	3.23
Average annual irrigation demands extracted from ponds for seasonal irrigation of private and public lands	kL/NHa/yr	600	400	500	580	700
Adopted imperviousness for waterway health calculations Imperviousness of alotments and roads	%	71%	78%	71%	82%	84%

** unless determined that it is not required in specific catchemnts through further analysis

9.2 Stormwater infrastructure mapping

Chapter 6 and Chapter 8 demonstrate the size of stormwater infrastructure which is also summarised in Figure 9-3 below. Stormwater asset templates are provided in Appendix B which demonstrate the total footprints of stormwater assets integrated into the landscape.

The templates show that the total footprint of stormwater asets must allow additial land take for maintenance tracks and batter slopes. The total footprint of a stormwater asset is between 120% and 200% of the combined wetland and pond water storage. shown in Figure 9-2.

Efficiencies of scale show that stormwater asset footprints are approximately 150% bigger than than the total wetland and water storage for typical catchment sizes mapped across the initial precinct. This rate has been applied to the combined wetland and stormwater storage pond surface areas in Table 9-1. These footprints have been mapped in Figure 9-2 to Figure 9-6.

With the exception of Lake Duncan, the majority of farm dams to be retained are not treated as wetland/stormwater management elements. Lake Duncan is proposed to be retained as a significant stormwater harvesting storage that may be able to offset the delivery of other assets in the Aerotroplois once operating and ownership arrangements are resolved.

All high ecological value farm dams identified to be retained are treated as receiving water bodies according to the INSW farm dam framework. Stormwater management basins around retained dams and Lake Duncan are required to meet water quality objectives before stormwater enters retained farm dams.

The following principles have been considered in the siting and sizing of WSUD wetlands and detention storages:

- WSUD wetlands (and ponds) have, as much as possible, been proposed outside of the 1% AEP floodway but are within the 1% AEP flood storage and flood fringe.
- WSUD wetlands have, as much as possible, been mapped outside of existing Cumberland plain vegetation, vegetated riparian zones and high ecological zones mapped for protection
- WSUD wetlands have been proposed at the upstream end of 3rd order streams while flow diversions pits will deliver waterway objectives for 1st and 2nd order waterways. This is necessary to consolidate the total number of assets across the precicnts
- In several cases on smaller creeks, the wetland zone identified will also include provision for a retained creek line or reconfigured natural trunk drainage channel adjacent to the wetland and/or detetion zone.

Further steps are required to resolve the orientation and configuration of the functional WSUD surfaces within each wetland zone mapped in Figure 9-2 to Figure 9-6. This includes detailed consideration of topography and heritage which cannot be properly assessed without detailed site investigations.

The recycled water pipeline is proposed to collect stored water from the wetlands and convey harvested stormwater to a central treatment location for polishing prior to reticulation.

An example of the typical wetland and storage pond configuration with notional recycled water pipeline is presented in Figure 9-1.

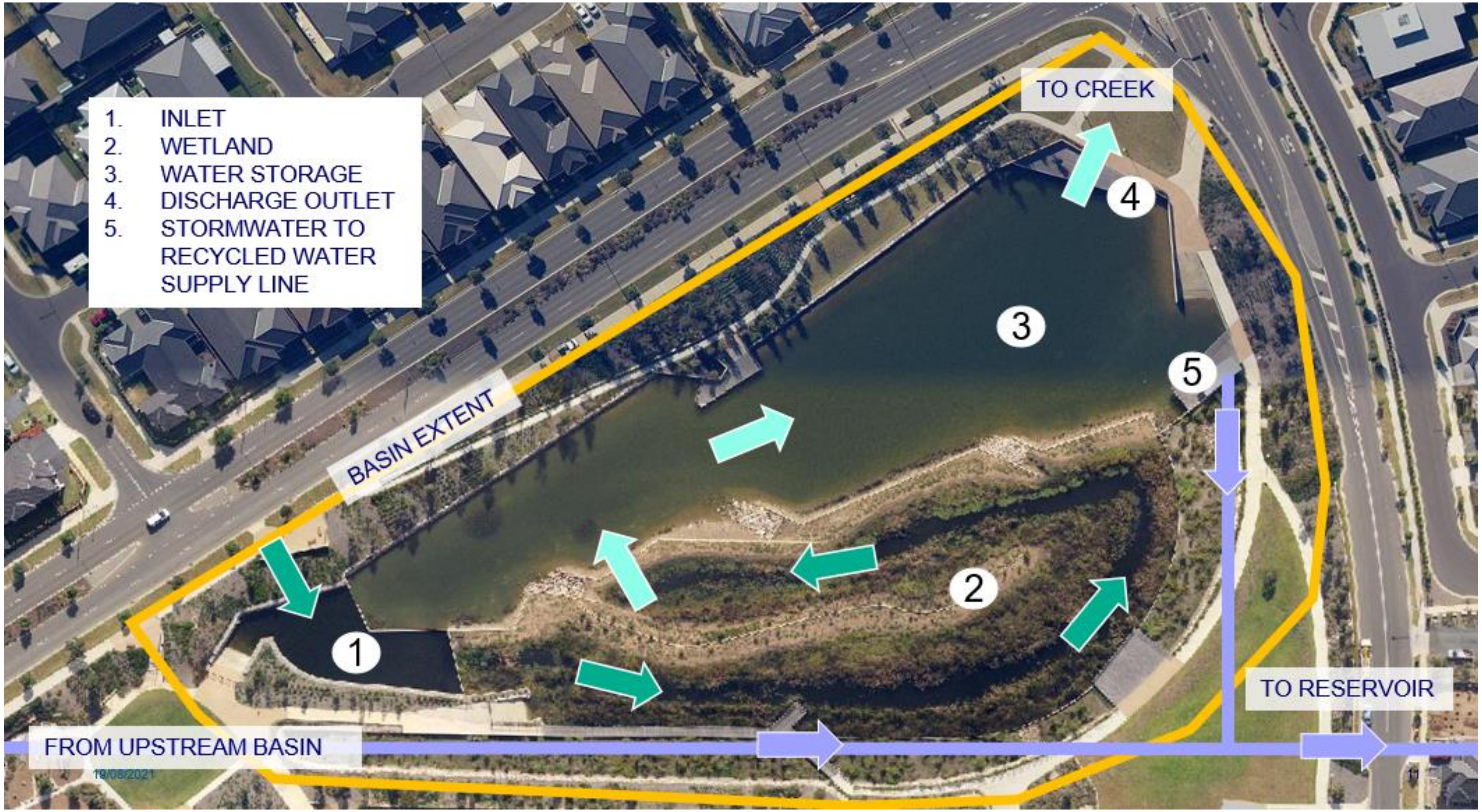
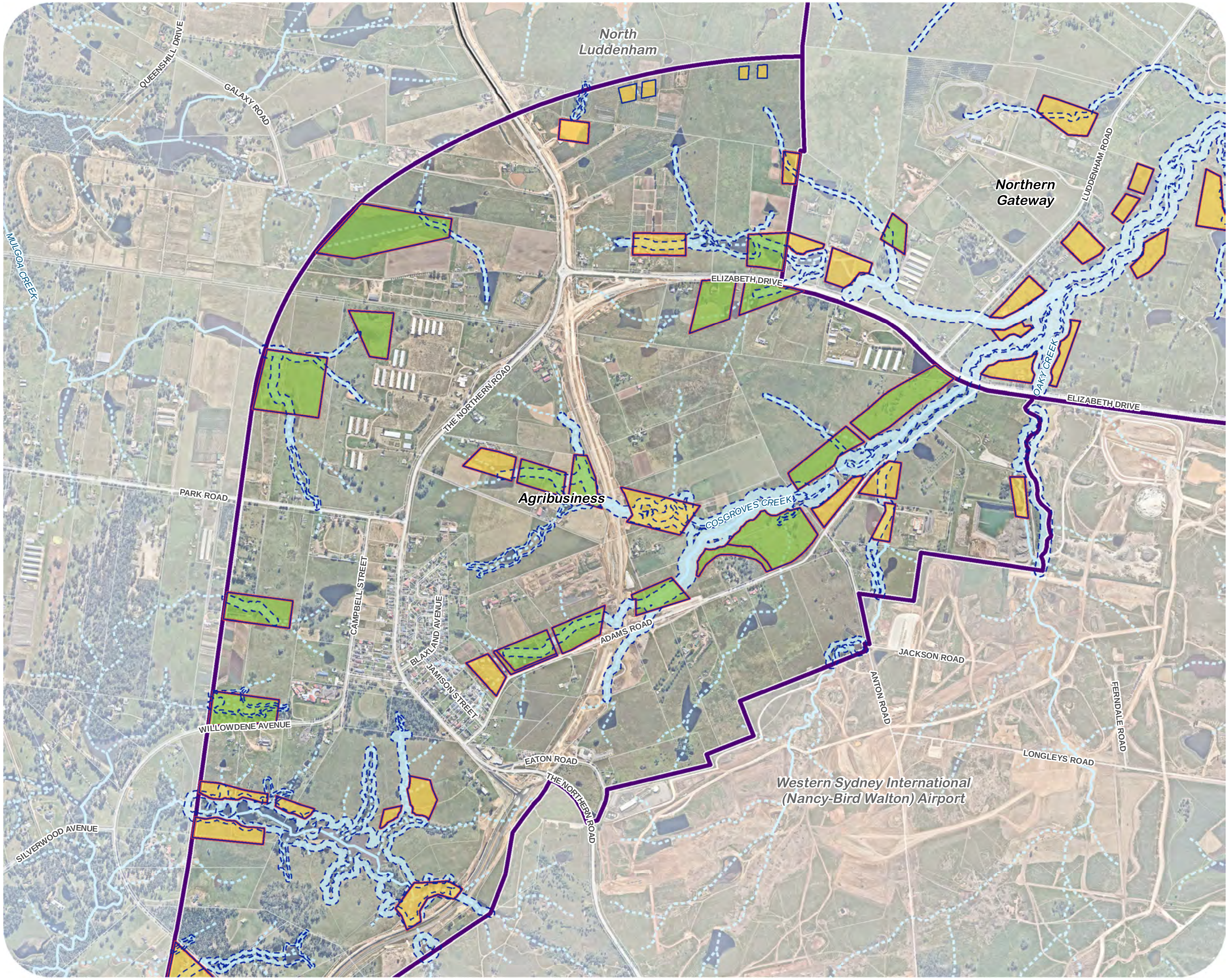


Figure 9-1 Example of wetland and stormwater storage pond configuration in Oran Park



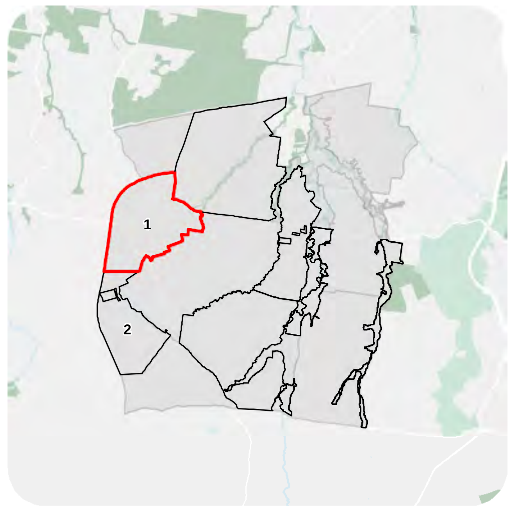
Sydney WATER

Initial precincts
Other precincts
Cadastre
Stormwater asset footprint
Combined WSUD wetlands and indicative detention zone
WSUD wetlands

Strahler Stream Order

< 3rd order
3rd order & higher
VRZs

Source: DPIE, WSPP, NSW Spatial Services, CSS, Aurecon, Arup, Nearmap



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Date: 6/12/2021
Projection: GDA 1994 MGA Zone 56

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Figure 9-3: Locations for regional stormwater detention, quality and flow management - Agribusiness (North)

