POWERHOUSE PARRAMATTA
ENVIRONMENTAL IMPACT STATEMENT

APPENDIX O
FLOOD RISK AND STORMWATER MANAGEMENT REPORT

Arup

NSW GOVERNMENT

Infrastructure NSW

Powerhouse Parramatta

SSDA Report – Flood Risk and Stormwater Management

PHM-ARP-CIV-REP-0001

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Glossary

1D/2D	One-dimensional/Two-dimensional
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AR&R	Australian Rainfall & Runoff
ARI	Average Recurrence Interval
BoM	Bureau of Meteorology
CoPC	City of Parramatta Council
DCP	Development Control Plan
DEM	Digital Elevation Model
DPI&E	Department of Planning, Industry and Environment
DYBD	Dial Before You Dig
EP&A Act	Environmental Planning and Assessment Act 1979
ESCP	Erosion and Sediment Control Plan
FDM	Floodplain Development Manual
FFL	Finished Floor Level
FPL	Flood Planning Level
GPT	Gross Pollutant Trap
IFD	Intensity-Frequency-Duration
INSW	Infrastructure New South Wales
LEP	Local Environmental Plan
LGA	Local Government Area
LiDAR	Light Detection and Ranging
MAAS	Museum of Applied Arts & Sciences
OSD	On Site Detention
PMF	Probable Maximum Flood
PSD	Permissible Site Discharge
RCP	Representative Concentration Pathways
SEARS	Secretary's Environmental Assessment Requirements (Section 78A(8A) of the Environmental Planning and Assessment Act)
SSDA	State Significant Development Application
UPRCT	Upper Parramatta River Catchment Trust
WSC	Water Services Coordinator
WSUD	Water Sensitive Urban Design

1 Executive Summary

This report presents the Arup stormwater and flood risk management strategies for the Powerhouse Parramatta development. It also demonstrates compliance with and adherence to applicable planning controls including the Secretary's Environmental Assessment Requirements (SEARS) and the City of Parramatta Council's (CoPC) Development Control Plan (DCP).

In preparing this report, Arup has reviewed existing flood studies for the Parramatta River to understand the historic patterns and records of former flooding episodes. The project team recognises that flooding risk to the development site is a function of two separate mechanisms; mainstream flooding of the Parramatta River, and overland flow flooding. The latter results from rainfall and runoff that exceeds the capacity of the locally installed stormwater infrastructure.

The report includes a comprehensive review of the currently available flood simulation models. These models have been created (by others) to study stormwater and flooding effects in the local vicinity. The review concluded that the models available to Arup at the time of preparing this report were not adequate for the assessment of flood risk to the Powerhouse Parramatta development. Therefore, Arup created a project specific, bespoke 1D/2D hydraulic TUFLOW flood model using data from existing models provided by CoPC. The model was validated against the existing models and correlates well.

Arup has used this project specific model to better understand the behaviour of rainfall and runoff surrounding and within the site. This model has allowed the team to estimate pre- and post-development flooding conditions during significant storm events and estimate maximum flood depths. Using this information, Arup has worked closely with the wider project team to minimise the changes in flood behaviour on the Powerhouse Parramatta development site.

In response to flooding constraints, the proposed buildings are designed to ensure the Powerhouse Collection is protected through flood storage capacity offered by the undercroft space as well as other external areas which connect to the Parramatta River banks. These undercroft spaces will contain floodwaters in the event of significant flooding thereby minimising flood risks to the Powerhouse development as well as minimising impacts upstream and downstream of the development site.

Likewise, flooding resilience is also being integrated into the design of the proposed buildings with Finished Floor Levels (FFLs) being raised to an elevation higher than the modelled maximum 1% Annual Exceedance Probability (AEP) flood level with an additional allowance of 500 mm freeboard. In the case of mainstream flooding from the Parramatta River, building FFLs have been raised to more than 1 m above the 1% AEP flood level, including consideration to the possible effects of climate change.

Elevating the building FFLs and the associated terrace spaces will provide protection to building assets, visitors and vehicles even in the event of a significant storm. A preliminary evacuation strategy has been set out for this scenario and will be integrated as the design evolves.

Arup proposed stormwater drainage, On-Site Detention (OSD) and & Water Sensitive Urban Design (WSUD) strategies are also presented in this report. These elements have been developed to complement our flood risk management strategy and to achieve both functional requirements and sustainability objectives.

2 Introduction

This report supports a State Significant Development (SSD) Development Application (DA) for the development of the Powerhouse Parramatta at 34-54 & 30B Phillip Street and 338 Church Street, Parramatta. The Powerhouse Parramatta is a museum (information and education facility) that has a capital investment value in excess of $30 million and as such the DA is submitted to the Minister for Planning pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

Infrastructure NSW is the proponent of the DA.

3 Background

The Powerhouse is Australia's contemporary museum for excellence and innovation in applied arts and sciences. The museum was established in 1879 in the Garden Palace which emerged from a history of 19th Century grand exhibition halls, including the Grand Palais. It currently encompasses the Powerhouse in Ultimo, Sydney Observatory in The Rocks and the Museums Discovery Centre in Castle Hill. The Powerhouse has occupied the Ultimo site since 1988.

Parramatta, in the heart of Western Sydney, is entering a period of rapid growth. It was identified in 2014's *A Plan for Growing Sydney* as the metropolis' emerging second Central Business District, with the provision of supporting social and cultural infrastructure regarded as integral to its success. The strategic importance of Parramatta as an economic and social capital for Sydney has been subsequently reinforced and further emphasised through its designation as the metropolitan centre of the Central City under the *Greater Sydney Region Plan*.

Powerhouse Parramatta will be the first State cultural institution to be located in Western Sydney – the geographical heart of Sydney. In December 2019, the Government announced the winning design, by Moreau Kusunoki and Genton, for the Powerhouse Parramatta from an international design competition. Powerhouse Parramatta will establish a new paradigm for museums through the creation of an institution that is innately flexible. It will become a national and international destination renowned for its distinctive programs driven by original research and inspired by its expansive collections. It will be a place of collaboration, a mirror of its communities forever embedded in the contemporary identity of Greater Sydney and NSW.

4 Site Description

The site is located at the northern edge of the Parramatta CBD on the southern bank of the Parramatta River. It occupies an area of approximately 2.5 hectares and has extensive frontages to Phillip Street, Wilde Avenue and the Parramatta River. A small portion of the site extends along the foreshore of the Parramatta River to the west, close to Lennox Bridge on Church Street. The site boundary is

identified in Figure 1. The site excludes the GE Office Building at 32 Phillip Street.

The site is currently occupied by a number of buildings and structures, including:

- Riverbank Car Park – a four-level public car park;
- Willow Grove – a two-storey villa of Victorian Italianate style constructed in the 1870s;
- St George's Terrace – a two-storey terrace of seven houses fronting Phillip Street constructed in the 1880s;
- 36 Phillip Street – a two-storey building comprising retail and business premises;
- 40 Phillip Street – a two-storey building comprising retail and business premises; and
- 42 Phillip Street – a substation building set back from the street.

The immediate context of the site comprises a range of land uses including office premises, retail premises, hotel, serviced apartments and residential apartments. To the north is the Parramatta River and open space corridor, beyond which are predominately residential uses. The Riverside Theatre is located to the north-west across the Parramatta River.

Figure 1: Aerial photograph of the site and its context

Source: Mark Merton Photography

Figure 2: Site boundary, key existing features, and immediate local context

Source: Ethos Urban

5 Overview of Proposed Development

The Powerhouse was established in 1879, and Powerhouse Parramatta will radically return to its origins through the creation of seven presentation spaces of extraordinary scale that will enable the delivery of an ambitious, constantly changing program that provides new levels of access to Powerhouse Collection. The Powerhouse will set a new international benchmark in experiential learning through the creation of an immensely scaled 360-degree digital space, unique to Australia.

Powerhouse Parramatta will reflect the communities and cultures of one of Australia's fastest growing regions. It will hold First Nations culture at its core and set a new national benchmark in culturally diverse programming. The Powerhouse will be highly connected through multiple transport links, and integrate into the fine grain of the city.

Powerhouse Parramatta will be an active working precinct and include the Powerlab, which will enable researchers, scientists, artists and students from across regional NSW, Australia and around the world to collaborate and participate in Powerhouse programs. The Powerlab will feature digital studios to support music and screen industries alongside co-working spaces, life-long learning and community spaces. Integrated into the Powerlab will be a research

kitchen and library that will support a NSW industry development program including archives and oral histories.

This application will deliver a new cultural institution for Parramatta in the heart of Sydney's Central City. The SSD DA seeks consent for the delivery of the Powerhouse Paramatta as a single stage, comprising:

- site preparation works, including the termination or relocation of site services and infrastructure, tree removal and the erection of site protection hoardings and fencing;
- demolition of existing buildings including the existing Riverbank Car Park, 'Willow Grove', 'St George's Terrace' and all other existing structures located on the site;
- construction of the Powerhouse Parramatta, including:
    - seven major public presentation spaces for the exhibition of Powerhouse Collection;
    - front and back-of-house spaces;
    - studio, co-working and collaboration spaces comprising the 'Powerlab', supported by 40 residences (serviced apartments) scientists, researchers, students and artists, and 60 dormitory beds for school students;
    - education and community spaces for staff, researchers and the Powerlab residents, the community, and education and commercial hirers;
    - commercial kitchen comprising the 'Powerlab Kitchen' used for cultural food programs, research, education and events;
    - film, photography, and postproduction studio that will connect communities with industry and content that will interpret the Powerhouse Collection;
    - public facing research library and archive for community, industry, students and researchers to access materials; and
    - a mix of retail spaces including food and drink tenancies with outdoor dining.
- operation and use of the Powerhouse Parramatta including use of the public domain provided on the site to support programs and functions;
- maintenance of the existing vehicular access easement via Dirrabarri Lane, the removal of Oyster Lane and termination of George Khattar Lane, and the provision of a new vehicular access point to Wilde Avenue for loading;
- public domain within the site including new public open space areas, landscaping and tree planting across the site; and
- building identification signage.

The project does not seek consent for the carrying out of works outside of the site boundary, and in particular does not involve any alterations to the existing edge of the formed concrete edge of the Parramatta River or to the waterway itself.

6 Assessment Requirements

6.1 Secretary's Environmental Assessment Requirements (SEARs)

The Department of Planning, Industry and Environment have issued Secretary's Environmental Assessment Requirements (SEARs) to the applicant for the preparation of an Environmental Impact Statement for the proposed development. This report has been prepared with consideration given to the SEARs as follows:

Table 1: SEARS aspects requirements for Flooding, drainage and stormwater

SEAR	Where Addressed
12. Flooding, drainage and stormwater The EIS shall include:	
• An assessment and proposed management of the stormwater, drainage, flooding and groundwater issues associated with the site, environs and the proposed development, including:	This report addresses flooding and stormwater
• Stormwater and drainage infrastructure, including a stormwater management plan, water sensitive urban design, roof gardens, green walls, and MUSIC link model (for water quality)	Refer to Appendix D | Stormwater Management Plan; WSUD is discussed in Section 9.3.3
• Assessment of flood risk in accordance with the guideline contained in the NSW Floodplain Development Manual 2005, including potential effects of climate change, sea level rise and an increase in rainfall intensity and integration with Council's wider flood risk management planning and flood modelling	Flood risk is discussed in Section 8 of this report
• Rainwater and stormwater runoff. The strategy must outline opportunities for the use of integrated water cycle management practice and principle, and demonstrate water sensitive urban design and any other water conservation measures	Stormwater management is discussed in Section 9 of this report
• Consideration as to how the proposal responds to City River and Civic Link precinct access and egress requirements, including evacuation in flood.	Flood evacuation is discussed in Section 8.7 of this report

This report also addresses additional relevant Strategic Policy and Technical Guidelines that are referred to in the SEARS as described in Table 2:

Table 2: Section 6.1 SEARs Strategic Policy and Technical guidelines

Policy or Guideline	Where Addressed
• Guidelines for controlled activities on waterfront land	Section 8 of this report discusses how impacts of development to the Parramatta River will be minimised An Erosion and Sediment Control Plan (ESCP) is presented in a separate technical memo (ref: PHM-ARP-TCN-CE-0001) and associated drawings prepared by Arup. These have been provided in Appendix J |. We note that the CoPC does not identify the reach of the Parramatta River fronting the development site as a riparian corridor, but appropriate consideration has nevertheless been given.

6.2 City of Parramatta Council

The development site is situated within the City of Parramatta Council (CoPC) Local Government Area (LGA). From both historical experience and the predictions of current flood studies, Parramatta is an area known to be at risk of flooding, principally as a function of the Parramatta River. More information on these issues is provided in Section 7.4.

As a consequence of the known flood risks, several stormwater and flooding related planning controls and instruments already exist for proposed development within the CoPC LGA. These controls exist because CoPC is responsible for local land use planning within their LGA together with associated flood risk management responsibilities. These controls generally complement the intent of the SEARs as outlined above.

Appendix A | presents a summary of how the Arup stormwater and flood risk management strategy presented in this report addresses the provisions of relevant City of Parramatta Council planning documents.

Arup has also liaised with Council's stormwater and engineering representatives to receive some preliminary input and direction. This advice has directly assisted the flood risk assessment presented in this report. Records of our correspondence with CoPC representatives are presented in Appendix G |.

6.3 Sydney Water

Sydney Water is the regulatory authority responsible for potable water, wastewater and some stormwater assets within the greater area of Sydney. Any works affecting Sydney Water assets require consultation before proceeding with construction.

There are no Sydney Water stormwater assets within or near the development site. The stormwater infrastructure (including Parramatta River) present in the development site are owned and managed by City of Parramatta Council.

Initial consultations were undertaken with Sydney Water with respect to their stormwater assets (refer to Appendix H | and it has been confirmed the Sydney Water Stormwater policy does not apply to Powerhouse Parramatta on the basis that there are no Sydney Water stormwater assets affected by the development site.

However, there are Sydney Water potable water and wastewater assets present on site which will be affected by the development site works. Some further commentary is offered in this report on the existing sewer asset (refer Section 9.3.1) because it is likely to be a consideration of the design of the proposed stormwater network. A Water Services Coordinator (WSC) will be engaged at a later stage of design development to manage the design and physical works in proximity to existing Sydney Water assets.

