Blackwattle Bay

State Significant Precinct

Attachment 12:

Water Quality, Flooding and Stormwater Study

June 2021

NSW GOVERNMENT

WATER, RIPARIAN LAND, FLOODING AND STORMWATER STUDY

Blackwattle Bay State Significant Precinct

AWE200202

Prepared for

Infrastructure New South Wales

31 May 2021

Cardno

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Executive Summary

This Flooding and Stormwater Strategy report has been prepared by Cardno (NSW/ACT) Pty Ltd (Cardno) and on behalf of Infrastructure NSW, to form part of the Blackwattle Bay State Significant Precinct Study (SSP Study). The SSP Study seeks a rezoning for new planning controls for Blackwattle Bay, located on the south-western side of Pyrmont.

Study Requirements for the Blackwattle Bay (formerly known as 'Bays Market District') investigation area were issued by the Minister on 28 April 2017. This report specifically addresses items related to Section 21 of the requirements related to water, riparian land, flooding and stormwater.

The key elements and findings of this Water, Riparian Land, Flooding and Stormwater study include:

- Stormwater Management and Water Quality
  - A Concept Stormwater Management Plan (SMP) has been developed
  - The strategy has been assessed using MUSIC software to demonstrate the water quality targets can be met
  - The strategy forms part of a broader Integrated Water Cycle Management Strategy which incorporates a range of water efficiency measures
- Groundwater
  - Available information on groundwater conditions has been reviewed
  - Minimal, if any, impacts are expected in relation to groundwater
- Flooding Assessment
  - A detailed flooding assessment has been undertaken
  - This assessment included modelling of both existing and climate change conditions
  - The assessment demonstrated that the Study Area is subject to overland flows during large storm events and that these can be appropriately managed through the site
  - The assessment demonstrated that the proposed development could have minor impacts on flooding outside the Study Area. It is anticipated that these potential impacts can be resolved during the detailed design stage and through inclusion of a modified drainage network
  - The study demonstrated that increased rainfall as a result of climate change will result in increased flood levels at and around the study site. However, impacts of sea level rise on the precinct will be limited due to the proposed terrain being above the raised sea level
  - Considering the short duration of flooding and limited ability to provide safe evacuation offsite, a shelter-in-place approach is recommended for the Blackwattle Bay SSP

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1 Introduction

Blackwattle Bay offers an extraordinary opportunity to reconnect the harbour, its surrounding neighbourhoods and the city; to showcase Sydney's living culture and stories of Country; to build an inclusive and iconic waterfront destination that celebrates innovation, diversity and community.

This Flooding and Stormwater Strategy report has been prepared by Cardno (NSW/ACT) Pty Ltd (Cardno) and on behalf of Infrastructure NSW, to form part of the Blackwattle Bay State Significant Precinct Study (SSP Study). The SSP Study seeks a rezoning for new planning controls for Blackwattle Bay, located on the south-western side of Pyrmont.

Blackwattle Bay presents a significant opportunity for urban renewal across 10.4 hectares of predominantly government owned land located approximately 1km from the Sydney CBD. NSW Government is also investigating the delivery of a Metro Station in Pyrmont and has recognised the potential to transform the Pyrmont Peninsula with a new 20-year vision and planning framework through the Pyrmont Peninsula Place Strategy.

In 2015 the NSW Government recognised The Bays Precinct as one of the highest potential urban transformation sites in Australia with the release of The Bays Precinct, Sydney Transformation Plan. Following this, the Minister for Planning identified the renewal of Blackwattle Bay and the broader Bays Precinct as a matter of State planning significance and to be investigated for rezoning through the State Significant Precinct (SSP) process. Study Requirements for the Blackwattle Bay (formerly known as 'Bays Market District') investigation area were issued by the Minister on 28 April 2017.

A critical part of Blackwattle Bay's revitalisation and vision has been the NSW Government's decision to relocate the Sydney Fish Market (SFM) from its existing location on Bank Street to the head of Blackwattle Bay. This was sought through a State Significant Development Application (SSDA) process and approved in June 2020. The new SFM was designed alongside the baseline Blackwattle Bay studies to ensure that key aspects of the project are consistent with the vision and principles for Blackwattle Bay.

The outcome of the Blackwattle Bay State Significant Precinct process will be a new planning framework that will enable further development applications for the renewal of the Precinct, connected to the harbour and centred around a rejuvenated SFM. The framework will also provide for new public open spaces including a continuous waterfront promenade, community facilities, and other compatible uses.

This report provides a comprehensive investigation of water, riparian land, flooding and stormwater to address a part of the Study Requirements and support the development of a new planning framework for Blackwattle Bay.

1.1 Blackwattle Bay State Significant Precinct

The Blackwattle Bay SSP Investigation Area ('Study Area') encompasses the land and water area, known as Blackwattle Bay, between Bank Street and the Glebe foreshore shown in **Figure 1-1**. The land is located within the City of Sydney local government area (LGA).

The land within the Study Area is approximately 10.4 hectares (ha) in size. It is largely government owned land containing the SFM (wholesale and retail), recreation and boating operations and facilities. There are three privately owned sites including a concrete batching plant operated by Hymix, seafood wholesaler Poulos Brothers and private developer Celestino which owns further wholesaling facilities. The Blackwattle Bay land area wraps around the southern and eastern edges of Blackwattle Bay and is bounded by Bridge Road to the south and Bank Street to the east. The Western Distributor motorway / Anzac Bridge viaduct is located adjacent to the eastern boundary before traversing over the northern section of the site. The water area of Blackwattle Bay is approximately 21 hectares.

Source: FJMT

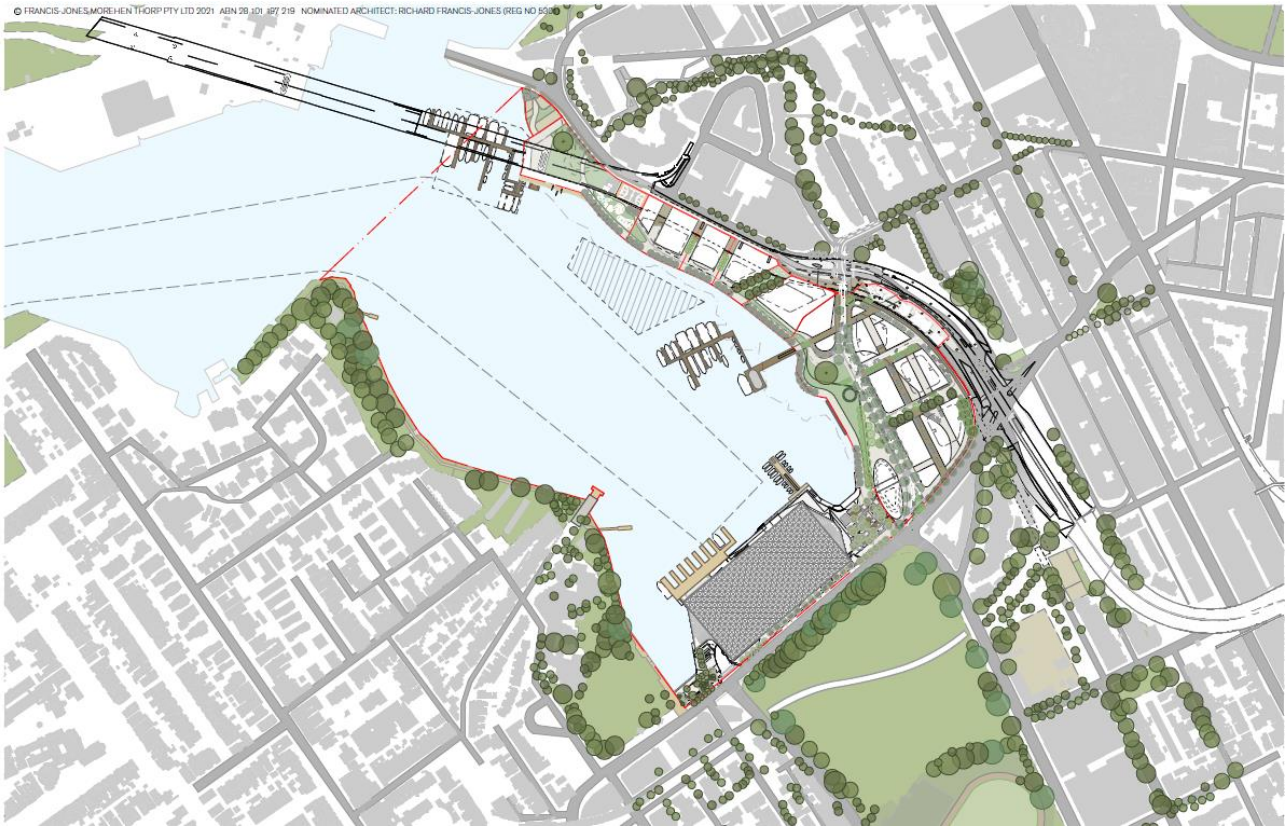
Figure 1-1 Location and Study Area

2 The Proposal

The SSP Study is proposing to rezone Blackwattle Bay with a new planning framework and planning controls to enable its future urban renewal.

