Prepared for
Transport for NSW
ABN: 18 804 239 602

Water Quality, Flooding and Stormwater Assessment (SSP Study No. 13)

Redfern North-Eveleigh - Paint Shop Sub-Precinct

June 2022
Redfern North-Eveleigh Precinct Renewal
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Prepared by

AECOM Australia Pty Ltd
Level 21, 420 George Street, Sydney NSW 2000, PO Box Q410, QVB Post Office NSW 1230, Australia
T +61 2 8008 1700 www.aecom.com
ABN 20 093 846 925

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Prepared by Priyamvada Awotar

Reviewed by Ricky Kwan / Courtney Henderson

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H	21-Jun-2022	Final Report	Jeannie van Zyl Principal Civil Engineer	

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Executive Summary

The NSW Government is investing in the renewal of the Redfern North Eveleigh (RNE) Precinct to create a unique mixed-use development, located within the important heritage fabric of North Eveleigh. The Redfern North Eveleigh Precinct comprises three sub-precincts, each with its own distinct character:

- The Paint Shop sub-precinct;
- The Carriageworks sub-precinct; and
- The Clothing store sub-precinct.

This report addresses study requirement *13.1- Water Quality, Flooding and Stormwater*. The purpose of this report is to provide a detailed water quality, flooding and stormwater assessment of the proposed changes, and consider any potential impacts that may result within and surrounding the Paint Shop Sub-precinct.

The site is located in the Munni Creek sub-catchment in the upper reaches of the Alexandra Canal catchment. The flow direction within this subcatchment is generally towards the Cooks River and eventually into Botany Bay. The site is highly urbanised and almost entirely impervious, covering a mix of commercial and residential buildings.

Key opportunities and constraints related to the site from a flooding and stormwater perspective are summarised in Section 2.2.

To inform this study, the following previous stormwater investigations were reviewed for relevance and are briefly discussed in this report:

- North Eveleigh Housing Project Stormwater Management Plan (NEHP, 14 March 2013)
- Stormwater Management Options Review – North Eveleigh (AECOM, August 2014)
- North Eveleigh Hydraulic Services Concept Design Report (WSP, April 2008)
- Alexandra Canal Catchment Flood Study (WMA, 2018)
- Illawarra Dive Study (Next Rail, August 2021).

Existing flood impacts on the site

Flood extents and depths for the 20% AEP and 1% AEP flood events have been modelled and included in this report.

The Illawarra Dive Study (Next Rail, 2021) assessed the existing flooding characteristics of the Illawarra dives downstream of the site. The study established the current drainage performance of the culverts crossing rail corridor and highlighted other sources of flooding for the dives including ingress through the northern Dive access. Recommendations comprised the following:

- Bunding the eastern end of North Eveleigh precinct
- Upstream detention tank within Carriageworks
- A new gravity 225 mm drainage pipe from the existing cross drain with connection to TC1, and modifications to the TC1 inlets to improve collection of the eastern local catchment runoff into the Dives.

These network upgrades are assumed to roll out in the next 5 years as defined by the Illawarra Dive Study report. As such the proposed measures were accounted for in the flood risk assessment for the Redfern North Eveleigh development, reflecting the likely infrastructural upgrades at the time of delivery of this concept design. The potential impacts from these changes mainly pertain to increased flooding within the site from bunding the section draining into the dives and connectivity to the existing drainage network.

Post-development stormwater management

The post-development is expected to result in changes to the flooding and water quality characteristics as well as impact on the performance of the existing drainage network for which relevant controls and mitigation measures need to be assessed against the relevant design criteria outlined in the DCP 2012. A post-development flooding and drainage assessment was undertaken following confirmation of the masterplan for RNE Precinct in April 2022.

Stormwater quality

The Redfern North Eveleigh Precinct Renewal Environmental Sustainability report (Arup, April 2022), highlighted relevant site opportunities and constraints towards sustainability and implementation of water-sensitive urban design initiatives. The points of relevance towards addition of WSUD incentives included:

- Collection and retention rather than discharge
- Incorporation of bioswales and improvement of water quality
- Incorporation of green open spaces for liveability
- Passive water treatments as part of the landscape design.

Individual lots

Given uncertainty concerning the ownership of the respective stormwater management controls across different buildings at this stage of design, it is assumed that water quality treatment would be implemented at a lot scale (see Figure 18), meaning that individual buildings would be expected to meet water pollution reduction targets before discharging to the stormwater drainage network. For individual lots, the stormwater management strategy includes rainwater tanks to be installed in each building.

Public domain

For the public domain, it is assumed that stormwater treatment would be provided within the public domain. Public domain areas have been assumed to have an overall impervious fraction of 34%, taking into account paved sections and footpaths. Bioretention systems to service public open spaces were assumed to cover 2% of the total area for the various sections with those land uses. The modelling shows that a total area of about 455 m^2 would need to be accommodated across the public domain areas for bioretention systems, to service the public domain and road sections within the Precinct.

Stormwater quality modelling

Results from preliminary modelling in MUSIC (Model for Urban Stormwater Improvement Conceptualisation) indicate that the implementation of stormwater controls can achieve target pollutant load reduction at the receiving node discharging from the overall Paint Shop sub-precinct. Improved outcomes may be possible through detailed design by integrating the water quality, civil and landscape design.

Flood risk

An assessment was undertaken of the hydrologic and hydraulic performance at the developed study site (post-development scenario). The report describes the methodology and assumptions employed. This modelling incorporated Next Rail's preferred upgrading option for the Dives and takes into account the constructability issues and proposed future development of the North Eveleigh Precinct.

The 20% and 1% AEP flood depth and impact maps for the post-developed conditions are provided in Section 7.2 of the report.

Recommended flooding controls

In addition to meeting the planning commitments for the North Eveleigh Precinct and the design criteria towards flooding and stormwater management, it is understood that the development is to have a permissible site discharge (PSD) of 0.25 - 0.3 m^3/s. This means increased site detention is required.

This report describes testing of the following options towards meeting the PSD requirements, and illustrates respective outcomes, summarised below:

Issue	Response
On site detention storage	The implementation of on-site detention (OSD) to assist with reduction of stormwater discharge from the site and meeting the permissible site discharge. This can be achieved either within the public open spaces or as OSDs on building roofs. Through preliminary testing of detention storage configurations primarily within the public open space and between the set of buildings adjacent to the bunded section (K2, L1 and P1-P2 buildings as per Figure 3), it was assessed that on-site detention would eliminate potential flooding within the Paint Shop sub-precinct and contribute towards reduced site discharge at TC1 pipe. Given the limited space within the Paint Shop sub-precinct, it is likely that additional detention would need to be provided on roofs of buildings for which the connectivity into external drainage lines can be considered during detailed design.
Increase in open space and park areas	The current TUFLOW (Two dimensional Unsteady Flow) modelling assumes an impervious site under existing conditions. However, as the proposed masterplan provides an increase in public open space and park areas, the opportunity exists for additional infiltration or flow attenuation within the proposed landscaped areas.
Concept drainage design	Flows coming from the east to TC1 outlet for the 1% AEP 1 hour storm event have a peak of about 1.2 m3/s. A concept drainage design which would allow conveyance of these flows to the outlet was established, taking into account the connectivity to TC1, the grade of the terrain and the constructability of any pipe network. Based on the site constraints, it is considered that a maximum size would be limited to a depth of 900 mm. It was assessed that either a 600 x 600 mm box culvert or a 450mm (2 barrels) pipe would be adequate. Feeder pipes from the sections between the buildings would need to be sized accordingly to capture the flows from the paved sections to connect into the above pipe section as part of the detailed design. Any excess flows would need to be contained either on-site or through the use of permeable paving or diverted for passive irrigation within the public domain.

Recommended development controls

Flooding

The Redfern North Eveleigh Precinct will need to manage an increase in flooding within the site for both the 20% and 100% AEP storm events. Surface runoff from the Precinct into the Dive drainage line (TC1) is limited to a Permissible Site Discharge (PSD) of 250-300 L/s under these conditions.

Recommended controls are aimed at minimising discharge from the site in line with the Permissible Site discharge (PSD) requirements whilst mitigating an increase in flooding for the developed conditions.

Proposed options include extending and upsizing the 225 mm low-flow gravity pipe which connects to TC1. Given the site constraints, upstream detention would need to be provided to contain the additional afflux from the eastern catchment.

The 2014 City of Sydney *Interim Floodplain Management Policy* specifies minimum building floor levels and below ground flood planning levels (FPL) for residential and industrial sites. Residential development requires a 1% AEP + 0.5 m flood planning level. For industrial and commercial areas, a flood planning level corresponding to the 1% AEP event applies. Compliance with this policy should be able to be achieved with implementation of one (or more) of the recommendations in Section 7.3.

Water quality

In terms of meeting the water quality requirements, the development would need to provide water quality treatment devices such as bioretention systems and rainwater tanks. It is estimated that approximately 455 m^2 bioretention areas would be required, in addition to rainwater tanks to be accommodated at a lot scale at the buildings.

1.0 Introduction

The NSW Government is investing in the renewal of the Redfern North Eveleigh Precinct to create a unique mixed-use development, located within the important heritage fabric of North Eveleigh. The strategic underpinning of this proposal arises from the Greater Sydney Region Plan and District Plan. These Plans focus on the integration of transport and land use planning, supporting the creation of jobs, housing and services to grow a strong and competitive Sydney.

The Redfern North Eveleigh Precinct is one of the most connected areas in Sydney, and will be a key location for Tech Central, planned to be Australia's biggest technology and innovation hub. Following the upgrading of Redfern station currently underway, the Precinct's renewal is aimed at creating a connected destination for living and working, and an inclusive, active and sustainable place around the clock.

The Redfern North Eveleigh Precinct comprises three Sub-Precincts, each with its own distinct character:

- The Paint Shop Sub-Precinct which is the subject of this rezoning proposal;
- The Carriageworks Sub-Precinct, reflecting the cultural heart of the Precinct where current uses will be retained; and
- The Clothing Store Sub-Precinct which is not subject to this rezoning proposal.

This State Significant Precinct (SSP) Study proposes amendments to the planning controls applicable to the Paint Shop Sub-Precinct to reflect changes in the strategic direction for the Sub-Precinct. The amendment is being undertaken as a State-led rezoning process, reflecting its status as part of a State Significant Precinct located within the *State Environmental Planning Policy (Precincts - Eastern Harbour City) 2021*.

The amended development controls will be located within the City of Sydney Local Environmental Plan. Study Requirements were issued by NSW Department of Planning and Environment (DPE) in December 2020 to guide the investigations to support the proposed new planning controls.

1.1 Purpose of this Report

The purpose of this report is to provide a detailed water quality, flooding and stormwater assessment of the proposed changes, and consider any potential impacts that may result within and surrounding the Paint Shop Sub-precinct. This report addresses study requirement *13.1- Water Quality, Flooding and Stormwater*. The relevant study requirements, considerations and consultation requirements, and location of where these have been responded to is outlined in **Table 1** below.

Table 1 Study Requirements, Considerations and Consultation Requirements

Ref.	Study Requirement	Report Reference
Water Quality, Flooding and Storm Water		
13.1	• Identifies the existing situation, including constraints, opportunities, key issues and existing network capacity;	Section 2.1, page 8 Section 2.2, page 8 Section 4.0, page 18 Section 5.3, page 24
13.1	• Assesses the potential impacts of the proposal on the hydrology of the precinct and adjoining areas;	Section 6.1.1, page 35

13.1	• Includes a concept stormwater management plan outlining the general stormwater management measures for the proposal;	Section 7.3, page 49
13.1	• Includes a flood risk assessment identifying flooding behaviours and flood impacts resulting from the proposal and providing recommendations for appropriate flood planning levels;	Section 7.0, page 41
13.1	• Provides concept level details of drainage to address stormwater flows in the precinct	Section 7.3, page 49
13.1	• Informs and supports the preparation of the proposed planning framework including any recommended planning controls or DCP/Design Guideline; and	Section 7.3, page 49
13.1	• Provides an analysis of the proposal measured as % difference in flooding shown in flood depth contours and hazard maps	Section 7.1, page 41
Considerations		
13.1	• A particular focus on water quality, the extent to which proposed development protects, maintains or restores water health and the community's environmental values and use of waterways for Sydney Harbour (also known as the NSW WQO)	Section 6.2, page 35
	• No increase to existing flooding and that flooding is reduced where possible	Section 7.0, page 41
	• Flood risk impact across the catchment area and all adjoining land uses	Section 7.2, page 42
	• How the planning framework will address water quality targets in Sydney DCP 2012	Section 6.2, page 35
	• WSUD options for the proposal, developed in conjunction with the Green Infrastructure and public space	Section 6.2.5, page 40

1.2 Redfern North Eveleigh Precinct

The Redfern North Eveleigh Precinct is located approximately 3km south-west of the Sydney CBD in the suburb of Eveleigh (refer to **Figure 1**). It is located entirely within the City of Sydney local government area (LGA) on government-owned land. The Precinct has an approximate gross site area of 10.95 hectares and comprises land bounded by Wilson Street and residential uses to the north, an active railway corridor to the south, residential uses and Macdonaldtown station to the west, and Redfern station located immediately to the east of the Precinct. The Precinct is also centrally located close to well-known destinations including Sydney University, Victoria Park, Royal Prince Alfred Hospital, the University of Technology Sydney, and South Eveleigh, forming part of the broader Tech Central District.

The Precinct is located within the State Heritage-listed curtilage of Eveleigh Railway Workshops and currently comprises the Platform Apartments with 88 private dwellings, Sydney Trains infrastructure and key state heritage buildings including the Paint Shop, Chief Mechanical Engineer's Building, and the Carriageworks and Blacksmith Shop which provide shared community spaces for events including the Carriageworks Farmers Markets.

A map of the Precinct and relevant boundaries is illustrated in **Figure 2**.

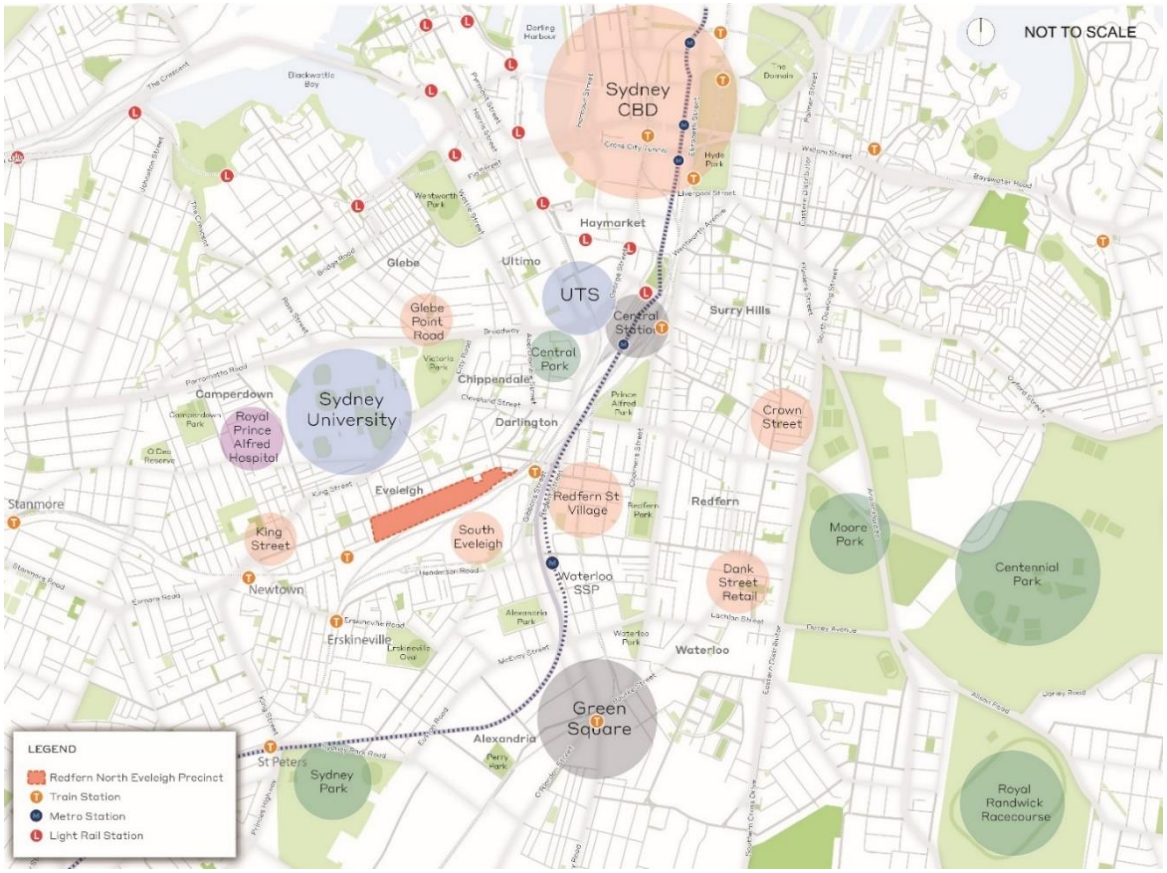

Figure 1: Location Plan of Redfern North Eveleigh Precinct (Source: Ethos Urban)

1.3 Redfern North Eveleigh Paint Shop Sub-Precinct

The Redfern North Eveleigh Paint Shop Sub-Precinct is approximately 5.15 hectares and is bounded by Wilson Street to the north, residential terraces and Redfern station to the east, the Western Line rail corridor to the south and the Carriageworks Sub-Precinct to the west. The Sub-Precinct has a significant level change from a Reduced Level (RL) height of RL25 metres to RL29 metres on Wilson Street.

The Paint Shop Sub-Precinct currently hosts a number of items of heritage significance, including the Paint Shop Building, Fan of Tracks, Science Lab Building, Telecommunications Building, and Chief Mechanical Engineer's Building. The Sub-Precinct has a number of disused spaces adjacent to the rail corridor as well as functioning Sydney Trains' infrastructure, offices and operational space. Vehicle and pedestrian access to this area is used by Sydney Trains. The site has a clear visual relationship to South Eveleigh and the Eveleigh Locomotive Workshops across the active rail corridor.

A map of the Paint Shop Sub-Precinct and relevant boundaries is illustrated in **Figure 2**.

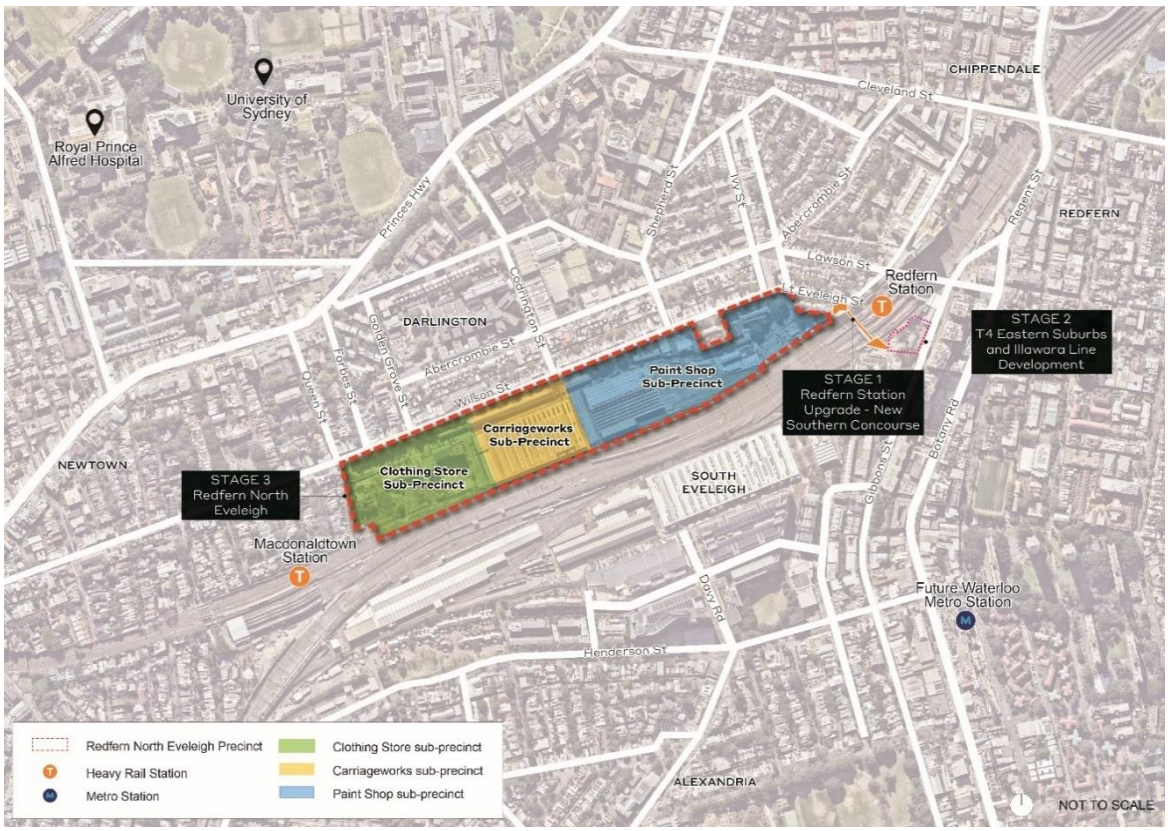

Figure 2 Redfern North Eveleigh and Sub-Precincts (Source: Ethos Urban)

1.4 Renewal Vision

The Redfern North Eveleigh Paint Shop Sub-Precinct will be a connected centre for living, creativity and employment opportunities that support the jobs of the future, as well as providing an inclusive, active and sustainable place for everyone, where communities gather.