7 Existing Site Conditions

7.1 Site Location and Boundaries

The site location and boundaries are described and illustrated in Section 4. The northern frontage of the development site connects to the Parramatta River which flows from north east to southwest in the immediate vicinity. The site is positioned between two existing bridge structures, Lennox Bridge at the upstream end of the site and Barry Wilde Bridge (together with a timber pedestrian bridge below the vehicular bridge deck just above the river wall level) at the downstream end of the site. The distance between these structures is approximately 270 m.

An extract of the CoPC LEP zoning map is reproduced in Figure 3. This illustrates that the development site is primarily classified as B4: Mixed Use and closer to the Parramatta river is classified as RE1: Public Recreation. The surrounding neighbourhood are also chiefly classified as B4: Mixed Use.

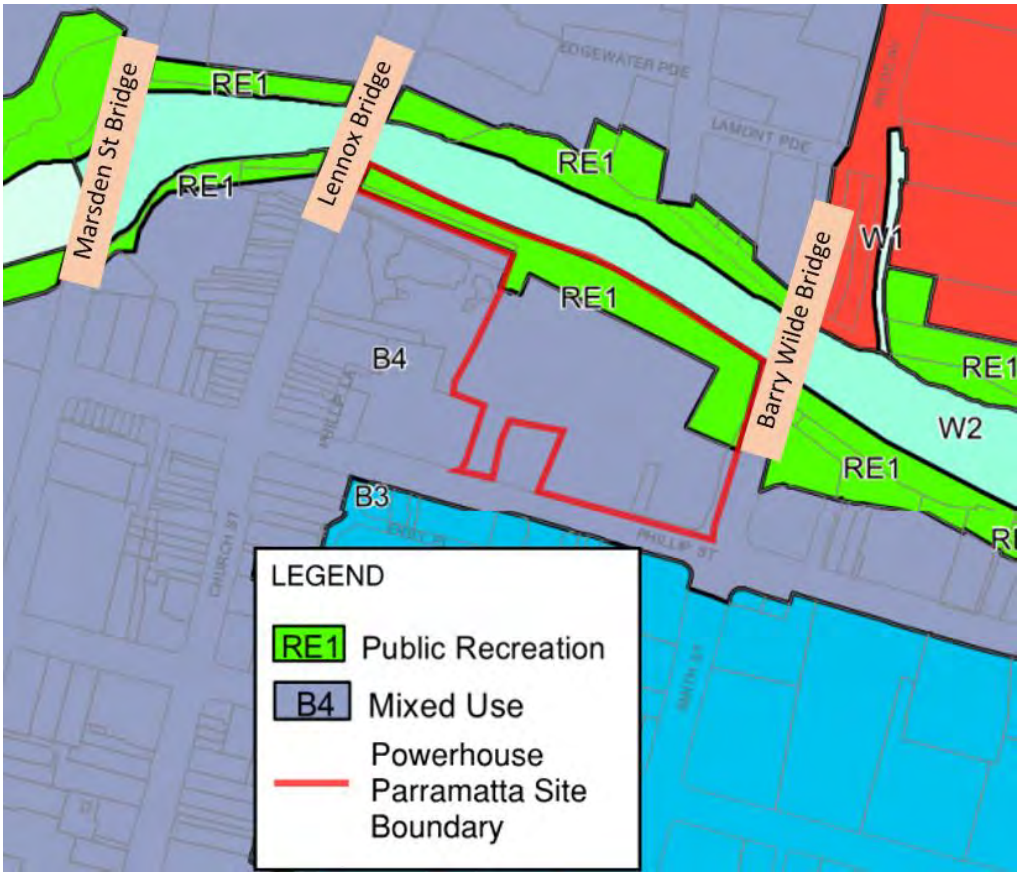


Figure 3: Land Zoning Map classification for site location and surrounding areas (Source: Parramatta Local Environmental Plan 2011)

Approximately 140 m upstream of the Lennox Bridge is the Marsden Street Bridge and Marsden Street weir. This weir structure incorporates the longest operating flow measurement gauge and depth gauge on the Upper Parramatta River and has been collecting data over the past 40 years. This is discussed further in Section 7.4.

7.2 Topography and Ground Surface Conditions

In the pre-developed condition, the highest site elevations in the vicinity of the Willow Grove building are in the order of RL: 7.5 mAHD. From this high point there is a shallow southerly gradient towards Phillip Street.

The southern wall of the existing Riverbank car park is an earth retaining wall. This effectively creates a step in the site levels, separating the southern half of the site typically at higher elevations (above RL: 6 mAHD), from the northern half which includes the lower ground floor level of the Riverbank car park, typically at lower elevations (below RL: 4 mAHD).

Elevations are lowest along the northern edge of the site at approximately RL: 2.0 mAHD – RL: 2.5 mAHD. This existing arrangement is illustrated by the contours shown in Figure 4.

Figure 4: Existing contours for site location and surrounding areas

Figure 5 illustrates the existing surface conditions within the site. This image illustrates the site is predominantly paved with impervious surfaces. These surfaces comprise parking areas, roads and footpaths near Dirrabarri and George Khattar Lane.

Figure 5: Existing surface conditions for site location and surrounding area (Source: Open Street Maps)

A portion of the site's northern frontage between the existing car park and the Parramatta River is grassed and is generally pervious. However, this area has been considered impervious in our flood risk modelling work due to the elevated water table that is known to exist within this landscaped region. There are also some permeable landscaped and lawn areas surrounding Willow Grove which are relatively small and have been ignored for the purposes of flood modelling.

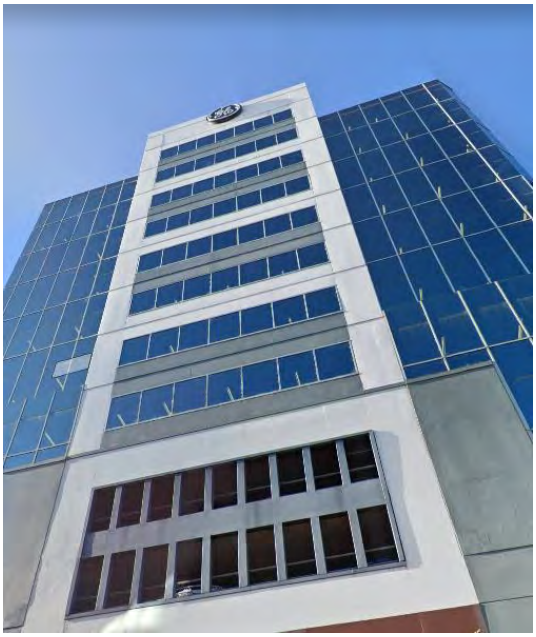
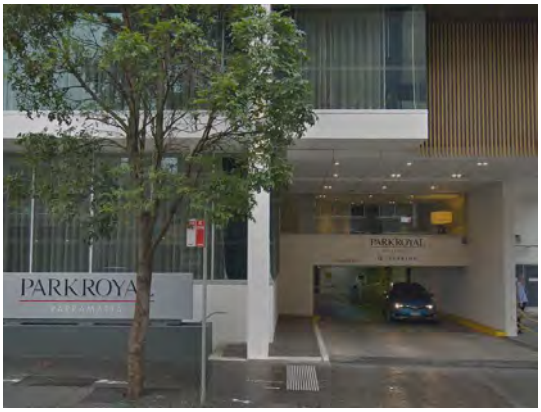
7.3 Surrounding Sites and Infrastructure

As described in Section 4, the development site and surrounding areas contain established buildings, roads, paved and landscaped areas. Many of these existing features will be maintained together with surrounding infrastructure (including pavements, kerbs and stormwater drainage) in their pre-development condition.

Table 3 presents a summary of the elements to be protected and retained.

Table 3: Existing surrounding buildings and infrastructure to be retained

Building/Infrastructure	**Reference Photograph**
Parramatta River, river channel walls and landscaped areas immediately along the north frontage of the site	
Barry Wilde bridge (on Wilde Avenue) with piers, abutments, underbridge car parking and storage facilities along the east frontage of the site	

Building/Infrastructure	Reference Photograph
GE building at 32 Phillip Street on the corner of Dirrabarri Lane and Phillip Street on the south frontage of the site	
Parkroyal Hotel at the corner of Dirrabarri Lane and Phillip Street to the south west of the site boundary	

Building/Infrastructure	Reference Photograph
Meriton Serviced Apartments and basement access on the west frontage of the site boundary	
Lennox Bridge (Church Street) with bridge abutments on the northwest frontage of the site.	

Existing buildings, roads, kerbs, landscaping, and associated infrastructure within the site boundary will generally require demolition and removal to permit construction of the Powerhouse Parramatta. Table 4 presents a summary of the buildings and features that will be removed to enable construction of the proposed development.

These alterations and adjustments to the existing site conditions have been considered as part of the proposed development flood modelling and stormwater management strategies presented in this report.

Table 4: Existing surrounding sites and infrastructure to be removed

Building/Infrastructure	Reference Photograph
Existing buildings including Willow Grove, 36, 40 & 42 Phillip Street and St George's Terrace generally located within the southern region of the site boundary	 
Parramatta Riverbank Car Park which is a four-storey car park with partial below ground basement level and generally located in the northern region of the site boundary	

7.4 Historic Flooding

Historic flooding episodes within the Parramatta area are relatively infrequent but are known to occur on a periodic basis, normally following heavy rainfall. Flooding is a natural part of how rivers and river catchments function and it is Parramatta's location, adjacent to the Parramatta River, as well as the low-lying local topography that increase this risk.

Several previous studies and numerical assessments of the Parramatta River catchment encompass the development site. Arup has obtained and reviewed the documents listed below as part of our assessment of the Powerhouse Parramatta development:

- Upper Parramatta River Catchment Floodplain Risk Management Study and Plan by Bewsher Consulting Pty Ltd, 2003;
- 330 Church Street Parramatta, Flood and Stormwater Management Report by Mott MacDonald, 2011;
- Riverbank Precinct Master Plan, Drainage and Flooding Study by Cardno, 2016;
- The New Museum, Parramatta, Flood Study by TTW, 2016; and
- Parramatta River Flood Study, Final Draft by Cardno, 2019.

We note that the Upper Parramatta River Catchment Flood Study (1997) report has been prepared by the Upper Parramatta River Catchment Trust (UPRCT) but this document has neither been finalised nor released as a public document (Bewsher, 2003). However, a flood model associated with this study was prepared in software package MIKE11 and has been made available to Arup courtesy of CoPC.

Many of the other studies listed above also involved the preparation of hydrological and hydraulic flood models to simulate the behaviour the Parramatta River and surrounding areas. Further detail on these studies and their relevance to the Powerhouse Parramatta development is provided in Section 8.2.

From our review, we are aware of two flooding effects that can occur on and near to the development site which are: mainstream flooding and overland flow flooding. Sections 7.4.1 and 7.4.2 discuss these different flooding behaviours.

7.4.1 Mainstream Flooding - Parramatta River

The development site is located adjacent to the Parramatta River within the Upper Parramatta River Catchment and is subject to mainstream flooding from the Parramatta River. Historical flood events within Parramatta CBD have been measured and recorded at the Marsden Street weir gauge and include April 1988, April 2015 and June 2016 (*Source: Cardno, 2019*).

Figure 6: Photograph of Riverbank car park facing east towards Wilde Avenue Bridge, taken in 1988; *Source: City of Parramatta Council*

One of the most significant of the recorded events was April 1988 (refer to Figure 6) which in part motivated regional flood mitigation works. This included construction of the Loyalty Road dam and flood retarding basin at Northmead in the 1990s which are intended to alleviate flooding risk in Parramatta.

The most recent flood event occurred during the period of 6th to 11th February 2020 following a sustained period of rainfall. Based on the rainfall and river level plot (the latter measured upstream of Lennox Bridge) as shown in Figure 7, this data demonstrates the river flood level peaked in the afternoon on the 9th February 2020 at an approximate RL: 5.4 mAHD. Modelling of the behaviour of the Parramatta River by Arup and others suggests the peak water level at the Powerhouse Parramatta development site is typically around 1 m lower (during smaller flood events) than the peak water level upstream of Lennox Bridge (approximately RL: 4.4 mAHD). This is due to the flow restricting effect that Lennox Bridge creates during high flow conditions.

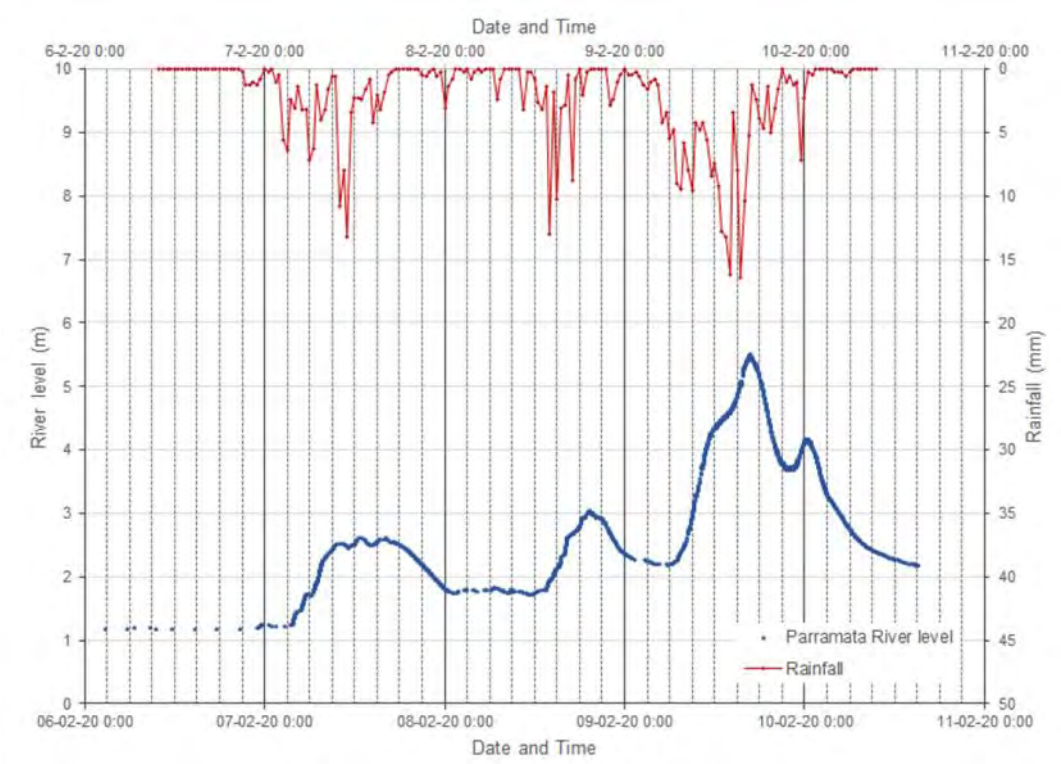


Figure 7: Rainfall (Olympic Park Gauge) and River Level Plot (Parramatta Riverside Theatre Station, upstream of Lennox Bridge) showing the February 2020 storm

Photos and videos of the flood event have been obtained, predominantly from the press, some of which are reproduced in Figure 8 and Figure 9. The photos show the flood depth and extents during the event, with the banks of the Parramatta River overtopped by floodwater and the lower ground floor level of the Riverbank Car Park on the development site inundated.