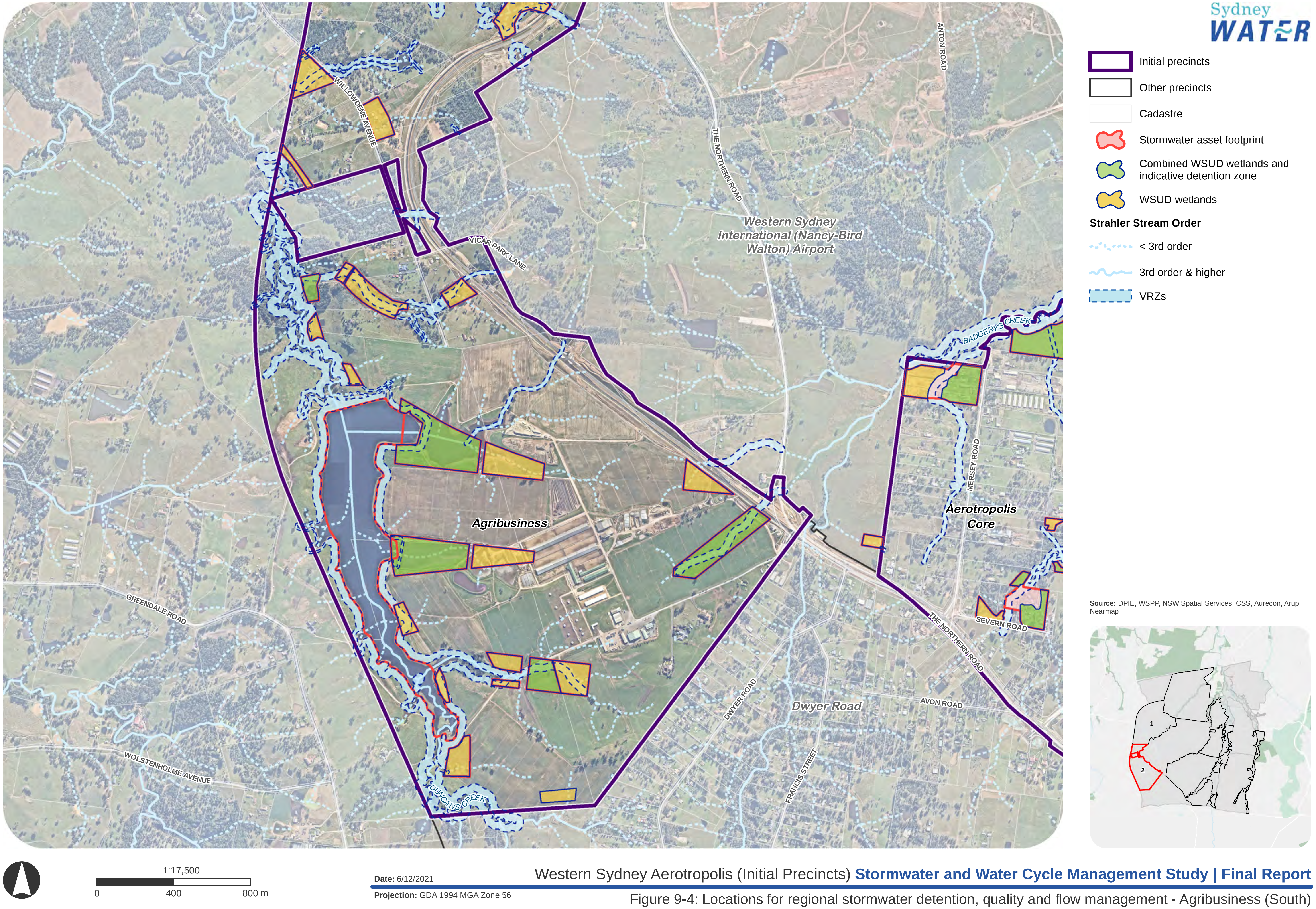

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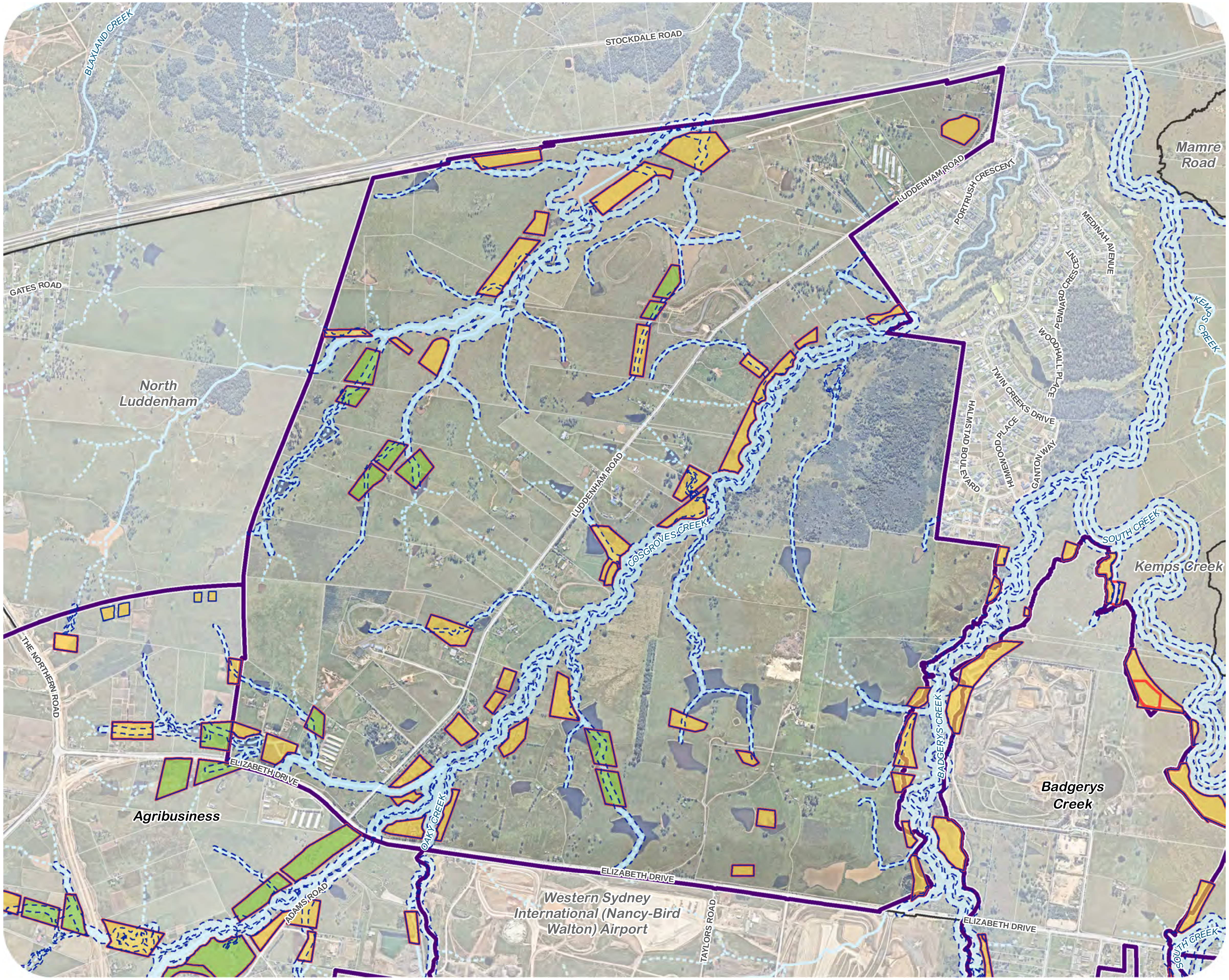
Figure 9-4: Locations for regional stormwater detention, quality and flow management - Agribusiness (South)



Sydney WATER

Initial precincts
Other precincts
Cadastre
Stormwater asset footprint
Combined WSUD wetlands and indicative detention zone
WSUD wetlands

Strahler Stream Order

< 3rd order
3rd order & higher
VRZs

Source: DPIE, WSPP, NSW Spatial Services, CSS, Aurecon, Arup, Nearmap

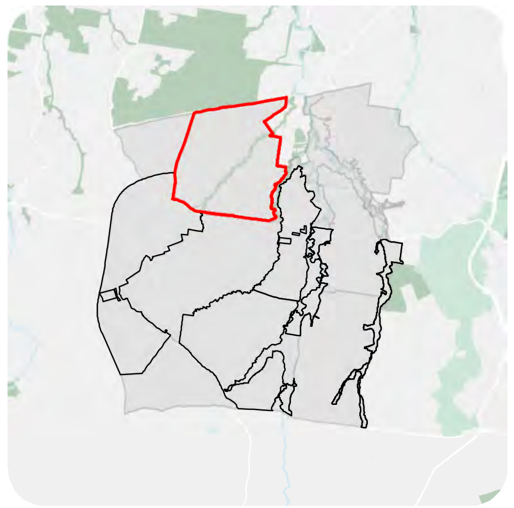


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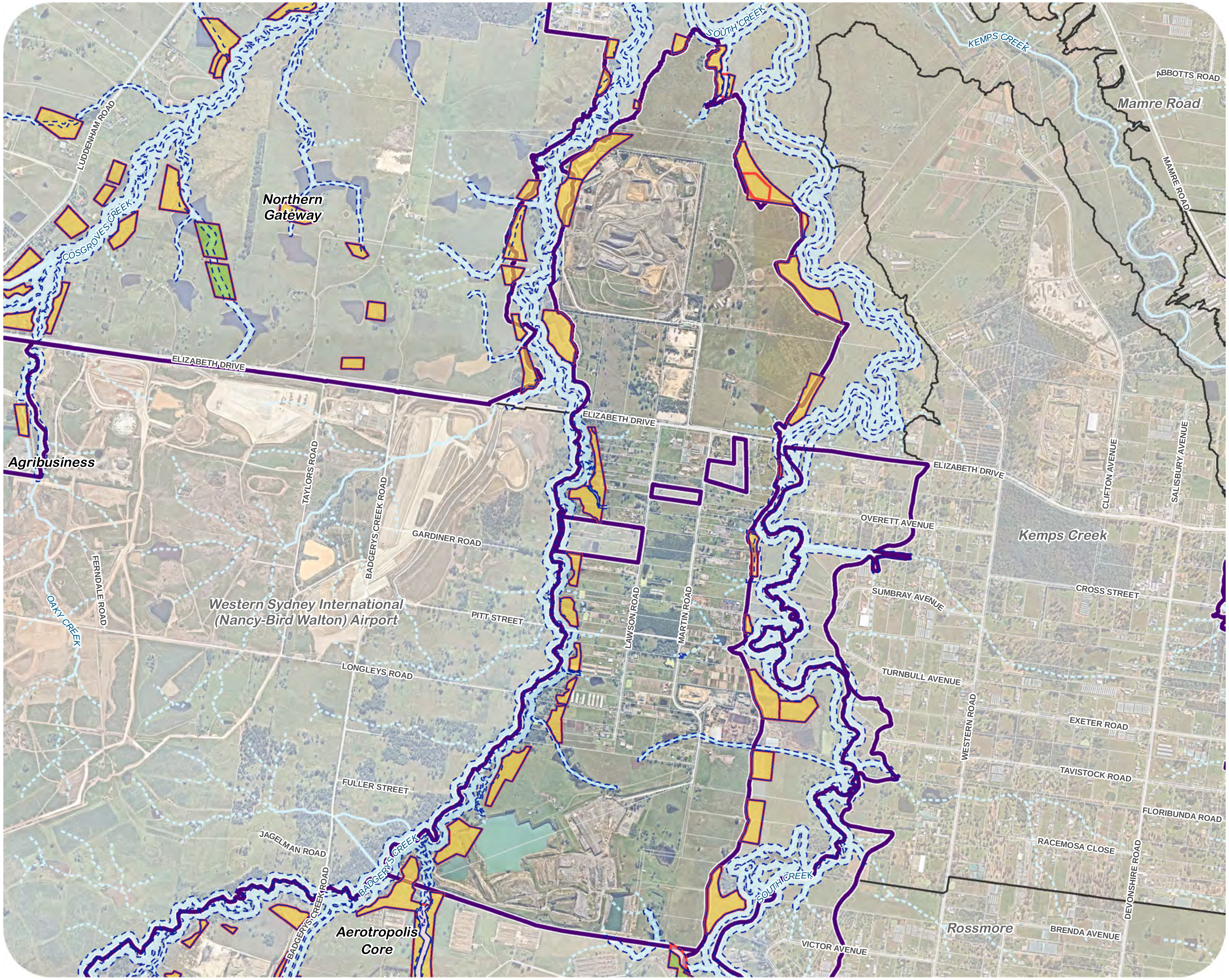
Figure 9-5: Locations for regional stormwater detention, quality and flow management - Northern Gateway



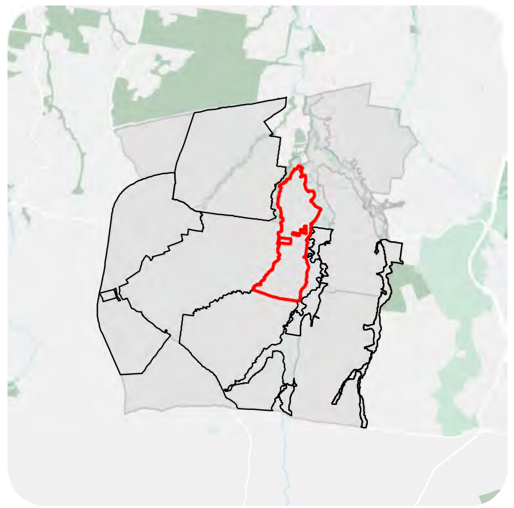
Sydney WATER

- Initial precincts
- Other precincts
- Cadastre
- Stormwater asset footprint
- Combined WSUD wetlands and indicative detention zone
- WSUD wetlands

Strahler Stream Order

- < 3rd order
- 3rd order & higher
- VRZs

Source: DPIE, WSPP, NSW Spatial Services, CSS, Aurecon, Arup, Nearmap



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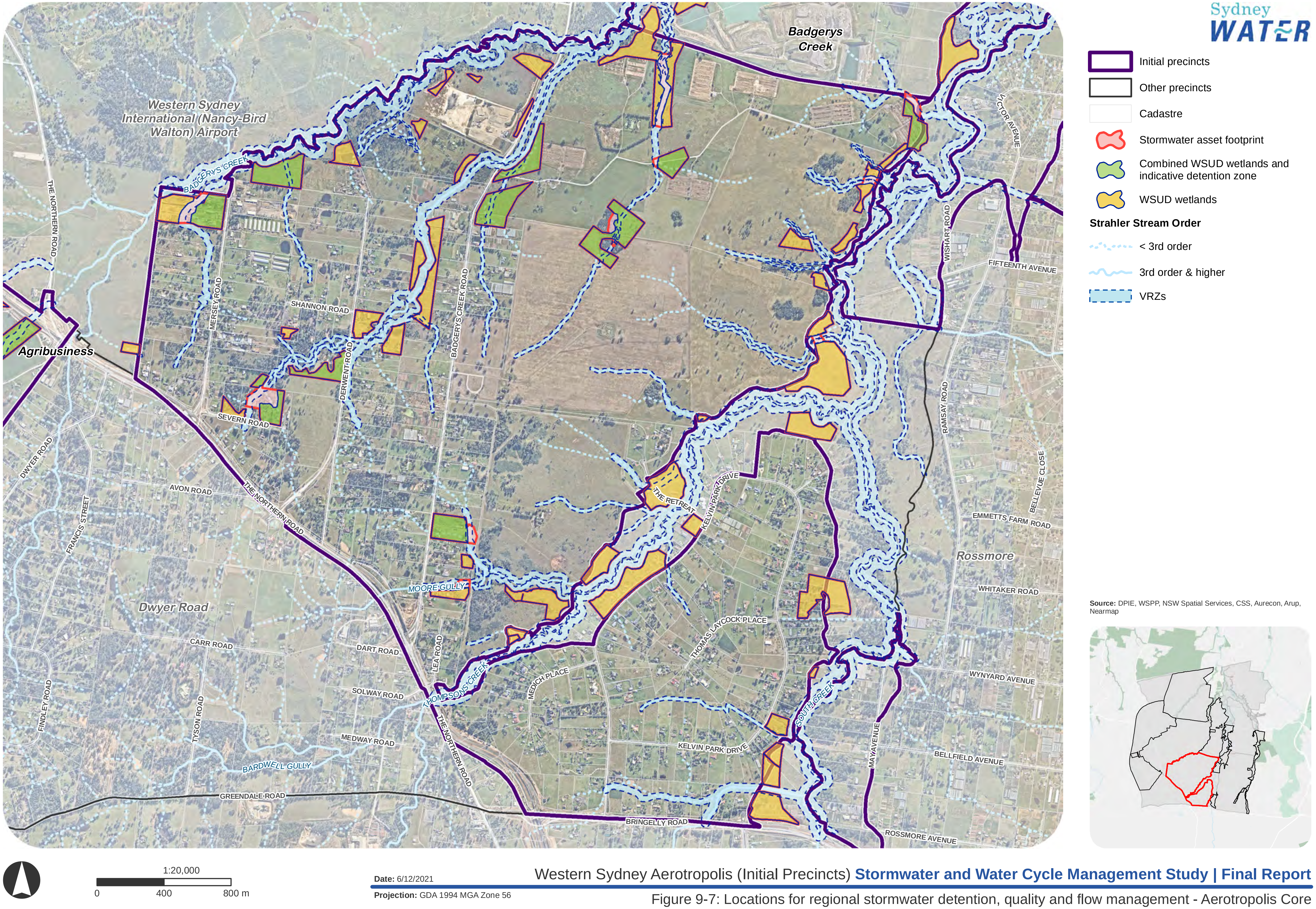
Date: 6/12/2021

Projection: GDA 1994 MGA Zone 56

Figure 9-6: Locations for regional stormwater detention, quality and flow management - Badgerys Creek



Date: 6/12/2021

Projection: GDA 1994 MGA Zone 56

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Figure 9-7: Locations for regional stormwater detention, quality and flow management - Aerotropolis Core

9.3 Stormwater asset land take

The land take of stormwater assets mapped in Figure 9-2 to Figure 9-6 are summarised below in Table 9-2.

Under the regional approach, the WSUD assets are located in public lands that have less development potential due to flood affectation. In addition to the basins within the Wianamatta South Creek precinct, 60% of stormwater asset footprints are expected to be flood affected. This makes the scheme more cost effective due to the overall reduced burden on developable lands and efficiencies of scale realised by consolidating assets and exploring the greater overall demands for non potable water across the precicnts.

Table 9-2 Summarised land take of stormwater assets and vegetated riparian zones (VRZ)

Initial precicnt	Stormwater assets (WSUD and detention) (Ha)	Strahler 1 and 2 VRZ* (Ha)	Strahler 3 and greater VRZ* (Ha)
Agribusiness	147.4	49.8	119.9
Aerotropolis Core	71.9	57.0	51.7
Badgerys Creek	23.1	7.7	24.7
Northern Gateway	88.7	58.1	104.2
Wianamatta-South Creek	66.2	22.5	296.8
Total land take for asset planning	**397.3**	**195.1**	**597.3**

9.4 Stormwater asset costs

Stormwater asset construction and maintenance costs have been developed from industry rates and are provided for comparing the cost-effectiveness of measures. These costs should not be relied on for detailed costing or feasibility assessments.

It is important to note that the costs below do not include an allowance for:

- land acquisition for regional infraustructure
- detention basins on private or public land
- pit and pipe drainage

Table 9-3 provides a summary of indicative stormwater infrastructure costs per hacter of typology, excluding recycled water reticulation and on-site stormwater detention costs.

Costs adopt a low rate for spoil management rather than disposal as general solid waste and therefore represent the lower end of delivery. Where spoil is disposed as general solid waste, construction cost of assets will increase by a factor of approximately four.