Next to one of the busiest train stations in NSW, the Sub-Precinct will comprise a dynamic mix of uses including housing, creative and office spaces, retail, local business, social enterprise and open space. Renewal will draw on the past, adaptively re-using heritage buildings in the Sub-Precinct and will acknowledge Redfern's existing character and particular significance to Aboriginal peoples, culture and communities across Australia. The Sub-Precinct will evolve as a local place contributing to a global context.

1.5 Project Description

An Urban Design and Public Domain Study has been prepared to establish the urban design framework for the Redfern North Eveleigh Paint Shop Sub-Precinct. The Urban Design and Public Domain Study provides a comprehensive urban design vision and strategy to guide future development of the Sub-Precinct and has informed the proposed planning framework of the SSP Study.

The Urban Design Framework for the Paint Shop Sub-Precinct comprises:

- Approximately 1.4 hectares of publicly accessible open space, comprising:
  - A public square – a 7,910 square metre public square fronting Wilson Street;
  - An eastern park – a 3,871 square metre park located adjacent to the Chief Mechanical Engineer's Building and the new eastern entry from Platform 1 of the Redfern station; and
  - Traverser No1 - a 2,525 square metre public square edged by Carriageworks and the Paint Shop.

- Retention of over 90% of existing high value trees.
- An overall greening coverage of 40% of the Sub-Precinct.
- A maximum of 142,650 square metre gross floor area (GFA), comprising:
    - between 103,700 - 109,550 square metres of gross floor area (GFA) for employment and community facility floor space (minimum 2,500 square metres). This will support approximately 6,200 direct jobs on the site across numerous industries including the innovation, commercial and creative sectors.
    - between 33,100 - 38,950 square metres of GFA for residential accommodation, providing for between 381 and 449 new homes (including 15% for the purposes of affordable housing).
- New active transport infrastructure and routes to better connect the Paint Shop Sub-Precinct with other parts of Tech Central and the surrounding localities.
- Direct pedestrian connections to the new Southern Concourse at Redfern station.
- Residential parking rates, comprising:
    - Studio at 0.1 per dwelling
    - 1 Bed at 0.3 per dwelling
    - 2 Bed at 0.7 per dwelling
    - 3 Bed at 1.0 per dwelling
- Non-residential car parking spaces (including disabled and car share) are to be provided at a rate of 1 space per 700 square metres of GFA.
- 66 car spaces are designated for Sydney Trains maintenance and operational use.

The key features of the Urban Design Framework, include:

- The creation of a new public square with direct pedestrian access from Wilson Street to provide a new social and urban hub to promote outdoor gatherings that will accommodate break out spaces and a pavilion structure.
- An eastern park with direct access from Redfern station and Little Eveleigh Street, which will provide a high amenity public space with good sunlight access, comfortable wind conditions and community character.
- Upgraded spatial quality of the Traverser No1 yard, retaining the heritage setting, and incorporating complementary uses and good access along Wilson Street to serve as a cultural linkage between Carriageworks and the Paint Shop Building.
- The establishment of an east-west pedestrian thoroughfare with new public domain and pedestrian links.
- A range of Water Sensitive Urban Design (WSUD) features.
- Activated ground level frontages with commercial, retail, food and beverage and community and cultural uses.
- Adaptive reuse of heritage buildings for employment, cultural and community uses.
- New buildings for the Sub-Precinct, including:
    - Commercial buildings along the rail corridor that range between 3 and 26 occupied storeys;
    - Mixed use buildings along the rail corridor, comprising a three-storey non-residential podium with residential towers ranging between 18 to 28 occupied storeys;
    - Mixed use buildings (commercial and residential uses) along Wilson Street with a four-storey street wall fronting Wilson Street and upper levels at a maximum of 9 occupied storeys that are set back from the street wall alignment;

- A commercial building on the corner of Wilson Street and Traverser No.1 with a four-storey street wall fronting Wilson Street and upper levels at a maximum of 8 occupied storeys that are set back from the street wall alignment. There is flexibility to allow this building to transition to a mixed-use building with active uses at ground level and residential uses above; and
- Potential options for an addition to the Paint Shop Building comprising of commercial uses. These options (all providing for the same GFA) include:
    - A 5-storey commercial addition to the Paint Shop Building with a 3m vertical clearance, with the adjacent development site to the east comprising a standalone 3-storey commercial building (represented in Figure 3);
    - A 3-storey commercial addition to the Paint Shop Building with a 3m vertical clearance which extends and connects to the commercial building on the adjacent development site to the east; and
    - No addition to the Paint Shop Building, with the adjacent development site to the east comprising a standalone 12-storey commercial building.

- Commitment to a 5 Star Green Star Communities rating, with minimum 5 Star Green Star Buildings rating.
- All proposed buildings are below the Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS) to ensure Sydney Airport operations remain unaffected.

The proposed land allocation for the Paint Shop Sub-Precinct is described in Table 2 below.

Table 2: Breakdown of Land Allocation within the Paint Shop Sub-Precinct

Land allocation	Existing	Proposed
Developed area	15,723 sqm / 30% of total site area	20,824 sqm / 40% of total site area
Public open space	Area not publicly accessible	14,306 sqm / 28% of total site area
Other public domain areas (including streets, shared zones, pedestrian paths and vehicular zones)	Area not publicly accessible	15,149 sqm / 29% of total site area (Excludes privately accessible public links and private spaces ~ 3% of total site area)

The Indicative Concept Proposal for the Paint Shop sub-precinct is illustrated in **Figure 3**

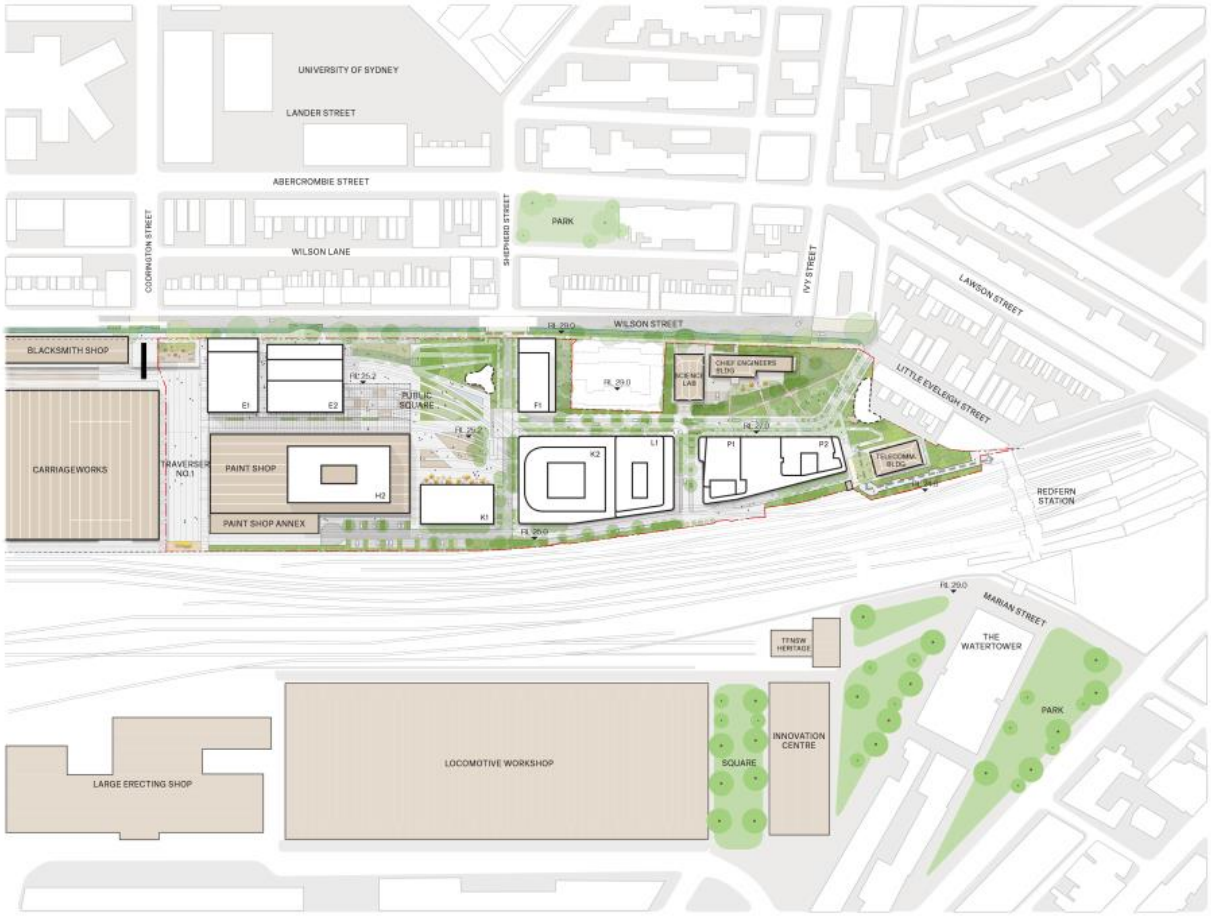

Figure 3 Indicative Concept Proposal (Source: Bates Smart and Turf)

2.0 Background

2.1 Existing site conditions

The Paint Shop sub-precinct is located in the Munni Creek sub-catchment in the upper reaches of the Alexandra Canal catchment. The flow direction within this subcatchment is generally towards the Cooks River and eventually into Botany Bay. The site is highly urbanised and almost entirely impervious, covering a mix of commercial and residential buildings.

The site covers a total area of 10.7 ha. It contains a mix of different buildings including:

- Blacksmiths' shop;
- Traverser no 1 and 2, adjoining Carriageworks building to the east and west respectively;
- RWA training centre in the former Carpenters, Plumbers and Food distribution building;
- General Store/ Clothing store;
- Chief Mechanical Engineer's Building;
- Science Lab;
- Paint shop; and
- Fan of tracks.

Wilson street to the north of the site is estimated to be 3-5 m above the level of the site, with a retaining wall along the Wilson Street boundary. The site is generally flat in topography with vehicular and pedestrian access from Wilson Street on the western end of the site. The topography of the area is shown in Figure 4 , together with the main drainage lines (Next Rail, August 2021). The RNE Paint Shop Sub-Precinct is located at the top of the figure.

2.2 Key constraints and opportunities

The flat topography of the site with approximately a 2% fall from east to west suggests that the drainage system allows for the effective conveyance of the stormwater flows discharging from the site, particularly during major storm events when ponding and culvert blockage are likely to occur.

The proximity of the development site to the railway corridor creates the potential for ponding of runoff against the railway corridor boundary wall. Presently, stormwater runoff from the site is conveyed across the railway corridor through a 600mm and a 1200mm diameter stormwater pipe, which then rejoins an existing 1250mm x 1125mm reinforced concrete box culvert (RCBC) along Alexander Street.

Based on discussions with Sydney Trains it is understood that the areas around the Illawarra Dive site experience overland flows generated by local catchment runoff within the rail corridor itself, in addition to areas immediately to the north of the railway (referred to as the North Eveleigh precinct, which includes the Carriageworks site). The Illawarra Dive is a railway underpass of the Illawarra Line under the Main Northern Line and Main Western Line. The Dive and tunnel form a drainage low point in which overland flows pond and result in flooding of the rail line.

An assessment of the existing flooding characteristics at the Illawarra Dive, as well as design options for mitigation of the flood impacts have recently been investigated by Next Rail (August 2021). The Redfern North Eveleigh Precinct Environmental Sustainability study has also recently been completed by Arup (April 2022).

The key site constraints and opportunities at the site, derived from the above studies, as well as previous flood studies, are summarised in Table 3.

Table 3 Summary of key constraints and opportunities

Aspect	Issue	Impact
Catchment Hydrology	The site sits at the top of the Alexandra Canal catchment and receives minimal external catchment flows. Noting this consideration of additional flows from bunding will need to be managed in the post-development scenario	Potential for implementation of on-site detention initiatives (e.g. through On Site Detention or rainwater tanks)
Site topography	Generally flat at around 25 mAHD with a 2% approximate slope from east to west which can be a limitation for any proposed drainage network Potential for culvert blockage and ponding within the site	Opportunity to maximise on-site detention and water sensitive Urban Design (WSUD) initiatives in open spaces Optimisation of space for services eg carparks for stormwater detention
Space	Additional building footprint from the Proposed development is likely to limit the space for stormwater detention/drainage	Opportunity for WSUD initiatives including roof detention tanks/green roofs/ passive irrigation
Proximity to rail corridor	Potential runoff against the railway boundary	Site configuration for the post-development conditions considers Illawarra network upgrades including 1m bunding south of the site to prevent overflows into the rail tracks
Existing trees	Existing trees across site require space and irrigation	Retaining existing trees works towards the Precinct's overarching green infrastructure strategy. Inclusion of rainwater tanks will supplement irrigation demands and contribute to reducing water demand
Flooding and on-site detention requirements	Flooding impacts on building or rail corridor due to low levels of site permeability.	Opportunities to utilise open spaces for on-site detention and WSUD initiatives in Precinct design Designing in consideration of future flood levels.

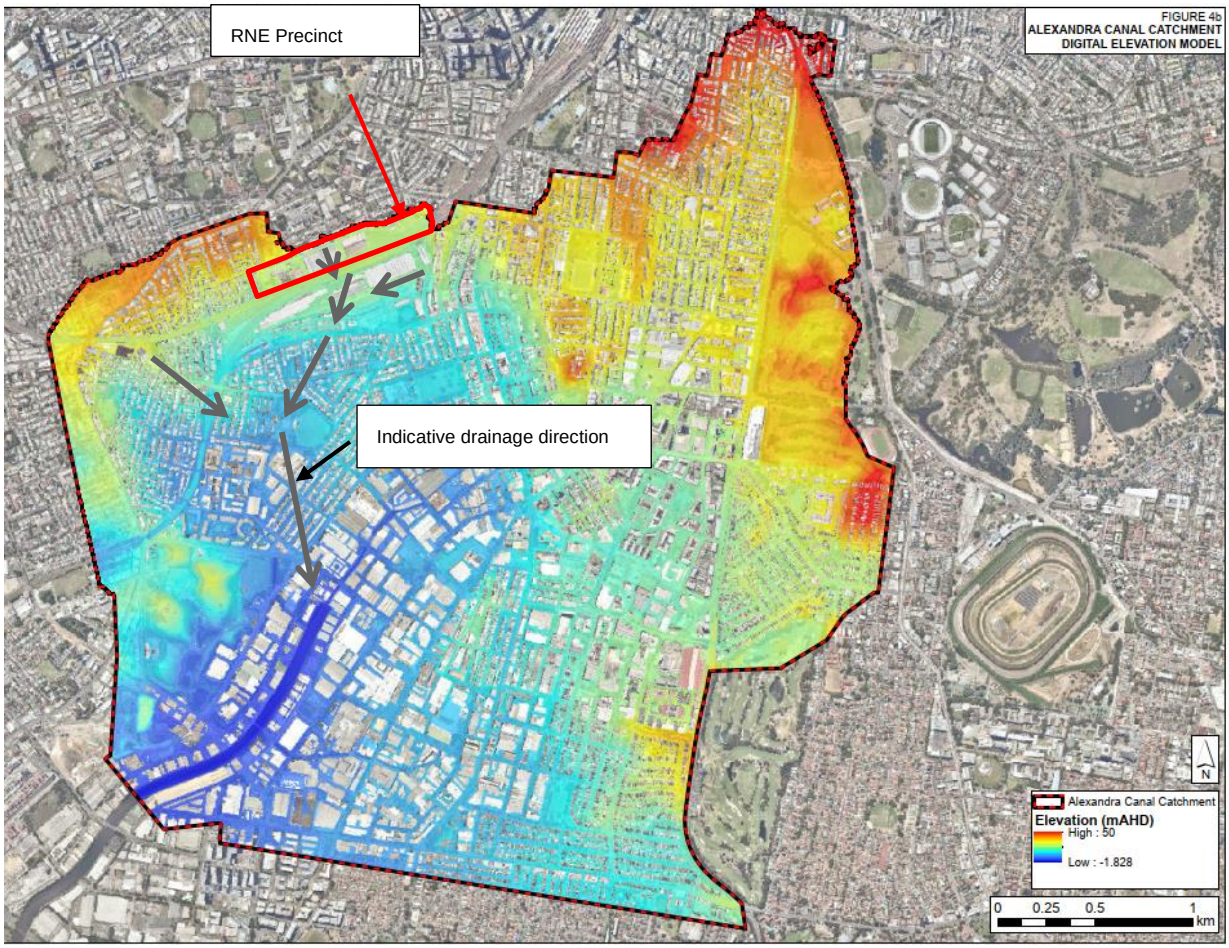

Figure 4 Digital elevation model from Alexandra Canal catchment (WMA Water, 2018)

3.0 Design Criteria

3.1 Planning Commitments from the North Eveleigh Concept Plan

In line with the Concept Plan proposed for the North Eveleigh redevelopment in 2008, the NSW Government Department of Planning Director General's requirements (DGR) covered key aspects of development applicable to the site. Item 13 of the relevant planning provisions highlighted issues related to drainage and flooding and was inclusive of the following:

- Address drainage/flooding issues associated with the development including stormwater, drainage infrastructure and incorporation of Water Sensitive Urban design measures;
- Address the issue of managing the downstream impacts of stormwater on Sydney Water's stormwater network, including a stormwater management system and the capture and reuse of rainwater;
- Exploring non-potable water supply sources including on-site recycling of grey water, rainwater and stormwater harvesting;
- Address the existing capacity and requirements of the development related to the provision of utilities including staging of infrastructure works; and
- Addressing stormwater and drainage impacts on rail corridor.

As part of the submission, the DGR also required the provision of a stormwater concept plan describing the concept for stormwater management on the development area as well as a landscape plan describing the treatment of open spaces on the site, screen planting along common boundaries and tree protection measures both on and off site where applicable.

The concept plan for the North Eveleigh redevelopment submitted in 2008 and approved by the Minister for Planning covered points related to water quality, stormwater and environmental sustainability.

For water quality and quantity management, the following was applicable:

- Provision of on-site detention of stormwater to mitigate drainage capacity constraints
- Collection of rainwater for reuse in irrigation
- Improvement of stormwater runoff quality by reducing the average annual load of:
    - Total Phosphorus by 45%
    - Total Nitrogen by 45%
    - Total suspended solids (TSS) by 80%
- For up to the 3-month ARI peak flow, visible oil and grease, litter of size greater than 50 mm and sediment particles greater than 0.125 mm are not to be discharged off-site.

Within the sustainability section in Schedule 3 of the Concept Approval Plan, the following were noted in relevance to on-site water management:

- Achievement of sustainability targets including BASIX water consumption benchmark in accordance with the regulation but also commitment towards achievement of higher targets
- Assessment of alternative water supplies including an external non-potable water supply. Sydney water requirements towards a proposed water supply network include an allowance for 24-hour unobstructed access for maintenance and repair, siting within uncontaminated or remediated soil and in a way that minimises damage risk from main brake.
- Adopting environmentally sustainable development principles towards:
    - Reuse and recycle of stormwater
    - Stormwater harvesting and reuse
    - Water efficiency measures including the use of low water fixtures and tapware

- Reuse of rainwater for spray irrigation with rain and moisture detector controls
- Recycling of grey wastewater

The above set of commitments towards environmental sustainability were also reproduced in the Draft statements of commitments section from the North Eveleigh Concept plan report.

The North Eveleigh Concept plan prepared for the Redfern-Waterloo Authority provides details to assist the Department of Planning and Environment (DPE) with an assessment of the concept plan as detailed in the Director- General's Environmental Assessment Requirements set out in a letter dated 17 March 2008.

The main findings of the report included:

- The targets that were specified in the base case for water quality adopted the widely accepted 'Best Management Practice' targets but more rigorous targets for stormwater quality improvements were recommended as a result of stormwater management updates from Sydney Metropolitan Catchment Management Authority.
- Modelling of the stormwater quality using MUSIC software in conjunction with the landscape concept plan showed that in order to meet the base case stormwater management quality improvement, bio-retention zones would need to be integrated into the drainage system in addition to a gross pollutant trap before the discharge point at the eastern traverser.
- A 200 m^3 rainwater tank collecting runoff from the Carriageworks roof would improve runoff quality in the central area and provide an opportunity for water reuse.
- In order to meet sustainability case targets, the area dedicated for bioretention systems would need to be doubled.
- The restorative approach towards runoff that was outlined included a 2-5% of the site area connected to the drainage network and the inclusion of swales and pervious surfaces to drain the majority of the runoff from the site.

A summary of the proposed stormwater quantity and quality objectives and outcomes as part of the North Eveleigh concept plan is found below.