Figure 8: Powerhouse Parramatta site as viewed from the North bank of the Parramatta River. Dry weather conditions (top image, *Source: Google Maps*); and flooded conditions (bottom image, *Source: Sydney Morning Herald, Feb 2020*)

Figure 9: Parramatta River and Powerhouse Parramatta site under flooded conditions during the February 2020 event as viewed from Lennox Bridge (*Source: Sydney Morning Herald*)

Siltation of the riverbanks was apparent during the Arup site visit on 10th February 2020 immediately following the flood event, as shown in Figure 10.

Figure 10: Powerhouse Parramatta site viewed from Barry Wilde bridge immediately following the February 2020 event, images illustrate silt deposits on the riverbanks

The peak (maximum) flood level on the Powerhouse Parramatta site is not precisely known because no accurate gauge exists in immediate proximity to the development site. However, Figure 11 shows the debris mark left by floodwaters on the façade of the Riverbank car park following this event. Arup has made a rough estimate of the peak flood level at approximate RL: 4.4 mAHD based on our site observations summarised on Figure 11.

This peak flood level approximation appears to correlate reasonably well with the gauge reading upstream of Lennox Bridge which as previously noted, is typically in the order of 1 m higher than the Powerhouse Parramatta site (refer to Figure 16 which illustrates this arrangement in longitudinal section).

Figure 11: Photograph of debris line on the façade of the Riverside car park following the February 2020. Arup estimate the peak flood level as 4.4 mAHD on the development site

The probability (chance) of a large storm event occurring that might produce flooding is important when considering flood risk management. In the industry, this is expressed in terms of the percentage chance of a given storm event magnitude occurring in any given year. Referred to as the Annual Exceedance Probability (AEP), this probability is calibrated against statistical assessment of historic records and are compiled and published by the Bureau of Meteorology (BoM).

This rainfall data can be fed into flood model simulations to predict the flood risk profile following rainfall and runoff associated with statistically significant rainfall events. The work presented in this report considers four key flood events as presented in Table 5.

Table 5: Statistically significant storm events considered as part of the Powerhouse Parramatta flooding risk investigations

Storm Event Probability	Description
5% AEP	5% probability of any storm event being equivalent to or exceeding this event in any given year (equivalent to a 1 in 20 year average recurrence interval, or ARI)
1% AEP	1% probability of any storm event being equivalent to or exceeding this event in any given year (equivalent to a 1 in 100 year average recurrence interval, or ARI)

Storm Event Probability	Description
1% AEP + climate change	1% probability of any storm event being equivalent to or exceeding this event in any given year with an additional allowance for climate change (equivalent to a 1 in 100 year average recurrence interval, or ARI, with allowance for climate change)
Probable Maximum Flood (PMF)	Statistical estimation of the most extreme storm event considered possible to occur that would produce the worst case flooding outcomes (approximately analogous to a 1 in 10,000,000 year ARI event)

Peak flood levels in the vicinity of the Powerhouse Parramatta development site for the four statistically significant storm events above have been predicted by the adopted Council flood model. These results were compiled by TTW in the 2016 flood study report described previously and are reproduced in Figure 12.

River Flood Level (Metres AHD)			
1:20 Year ARI	1:100 Year ARI	1:100 Year ARI + CC*	PMF
5.41	5.95	6.22	10.39

Regional Parramatta River Flood Levels (CH 2537)

Figure 12: Parramatta River peak mainstream flood levels collated by TTW (2016) from the published CoPC flood maps local to the development site

Based on these predictions, it is likely the February 2020 flood event corresponds to a flooding event less than the 5% AEP flood (or 1 in 20 ARI). It is noted that these peak flood levels exceed the finished level of the Riverbank Car Park lower ground floor level and landscape areas north of the car park. We therefore know that these areas are likely to experience to mainstream flooding in storm events up to and including the 5% AEP as well as the 1% AEP and rarer events.

The observed behaviour and flood extents captured in Figure 8 and Figure 9 generally matches these predictions of published flood studies and associated flood models for flood events of this magnitude.

7.4.2 Overland Flow Flooding

In addition to the risk of mainstream flooding from Parramatta River, overland flow paths impacting the site have also been identified as shown in Figure 13. The flow paths, originating from the Parramatta CBD catchment which extends south of the site, converge on Phillip Street and subsequently flow onto Dirrabarri Lane as well as the east of the existing GE building before eventually discharging into Parramatta River.

Flood maps issued by CoPC (dated 22 July 2016) covering the development site and its surrounds have been reviewed to understand the site flood affectation and to identify major flow paths traversing the site.

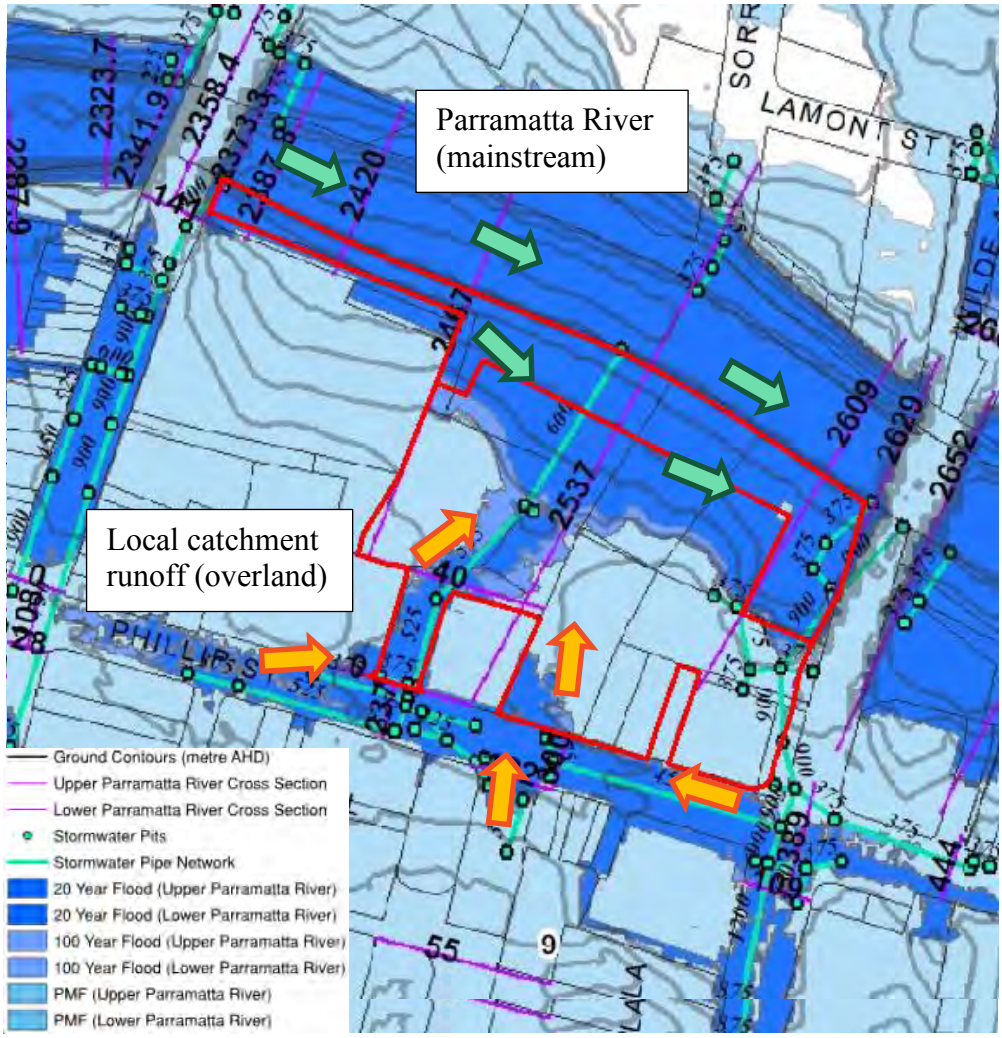


Figure 13: Major flow paths affecting the development site

The previous flood study undertaken for the development site by TTW (2016) collated the peak flood levels for overland flows. The flood levels, as shown in Figure 14, have been extracted from the adopted UPRCT Parramatta River MIKE 11 model for the 5% AEP, 1% AEP, 1% AEP with climate change (i.e. 15% increase in rainfall) and the Probable Maximum Flood (PMF).

Local Overland Flood Level (Metres AHD)				
	1:20 Year ARI	1:100 Year ARI	1:100 Year ARI + CC*	PMF
Phillip St CH237	6.90	6.95	6.99	11.32
Access Road CH40	6.89	6.94	6.98	11.36

Local Overland Flow Flood Levels

Figure 14: Overland flow peak flood levels in Phillip Street and Dirribarri Lane (referred to as Access Road) collated by TTW (2016) from the published CoPC flood maps local to the development site

These levels are generally higher than the mainstream flood levels for the Parramatta River as presented in Figure 12, primarily as a function of the terrain levels being elevated above the river levels. These peak flood levels have been used to validate the Arup flood model results developed as part of the assessment presented herein.

7.5 Stormwater

The available site information suggests that the existing stormwater network within the development site is a combination of private and City of Parramatta Council owned assets. The existing stormwater network has been surveyed by LTS Lockley (reference: 41692011DT; revision A; dated 12 March 2020), however, the survey was limited to only sizes, levels at the locations of the existing stormwater pits. Pipe alignments are inferred between pit positions.

It is noted that the stormwater network within the SSDA boundary requires confirmation due to incomplete survey information and known information gaps. Further investigations are being undertaken as of the date of this report to confirm further extents, details and condition of stormwater assets across the site including CCTV.

Despite these limitations in survey information, Arup is aware of at least three existing CoPC owned trunk drainage lines crossing through the Powerhouse Parramatta site illustrated in Figure 13 and summarized as follows:

- Ø900 mm trunk network along the east side of the site and discharging into the river underneath Wilde Avenue bridge;
- Ø600 mm trunk network through Dirrabarri Lane, underneath the existing Riverside Car Park and discharging into the river; and
- Ø900 mm trunk network along Church Street and discharging into the river near Lennox Bridge on the west side of the site.

Privately owned stormwater assets identified on the LTS Lockley site survey service the existing developments (as described in Section 7.3). These assets are not indicated in CoPC's flood maps & asset plans because they are not owned by CoPC.

Many of these private drains connect to either the CoPC network or discharge directly to Parramatta River via smaller outlets into the river channel walls. Based on information in the site survey, the following items of stormwater infrastructure are known to exist within the development site:

- Drainage pipes with sizes ranging from Ø100 mm to Ø900 mm and a reinforced concrete box culvert;
- Pits including:
  - grated kerb inlet pits with lintels;
  - grated inlet pits;
  - solid lid maintenance pits; and
  - gross pollutant traps near the outlet at Parramatta River.
- Grated trench drains and concrete dish drains collecting surface water; and

- Pipes discharging into Parramatta river via penetrations through the Parramatta River channel walls.

It is noted the scope of the Powerhouse Parramatta project does not include modifications to the existing river channel walls. As part of the development of the stormwater and flooding risk management strategy presented in this report, efforts have been made to avoid such works.

7.6 Utilities

Arup has undertaken a Dial before you Dig (DBYD) search to check for the presence of existing utilities within and surrounding the site. The DBYD search provides some information about the existing stormwater networks as discussed in Section 7.5 and provides information about other services. This is an important consideration because utilities may be sensitive to flooding and/or may be otherwise affected by the development proposals.

The following utilities and relevant authorities are known to be present within and around the development, noting that this list may not be exhaustive:

- Telecommunications: AAPT, AARNet, NBN, Nextgen, Optus/Uecomm, PIPE Networks, Telstra, Verizon, Vocus;
- Electrical: Endeavour Energy;
- Gas: Jemena;
- Telecommunications and electrical: RMS roads infrastructure;
- Potable water and sewer: Sydney Water;

Additional assets may be discovered as ongoing consultation continues with the relevant authorities through design development. At the time of publication, two key items have been identified which will require specific stormwater and flood risk related considerations. These are:

- There is an existing active Sydney Water Ø525 mm sewer trunk main running along the north area of the site parallel to Parramatta River which is installed at a shallow depth and is located close to the existing car park. Any in-ground works (including stormwater modifications and proposed foundations) will need to be designed to protect this existing asset as discussed further in Section 9.3.1; and
- There are existing Endeavour Energy substations on the site servicing some of the existing buildings and facilities described in Section 7.3 which are sensitive to flooding. Any modifications to these electrical assets as part of the redevelopment will need to be designed to reduce the risk of flood damage as discussed further in Section 8.6

8 Flood Risk Management

8.1 Flood Risk Management Approach

The Arup approach to flood risk management for the Powerhouse Parramatta development is systematic and scientific. The steps below outline the key activities. The findings from our modelling and the associated engineering recommendations have been regularly communicated to and discussed with the project team:

a) Arup completes a thorough investigation of the existing site conditions, surveys and record drawings, undertakes site inspections and reviews the available flood studies;

b) Interrogation of the existing available flood models, to identify their strengths and weaknesses, assess them for their suitability for use on this project and consideration of how they could be improved;

c) Arup staff liaise with Sydney Water and CoPC in relation to their requirements for flood risk management and the application of DCP requirements and flood risk policy guidelines to the development site;

d) Hold meetings and discussions with the project team to discuss preliminary strategies for managing flood risk and how these might be integrated into the development proposals;

e) Preparation of an Arup project-specific flood model to investigate the pre- and post-development flooding conditions in greater detail. This includes testing the effectiveness of preferred flood risk management strategies discussed within the project team;

f) Development of preliminary proposals for stormwater management including drainage infrastructure plans and 3d terrain models and further coordinated with the project team;

g) Testing of design proposals in the Arup Powerhouse Parramatta flood model to verify that flood planning outcomes could be achieved; and

h) Production of flood maps, flood animation videos, drawings and reports to capture the completed work and offer commentary on the strategic flood risk management approach.