The rezoning proposal is based on the Blackwattle Bay Precinct Plan ('Precinct Plan') which provides a conceptual layout to guide the development of planning controls for the precinct and has informed this report. The Precinct Plan is shown in **Figure 2-1** below. The Precinct Plan provides overarching guidance about how the area should be developed based on community and stakeholder input, local character and place, current and future demographics, economic and social trends, cultural and environmental considerations, and urban renewal aspirations and needs regarding land use, community recreation, transportation, housing, and jobs. Key characteristics of the Precinct Plan include:

- New homes, jobs and services close to the CBD including:
  - 5,636 jobs / or approximately 5,600 jobs
  - 2,795 residents /or approximately 2,800 residents
  - 1546 dwellings
- A continuous waterfront promenade – the missing link in an otherwise 15km foreshore walk from Woolloomooloo to Rozelle
- New active transport connections to bring the neighbourhood closer to the harbour through new and improved pedestrian and cycling links
- Improved public transport options and minimised vehicle usage strategies including:
  - Minimising car parking spaces with limited on-street parking.
  - Ferry wharf
  - Opportunity for buses to service through site link
  - Connections to the existing light rail
  - Access to a future Sydney Metro West Station in Pyrmont
- New parks and green space with 30,000 m2 of new open space
- An authentic, and world class new SFM at the heart of Blackwattle Bay
- An authentic place that builds on Indigenous and industrial stories and celebrating the local character.



Source: FJMT

Figure 2-1 Precinct Plan

2.2 Vision & Principles

Principles for a future Blackwattle Bay were formed through extensive community consultation in August 2017. These were further developed in 2019, together with a vision for the precinct. Both are provided below. These have guided the development of the Precinct Plan and will continue to guide future development proposals within the Study Area.

Vision:

"*Blackwattle Bay offers an extraordinary opportunity to reconnect the harbour, its surrounding neighbourhoods and the city; to showcase Sydney's living culture and stories of Country; to build an inclusive and iconic waterfront destination that celebrates innovation, diversity and community.*"

Principles:

1. Improve access to Blackwattle Bay, the foreshore and water activities for all users
2. Minimise additional shadowing to Wentworth Park and Glebe Foreshore (in mid-winter) and create new places with comfortable conditions for people to enjoy.
3. Pursue leading edge sustainability outcomes including climate change resilience, improved water quality and restoration of natural ecosystems.
4. Prioritise movement by walking, cycling and public transport.
5. Balance diverse traffic movement and parking needs for all users.
6. Link the Blackwattle Bay precinct to the City, Glebe Island and White Bay and other surrounding communities and attractors.
7. Mandate Design Excellence in the public and private domain.
8. Integrate housing, employment and mixed uses to create a vibrant, walkable, mixed use precinct on the city's edge.
9. Maintain and enhance water uses and activities.
10. Allow for co-existence and evolution of land uses over time.
11. A place for everyone that is inviting, unique in character, socially inclusive and affordable.
12. Expand the range of recreational, community and cultural facilities.
13. Plan for the future community's education, health, social and cultural needs.
14. Deliver development that is economically, socially, culturally and environmentally viable.
15. Embed and interpret the morphology, heritage and culture of the site to create an authentic and site responsive place.
16. Foster social and cultural understanding and respect to heal and grow relationships.

2.3 Study Requirements

Study Requirements for the Blackwattle Bay (formerly known as 'Bays Market District') investigation area were issued by the Minister on 28 April 2017. This report specifically addresses items related to section 21 of the requirements related to water, riparian land flooding and stormwater. The requirements are summarised in **Table 2-1** and included in **Appendix C.**

Table 2-1 Study Requirements Summary

Study Requirement	Relevant Section of this Report
21.1. Provide an assessment of any potential impacts of the proposal on the hydrology and hydrogeology of the precinct and adjoining areas. Include particular focus on water quality, the extent to which 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). Consider these water quality targets in Sydney DCP 2012: ▪ Reduce the baseline annual pollutant load for litter and vegetation larger than 5mm by 90% ▪ Reduce the baseline annual pollutant load for total suspended solids by 85% ▪ Reduce the baseline annual pollutant load for total phosphorus by 65%, and ▪ Reduce the baseline annual pollutant load for total nitrogen by 45%.	**Section 6** and **Section 8**
21.2. Provide a concept Stormwater Management Plan outlining the general stormwater management measures for the proposal, with particular emphasis on possible WSUD options. This should also include measures for ongoing maintenance including any associated funding approaches for ongoing management.	**Appendix C** and **Section 6.6**
21.3. Consider the effect of climate change and changing rainfall patterns on stormwater and floodplain management and undertake a sensitivity analysis to address the risks and impacts including sea level rise.	**Section 9.6**
21.4. Provide details, and an assessment, of impacts of the proposal on watercourses, wetlands and riparian land on and adjoining the urban renewal precinct, including proposed rehabilitation, management and maintenance, zoning and proposed future ownership of riparian land.	**Section 4**
21.5. Provide a hydrogeological assessment, including details on groundwater quality, quantity, levels and flow, groundwater dependent ecosystems, water licensing requirements, proposed monitoring, and consideration of the NSW Aquifer Interference Policy.	**Section 8**
21.6. Provide a flood risk assessment developed in consultation with City of Sydney Council identifying flooding behaviours for existing and developed scenarios in order to outline the suitability of the land for proposed uses. The flood assessment should identify flooding characteristics i.e. flow, levels, extent, velocity, rate of rise, hydraulic and hazard categories, for the full range of flooding up to the probable maximum flood (PMF), for both mainstream and overland flow path.	**Sections 2.4 and 9**
21.7. Consider the future cumulative flood risk impact across the entire Bays Market District and adjoining land areas.	**Section 9**
21.8. Address the impact of flooding on future proposed development including flood risk to people and properties for key flood events including the 1% AEP and the probable maximum flood (PMF) event. The assessment should address relevant provisions of the NSW Floodplain Development Manual (2005) and the City's Interim Floodplain Management Policy.	**Sections 3.1, 3.5 and 9.5**
21.9. Provide an assessment of possible impacts of the proposal on the flood behaviour (i.e. flow levels, extent, velocities and duration of flooding) and the impact of the proposal on adjacent, downstream and upstream areas.	**Section 9.5.2**
21.10. Provide concept level information on the impacts of future earthworks and filling of land within the proposal. This assessment should be based on an understanding of staging and cumulative flood impacts.	**Sections 5 and 9.5.2**
21.11. Provide preliminary assessment on recommended flood management measures including mitigation works and development controls in accordance with the City's Interim Floodplain Management Policy.	**Sections 9.5.2 and 9.5.3**

21.12. Provide recommendations regarding the most appropriate emergency response strategy to manage risk to life and property.	**Section 9.7**
21.13. Provide concept level details of the drainage associated with the proposal, in accordance with the City's Stormwater Drainage Design Code including stormwater drainage infrastructure and address the impact of stormwater flows on the site from other catchments.	**Appendix C**
21.14. In addition to securing an acceptable level of personal and property safety from flooding, the proposal is to ensure that measures to address flooding can achieve high quality urban design outcomes, including ground floor public – private domain engagement i.e. how ground floor retail can be entered at ground at footpath level, and promote water quality outcomes through measures such as water sensitive urban design (in the public and private domains).	**Section 6** and **Section 9**
21.15. Prepare an implementation plan for the concept Stormwater Management Plan and Flood Risk Assessment.	**Section 6.7**
21.16. Demonstrate, through assessment against established criteria, how the proposed flooding and stormwater strategy achieves acceptable water quantity and quality outcomes, and in particular promotes water sensitive urban design.	**Section 6**
16.2 Provide an Integrated Water Cycle Management Strategy that considers water, wastewater and stormwater. The Strategy must consider water sensitive urban design and any future water conservation measures, including water efficiency and reuse, following appropriate best practice and guidelines and priorities meeting non potable water demands with recycled water or harvested stormwater.	**Section 7**

2.4 Consultation

Consultation related to this study was undertaken with the City of Sydney (CoS) at a Project Working Group (PWG) meeting on 24 September 2020. The approach for this study was presented to CoS and follow-up from CoS was received on 6 October 2020 confirming the approach.

3 Policies and Plans

The policies and plans as summarised below have formed the guiding documents in the development of the water, riparian load, flooding and stormwater strategy.

