City & Southwest

Flood and Stormwater Assessment

Detailed State Significant Development Application
Site C, Crows Nest over station development

April 2021 | Version: 1

Contents

Author:	CNDC
Date:	April 2021
Version:	1
Reference:	SMCSWSCN-SMC-SCN-EM-REP-000012
Division:	Division
Review date:	April 2021

1 Introduction

1.1 Purpose of the report

This Flood and Stormwater assessment supports a State Significant Development (SSD) Application for the detailed design, construction and use of over station development (OSD) on Site C of the Crows Nest Station precinct. It is submitted to the Department of Planning, Industry and Environment (DPIE) pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The detailed SSD Application for Site C OSD is classified as SSD pursuant to Clause 12 of *State Environmental Planning Policy (State and Regional Developments) 2011* (SRD SEPP). Under Clause 12 of the SRD SEPP, any development application that is pursuant to a concept SSD Application is also classified as SSD whether or not that part of the development exceeds the minimum capital investment value specified in the relevant schedule of the SRD SEPP.

In this regard, the proposed development on Site C is pursuant to the approved concept SSD Application and has not been delegated to Council under Section 4.37 of the EP&A Act. The proposed development is therefore, classified as SSD and is submitted to DPIE for assessment and determination.

1.2 Overview of Sydney Metro in its context

Sydney Metro is Australia's biggest public transport project (**Figure 1**). There are four core components:

- **Metro North West Line (formerly the 36 kilometre North West Rail Link)** - Services started in May 2019 in the city's North West between Rouse Hill and Chatswood, with a metro train every four minutes in the peak. The project was delivered on time and $1 billion under budget
- **Sydney Metro City & Southwest** – The Sydney Metro City & Southwest project includes a new 30km metro line extending metro rail from the end of the Metro North West Line at Chatswood, under Sydney Harbour, through new CBD stations and southwest to Bankstown. It is due to open in 2024 with the ultimate capacity to run a metro train every two minutes each way through the centre of Sydney. Sydney Metro City & Southwest will deliver new metro stations at Barangaroo, Crows Nest, Victoria Cross, Martin Place, Pitt Street, Waterloo and new underground metro platforms at Central Station. In addition it will upgrade and convert all 11 stations between Sydenham and Bankstown to metro standards
- **Sydney Metro West** – Sydney Metro West is a new underground railway connecting Greater Parramatta and the Sydney CBD. This once-in-a-century infrastructure investment will transform Sydney for generations to come, doubling rail capacity between these two areas, linking new communities to rail services and supporting employment growth and housing supply between the two CBDs. Sydney Metro West stations have been confirmed at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock, The Bays, Pyrmont and the Sydney CBD. Further planning is underway to determine the locations of the Pyrmont and Sydney CBD stations
- **Sydney Metro - Western Sydney Airport** – Metro rail will also service Greater Western Sydney and the new Western Sydney International (Nancy Bird Walton) Airport. The new railway line will become the transport spine for the Western Parkland City's growth for generations to come, connecting communities and travellers with the rest of Sydney's public transport system

with a fast, safe and easy metro service. Six new stations will be delivered at St Marys, Orchard Hills, Luddenham, Airport Business Park, Airport Terminal and Western Sydney Aerotropolis. The Australian and NSW governments are partners in the delivery of this new railway.

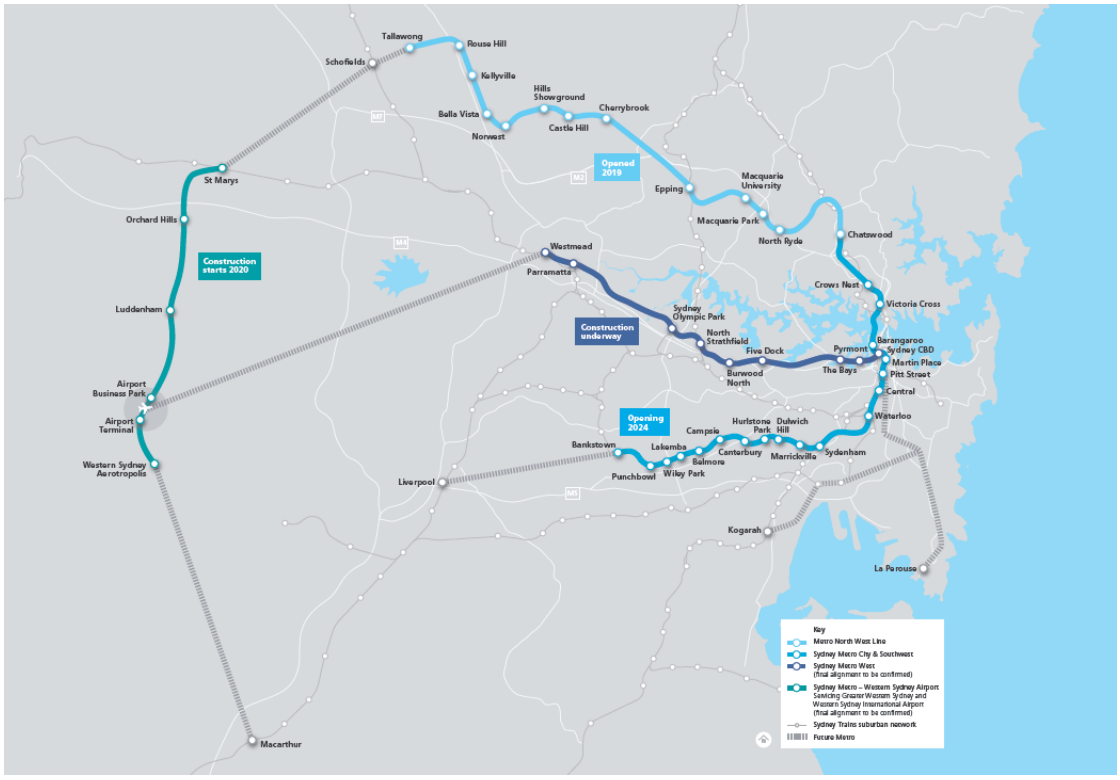

Figure 1: Sydney Metro network

1.3 Background and Concept Approval

Sydney Metro is seeking to deliver OSD above the approved Crows Nest Station. On 23 December 2020, the Minister for Planning and Public Spaces granted consent to the concept proposal for OSD at the Crows Nest Station including building envelopes, development parameters and strategies for a future development above the approved Crows Nest Station, and the use of the OSD spaces approved within the station under the CSSI Approval.

While the Crows Nest Station and OSD will form a single integrated station development (ISD), the planning pathways defined under the EP&A Act requires separate assessment for each component of the development. In this regard, the approved station works (CSSI Approval) are subject to the provisions of Part 5.1 of the EP&A Act (now referred to as Division 5.2) and the OSD component is subject to the provisions of Part 4 of the EP&A Act.

The concept proposal for Crows Nest OSD complements the St Leonards commercial core and seeks to minimise overshadowing and amenity impacts and integrate with the broader Crows Nest village including Willoughby Road. It provides an opportunity for a mixed-use development that capitalises on its immediate access to Australia's biggest public transport project that delivers significant improvements to the amenity of the local area. This aligns with the vision for the area, as outlined in key strategic planning documents, including the Greater Sydney Commission's (GSC) *North District Plan* and the St Leonards and Crows Nest 2036 Plan prepared by DPIE.

In October 2018, DPIE released a draft Rezoning Proposal for the Crows Nest metro site. The Rezoning Proposal sought to increase the relevant planning controls

applying to the site to be commensurate with the built form proposed in the concept SSD Application.