Table 4 Drainage and Flooding Management (North Eveleigh Concept Plan 2008)

Stormwater quality improvement	▪ Improve storm water runoff quality by reducing the average annual load of: Total Phosphorous by 45%; Total Nitrogen by 45%; Total Suspended Solids (TSS) by 80%; ▪ For up to the 3 month ARI peak flow retain: Visible oil or grease; Litter >50mm, and Sediment >0.125mm	▪ Improve storm water runoff quality by reducing the average annual load of: Total Phosphorous by 65%; Total Nitrogen by 45%; Total Suspended Solids (TSS) by 85%; ▪ Gross pollutants (>5mm) by 90% ▪ [In accordance with recommendations from SMCMA (2007).]	▪ Focus on reducing stormwater impacts on downstream ecosystems. ▪ Reduce the directly connected impervious area of a site to 2-5% of the catchment area. ▪ Use green roofs to provide thermal benefits as well as maximise evapotranspiration and provide habitat / increase biodiversity.
Stormwater quantity management	▪ Provide on-site detention of stormwater to mitigate drainage capacity constraints ▪ Collect rainwater for reuse in irrigation	▪ Provide on-site detention to meet with capacity constraints and use WSUD to slow stormwater ▪ Use distributed tank storages located around the site and bioretention zones to encourage slow subsurface flow and infiltration ▪ Use rainwater and stormwater for non-potable uses	▪ Maximise on-site rainwater reuse, retention, detention, infiltration and evapotranspiration ▪ Reduce directly connected impervious area to 2-5% of catchment. ▪ Maximise green areas, incorporate roof gardens, streets trees and bioretention trenches ▪ Reinstate pre-development creek beds as swales

3.1.1 North Eveleigh 2008 Concept Plan Hydraulic Services Concept Design

The hydraulic services concept design report by Warren Smith & Partners dated April 2008 outlines stormwater management steps to comply to the objectives and requirements from City of Sydney Council and included the following:

- On-site detention above and below ground systems are to be retrofitted with trash screens and sedimentation traps to control coarse litter and sediment in each of the individual allotments presented in the concept plan
- A series of drainage structures are to be located along kerb lines and are to service road flows with the potential for implementation of Enviropods as outsource control screening to control coarse debris and sediment
- Residual flow is to be treated within a series of bioretention swales (bioswales) and shallow water bodies which will aim to trap and treat coarse and fine sediment and phosphorus
- For any proposed water supply network, dead-end mains are to be eliminated in order to prevent water quality deterioration.

Appendix C of North Eveleigh Landscape Plan also outlines the location of the respective bioswales that are to integrate the environmental infrastructure within the post-development configuration (**Figure 5**).

Figure 5 Location of Bioswales (North Eveleigh Landscape Plan)

3.2 City of Sydney Requirements

In addition to the Director General Requirements which guided the North Eveleigh Concept Plan in 2008, the City of Sydney rolled out a set of Development Control Plans (DCPs) in 2012 against which proposed developments are to comply for key issues inclusive of flooding, drainage and stormwater management.

Best practice levels in the precinct that were described included:

- Post-development stormwater peak discharge event that does not exceed pre-development levels;
- BASIX water target of 40% potable water reduction as a minimum; and
- Pollutant load reductions for Total Suspended Solids, Total Nitrogen, Total Phosphorus and Gross Pollutants (see **Section 3.6).**

On the 14 December 2020, the City of Sydney (CoS) approved an amendment to the Sydney Development Plan (DCP) 2012 as it applies to Central Sydney. However, in terms of flooding and stormwater management there are no changes, and DCP applies. DCP 2012 includes:

- Definition of the interactions of existing local planning controls in Sydney Local Environmental Plan 2012 and the Sydney Development Control Plan 2012; and
- Development of a flood risk assessment for the site, with reference to the City of Sydney's Interim Floodplain Management Policy and all relevant flood studies.

Table 5 compares the controls set out in the 2008 North Eveleigh Concept design and the overarching legislative requirements towards stormwater management and flooding as stated in the City of Sydney DCP 2012.

Table 5 Summary of North Eveleigh Concept design controls

2008 approved controls for the North Eveleigh Concept design	City of Sydney DCP 2012 requirements (Section 3.7 -General Provisions: Water and Flood Management)
Provision of on-site detention of stormwater to mitigate drainage capacity constraints	Stormwater detention devices are to be designed to ensure that the overflow and flowpath have sufficient capacity during all design rainfall events, discharge to public stormwater and have no impact to public stormwater system
Collection of rainwater for reuse in irrigation	Post-development runoff from impermeable surfaces is to be managed by stormwater source measures that: *Remove some pollutants prior to discharge into receiving waters and enable appropriate use of rainwater and stormwater*
Improvement of stormwater runoff quality by reducing the average annual pollutant load	Where filtration and bio-retention devices are proposed, they are to be designed to capture and provide temporary storage for stormwater
Assessment of alternative water supplies including BASIX water consumption benchmark and external non-potable water supply	Development proposals seeking to re-use water runoff from paved surfaces for irrigation and wash down purposes are to incorporate appropriate measures
Provision of a flood risk assessment and assess flood mitigation and drainage conveyance options	Site-specific flood study to show pre and post development scenarios and assuming worst case scenario conditions for blockages to pipes, culverts, infrastructure

3.3 Design Standards

Design standards for this study include hydrological methods for the flood risk and stormwater management assessment. For any flood mitigation infrastructure proposed as part of this study, the design standards would need to be consistent with the Australian Standards for Plumbing and Drainage and City of Sydney standards. A summary of the design codes and industry standards adopted for stormwater infrastructure design for the development is presented in **Table 6.**

Table 6 Design Standards and Reference Documents

Reference	Title	Type
CoS A4	City of Sydney Design Specification A4 Drainage Design	Design Standard
ARR	Australian Rainfall and Runoff “A guide to flood estimation” 2019	Guidance document
AS 3500.3	Australian Standard AS3500.3: Plumbing & Drainage Code – Stormwater Drainage (2003)	Design Standard
AS 3725	Australian Standards AS3725: Design for Installing of buried concrete pipes	Design Standard
SSTS	Sydney Streets Technical Specifications	Guidance document
DCP	Sydney DCP 2012	Design Standard
CoS PS	City of Sydney Central Sydney Planning Strategy	Guidance document
NSW FDM	NSW State Government’s Flood Prone Lands Policy and Floodplain Development Manual (2005)	Guidance document
CoS IFMP	City of Sydney Interim Floodplain Management Policy	Design Standard

3.4 Adopted Design Criteria

Unless otherwise specified by DPE, the City of Sydney's DCP controls are adopted as the design criteria with respect to water quality targets and thresholds for flooding and stormwater impacts.

In terms of hierachy and importance for this project, the reference documents were as follows:

- City of Sydney Interim Floodplain Management Policy
- Sydney DCP 2012
- City of Sydney Central Sydney Planning Strategy
- NSW State Government's Flood Prone Lands Policy Guide and Floodplain Development Manual
- Development Manual (2005)
- Other reference documents and guidelines outlined in Table 6.

City of Sydney Development Control Plan 2012

The City of Sydney Development Control Plan (DCP) provides detailed planning and design guidelines to support the planning controls throughout the local government area. The DCP requirements are outlined in Section 3.7 of the City of Sydney Development Control Plan 2012 (City of Sydney 2012).

Specific key requirements relating to flooding and stormwater include:

- A site-specific flood study assessment needs to be prepared to support the development of the site;
- Major drainage systems are to be designed to ensure that public safety is not compromised;
- The connection to the existing stormwater network is not to reduce the capacity of that infrastructure by more than 10%; and
- Post-development runoff is to be managed in accordance with the principles of Water Sensitive Urban Design (WSUD), including assessment of opportunities for rainwater and stormwater capture, and prevention of nuisance flows from adjacent properties.

In addition to the above, the design flow criteria set by TfNSW, for flows discharging frorm the Paint Shop precinct sub catchment into the Illawarra Dive structure is set at between 250 to 300 L/s. This was to assist in mitigating the flooding issues at the Dive and take into account the capacity of the downstream drainage system.

Stormwater drainage design criteria derived from the City of Sydney *Design specification D5 Stormwater Drainage design* were adopted for design purposes for the proposed development. Additional details are provided in **Table 7.**

Table 7 Design Criteria Adopted

Item	Standard	Adopted
Hydrology and Hydraulics	ARR 2019	DRAINS and TUFLOW software
Minor design storm	COS D5	20% AEP
Major design storm	COS D5	1% AEP
Freeboard	COS D5	Min 150mm in pits Min 500mm to habitable floor levels Min 300mm for carpark entrances
Pipe size	COS D5	Min 150 mm diameter;
Pit spacing	COS D5	Max 100 mm
Maximum allowable ponding	COS D5	Max depth 0.2 m
Blockage	DCP 2012	Sag pit -100%

Item	Standard	Adopted
		Kerb inlets – 50% Culverts and bridges – 50%
Climate change	Practical Consideration of Climate Change (DECC 2005)	10%, 20% or 30% rise in rainfall intensities. 0.18m rise in sea level by 2090 and 0.91m rise in sea level by 2100*

**It is noted that TFNSW standards do not allow for 150 mm diameter pipes*

*** Current NSW policy (NSW FDM) is a rise of 0.4m by 2050 and 0.9m by 2100 relative to 1990 mean sea level.*

City of Sydney Interim Floodplain Management Policy

The Floor planning level (FPL) defines the permissible minimum building floor level to which a new development is to be built. The interim floodplain management Policy has been developed by the City of Sydney (2014) to document the requirements for the management of flood risk for all new developments within the City's LGA. City of Sydney has a responsibility to manage floodplains to ensure that:

- New development will not experience undue flood risk; and
- Existing development will not be adversely affected through increased flood damage or hazard as a result of any new development.

The 2014 Interim Floodplain Management Policy specifies minimum building floor levels and below ground flood planning levels (FPL) for residential and industrial sites. Residential development requires a 1% AEP + 0.5 m flood planning level. For industrial and commercial areas, a flood planning level corresponding to the 1% AEP event applies.

3.5 Stormwater Quantity Control Requirements

Section 3.7 of the General Provisions for the Sydney Development Control Plan 2012 ascertains that development above flood planning level as defined in the Sydney LEP 2012 is to have minimal impact of stormwater and flooding on other developments and the public domain both during the event and after the event and that the flood risk management accounts for public safety and protection from flooding.

For sites covering an area greater than 1000 m^2, the minor drainage system is to accommodate flows up to the 20% AEP flood event and excess flows are to be conveyed by the major drainage system. Post development runoff volumes during an average rainfall year are to be 70% of the volume if no measures are undertaken to reduce stormwater volume.

Post development stormwater peak discharge is not to exceed the pre-development level. It is noted that this requirement is less conservative than TFNSW requirement of a permissible site discharge of 250 to 300 L/s from the Paint Shop Precinct.

The 'worst case scenario' conditions for blockages to pipes, culverts and other infrastructure are to incorporate assessment of the following:

- 50% blockage of kerb inlets;
- 100% blockage of sag pits; and
- 50% blockage of culverts and bridges with an open area less than 6 m measured along the diagonal.

Planning control requirements also stipulate that car parking areas and access aisles are to be designed, surfaced and graded to minimise runoff whilst allowing for containment of stormwater within the site and provision of natural infiltration of stormwater runoff through landscaping.

3.6 Stormwater Quality Control Requirements

Water quality objectives are defined in terms of pollutant reduction targets. According to the general provisions of the Sydney Development Control Plan 2012, the development site is to achieve the following post-development pollutant load reduction targets:

- 90% reduction of baseline annual pollutant load for litter and vegetation, larger than 5 mm;
- 85% reduction of baseline annual pollutant load for total suspended solids;
- 65% reduction of baseline annual pollutant load for total phosphorus; and
- 45% reduction of baseline annual pollutant load for total nitrogen.
- No discharge of visible oil, GP over 50 mm and TSS over 0.125 mm

The 2008 North Eveleigh Concept Plan highlighted the need for bio-retention zones to be integrated as part of the drainage system and the inclusion of swales and pervious surfaces to drain the majority of runoff from the site. These stormwater management controls are to be tested through appropriate modelling to confirm the effectiveness of the proposed measures.

4.0 Previous Stormwater Investigations

4.1 North Eveleigh Affordable House Project – Stormwater Management Plan

The North Eveleigh Housing Project (NEHP, 14 March 2013) involved the delivery of infrastructure and landscaping to support the development of four residential buildings. The residential buildings facilitated by the NEHP infrastructure were referred as A2, A3, C4 and D4 in the North Eveleigh Concept Plan, as presented in **Figure 6**. Building D4 was designed to accommodate affordable housing, to be developed and managed by City West Housing Pty Ltd.

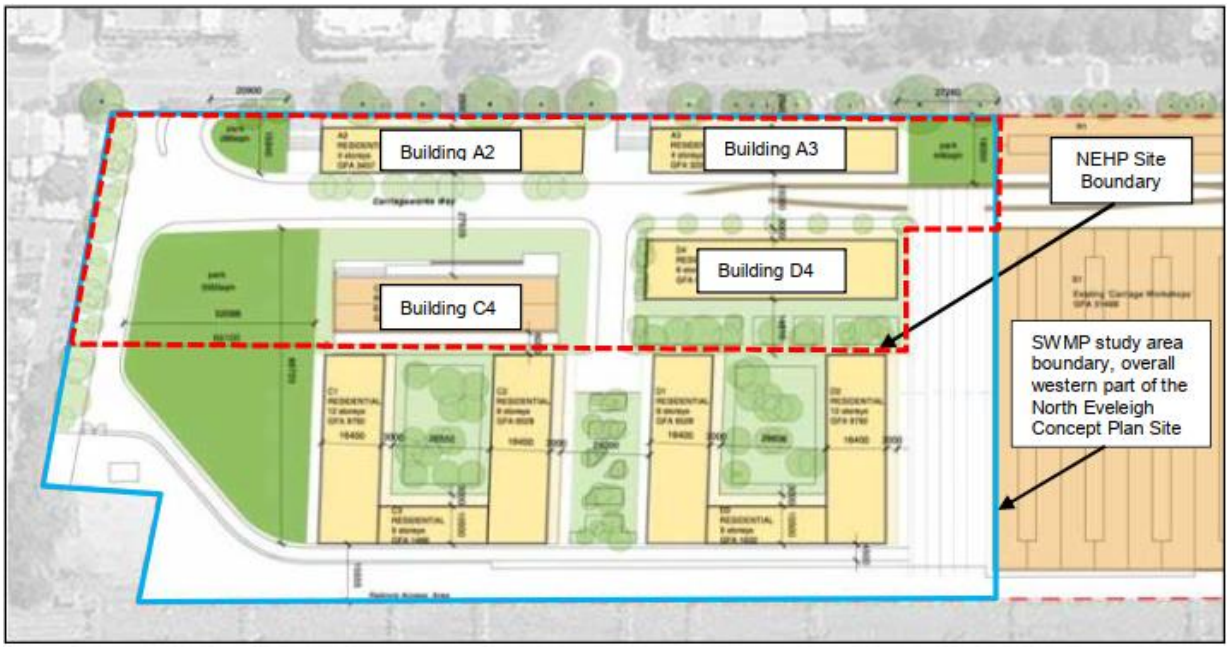

Figure 6 North Eveleigh Affordable House Project Concept Plan (2013)

The proposed stormwater drainage system for the NEHP development was designed to comply with the design requirements, with the main design considerations being:

- Provision of a pipe drainage network with capacity to convey the 5% AEP storm;
- Provision of overland flow routes to safely convey runoff from the 1% AEP storm through the site;
- Provide drainage connections points for buildings;
- Management of water quality through the incorporation of WSUD techniques; and
- Management of water quantity to ensure no increase in stormwater discharge from the site.

A DRAINS model was used to assess the hydrological and hydraulic conditions under existing and post-development conditions. In accordance with the Statement of Commitments, in addition to providing the Sydney Water stormwater detention requirements for each building, the NEHP development ensured that the stormwater discharge from the site would not exceed existing levels for any development phase within the project scope.

The findings from this assessment include:

- Director General requirements were met for stormwater quantity and quality targets for each development phase;
- Overland flows discharged towards the rail corridor would not increase for each development phase;

- The overall discharge from the site under post-development conditions would not exceed existing levels;
- Rainwater collection for irrigation and toilet flushing would be investigated for each building;
- A proposed stormwater management strategy which redirects overland flow away from existing areas of ponding for each development phase. This includes the incorporation of additional peak flow mitigation measures to ensure that the peak flow discharged from the site does not increase at any of the development stages.

4.2 Stormwater Management Options Review – North Eveleigh

The Stormwater Management Options Review – North Eveleigh (AECOM, August 2014) was developed by AECOM to investigate different on-site detention (OSD) configurations for the North Eveleigh West development. Specifically, the development of buildings towards the south-west of the site was assessed for compliance to On Site Detention (OSD) and Permissible Site Discharge (PSD) requirements.

An updated DRAINS model was created, and the report concluded that a storage basin near Iverys Lane toward the western boundary of the site would provide acceptable drainage outcomes for the North Eveleigh West site, with the following results:

- A reduction in peak flows discharged from the site;
- A minor reduction in flood levels; and
- A reduced flood hazard in Leamington Lane.

The report advised that the preliminary hydraulic assessment would need to be further developed as part of future design, including the assessment of the Iverys Lane's drainage system.

4.3 North Eveleigh Concept Plan – Hydraulic Services Concept Design Report

As part of the submission for the North Eveleigh Concept Plan, Warren Smith and Partners (WSP) prepared the Hydraulic Services Concept Design Report (WSP, April 2008) which presented a concept layout of the proposed drainage infrastructure.

The Hydraulic Services Concept Design Report reviewed the available RailCorp drainage records to determine the existing drainage configuration. This review identified the western end of the North Eveleigh site as primarily draining to Traverser 2 and then across the Western Rail Corridor through the existing 600 mm and 1,200 mm culverts. The report does not include any plans identifying the existing sub-catchment layout.

A more detailed assessment of the existing internal hydrology for the NEHP is presented in Section 5. The WSP report includes a high-level assessment of the external catchment to the North Eveleigh site, making the following conclusion:

> *The existing North Eveleigh site for the purposes of runoff analysis is considered to be a wholly self-contained catchment zone. The Wilson Street catchment immediately to the north is self-draining into the SWC trunk drainage system and is completely separated from the North Eveleigh site. For the purposes of flood assessment, the discussion below emphasises that the North Eveleigh site is completely self-contained and drains in the direction of existing drainage infrastructure below the rail corridor.*

The stormwater concept design states that it seeks to achieve the following:

- A network of drainage pipelines and pits to comply with the requirements of CoS and relevant Australian Standards and Policies;
- A roof water system for each building complying with the relevant Australian Standards, the BCA and other relevant guideline documents;

- A below ground basement pump out system complying with the relevant Australian Standards, the BCA and other relevant guideline documents;
- An OSD system comprising below ground storage tanks of a minimum height of two metres and varying cross sectional area to comply with the relevant PSD for that precinct;
- A PSD exiting the North Eveleigh site not exceeding the capacity of the 600mm, 1200mm and 1250mm wide x 1125mm high Munni Creek culvert.

The Stormwater Management Catchment Plan drawing included in the WSP report presented a proposed drainage system for the area of the North Eveleigh Housing Project which drained towards Traverser 2 and the existing 600 mm and 1,200 mm culverts crossing the rail corridor. This proposal is reviewed in **Section 6.0**, based on detailed review of the existing site topography and drainage configuration.

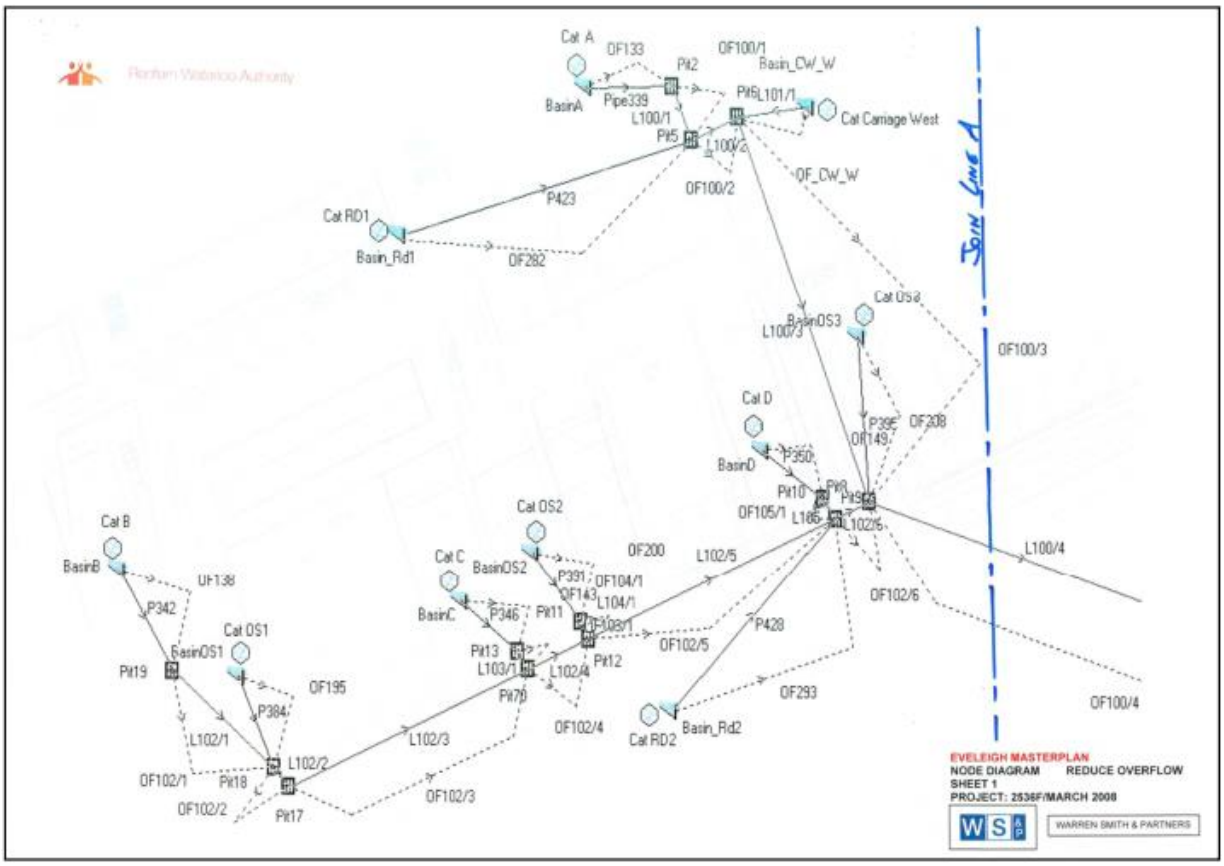

Figure 7 DRAINS Model Configuration (WSP 2008)

The report included the DRAINS model layout used to estimate the on-site storage requirements, with the model layout for the western end of the site presented in Figure 10 of the WSP report. The NEHP site appears to be located in catchments A, B and RD1, which have a combined estimated detention storage requirement of 1,143 m3. The report presented the following provisions for water quality management following consultation with City of Sydney and other agencies:

- OSD above ground or below ground systems complete with trash screens and sedimentation traps to control coarse litter and coarse sediment within each of the individual allotments;
- Road flows discharging into a series of drainage structures located along kerb lines, incorporating Enviropods (flow baskets) to manage coarse debris and coarse sediment;
- Treatment of residual flows within a series of bio-retention swales and shallow water bodies to treat and facilitate the removal of sediments and nutrients.