3.1 Flood Prone Land Policy and Floodplain Development Manual 2005

In NSW, flood risk management promotes a flexible merit-based approach as outlined within the first policy provision of the Flood Prone Land Policy (NSW Government, 2005). The original plan was prepared in 1984 by the NSW Government with the following objective:

"*To reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone land, and to reduce public and private losses resulting from floods. At the same time the policy recognises the benefits flowing from the use, occupation and development of the floodplain*."

The Floodplain Development Manual (FDM) was prepared to support the NSW Government's Flood Prone Land Policy. The manual was prepared to provide a framework for implementing the policy. The Manual has established the flood risk management process across NSW since its release, and sets out the roles and responsibilities of Councils and other consent authorities as well as developers and residents.

Flooding assessment and development of the flooding and stormwater strategy will be undertaken in accordance with the Floodplain Development Manual.

3.2 City of Sydney Local Environmental Plan (LEP) 2012

Section 7.15 Flood Planning of the LEP outlines control and objectives for land below the flood planning level (FPL) which is defined as the 1% AEP flood level plus 0.5m freeboard. The objectives of this section of the LEP are:

- To minimise the flood risk to life and property associated with the use of land;
- To allow development on land that is compatible with the land's flood hazard, taking into consideration projected changes as a result of climate change; and
- To avoid significant adverse impacts on flood behaviour and the environment.

3.3 City of Sydney Development Control Plan (DCP) 2012

The DCP supports the LEP with more detailed planning and design guidelines. It identifies the following objectives with regards to flooding and stormwater management:

- Ensure an integrated approach to water management across the City through the use of water sensitive urban design principles;
- Encourage sustainable water use practices;
- Assist in the management of stormwater to minimise flooding and reduce the effects of stormwater pollution on receiving waterways;
- Ensure that development manages and mitigates flood risk, and does not exacerbate the potential for flood damage or hazard to existing development and to the public domain; and
- Ensure that development above the flood planning level as defined in the Sydney LEP 2012 will minimise the impact of stormwater and flooding on other developments and the public domain both during the event and after the event.

Specific to stormwater quality, the DCP has set targets for urban developments and redevelopments (these are also referenced in the study requirements). All redevelopments are required to achieve the following post-development pollutant load reduction targets.

- Reduce baseline annual load for Gross Pollutants (GP) by 90%;
- Reduce baseline annual load for Total Suspended Solids (TSS) by 85%;
- Reduce baseline annual load for Total Phosphorus (TP) by 65%; and
- Reduce baseline annual load for Total Nitrogen by 45%.

These targets form the baseline for developing and sizing the water quality options.

3.4 Decentralised Water Master Plan 2012 - 2030

The Decentralised Water Master Plan aims to:

- Reduce mains water consumption across the City of Sydney local government area by 10% of 2006 levels by 2030 through water efficiency programs;
- Reduce mains water consumption in Council's own buildings and operations to 10% below 2006 levels by 2030 through water efficiency and connection of Council facilities to park-based or precinct scale recycled or alternative non-potable water supplies;
- Replace 30% of mains water demand across the City of Sydney local government area with recycled or alternative non-potable water generated from local water resources by 2030; and
- Reduce sediments and suspended solids by 50% and nutrients by 15% discharged into the waterways from stormwater run-off generated across the City of Sydney local government area by 2030.

Floodplain management in the Blackwattle Bay SSP needs to consider the objectives of the Master Plan, primarily to look for opportunities to achieve the dual outcomes of flood risk reduction and alternative water delivery (e.g. detention and retention storage, groundwater recharge).

3.5 City of Sydney Interim Floodplain Management Policy 2014

The purpose of the City of Sydney Interim Floodplain Management Policy 2014 is to ensure the flood related objectives of the City of Sydney LEP 2012 are met and to provide specific development principals, controls and guidance not available in the LEP or DCP.

The Policy identifies the following components:

- Development application requirements and inclusions;
- Performance criteria;
- Allowances for concessional development;
- Specific controls relating to residential and industrial / commercial development, fencing, car parking, filling, on-site sewer management and storage hazardous substances;
- Flood planning levels (FPLs) for various development types; and
- Details regarding flood compatible materials.

4 Existing Conditions

The conditions within the Study Area are characterised by highly modified hydrological systems. Drainage systems, which drain the Study Area and also upstream areas, are all piped. The Study Area itself is also dominated by impervious surfaces, such as carparks and roofs. The site does not include any mapped watercourses or wetlands. It follows that it also does not include any riparian land.

5 Proposed Conditions

A preliminary site grading and stormwater layout for the site was developed to inform this assessment. Proposed conditions are presented in **Appendix C** (Stormwater Management Plan) and **Appendix E** (Site Grading).

The site generally falls from Bank Street down to Blackwattle Bay under existing conditions and this is proposed to be maintained under proposed conditions (as shown in the site grading plan). The key modifications to existing conditions include the introduction of new roads and trunk stormwater pipe systems which will modify the location of local overland flowpaths within the site and also discharge locations. Further, the introduction of water sensitive urban design (WSUD) elements, as shown in the stormwater management plan, is expected to contribute to an improvement in local water quality.

An assessment of the potential impacts of the proposed changes is included in the following sections.

6 Stormwater Management and Water Quality

6.1 Strategy Overview

There are a large range of options available to achieve stormwater management targets. Considerations in developing a strategy for the Study Area have included:

- Performance of specific measures to achieve objectives;
- Ownership (measures on private vs public land);
- Maintenance requirements; and
- Staging of development.

It is important to note that the various items discussed below are considered to be flexible and it is expected that this strategy will evolve as the precinct plans are progressed and further design detail established.

The minimum requirement is to adopt water sensitive urban design (WSUD) principles in order to meet City of Sydney water quality targets as detailed in the Study Requirements and summarised in **Section 0**.

The general strategy that has been adopted is:

- Filtration devices (either bioretention/raingardens or cartridge systems) have been applied to all areas. These could ultimately be applied in various forms to suit the development (eg; cartridge systems within building footprints, tree pits within road reserves, small raingardens in road reserves or open spaces, larger bioretention basins in open spaces).
- Potential to provide gross pollutant traps (GPTs) as end of pipe systems;
- Potential to harvest rainwater from roofs for potable or non-potable purposes within buildings; and
- Potential to harvest stormwater to reuse for irrigation or other non-potable purposes.

Trunk drainage infrastructure (pits and pipes) will be required to be constructed to suit the proposed precinct plan layout. A preliminary layout has been provided as part of the concept Stormwater Management Plan included in **Appendix C**. We note that on-site detention (OSD) is not proposed as part of this strategy. This is due to:

1. The Study Area is largely impervious under existing conditions and therefore no measurable increase in peak flows is anticipated once development occurs; and

2. The Study Area discharges directly to Blackwattle Bay where any potential increase in peak flows would have no measurable effect.

6.2 Water Quality Targets

The Study Area drains directly into Blackwattle Bay. The Baseline Assessment of Ecological Structure and Environmental Conditions at The Bays Precinct (University of NSW, 2017) recommends that, in order to improve water quality to restore various species to Blackwattle Bay, "a reduction in contaminant loads from stormwater" is required. This report also provides information on the environmental condition of sediments. Grab samples were collected at various sites adjacent to natural or artificial habitats to measure nutrients and metals. Sediments found were predominantly silty with the highest concentration of metal at Blackwattle Bay. The sediment concentration of around 2000mg/kg of total nitrogen and 1000mg/kg of phosphorous were found. The metal and nutrient levels were found to be above recommended values.

No additional water quality information was available to establish baseline water quality for Blackwattle Bay. In addition, there was no information on any existing Water Sensitive Urban Design (WSUD) features within the Study Area and it is assumed that none of any significance are present.

The Sydney Development Control Plan (DCP) 2012 sets stormwater quality targets for urban developments. All developments greater than 1,000m^2 are required to achieve the following reductions in post-development baseline (ie. proposed development without any water quality treatment) annual pollutant loads:

- Gross Pollutants (GP) (litter and vegetation >5 mm) 90%
- Total Suspended Solids (TSS) 85%
- Total Phosphorus (TP) 65%
- Total Nitrogen (TN) 45%

These targets have been adopted for the purpose of this assessment.

6.3 Water Quality Assessment

6.3.1 Model Set-Up

The industry standard Model for Urban Stormwater Improvement Conceptualisation (MUSIC) was used to assess the performance of the proposed stormwater management strategy. The City of Sydney WSUD Technical Guidelines (Alluvium, 2014) were used as a basis to set-up a MUSIC model for the proposed development.

Climate Data

Pluviograph rainfall data was obtained from City of Sydney's MUSIC-link data. Details are summarized in **Table 6-1**.

Table 6-1 Rainfall Data

Bureau of Meteorology Station No.	066062
Location	Sydney Observatory Hill
Data Period – Start	1/01/1982
Data Period – End	1/01/1986
Data Type	Pluviograph (6-minute)
Number of Years	4
Average Annual Rainfall (mm)	1290

Potential Evapo-transpiration (PET) data was also obtained from MUSIC-link. Average monthly PET is summarised in **Table 6-2**.