The release of the Rezoning Proposal was simultaneous to the release of the (then) draft strategic planning documents including the *St Leonards and Crows Nest 2036 Draft Plan* (2036 Draft Plan). The *2036 Draft Plan* recommended significant changes to the planning controls for the immediate area surrounding the Crows Nest OSD site subject to consideration of community feedback to its exhibition.

The 2036 Plan and the associated Special Infrastructure Contribution (SIC) scheme were finalised by DPIE on 29 August 2020. The Rezoning Proposal was also finalised, and new planning controls gazetted, on 31 August 2020 applying new planning controls to the Crows Nest metro site.

1.4 Site description

The Crows Nest Station precinct is located between the Pacific Highway and Clarke Street (eastern side of the Pacific Highway) and Oxley Street and south of Hume Street, Crows Nest. It is wholly located within the North Sydney local government area (LGA). It is also near the boundary of both the Willoughby and Lane Cove LGAs.

The Crows Nest Station OSD site comprises three sites (**Figure 2**). The following building envelopes and land uses were approved for each of the sites in the concept SSD Application:

- **Site A** (497-521 Pacific Highway, Crows Nest): 21 storey (RL 180m including a 4.4m rooftop building services zone) commercial office building with a maximum floor space of 40,300m^2
- **Site B** (477-495 Pacific Highway, Crows Nest): 17 storey (RL 155m) residential accommodation building with a maximum floor space of 13,000m^2
- **Site C** (14 Clarke Street, Crows Nest): 9 storey (maximum RL 132m including a 5m rooftop building services zone) commercial office building with a maximum floor space of 3,100m^2 (not including Crows Nest station floor space under CSSI Approval).

This SSD Application relates only to the detailed design and delivery of Site C, with applications for Sites A and B to be undertaken separately in the future.

Figure 2: Aerial photograph of Site C within the greater Crows Nest Station precinct

Site C is located at the north-western corner of Hume Street and Clarke Street, and comprises one allotment with the address of 14 Clarke Street, Crows Nest. It is legally described as Lot 1 in DP1123850.

The site is roughly rectangular in shape, and is located within the Crows Nest village centre. Adjoining Site C is a seven storey residential building (known as 'Wyndel Apartments') at 22-26 Clarke Street and a five storey commercial building at 20 Clarke Street.

The existing buildings on the site have been demolished to facilitate the construction of Crows Nest Station under the CSSI Approval. The demolition works are now complete, and the site is vacant and surrounded by construction hoarding. Once the station is completed as per the CSSI Approval, the entry within Site C will provide connection to the east towards Willoughby Road.

1.5 Overview of the proposed development

This detailed SSD Application will seek consent for the construction of a commercial office building on the site. It will be highly integrated with the approved Crows Nest Station under construction below.

Specifically, consent is sought for the following works:

- Construction, use and fitout of a new commercial building with the following parameters:
  - A total gross floor area (GFA) of 3,097m^2 (not including 245m^2 of station GFA under the CSSI approval)
  - A maximum building height of RL 127m, with an additional 5m 'building services zone' to accommodate rooftop plant and equipment, lift overruns and services (RL 132m total)
  - Nine storeys, comprising:
    - Building entrance lobby on the ground level
    - Bicycle parking and end of trip facilities on level 1
    - Commercial offices on levels 2 – 8

    - An accessible garden on part of level 9 for use by tenants
    - Rooftop plant and service areas
- Associated building servicing and building landscaping elements not associated with the rail infrastructure
- Signage zones for building / business identification.
- No vehicle parking will be provided on site.

The CSSI Approval for the metro station includes space provisioning on the ground level (building entrances) and level 1 (bicycle parking and EoT) for the Site C OSD. The use and fit-out of these OSD spaces requires approval under Part 4 while the actual station structure itself is approved as part of the Sydney Metro City & Southwest project.

1.6 Assessment requirements

DPIE has issued the Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an Environmental Impact Statement for the proposed development. This report has been prepared having regard to the SEARs as follows:

SEARs Requirement	Where addressed
Stormwater:	
• *Provide an Integrated Water Management Plan for the development that:* - *Is prepared in consultation with the local council and any other relevant drainage authority* - *Details the proposed drainage design for the site including the nominated discharge points* - *Demonstrates compliance with the local council or other drainage authority requirements and avoid adverse impacts on downstream properties* • *Where drainage infrastructure works are required that would be handed over to the local council, provide full hydraulic details and detailed plans and specification of proposed works that have been prepared in consultation with the local council and comply with the local councils relevant standards.*	Section 4 and Section 5
Flooding :	
• *Identify any flood risk onsite having regard to adapted flood studies for the development site, consideration of any relevant provisions of the NSW Floodplain Development Manual and the potential effects of climate change, sea level rise and an increase in rainfall intensity.* • *Assess the impacts of the development, including any changes to flood risk on-site or off-site, and detail design solutions to mitigate flood risk where required*	Section 3

2 Previous Flood Studies and Reports

2.1 North Sydney LGA Flood Study

The North Sydney Local Government Area (LGA) Flood Study (WMAwater, 2017) model was provided to CNDC by North Sydney Council (NSC) to use as the base case flood model for defining flood behaviour in the vicinity of Crows Nest Station. The objective of the North Sydney LGA Flood Study (WMAwater, 2017) was to investigate local overland flooding and mainstream flooding to determine the nature and extent of the flood hazard over the entire LGA. It is acknowledged that this Flood Study model represents the best estimate of flood behaviour in the North Sydney LGA. Key features of the model are described in **Error! Reference source not found.**.

Table 3-1 North Sydney LGA Flood Model Characteristics

Consultant	WMAwater
Industry Standards used	Floodplain Development Manual (2005) and Australian Rainfall and Runoff Guidelines 1987 (AR&R1987)
Year Developed	February 2017
Hydrologic Modelling Software Used	DRAINS
Rainfall-Runoff Modelling Approach	ILSAX
Depression Storage	Paved Area: 1mm Supplementary Area: 1mm Grassed Area: 5mm
Soil Type (Horton Infiltration Curves)	3
Routing Method	Kinematic Wave Equation
Hydraulic Modelling Software Used	TUFLOW
Hydraulic Model Build	TUFLOW.2013-12-AC-w64 (Double Precision)
Hydraulic Model Grid Resolution	2 m

2.2 CNDC Flood Study

Following the approved Crows Nest OSD concept SSD Application, the North Sydney LGA-Wide Flood Study model was been made available to CNDC for the further stages of detailed design. The resolution of this model was increased and the CSSI Approval building footprint, civil roadworks and proposed stormwater upgrades were modelled. The model was updated according to the more recently published Australian Rainfall and Runoff 2016 (AR&R2016) guidelines for flood estimation. The flood model was simulated for both the existing and Stage 2 post-development scenarios to define flood levels and velocities in the vicinity of Crows Nest Station.

Flood protection levels for the revised OSD and station entrances were determined and a flood impact assessment has been undertaken to visualise flood level and velocity impacts caused by proposed works to ensure compliance with Sydney Metro - Chatswood to Sydenham SPIR REMM FH9. The impact of increased rainfall intensity due to climate change was assessed according to AR&R2016 procedures.

3 Proposed Flood Study

A review of the North Sydney LGA Flood Study model was undertaken to determine if the model was fit for purpose for defining flood behaviour within the immediate vicinity of the Site C OSD. A number of refinements were made to the original LGA Flood Study model. Changes adopted for the study are consistent with the Concept SSD Application.

3.1 Hydrologic Model Review

Following a review of the existing hydrologic model, the following refinements were made. These refinements are consistent with the previous assessment and the inherited LGA Flood Study hydrologic model was unchanged.