Sections 8 and 9 together with the information contained the Appendices of this report provide more detail of the activities outlined above. Sections 10 and 0 of this report present the conclusions of these works, any limitations and the further work that is likely to be required.

8.2 Review of Existing Flood Models

As discussed in Section 7.4, several existing studies and flood models have been prepared to simulate the behaviour of the Upper Parramatta River. Arup has interrogated and reviewed the available models at the time of publication and

considered their suitability for assessing the Powerhouse Parramatta development as summarised in Table 6.

The MIKE11 modelling first developed in 2003 is the basis of the currently adopted CoPC flood model. The results of this model are used by CoPC today for flood planning purposes within their LGA.

CoPC is now the custodian of the two draft versions of the MIKE11 model, specifically referred to as Draft 8 and Draft 9, following the dissolution of UPRCT who originally developed the model. No supporting document which accompanies the MIKE11 model is available.

Arup notes that the there is no published supporting document which elaborates further on the MIKE11 flood modelling undertaken by UPRCT for the Upper Parramatta River catchment. A summary of what is known about the two draft versions is provided in Table 6 below.

CoPC has made known that a new Parramatta River flood study and associated TUFLOW model is currently being prepared by Cardno based on the recently published ARR2019 guidelines. A report describing this study has been published in draft but has yet to be formally adopted at the time of publication of this report. Public exhibition of the draft report is planned by CoPC and we understand the associated flood model will be made available, possibly as soon as late 2020. As such, this forthcoming flood model was not available to Arup for use in the assessment of Powerhouse Parramatta.

A preliminary flood model has also been developed by TTW (2016) using TUFLOW for the development site. However, a review undertaken by Arup (refer Appendix E |) found that the flood model is not suitable for the purposes of the current assessment and hence could not be adopted herein.

Table 6: Summary of previous flood models developed for the Parramatta River

Flood Model and Author	Year Developed	Strengths	Limitations	Applicability to Powerhouse Parramatta Assessment
UPRCT - Upper Parramatta River MIKE11 model (Draft v.8)	Circa 2006	• CoPC adopted flood model for flood planning in the LGA	• Flow paths represented in 1D • Not calibrated to historical events • “Glass-wall” effect present with floodplain storage under-estimated	• Parramatta River flows and levels from this model adopted as boundary conditions in the current assessment • River cross-sections from the model used to define the

Flood Model and Author	Year Developed	Strengths	Limitations	Applicability to Powerhouse Parramatta Assessment
			• Climate change scenarios not modelled • Out-of-date Parramatta River bathymetry • CoPC flood maps and levels developed based on results from this model, used to validate the model developed for the current assessment	
UPRCT - Upper Parramatta River MIKE11 model (Draft v.9)	Circa 2012	• Further refined from the Draft 8 version • Calibrated to historical events • Climate change scenarios modelled	• Not officially adopted by CoPC for flood planning in the LGA despite being a more robust model build • Similar limitations to the Draft 8 version, i.e. flow paths represented in 1D, under-estimation of floodplain storage	• Not used in the current assessment
TTW - Preliminary Museum Parramatta TUFLOW model	2016	• 2D model which simulates both mainstream and overland flow flooding accounting for floodplain storage	• Boundary conditions not based on flows from the CoPC adopted MIKE11 model • Various issues associated with the model schematisation including the absence of Parramatta River bathymetry, stormwater network, inaccurate representation of head losses of the bridge structures (also	• Not used in the current assessment

Flood Model and Author	Year Developed	Strengths	Limitations	Applicability to Powerhouse Parramatta Assessment
			refer to Appendix E |)	
Cardno - Parramatta River TUFLOW model	2019	• Utilised latest ARR2019 approach in model development • Incorporates up-to-date stormwater drainage and topographic conditions • Calibrated to historical events • Peer-reviewed	• Not officially adopted by CoPC for flood planning in the LGA as study has yet to undergo public exhibition and review by other stakeholders	• Model could not be issued by CoPC as it is not officially adopted • Results from the draft report used to validate the Arup model developed for the current assessment

Following discussion with CoPC (refer Appendix G |) and recognising the limitations associated with the Parramatta River flood models available (also refer to Appendix E |), it became imperative that a new flood model needs to be developed to provide a more robust and reliable simulation of the flood behaviour for the development site, utilising up-to-date information and following AR&R guidelines.

This model (referred to herein as the Arup Powerhouse Flood Model) incorporates the CoPC adopted MIKE11 model Parramatta River flow and tailwater hydrographs as the boundary conditions, provides simulation of both overland flow and mainstream flood behaviour, as well as addresses limitations identified in the existing flood models.

8.3 Existing Conditions Assessment

Detail description of the Arup Powerhouse Flood Model is provided in Appendix C |. In summary, the approach undertaken is the development of a DRAINS hydrological model coupled with a 1D/2D (One-dimensional and two-dimensional) TUFLOW hydraulic model that simulates both mainstream flooding from the Parramatta River as well as overland flow flooding within the Parramatta CBD catchment. Both software packages are industry standard and widely used in Australia for undertaking flood assessments.

Key enhancements to the flood models developed as part of the assessment herein include:

- Use of most recent LiDAR survey (dated June 2019) sourced from NSW Spatial Services in the development of the Digital Elevation Model (DEM) of the Parramatta River catchment;

- Incorporation of detailed topographic survey of the development site undertaken by LTS Lockley;
- Inclusion of Council stormwater pits and pipes network, and development of pit inlet rating curves;
- Schematisation of Parramatta River bridge structures based on information deduced from survey, site visit and Google Street View, including the Lennox Bridge portals;
- Incorporation of Parramatta River bathymetry derived from the MIKE11 model river cross-sections to more accurately simulate river flow conveyance;
- Use of updated building footprints based on survey, recent aerial photos and Open Street Map; and
- Introducing appropriate pit blockage factors and blockage of hydraulic structures, i.e. bridges, as per ARR2019 recommendations.

An overview of the model setup is shown as Figure 15.

Figure 15: Overview of TUFLOW model setup

The DRAINS and TUFLOW models developed herein have been used to simulate the 5% AEP, 1% AEP, 1% AEP with climate change (i.e. 20% rainfall increase)

and PMF events. It is important to note that the ARR87 hydrology has been adopted for the current assessment since the model boundary conditions are based on the MIKE11 flows which have been derived using ARR87. For subsequent design stages, sensitivity runs will be undertaken adopting the ARR2019 hydrology and any changes to the predicted flood behaviour will be assessed. Experience from other Sydney based projects has shown that the peak flood levels would reduce when the ARR2019 hydrology is adopted compared to those developed using ARR87 hydrology.

In modelling the climate change scenario following ARR2019 recommendations, the 2090 RCP (Representative Concentration Pathways) 8.5 emission scenario was adopted cognisant of the Powerhouse Parramatta project would have a design life spanning more than 100 years. A 19.7% rainfall increase has been predicted for this scenario and this has been modelled herein for the 1% AEP event. Sea level rise has not been modelled herein as it generally affects the tidal areas downstream of Charles Street Weir (Cardno, 2019) and not the development site. Further, the probability of a flood event occurring coincidentally with a high tide is generally low.

The critical storm durations for each AEP flood and each flooding mechanism (i.e. overland flow and mainstream flooding) have been ascertained. Further details are provided in Appendix C |. The model results have been validated via comparison against the Parramatta River flood level profiles as obtained from the CoPC flood maps and Cardno (2019) draft flood study as shown in Figure 16.

It can be seen that the results compare quite well with the published results. The discrepancy in the 1% AEP river flood levels when compared to the CoPC adopted levels is generally in the order of 0.2 – 0.3 m adjacent to the development site. This difference can be attributed to the limitations associated with the MIKE11 model, which has not accurately accounted for floodplain storage and the absence of the Lennox Bridge portals (constructed in the 2010s).

Comparison has also been undertaken for the local overland flow flood levels at the development site as summarised in Table 7. The difference in peak flood levels between the MIKE11 model and the Arup Powerhouse model is generally in the order of 0.1 m for events up to the 1% AEP with climate change event. Hence, the results are relatively similar. For the PMF, the difference is in the order of 0.5 m.

Table 7: Comparison of Overland Flow Flood Levels on Development Site

Flood Events (AEP)	**UPRCT MIKE11 Model**		**Arup Powerhouse TUFLOW Model**	
	Phillip St	**Dirrabarri Ln**	**Phillip St**	**Dirrabarri Ln**
5%	6.90	6.89	6.85	6.77

Flood Events (AEP)	UPRCT MIKE11 Model		Arup Powerhouse TUFLOW Model	
	Phillip St	Dirrabarri Ln	Phillip St	Dirrabarri Ln
1%	6.95	6.94	6.93	6.83
1% with Climate Change*	6.99	6.98	7.00	6.97
PMF	11.32	11.36	10.82	10.80

* UPRCT adopted 15% rainfall increase for the climate change scenario whilst the Arup model adopted 20% rainfall increase following ARR2019 recommendations

The flood maps for the existing conditions are provided in Appendix B |. The results show that the existing car park basement is significantly inundated by floodwaters mainly from Parramatta River, with more than 1 m of flood depth expected for the 5% AEP event. The overland flow paths are shown to converge near the intersection of Phillip Street and Horwood Place, before flowing onto Dirrabarri Lane as well as traversing east of the existing GE building.

Floodwaters eventually pool around the low point at the open-air car park located adjacent to the multi-storey Riverbank car park which is drained primarily by the Ø600mm trunk found under the car park. For the 1% AEP event, the flood levels increase such that the floodwaters start to flow around the south-west corner of the multi-storey car park, down the ramp and discharges towards Parramatta River. Most of the floodplain including the development site is shown to be flooded by more than 2 m of floodwaters in the PMF event.

Hazard maps have also been provided for the 1% AEP and PMF events, based on the hazard category recommended by the AIDR (2017) guidelines. It can be seen that for the 1% AEP event the existing car park is subject to high hazard flow up to the “H5” category, which is unsafe for all people and vehicles. For the overland flow flooding, flows up to the “H2” category can be expected for Phillip Street and Dirrabarri Lane, which is unsafe mainly for small vehicles; and “H3” category for the trapped low point at the open-air car park, which is unsafe for vehicles, children and the elderly. For the PMF event, most of the development site and adjacent floodplain are subject to “H6” hazard flow which is dangerous flows not suitable for evacuation access.

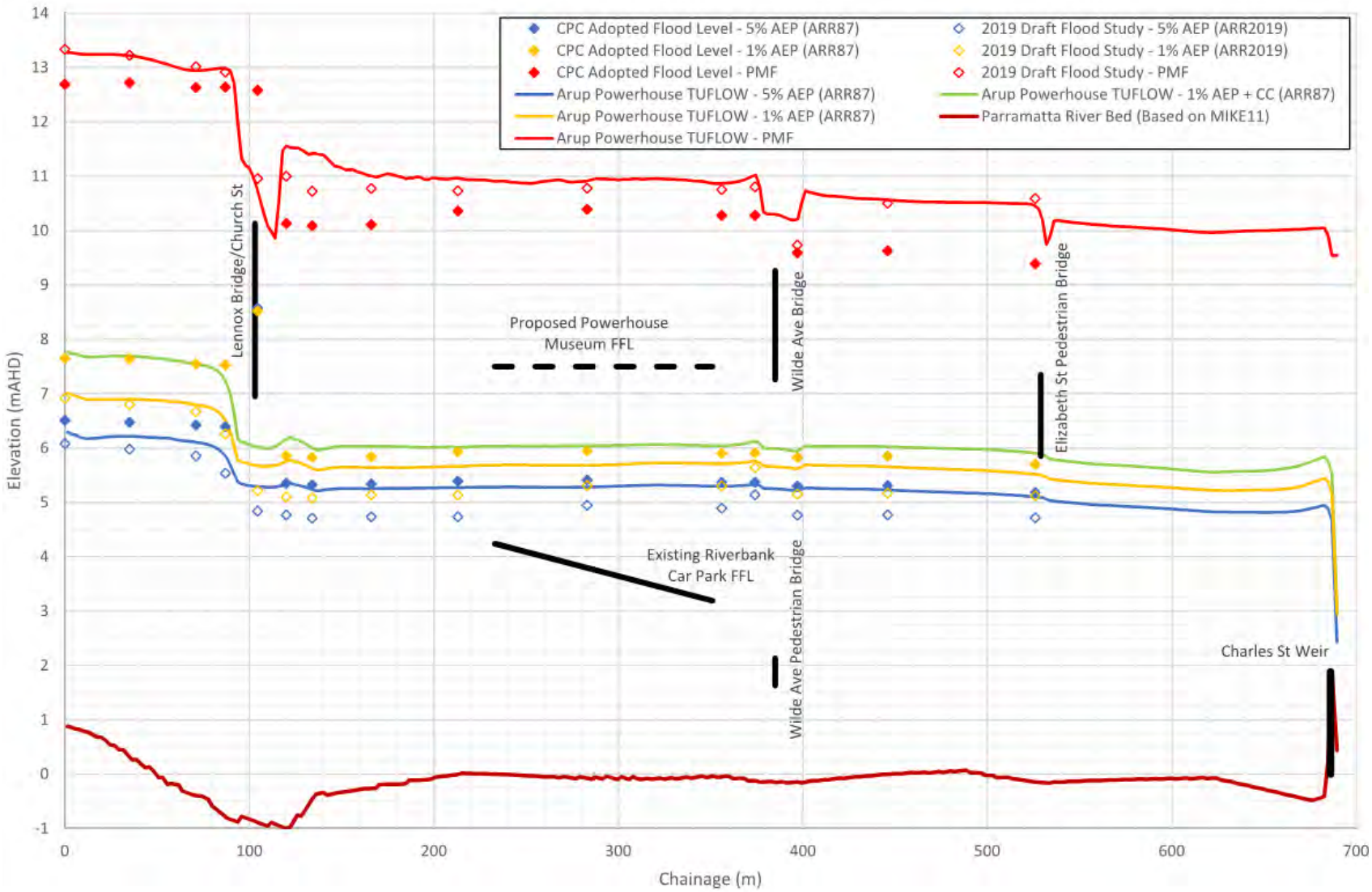


Figure 16: Parramatta River peak flood levels – longitudinal section comparing the results of the various flood model simulations of the river behaviour

8.4 Flood Risk Management Strategy

The Powerhouse Parramatta development proposal seeks to provide passive flood protection of the development up to the 1% AEP plus 0.5 m freeboard, which is also a requirement stipulated by the Parramatta DCP 2011. To facilitate the tie-in of the development Finished Floor Level (FFL) with the surrounding ground elevation, there would be modification to the existing ground levels as part of the regrading works undertaken for the public domain. The flood risk management strategy proposed herein strives to achieve a balance whereby the impact of the civil works on existing flood storage and flow conveyance on site can be reduced to a minimum, and consequently the adverse impacts on neighbouring properties would be negligible.