Table 6-2 Average Monthly Potential Evapo-transpiration (PET) (mm/month)

Month:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
PET:	180	135	128	85	58	43	43	58	88	127	152	163

Land Use

The proposed land use types within the Study Area were established based on the precinct plan. The land uses, representative surface types, areas and adopted impervious percentages for the purposes of the MUSIC model are provided in **Table 6-3**.

Table 6-3 Proposed Land Use and Catchment Characteristics

Land Use	Surface Type	Area (ha)	% Impervious
Roof	Roof	2.54	100%
Public Domain / Open Space	Mixed	3.1	0%
Paved / Roads	Sealed Road	0.99	100%
Total		**6.63**	**53%**

Rainfall Runoff Parameters

The adopted rainfall-runoff parameters are listed in **Table 6-4**. The pervious area properties have been based on sandy loam soils, which assumes the public domain will largely have imported soils for planting purposes.

Table 6-4 Rainfall Runoff Parameters

Parameter	Roof	Public Domain / Open Space	Paved / Roads
Impervious Area Properties			
Rainfall Threshold (mm/day)	0.3	1.5	1.5
Pervious Area Properties			
Soil Storage Capacity (mm)	-	195	-
Soil Initial Storage (% of Capacity)	-	30	-
Field Capacity (mm)	-	135	-
Infiltration Capacity Coefficient –a	-	250	-
Infiltration Capacity Exponent –b	-	1.3	-
Groundwater Properties			
Initial Depth (mm)	-	10	-
Daily Recharge Rate (%)	-	60	-

Parameter	Roof	Public Domain / Open Space	Paved / Roads
Daily Baseflow Rate (%)	-	45	-
Daily Deep Seepage Rate (%)	-	0	-

6.3.2 Pollutant Generation

In MUSIC, stormwater quality is characterised by event mean concentrations (EMC) for storm flow and base flow conditions. Base flow parameters are summarised in **Table 6-5** and storm flow parameters are summarised in **Table 6-6**. Baseflow parameters are only relevant to pervious areas and hence these are the only parameters included in **Table 6-5.**

Table 6-5 Base Flow Pollutant Concentration Parameters

Surface Type	Concentration (mg/L-log$_{10}$)					
	TSS		TP		TN	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Roof	-	-	-	-	-	-
Public Domain / Open Space	1.20	0.17	-0.85	0.19	0.11	0.12
Paved / Roads	-	-	-	-	-	-

Table 6-6 Storm Flow Pollutant Concentration Parameters by Land Use

Surface Type	Concentration (mg/L-log$_{10}$)					
	TSS		TP		TN	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Roof	1.30	0.32	-0.89	0.25	0.30	0.19
Public Domain / Open Space	2.15	0.32	-0.60	0.25	0.30	0.19
Paved / Roads	2.43	0.32	-0.30	0.25	0.34	0.19

6.3.3 Proposed Measures

Given the limited design details available during precinct planning, a simplified approach has been used to demonstrate that the water quality targets are able to be met for any future proposed development. This approach has included sizing a total bioretention filter area that would be required to meet the targets, but understanding that this would be:

- distributed throughout the development proportional to contributing catchment areas; and/or
- reduced/substituted at a later date through incorporating other measures such as proprietary filtration devices, green roofs, rainwater tanks and stormwater harvesting systems to best suit the final development and optimise potable water savings.

The design parameters adopted for the bioretention systems are shown in **Table 6-7**.

Table 6-7 Bioretention Input Parameters

Parameters	Values
Saturated Hydraulic Conductivity (mm/hr)	100
Filter Depth (m)	0.6
Extended Detention Depth (m)	0.1
TN Content (mg/kg)	600
Orthophosphate Content (mg/kg)	40
Exfiltration Rate (mm/hr)	0.0
Base Lined	Yes
Submerged Zone	No

6.4 Model Setup

The MUSIC model set-up for the proposed development with bioretention treatment included is shown in **Figure 6-1.**

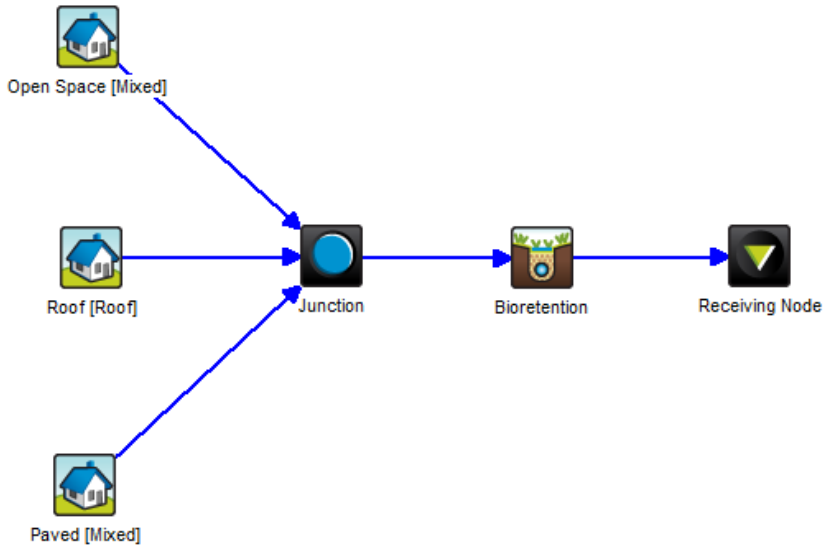


Figure 6-1 MUSIC Model Set-up

6.5 Model Results and Discussion

The water quality modelling results for the key pollutants are summarised in **Table 6-8** and this demonstrates that the water quality targets can be met.

Table 6-8 Water Quality Results

Pollutant	Load Generated (kg/year)	Residual Load after Treatment (kg/year)	% Reduction Achieved	% Reduction Target
Gross Pollutants (GP)	1,100	3.6	99%	90%
Total Suspended Solids (TSS)	3,640	468	87%	85%
Total Phosphorus (TP)	10.6	3.8	65%	65%
Total Nitrogen (TN)	113	39	66%	45%

To achieve the targets, a total bioretention filter area of 3,100 m^2 was found to be required. This represents approximately 0.5% of the total Study Area and is typical of the area required to achieve targets for similar developments.

The results of the MUSIC modelling indicate that there is a WSUD solution capable of achieving the water quality targets.

In addition to achieving the water quality targets, applying WSUD principles includes consideration of reducing runoff volumes to more closely match natural levels. The total runoff from roofs within the Study Area is estimated in the model to be approximately 32 ML / year, this indicates there is significant potential to collect and harvest rainwater for use within buildings. However, the best approach for each building will depend on the demand profiles (how is water expected to be used in each building) and also roof types (it is expected that some or all buildings would include green roof areas which would reduce the predicted runoff volume). Each building would include an assessment to determine the optimal approach in this regard. The flow on effects to other water quality measures would then need to be considered.

Reducing runoff volumes could also be achieved through a stormwater harvesting system. This could include an offtake from one or more of the larger stormwater drainage lines, storage in a tank (most likely underground) and then a treatment system prior to reuse (typically for irrigation). The feasibility of a system such as this would typically require there to be a significant irrigation demand (the cost to treat stormwater for potable uses is not typically cost effective) and is therefore dependent on the landscape design. As the landscape design develops, if a high irrigation demand is considered likely, then further consideration of alternative sources such as stormwater harvesting is recommended. Similar to rainwater harvesting, the flow on effects to other water quality measures would need to be considered if this was pursued further.

The model also assumes an ‘at source’ treatment approach is adopted and doesn’t specifically model any GPTs. If there are significant areas within the public domain which are unable to drain to bioretention or filtration devices, then GPTs may be appropriate. To treat only the Study Area, these should be located at connection points to the trunk drainage system. There is also an opportunity to consider GPTs on the trunk drainage system itself, which would treat runoff from catchments outside of the Study Area, to the east.

6.6 Ownership and Maintenance

Ownership and maintenance responsibilities of WSUD assets are expected to rest with the land owner or responsible government authority. Indicatively, assets located within:

- Private buildings or infrastructure located within individual lot boundaries would be expected to be privately owned and maintained
- Road reserves would most likely be owned and maintained by the government authority responsible for road maintenance
- Public open spaces will be owned at either a local or state government agency level

The responsible government authority for public open spaces and road reserves cases could be the City of Sydney or a state government entity.

Ownership and maintenance of the trunk stormwater network is expected to rest with the City of Sydney.

6.7 Implementation

The implementation of stormwater measures will depend on the delivery strategy that is ultimately adopted for the broader precinct. Most stormwater assets are expected to be installed in combination with other assets (eg; any WSUD and stormwater pits/pipes in road reserves would be installed during road construction). However, depending on the ultimate staging of the development, there may be a requirement to install some stormwater pipes through to their outfall location to Blackwattle Bay, even when construction of roads or open spaces has not yet occurred. Further assessment would be undertaken during subsequent design phases to ensure construction of all stormwater assets was appropriately staged.