- The sub-catchment delineation in the LGA Flood Study model was coarse in the upstream reaches of the catchment where the Site C OSD is located. As such, the flood extent in the LGA Flood Study was not defined on the Pacific Highway adjacent to Sites A and B. Sub-catchments "NSB002", "NSB003" "NSB004" and "NSB005" are split into smaller sub-catchment areas to enable the visualisation of overland flow paths upstream of the station and in adjacent road corridors. This was necessary to provide flood protection levels at the site of the OSD around entrances and egress points leading underground.
- Shorter 5 minute and 10 minute storm durations added to the DRAINS model and determined that the 5 minute storm duration was critical storm event for Crows Nest Station and the Site C OSD. This resulted in a marginal increase in flows at Crows Nest station compared to the flows generated by the LGA Flood Study DRAINS model

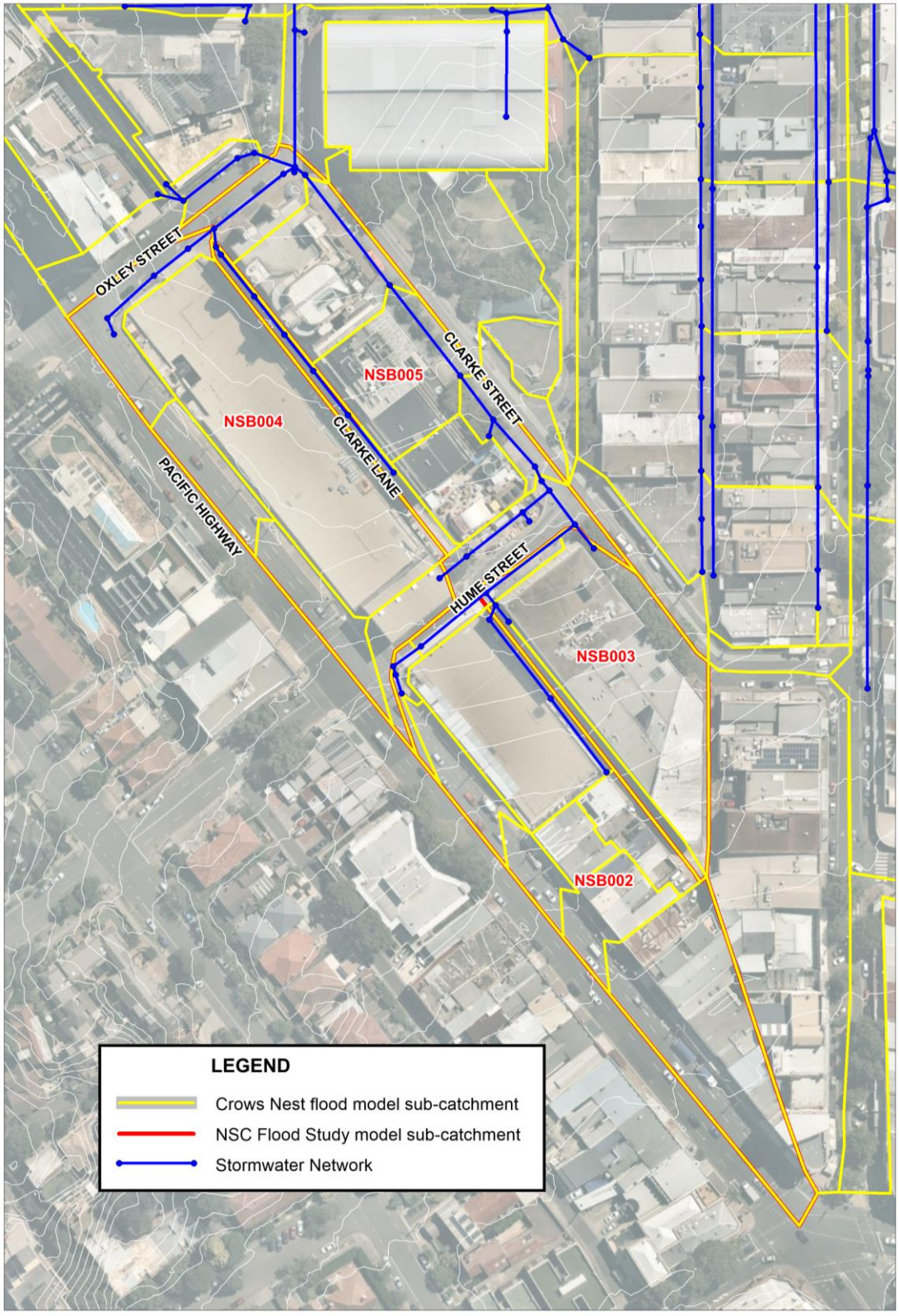

Figure 3-1 Sub-catchment delineation in the vicinity of Crows Nest station.

3.2 Hydraulic Model Review

Following a review of the existing hydraulic model, the following refinements were made. These refinements are consistent with the previous assessment and the inherited LGA Flood Study hydrologic model was unchanged.

- The TUFLOW model resolution was increased by adjusting the 2D cell size from 2 m to 1 m
- The extent of the LGA Flood Study TUFLOW model was trimmed such that the downstream boundary is 400 m downstream of Crows Nest station. This vastly reduced the model computational time
- The TUFLOW model build was upgraded to TUFLOW.2018-03-AB (Single Precision) to utilise the TUFLOW HPC solver with GPU hardware
- Detailed site survey and breaklines in the gutter inverts (issued on 30/08/2019) were read into the TUFLOW model to represent the ground topography for existing conditions around Crows Nest station
- Pipe elements in the LGA Flood Study model less than 450 mm in diameter were assumed fully blocked. CNDC activated these pipe elements to visualise flood impacts resulting from upgrading the stormwater network in the vicinity of Crows Nest station
- Some 1d network branches were discontinuous near the site of interest in the LGA Flood Study TUFLOW model. This was rectified by SMEC
- Some inlet pits in the vicinity of Crows Nest station were moved to the gutter invert captured in the detailed site survey and the ground elevation at the pits was lowered using a “SXL” flag to ensure pit inlet capacity was not underestimated
- AR&R2016 inlet blockages were applied to inlet pits in the vicinity of the station (refer Table 3-1)

Table 3-1 AR&R2016 pit inlet blockages adopted in the vicinity of Crows Nest station

Inlet type	Type of structure	Ar&r2016 design blockage1	Adopted blockage
Sag kerb inlets	Kerb inlet only	0-20%	20%
	Grated inlet only	0-50%	50%
	Combined inlets	Capacity of kerb opening with 100% blockage of grate	50%
On grade kerb inlets	Kerb inlet only	0-20%	20%
	Grated inlet only	0-50%	50%
	Combined inlets	10% blockage of combined inlet capacity on continuous grade	10%

- A post-development TUFLOW scenario was made to represent the Civil Works associated with the Crows Nest station for undertaking a flood impact assessment. The date of issue of the Civil design modelled in TUFLOW is 30 August 2019.
- Stormwater upgrades for the local roads surrounding Crows Nest station were modelled as part of the post-development TUFLOW scenario. The modelled stormwater network was based on the design discussed in Section 4.4 (dated 15 October 2019).

[1] AR&R2016 Book 9, Chapter 6, Table 9.5.1 – Suggested Design and Severe Blockage Conditions for Inlet Pits Book 6, Chapter 6.

These changes to the inherited flood model were made to better represent the topography and stormwater system capacity in the vicinity of the Site. This in turn has allowed SMEC to estimate flow conveyance in the road corridors more accurately near the Site. The flood levels did not change significantly as a result of the changes made to the inherited flood model.

3.3 Flood Modelling Results

Figures showing depth, velocity, flood level impact and velocity impact mapping are provided in Appendix A.