The main challenge, therefore, is to replicate the existing flood behaviour for both mainstream flooding from Parramatta River as well as the Parramatta CBD overland flow flooding. Our proposed approach seeks to manage these two flooding mechanisms concurrently but separately making use of the undercroft spaces, open spaces at similar levels to the riverbanks and located below the built form of the Powerhouse Parramatta development.

The strategy is to make use of the architectural undercroft spaces together with the open landscape area north of the buildings to provide mainstream flood storage and maintain existing elevations. The overland flow flooding that is known to occur on the existing on-grade car park shown in Figure 17 must be mitigated, principally by raising ground levels, to facilitate the new West Building. The displaced overland flow flooding will be managed with new conveyance infrastructure.

Further, the Ø600 mm trunk drainage will be relocated to facilitate the new building footprint. Hence, the proposed flood risk management strategy serves to offset the negative effects generated by these changes to the pre-development flood behaviour.

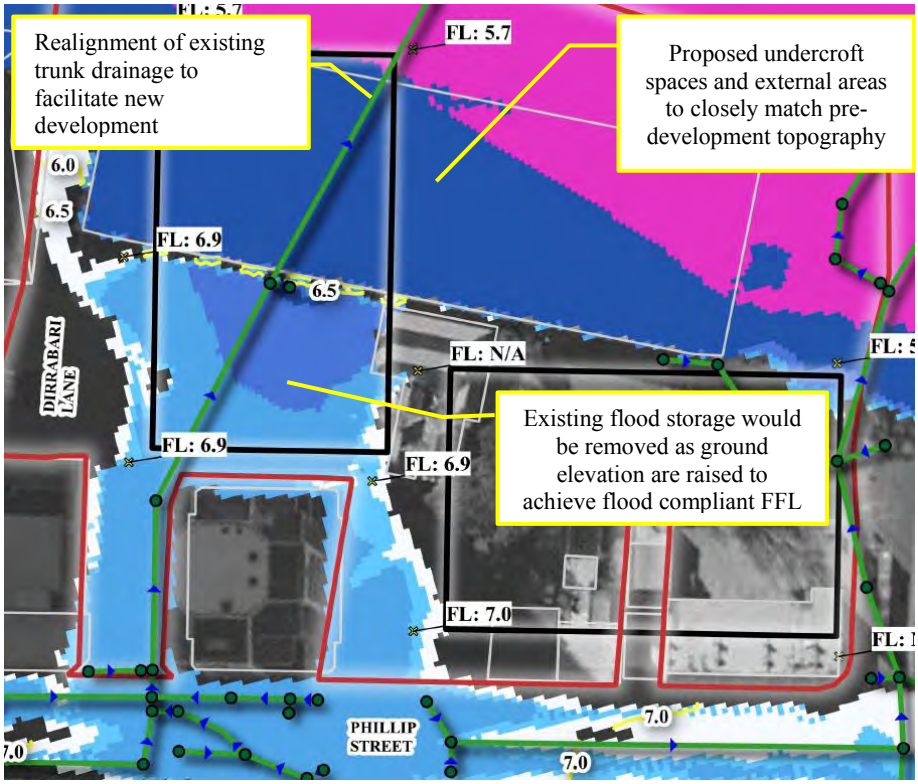


Figure 17: Summary of key changes proposed as part of the Powerhouse Parramatta development proposal and flood risk management strategy

Both civil and stormwater drainage solutions have been considered herein as part of the management strategy, details of which are outlined in Appendix I |. A summary of the proposed solutions is as follows:

- Local regrading of surface elevation along Dirrabarri Lane to maintain the Phillip Street overland flow path;
- Upgrading/augmenting the existing Ø600mm trunk drainage to convey additional flows; and
- Proposing new drainage line to convey flows east and connect with the Ø900mm trunk drainage under Wilde Avenue Bridge.

Further discussion of the proposed stormwater design is provided in Section 9.3.1. The enhanced drainage solutions serve to convey floodwaters displaced by the new development and discharge directly to Parramatta River. Once the proposed stormwater drainage reaches capacity, floodwaters will be conveyed above ground along Dirrabarri Lane before discharging to Parramatta River.

8.5 Proposed Conditions Assessment

The flood maps for the post-development conditions which incorporate the flood risk management strategy outlined in Section 8.4 are provided in Appendix B |. The results show that the West Building undercroft and open landscaped areas north of East Building are subject to significant inundation by floodwaters from

Parramatta River. This flood behaviour matches that observed for existing conditions with peak flood depth of more than 1 m expected for the 5% AEP event. The results also show that the Phillip Street overland flows are now fully contained within the proposed stormwater drainage in the 5% AEP event. The crest located on Dirrabarri Lane gets overtopped only for the 1% AEP event and above with floodwaters flowing north down the ramp and discharge towards Parramatta River. Post-development conditions for the PMF also match existing conditions whereby most of the floodplain including the development site is shown to be flooded by more than 2 m of floodwaters.

Hazard maps have also been provided for the 1% AEP and PMF events, based on the hazard category recommended by the AIDR (2017) guidelines. It can be seen that for the 1% AEP event the West Building undercroft and open landscaped areas north of East Building are subject to high hazard flow up to the "H5" category, which is unsafe for all people and vehicles. For the overland flow flooding, flows remain at "H1" category which is benign condition for both vehicles and pedestrian for most of Phillip Street and Dirrabarri Lane. This is an improvement to flow conditions when compared to existing conditions. For the PMF event, most of the development site and adjacent floodplain are subject to "H6" hazard flow which is dangerous flows not suitable for evacuation access.

The flood afflux maps compare the post-development peak flood levels against those of existing conditions. Afflux (or change in flood level) of ± 0.01 m is within the tolerance of model accuracy, hence is considered as "no impact". Level difference which exceed 0.01 m is considered as "adverse impact". Parramatta DCP 2011 stipulated that any development should not adversely increase the potential flood affectation on other development or properties, and this has been investigated herein for events up to the 1% AEP plus climate change.

For the 5% AEP event, the post-development conditions incorporating the flood risk management strategy resulted in decrease in peak flood levels up to 0.1 m as well as reduced flood extent for Phillip Street. This is a beneficial impact introduced by the development which reduces flood affectation for existing properties on Phillip Street. There is a slight increase in peak flood level at the Parkroyal entry driveway and this can be resolved at a later design stage with the augmentation of the local drainage system around the driveway. The impact of the development proposal on Parramatta River peak flood levels is generally negligible. Small pockets of adverse flood impacts are found downstream of the southern Lennox Bridge portal. Nevertheless, the 5% AEP mainstream flood levels of approximately 5.3 mAHD are well below the FFL of the adjacent Meriton development, which has a retaining wall height above 7 mAHD. Hence, there is no change in the flood affectation for this property.

The 1% AEP afflux generally shows a reduction in peak flood levels on Phillip Street and negligible impact on Parramatta River flood levels. This confirms the development proposal does not cause adverse impacts on other development or properties for the 1% AEP flood.

For the 1% AEP event with climate change (i.e. 20% rainfall increase), there is reduction in peak flood levels of more than 0.1 m on Phillip Street as well as reduced flood extent. There is, however, a slight increase in Parramatta River peak

flood levels under the Wilde Avenue bridge though this flood impact does not affect any existing property (including 16 Lamont Street which is located adjacent to the northern abutment of Wilde Avenue bridge). This impact can be resolved at a later design stage by revisiting the surface grading along the eastern boundary of the development site so that its influence on the mainstream flood behaviour matches that of the existing conditions as closely as possible.

8.6 Flood Planning Levels

The proposed Powerhouse Parramatta building Finished Floor Levels (FFLs) shall comply with the minimum flood planning levels (FPL) as stated in CoPC's development control plan (DCP). This is to minimise the risk of surface flooding entering the building where it can cause damage and present a risk to occupants.

For a museum development this is calculated as the maximum adjacent 1% AEP flood level + freeboard (an additional vertical clearance above the maximum flood level of 500 mm).

The flood model maps for the 1% AEP post-development scenario (refer Appendix B |) demonstrate the maximum flood level near the West Building is approximately RL: 6.8 mAHD. Adding the 0.5m freeboard the FPL is RL: 7.3 mAHD. There is no flooding immediately adjacent to the East building however, because the maximum flood level on Phillip Street is in the order of RL: 7.0 mAHD and peak depths are less than the height of a kerb, thus floodwaters are safely contained in the road corridor.

The architectural design has both the West and East Buildings with a FFL of RL: 7.5 mAHD. For both buildings, this FFL will exceed the FPL and comply with the CoPC DCP control.

It is also noted that the driver for FPLs and the proposed building FFLs is overland flow flooding in the public streets rather than flooding of the Parramatta River itself. Arup flood model results indicate that the River reaches a peak level of RL: 5.7 mAHD in the 1% AEP event and RL: 6.0 mAHD in the 1% AEP event with climate change. It is noted these levels are similar to the CoPC adopted results presented in Figure 12.

This assessment demonstrates the proposed museum buildings will be established at an elevation more than 1.0 m and as much as 1.5 m higher (with freeboard) than the peak river flood level. This design approach is considered to offer a good level of protection to the development to guard against the risk of mainstream flooding.

Raising buildings to a higher FFL (and thereby offering even greater freeboard) will create difficulties with the design of the public domain levels and grades surrounding the building. This is a common consideration when setting building finished floor levels to achieve flooding protection and given the nature of the development as a public facility it is important that accessibility is given careful consideration.

A vehicular entrance into the East Building via Wilde Avenue is also currently under consideration at the time of publication. Subject to detailed design of the finished levels of the driveway, some local detailing is likely to be required to

manage local overland flow in the west gutter of Wilde Avenue. This will be considered in greater detail as the design develops.

Consideration has also been given to the locations and elevation of proposed development substations to mitigate against a flood risk as described in Section 7.6. The minimum Endeavour Energy requirement for substation flood protection is the 1% AEP flood level and advice has been provided to the electrical engineering team to achieve this outcome. Efforts will also be made to exceed this level of flood protection where reasonably practical to offer enhanced risk mitigation. For further details refer to the Arup electrical engineering documentation.

8.7 Emergency Evacuation Strategy

Management of flood risk for the development and the mitigation of flooding impacts for the surrounding properties has been a major consideration in the development of the SSDA. Protection of the Powerhouse Collection, enjoyment of the public domain, public safety and risk management are paramount to the Powerhouse. The Powerhouse is particularly cognisant of the need to manage the risk to the public and staff whilst wishing to allow the activation of the space adjacent to the Parramatta River.

As previously discussed (refer to Section 8.6), the floor levels for the Powerhouse Parramatta have been set above the 1% AEP flood level with a suitable freeboard allowance. Access points for the two buildings have also been located above the 1% AEP flood level and there is no increased risk to public safety for people within the building. These key design outcomes have been achieved by the inclusion of the undercroft area.

A major benefit of the undercroft is maintaining the existing flood levels, by providing the same volume of flood storage (as the existing car park) on the site. Importantly, in terms of evacuation, the undercroft maintains the flood storage at similar times within the storm profile. This minimises changes to the existing times of inundation for surrounding properties and therefore the development does not materially change the flood warning / evacuation procedures for the surrounding properties.

However, the inclusion of the undercroft does require an assessment for the evacuation of this open space which is within the modelled flood extents. The development, including the undercroft, is inundated in both local catchment and Parramatta River mainstream flooding events. The time of inundation for local catchment flooding is less than an hour (refer Figure 18). This is significantly less than the time of inundation from Parramatta River flood events, which although much larger, take longer to pass through the catchment and inundate the site.

For this reason, the most likely event to require an unplanned evacuation of the undercroft area is a local storm flood from the stormwater network. This would restrict access from Dirrabarri Lane and Wilde Avenue.