Flooding also needs to be considered as part of this delivery strategy, to ensure that overland flows are appropriately managed at all times. In particular, attention would need to be given to overland flows from external catchments. The most significant overland flow path through the development occurs in the extension of Miller Street (Refer **Section 9.5.3** for further details). However, given this is a relatively short length of road reserve and would most likely be constructed in a single stage it is expected this can be easily managed.

7 Integrated Water Cycle Management Strategy

The stormwater management strategy, as outlined in **Section 6.1**, forms a significant component of the broader integrated water cycle management strategy (IWCMS). In addition to stormwater management, the Ecologically Sustainable Development (ESD) Report (AECOM, 2021) identifies a range of water initiatives which could be implemented within the precinct, some of which are also addressed in detail in this report.

At a high level, the IWCMS includes water in the public domain (road reserves and open space) being managed through WSUD initiatives as described in **Section 6.1.** Within private lots, it is expected that **o**ther water initiatives will be implemented (subject to further assessment of benefits and challenges) as per the ESD Report, including:

- Water efficiency measures and fixtures;
- Rainwater harvesting; and
- On-Site water recycling systems

The ESD Report also recommends a range of planning controls, which will influence which initiatives are ultimately adopted. This includes consideration of Green Star, BASIX and NABERS targets related to water.

8 Groundwater

The Revised Geotechnical Report for Proposed Baysmarket District (J&K Geotechnics, July 2017) provides background information on the geology at the site. The site is underlain by the Hawkesbury Sandstone of the Wianamatta Group, consisting of medium to coarse grained quartz sandstone with very minor shale and laminate lenses. At least two dolerite dykes are believed to extend through the site in a rough north-west alignment.

Groundwater is expected to be present within the Hawkesbury Sandstone at the site and will be a consideration for any future basement excavation, however no significant impacts are expected and no groundwater dependent ecosystems have been noted within the Site Area.

9 Flooding Assessment

9.1 Introduction

This flooding assessment has been undertaken in accordance with the principles contained in the NSW Floodplan Development Manual (2005) and the City of Sydney Interim Floodplain Management Policy

9.2 Previous Studies

9.2.1 Blackwattle Bay Catchment Flood Study (FS) and Floodplain Risk Management Study (FRMS) (WMAwater 2015)

The Study Area is located within the Blackwattle Bay catchment. In 2015 WMAwater undertook the Blackwattle Bay Catchment Flood Study (FS), Floodplain Risk Management Study (FRMS) and Floodplain Risk Management Plan (FRMP) for the CoS as part of the NSW State Government floodplain planning process. These studies and plans provide the basis for the future management of those parts of the Blackwattle Bay catchment which are flood liable and within the CoS local government area.

9.2.2 New Sydney Fish Market Flooding and Water Quality Assessment (Cardno 2019)

Cardo undertook an assessment of impacts of the proposed new Sydney Fish Market on flooding. The flood model developed as part of the Blackwattle Bay Catchment Flood Study was utilised as a basis for undertaking the flooding assessment for the new Sydney Fish Market. The model was updated to include the following:

a) Terrain

The terrain adopted for the Blackwattle Bay flood model was based on a combination of 2007 and 2008 LIDAR data. Detailed ground survey for the Blackwattle Bay SSP and Bridge Road was included in the model. This has been incorporated into the model terrain to provide greater definition of the existing surface profile within the Study Area.

b) Building Footprints

The existing building footprints in the Blackwattle Bay Catchment Flood Study model were reviewed and it was identified that the building polygons did not match with the latest Nearmap imagery within the Study Area. A number of existing buildings within the Study Area have therefore been refined based on this more recent aerial imagery (Nearmap 2017) to provide a better representation of flood behaviour in the existing Conditions.

c) Pit and Pipe Network

The pit and pipe network adopted in the model has largely been based on the City of Sydney (CoS) GIS database dated March 2011. Where the pit and pipe information was not available, estimates were made using engineering judgment, site inspection, and via Street View in Google Maps. A more recent GIS database received from the CoS in September 2017 was used to update the pit and pipe network within the Study Area to allow more accurate representation of the existing flood behaviour.

The Blackwattle Bay Catchment FS model was established as a regional model for the entire catchment. It adopted the following methodology for the pit and pipe network:

- The hydraulic capacity of inlet pits has not been assessed in the model and unlimited capacity was assumed for all inlet pits;
- Pipes with a diameter less than 450 mm have been excluded from the model; and
- A blockage factor of 25% has been applied to all the modelled pipes.

This approach effectively applies blockage to the entire network upstream rather than just the immediate upstream pits. This usually results in the majority of pipes in the network running full in the smaller events and does not provide an accurate representation of the actual capacities of the pipe network.

Inlet capacity is one of the key factors that may constrain flows into the drainage system in urban hydraulic modelling. The capacity of inlets depends on the depth and velocity of approaching run-off and the configuration of the inlets. As observed in the stormwater network assessment undertaken in the flood study (WMAwater 2015), the majority of the pipes in the network are running full in relatively small events.

To address these limitations the model was refined to incorporate additional details within the Blackwattle Bay SSP including the new Sydney Fish Market. The following approach has been adopted for the pit and pipe set-up:

- The surface inflows were separately defined for different pit types in the model. Pit inflow relationships were defined in terms of flow depths versus pit inflow;
- The kerb inlet pits in the study area are typically sag or on grade pits and the types are as follow:
  - Lintel and single grate with the inlet lengths of 0.9m, 1.2m, 1.8m, 2.4m, 3.0m, 3.6m and 4.2m;
  - Lintel and double grate with the inlet lengths of 0.9m, 1.2m, 1.8m, 2.4m, 3.0m, 3.6m and 4.2m;
  - Grated pit only; and
  - Kerb inlet pit without grate with various lintel lengths;
- The following assumptions for the pits within the study area were made to calculate the inlet curves:
  - Road cross fall or side slope is 3%;
  - Gutter cross fall is 8%;
  - Longitudinal grade is 1%;
  - Gutter width is 0.5m;
  - Manning's "n" for streets is 0.014; and
  - Manning's "n" for gutters is 0.013;
- For large specialised inlet pits (double grate) the length of the grated lid has been doubled;
- Blockage factors for pits and pipes have been adopted based on Council's stormwater drainage design specification as shown in **Table 9-1** below;
- The pit inlet rating curves have been adopted for the on-grade and sag pits within the Study Area and its surrounds. Figure 9-1 shows the area for which pit inlet curves have been adopted in the flood model;
- Pipes with a diameter less than 450 mm have been included in the model for the Study Area and its surrounds as shown in **Figure 9-1**.

Table 9-1 Pit design blockage factors

Pit type	On Grade Blockage factor	Sag blockage factor
Kerb inlet <= 1.0m	50%	70%
Kerb inlet >1.0m	20%	50%
V grate or Grate only	90%	90%
Strip drain or other	95%	90%

d) Proposed new Sydney Fish Market

- The Tuflow model was further modified to include details of the Concept Design and Stage 2 Main Works for the new Sydney Fish Market as follows:
  - Extending the model to include the Study Area and proposed buildings extents;
  - Proposed Sydney Fish Market building;
  - Finished surface levels of the public domain;
  - New finished surface levels for Bridge Road;
  - Inclusion of proposed drainage networks for the Eastern Plaza and western Plaza (refer below for details);

- Modifications to the outlet structures discharging into the bay (refer to SFM Structures, Civil and Maritime DA Design Report, Mott Macdonald, 26 September 2019).
- Eastern/Civic Plaza Drainage Network
- Western Plaza Drainage Network

The modified Tuflow model including the Fish Market Concept Design is referred to as the Sydney Fish Market Proposed Conditions model in this report.