Table 9-3 Stormwater infrastructure required to meet Wianamatta South Creek stormwater management targets (DPIE, 2022c) using a centralised trunk drainage approach

WSUD element construction cost rate (Thousands / Ha)	Mediaum Density Residential	High Density Residential	Commercial	Strata and Bussiness Park	Large Format Industrial	Enterprise Zone - industrial and commercial	Mixed Use - integrate commercial and residential	Agribusiness - Industrial
GPT on alotment	$0	$0	$11	$11	$11	$11	$6	$11
Regional wetland*	$59 to $87	$59 to $87	$59 to $87	$89 to $131	$89 to $131	$89 to $131	$59 to $87	$89 to $131
Regional pond	$170 to $307	$170 to $307	$213 to $384	$340 to $614	$340 to $614	$340 to $614	$191 to $345	$340 to $614
Passive irrigation of street trees	$73	$73	$66	$66	$66	$66	$70	$66
Stormwater harvesting and irrigation of downstream open space	$2	$2	$2	$2	$2	$2	$2	$2
Total (Thousands / Ha)	**$304 to $470**	**$304 to $470**	**$350 to $550**	**$507 to $824**	**$507 to $824**	**$508 to 824**	**$327 to 509**	**$508 to 824**
Regional land take (m^2 per hectare of development and POS*)	**Mediaum Density Residential**	**High Density Residential**	**Commercial**	**Strata and Bussiness Park**	**Large Format Industrial**	**Enterprise Zone - industrial and commercial**	**Mixed Use - integrate commercial and residential**	**Agribusiness - Industrial**
Stormwater asset footprints (wetland + pond)	586	586	660	1,026	1,026	1,026	623	1026

* Public open space has been adopted at 15% of catchments

9.5 Discussion of cost effectiveness

From the list of measures considered, the following is noted on the effectiveness of each WSUD measure's contribution to the waterway objectives (DPIE, 2022b):

- Regional stormwater harvesting is an effective means of managing stormwater run-off volumes in frequent events, however it is acknowledged that stormwater is not entirely reliable as a single source of non-potable water and a top up supply is required to make up the shortfall in reliability across prolonged dry spells. Recycled stormwater will reduce potable water demands and complies with BASIX legislation. Regional stormwater harvesting costs are significant but comparable to rainwater tanks and on-lot measures that achieve the stormwater management targets.
- Delivering passive irrigation to street trees can be expensive measure if the tree pit is designed as a biofiltration pit, however it should be noted that trees require a generous soil volume to reach its potential and achieve the tree canopy targets including access to water and oxygen in the street scape (~8m^3/tree). This is likely to require ameliorated soil and water delivery to achieve the desired tree canopy growth. It is therefore a simple matter to convert this soil volume into a biofiltration basin. Advice from DPIE EES has also pointed to the need for regular grids of trees to manage groundwater and biofiltration street trees are considered to provide this function and are therefore an important part of mitigating waterways from other impacts or urbanisation.
- While biofiltration is a cost-effective means of reducing pollutants, it is not as cost effective in reducing stormwater volumes.
- Wetlands (or ponds) and stormwater harvesting are the most cost-effective means of reducing stormwater volumes in frequent events. Wetlands and ponds are important to achieving the range of flow metrics in a cost-effective way. The maintenance costs adopted above are applied for lack of better data sets on the actual costs, and these are expected to be on the higher side of actual costs to maintain a well designed and implemented wetland/pond. However, the costs above do not include the associated land take or costs for retaining walls or disposal of excess spoil off-site.
- The treatment train outlined above shows that the waterway health objectives will be achieved and there is an implicit assumption that the erosion of waterways will be limited, however it is likely that there will still be a need for bed and bank stabilisation works, particularly where waterways have begun or continue to erode due to historical land uses. The costs of revegetation and stabilisation are included in the separate Riparian Corridor Assessment document.
- Transverse drainage and culverts beneath proposed road crossings have been notionally sized but costs have not been included at this time.
- Stormwater detention and on-site stormwater detention basins have been notionally sized to achieve flow objectives however they have not been included at this time.
- Stormwater diversion pipes described in (Template 10) and stormwater reticulation pipes that carry recycled water back to businesses and resdiences have not been included in the costs above.

10 Conclusion

This Plan details integrated water management approaches to deliver sustainable outcomes for the Western Parkland City by integrating stormwater and wastewater management into the landscape to support the blue-green grid. Management of the urban water network through an integrated approach makes the challenge of balancing economic, social and environmental factors in decision-making more feasible.

This *Stormwater and water cycle management study* is a technical planning document that outlines how stormwater, wastewater, recycled water, trunk drainage and riparian zones should be managed to achieve the Western Parkland City vision within the Agribusiness, Aerotropolis Core, Badgerys Creek and Northern Gateway precincts.

Starting with Country

The Aerotropolis lies mostly within the catchment of Wianamatta-South Creek. Wianamatta meaning, 'mother's place' or 'mother's creek in the Dharug language, is highly significant to First Nations people. Caring for this landscape and its remnant Cumberland Plain vegetation means protecting the local waterways from the impacts of the urbanising catchment. This in turn will protect the indigenous and non-indigenous community values and uses of Wianamatta-South Creek and the Hawkesbury Nepean River.

New waterway health objectives have been established by DPIE EES by applying the Risk-Based Framework. These objectives were derived from stream flow gauges in the catchment to establish a sustainable hydrologic regime while facilitating urbanisation of the catchment. In this way, the objectives seek to deliver the Western Parkland City District Plan vision and City Deal objective of protecting and restoring waterways.

Waterway health

This Stormwater and Water Cycle Management Study adopts the new flow and water quality objectives (DPIE, 2022b) to ensure that the rezoning of the Initial Precincts satisfies the directive to adopt the Risk Based Framework.

This study and others (DPIE 2022d) show that a range of approaches are required to achieve the objectives. This must include reduced urban imperviousness, passively irrigated street trees, gross pollutant traps, biofiltration, wetland/ponds, and stormwater harvesting. Chapter 6 has demonstrated that the full suite of measures would be required and that failing to deliver any one measure will result in a failure to achieve all the objectives on a sub catchment scale or across the Aerotropolis.

The new flow and water quality objectives requires a more complex arrangement of stormwater assets than required to achieve traditional pollution reduction targets and stream erosion index prescribed for the South West Growth Centres, and adopted in Councils' development control plans. However, the treatment train measures required to achieve the new flow and water quality objectives are generally required for other reasons in that they contribute to other Government objectives regarding open space, protection and re-establishment of native riparian vegetation, salinity management, street tree canopy targets, urban heat mitigation and conserving potable water supplies.

This study also promotes the replacement of private stormwater management infrastrtucture with a regional stormwater harvesting strategy that collects stormwater in a network of centrally managed ponds or wetlands and reticulates filtered stormwater across the Aerotropolis to supply non-potable water demands on private development and public open space.

This requires integrated water servicing rather than the traditional siloed approach to stormwater management and wastewater management.

Recommendation: Waterways, riparian corridors, selected farm dams, open water bodies and other water-dependent ecosystems identified in this study should be protected, restored and maintained to ensure the objectives of waterfront land policy and the Western City District Plan are delivered.

Stormwater basin footprints mapped as part of this study should be set aside for WSUD and stormwater management basins to deliver waterway health objectives at sub catchment and precinct scales. These basin footprints should be further explored for constraints and integrated into public open space to provide a stormwater management and amenity function. A 3D model of basins, flood levels, trunk drainage infrastructure and precinct earthworks should be developed to provide a coordinated basis for prescribing finished flood planning levels, drainage inverts and WSUD surface levels.

Development and public infrastructure must contribute towards the waterway health objectives (DPIE 2022b) by maximising the reuse and retention of stormwater within the landscape. Development is to ensure that the stormwater pollution removal and flow management requirements identified in this study are achieved:

- through the delivery of a centralised, regional stormwater harvesting scheme that achieves the waterway health objectives and minimises and consolidates stormwater elements in the public domain. or
- where a centralised stormwater harvesting scheme is not available, development must achieve the same objectives, through reduced urban imperviousness, passively irrigated street trees, biofiltration, wetlands/ponds and local stormwater harvesting on the alotments and within the private domain.

Integrated water servicing

Several possible servicing scenarios were differentiated by levels of recycled water and stormwater harvesting. Indicative maps of trunk wastewater, drinking water, stormwater and recycled water infrastructure are provided.

The integration of stormwater harvesting, and recycled water schemes provides an opportunity to achieve cost efficiencies and reduce operational risks associated with the delivery and management of private stormwater infrastructure.

Recycled water for non-drinking end uses will be provided to the area. The preferred water balance demonstrates that a combination of stormwater and recycled water is resilient to climatic variability, reduces demands on drinking water supplies. Recycled water also responds to NSW Government Policy directions for the Western Parkland City including:

- creating a cool, green Parkland City in Western Sydney, with Wianamatta-South Creek as a core element and central to the amenity of the City
- increasing tree canopy across Greater Sydney, contributing to the Government’s target of 5 million additional trees, resulting in 40% canopy cover across the City
- promoting a circular economy where waste is minimised and resources are used sustainably to optimise economic, environmental and social benefits
- creating a ‘Smart’ and resilient City which adopts the best available technology and adapts to global trends such as climate change to meet the lifestyle needs of the community.

Recommendation: Water servicing for precincts is to feature total water cycle management that integrates and balances drinking water, wastewater, recycled water and harvested stormwater. All suitable open spaces, areas of landscaping, parks and streets must include irrigation infrastructure to ensure adequate opportunities to dispose of stormwater and provide urban cooling benefits.

Recycled water and harvested stormwater will be used in a complimentary way, prioritising stormwater to reduce run off ensuring waterway health outcomes are not compromised, while recycled water provides the balance of non-drinking water supply.

Stormwater detention

The Aerotropolis precincts represent a significant change to the imperviousness of catchments upstream of existing development within the Penrith and Liverpool LGAs. This study shows that development has the potential to impact peak flows associated with

- frequent events (50% AEP) that would result in adverse impacts to stream morphology
- rare events (1% AEP) that may result in an increase downstream flooding extents.

Strategies have been developed that aim to preserve peak flows using a combination of stormwater detention on private land and open space to attenuate flows to meet existing case peak flows. This work has been undertaken following the general principles espoused by Penrith and Liverpool Councils.

Recommendation: To manage local run-off and the potential impact that the Western Sydney Aerotropolis has on geomorphology, stormwater flows should be detained within the landscape. This Plan, developed in consultation with stakeholders, has shown that a combination of on-site stormwater detention (for industrial and commercial areas), on-line stormwater detention (on first and second order creeks) can sufficiently manage precinct scale run-off to ensure no adverse change in peak flow rates.

Where the Flood Risk and Impact Assessment or subsequent flood planning studies confirms that flood detention is required, then an allocation of sufficient, suitably located land area to allow for stormwater assets must be provided. Detention assets in the public realm shall be designed as multifunctional also contributing to waterway health, biodiversity and public amenity.

Future floodplain management studies should consider a full catchment review to assess the function and suitability of stormwater detention within the Wianamatta-South Creek catchment.

Riparian land management

The protection, restoration and maintenance of waterways, riparian corridors, and water dependent ecosystems is essential in achieving the cultural, social and biodiversity aspirations as well as tree canopy targets of the Western Parkland City. Creeks within the initial precincts have been validated and mapped with associated vegetated riparian zones to support waterway health. Water-dependent ecosystems and key fish habitat have also been identified and mapped. A riparian revegetation strategy has been developed that recommends the areas and likely costs of riparian land that should be revegetated. Figures are provided in section 4 depicting proposed vegetated riparian zone and farm dam prioritisation.

Recommendation: Vegetated riparian zones (VRZ) adjacent to creeks and other water bodies mapped must be protected, restored and maintained. Opportunities to revegetate beyond standard VRZs should be explored to maximise biodiversity outcomes and achieve urban canopy targets, particularly within the Wianamatta Precinct. The ongoing ownership and management of these assets must ensure adequate access and sustainable funding for maintenance is available. Figures are provided in section 4 as well as in the separate Riparian Corridor Assessment (Sydney Water 2022) depicting field and desktop survey results and analysis as well as the revegetation strategy. The revegetation strategy should be further refined based on specific flood impact testing and location specific concept design development.

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Appendices

Appendix A – Stormwater assumptions

Land Use Parameter	Standard/Source	Adopted	Comment
Typologies split for Mixed Use Land Use Zone	PPO guidance	High Density Residential - 25% Medium Density Residential - 25% Commercial - 50%	For use in MUSIC modelling of WSUD elements and water balance
Typology split for Enterprise Use Zone	PPO guidance	Large format ndustrial - 50% Strata industrial - 50%	
Typology split for Agribusiness Land Use Zone	PPO guidance	Large format industrial - 90% Environment and rec - 10%	
Total imperviousness for Base Case	PPO Guidance Provided by email Monday, 3 August 2020	Enterprise Zone (%) -80% Mixed Use (%) - 85% Enviornment and Rec (%) - 15% SP1 (%) - Airport and Associated - 80% SP2 (%) - Transport Corridors - 85% Low / Med Density Residential (%)65% Agribusiness (%) - 60% Infrastructure / Transport Corridors as per GSC GIS-85%	For use in XP RAFTS modelling of stormwater detention for trunk drainage
Total imperviousness for Parkland typologies	PPO Guidance	Enterprise Zone (%) - 60% Mixed Use (%) - 65% Enviornment and Rec (%) - 10% SP1 (%) - Airport and Associated - 70% SP2 (%) - Transport Corridors - 75% Low / Med Density Residential (%) - 50% Agribusiness (%)- 50% to Infrastructure / Transport Corridors as per GSC GIS 75%	For use in MUSIC modelling of WSUD elements in parkland typologies
Road coverage (percentage of rezoned land that will be road corridors)	PPO Guidance and GIS review of aerial photos	High and medium density residential – 24% Commercial – 20% Industrial – 7% to 15%	Draft based on business as usual development need confirmation from PPO/Urban designers. For use in XP RAFTS and MUSIC modelling
Number of street trees per Ha	PPO Guidance	Trees spaced at 15 m centres to achieve NSW Government canopy targets resulting in: Low Density Residential - 18 trees/Ha Medium Density Residential - 16 trees/Ha High Density Residential - 16 trees/Ha Large Form Industrial - 14 trees/Ha Strata Industrial - 14 trees/Ha Commercial (Business Park)- 14 trees/Ha	Based on advice provided by JMD and Hassell 22 Sept 2020 Used in MUSIC modelling to determine stormwater volume losses
Public open space (percentage of rezoned land that will be road park excluding riparian corridors and South Creek Wianamatta precinct)	PPO Guidance	Low Density Residential - 10% Medium Density Residential - 14% High Density Residential - 18% Strata Industrial - 14% Large Form Industrial - 14% Commercial (Business Park) - 18% Environment and Recreation - 90%	
Design rainfall for stormwater modelling	Australian Rainfall and Runoff 1987	ARR1987 for hydrologic modelling of detention basin strategies consistency with regional planning	Adopt ARF=1 due to scale of precinct based assessments
Rural Rainfall Losses	Consultants (CSS) validated against historical flood events	Callibrated to existing data sets for 1986, 1988 and 2020 historical events	Applied in XP RAFTS for consistency with existing stormwater and flood planning
Urban Rainfall Losses	Consultants (CSS)	Urban pervious IL = 23mm Urban pervious CL = 0.9 mm/h Impervious IL = 1.0 mm Impervious CL = 0.0 mm/h	Applied in XP-RAFTS stormwater modelling
Pervious Catchment Roughness (PERN)	Liverpool Overland Flow Path Study for Rural Catchments study (CSS, 2020)	Trees - 0.100 Grass - 0.040 Greenhouses - 0.100 Quarry/gravel - 0.020 Roads - 0.016 Concrete - 0.015 Creeks/watercourses - 0.050 Buildings/roof area - 0.015	Applied in XP RAFTS for stormwater detention calculations
Existing culvert capacity	Councils/ARR2019	Apply Council's blockage and freeboard criteria	
Appropriate Safety Criteria for People	Stormwater Drainage Specifications for Building Developments	Max. Depth x Velocity = 0.4m^{2}s-1 Max. Depth = 0.8m Max. Velocity = 2.0ms-1	
Manning's Coefficient for new tunk drainage channels	Common practice	New trunk drainage channels: Rock/Grassed - 0.035 Vegetated - 0.065	Used to indicate trapezoidal channel dimensions to inform development set backs from trunk drainage channels where catchments exceed 15 Ha. Dimensions and configuration of channels outlined below