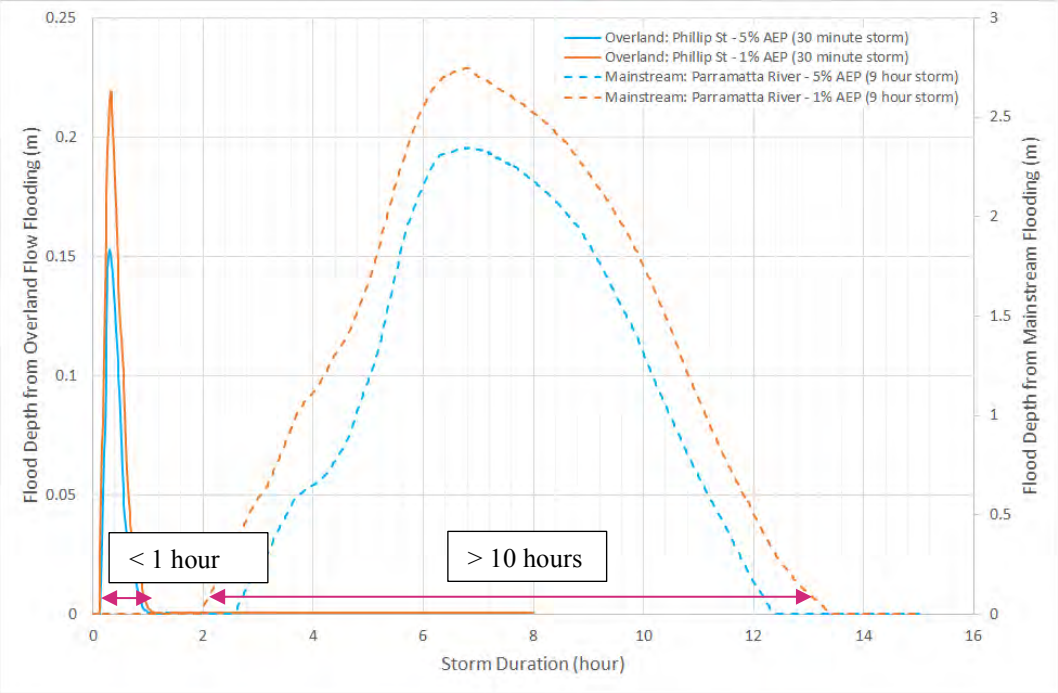


Figure 18: Inundation duration based on the critical storm for the development site

It is anticipated that an early warning system, using rainfall forecasts will be used to determine if the undercroft space should be open for use or not. This would be a daily procedure undertaken prior to the daily opening of the undercroft and managed within the building operations. This daily review would be supported by on site observations and permanent warning signage within the undercroft area.

Figure 19 shows the proposed surface levels within the undercroft and the modelled flood contours, for the 5% AEP and 1% AEP flood events. The top of bank level is also shown.

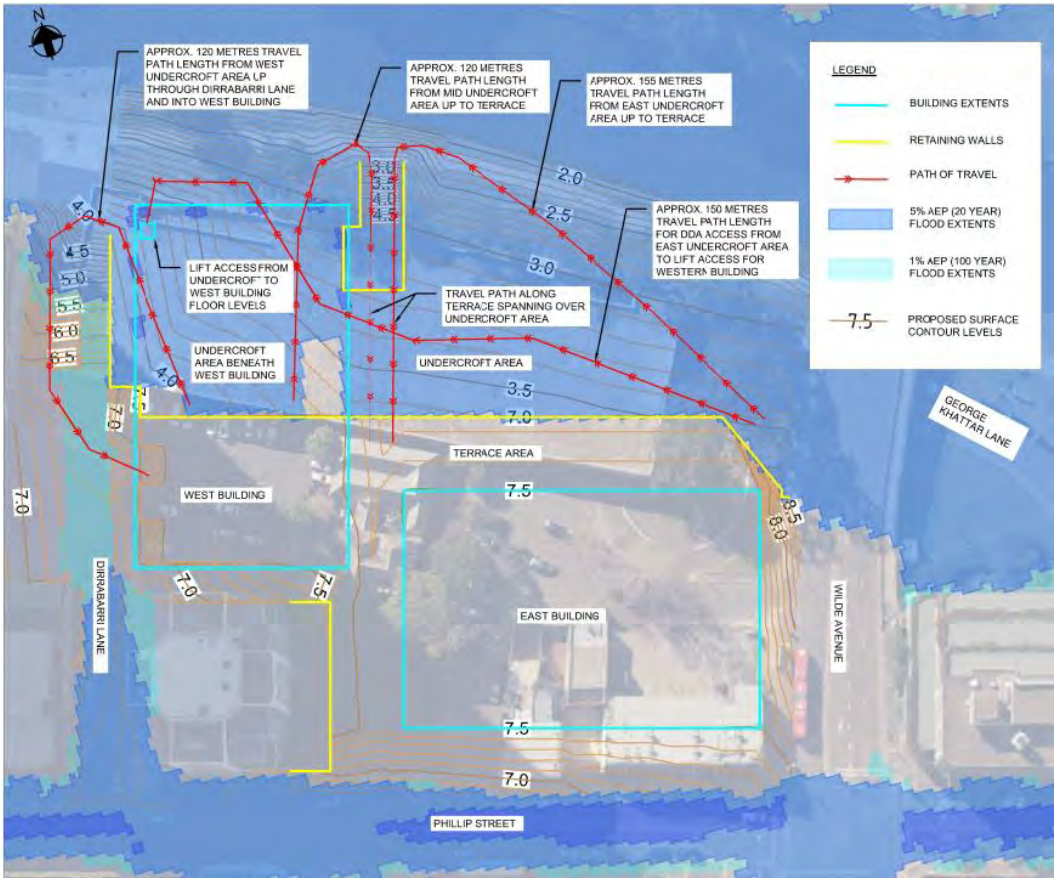


Figure 19: Flood evacuation assessment illustrating paths of travel

Figure 19 also shows indicative distances from various points within undercroft to possible points of emergency evacuation – escalators, stairs, adjacent laneways, lifts and DDA lift. During detailed design this figure will be refined with the Powerhouse and architectural team to estimate the evacuation time for based on the maximum number of people within the undercroft area.

As shown on Figure 19, the maximum travel distance from the undercroft to above the 1% AEP contour is 155m. We believe it is feasible to safely evacuate people from this area in a matter of minutes and long before the peak of the storm arrives in approximately 30 minutes. This will be reviewed and confirmed within the detailed design as the purpose and number of people within the undercroft area is confirmed.

As part of the detailed design full consideration of warning signage and other mitigation measures such as voice messages / flashing lights, will be undertaken. As part of the design development and documentation an evacuation plan detailing the management procedures to be followed in an emergency will be prepared. This will include details of any operational measures such as automated warning, visual surveillance, evacuation drills and training for security / site management teams required for the long-term operation of the Powerhouse Parramatta.

In the event of a major flood the advice given by SES and CoPC is to remain in a safe location above the flood level and not to enter flood waters. Any staff or visitors "trapped" by a flood event would be directed into the Powerhouse Parramatta, which is located above the 1% AEP flood level. The existing site is inundated in events as frequently as the 5% AEP event, this is unchanged by the Powerhouse Parramatta development.

Modelling suggests that flooding from the local catchment would generally ease within an hour (refer Figure 18) and then people could exit and return to Phillip Street. The time of inundation for a Parramatta River flood is greater and estimated in the order of 10 hours or more for the critical storm event but is still a number of hours rather than days and the advice to remain in the Powerhouse Parramatta buildings and wait until the storm / flood has passed would remain the same. Though parts of the Phillip Street road corridor currently experience inundation in events as frequent as the 5% AEP, it is noted that emergency egress via the Phillip Street remains possible during emergency in view of the benign flow conditions (refer Section 8.5).

The development removes the existing car parking from the site and does not include parking within the 1% AEP flood extents. This is considered an improvement on the existing use for the site. Vehicular access is currently still being defined for the Powerhouse Parramatta and at this point it is anticipated to be via George Khattar Lane for the undercroft area, Dirrabarri Lane for the West Building and Wilde Avenue for the East Building.

9 Stormwater Infrastructure

9.1 Existing Case Stormwater

9.1.1 Existing Stormwater Network

With reference to Section 7.5 for the summary of existing stormwater assets in the development, the following trunk networks have been inferred based on the available survey and site information to date and which include:

- Ø900mm trunk network along the east side of the development site - Catchment area of approximately 17.5 hectares and consists of the east half of the development site, the Smith Street corridor to Parramatta Station, Parramatta Square and up to the intersection of Church Street and Fitzwilliam Street;
- Ø600mm trunk network through Dirrabarri Lane – Catchment area of approximately 3.65 hectares and consists of approximately half of the development site, half of the Phillip Street frontage and a portion of the commercial block south of Phillip Street; and
- Ø900mm trunk network along Church Street – Catchment area of approximately 5.45 hectares and consists of the Church Street corridor up to the intersection with Macquarie street before Parramatta Square.

Refer to Figure 20 for the catchment area plan.

The existing pits and pipes appear to consist of reinforced concrete and the network generally appears to be in fair condition with no signs of significant blockage based on visual ground inspection on a dry day.

It is unclear which areas and existing buildings within the development site drain into which specific stormwater network. However, Figure 20 generally illustrates the assumed arrangement.

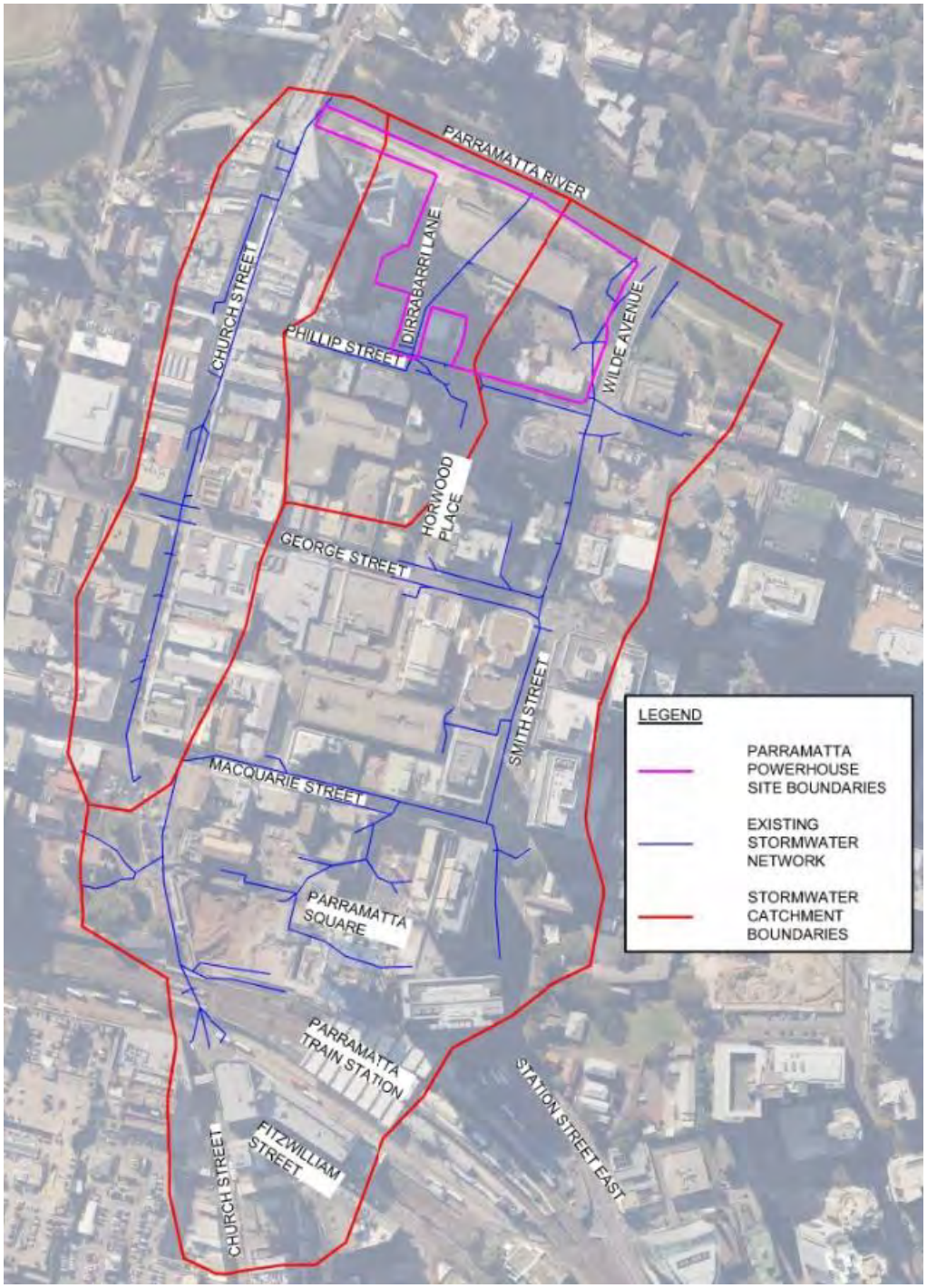


Figure 20: Existing stormwater drainage infrastructure catchment plan for areas in close proximity to the Powerhouse Parramatta development site

9.1.2 Existing On Site Detention (OSD)

The currently available site and survey information does not indicate the use of on site detention (OSD) systems for the existing car park or private development lots. During storm events, it is understood stormwater network flows are unrestricted

and will discharge freely into Parramatta River while overland flows will cascade through the site over the riverbank into the river.

Flood modelling of the pre-development condition demonstrates portions of the existing development site catchment act as temporary flood storage as illustrated in Figure 21 and summarized as follows:

- Mainstream flooding from Parramatta River – river water level rises inundating the landscape area fronting the river and the lower ground level of the Riverside Car park. The storage volume around the existing car park area is approximately 18,500 m³ for the 1% AEP (100 year) flood event including allowances for climate change; and
- Overland flooding from Smith, Church and Phillip Street – ponding around intersection of Dirrabarri Lane and Phillip street, the existing GE building and outside car park area before entering in the Ø600mm network underneath the existing car park and discharging into the river.