4.4 Alexandra Canal Catchment Flood Study

It is noted that while the Precinct abuts the Blackwattle Bay catchment to its north, the overall grading of the site is to the south and therefore falls wholly within the Alexandra Canal catchment.

The Alexandra Canal Catchment Flood Study was undertaken by WMA Water for the City of Sydney in 2018 to assess the flood behaviour across the Alexandra catchment under existing and ultimate development conditions (as of 2017) for the catchment. The base case (2013 conditions) did not account for development in Ashmore, Lachlan and Green Square Precinct while the Ultimate Development 2017 scenario reflected catchment conditions with approved and constructed developments within Precincts and other major trunk drain upgrades.

This study concluded that the works included in the Ultimate Development 2017 Scenario generally resulted in peak flood level reductions across the catchment (in comparison with 2013 conditions), without producing areas of significant increases in peak flood levels for both the 1 in 20-year (5% AEP) and 1 in 100-year storm events (1% AEP). The results are generally consistent with the individual assessments for each Precinct (Figure 8 and Table 8) which confirmed that the flood modelling undertaken for the design of these upgrades was valid and provides confidence in the modelling outcomes for the City of Sydney's ongoing planning and decision making. Since then however, investigations towards additional network upgrades including the Illawarra Dives have been undertaken which are of relevance for the study site. These considerations are detailed in the next section.

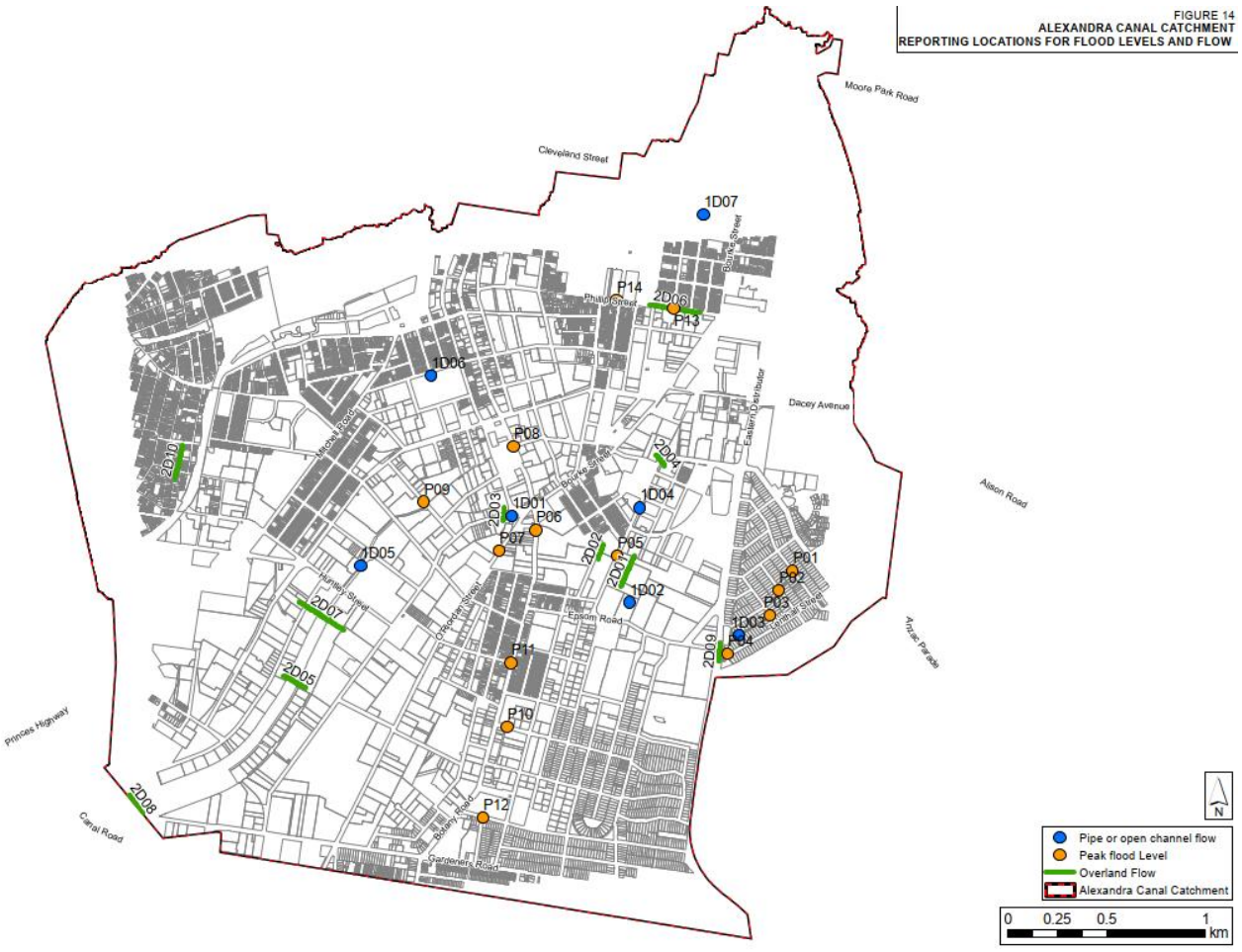

Figure 8 Reporting locations for Alexandra Canal Catchment Study (WMA Water)

Table 8 Summary of comparison with previous studies (WMA Water)

Location	20 year ARI					100 year ARI				
	Current	2016 Alexandra Canal Model Conversion (Ref 9)	Green Square Trunk Drain – Hydraulic & Flood Modelling (Ref 6)	Alexandra Canal Flood Study 2014 (Ref 7)	West Kensington Flood Study (Ref 5)	Current	2016 Alexandra Canal Model Conversion (Ref 9)	Green Square Trunk Drain – Hydraulic & Flood Modelling (Ref 6)	Alexandra Canal Flood Study 2014 (Ref 7)	West Kensington Flood Study (Ref 5)
P01	24.9	24.9	24.8	-	25.0	25.0	24.9	24.9	-	25.1
P02	24.0	23.8	23.8	-	24.3	24.1	23.9	23.9	-	24.6
P03	24.1	24.1	24.1	-	24.1	24.1	24.2	24.1	-	24.1
P04	21.6	21.6	21.6	-	22.1	21.7	21.7	21.6	-	22.1
P05	18.8	18.7	18.7	18.6	-	18.9	18.9	18.8	18.7	-
P06	13.9	14.0	14.0	13.9	-	14.2	14.1	14.2	13.9	-
P07	11.8	11.7	11.8	11.7	-	11.9	11.9	11.9	11.8	-
P08	12.8	12.8	13.0	12.6	-	12.9	12.9	13.1	12.7	-
P09	6.9	7.0	7.0	6.7	-	7.1	7.2	7.2	7.2	-
P10	12.9	12.9	-	12.8	-	13.1	13.1	-	12.9	-
P11	13.7	13.8	-	13.5	-	13.9	14.0	-	13.7	-
P12	11.9	11.9	-	11.9	-	12.1	12.0	-	12.0	-
P13	29.3	29.3	-	29.0	-	29.5	29.5	-	29.3	-
P14	30.6	30.6	-	30.6	-	30.8	30.9	-	30.8	-

4.5 Illawarra Dive Study

The Illawarra Dive Study undertaken by Next Rail in August 2021 assessed the existing flooding characteristics of the Illawarra dives under Phase 1 of the STAR project (Next Rail project reference) to enable the new ten (10) car trains operating on the T4 south coastline to reliably terminate at Sydney Terminal. The study included site and culvert inspections to investigate the existing drainage network and drainage paths. The study highlighted main sources of flooding for the dives and the current drainage performance. This included the following:

- Overland flows from local catchment runoff occurs within the rail corridor from the North Eveleigh catchment, with a large portion of the surface inflow into the dives coming from a north-eastern external catchment adjacent to the North Eveleigh Precinct;
- Stormwater pumps have been installed in the nearby service tunnel subway. The stormwater pump and sump are located at the service tunnel entrance just south of the Down Illawarra Dive track;
- Shorter duration storms are likely to result in a larger peak for the local dive catchments and review of the flood model showed that the existing drainage capacity is inadequate for managing catchment runoff in events as frequent as the 1 EY event (ARR, 2019).

The proposed mitigation options are expected to be implemented in the near future (within the next 5 years) and within the existing site development conditions. Hence, the upgraded drainage conditions and functionality of the constructed flood mitigation options need to be accounted for as the development of the Paint Shop sub-precinct development progresses.

5.0 Pre-development Stormwater Management

5.1 External Catchment Extent

Existing site conditions have been previously outlined in Section 2.0. In addition to this, an assessment of the Illawarra Dive was undertaken by Next Rail in August 2021 to investigate the existing flooding conditions and available drainage design options for improved operational performance of the dives. It is noted that the Illawarra Dive study refers to an external catchment draining towards the culverts. This catchment is about 1.4 ha and is located within the Paint Shop sub-precinct immediately to the east of the Paint Shop and drains into the Illawarra dives at the southern end.

5.2 Internal Sub-Catchments

The RNE sub-precincts outlined in the Redfern North Eveleigh Strategic Framework document have a total area of 10.7 ha and consist of the Clothing Store sub-precinct, Carriageworks sub-precinct and Paint Shop sub-precinct as described in **Figure 9**.

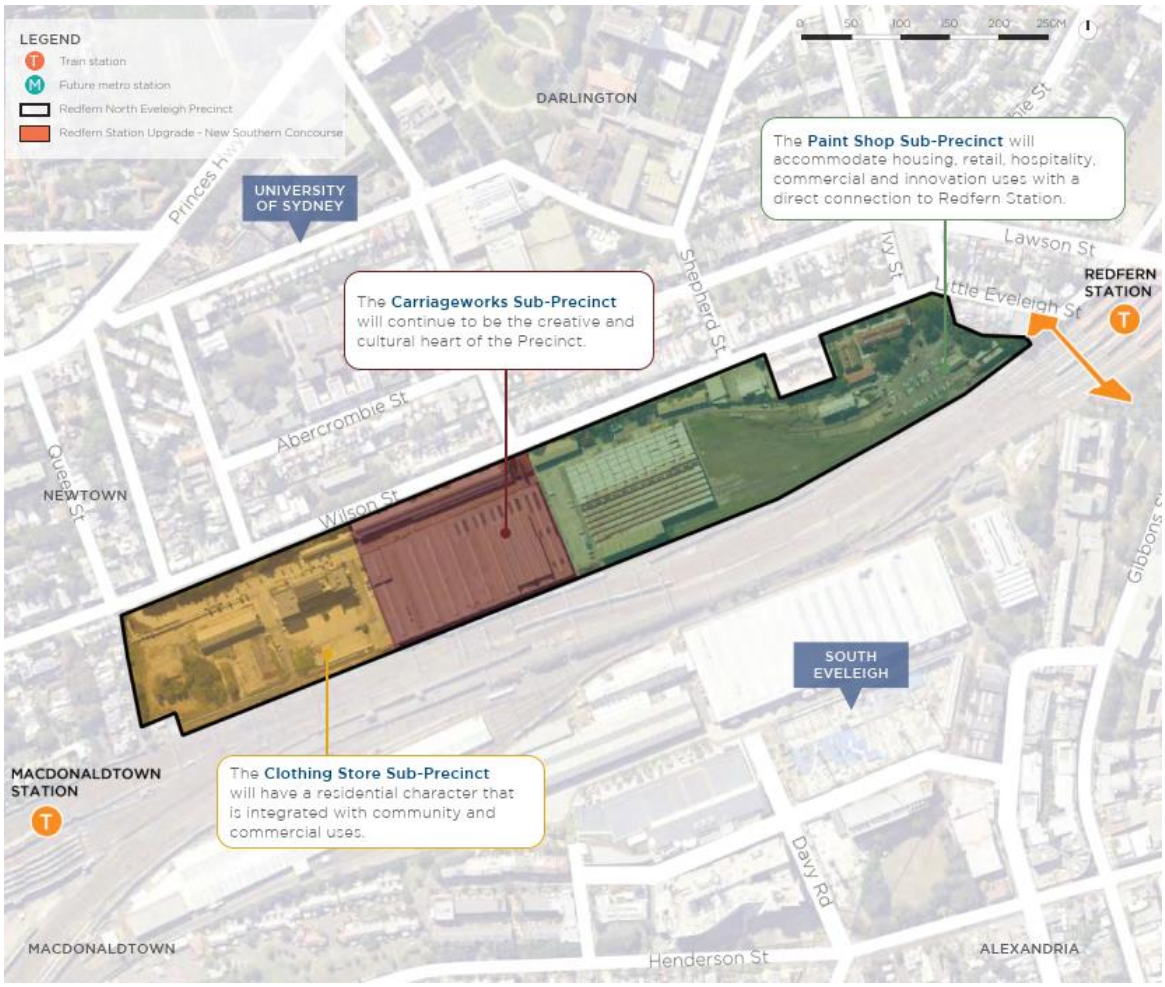

Figure 9 RNE Sub-Precincts (Redfern North Eveleigh Strategic Framework)

There are 4 distinct sub-catchments draining to the 2 outlets in the southern area adjacent to the rail corridor. The internal sub-catchments have also been described in the Illawarra Dive study (see **Figure 10**).

5.3 Pre-development Stormwater Management Approach

The existing RNE site presently manages stormwater and flooding through a network of pits and pipes. As per the 2008 Hydraulic services concept design report for North Eveleigh, the current drainage system consists of:

- Existing 525 mm diameter pipe west to east along Wilson Street;
- Existing 300 mm diameter pipe outside and north of the Paint Shop;
- Existing 300 mm diameter pipe between Carriage workshop and Blacksmith's workshop;
- Existing 900 mm diameter pipe along Traverser no.1 between Paint Shop and the Carriage workshop;
- Existing 450 mm diameter pipe immediately south of the Carriage workshop and draining towards Traverser No 1;
- Existing 450 mm diameter pipe immediately south of the Fan of tracks, drainage west past the southern side of the Paint Shop;
- A 1200 mm diameter drainage line draining diagonally across the rail corridor from Traverser No 1.
- A series of smaller diameter drainage lines in Traverser No. 2 draining into a 600mm diameter drainage line across the rail corridor;
- A 300 mm diameter drainage line draining east to west along the Northern face of the Locomotive workshop
- The 1200 mm and 600 mm diameter drainage line serving Traversers No. 1 and 2 into a single 1.25m wide x 1.125 m high rectangular box culvert running along Henderson Road and south bound along Alexander Street; and
- A new 375 mm diameter drainage between the Carriage workshop and the Blacksmith's workshop with connection onto the existing 900 mm brick stormwater drain in Traverser No.1.

The NextRail Study describes the existing drainage at Illawarra Dive as including the two main transverse culvert lines, namely Traverser 1 (TC1) and Traverser 2 (TC2), which drain the railway and North Eveleigh precinct. Drainage in the Dive/tunnels is complex and connected to TC1 via several drainage openings 0.3m higher in elevation than the track sag point of the rail tunnel/Dives, which is located about 45m to the west. The Dive low points are connected to TC2 via a cross drain and small 225mm pipe connection. The track sag point is 0.1m lower in elevation than the connection point to the TC2 sub-branch (**Figure 11**)**.**

As part of the NextRail study Sydney Trains indicated that stormwater pumps have been installed in the service tunnel subway. The service tunnel crosses underneath the main line and Dive tracks near the western end Dive tunnel portals. The authors of the report had been provided a diagram of the pumping system by Sydney Trains which showed the stormwater sump and pump located at the service tunnel entrance just south of the Down Illawarra Dive track (AECOM has referenced this report but has not seen the sketch). The report notes the diagram also shows that the pumping system connects to the nearby track drainage via a small (assumed DN100) PVC pipe.

It is noted that upstream on-site stormwater detention is likely to have a bearing on the performance of the existing pumping system. Any potential impacts will be discussed as part of the recommendations following the stormwater and flooding assessment for the proposed site detailed in Section 7.3 of this report. Investigations to upgrade of the existing pumping infrastructure are outside the scope of this study.

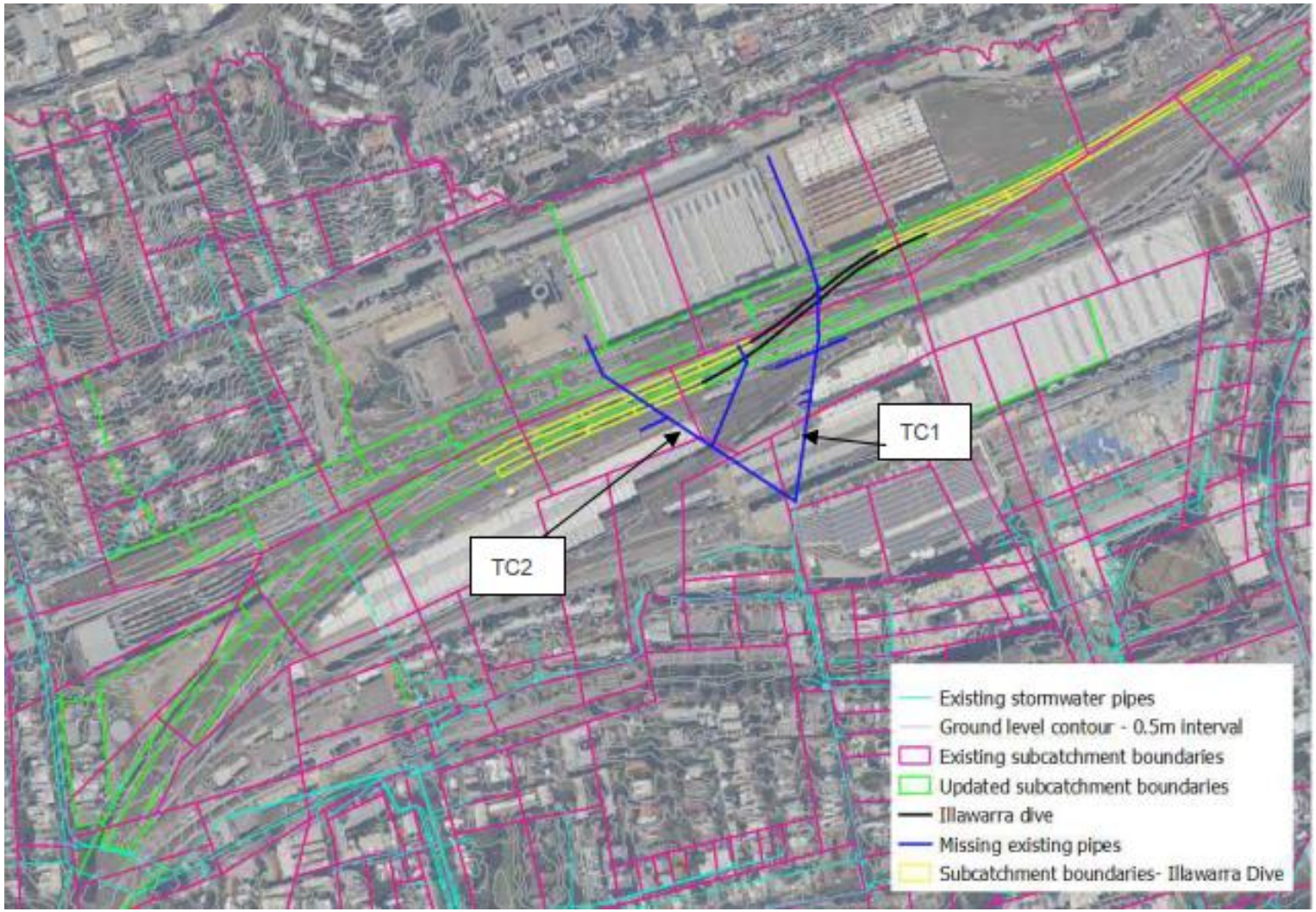

Figure 10 Subcatchment Boundaries (from Next Rail 2021)