Land Use Parameter	Standard/Source	Adopted	Comment
MUSIC Rainfall, PET and nodes for standard treatment train	MUSIC Link Callibrated SOURCE model	As per MUSICLink for Penrith 30 hours of hourly data used for long periods of stormwater harvesting and wetlands	
Rainwater tank demands for non potable internal demands	Sydney Water and DPIE Water GSWS	Low Density Residential - 3.0 kL/NHa/d Medium Density Residential - 4.9 kL/NHa/d High Density Residential - 9.8 kL/NHa/d Large Form Industrial - 2 to 2.3 kL/NHa/d Strata Industrial - 2 to 5.6 kL/NHa/d Commercial (Business Park) - 2 to 12.2 kL/NHa/d	To be confirmed with Sydney Water and DPIE Water For use in MUSIC modelling Low water demands preferred for recycled water use assessment.
Rainwater and recycled Irrigation rates for public open space	Advice from specialist consultants - Decentralised Water Solutions	The following to be adopted for **plant survival** and scaled for seasonal variations in PET and where soils are suitable: Private yards and street verges ~ 2.5 ML/Ha/yr Local passive open space ~ 3.2 ML/Ha/yr Local active open space ~ 4.5 ML/Ha/yr Elite sports fields ~ 9 ML/Ha/yr Additional, higher irrigation rates for cooling are to be confirmed with PPO consultants	Irrigation rates for public open space are slightly conservative to avoid over reliance on irrigation in a saline landscape
Industrial and Commercial Lands Pipe Drainage Network (Minor)	Design Guidelines for Engineering Works on Subdivisions and Developments, 1997 Liverpool and Penrith Engineering Standards.	5% Annual Exceedance Probability (Penrith) 10% Annual Exceedance Probability (Liverpool)	Minor drainage network capacity
Residential Lands Pipe Drainage Network (Minor)	Design Guidelines for Engineering Works on Subdivisions and Developments, 1997 Liverpool and Penrith Engineering Standards.	20% Annual Exceedance Probability	Minor drainage network capacity
Trunk Drainage Network (Major)	Design Guidelines for Engineering Works on Subdivisions and Developments, 1997	1% Annual Exceedance Probability	Flows exceeding minor drainage network capacity overflow to streets
Stormwater detention basins - offline	Council guidance	1% AEP flood depth at the discharge point < 1.2m Internal side batter – 1(V):6(H) ideal	Performance and typical details to be developed and agreed with TWG
Stormwater detention basins - online	Council guidance	Only on 2nd order waterways Debris racks	To be agreed with Council Performance and typical details to be developed agreed with TWG
OSD for industrial lots	Council guidance	On-site stormwater detention to match agreed flow performance requirements	To be developed and agreed with Council Performance and typical details to be agreed with TWG
OSD for roads	Council guidance	Council controlled basins where possible with on-lot measures to compensate for the shortfall	To be developed and agreed with Council Performance and typical details to be agreed with TWG
Overland flow paths / vegetated trunk drainage channels	Council guidance and templates from Blacktown Council	Inverts – match existing Base width – Varies Side batter – 1(V):4(H) Benched to provide Low flow channel – 1EY capacity Bike path/access track – 10% AEP immunity Overland flow path width – 1% AEP capacity	To be developed and agreed with Council
GPTs	Council/PPO guidance	Provided upstream of each biofiltation basin or wetland Notional high flow bypass required	Concept designs to be prepared in accordance with DPIE EES guidelines
On lot WSUD	Council/PPO guidance	Not modelled explicitly but is to be designed to provide the volumetric controls as nescessary	Concept designs to be prepared in accordance with DPIE EES guidelines
Street trees/street-scape biofiltration	Council/PPO guidance	Street scape biofiltration is provided as street trees to recieve runoff as follows : Low Density Residential - roads and lots Medium Density Residential - roads and lots High Density Residential - roads and lots Large Form Industrial - roads only Strata Industrial - roads only Commercial (Business Park) - roads only	Concept designs to be prepared in accordance with DPIE EES guidelines

Land Use Parameter	Standard/Source	Adopted	Comment
End of pipe biofiltration	Council/PPO guidance	Explicitly modelled to reduce nutrient loads to wetlands and open water to mitigate algal risk Max cell size to be $500m^2$ Max EDD to be 300mm Concept design required to finalise/confirm filter depth	Concept designs to be prepared in accordance with DPIE EES guidelines
Stormwater harvesting	Council/PPO guidance	Water extracted from wetlands Concept design to include post storage filtration and UV treatment prior to irrigation Concept design required to finalise netowork design, storage draw down and active storage volume to be finalised during concept design	Concept designs to be prepared in accordance with DPIE EES guidelines
Wetlands and open water bodies	Council/PPO guidance	Modelled to retain flows to achieve flow objectives and provide storage of stormwater for harvesting Concept design required to finalise confirm extended detention depth and draw down time	Concept designs to be prepared in accordance with DPIE EES guidelines

Appendix B – Landscape-led design templates

Western Sydney Aerotropolis (Initial Precincts)

Stormwater and Water Cycle Management Study

Appendix B – Landscape Led Design Templates

May 2021

Sydney WATER

Sydney Water respects the traditional 'Caring for Country' restorative approaches practiced over tens of thousands of years by Aboriginal people and play our part to improve the health of the landscape by recognising and nurturing all values of water in our environment.

In doing so, we acknowledge the traditional custodians and their ancestors of the lands and waters in Western Sydney where we are working and learning: the D'harawal and Dharug nations, as well as their neighbours the Gundungurra.

Their lore, traditions and customs nurtured and continue to nurture the sweet waters in this area, creating wellbeing for all. We also pay our respects to Elders, past and present

Contents

Introduction

This appendix report is to be read in conjunction with Chapter 8 of the Western Sydney Aerotropolis Stormwater and Water Cycle Management Study.

This study outlines how storm-water, wastewater, recycled water as well as trunk drainage and riparian zones should be managed to achieve the Western Parkland City vision within the Agribusiness, Aerotropolis Core, Badgerys Creek and Northern Gateway precincts.

This report helps to illustrate how water servicing for these precincts can be provided in an integrated and balanced manner that minimizes demands on potable water and enhances the cultural, ecological and recreational benefits of the new and existing waterway network. It is directed at developers, land owners and government to inform the next stages of precinct planning

The report is split into the following sections:

- **Section 1** presents the principles associated with a landscape-led approach
- **Section 2** presents how 10 typical WSUD templates can be integrated into the landscape

Section 1: Landscape led principles

Overview to principles

By adopting a landscape led approach to the design of all future water assets we can ensure that the design and management of the future stormwater management system is appropriate to context and also maximises benefits for the local economy, environment and population.

The Wianamatta South Creek precinct and its tributary waterways is the dominant landscape feature of the Aerotropolis and will play multiple roles to the existing and future community.

The key objectives of this Stormwater and Water Cycle Management study is to achieve a reduction in stormwater runoff volumes that can mimic the existing hydrological characteristics of the rural catchment within the future precincts.

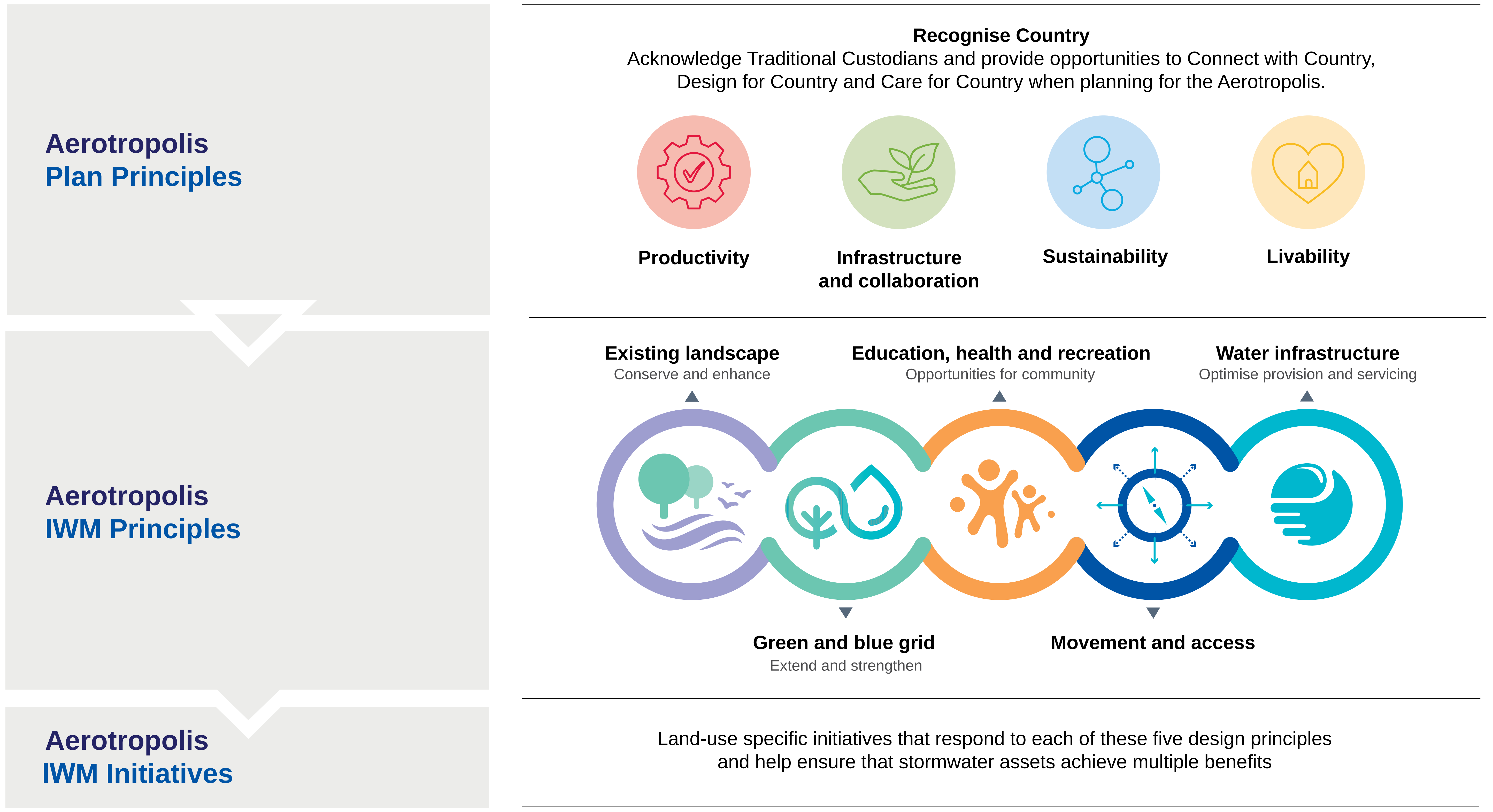
This requires a combination of at-source controls, rainwater and stormwater harvesting and Water Sensitive Urban Design (WSUD).

The elements that comprise WSUD include street trees, planting, biofiltration basins and wetlands that need to be successfully integrated into the land use planning of these precincts.

By adopting a landscape led approach to the design of all the future WSUD features we can ensure that the design and management of the future storm water system is appropriate to context and also maximises benefits for the local economy, environment and population.

Using principles from the Western Sydney Aerotropolis Plan (September 2020) the following five Aerotropolis Integrated Water Management design principles have been developed to guide the integration of the WSUD stormwater assets.

Aerotropolis Integrated Water Management Design Principles



landscape led principles and design initiatives

The table below provides examples of land-use specific initiatives that respond to each of the principles and will help ensure that stormwater assets achieve multiple benefits.

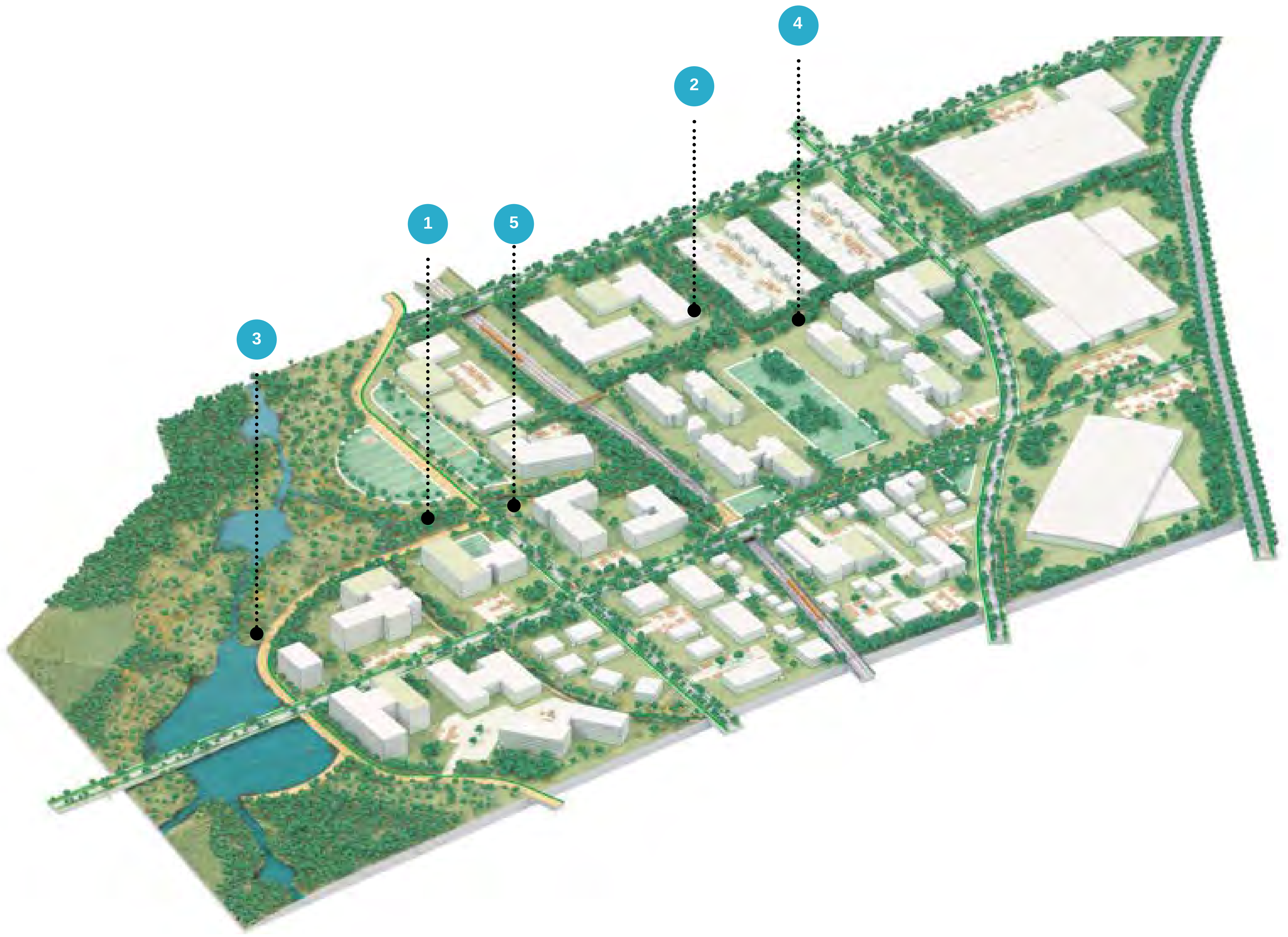
Land Use	Landscape led design initiatives				
Landscape led principles	Existing landscape	Green and blue grid	Education, health and recreation	Movement and access	Water infrastructure
Enterprise	• Design with existing landform to reduce cut and fill and help integrate assets into landscape	• Provide shelter belts and screen planting as part of storm water features to improve visual and noise buffers, air quality, and reduce urban heat	• Provide outdoor amenity and recreational opportunities as part of storm water features		• Provide viewing opportunities and improve connectivity to the creek corridors
Agribusiness	• Embed traditional water and land management practices in the design of water assets	• Retain agricultural dams/existing water bodies and associated woodlands high in ecological value	• Create opportunities for research and collaboration between WSUD and agriculture • Provide local employment opportunities for construction and management of WSUD (agribusiness related)		• Include water management assets as integral components of agribusiness operation • Embed sustainable land management and agro-forestry principles as part of WSUD
Environmental + recreation	• Design with landforms to enhance view corridors and vistas and safeguard existing native vegetation • Locate and orientate water bodies to maximise down wind cooling and ensure tree canopy cover to improve micro-climate conditions	• Restore native habitat within storm water features and enhance biodiversity within recreational corridors by incorporating diverse planting	• Integrate storm water features as innovative and diverse recreation spaces - playscapes, sporting amenity, fitness Explore opportunities for knowledge sharing, exchange and education promoting more sustainable environments and water management	• Extend and strengthen the walking and cycling network across all storm water assets	• Design storm water features as a diverse and connected network
Mixed Use	• Embed planting into the water assets to improve environmental quality and reduce urban heat	• Strengthen biodiversity through re-vegetating storm water features, linking to existing habitats and linear parklands along ephemeral creeks	• Collaborate with local Aboriginal communities on design and programming of water assets		• Extend the stormwater features to connect with community allotments and open spaces to provide passive irrigation
Infrastructure	• Integrate placemaking and wayfinding features into stormwater feature (art work or landform as markers and gateways)	• Provide visual connections between transport corridors and existing water environments		• Design assets to maximise ease of access, maintenance and safety	• Maximise integration of features into road and infrastructure network

Section 2: Templates

Overview to templates

The following section presents 10 typical WSUD elements and how they can be configured and integrated into the landscape.