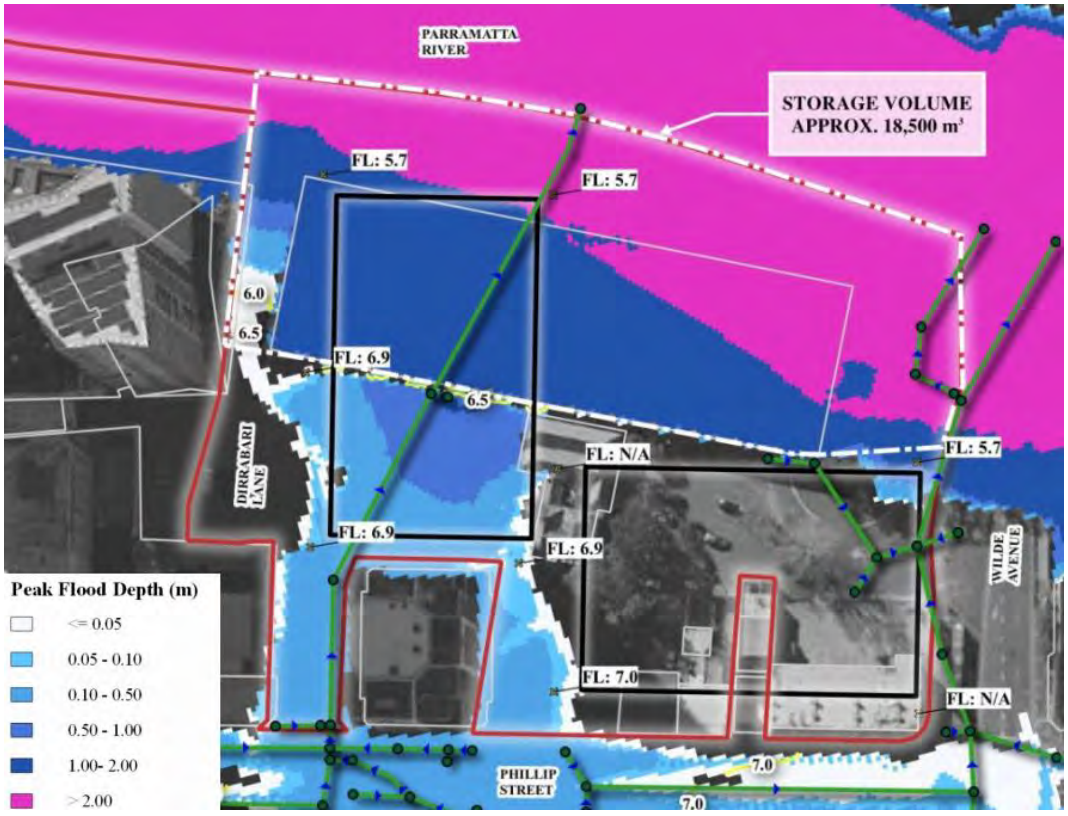


Figure 21: Flood depths during 1% AEP (100 year)

9.1.3 Existing Water Quality

The currently available site and survey information indicates the following water quality treatment items on the existing development site:

- Gross pollutant trap (GPT) at the outlet of the Ø600mm trunk network before discharging to Parramatta River (refer to Figure 22); and

- Vegetated landscape areas fronting Parramatta River and at various locations across the site.

It is currently not known the configuration of the GPT unit and how well the existing system performs in terms of water quality improvements.

Figure 22: Existing GPT near Ø600 mm trunk outlet

9.2 Impacts of Proposed Development on Existing Stormwater Network

The Powerhouse Parramatta development consists of proposed landscape areas around the frontage to Parramatta River, a raised terrace level above the riverbank level, two buildings with undercroft spaces addressing the riverbank level and a rooftop containing gardens (refer Figure 23).

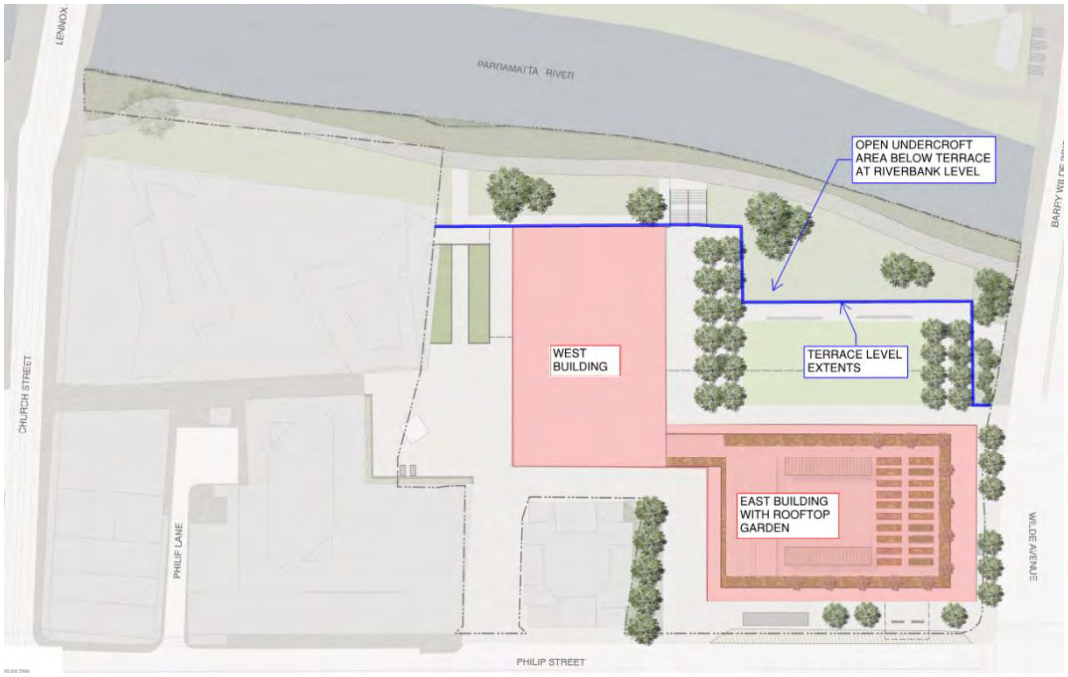


Figure 23: Post-development architectural plan (source: McGregor Coxall Powerhouse Parramatta SSDA issue dated 02/04/2020)

These proposed development items have the following impacts on the existing stormwater network:

1. Existing drainage clashing with proposed building footprints (refer Figure 24)
    - The proposed footprint of the West Building clashes with the existing Ø600mm stormwater trunk main. This trunk main is to be removed to accommodate the proposed building. An upsized trunk culvert is proposed to the west of the building which is further discussed in section 9.3.1; and
    - The proposed footprint of the East Building clashes with existing Ø375mm stormwater mains and pits. These existing stormwater assets are to be removed to accommodate the proposed building.

Figure 24 Existing stormwater assets within proposed building footprints

2. Catchment area surface conditions

- When comparing the pre-development conditions (Figure 25) to the proposed development design (Figure 23), the proposed development generally consists of approximately the same amount of permeable surfaces with opportunity for more. Permeable surfaces help reduce the amount of peak flow expected through the stormwater network in the event of a rainfall and also helps reduce suspended solids from discharging into the river. Efforts are to be made during the design development to maintain the same amount or more of permeable surfaces.

Figure 25: Pre-development aerial plan (source: SIX Maps retrieved on 07/04/2020)

3. Proposed building catchments and connection into stormwater network
    - The West Building is proposed to connect to the stormwater trunk network near Dirrabarri Lane. The catchment characteristics of the proposed building are not dramatically different from pre-development conditions and are not expected to significantly impact the Dirrabarri Lane trunk network.
    - The East Building is proposed to connect to the existing Ø900mm east stormwater trunk network running underneath Wilde Avenue bridge. The catchment characteristics of the proposed building are not dramatically different (and may be considered more permeable because of the rooftop gardens) from pre-development conditions and are not expected to significantly impact the Ø900mm trunk network.
4. Finished ground levels and grading
    - The general grading strategy for the proposed site is to maintain the existing topography as feasibly as possible while achieving the required finished floor entry levels into the buildings as protection against flooding (refer to Figure 26).
    - The ground and terrace levels surrounding the proposed buildings grade away from the building edges to stormwater network corridors on Dirrabarri Lane and Phillip Street. The exception is the east face of the

East Building interfacing Wilde Avenue. This is to be further refined in the design development to prevent surface runoff from ponding along the edge of the building.

- Dirrabarri lane is grading to either Phillip Street and its associated stormwater network or northwards to Parramatta River.
- The landscape and undercroft area fronting Parramatta river grades toward the river.
- This strategy generally maintains the same amount of catchment area allocation between the pre and post development conditions to the respective existing stormwater trunk networks in the site.

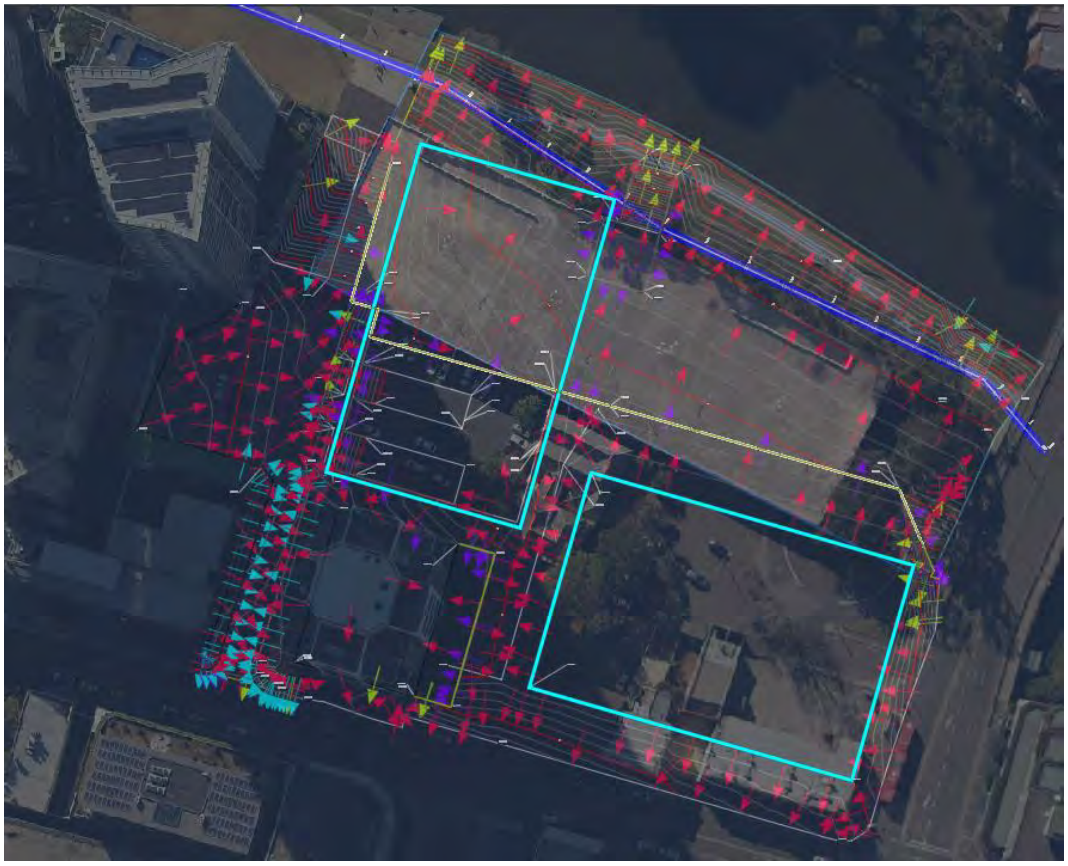


Figure 26 Post-development finished ground levels and grading strategy

5. Overland flow paths

- In the pre-development condition, there are two overland flow paths on the east and west side of the existing car park (refer to Figure 27). The existing car park acts as a blockage structure to overland flow and results in ponding at the south face of the existing car park above the inlet pit into the Ø600mm trunk main.
- For the post-development case with the two proposed buildings, there is now an additional overland flow path through the development site to help with surface runoff conveyance (refer to Figure 28). The three overland flow paths are:

- Dirrabarri Lane is retained as a flow path;
- New flow path in between East and West Buildings; and
- East pathway along Wilde Avenue is retained as an existing flow path.

Figure 27: Pre-development 1% AEP peak flood depth map and key overland flows

Figure 28: Post-development 1% AEP peak flood depth map and key overland flows

9.3 Proposed Case Stormwater Development

9.3.1 Proposed Stormwater Network

The Powerhouse Parramatta preliminary stormwater design generally comprises of three catchments. Figure 29 shows the approximate catchment areas. As per CoPC's engineering design guidelines, the stormwater network has been designed for the 5% and 1% AEP storm events.

New stormwater infrastructure is required to convey stormwater flows into Parramatta River during rainfall events and mitigate flooding risk across the site including Dirrabarri Lane and Phillip Street. This is because in the pre-development flooding conditions water can freely flow overland through the site towards the existing car park. In the post-development condition, the proposed buildings and raised ground levels required for flood protection of building entryways restrict overland flow.

The proposed preliminary works for the stormwater network are illustrated in Appendix D | and summarized as follows:

Existing council stormwater assets to be made redundant and removed include:

- the existing Ø600mm trunk main near Dirrabarri Lane within the proposed West Building footprint is to be removed;

- the existing Ø375mm mains and pits within the proposed East Building footprint are to be removed; and
- it is likely these works will need to be completed as early works but following demolition of the existing car park. Refer to Arup's erosion and sediment control plan (PHM-ARP-SKE-CE-000002 to 000004) and technical memo (PHM-ARP-TCN-CE-0001) for the strategy in managing stormwater during construction.

Proposed stormwater infrastructure to service the development is likely to include:

- a Ø1200mm culvert is proposed along Dirribarri Lane replacing the existing Ø600mm trunk main. It is proposed to split the Ø1200mm culvert into smaller mains near Parramatta River to connect to multiple existing points of discharge along the existing river channel walls. The reason for this approach is to avoid modifying the existing river channel walls and to clear the existing Ø525mm Sydney Water sewer main;
- a Ø600mm pipe is proposed through the Site Link (between West and East Buildings) and connects to the Wilde Avenue east trunk network;
- grated inlet pits or grated drains are proposed at the upstream areas of the proposed networks within Dirrabarri Lane and terrace areas;
- surcharge pits are proposed at the downstream areas of the proposed networks near the river and within the undercroft areas. These surcharge pits will have visible elevated grates that are designed to allow water escape from the in-ground system and flow overland into the river;
- building stormwater connections to either the Dirrabarri Lane and Wilde Avenue stormwater networks;
- These proposed stormwater assets, sizes and arrangement are preliminary and may be optimised through design development.
- This proposed drainage infrastructure will be superior to the existing pre-development configuration meaning more floodwater will be captured and conveyed in the proposed pits and pipes and less water flowing overland.