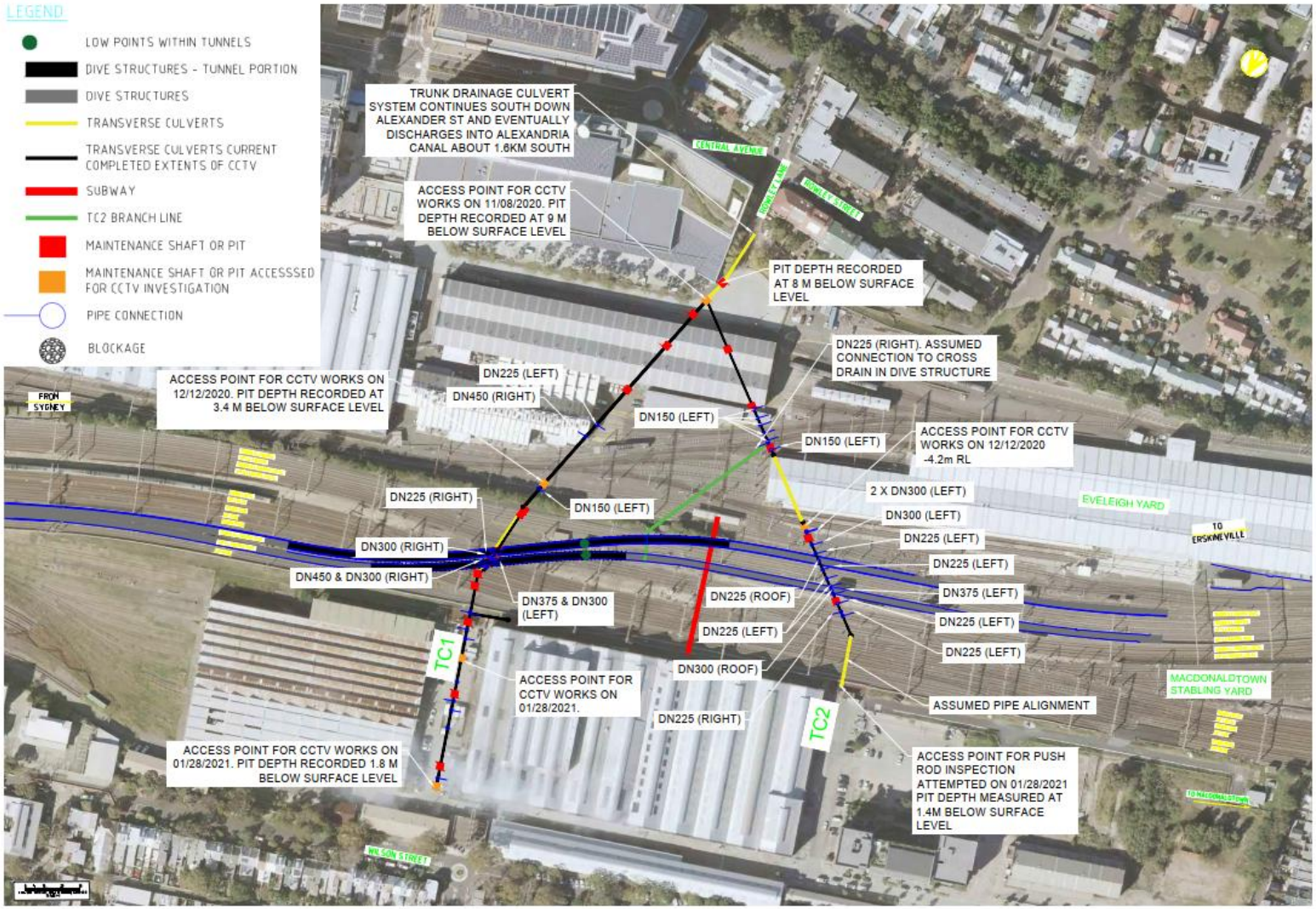

Figure 11 Drainage and Hydraulic Features in the Study Area (Illawarra Dive – Assessment of Existing Flood Characteristics and Design Options Study, August 2021)

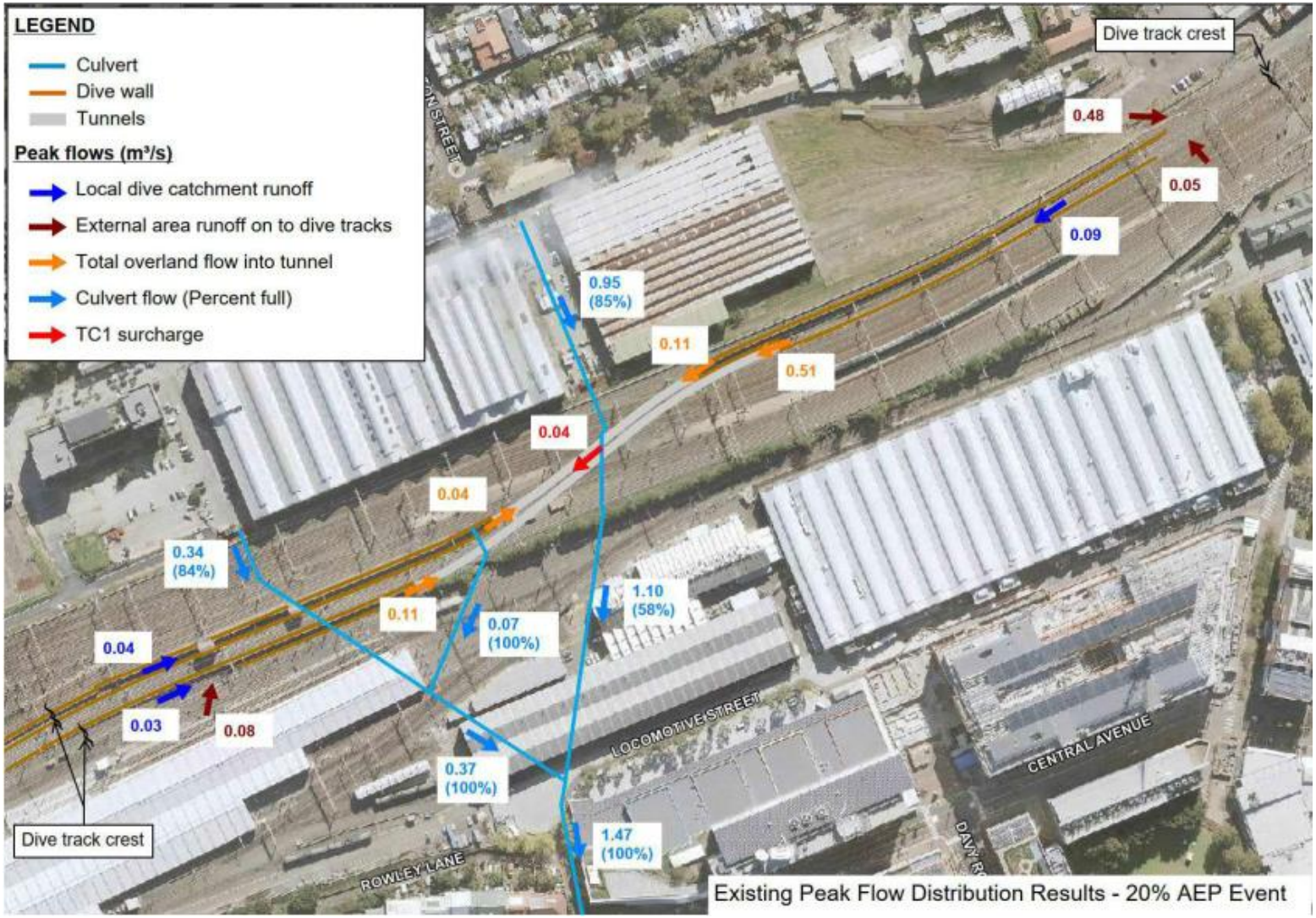

Figure 12 Existing Conditions Flow Distributions (20% AEP storm event – NextRail 2021)

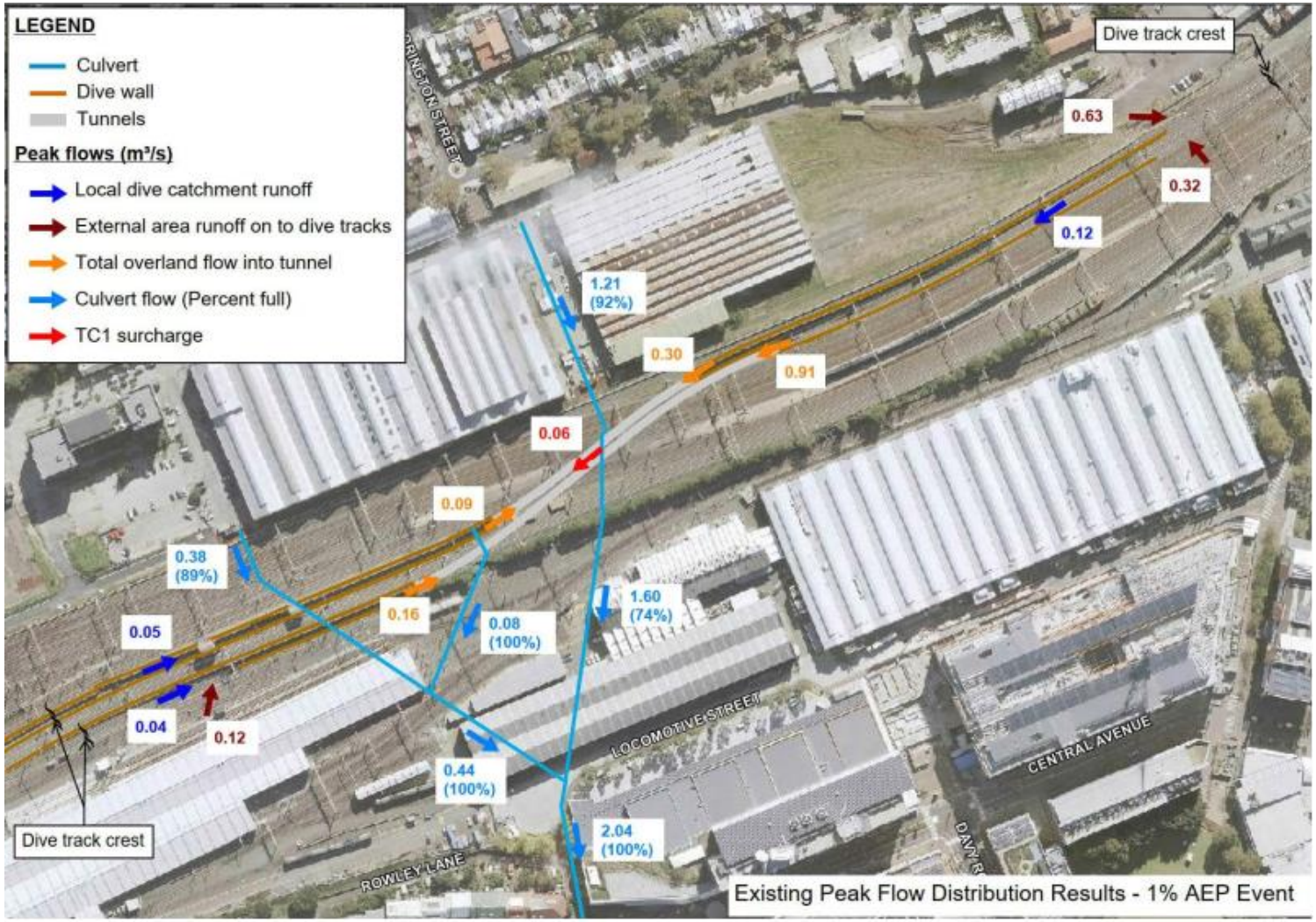

Figure 13 Existing Conditions Flow Distributions (1% AEP storm event – Next Rail 2021)

5.4 Pre-development Hydrology and Hydraulic Performance

The *Illawarra Dive- Assessment of Existing flooding characteristics and design options* by Next Rail (August 2021) assessed the existing flood behaviour across the development precinct for the 20% and 1% AEP design flood events and described the existing capacity of the culverts running across the railway corridor. ARR2019 hydrological methods were used for this assessment but there is no mention of culvert or sag pit blockages and what parameters were assumed.

For the 600 mm and 1200mm culverts in the southern area of the site running across the rail corridor, the following were reported regarding existing capacity:

- The 1200mm culvert is 58% full in the 20% AEP event and 74% full in the 1% AEP event at the upstream end draining from the Precinct;
- The Hydraulic Grade Line (HGL) is 0.2 m above the tunnel level at the connection point in the 20% AEP event and 0.9 m above the tunnel level in the 1% AEP event;
- The 600mm culvert adjacent to Precinct 1 flows at 84% of full capacity in the 20% AEP event at the upstream end and 89% capacity in the 1% AEP event;
- The drainage pipe running between the proposed Carriageworks and Paint Shop sub-precinct (currently the locomotive workshop) is at 85% capacity in the 20% AEP, and 92% capacity in the 100% AEP event.

Design flood levels for the 20% and 1% AEP events obtained from the report are presented in **Figure 14** and **Figure 15.**

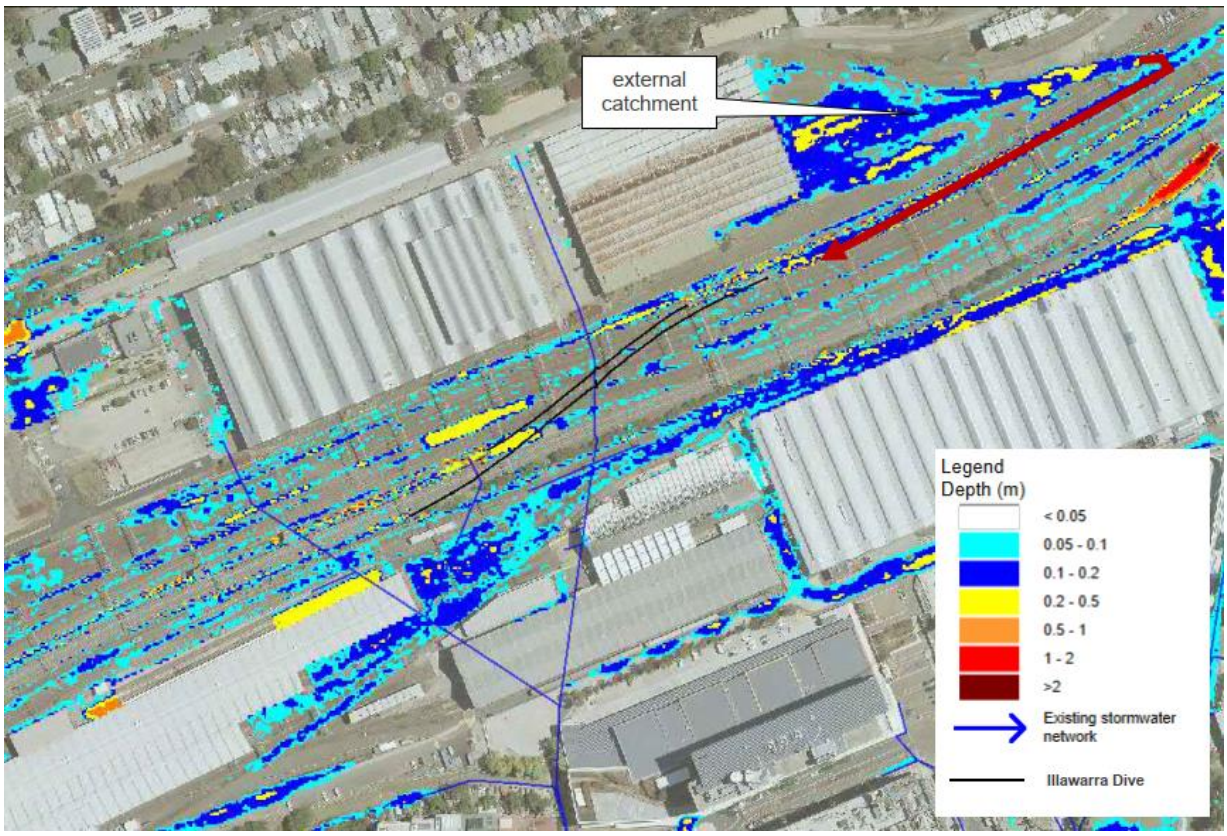

Figure 14 Flood Depths for 20% AEP Event

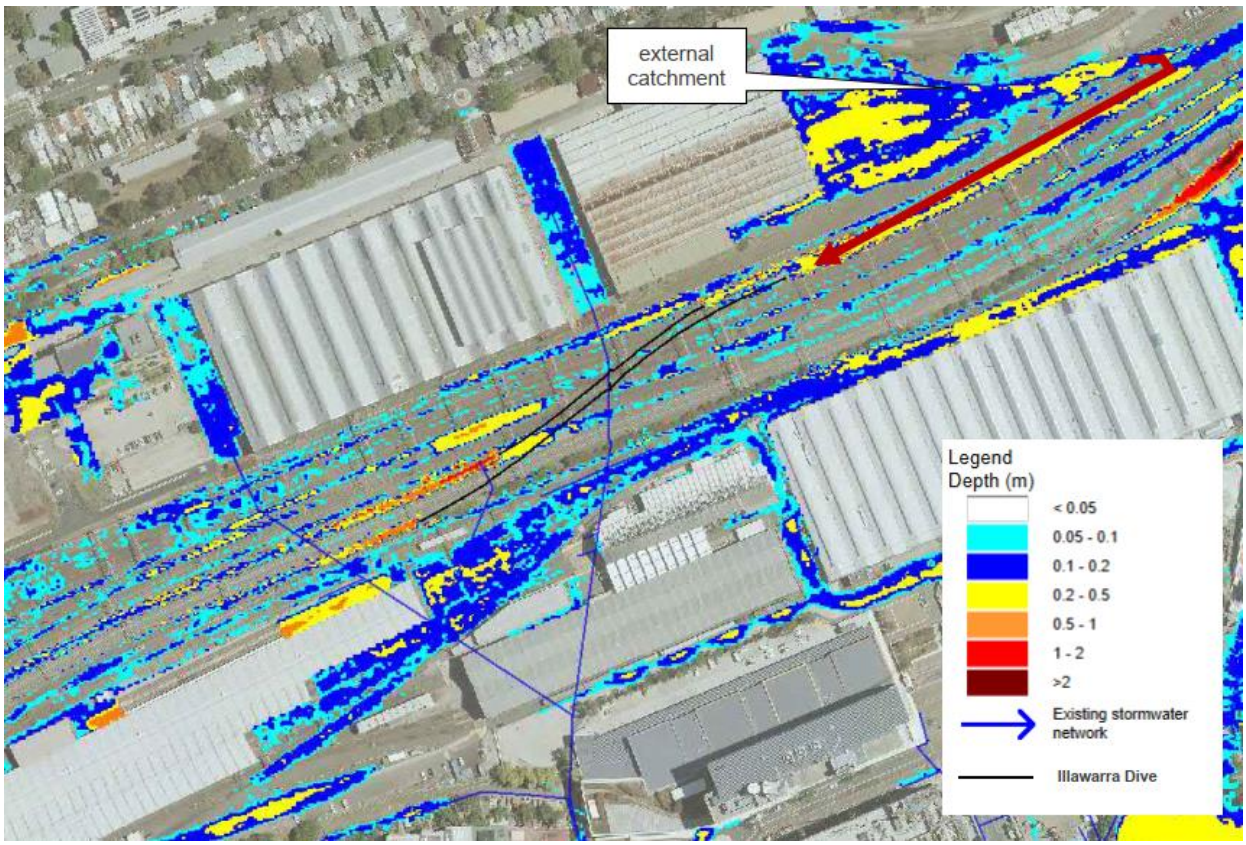

Figure 15 Flood Depths for 1% AEP Event

As part of the current study AECOM has undertaken additional TUFLOW modelling work for the 20% and 1% AEP events under existing precinct and Dive conditions. The following methodology was adopted in the assessment:

- Review of CoS TUFLOW model for Alexandra Canal Catchment Study (WMA 2018);
- Modelling of dive and rail flows based on the Alexandra Canal DRAINS model and a localised DRAINS hydrology model for the dive sections;
- Updating of hydrology in accordance with ARR 2019 guidelines;
- Refinement of sub-catchment boundaries in the vicinity of the project site on the basis of field investigation, aerial imagery, alignment of the railway corridor and the existing terrain;
- Incorporation of runoff from the “external” catchment east of the Paint Shop;
- Incorporation of culvert drainage data surveyed as part of the Illawarra Dive study (Next Rail, March and April 2021); and
- Undertaking updated TUFLOW runs for the site.

The 20% and 1% AEP flood extents obtained from the current modelling are shown in Figure 16 and Figure 17**.** These results are found to be generally consistent with the results in Figure 14 and **Figure 15** obtained by Next Rail (August 2021).

5.5 Pre-development flood impacts on the Site

The results from the current TUFLOW flood assessment are presented in **Figure 16** for the 20% AEP (2hr critical duration) and **Figure 17** for the 1% AEP (1hr critical duration) event. It is noted that in **Figure 17**, the flood depth bands are defined differently to that in **Figure 15**.

A summary of the findings is provided below:

- Flows from the “external” catchment to the east of the Paint Shop result in flood depths of about 250 to 330 mm at the eastern boundary of the Precinct. Excess runoff from the “external” catchment overflows on to the dive tracks and into the dive tunnel, in addition to local flows within the dive tracks. Site runoff from the North drain adds to the flow and collectively discharges into the downstream section of TC1 before joining the existing Munni culvert; It is noted that this takes into account the on-site detention system proposed as part of the Illawarra Dive project.
- The downstream drainage section of TC2 receives flows from both site runoff and local runoff from the dive section. The pipe is at 100 % capacity for the 1% AEP event. It then joins the existing Munni culvert to the south, as in the case for TC1.
- Local runoff into the Northern dive walls results in a flood depth of about 1.5 m. These local flows are conveyed into the drainage system connecting to the TC2 pipe, which results in the downstream pipe flowing at 100 % capacity for the 1% AEP design storm event. The Southern dive wall receives local runoff and flows from the Illawarra dive tunnel and overtops, causing flooding against the building to the South;
- A 715 mm flood depth was estimated along Carriageworks Way near the Platform Apartments. Based on lidar information, there appears to be a local depression at this location.
- Overall, the TC1 and TC2 pipes are able to convey the majority of the runoff from the sections adjacent to the Locomotive and Carriageworks building for the 1% AEP event. The TC1 and TC2 pipe sections exiting the site are at 97% and 68% capacity, respectively. Flood depths in the section between the Carriageworks building and Paint Shop sub-precinct are between 75 to 115 mm and between 30 to 150 mm for the section adjacent to the Platform Apartments and Carriageworks building.