Each scenario contains technical information, precedent images, sections and sketch templates based on indicative locations within the precincts and to represent the widest range of land uses.



Employment Precinct

1. **Template 1:** Typical Bio-retention and Wetland Treatment
2. **Template 2:** Space Restricted Bio-retention and Wetland Treatment
3. **Template 3:** Steep Terrain Profile Bio-retention and Wetland Treatment
4. **Template 4:** Bio-filtration - Tree Pit Typical Detail
5. **Template 5:** Online Detention on First/Second Order Creek

Residential Precinct

6. **Template 6:** Riparian Revegetation
7. **Template 7:** Recreated Natural Trunk Drainage Channel
8. **Template 8:** Reprofiled Farm Dams For Ecology
9. **Template 9:** Retained Farm Dams For Recreation
10. **Template 10:** Bypass Pipelines

Illustrative example of possible locations for landscape led water-infrastructure templates.

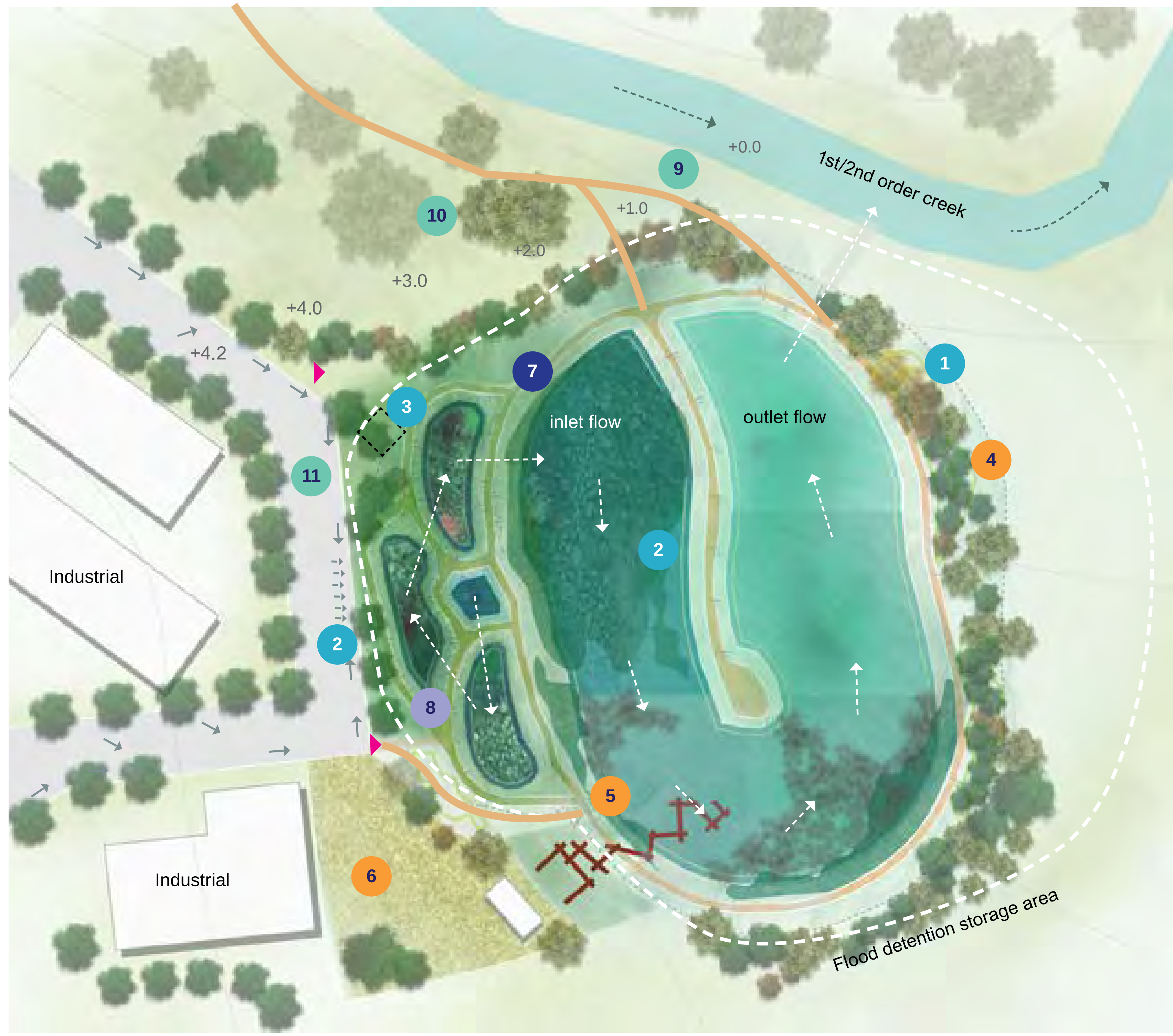
Underlying graphic from Aerotropolis Urban Typologies, Sydney Water, 2020

Template 1

Typical bio-retention and wetland treatment

Template 1 provides a typical configuration of sediment pits, bio-retention basins and wetlands to treat storm water before discharge into adjacent existing creeks.

This typical configuration has a wide range of applications, including on the edge of a recreational playing field, within a public open space or business park landscape.



Water infrastructure

1. Flood detention storage and embankments integrated around WSUD element
2. Shallow marsh wetlands with internal ridges to maximise detention
3. Flow diversion pit or weir to direct treatable low flow rate to bio-retention and wetland zone

Education, health and recreation

4. Mixed-use path linking in to wider recreational network. Includes furniture along waters edge to improve public safety.
5. Decorative Industrial Park water feature/artwork integrated with open water basin
6. Industrial Park Gateway plaza integrated with WSUD design, recreational facility (seating / BBQ / canopy) overlooking water feature

Movement and access

7. Reinforced grass access tracks around basins to provide maintenance access

Existing landscape

8. Basins integrated into local terrain to minimise cut and fill and maximise viewing corridors

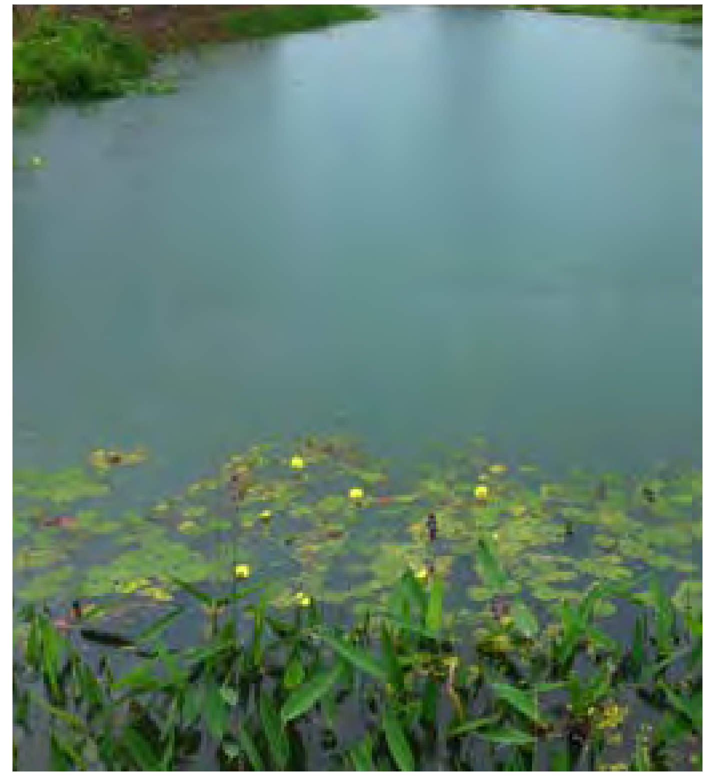
Green and blue grid

9. Enhanced health and recreational opportunities for industrial park community through connected active transport networks
10. Proposed riparian vegetation integrated into existing planting, enhancing setting and connectivity of existing landscape
11. Urban water and runoff directed into bio-retention system

Legend

- Trunk drainage asset
- Existing Vegetation
- Proposed Vegetation
- Hard surfaced vehicular access for maintenance
- Reinforced grass track
- Access point for maintenance
- Overland water flow direction
- WSUD water flow direction
- Water course flow direction
- +0.0 Relative level to top of bank

0 20 40 60 80 100
1:2000 @ A3



Supportive imagery:

L-R

Recreational facilities overlooking water feature, such as boardwalks and canopies. Opportunities are provided for pedestrian movement as part of the water infrastructure.
Image: Hong Kong Wetland Park, Arup

Active recreation, with decorative water features integrated into open water basin.
Image: Sydney Park water re-use, Government Architect New South Wales

Decorative water features integrate with stormwater capture infrastructure, providing aesthetic interest.
Image: Sydney Park water re-use, Government Architect New South Wales

New planting enhances setting, performance of water filtration and treatment, and connection to existing landscape features.
Image: Chengdu Waterway, Arup

Template 1

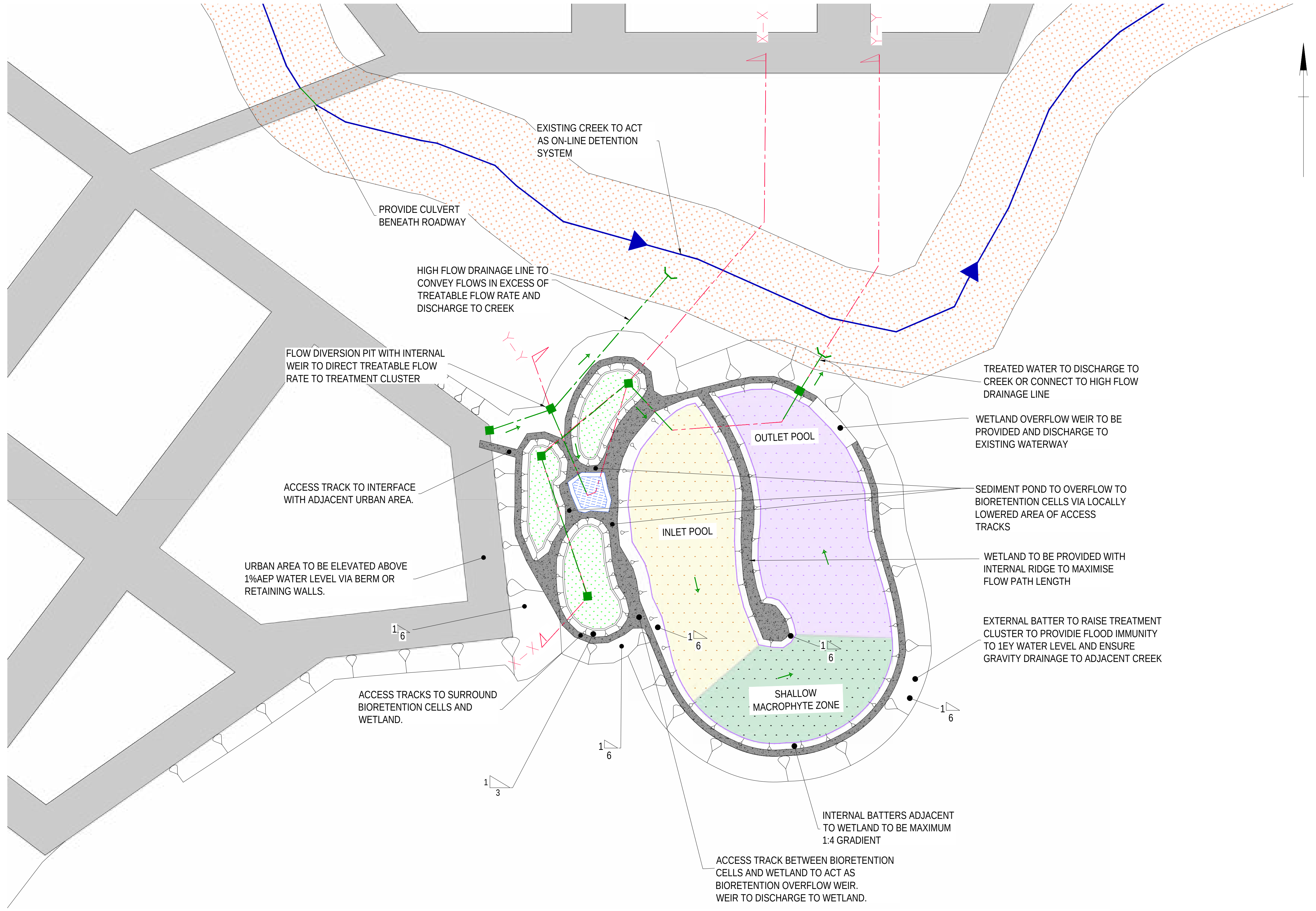
Technical Plan

LEGEND

- STORMWATER PIT
- STORMWATER PIPE
- FLOW DIRECTION
- RECYCLED PIPE
- BYPASS PIPE
- HEADWALL OUTLET
- ACCESS TRACK
- BIORETENTION
- WETLAND
- URBAN ROAD
- VEGETATED RIPARIAN ZONE
- EXISTING WATERWAY
- MAX. PERMITTED GRADIENT
- GPT STRUCTURE

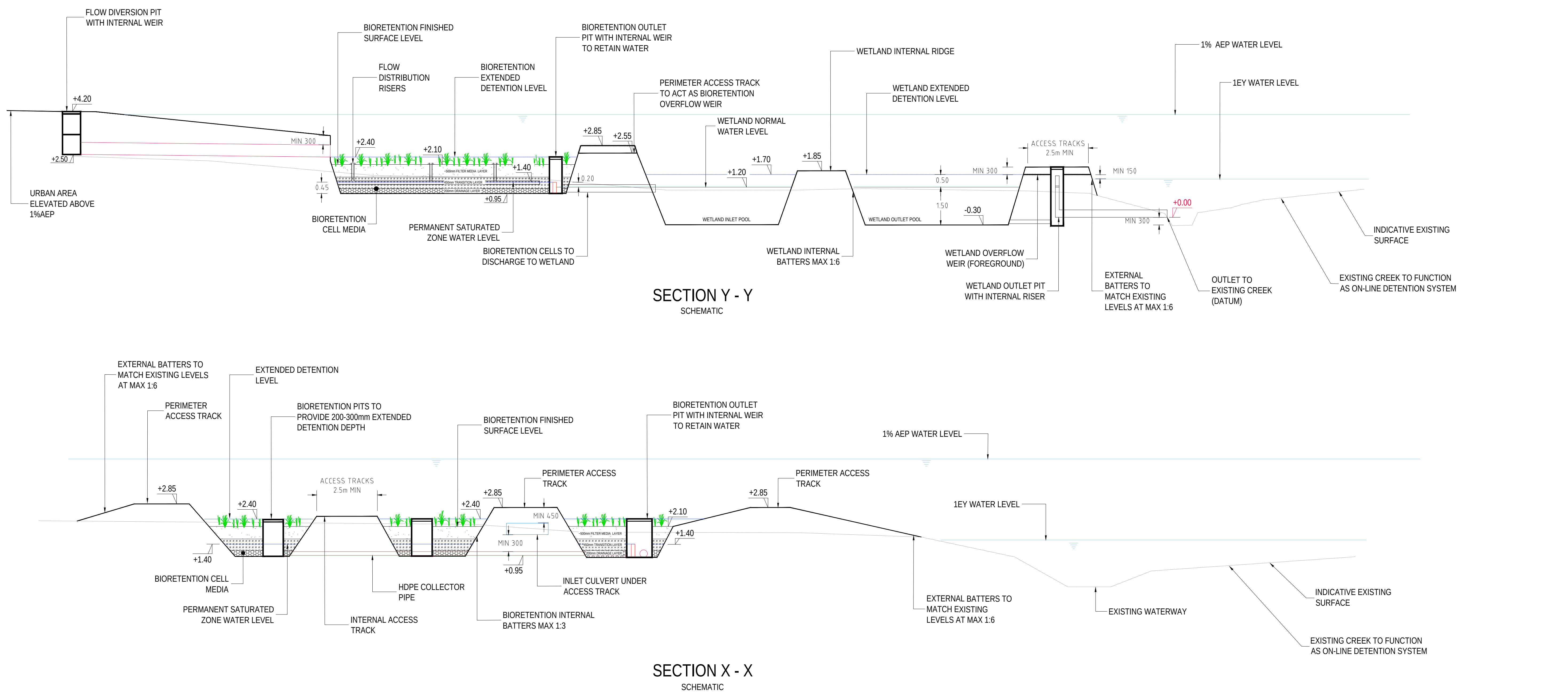
GENERAL NOTES

1. ALL ACCESS TRACKS TO BE MINIMUM 3m WIDE
2. ACCESS TRACKS TO BE GRADED AND TURNING HEADS PROVIDED AS REQUIRED TO SUIT MAINTENANCE VEHICLE. TRACKS TO PROVIDE WET WEATHER ACCESS TO TOP OF EXTENDED DETENTION LEVELS FOR 9m RIGID VEHICLE.
3. EXISTING CREEK TO ACT AS ON-LINE DETENTION SYSTEM ONLY WHERE CATEGORISED AS SECOND ORDER STREAM OR LOWER.
4. BIORETENTION AND WETLAND AREAS TO CONTRIBUTE TO DETENTION STORAGE VOLUME FOR STORMS IN EXCESS OF 1EY EVENTS
5. DETENTION BASIN FLOOR TO BE MINIMUM 0.5% GRADIENT TO PROVIDE ADEQUATE FALL TO BASIN OUTLET