3.3.1 Flood Depth

The flood depths for the Amended OSD scheme are similar to those reported for the Approved Concept Design. Given the positioning of the Site at the top of the catchment and steep gradient of the adjacent roads, the 1% AEP flood depths in the gutter next to the Site are typically less than 150 mm. Similarly, the PMF flood depths in the gutter next to the Site are typically less than 250 mm.

3.3.2 Flood Level Impacts

Flood level impacts were not previously assessed for the OSD.

For the Approved Concept Design for the OSD scheme, 1% AEP flood level impacts are shown in Figure 3-2. As per Sydney Metro – Chatswood to Sydenham SPIR REMM FH9, 1% AEP flood impacts up to 50 mm are acceptable.

It is noted the OSD building footprint covers the same surface area as the existing site. The adverse flood impacts are therefore not a result of flow obstructions related to an increased building footprint occupying the Site, rather by regarding the roads and footpaths near the Site.

Proposed regrading of Hume Street near the intersection with Pacific Highway will direct an additional 0.15 m3/s of flow along Hume Street that would otherwise bypass and continue flowing north-west along Pacific Highway. A large portion of this flow will be captured by the upgraded stormwater system along Hume Street and Clarke Street. Flood level impacts greater than 50 mm are observed in the road corridor along Hume Street as a result of the road level being lifted and the flood level being lifted with it. However, as demonstrated in Figure 3-3, the flood depth increase is less than 50 mm across the site, demonstrating compliance with Sydney Metro - Chatswood to Sydenham SPIR REMM FH9.

The proposed regrading of Clarke Lane has reduced the flood extent on the lane itself but has resulted in a new flood extents along the boundary of 28-34 Clarke Street (corner of Oxley Street and Clarke Street). However, the flood depth at the property boundary is very shallow in the design scenario (less than 50 mm) and the building would not experience above-floor inundation.

The proposed regrading/lifting of Hume Street between Pacific Highway and Clarke Street has caused flood impacts greater than 50 mm in the road corridor, as well as new flood extents along the boundary of 28-34 Clarke Street (corner of Oxley Street and Clarke Street). However, the flood depth at the property boundary is very shallow

in the design scenario (less than 50 mm) and the building would not experience above-floor inundation.

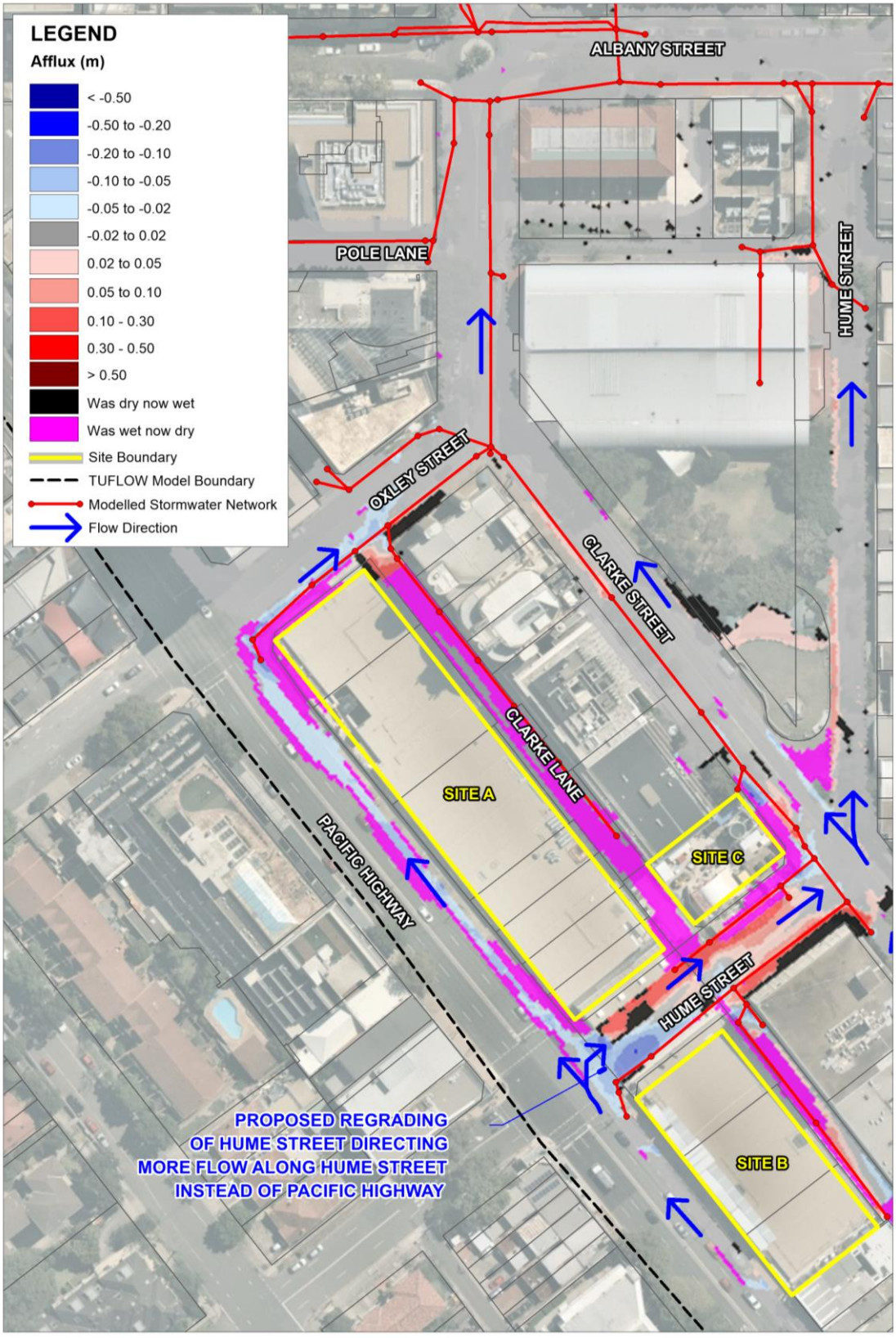

Figure 3-2 1% AEP flood level impacts in the vicinity of Crows Nest Station.