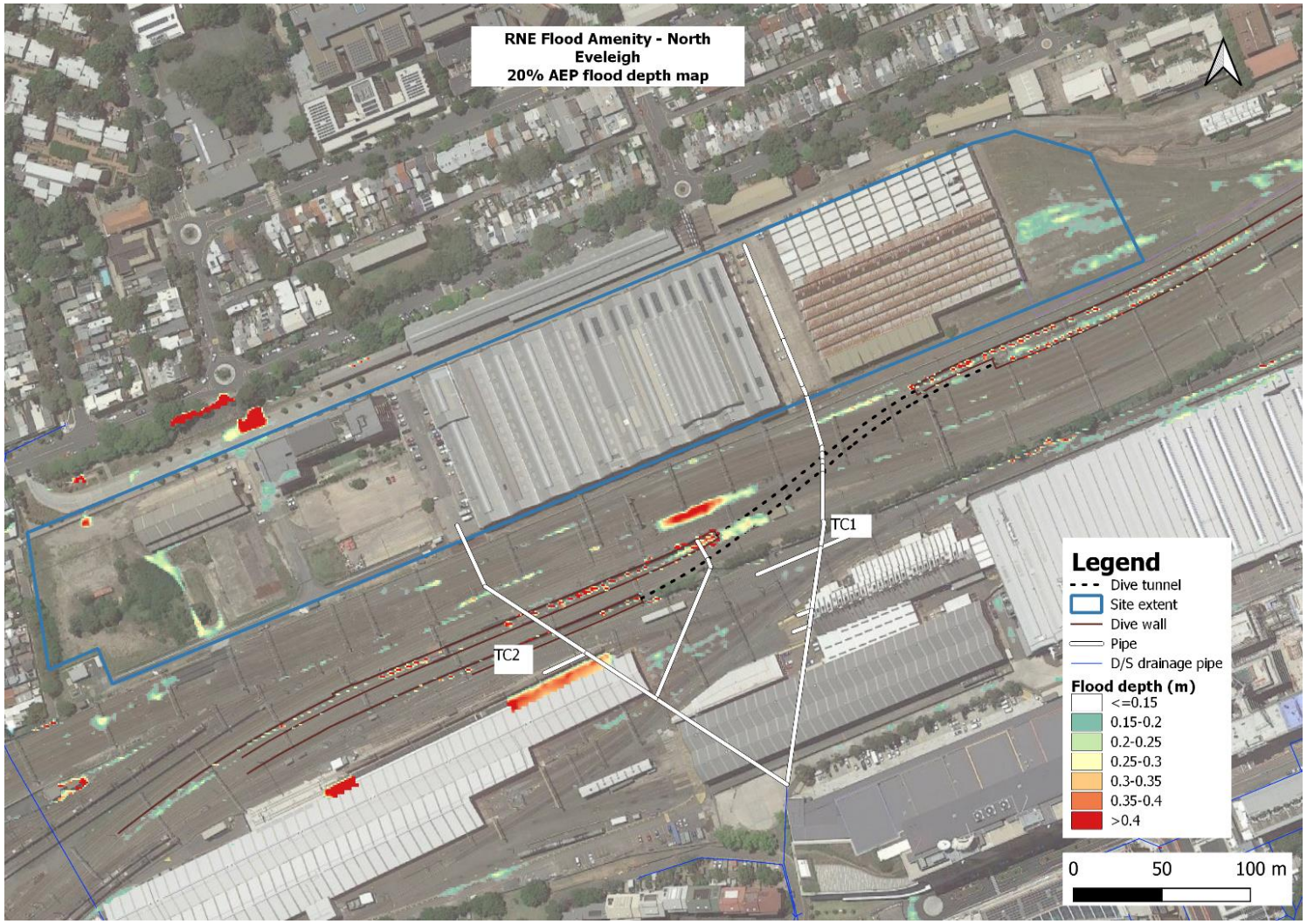

Figure 16 Flood Extents and Depths for the 20% AEP Flood Event (AECOM, Present Study)

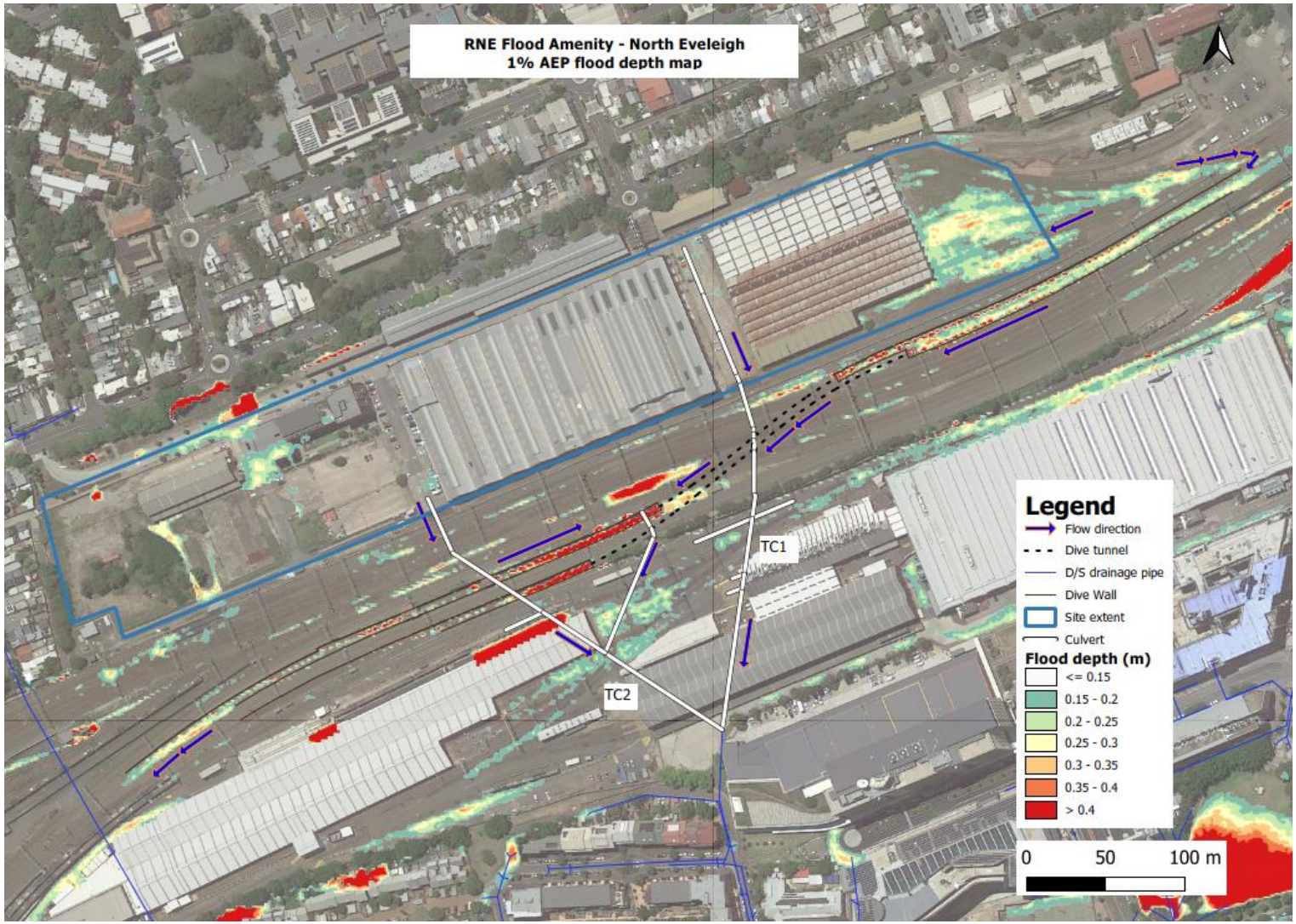

Figure 17 Flood Extents and Depths for the 1% AEP Flood Event (AECOM, Present Study)

5.6 Proposed Network Upgrades

The Illawarra Dive Study undertaken by Next Rail in August 2021 assessed the existing flooding characteristics of the Illawarra dives. The study included site and culvert inspections to investigate the existing drainage network and drainage paths. The study highlighted main sources of flooding for the dives and the current drainage performance. As part of the optioneering process for mitigating flooding in the dives, three options were tested, of which a preferred option was recommended. This comprised of the following:

- Bunding the eastern end of North Eveleigh precinct
- Upstream detention tank within Carriageworks
- A new gravity 225 mm drainage pipe from the existing cross drain with connection to TC1, and modifications to the TC1 inlets to improve collection of the eastern local catchment runoff into the Dives.

These network upgrades are assumed to roll out in the next 5 years based on the Illawarra Dive Study report and were hence accounted for in the flood risk assessment for the proposed Paint Shop sub-precinct, reflecting the infrastructural upgrades at the time of construction for the post-development conditions. The potential impacts from these changes mainly pertain to increased flooding within the site from bunding the section draining into the dives and connectivity to the existing drainage network.

The Paint Shop precinct provides an underground detention system. The external catchment to the east provides an open detention system which will have shallow flooding during storm events. The detention basins have been sized to ensure that the peak post development flows dischaging into the Dive structure and Council's downstream drainage system will be less than those under existing conditions.

6.0 Post-Development Stormwater Management

A post-development flooding and drainage assessment was undertaken following confirmation of the masterplan for Paint Shop sub-precinct in April 2022. The details of the new development site including land use, building footprint and general site layout have been previously covered in Section 1.3. The following sections outline the stormwater, flooding and drainage performance of the site under the proposed development conditions as well as relevant stormwater and flooding management measures for the site to comply with the relevant stormwater management guidelines and controls.

6.1 Proposed Stormwater Management Approach and Quantity Control

6.1.1 Impact Assessment

The proposed Paint Shop sub-precinct masterplan is expected to result in changes to the flooding and water quality characteristics as well as impact on the performance of the existing drainage network for which relevant controls and mitigation measures need to be assessed against the relevant design criteria outlined in the DCP 2012. From a study of the Paint Shop sub-precinct, the following are of relevance:

- Proposed 19% permeable surfaces onsite (9784 m^2) allowing for 14.4% soft landscaping (7399 m^2) and 4.6% permeable paving (2385 m^2) from an existing permeable area of 45% (23,202 m^2)
- Proposed 25.9% canopy cover on ground including high value tree retention, new canopy on ground and new canopy cover on podium.
- The incorporation of green roofs, cool roofs and green walls into the design of future buildings

The impact assessment of stormwater quality, flooding and drainage is presented in the following sections.

6.2 Post-Development Stormwater Quality Control and WSUD Measures

6.2.1 Impact Assessment

Stormwater runoff at a site generally increases where there is an increase in impervious area. Increased impervious areas may result from additional road surface, increase in footpath areas site earthworks and increased building footprint. Contaminants leaving the site through stormwater flows may include lubricants, effluents, chemicals and sediments. These may be toxic to downstream waterways and watercourses, and could result in other impacts such as increased turbidity, lowered dissolved oxygen levels, increased nutrient and pollutants.

On-site containment and treatment of contaminated waters are generally provided to protect the downstream environments. This will be in accordance with the NSW Water Quality and River flow objectives which define agreed environmental values and long-term goals for NSW's surface waters. These are consistent with the agreed national framework for assessing water quality set out in the ANZECC 2000 guidelines. They both articulate consideration of water quality objectives in strategic planning at a local level towards assessing impacts of developments.

The Redfern North Eveleigh Precinct Renewal Environmental Sustainability report, highlighted the relevant site opportunities and constraints towards sustainability and implementation of water-sensitive urban design initiatives. The points of relevance towards addition of WSUD incentives included:

- Collection and retention rather than discharge
- Incorporation of bioswales and improvement of water quality
- Incorporation of green open spaces for liveability
- Passive water treatments as part of the landscape design.

6.2.2 Water Quality Modelling

MUSIC software models a range of treatment devices to identify the best way to capture and reuse stormwater runoff, remove contaminants from surface runoff and reduce runoff frequency. These treatment strategies can be applied at a lot, precinct or catchment scale. In order to assess the post-

development water quality outcomes, a “developed conditions” MUSIC model was set up, representing the different land use types such as roof, paved sections and public domain/open space areas. A measurement of these areas was undertaken with reference to the overall Masterplan Layout and the Area Schedule for the Redfern North Eveleigh Masterplan prepared by Bates Smart (23/03/2022).

As ownership of respective stormwater management controls across different buildings has not been defined at this stage of the design, it is assumed that water quality treatment would be implemented at a lot scale (see **Figure 18**), meaning that individual buildings would be expected to meet water pollution reduction targets before discharging to the stormwater drainage network. For the public domain, it is assumed that stormwater treatment would be provided within the public domain (Figure 18). It is assumed that all the sub-catchments would eventually discharge into TC1. The MUSIC model is represented in **Figure 19**.

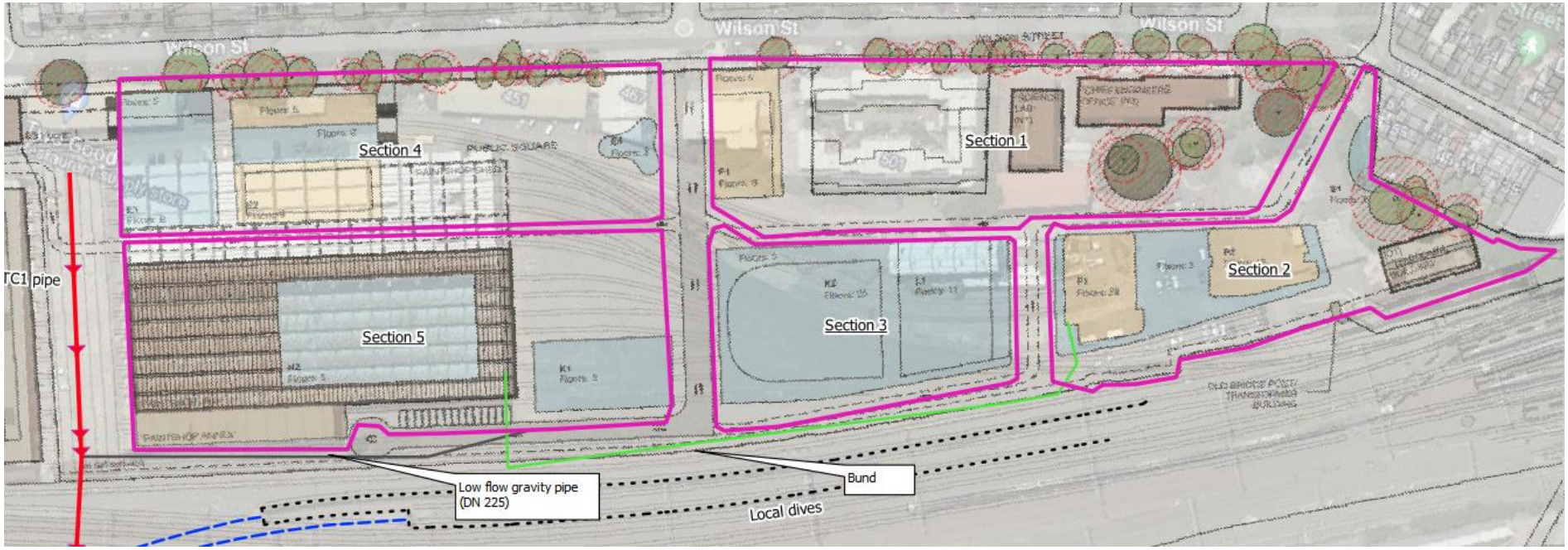

Figure 18 Section delineation for water quality assessment

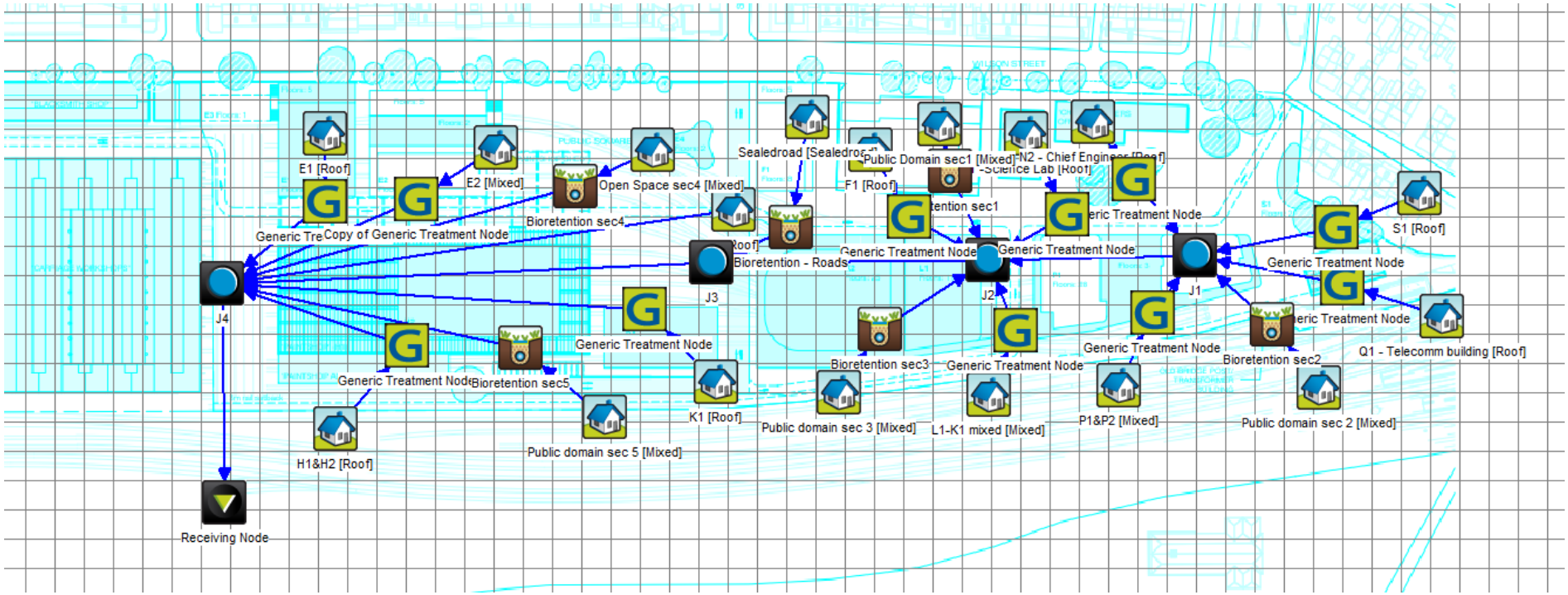

Figure 19 Layout of MUSIC model

A summary of the source node treatment method for each of the land use types is detailed in Table 9.

For individual lots, the stormwater management strategy would include rainwater tanks to be fitted to each building. There may be opportunities for lots to share more centralised rainwater capture facilities (where building stormwater controls are consolidated).

Public domain areas have been conservatively assumed to take into account paved sections and footpaths. Bioretention systems to service public open spaces were assumed to cover 2% of the total area for the various sections with those land uses. The modelling shows that a total area of about 455 m^2 would need to be accommodated across the public domain areas for bioretention systems, to service the public domain and road sections within Paint Shop sub-precinct. This includes the filter area and the landform needed for the batters.

Table 9 Summary of source node treatment

Source Node	Type	Treatment type	Details
E1	Building	Rainwater tanks may be used to meet toilet flushing and irrigation demands. Proprietary products such as litter baskets and filter cartridges to be used to filter runoff discharging from site. Minimum on-site storage requirements have been calculated separately.	Proprietary products such as litter baskets and filter cartridges to be integrated into built form (or open space) for each building. Efficiencies may be achieved by consolidating treatment trains.
E2	Building		
E4	Building		
E3	Building		
S1	Building		
K2	Building		
L1	Building		
K1	Building		
H1&H2	Building		
N2	Building		
N2	Building		
F1	Building		
501	Building		
P1&P2	Building		
Q1	Building		
F1	Building		
S1	Building		
Public domain Section 1	Open Space (66% impervious fraction)	Bioretention system*	2% of catchment, 132 m^2
Public domain Section 2	Open Space (66% impervious fraction)	Bioretention system*	2% of catchment, 65 m^2
Public domain Section 3	Open Space (66% impervious fraction)	Bioretention system*	2% of catchment, 28 m^2
Public domain Section 4	Open Space (66% impervious fraction)	Bioretention system*	2% of catchment, 105 m^2
Public domain Section 5	Open Space (66% impervious fraction)	Bioretention system*	2% of catchment, 48 m^2
Roads	Paved areas (100% impervious fraction)	Bioretention system*	2% of catchment, 75 m^2

**Bioretention systems have been modelled with a specified high-flow bypass of 100 m3/s, extended detention depth of 0.3 m and saturated hydraulic conductivity of 100 mm/hr.*

6.2.3 Opportunities for individual lots

Rainwater tanks can be used to treat runoff from each roof catchment. Rainwater can be used to meet irrigation demands and toilet flushing. For individual lots, site specific design will be prepared in subsequent stages demonstrating DCP pollution reduction targets are met. Proprietary products such as litter baskets and filter cartridges may be required where treatment cannot be accommodated within the landscape.