Note: Drawing Not To Scale

Technical Section



LEGEND

- FILTER LAYER MEDIA
- TRANSITION LAYER MEDIA
- DRAINAGE LAYER MEDIA
- SEDIMENT POND/FOREBAY

GENERAL NOTES

1. ALL ACCESS TRACKS TO BE MINIMUM 2.5m WIDE
2. BIORETENTION BASIN FLOOR TO BE PROVIDED WITH NON-WOVEN GEOTEXTILE FILTER MATERIAL. ADDITIONAL IMPERMEABLE LINER OR CLAY BASE TO BE PROVIDED WHERE BASIN ENCROACHES INTO AREAS OF ELEVATED WATER TABLE OR HIGH SALINITY/LOW PERMEABILITY SOILS
3. WETLAND BASE TO BE PROVIDED WITH IMPERMEABLE LINER OR CLAY BASE
4. EXISTING CREEK TO ACT AS ON-LINE DETENTION SYSTEM ONLY WHERE CATEGORISED AS SECOND ORDER STREAM OR LOWER.
5. BIORETENTION AND WETLAND AREAS TO CONTRIBUTE TO DETENTION STORAGE VOLUME

Note: Drawing Not To Scale

Template 2

Space restricted bio-retention and wetland treatment

Open space in and around building plots within the precincts is likely to be constrained and therefore this template presents a typical linear configuration of bio-retention features within a restricted /narrow infrastructure corridor.

The features are located close together and following contours to reduce need for large batters and earth works. This typical configuration is most likely set within an agri-business land use.

Water infrastructure

1. Hard surface vehicular access for maintenance
2. Flood detention storage and embankments integrated around WSUD element
3. Reinforced grass access tracks around basins to provide maintenance access

Education, health and recreation

4. Potential agricultural plots integrated with WSUD for potential agribusiness research and education opportunities
5. Collaborate with local Aboriginal communities on design and programming of water assets

Movement and access

6. Proposed road crossing for a continuous walking trail integrated into the park
7. Safeguard existing ecological zones along the creek, and create enhanced linkage for walking and cycling

Existing landscape

8. Existing mature trees retained as part of WSUD design

Green and blue grid

9. Retain and safeguard existing agricultural dams and associated native ecology
10. Proposed walking trails and increased canopy cover to provide outdoor amenity and recreational space
11. Maximise integration of WSUD into road and infrastructure network

Supportive imagery:

L-R

Form allows for optimised water management, maintenance access, and recreational activities.
Image: Sydney Water

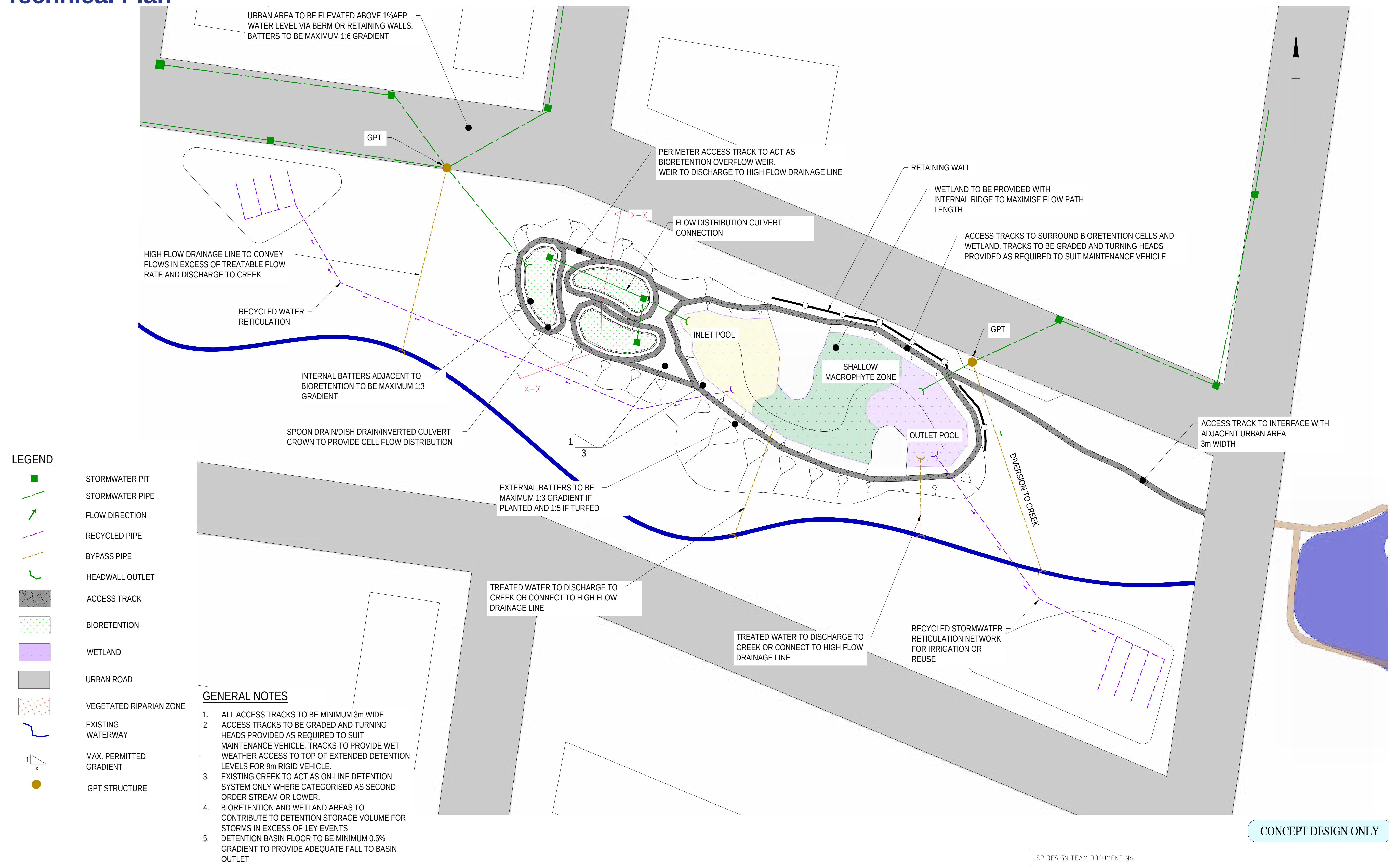
Safeguard existing ecological zones along the creek, and create enhanced linkage for walking and cycling.
Image: Badu mangrove, Sydney Olympic Park Authority, NSW Government

Potential agricultural plots integrated with WSUD for potential agribusiness, research and education opportunities.
Image: Rodley Nature Reserve, Arup

Introduce bush tucker trails and signage to increase connection to Country, and ecological understanding.
Image: Ngurin Bush Tucker Trail, City of Karratha

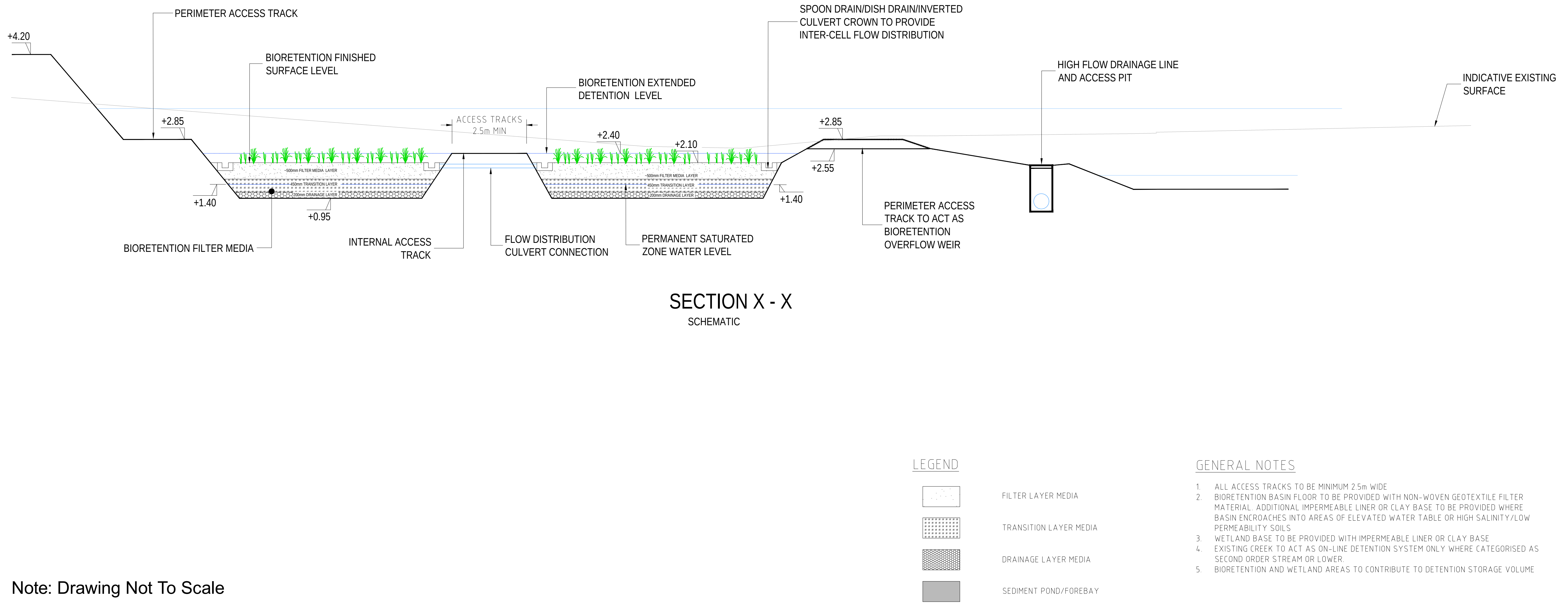
Template 2

Technical Plan



Note: Drawing Not To Scale

Technical Section



Note: Drawing Not To Scale

Template 3

Steep terrain profile bio-retention and wetland treatment

This template has been selected to demonstrate design considerations in areas where gradients exceed slopes of 1 in 4 or greater.

As with Template 2 the features follow site contours to reduce the need for large batters. Although space is less of a limiting factor, careful orientation is needed to allow for optimal flow rates between basins, and reduced earthworks.

Water infrastructure

1. Reinforced grass access racks around basins to provide maintenance access
2. Low gradient surface water discharges into vegetated wetland or directly into wetland

Education, health and recreation

3. Organically shaped water treatment feature keeps character of landscape and lookout point integrating watercourse view.
4. Recreational facility (seating/ BBQ/ canopy) integrated into bank and overlooking water feature

Movement and access

5. Walking trails connect to adjacent open streams

Existing landscape

6. Design with landforms to minimise cut and fill, enhance view corridors and vistas.
7. Linking habitats and utilise linear parklands along creek channel to strengthen biodiversity

Green and blue grid

8. Wetland planted with shallow macrophyte planting for plant water treatment

Supportive imagery:

L-R

Integrate WSUD with boardwalks and stepping stones as innovative recreation spaces.

Image: Chengdu Waterway, Arup

Wetlands as part of recreational facilities integrated with public outdoor amenity, seating and canopy.

Image: Blacktown Showground, Sydney Water

Opportunities for knowledge sharing, exchange and education to promote sustainable environments.

Image: Green City Action Plan, Arup

Design with landforms minimises cut and fill and allows water treatment to navigate steep terrain existing on site.

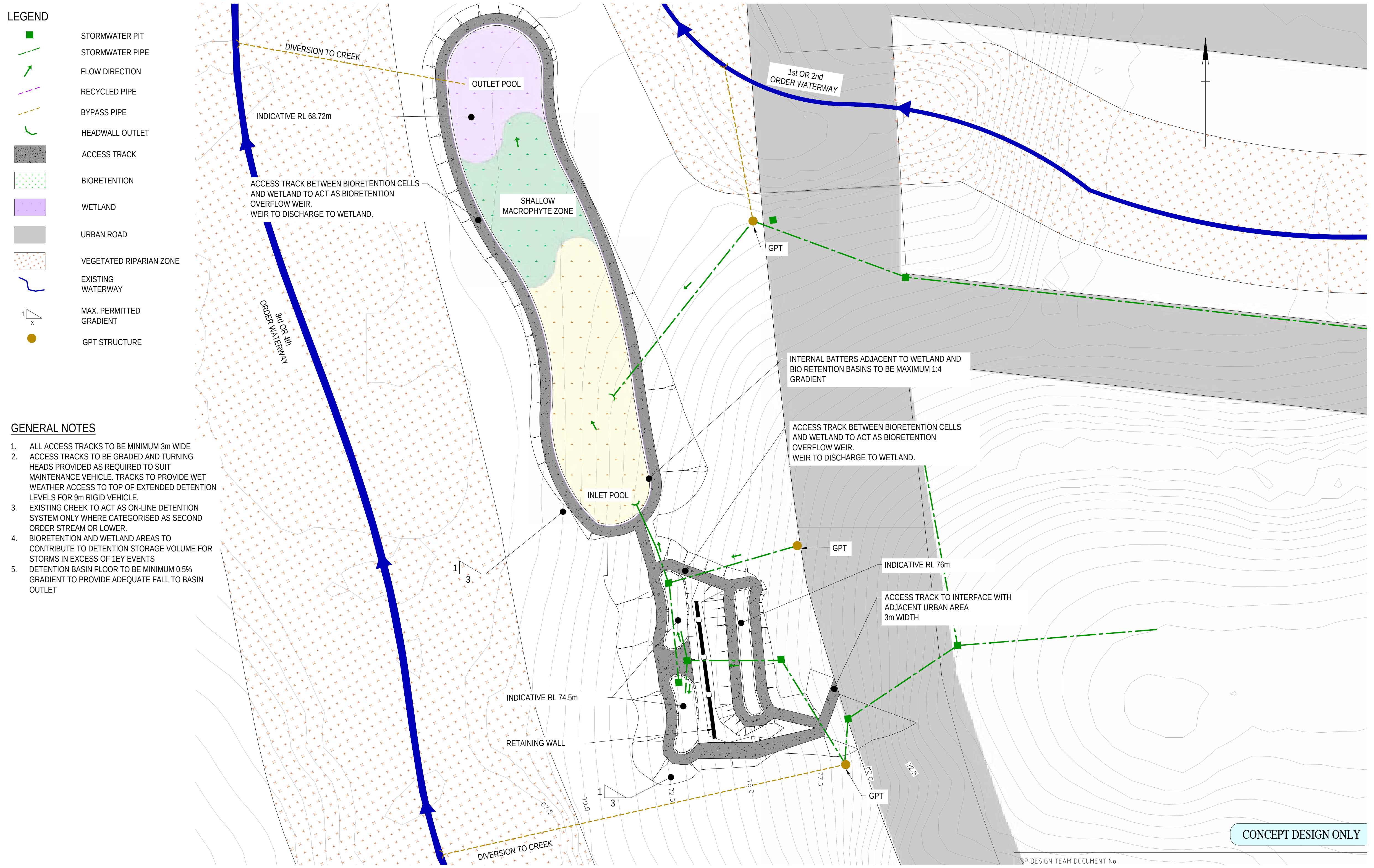
Image: Sydney Park, Government Architect New South Wales

Safeguard existing ecological zones along the adjacent first/second order creek.