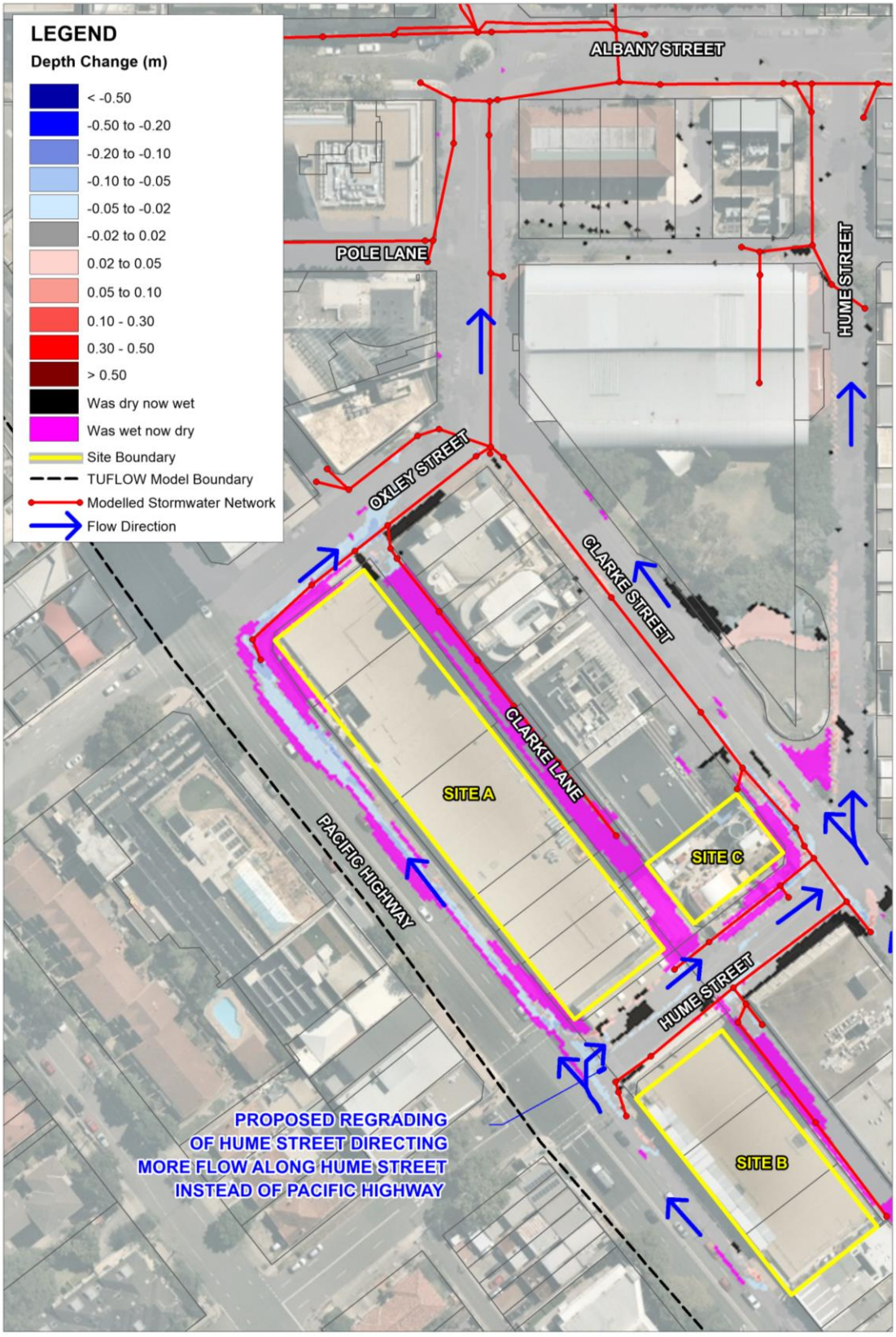

Figure 3-3 1% AEP flood depth impacts in the vicinity of Crows Nest station.

3.3.3 Flood Velocity Impacts

Flood velocity impacts were not previously assessed for the OSD.

The percentage change in flow velocity from the existing scenario to design scenario was mapped to determine if there were any locations subject to new scour risk as a result of the Works. Where existing flow velocities are greater than 1 m/s, all surfaces experiencing a velocity increase are paved and resistant to scour. Percentage changes in absolute velocities less than 1 m/s are not considered significant.

3.3.4 Changes to Inundation Time

As per Sydney Metro – Chatswood to Sydenham SPIR REMM FH9, a maximum increase in time of inundation of 1 hour in the 1% AEP flood event is acceptable. The critical storm duration in the vicinity of the Site is short (5 – 15 minutes) and there is very little flood attenuation occurring due to the steep and paved nature of the catchment. As a result, time of inundation as a result of the Works would not increase.

3.4 Flood Planning Requirements

Sydney Metro – Chatswood to Sydenham SPIR REMM FH10 states that, where feasible and reasonable, station and service entrances to underground stations must be set above the greater of the 1% AEP flood level plus 500 mm freeboard or the PMF. This requirement contradicts the public exhibition version of the Crows Nest OSD concept SSD Application, which states that flood protection levels for all station and OSD entries are to be determined as the maximum of:

- The PMF flood level
- 300 mm above the surveyed ground level at the entrance thresholds.

The study identified the following with this flood protection definition:

- The Approved Concept Design has one OSD egress stair that will be interconnected with the underground railway infrastructure (OSD_01 shown in Figure 3-4). The remaining OSD entrances would either connect with above ground floor levels of the OSD or are not connected with the underground rail infrastructure and therefore do not require additional flood protection requirements
- Providing flood protection by setting entrances 300 mm above the surveyed existing ground level does not account for the possibility of the proposed Civil level at the entrance threshold being higher than the surveyed level. In this case, less than 300 mm freeboard would be achieved.

3.4.1 Sydney Metro City and Southwest Design Criteria

The Crows Nest station design adopted a flood protection level for all entrances, ventilation openings, tunnel portals and other openings into underground railway infrastructure as the maximum of:

- The PMF flood level; and
- 300 mm above the surrounding finished ground level or sufficient to prevent local flash flooding entering the underground structures. At the station entrances, this requirement must be met by sloping the surface away from the threshold and not by a step.

The PMF flood depth at the boundary of Site C would not exceeds 300 mm. This indicates that the governing flood protection level for all entrances, ventilation openings, tunnel portals and other openings into underground railway infrastructure is 300 mm higher than the surrounding finished ground level or sufficient to prevent local flash flooding.

The surrounding finished ground level refers to the proposed Civil level at the site boundary. Surrounding finished ground levels were sampled directly adjacent to the upstream side of the station entrances.

Flood protection levels were determined at a number of locations around the perimeter of the Site for entrances into underground railway infrastructure based on the architectural Revit model issued for coordination on 17 October 2019 (refer Figure 3-4 and Table 3-2). A number of additional accesses to underground infrastructure

have been added since the Stage 1 concept design upon which the Crows Nest OSD SSD Application is based.