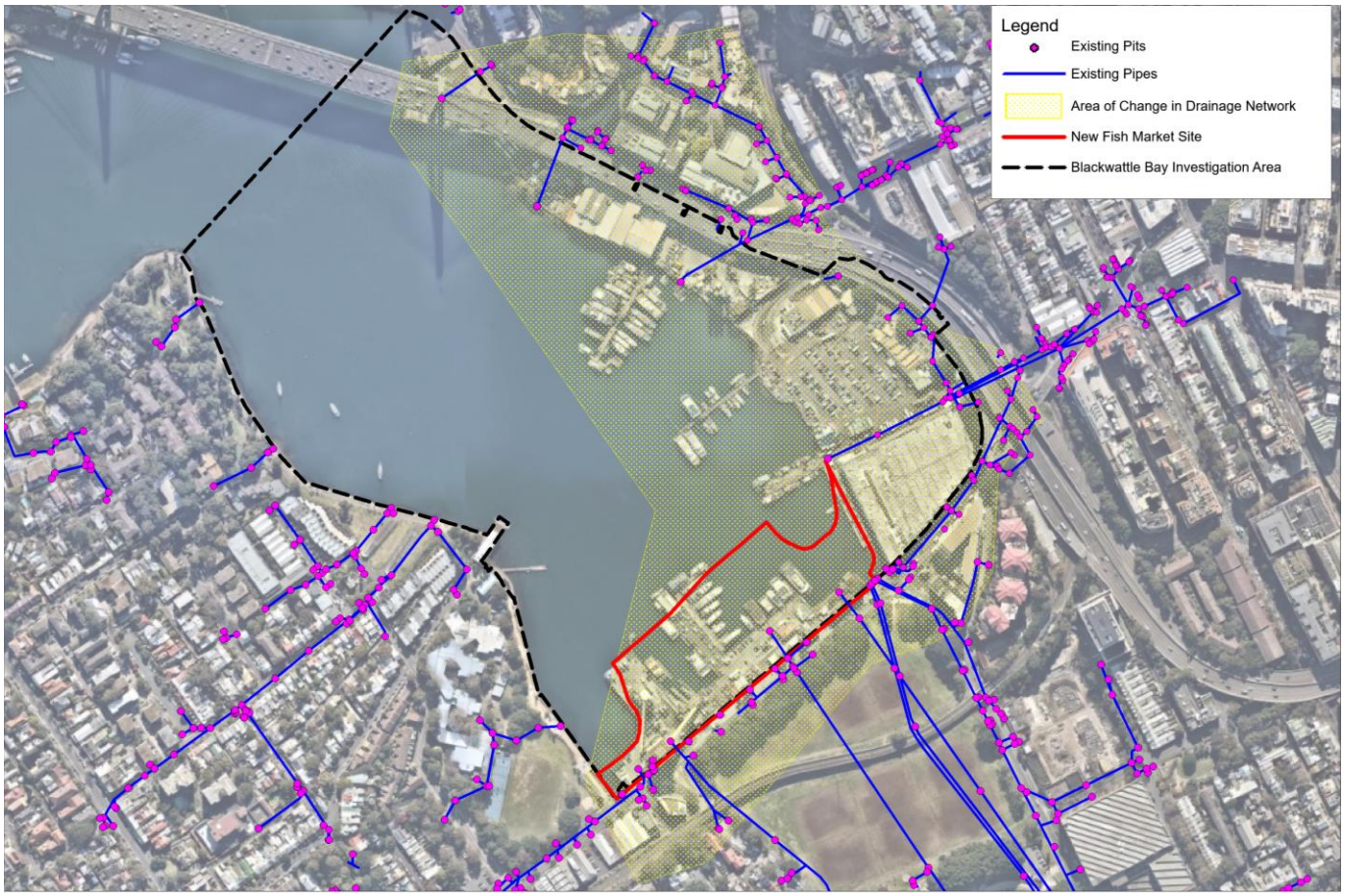


Figure 9-1 Area of change in drainage network

9.3 Modelling Approach

9.3.1 Pre-development Conditions Model

The Sydney Fish Market Proposed Conditions model was adopted for the purpose of this study. The model was further modified to provide a better representation of flood behaviour within the Study Area. Below are the details of model and modifications applied into it to form the Pre-development Condition model for the current study:

> Additional survey was included in the model;

> Model topography was modified to assure the flowpaths under the Western Distributor are represented appropriately;

> Building footprints for the study site were edited to better represent the existing conditions;

> Minor edits to the location rainfall inflow polygons were undertaken.

The above modifications are discussed in further detail in Sections 9.3.1.1 to 9.3.1.5.

9.3.1.1 Hydrology

The Blackwattle Bay catchment is divided into 720 sub-catchments. Review of the Blackwattle Bay Flood Study model indicates that the discreet inflow method was adopted for the hydrology calculations within the TUFLOW

model. In this method, rainfall is applied to each sub-catchment and the flow generated is applied at a discreet region or “inflow” location within that sub-catchment. This approach is suitable for the purposes of this study. The location of some of inflow polygons within the study site were modified minorly to provide a better application of inflows into the model.

9.3.1.2 Terrain

The topography was adopted from the Fish Market Proposed Conditions model which includes survey for Blackwattle Bay SSP and Bridge Road as well as the proposed concept design for the new Fish Market. The model topography was further updated to include the detailed survey of Bank Street undertaken by Craig & Rhodes (2015). The Bank Street and Bridge Road surveys are provided in **Appendix B** of this report. In addition to that the topography was modified to make sure the flowpaths under the Western Distributer are represented appropriately.

9.3.1.3 Building Footprints

Building footprints were adopted from the Fish Market Proposed Conditions model which includes the existing buildings plus the proposed new Sydney Fish Market buildings. The building footprints were further modified within the study area to provide a better presentation of the existing buildings.

9.3.1.4 Downstream Boundary Condition

A water level of 1.38 m AHD was adopted as the downstream boundary condition (similar to Fish Market Proposed Conditions model). This level is the 5% AEP ocean water level in Sydney Harbour.

9.3.1.5 Pit and Pipe Network

Drainage network was adopted from the Fish Market Proposed Conditions model which includes the existing drainage network plus the proposed new Sydney Fish Market drainage. Dummy culverts were included in the model to represent railway opening under Western Distributer.

9.3.2 Critical Duration

Blackwattle Bay Catchment Flood Study (WMAwater 2015), had adopted the 2 hour as the critical duration for all events excluding the Probable Maximum Flood (PMF). For the PMF, the 1 hour duration was determined to be the critical.

For the purpose of current assessment, considering the size of the catchment associated with the study area, a range of durations were tested and it was concluded that 15 minute is the critical duration for all the events except from PMF. For the PMF event, 15 minute, 30 minute and 1 hour durations were run and peak of the results were extracted.

9.4 Existing Conditions Flood Behaviour

The hydraulic model was run for the 1% Annual Exceedance Probability (AEP) and PMF events. Peak levels, depths, velocity and hazard were established for the existing Conditions. These have been provided in **Appendix D**.

A summary of the results provided is as follows:

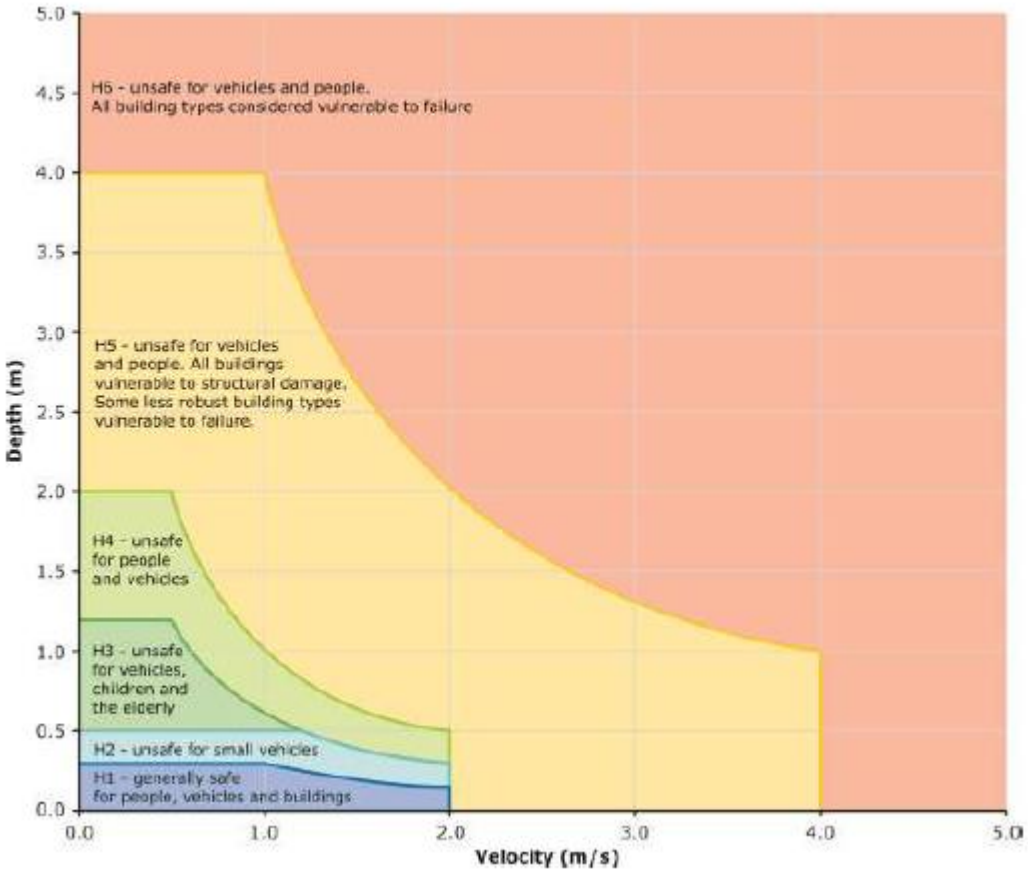
- Figure 1: Existing 1% AEP Flood Depth and Water Level Contours
- Figure 2: Existing 1% AEP Flood Velocity
- Figure 3: Existing 1% AEP Flood Combined Hazard
- Figure 4: Existing PMF Flood Depth and Water Level Contours
- Figure 5: Existing PMF Flood Velocity
- Figure 6: Existing PMF Flood Combined Hazard

Under the Existing Conditions in the 1% AEP and PMF events the study area is mostly flood free with the exception of the overland flow coming from Miller Street and discharging into the bay and also localised water ponding at the existing carpark and adjacent to the bay.