Image: Hong Kong Wetland Park, Arup

Template 3

Technical Plan



Note: Drawing Not To Scale

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Template 4

Tree pit typical detail

Trees and vegetation will be used to increase the capture of stormwater volumes. This typical configuration illustrates the inclusion of trees and vegetation in the streetscape.

Water infrastructure

1. Passively irrigated street. Utilise street trees as means to reduce stormwater volumes
2. Tree pits allow runoff to flow directly into the drainage layer. The pit is fitted with a coarse filter to remove debris, water is held below the root zone

Education, health and recreation

3. A diverse mix of street trees placed at variable densities on one or both sides of the road, dependent on land use

Existing landscape

4. Large canopied trees providing canopy shade and reducing urban heat

Green and blue grid

5. Provide shelter belts and screen planting as part of WSUD features to improve visual and noise, buffers, and air quality
6. Provide pedestrian friendly green boulevards that link into wider green infrastructure network

Image: Bligh Tanner Architects,
Aerotropolis Urban Typologies, Sydney Water, 2020

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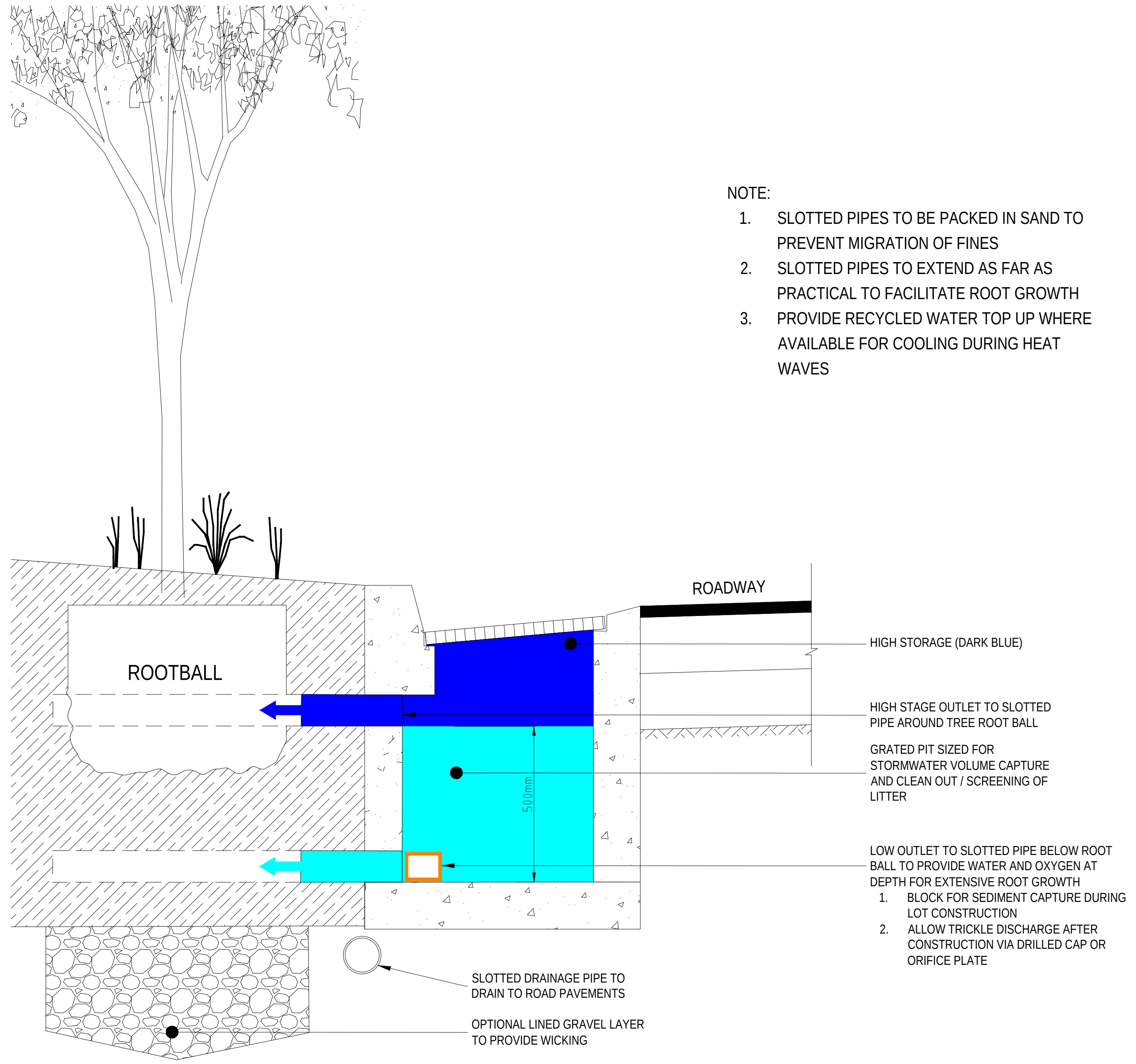


Typical technical detail

Supportive imagery:

L
Aerotropolis planting detail outling tree placement and irrigation, in relation to footpath, road, and utilities.

Image: Arup/Aecom

R, top to bottom
Typical passively irrigated centre road median planting.

Image: Vegetated swale at Bungarribee, Blacktown City Council

Street trees provide shelter belts and screen planting as part of WSUD features.

Image: State of New South Wales through the Greater Sydney Commission

Template 5

Online detention on first/second order creek (outside VRZ and HEV)

Template 5 illustrates how, during a storm event, a naturalised creek channel can be protected from stormwater surges. This is achieved by designing in a 100 year retention basin that is integrated with adjacent infrastructure, in this case a pedestrian and cycle path that crosses the creek.

Water infrastructure

1. Road crossing above water level during 1% AEP Flood Extent
2. Culvert provides fauna crossing to enhance biodiversity

Education, health and recreation

3. Collaborate with local Aboriginal communities on design and programming of water assets
4. Bike and pedestrian underpass

Movement and access

5. Pedestrian and cycling path matches level of road and footpath networks. Embankment acts as detention storage

Green and blue grid

6. Enhanced health and recreational opportunities through connected active transport networks
7. Drainage system daylights into creek, transitioning from pipes to above ground

Supportive imagery:

L-R
Online detention area with possible additional storage area and embankment.
Image: Arup

Work with Aboriginal communities to restore waterways with the introduction of native endemic riparian and aquatic ecology.
Image: Sydney Water

Integrate play into WSUD features, including local material elements and endemic ecological conditions.
Image: Sydney Park, Government Architect New South Wales

Waterway restoration, flood detention, and culverted water flows adjacent to transport infrastructures.
Image: Blacktown Showground, City of Blacktown

Template 5

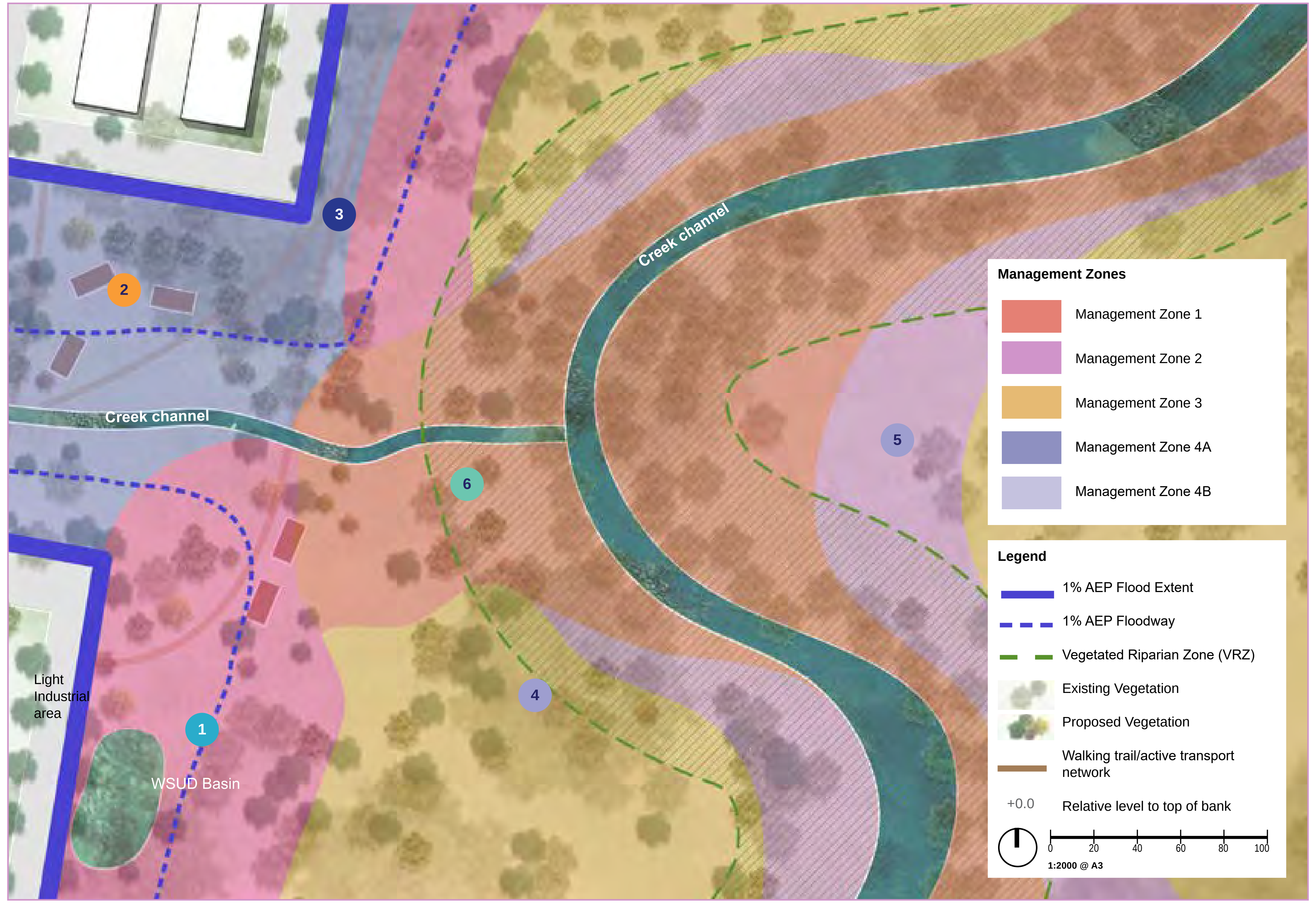
Illustrative Section AA

Template 6

Riparian revegetation

The network of creeks and tributary waterways contain areas of remnant biodiversity that should be fortified with complementary re-vegetation works to restore continuous habitat corridors.

This typical configuration illustrates how new development can be planned to accommodate localised flood levels, introducing and managing vegetation communities, and floodplain roughness.



Water infrastructure

1 Proposed WSUD Basin within 1% AEP flood extent to be part of the flood detention storage

Education, health, recreation

2 Enhanced health and recreational opportunities for working community with park facility (seating / BBQ / canopy)

Movement and access

3 Potential connected active transport network along the riparian corridor

Existing landscape

4 Vegetated Riparian Zone (VRZ) approx. 40m offset from top of the bank, the width varies depending on order of creek.

5 Management approach 1 and 2 to any existing native plant community in this zone. Management 3 of revegetation to the rest of the area in floodway

Green and blue grid

6 Restore native habitat with revegetation of tree canopies and understorey to enhance biodiversity along the riparian corridor

Riparian habitat revegetation strategy

Management 1 – HEV Protect Area

Incorporates land mapped as HEV 'Protect' between creek channel to the outer edge of the 1% AEP extent. The primary function of this zone is to protect remnant biodiversity.

Management of this zone seeks to protect existing native vegetation patches and restore a fully structured Riverflat Forest plant community (canopy, understory and ground cover).

Management 2 – HEV Improve Area

Incorporates land mapped as HEV 'Improve' between the creek channel to the outer edge of the 1% AEP Flood extent. The primary function of this zone is to improve the connectivity of remnant biodiversity and provide buffers to HEV 'Protect'.

Management of this zone seeks to either

- revegetate a fully structured Riverflat Forest plant community within the vegetated riparian zone (VRZ), or
- create a near continuous tree canopy while maintaining flood conveyance in areas outside the VRZ.

This zone may include WSUD elements (outside the VRZ) if desired flood planning levels are not affected.

Management 3 – Floodway

Incorporates land mapped as the 1% AEP extent that excludes areas mapped as HEV and VRZ. The primary function of this zone is flood conveyance.

Management of this zone aims to create a mosaic of native tree canopy cover with native groundcover (i.e. native grasses, forbs and herbs). This zone may include WSUD elements if desired flood planning levels are not affected.

Management 4A – VRZ not mapped as HEV

Incorporates Vegetated Riparian Zones for waterways that are not mapped as HEV. The primary function of this zone is to apply the Waterfront Lands policy to waterways that are to be retained. The management of this zone seeks to reinstate a fully structured Riverflat Forest plant community (canopy, understory and ground cover) on to land that contains little existing ecological value (similar to zone 4b).

Management 4B – Increase habitat opportunities

Incorporates public open space between the 1% AEP floodway and 1% AEP flood extent that are not mapped as HEV. The primary function of this zone is to expand habitat and tree canopy outside of remnant native vegetation patches and into zones that are less critical for flood conveyance.

The management of this zone seeks to reinstate a fully structured Riverflat Forest plant community (canopy, understory and ground cover on to land that contains little existing ecological value (similar to zone 4a). This zone may include WSUD elements if desired flood planning levels are not affected.

Management 1 - HEV 'Protect' Area
Image: State of New South Wales through the Greater Sydney Commission

Management 2 - HEV 'Improve' area
Image: Tyrrellstudio

Management 3 - Floodway
Image: Tyrrellstudio

Management 4a and 4b - reinstate vegetation
Image: Blacktown City Council

Template 6

Typical Section

Riverflat Eucalyptus Forest on Coastal Floodplains

Typical species:

Tree:
Eucalyptus tereticornis, Eucalyptus amplifolia, Angophora floribunda, Angophora suvelutina, Eucalyptus baueriana, Eucalyptus elata.

Small tree:
Melaleuca decora, Backhousia myrtifolia, Casuarina cunninghamiana, Causurina glauca

Shrubs:
Bursaria spinosa, Solanum prinophyllum, Ozothamnus diosmifolius, Acacia floribunda

Groundcover:
Microlaena stipoides, Dichondra repens, Glycine clandestina, Veronica plebeia, Pratia purpurascens

Template 7

Reconstructed natural trunk channel (outside HEV)

This template illustrates the creation of a natural stormwater channel within a proposed parkland (outside of HEV zone) and in a light industrial land use area.

Integrated into the character of the landscape it extends green links through the linear park and connects to the biodiversity network.

Education, health and recreation

1 Creekside plaza and lookout serves as flood infrastructure and for creating landscape views

2 Recreational facilities adjacent to proposed industrial zoning

Movement and access

3 Restore native habitat to enhance biodiversity and connect the existing riparian corridor with Integrated education trails and enhanced walking cycling network.