6.2.4 Opportunities in the Public domain

Treatment by bioretention systems has been modelled as the minimum treatment requirement. Treatment devices will need to be spread out across the public domain, including at regular intervals in the streetscape. Where possible runoff should be directed to passively irrigate street trees and landscapes (an approach generally aligned to meet the irrigation requirements defined in the Street Typologies defined in Section 10 of BatesSmart Urban Design Report). The benefits are an improvement in the health and longevity of trees and plants and a greater canopy cover for trees as well as overall improvement of pollutant reduction targets.

6.2.5 Preliminary water quality outcomes

Water quality outcomes for the proposed site layout with the implementation of the stormwater controls have been quantified through pollutant load results at the receiving node discharging from the overall Paint Shop sub-precinct in MUSIC. This has been summarised in Table 10. It is noted that these results are preliminary, and improved outcomes are expected by integrating the water quality, civil and landscape design.

Table 10 Summary of pollutant load reductions

Sources	Pre-treatment Load (kg/yr)	Residual Load (kg/yr)	% Reduction	Target (%)
Total suspended solids	6780	785	88	85
Total Phosphorus	13	4.3	67	65
Total Nitrogen	104	50	52	45
Gross pollutants	1190	73	94	90

Based on the preliminary results shown in Table 10 it is expected that a mix of treatment types as defined in in Table 9 can be adopted to meet the required pollution reduction targets. These will be coordinated with the built form and public domain during detailed design. It is expected that improved outcomes requiring less dedicated treatment can be achieved through optimising the use of multipurpose infrastructure elements between built environment disciplines, including architecture, building services, landscaping, civil engineering and stormwater and greening.

7.0 Flood Risk and Drainage Assessment

A flood impact assessment was initially undertaken on the basis of a draft masterplan for the site provided in April 2022. The masterplan has since been updated by Bates Smart (March 2022) for the current impact assessment to provide the following improvements:

- At least 30% reduction of residential floorspace for the overall building footprint
- Provision of two large high amenity and fit for purpose, consolidated public open spaces

The reduced building footprint for the current layout has required updating of the potential rainwater harvesting volumes and on-site detention storages as well as new TUFLOW runs for the post-developed case scenario for the 20% and 1% AEP storm events. This is further discussed in the following section.

7.1 Flood Impact Assessment for Post Development

The hydrologic and hydraulic performance of the study site in the post-development scenario was undertaken adopting the following methodology:

- Generation of a design Digital Elevation Model (DEM) approximating the surface elevation for the proposed buildings, roads and other paved/unpaved areas
- Incorporation of the network upgrades for the Illawarra Dive (Figure 20) For this, the components comprising of the refined preferred option for the Dives outlined in the Illawarra Dive – Assessment of Existing Flooding characteristics and design options memo were considered. These included:
  - Bunding the eastern end of North Eveleigh precinct, with new 225mm pipe outlet connection to TC1
  - Retainment of the existing 225mm pipe from the existing Dive cross drain with connection to TC2,
  - Retainment of the existing TC1 inlets and drainage connections from the Dives (ie. no modifications to existing arrangement).
  - Provision of on-site detention system to meet a permissible site discharge (PSD) of 250-300 L/s.

As a conservative approach it was assumed that there was no change to the impervious fraction to the internal catchments from existing to proposed conditions.

The above model update was based on the Next Rail's preferred upgrading option for the Dives and took into account constructability issues, proposed future development of the Paint Shop sub-precinct, and the proposed permissible site discharge from the site.

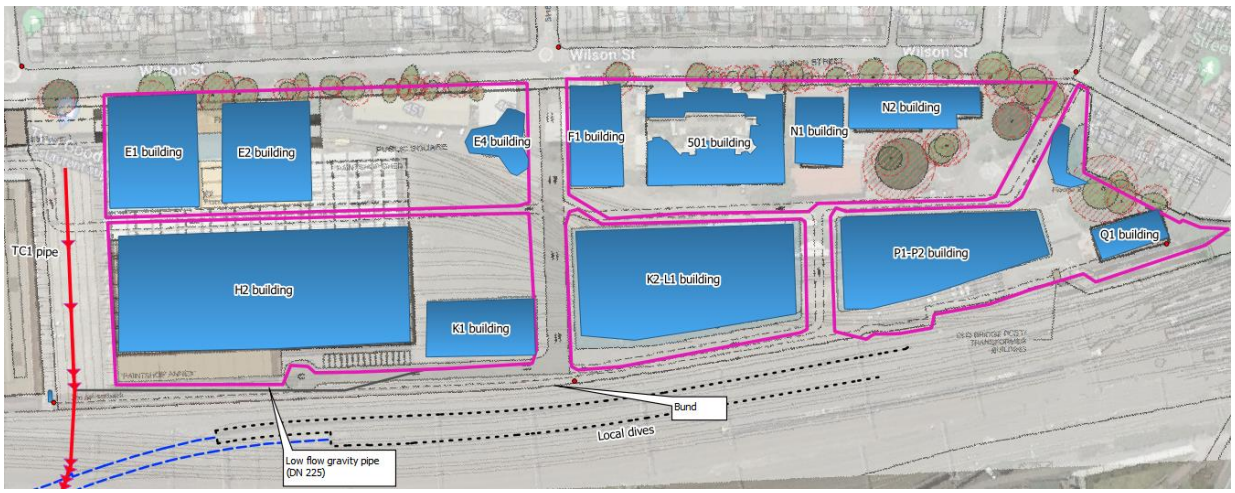

Figure 20 Proposed site and layout of network upgrades

7.2 Flood Impacts from Post development

The 20% and 1% AEP flood depth and impact maps for the post-developed conditions are outlined in Figure 21 to Figure 24. The following relate to the post-development site hydraulics and drainage:

- Additional structural items at the south-western end of the Paint Shop sub-precinct, including bunding adjacent to the dives and implementation of a low-flow gravity pipe to reduce the amount of flow draining to the south-western corner of the site into the dives have been incorporated and hence, have a bearing on resulting flooding within the site.
- Figure 21 and Figure 22 outline the flood depth and afflux outcomes for the 20% AEP storm event. It was understood that afflux is primarily contained within the western and southern side of K2/L1 buildings, and ranges between 130 and 340 mm. No increase in flood depth or afflux is expected in the section between the Carriageworks and Paint Shop sub-precinct.
- Figure 23 and Figure 24 demonstrate the resulting flood depths and afflux outcomes for the 1% AEP event. As a result of the site modifications an additional afflux in the range of 220 to 440 mm in the 1% AEP is observed south of the proposed section of buildings P1/P2 and L1/K2 as observed in Figure 24. The inflow to the dive structure of about 380 L/s will also exceed the design criteria of 250-300 L/s as shown in Figure 25.
- The addition of an on-site detention (OSD) storage tank of up to 5000 m^3 between the Carriageworks and Paint Shop sub-precinct before off-site discharge at TC1 resulted in a 46% decrease in flow rate compared to pre-developed conditions for the 1% AEP event. This is found to be inadequate to limit the site discharge to the PSD of 250-300 L/s as defined by NextRail. Refer to Section 7.3 for recommendations on achieving compliance.
- Additional stormwater measures from the post development conditions are expected to result in a 30 to 100 mm reduction in flood depths in the dive sections. However, this would lead to about a 30 to 50 mm flood depth increase in the area bounded by the Carriageworks and Paint Shop sub-precinct which would require additional detention storage (see Figure 23).
- The *City of Sydney Interim Floodplain management policy* ascribes relevant floor planning levels (FPL) based on the type of flooding (mainstream or local). The FPL criteria for residential floors and habitable rooms is that any development is to be free from flooding from up to the 1% AEP + 0.5 m. The storeys for the proposed development at North Eveleigh range between– 1 to 28.

  Based on the 1% AEP flooding results for developed conditions, the flood model developed assumes the proposed building layout is above the flood planning level and flooding is contained within the public open spaces in the vicinity of the building.

  Recommendations to achieve compliance with this policy are discussed in Section 7.3

- The *Geotechnical and Contamination – Phase 1* report (AECOM, 2019) states that groundwater seepage where encountered by previous investigations beneath North Eveleigh East has typically occurred in the underlying relatively low permeability shale bedrock and hence is of relatively low yield. Standing water levels have been reported within the range of 1 to 3 m below the current site levels. There is hence expected, based on these geotechnical assessment outcomes that there would be minimal impact of the proposed development on hydrogeology.

  As part of future stages it is recommended that supplementary investigations be carried out to provide more consolidated data of the current groundwater conditions and confirm the hydrogeological impacts from previous investigations.

  In order to minimise any potential groundwater contamination, mitigation measures related to on-site detention where tanks would need to be drained would require design of retaining walls to resist hydrostatic pressures with an additional drainage layer beneath the base layer.

The flood mitigation measures necessary to mitigate the impacts identified above are discussed in more detail in Section 7.3