Combined hazard categories were adopted to assess the flood hazard at and around the study site. A general classification of flood hazard on a floodplain and also vulnerability curves are presented in **Figure 9-**

2 (source: Technical flood risk management guideline: Flood hazard, 2012). The combined curves are divided into hazard classifications that relate to specific vulnerability thresholds as described below:

- **H1:** Generally safe for vehicles, people and buildings.
- **H2:** Unsafe for small vehicles.
- **H3:** Unsafe for vehicles, children and the elderly.
- **H4:** Unsafe for vehicles and people.
- **H5:** Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure.
- **H6:** Unsafe for vehicles and people. All building types considered vulnerable to failure.



Source: Technical flood risk management guideline: Flood hazard, 2012

Figure 9-2 Combined Flood Hazard and Vulnerability Curves

According to the results there is no flood hazard across the majority of the site due to being outside the flood extent in all events up to PMF. Flood hazard of category H5 is observed along the overland flow coming from Miller Street and also at the localised water ponding at the existing carpark and adjacent to the bay.

9.5 Proposed Conditions (Concept Design) Flood Behaviour

The Existing Conditions flood model was revised to represent the proposed Blackwattle Bay SSP precinct through inclusion of the proposed grading. The proposed grading plan based on the design undertaken by Cardno (Nov 2020) as included in **Appendix E**.

The existing building footprints were also revised to represent the proposed building footprints for the Blackwattle Bay SSP. **Figure 9-3** shows the changes in the terrain levels and building footprints in the Proposed Conditions compared to the Existing Conditions.

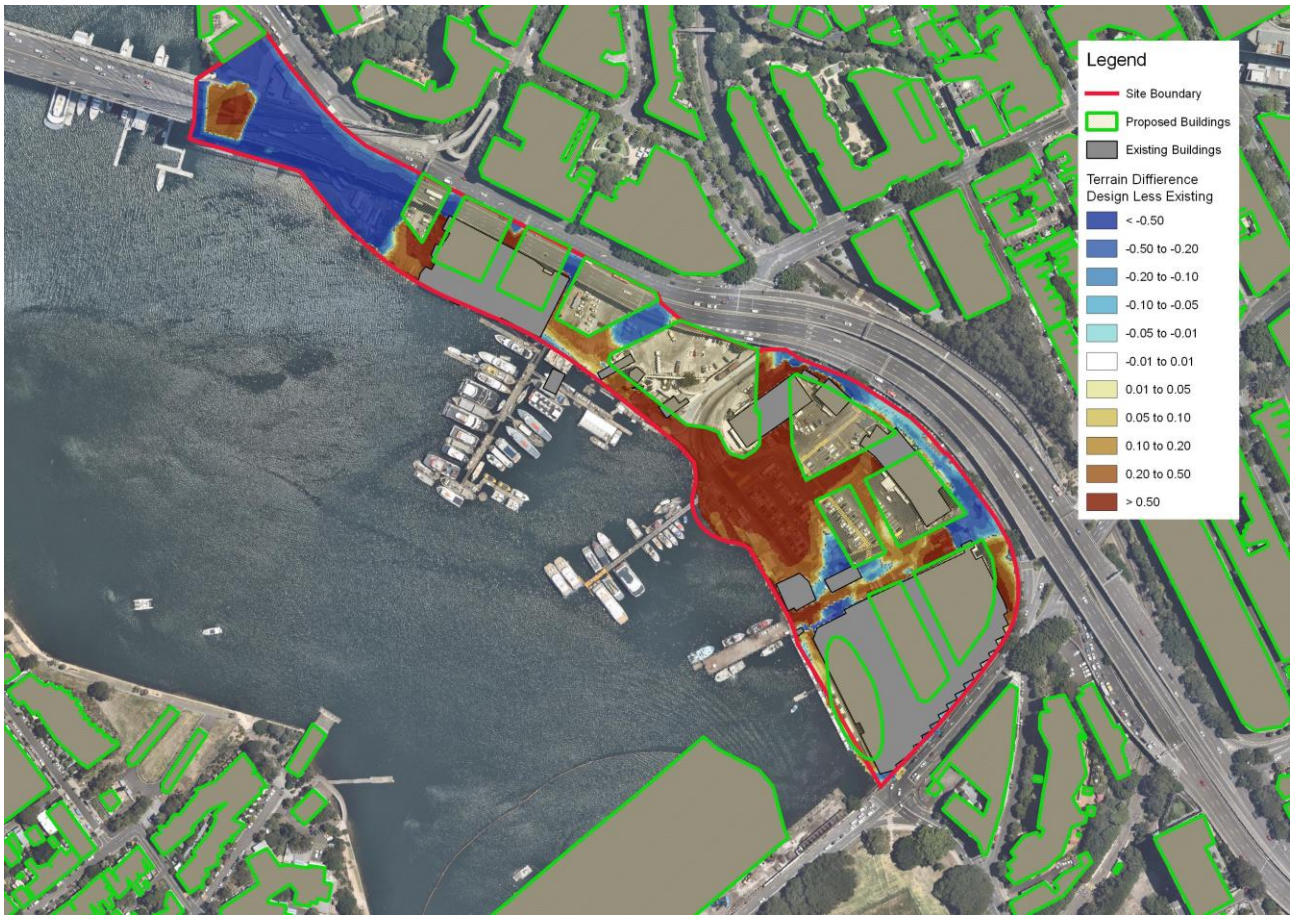


Figure 9-3 Changes in the Terrain levels (Proposed Less Existing) and Building Footprints

The Proposed Conditions model was run for the 1% AEP and PMF flood events. The results have been provided in **Appendix D**. A summary of the results provided is as follows:

- Figure 7: Proposed 1% AEP Flood Depth and Water Level Contours
- Figure 8: Proposed 1% AEP Flood Velocity
- Figure 9: Proposed 1% AEP Flood Hazard
- Figure 10: Proposed PMF Flood Depth and Water Level Contours
- Figure 11: Proposed PMF Flood Velocity
- Figure 12: Proposed PMF Flood Hazard
- Figure 13: Water Level Difference – Proposed Less Existing 1%AEP

The flood behaviour for 1% AEP and PMF events shows that the proposed changes in Blackwattle Bay SSP surface levels has resulted in minor changes in the flood behaviour within and surrounding the Study Site.

9.5.2 Flood Impact Assessment

- **Figure 13 (Appendix D)** shows the difference in 1% AEP flood levels between the Existing and Proposed Conditions. Localised increases of 0.2m are observed on Bank Street carriageway and at the immediate vicinity of study site. Increases of up to 0.06m are observed on Bank Street adjacent to 1 Saunders St. Minor increases of up to 0.03m in flood levels are observed along Pyrmont Bridge Road.
- It should be noted that at this stage no modifications or upgrades to the drainage network are included in the models. It is expected that these impacts can be resolved in the detailed design stage through inclusion of drainage network modifications and refinement of the civil grading.

In relation to hazard, there is minimal difference in hazard between the Existing and Proposed Conditions within and outside the study area.

It should be noted that the above flood impact assessment has been undertaken based on the concept level design information. Further assessments are required in the detailed design stage of the project through inclusion of the detailed design TIN as well as the designed drainage network have been included in the model.

If the detailed design stage reveals that mitigation options are required to resolve the off-site flood impacts, any proposed options will be communicated with the urban designers to assure the high quality urban outcomes will be achieved.

9.5.3 Urban Design and Development Control Outcomes

The flood assessment, in particular **Figure 7** (**Appendix D**), shows that most road reserves within the precinct are expected to convey minimal overland flow. Therefore, in most cases flooding will not be a constraint to achieving high quality urban design outcomes or complying with Council requirements as detailed in their Interim Floodplain Management Policy.

The key exception is the road reserve which is an extension of Miller Street and includes an overland flowpath here which conveys flows from the upstream catchment to the north of the western distributor (refer **Figure 9-4**). However, it is expected that trunk drainage system upgrades at this location (refer **Appendix C**), which are not currently incorporated into the flood modelling, and further design of the road itself, would reduce overland flow at this location. Ultimately, given flooding at this location is relatively minor to start with (flow depths are generally <0.3 m), it is expected that following further design development, flooding will not form a significant constraint to achieving high quality urban design outcomes at this location. It also follows that it is expected that Council's requirements, as detailed in their Interim Floodplain Management Policy, will be able to be met.