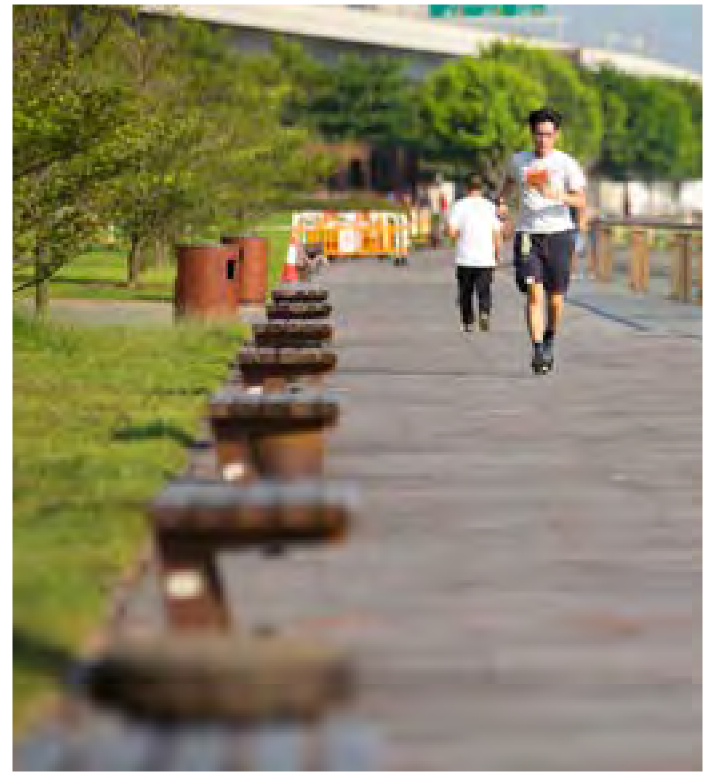
Existing landscape

4 Integration of stormwater channel with park space to create nature encounters and increase biodiversity

5 Flood detention storage and embankments integrated around trunk drainage channel

Green and blue grid

6 Native plants on bed and bank with canopy trees along the trunk drainage channel



Supportive imagery:

L-R
Integration of stormwater channel with park space, allowing for recreation and connection to nature.
Image: Kwung Tong Promenade, Arup

Landscape design that connects across infrastructure, increasing accessible areas of public space.
Image: Waterway restoration, Blacktown City Council

Naturally graded banks to integrate storm water channels into landscape.
Image: Strangers Creek Rehabilitation, Sydney Water

Naturalised constructed creekway, adjacent to and integrated with city infrastructure.
Image: Madrid Phase 3, Arup

Native wetland planting community along the trunk drainage channel.
Image: Waterway Restoration Doonside, Blacktown City Council

Template 7

Illustrative Section CC

Template 8

Retained farm dams for ecology

Selected existing farm dams of ecological value and located within an HEV protected area will be safeguarded. A new engineered dam and bioretention basin/wetlands will be designed into the existing dam landscape to protect endangered ecological communities. Revegetation along the new dam wall will also help restore native habitat and connect to existing vegetation associated with the retained farm dam. These retained dams will function as places for ecology and focal areas for learning. In this example there is proposed a community education facility to engage with First Nations land, water and agricultural management practices associated with Darug country.

Education, health and recreation

1. Proposed public amenity / focal point for community to engage with water bodies and learn about Aboriginal culture and practices associate with endemic ecological habitats
2. Vegetated embankment and reconstructed dam wall

Movement and access

3. Walking trails are integrated with maintenance infrastructure

Existing landscape

4. Proposed pre-treatment bio-retention/ wetland integrated into existing landscape whilst safeguarding the dam and to increase safety for public access
5. Critical endangered ecological communities to be protected and enhanced

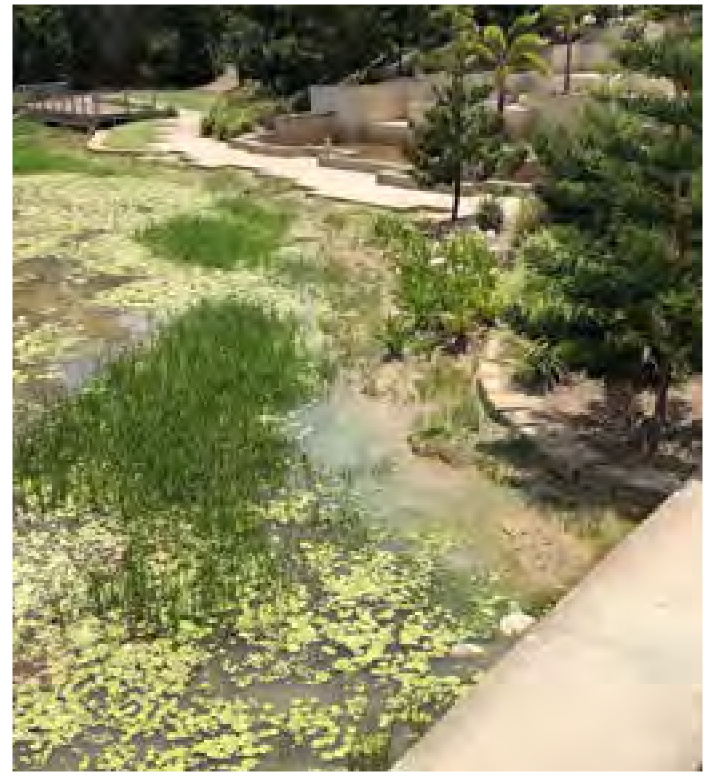
Green and blue grid

6. Proposed walking trails and increased canopy cover to contribute to wider active transport network
7. Hydrological and ecological operation of the landscape becomes visible to the community
8. Restore native habitat to enhance biodiversity and provide habitat for non-human creatures

Supportive imagery:

L-R
Existing vegetation around the Low lying area surrounding dam is safeguarded with the retention of the dam.
Image: NIRAH Bedfordshire, Arup

Reconstruction of agricultural dam wall, to provide safety and community amenity.
Image: Dragonfly pond, Blacktown City Council



Reinforced park basins provide structural capacity for existing water infrastructures.
Image: Arup

Native plant revegetation in adjacent creek profile
Image: First Creek, Blacktown City Council

Multi-functional infrastructure, with native habitat restoration further enhancing walking and cycling network.
Image: Cycling in Barangaroo, Arup

Template 8

Illustrative Section DD

Template 9

Reprofiled farm dams for recreation

This template illustrates how existing farm dams can be reprofiled to provide enhanced WSUD basins as well as new recreational assets for the surrounding community.

By re-engineering the dam walls to meet necessary engineering standards for recreational and biodiversity features can be integrated into the WSUD basin design. In this example the basins incorporate walking trails and gathering spaces together with boardwalks, stepping stones and seating. New planting could also be provided that helps connect creek-side vegetation with new parklands.

Water infrastructure

1. Reconstructed low flow channel along ephemeral creeks

Education, health and recreation

2. Existing farm dam to be reconstructed and enhanced WSUD basins as a water feature with integrated recreational elements (viewing deck, boardwalk, stepping stones, seating)
3. Design with landforms for an amphitheatre for outdoor recreation, enhance view corridors and visual connections to water environments

Existing landscape

4. Safeguard existing native vegetation

Supportive imagery:

L-R
Reprofiled farm dam as a water feature, with integrated recreational elements.
Image:Kings Park, Arup

Rebuild farm dam with spillway, connecting to high flow bypass and other WSUD asset for additional possible storage for flows.
Image: Bay Meadows, Arup

Integrated pathway along water edge for walking and cycling.
Image: Fairweather Detention Pond, Blacktown City Council

Detention pond as part of WSUD facilities in employment land for business and recreational purpose.
Image: Chengdu Waterway, Arup

Template 10

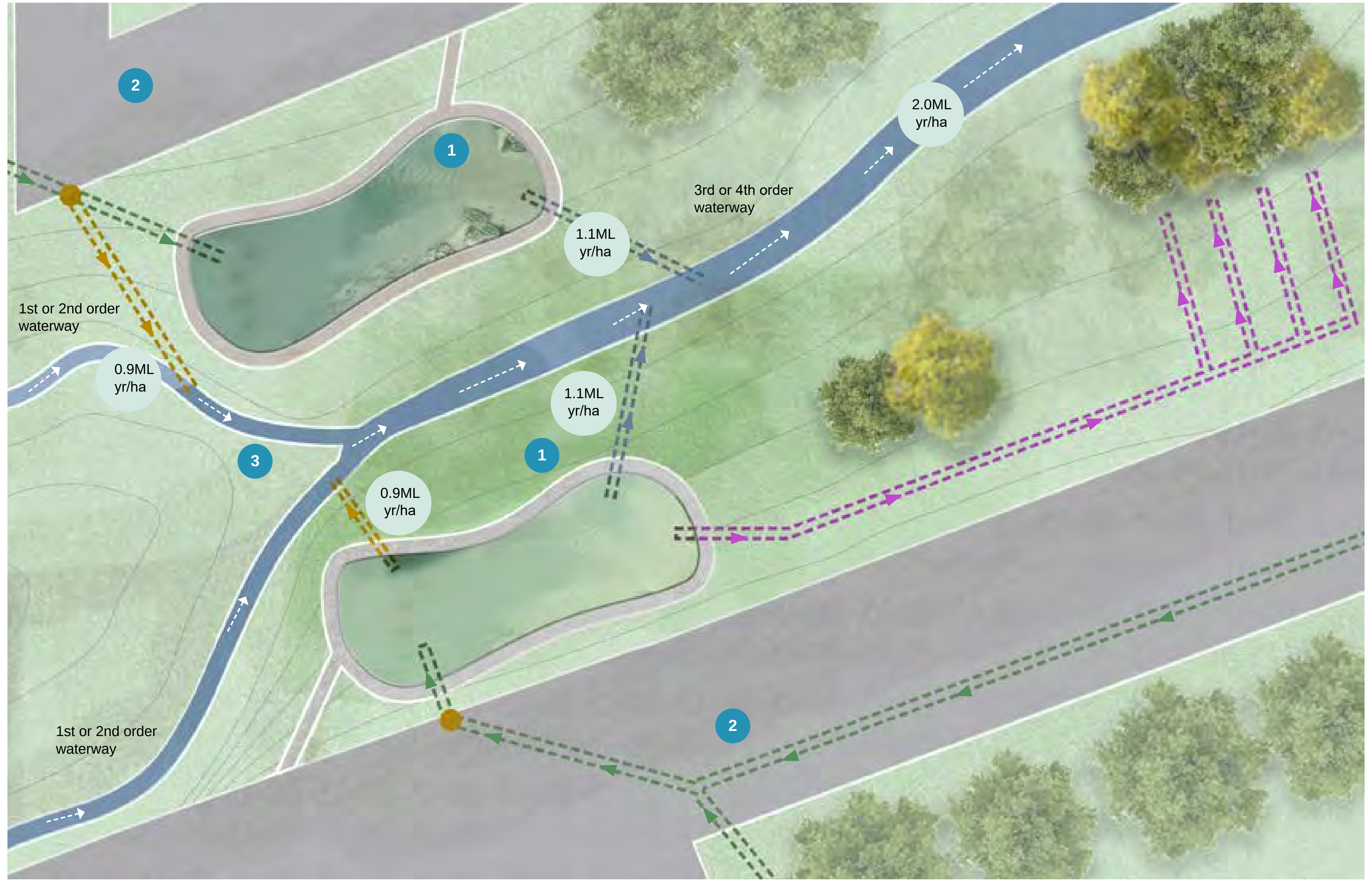
Bypass pipelines

This template demonstrates the need for sensitive water balancing through the use of bypass pipelines to safeguard natural flow rates within existing creeks.

With careful analysis of existing and projected flow rate data a bypass pipeline can be designed to collect excess runoff from the street and then bypass to a new WSUD basin downstream. The design of the bypass system will be nuanced to the specific catchment characteristics of each creek.

The bypass system will be designed to:

- Assume that the pipes running down the hills towards the creek should be 1200RCPs
- the diversion pipe should be a 375RCP minimum

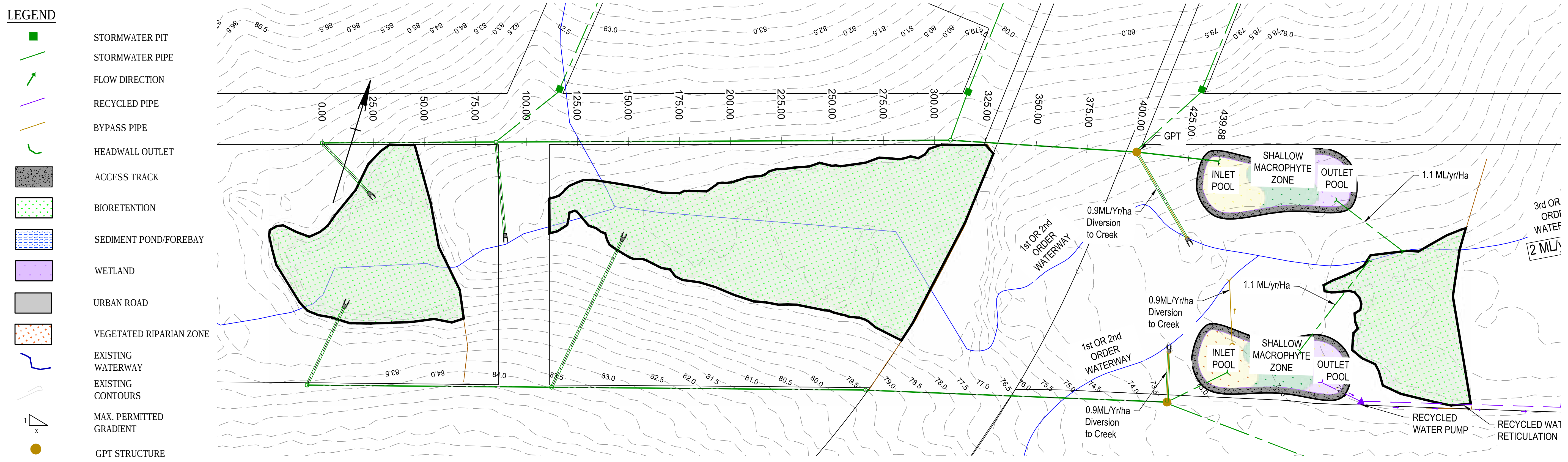


Bypass design safeguarding existing creek flow rates

- 1 Indicative bioretention basin
- 2 Introduced urban form
- 3 Indicative landscape context
- Flow direction of creek
- Stormwater pipeline
- Gross pollutant trap
- Bypass pipeline
- Recycled water pipeline
- Treated water pipeline
- 1.1ML yr/ha Average yearly discharge per ha

Note: Drawing Not To Scale

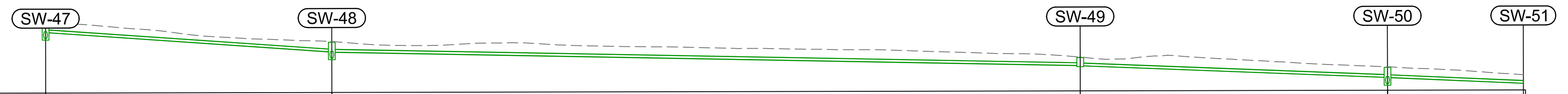
Bypass pipelines – Technical Plan



KEY PLAN
SCALE: 1:1000

GENERAL NOTES

1. ALL ACCESS TRACKS TO BE MINIMUM 3m WIDE
2. ACCESS TRACKS TO BE GRADED AND TURNING HEADS PROVIDED AS REQUIRED TO SUIT MAINTENANCE VEHICLE. TRACKS TO PROVIDE WET WEATHER ACCESS TO TOP OF EXTENDED DETENTION LEVELS FOR 9m RIGID VEHICLE.
3. EXISTING CREEK TO ACT AS ON-LINE DETENTION SYSTEM ONLY WHERE CATEGORISED AS SECOND ORDER STREAM OR LOWER.
4. BIORETENTION AND WETLAND AREAS TO CONTRIBUTE TO DETENTION STORAGE VOLUME FOR STORMS IN EXCESS OF 1EY EVENTS
5. DETENTION BASIN FLOOR TO BE MINIMUM 0.5% GRADIENT TO PROVIDE ADEQUATE FALL TO BASIN OUTLET



	SW-47		SW-48		SW-49		SW-50		SW-51
PIPE DIAMETER (mm) PIPE TYPE & CLASS		∅381 375 NB RCRRJ CLASS 2		∅381 375 NB RCRRJ CLASS 2		∅381 375 NB RCRRJ CLASS 2		∅381 375 NB RCRRJ CLASS 2	
PIPE GRADE (%)		3.50%		1.00%		2.00%		2.21%	
INVERT LEVEL	81.00		78.02 / 78.00		75.77 / 75.75		73.92 / 73.90		73.01
PIT LEVEL	82.65		79.55		77.03		75.49		74.28
EXISTING LEVEL	82.65		79.55		77.03		75.49		74.28
PIPE CHAINAGE	0.00	85.20	85.20	222.76	307.96	91.45	399.42	40.46	439.88

LONGITUDINAL SECTION

Note: Drawing Not To Scale

For more info email multimedia@sydneywater.com.au

SW100 10/20

For more info email multimedia@sydneywater.com.au