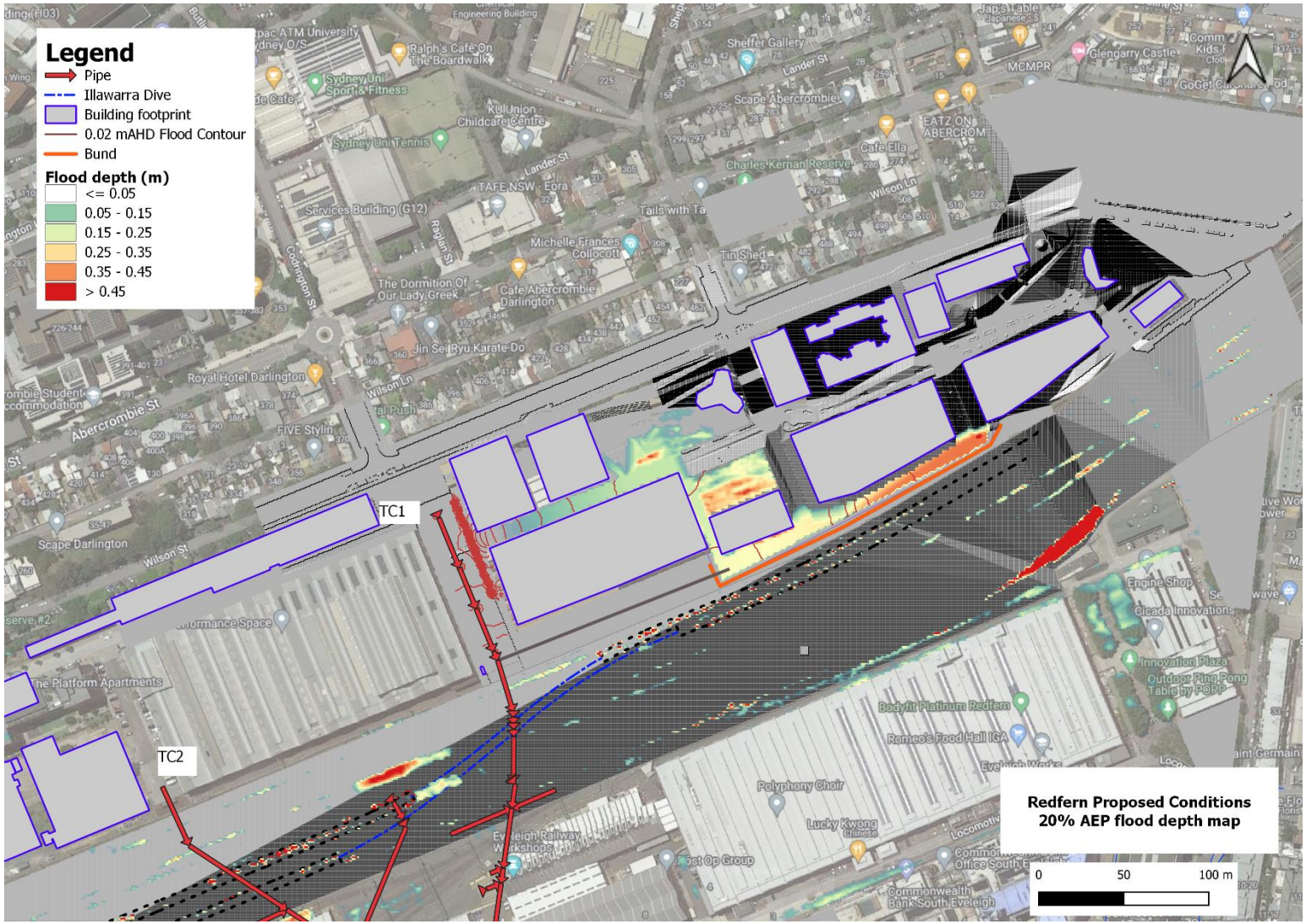

Figure 21 Post-Developed Conditions - 20% AEP Flood depth map

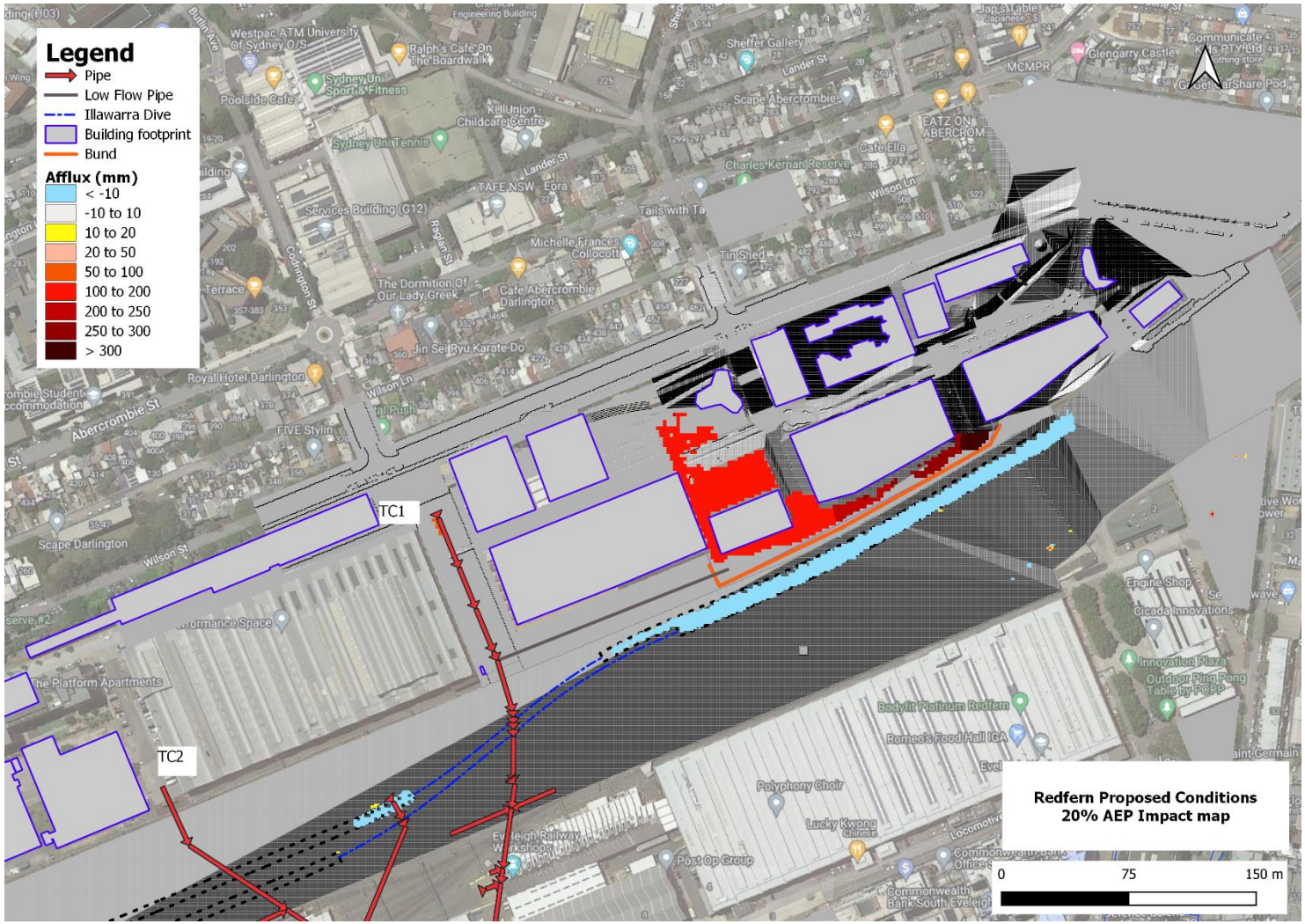

Figure 22 Post-Developed Conditions - 20% AEP event afflux map

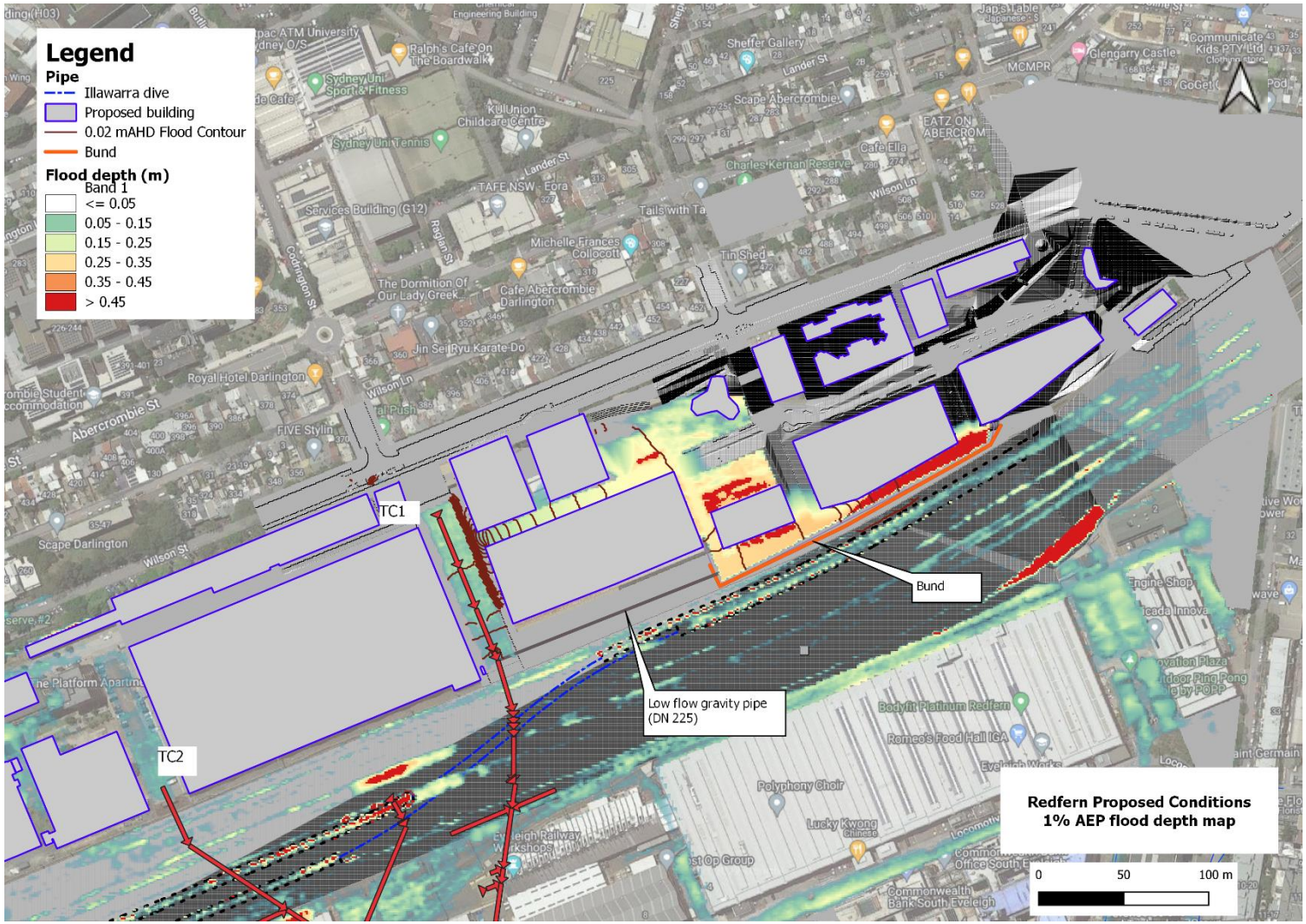

Figure 23 Post-Developed Conditions - 1% AEP flood depth map

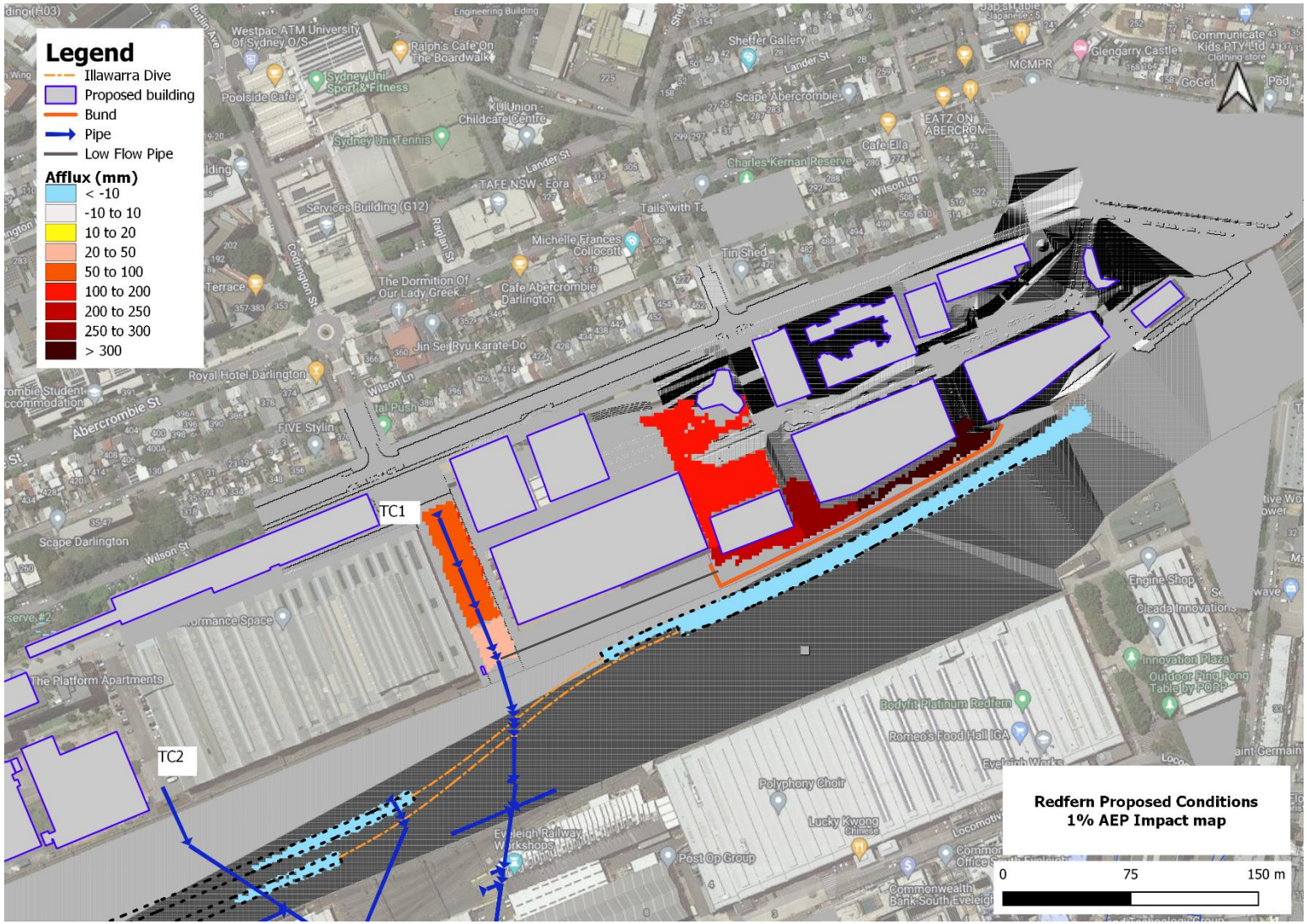

Figure 24 Post-Developed Conditions - 1% AEP event afflux map

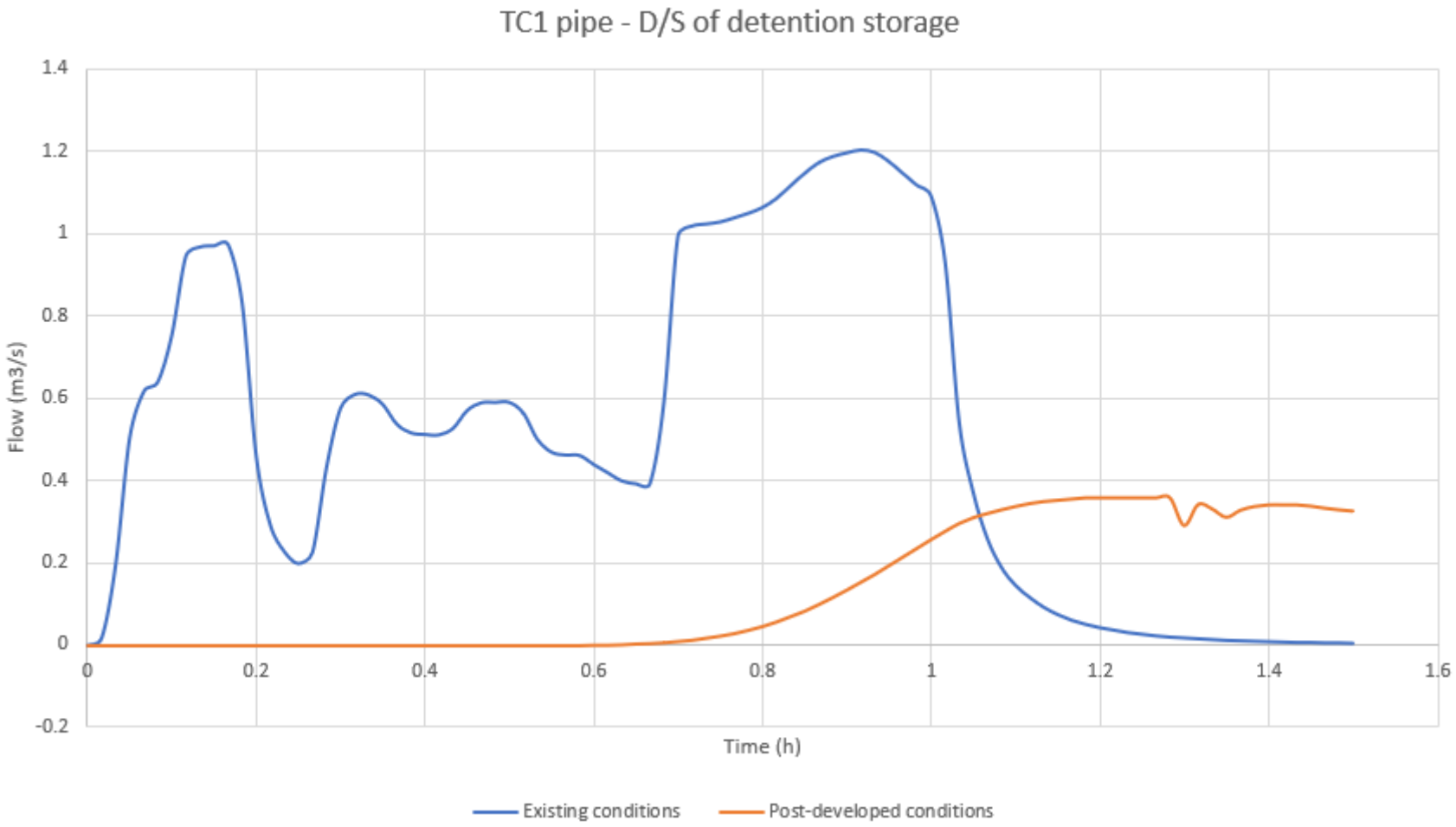

Figure 25 TC1 pipe Flow rate (Downstream of detention OSD)

7.3 Recommended Flooding and Drainage Controls

The stormwater quantity controls outlined in Section 3.0 indicate that, in addition to the DCP requirements set by the City of Sydney, a permissible site discharge (PSD) of 250 – 300 L/s will apply for the site (specifically as a result of the constraints imposed by the Illawarra Dives). These constraints and the flood impacts identified in Section 7.2 indicate that additional mitigation measures will be required to mitigate the overall flood impacts. AECOM has investigated these additional measures, as discussed in the following sections.

7.3.1 Provision of New Drainage Line at Southern Edge of Paint Shop sub-precinct

Flows coming from the east to the TC1 outlet for the 1% AEP 1 hour storm event have a peak of about 1.2 m^3/s. AECOM has prepared a concept drainage design at the southern edge of the Paint Shop precinct, which conveys these flows to the outlet, considering the connectivity to TC1, the grade of the terrain and the constructability of the pipe network.

Based on the site constraints, it is considered that the proposed drainage pipe would need to be limited to a maximum of 900 mm in depth. Preliminary assessment indicated that either a 600 x 600 mm box culvert or a set of twin 450mm (2 barrels) pipe would be adequate as the trunk line along the drainage corridor. Feeder pipes from between the buildings would need to be sized appropriately during detailed design to capture the flows from public domain to connect into the trunk line.

Figure 26 outlines the location of the proposed trunk line at the southern edge of the Paint Shop, extending from the south-eastern section of the proposed development to the pipe connection TC1 between Carriageworks and the Paint Shop Precinct. It is noted that the pipe can convey a total flow of 0.93 m^3/s; and hence it is expected that the excess flow of 0.25 m^3/s would need to be contained either on-site through additional OSD, through the use of permeable paving or diverted for passive irrigation within the public domain in order to meet the PSD requirements.

Afflux results following implementation of the above drainage infrastructure indicate that the afflux around the proposed L1 building would reduce to between 10 to 54 mm for the 1% AEP event. This is a significant improvement compared to an afflux of between 150 to 540mm observed in the vicinity of buildings P1/P2 and L1/K2 for the proposed development without this new drainage pipe option (see Section 7.2).

In addition to the above benefits, a reduction of more than 10 mm in flood level is also observed in the area between the Carriageworks and Paint Shop sub-precinct relative to existing conditions.

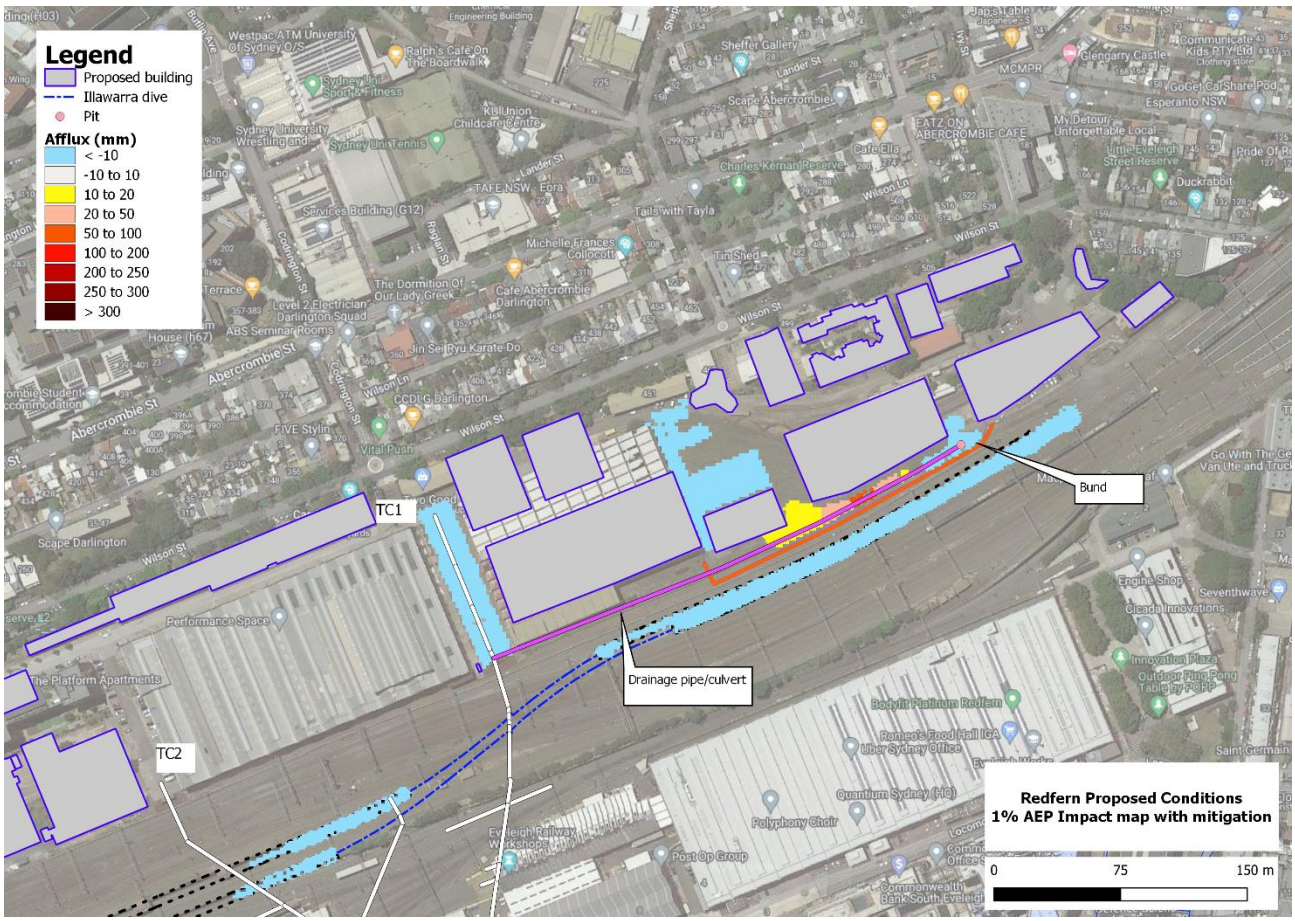

Figure 26 Drainage concept design for North Eveleigh

7.3.2 Provision of Additional On-Site Detention

Another consideration is the implementation of additional on-site detention (OSD) to assist with reduction of stormwater discharge from the site and meeting the permissible site discharge. It is noted that this is in addition to the proposed main OSD storage tank of 4000 m^3 proposed by Next Rail to be located between the Paint Shop and Carriageworks buildings. This additional OSD can be achieved either within the public open spaces or as OSDs in buildings or on building roofs.

Preliminary options by Next Rail investigated the use of an OSD storage tank of 4000 m3 in the vicinity of Paint Shop and Carriageworks buildings. Based on the results of the current study, it is estimated that a total detention storage volume of 10,000 m3 would be required of which 5,000 m^3 may be accommodated in the area between Carriageworks and the Paint Shop. This means an additional 5,000 m^3 may need to be provided in the public open spaces, as OSDs in buildings, or on roofs, as noted earlier. Given the limited space within the Paint Shop sub-precinct, it is likely that some detention would need to be accommodated within building footprints (roof or basements) for which the connectivity into external drainage lines should be considered during detailed design. This flood mitigation option aligns with the objectives set out in the 2008 North Eveleigh Masterplan Approval document towards stormwater quantity management, which highlighted the need for maximising on-site rainwater reuse, retention and detention and the incorporation of green areas and bioretention systems as water management strategies.

In terms of on-site detention, preliminary estimates of rainwater volumes that can be captured within the building roofs footprints have been undertaken. Rainwater storage depths not exceeding 200 or 300 mm were considered appropriate for implementation on the roof of buildings, taking into account constructability and safety outcomes as well as limiting the load on top of buildings. In order to meet a target volume of 5,000 m^3 for an overall gross building area of 33,060 m^2 within the Paint Shop sub-

precinct, the following tank heights and tank to roof ratios were estimated (Table 11). Thus, for storage depths of 300mm, less than 45% of the building roofs would need to be utilised to provide this 5,000 m^3 volume.

Table 11 Indicative rainwater tank specifications for additional storage

Tank depth (mm)	Tank to roof area ratio (%) per building	Potential overall volume (m3)
200	65	3,330
300	45	3,210

Preliminary calculations for rainwater tank sizing indicated that it would be insufficient to capture 5,000 m^3 from roof stormwater capture only, and hence would require the implementation of on-site detention storage in public spaces in order to meet the permissible site discharge criteria. In addition to this, based on design rainfall intensities for the 1% AEP event, it is estimated that only up to 2,420 m^3 of rainwater would be available for capture for the critical design storm, assuming empty tanks at the start of the storm. On this basis, the remaining 2,580 m^3 would need to be captured along the drainage lines and other areas such as public domain and public open spaces. The updated masterplan indicated that a total of 10,750 m^2 will be allocated for public domain areas which is considered sufficient for this purpose.

An assessment of likely areas where this is possible, considering minimum cover, ability to drain and land topography, is shown in Figure 27. In Table 12, it can be seen that the selected areas would provide the required 2,580 m^3 volume of storage.

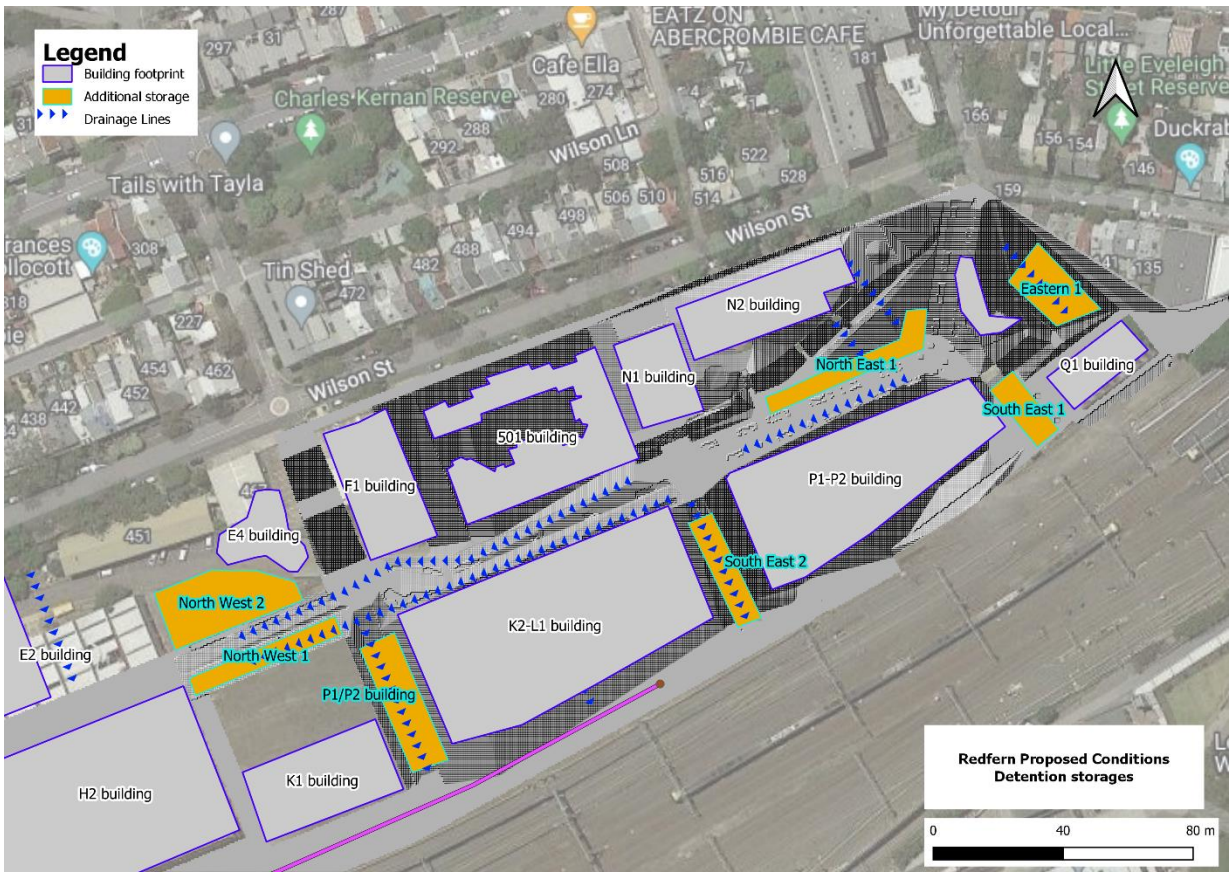

Figure 27 Potential detention storage locations

Table 12 Additional detention storage volumes and locations

Label	Surface Area (m^2)	Depth (m)	Volume (m^3)
South East 1	202	1	202

Label	Surface Area (m^2)	Depth (m)	Volume (m^3)
North East 1	337	1.2	404
North West 1	254	1.2	305
P1/P2 building	437	1	437
South East 2	281	1	281
North West 2	646	1	646
Eastern 1	341	1	341
		TOTAL (m^3)	2,615

Overall, the total OSD volume of 10,000 m^3 provided for the site would consist of the following:

- 4,000 m^3 in main OSD tank between Paint Shop and Carriageworks;
- 2,420 m^3 in building roof tops; and
- 2,615 m^3 in supplementary on-site detention storages.

It is noted that the above estimates are preliminary at this stage and would need to be refined and confirmed during detailed design. Landscaping and structural considerations would also need to be taken into account as part of the design.

8.0 Summary and Conclusions

The Paint Shop sub-precinct development will require stormwater control measures to manage increase in flood depths within the site for both the 20% and 100% AEP storm events. Surface runoff from the Precinct into the Dive drainage line (TC1) is limited to a Permissible Site Discharge (PSD) of 250-300 L/s under these conditions.

8.1 Recommended Development Controls – Stormwater Quality

In terms of meeting the water quality requirements, the development would need to provide water quality treatment devices such as bioretention systems and rainwater tanks. It is estimated that approximately 455 m^2 bioretention areas would be required, in addition to rainwater tanks to be accommodated at a lot scale at the buildings.

8.2 Recommended Development Controls – Flooding

Recommended controls are aimed at minimising the discharge from the site in line with the PSD requirements whilst mitigating flooding under post-development conditions. Options assessed included extending and upsizing the 225 mm low-flow gravity pipe which connects to TC1. Given the site constraints, upstream detention would need to be provided to attenuate or contain the additional flows from the eastern catchment.

The 2014 Interim Floodplain Management Policy specifies minimum building floor levels and below ground flood planning levels (FPL) for residential and industrial sites. Residential development requires a 1% AEP + 0.5 m flood planning level. For industrial and commercial areas, a flood planning level corresponding to the 1% AEP event applies. Compliance with this policy should be able to be achieved with implementation of one (or more) of the recommendations in Section 7.3.

8.3 Recommended Development Controls – Drainage

To achieve the PSD and manage flood afflux a combination of building and public domain OSD measures will be required. A range of options for OSD locations and sizes is provided in Section 7.3.2 of this report. It is anticipated that a combination of these options can be implemented to achieve the required discharge rate and minimise any potential flood impacts.