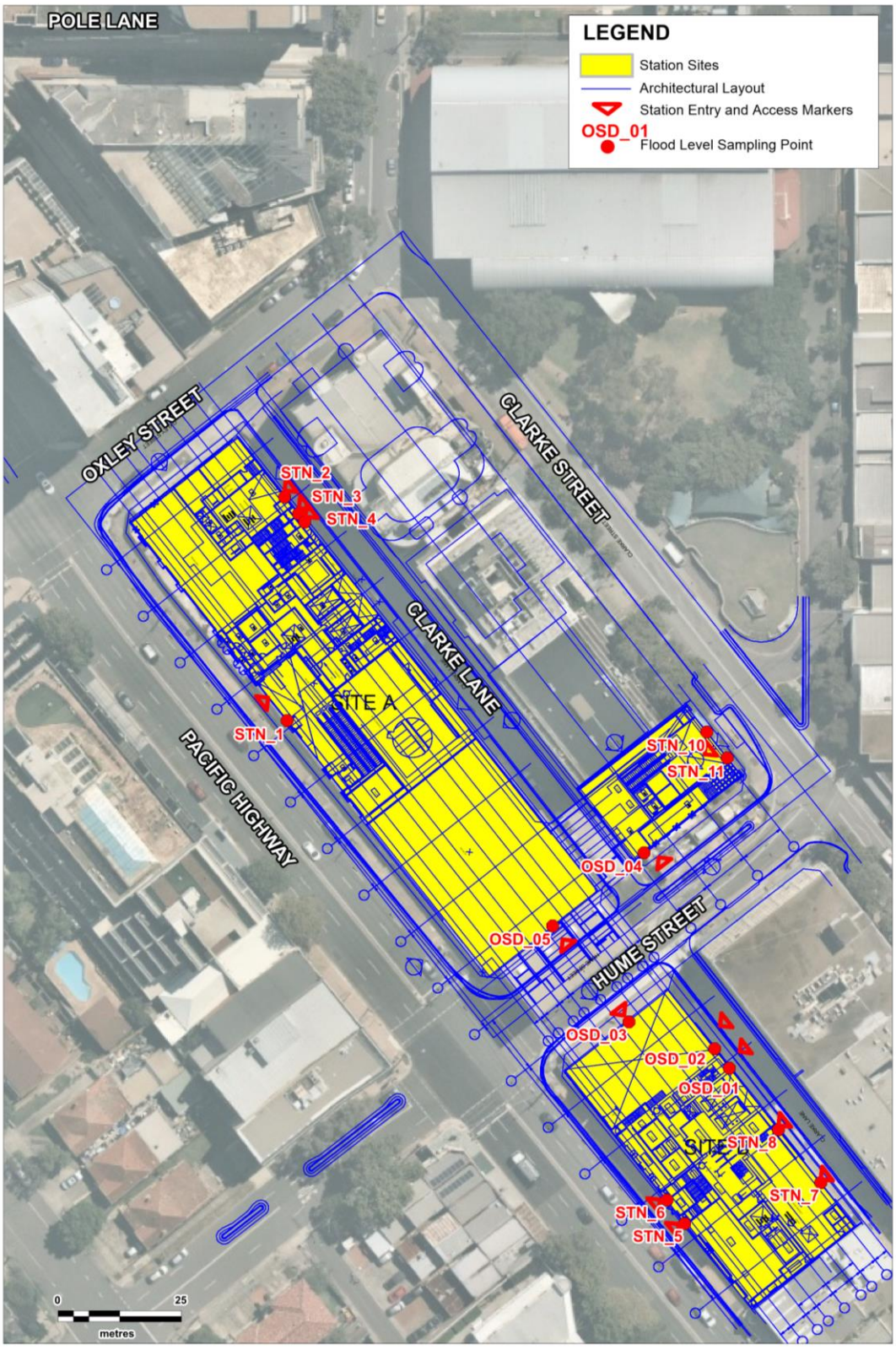

Figure 3-4 OSD Entries and Egresses to the underground Crows Nest station.

Table 3-2 CNDC Stage 2 Site C Design Finished Floor Levels. Comparison provided to Concept Approved Flood Protection Level (FPL).

ID*	ENTRY TYPE	PMF FLOOD LEVEL (M AHD)	SURROUNDING FINISHED GROUND LEVEL (SFGL) (M AHD)	FINISHED FLOOR LEVEL (FFL) (M AHD)	FFL - SFGL (M)	COMPARISON TO EXHIBITED FPL
STN_10	Clarke Street Entrance (Escalator)	88.44	88.38	88.59	210	FPL = 88.92 m AHD FFL = 89.00 m AHD No additional flood protection measures required.
STN_11	Clarke Street Entrance (Lift Shaft)	88.69	88.71	88.69	-20	Entrance not present in Stage 1 Design

* refer to Figure 3-4 above for location of OSD_04, STN_10 and STN_11

All egress routes directed to underground structures are designed with a minimum 300 mm internal step - see DP01 - Architecture Design Package for section details. Therefore, flood protection is achieved to 300 mm above surrounding finished ground level.

The Clarke Street station entrance is subject to significant architectural constraints. As such, it is not possible to achieve 300 mm crest protection to the surrounding finished ground level at the station entrances. However, a more detailed hydraulic assessment using Manning's equation was undertaken adjacent to the station entrance to estimate the required 1% AEP freeboard to prevent ingress of flood water into Crows Nest station.

Based on this hydraulic assessment, providing a freeboard of 210 mm to surrounding finished ground level at the Clarke Street entrance escalator and 210 mm at the Pacific Highway entrance is considered adequate to prevent local flash flooding entering the underground infrastructure.

3.4.2 Other Entrances

No guidance has been provided by Sydney Metro on setting flood protection levels for OSD entrances which do not lead into underground railway infrastructure. However, the flood modelling undertaken as part of this assessment demonstrates that there is low risk of flooding around the Hume Street entrance to Site C as it is outside of the PMF flood extent.

Under the now approved Concept SSD Application entrances not leading to underground railway infrastructure are set above the Flood Protection Level defined in Table 3-3. The Flood Protection Level was based on the larger of the PMF flood level and the surrounding finished ground level at the entrance threshold. No freeboard was considered to be required for these entrances as it is above the PMF flood level.

Table 3-3 Required Flood Protection Levels for OSD entrance.

ID	ENTRY TYPE	PMF FLOOD LEVEL (M AHD)	SURROUNDING FINISHED GROUND LEVEL (SFGL) (M AHD)	REQUIRED FLOOD PROTECTION LEVEL (M AHD)	BASIS OF FLOOD PROTECTION LEVEL
OSD_04*	OSD Entry (Site C)	90.25	90.27	90.27	SFGL

* refer to Figure 3-4 above for location of OSD_04

The Site C OSD entry lobby level meets the requirements for flood level.

3.5 Climate Change Sensitivity

Under the METRON Stage 1 Civil design report, the Department of Environment and Climate Change (DECC) Floodplain Risk Management Guideline – Practical Consideration of Climate Change, version 1 (October 2007) has been relied upon for guidance on increased rainfall intensity caused by climate change. This document recommended undertaking a sensitivity analysis with a 10%, 20% and 30% increase in rainfall intensity to represent the effects of climate change. However, guidance in this document has been superseded by the Australian and Runoff 2016 guidelines.

The adopted climate change factor of 19.7% for the 1% AEP event rainfall is derived from the 2090 representative concentration pathway (RCP) scenario 8.5 conditions for the Crows Nest location, as recommended by AR&R 2016. It is noted that sea-level rise will not impact Site C which is situated at an elevation of around 88 m AHD.

As shown in Appendix A, the 1% AEP + 19.7% increase in rainfall intensity flood level adjacent to the Site C would be lower than the PMF flood level. This indicates that climate change will have no impact on the flood protection levels for the Site C OSD. Furthermore, 1% AEP flood levels are not sensitive to climate change in the vicinity of Crows Nest station. The flood level increase as a result of climate change at station entrances and accesses is shown in

Table 3-4. The Site C OSD entry lobby level has been designed to meet the requirements of changes to flood patterns as a result of climate change.

Table 3-4 Flood Level Climate Change Sensitivity

LOCATION ID*	FLOOD DEPTH (M)		FLOOD LEVEL (M AHD)		FLOOD LEVEL SENSITIVITY TO CLIMATE CHANGE (M)
	1% AEP	1% AEP plus 19.7% increase in rainfall intensity	1% AEP	1% AEP plus 19.7% increase in rainfall intensity	
OSD_04	0.00	0.01	90.08	90.09	0.01
STN_10	0.03	0.04	88.34	88.36	0.02
STN_11	0.07	0.09	88.61	88.64	0.02

* refer to Figure 3-4 above for location of OSD_04, STN_10 and STN_11

4 Stormwater Drainage Design

This section describes the revised stormwater management strategy adopted for the OSD.

It should be noted that in-ground stormwater management, including the modification of existing stormwater assets and installation of new stormwater assets will be undertaken as part of the CSSI approval. This strategy was developed in the CSSI Approval to reduce the potential for the future disruption of footpath access should the construction of OSD be delayed after the completion of the station, removing the need for detrimental construction works to the Metro Station and surrounding areas after the station is operational.

Accordingly, as all servicing will occur as part of the CSSI Approval, no assets will be handed over to Council as part of this application. Separate coordination with Council has commenced/will occur as part of the CSSI Approval.

4.1 Design Objectives

Technical requirements for site detention have been developed to comply with NSC's Stormwater Management Policy and Permissible Site Discharge (PSD) for the 100-year Average Recurrence Interval (ARI).

NSC's detention system design requirement is that the maximum site discharge does not exceed that which would occur during a 5-year average recurrence interval (ARI) event (under existing site conditions) for all storm events up to and including the 100-year ARI event. The discharge for the 5-year average recurrence interval (ARI) event is presented in

Table 4-1**Error! Reference source not found.**.

4.2 Existing Drainage

As shown in Figure 4-1, NSC owns existing underground stormwater drainage assets (solid blue lines) along the southern side of Oxley Street, the western side of Clarke Street and the southern side of Hume Street.