Figure 9-4 Overland Flow in Extension of Miller Street

9.6 Climate Change Assessment

Climate change is expected to cause increased rainfall intensities and sea level rise. The NSW Government's Floodplain Risk Management Guideline Practical Consideration of Climate Change (2007) provides recommendations on assessing the impact of climate change on flood behaviour which were considered in the climate change assessment for the current study.

9.6.1 Increases in Rainfall Intensity

A sensitivity analysis has been undertaken by assessing the 0.5% and 0.2% AEP flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events (approximately 7% and 27% respectively) due to climate change. This approach is consistent with the sensitivity analysis undertaken for the New Sydney Fish Market Flooding and Water Quality Assessment (Cardno 2019).

The peak flood depth results for the 0.5% and 0.2% AEP are provided in **Appendix F**. A summary of the results provided is as follows:

> Figure 14– Proposed 0.5% AEP Peaks Depths and Water Level Contours;

- Figure 15 –Water Level Difference –Proposed 0.5% AEP Less Proposed 1% AEP;
- Figure 16 – Proposed 0.2% AEP Peaks Depths and Water Level Contours; and
- Figure 17–Water Level Difference – Proposed 0.2% AEP Less Proposed 1% AEP.

For the 0.5% AEP event, increase in flood levels of less than 0.05 m are observed within the study site and also along Bank Street, Saunders Street and Pyrmont Bridge Road. Increases of up to 0.10 m are observed along the railway line. Extents of flooding will remain the same within and outside the study area.

For the 0.2% AEP event, increase in flood levels of less than 0.1 m are observed within the study site and along Pyrmont Bridge Road. Increases of up to 0.20 m are observed along Bank Street and Saunders Street. Extents of flooding within and outside the study area will change slightly.

In summary, the impacts of increased rainfall intensity on flood levels within the study site and surrounds in the 0.5% AEP are not significant. While the impacts in the 0.2% AEP event are more significant, overland flows are still expected to be contained within road reserves / open spaces and flood risk able to be appropriately managed.

9.6.2 Sea level rise

Climate change scenarios incorporating a 0.4 m and a 0.9 m rise in sea levels were modelled for the 1% AEP event, representing 2050 and 2100 climatic conditions in accordance with the *NSW Sea Level Rise Policy Statement* (NSW Government, 2009).

The peak flood depth results for the 1% AEP flood event with 0.4 m and 0.9 m rise in sea levels are provided in **Appendix F.** A summary of the results provided is as follows:

- Figure 18 – Proposed 1% AEP with 0.4m Sea Level Rise Peaks Depths and Water Level Contours;
- Figure 19 –Water Level Difference – Proposed 1% AEP with 0.4 m Sea Level Rise Less Proposed 1% AEP;
- Figure 20 – Proposed 1% AEP with 0.9m Sea Level Rise Peaks Depths and Water Level Contours; and
- Figure 21 –Water Level Difference – Proposed 1% AEP with 0.4 m Sea Level Rise Less Proposed 1% AEP;

Impacts of sea level rise on flood levels within Study Area are generally limited due to the proposed terrain levels being higher than both the 0.4m and 0.9m sea level rise levels (1.78 m AHD and 2.28 m AHD respectively). The western corner of the site is an exception with proposed terrain levels lower than the raised sea level. However, this will be addressed in design and with appropriate uses (eg; open space / boating related uses / launch area).

9.7 Emergency Response Management

9.7.1 Background

When determining the risk to life from flooding, the flood hazard for an area does not directly imply the danger posed to people in the floodplain. This is due to the capacity for people to respond and react to flooding, ensuring they do not enter floodwaters. This concept is referred to as flood emergency response.

To help minimise the flood risk to occupants of the floodplain, it is important that there are provisions for flood emergency response. There are two main forms of flood emergency response that may be adopted:

- Evacuation: The movement of occupants out of the floodplain before the property becomes flooded;
- Shelter-in-place: The movement of occupants to a building that provides vertical refuge on the site or near the site before their property becomes flood affected.

The emergency response provisions for a local area are outlined in documentation provided by the relevant emergency authority for New South Wales, the State Emergency Service (SES). The NSW SES typically prepare two documents relevant to flood emergency response:

- Emergency Management Plan (EMPLAN); and
- Flood Plan, which is a sub-plan of the EMPLAN.

These documents are intended to provide information to SES coordinators and other authorities relating to identified responsible personnel and agencies, as well as evacuation centres, evacuation procedures and actions in the event of flooding.

9.7.2 Flood Emergency Response Management Documentation

The Blackwattle Bay catchment is located within the Sydney West Emergency Management District. Flood emergency management for this district is organised under the NSW Disaster Plan (2010). No district DISPLAN has been prepared for the district within which the Blackwattle Bay catchment and new Sydney Fish Market Study Area lies.

The Blackwattle Bay Floodplain Risk Management Study and Plan (WMAwater 2015) recommends that a DISPLAN be prepared for the Sydney West Emergency Management District.

In addition, a local flood plan has not been prepared for the local area containing the Blackwattle Bay catchment.

9.7.3 Emergency Service Operators

The Blackwattle Bay Floodplain Risk Management Study and Plan (WMAwater 2015) identifies that emergency response to any flooding within the Blackwattle Bay catchment will be coordinated by the lead combat agency, the SES, from their Local Command Centre located at Erskineville.

9.7.4 Flood Warning

The Blackwattle Bay catchment is affected by flash flooding (i.e. for the Blackwattle Bay SSP the critical duration of flooding for most events is 15min) and as such it is difficult to provide any warning in advance of floods. However, for flash flood catchments the BoM provides general warning services, including:

- Flood Watches – early appreciation of a developing weather system that could lead to flooding;
- Flood Warnings – water level readings from gauges;
- Severe Weather Warnings; and
- Severe Thunderstorm Warnings. As such, it is difficult to provide any flood warning in advance of floods.

9.7.5 Access and Movement and Shelter-in-Place

Any flood response must take into account the availability of flood free access, and the ease with which movement can be accomplished. Movement includes evacuation of people from flood affected areas, medical personnel attempting to provide aid and/or SES personnel installing flood defences. Pyrmont Bridge Road and Bank Street will be unsafe for evacuation during both 1% AEP and PMF events.

The advantage of shelter-in-place is that people do not require as long to respond for this type of emergency response to be appropriate. As opposed to evacuation, where people are likely to have to travel a significant distance to reach flood free land, for shelter-in-place people are likely only going to need to access a mezzanine level or first floor within the same building. Therefore, this type of response is far more appropriate for flash flooding environments, in particular where the duration of flooding is expected to be relatively short and high hazard conditions are expected in surrounding access routes.

Considering the short duration of flooding for the study site and limited ability to provide safe evacuation offsite, a shelter-in-place approach is recommended for the Blackwattle Bay SSP.

10 Conclusion

This Study was undertaken to address the items related related to water, riparian land, flooding and stormwater of the Study Requirements.

The key elements and findings of this Water, Riparian Land, Flooding and Stormwater study include:

- Stormwater Management and Water Quality
  - A Concept Stormwater Management Plan (SMP) has been developed
  - The strategy has been assessed using MUSIC software to demonstrate the water quality targets can be met
- Groundwater
  - Available information on groundwater conditions has been reviewed
  - Minimal, if any, impacts are expected in relation to groundwater

- Flooding Assessment
  - A detailed flooding assessment has been undertaken
  - This assessment included modelling of both existing and climate change conditions
  - The assessment showed that the Study Area is subject to overland flows during large storm events and that these can be appropriately managed through the site
  - The assessment showed that the proposed development could have minor impacts on flooding outside the Study Area. It is anticipated that these potential impacts can be resolved during the detailed design stage and through inclusion of a modified drainage network
  - The study showed that increased rainfall as a result of climate change will result in increased flood levels at and around the study site. However, impacts of sea level rise on the proposed development will be limited due to the proposed terrain being above the raised sea level
  - Considering the short duration of flooding and limited ability to provide safe evacuation offsite, a shelter-in-place approach is recommended for the Blackwattle Bay SSP

11 References

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10. WMAwater (2015), Blackwattle Bay Catchment Floodplain Risk Management Study.

APPENDIX

A

PRECINCT PLAN

APPENDIX

B

SURVEY

APPENDIX

C

STORMWATER MANAGEMENT PLAN

APPENDIX

D

HYDRAULIC MODEL RESULTS - CURRENT CLIMATE CONDITIONS

APPENDIX

E

PROPOSED GRADING PLAN

APPENDIX

F

CLIMATE CHANGE FLOOD BEHAVIOUR