Detailed stormwater survey indicates that the drainage line along Clarke Street to the junction at Oxley Street is a nominal 375mm pipeline. This was assumed to be a 450mm pipe in the Original Scheme. The drainage lines in Hume Street are noted to range between 300mm, 375mm and 525mm nominal pipe size eventually connecting into a 750mm pipe at the corner of Clarke Street and Oxley Street.

Figure 4-1 Pre-Existing Council Stormwater Drainage assets (solid blue lines) indicatively shown (North Sydney Council, 2017)

4.3 Existing Site Runoff

Existing site runoff was derived from the calculated area of each Lot (Sites A, B and C) as part of the approved Concept SSD DA. The existing 5yr ARI runoffs were subsequently calculated and are presented in

Table 4-1 **Error! Reference source not found.**. The calculated runoff values are slightly lower (and therefore more conservative) than those indicated in the approved Concept SSD DA. The design also uses a conservative approach by not applying climate change factors to these existing site runoff flows. This results in more stringent PSD requirements.

The OSD detention strategy is only applicable to the area within the property boundary at Site C. This includes the proposed building footprint and a small pavement catchment that envelopes the building. DRAINS model data has been included in **Error! Reference source not found.**.

Table 4-1 Pre-Existing Condition Site Flows

Catchment	Lot Area (m2)	Existing 5YR ARI flow (L/s)

Site C	606.8	24

4.4 Proposed Drainage Strategy

The proposed detention strategy requires installation of a detention tank within the future OSD for Site C. The stormwater and detention strategy considered in the approved Concept SSD DA at Site C has been retained for the proposed design.

4.4.1 Detention Tanks and Downpipes

All detention tanks will discharge rainwater into the Council stormwater system. The discharge from the site will be restricted to comply with NSC on-site detention and permissible site discharge (PSD) requirements.

The downpipes provided to direct the flows to the detention tank have the capacity to take unattenuated flows for a 100-year ARI event from the site. This is to cater for blocked conditions within the detention tank that could result in unattenuated flows leaving the site.

Site C is considered to be a high-rise building. Vertical face catchments arising from wind-driven rain (as described in Australian Standards AS3500 Section 3.4.4) has not been considered in detention modelling. However, the downpipes are sized to take unattenuated flows from vertical face catchments (for example from balcony drains and awnings) have been design for a 100 year ARI storm event.

4.5 Detention Modelling

Similar to the modelling approach documented in the Approved Concept Design, DRAINS was used for hydrologic and hydraulic modelling to develop a detention strategy. DRAINS is a computer simulation model that incorporates the ILSAX hydrologic model for calculating peak flows and then performs hydraulic modelling of the drainage network including pits, pipes and tanks.

The model was run for storms up to the 100-year ARI events. Results for these events have been included in this Appendix C.

Modelling parameters and assumptions used are consistent with those documented in the Approved Concept Design.

It should be noted that the existing 5 yr ARI flows have been determined with no climate change factor applied to rainfall data. However, the 100 yr ARI discharges for the OSD Configuration use a 19.7% climate change factor applied in line with ARR 2016 recommendations. This conservative approach results in more stringent PSD requirements.

4.6 Modelling Results

The analysis in DRAINS has been undertaken to provide preliminary detention tank sizing. The DRAINS model confirms Site C meets Council's PSD objectives. Refer to Table 4-2 below. See **Error! Reference source not found.** for proposed catchment plan and Appendix C for the proposed OSD DRAINS detention modelling data.

Table 4-2 DRAINS Modelling Results

Catchment	Existing 5YR ARI flow (Permissible Site Discharge) (L/s)	100 YR ARI Discharge Over Station Development Configuration (L/s)
Site C	24	21

The preliminary tank sizing requirements that comply with NSC's Permissible Site Discharge limits are indicated in Table 4-3 below:

Table 4-3 Preliminary Tank Sizing

Catchment	Number of Tanks	Tank Surface Area (m^2)	Tank Height (m)	Tank Orifice Size (mm)
Site C	1	35	2.5	75

4.7 Down Pipe Coordination

As per the approved Concept SSD Application, all proposed OSD down pipes and their connections are to be constructed during the CSSI Approval to enable OSD drainage after the construction of the Crows Nest Station. This is to prevent additional, detrimental, construction works within and around the proposed Crows Nest Station.

5 Stormwater Quality

A water quality strategy has been developed for the OSD design consistent with the Approved Concept Design.

5.1 Water Quality Objectives

The pollution reduction targets from the relevant councils / authorities are summarised in Table 5-1. NSC has confirmed the below targets which differ from those documented in the approved concept scheme. Correspondence with NSC is captured in Appendix E.

Table 5-1 Pollution Reduction Targets

Reference	Pollution Reduction Target				Reference
	Total Suspended Solid (kg/yr)	Total Phosphorous (kg/yr)	Total Nitrogen (kg/yr)	Gross Pollutants (>5mm)	
North Sydney Council	80%	45%	45%	70%	Appendix K
Green Star 5 Star Design and As Built	80%	60%	45%	90%	Green Building Council of Australia, (2010), “Emi-5 Stormwater”

The detailed OSD scheme is targeted to provide necessary pollution reduction measures to achieve the Green Star rating target for stormwater.

5.2 Modelling Approach

5.2.1 MUSIC

A MUSIC model was developed to assess the revised water quality strategy. The modelling approach and assumptions used in the approved Concept Design have been retained. The landscaped terrace on Site C was modelled using the ‘Bioretention’ treatment node in MUSIC.

Refer to **Error! Reference source not found.** for Further MUSIC Data inputs and information.

5.2.2 Methodology

A post development model of the OSD was developed to estimate the pollutant loads generated by the site as a result of re-development.

As part of the MUSIC model developed for the site, treatment systems have been incorporated such as Gross Pollutant Traps (GPTs), Rainwater tanks and proprietary filtration systems. Figure 5-1 below shows the indictive roof type drainage system for Site C.

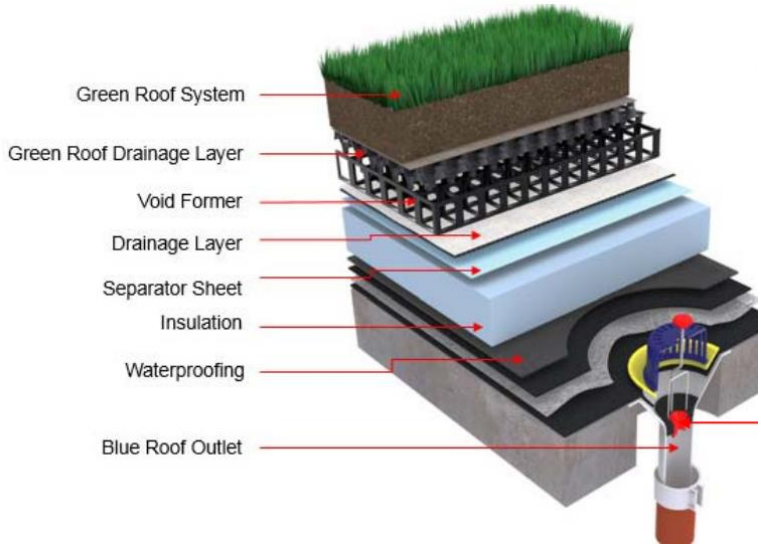

Figure 5-1 Proposed Roof Drainage system

5.3 Model Inputs

Modelling inputs and assumptions including meteorological data, evapotranspiation, soil properties are retained from the original scheme. However, catchment areas for the OSD buildings have changed due to the revised OSD design.

The catchment summary for the revised MUSIC model is presented in the Table 5-2 below.

Table 5-2 Catchment Summary

Catchment ID	Area (ha)	Area Type	Percent Impervious
A	0.115 (Roof Catchment 1) 0.107 (Roof Catchment 2) 0.117 (Roof Catchment 3) 0.015 (Pavement Catchment 1) 0.035 (Pavement Catchment 2-Bypass)	Mixed	100%
B	0.077 (Roof Catchment 1) 0.083 (Roof Catchment 2) 0.009(Pavement Catchment 1) 0.019 (Pavement Catchment 2 -Bypass)	Mixed	100%
C	0.053 (Roof Area) 0.007 (Pavement Catchment -Bypass)	Mixed	100%

A high impervious area was selected as there is a concrete slab under the vegetated area and it is likely that most of the run-off will be captured by the rainwater harvesting system.

5.4 Proposed Treatment Devices

A preliminary MUSIC model was developed, incorporating potential feasible water quality treatment measures to achieve the more stringent Green Star (B) stormwater quality targets. Refer to Table 5-1.

The revised site MUSIC model layout is shown in Figure 5-2. The areas boxed in red represent treatment measures that are the responsibility of the OSD developer to further investigate as part of their design.

Water quality outcomes for the OSD are improved by in-ground treatment methods proposed to be installed as part of the station design. These measures are shown inside the blue box in Figure 5-2. A hydrodynamic separator unit (Humes Humeceptor STC2 or approved equivalent) is proposed to receive and treat catchment runoff from Site A. Litter Baskets (EcoSol or approved equivalent) are also proposed to be installed in several in-ground stormwater pits to capture gross pollutants and suspended solids. Pits with litter baskets incorporate a 350mm drop to facilitate the installation of the basket. They will require regular maintenance and cleaning particularly after major storm events.

Trench drains have been incorporated in the footpath as part of the station drainage design. These will capture and direct footpath runoff to litter baskets and the Humeceptor unit to improve pollutant removal.

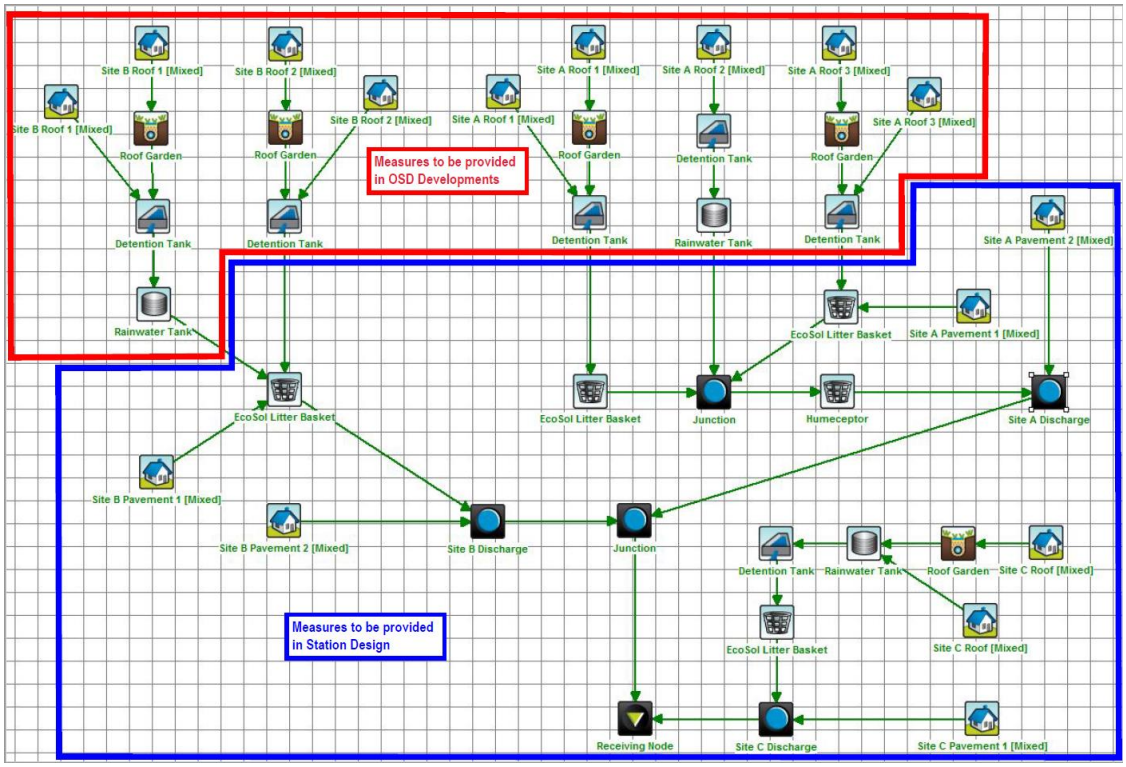

Figure 5-2: MUSIC Model Layout

5.4.1 Treatment Measures within OSD Envelope

The OSD developer will need to incorporate treatment measures within the OSD building design for Sites A and B. For example, roof gardens and rainwater tanks could be used to achieve water quality outcomes. For the roof gardens, the revised MUSIC model assumes 50% of the related roof catchments is treated while 50% will bypass this treatment measure. Detention tanks required for attenuation will also perform a treatment function.

As part of future development applications a detailed water quality analysis to demonstrate the compliance of the OSD with NSC requirements will be required.

5.5 Stormwater Quality Modelling Results

Preliminary MUSIC model results and treatment train effectiveness for the revised scheme are summarised in Table 5-3**Error! Reference source not found.**. Modelled results indicate that the proposed treatment train will meet Council requirements and Green Star target rating targets.

Table 5-3 MUSIC Modelling Results

Model Output Parameters	Developed Scenario		Pollutant Reduction	Green Star rating Targets[1]
	Source Load	Residual Load		
Total Suspended Solids (kg/yr)	1830	268	85.4%	80%
Total Phosphorus (kg/yr)	3.64	1.06	70.9%	60%
Total Nitrogen (kg/yr)	25.2	13.7	45.7%	45%
Gross Pollutants	209	20.1	90.4%	90%

[1] Emi-5 Storwater reduction B targets (Table Emi-5.1; Green Building Council of Australia)

This water quality management strategy will be further developed as part of detailed design of the OSD to meet pollution reduction targets.

6 Conclusion

This report provides an assessment of the stormwater and flooding impacts of the Crows Nest Site C detailed design SSDA.

Detailed flood modelling undertaken since the public exhibition has demonstrated that the amended OSD will not generate adverse flood impacts to nearby properties. It is proposed that flood protection levels for all OSD below ground entrances such as to the underground rail infrastructure are to be set above the PMF flood level or 300 mm higher than the surrounding finished ground level or sufficient to prevent local flash flooding ingress.

For the OSD entries for Site C, the recommended flood protection level shall be the larger of the PMF flood level and the surrounding finished ground level at the entry threshold.

As per approved Concept SSD Application, all in-ground stormwater management, including the modification or diversion of existing stormwater assets will be undertaken as part of the CSSI Approval. This strategy is aimed at reducing the potential for future disruption of footpath access should the OSD construction be delayed after the completion of the station and remove the need for detrimental construction works to the Metro Station and surrounding areas.

The on-site detention strategy has been refined for the Site C OSD. These refinements are consistent with the approved Concept SSD Application. Tank sizing has been revised based on Amended OSD Scheme to meet NSC's permissible site discharge requirements.

The water quality analysis for Site C OSD as part of the Crows Nest Station precinct demonstrates that the treatment train strategy can meet both Council's treatment targets and the Green Star rating target for stormwater. The design for areas of the roof catchments to would meet NSC water quality improvement targets. Other treatment measures include measures such as the proposed rainwater tank.