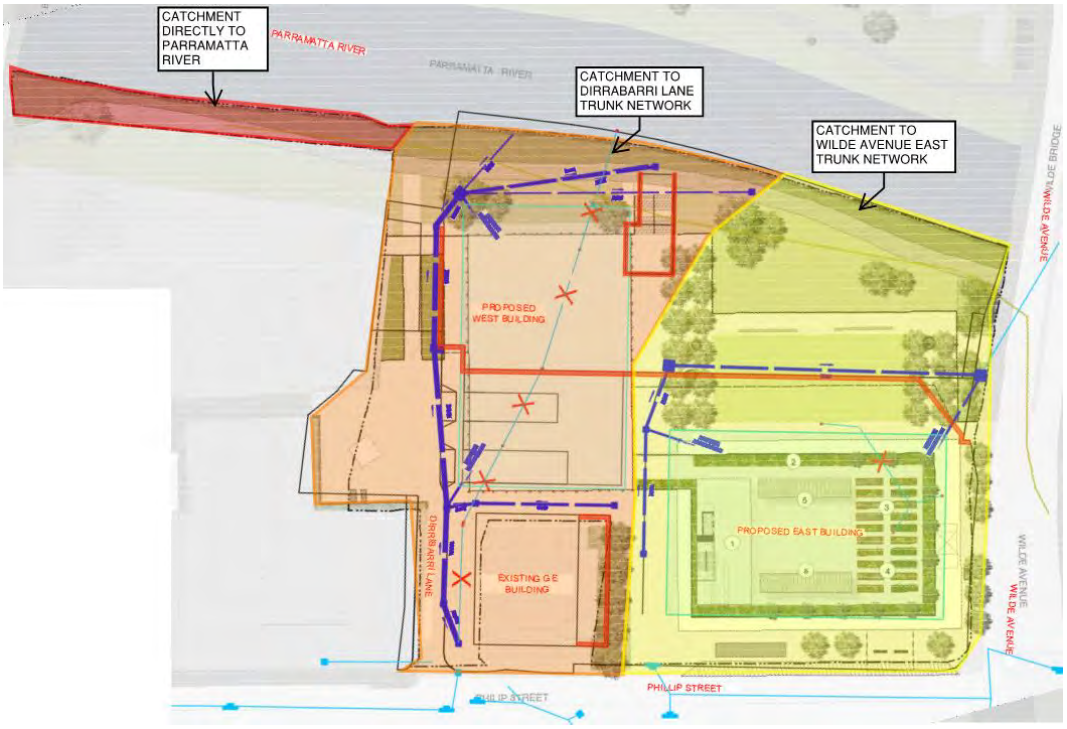


Figure 29: Proposed stormwater network catchments

Proposed stormwater impacts to the existing Ø525mm Sydney Water sewer main

- There is an existing Ø525mm Sydney Water owned trunk sewer main running through the site on the alignment illustrated in Figure 30. This sewer is understood to be constructed in vitrified clay (VC), is several decades old and is installed at shallow depth based on Sydney Water records and the recent survey.
- It is likely the downstream stormwater connections will cross below the existing sewer before discharging to Parramatta River, however this will be further assessed as part of the design development of the project.
- Consultations with Sydney Water through a Water Services Coordinator will be undertaken to confirm the requirements associated with working near the existing sewer.

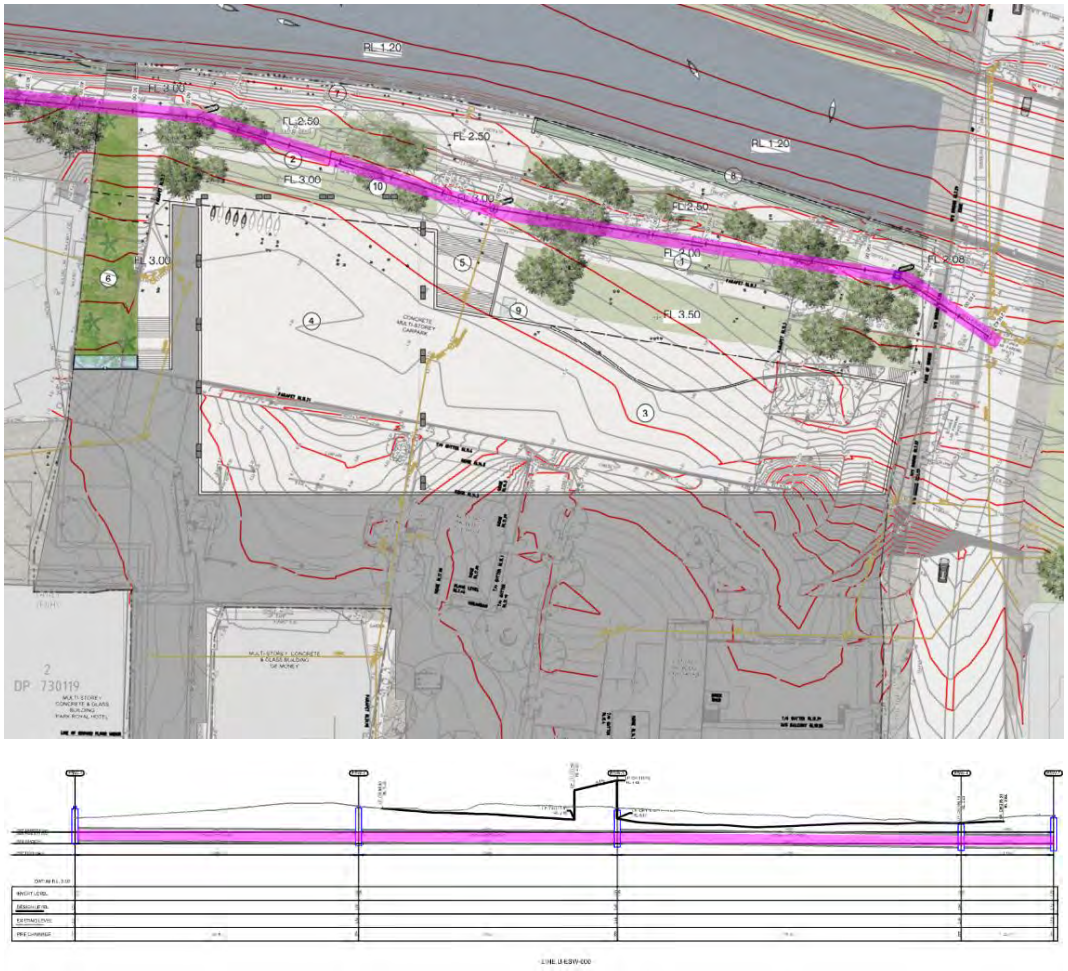


Figure 30: Existing Ø525mm Sydney Water sewer main plan and section (highlighted pink) draining foul water from west to east across the site. The longitudinal section illustrates the pipe is buried at shallow depth

9.3.2 Proposed On Site Detention (OSD) Strategy

The CoPC DCP and the UPRCT call for on site detention (OSD) to be provided for all new developments. Based on preliminary calculations using UPRCT's on-site detention handbook (for non-high early discharge of the building catchment areas only, with a plan area of approximately 6630 m²), for the Powerhouse Parramatta development an OSD volume of approximately 345 m^3 is required with permissible site discharge of approximately 126 l/s.

Through this assessment the requirement for OSD has been analysed and is not recommended for the following reasons:

- The development site is directly adjacent to Parramatta River and discharging flows into the river in the quickest manner possible, before the river reaches its peak flood conditions, would be favourable to mitigate flood risk to the site;
- The development site is subject to both overland and mainstream river flooding. The worst case overland flood event through the site happens over the first hour of the storm event whereas the worst case river flood event

begins to rise above the riverbanks approximately two hours after the storm event. Based on this, an underground OSD system would provide little benefit as it would be inundated by the river flood shortly after a storm event; and

- An OSD system within the building would require additional efforts on design, construction and maintenance of the OSD system while coordinating it with other building components. Given the little to no flooding benefit provided from the OSD, consideration needs to be given to the impact on the built form and cost for the project. In addition, this also results in the loss of valuable "real estate" within the building which could be utilized for more valuable and functional spaces as part of this state significant development.

With respect to flood and stormwater storage, the proposed undercroft area acts as a temporary flood storage area with approximately 18,600 m³ for the 1% AEP (100 year) flood event (refer to Figure 31). This is approximately the same amount of flood storage as the pre-development conditions as discussed in Section 9.1.2.

Further discussions with INSW, Powerhouse, CoPC and wider design team are as part of the detailed design are required to determine the feasibility of implementing an on-site detention system as part of the development.

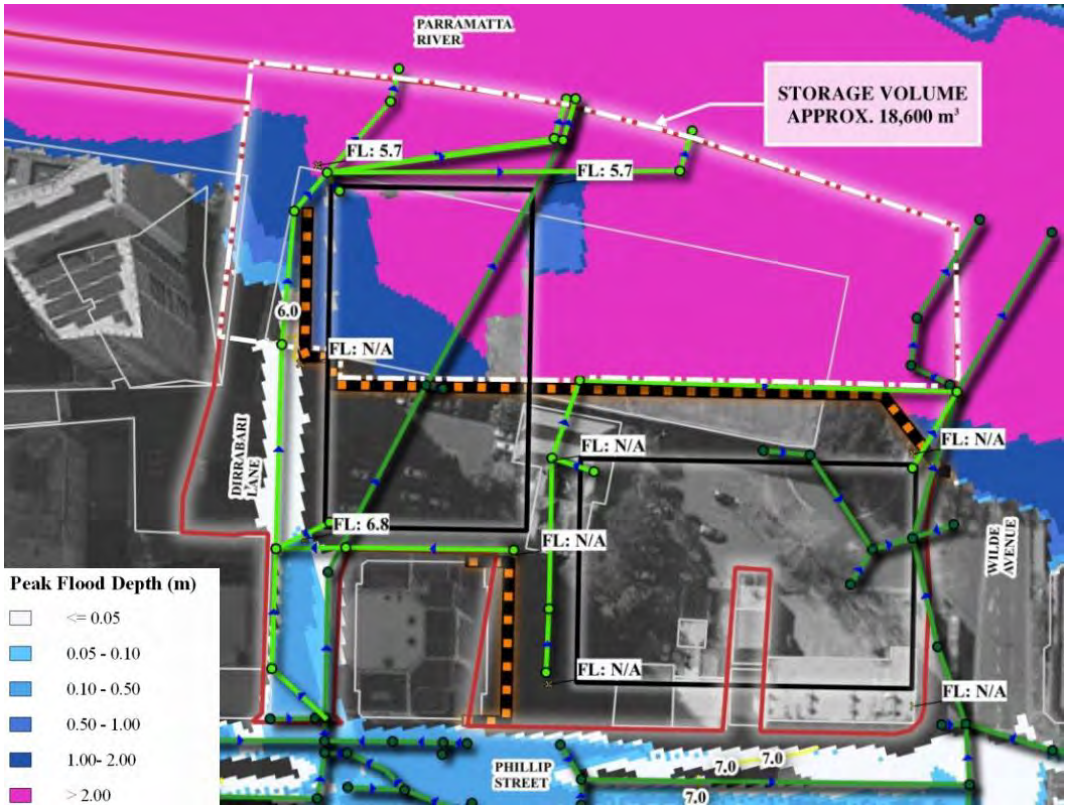


Figure 31: Post-development flood depths during 1% AEP (100 year)

9.3.3 Proposed Water Quality Strategy

Well integrated Water Sensitive Urban Design (WSUD) measures can provide positive visual, water quality and public amenity. The landscape design for the Powerhouse Parramatta allows opportunities for the incorporation of WSUD technologies to treat stormwater prior to discharge into the Parramatta River. A preliminary WSUD strategy has been considered based on current best practice, taking guidance from the CoPC DCP for Water Sensitive Urban Design Guidelines (2011) and Water Sensitive Urban Design Technical Guidelines for Western Sydney (UPRCT 2004) documents.

Drawing upon this guidance, the possible WSUD technologies that could be incorporated into external areas of the development site may include:

- Gross Pollutant Traps (GPTs) strategically positioned to capture gross pollutants and suspended solids. This provides primary treatment of runoff from hard paved areas including Dirrabarri Lane and terrace areas. Efforts are made to retain the existing GPT's near Parramatta River if possible;
- Pit filter baskets or media-filled cartridge products which may be installed into existing or proposed pits to capture gross pollutants, total suspended solids or other pollutants;
- Use of grass swales to landscaped areas to drain surface flows such as the landscape areas fronting the river. This removes gross pollutants and large sediment particles;
- Maximised pervious areas in landscaped areas which are serviced by passive irrigation using rainfall runoff from adjacent impervious areas wherever possible. This runoff is encouraged to collect in planted areas and thereby infiltrate soil layers to water root systems. Water that exceeds the vegetation uptake percolates through to the deeper layers of the planted areas and ultimately collects into subsoil drains to prevent water logging. This filtration process removes pollutants, reduces potable water demand and also attenuates peak stormwater runoff from the site;
- Bioretention rain gardens treat runoff from the residential courtyard area and removes key nutrients such as phosphorus and nitrogen from runoff; and
- These strategies shall be considered to be outside of the flood extents as inundations of these items may result in compromised pollutant removal, damage and associated maintenance efforts for the WSUD elements.

In addition, WSUD technologies can also be incorporated within the building envelopes and consideration may include:

- Rooftop garden and planting are proposed which increases the pervious area, encourages passive irrigation and treats any stormwater runoff; and
- A rainwater harvesting tank is currently being investigated if it is feasible for the development. If proposed, it will help with water reuse within the development and reduce wastewater and stormwater discharge from the site; and

- Connection to the proposed Sydney Water recycled water network that is expected to service the Parramatta area.

Ideally, these technologies would be strung together in series to create a water quality treatment train which aims to gradually improve the quality of stormwater prior to discharge offsite. This improvement in water quality can be estimated with bespoke water quality modelling software, MUSIC. This modelling measures the effectiveness in terms of the percentage of pollutants removed. City of Parramatta Council's DCP also contains targets for water quality pollutant reduction which are summarized in Table 8.

Table 8: CoPC DCP stormwater quality pollutant reduction targets

Pollutant	**City of Parramatta Council pollutant reduction targets (% reduction)**
Total Suspended Solids	85 %
Total Phosphorous	60 %
Total Nitrogen	45 %
Goss Pollutants	90 %

At the time of publication, the architectural, landscape and stormwater designs are still being developed and an agreed strategy has not yet been agreed on. However, Arup has completed a preliminary assessment of one possible configuration of some of the WSUD technologies described above as presented in Figure 32.

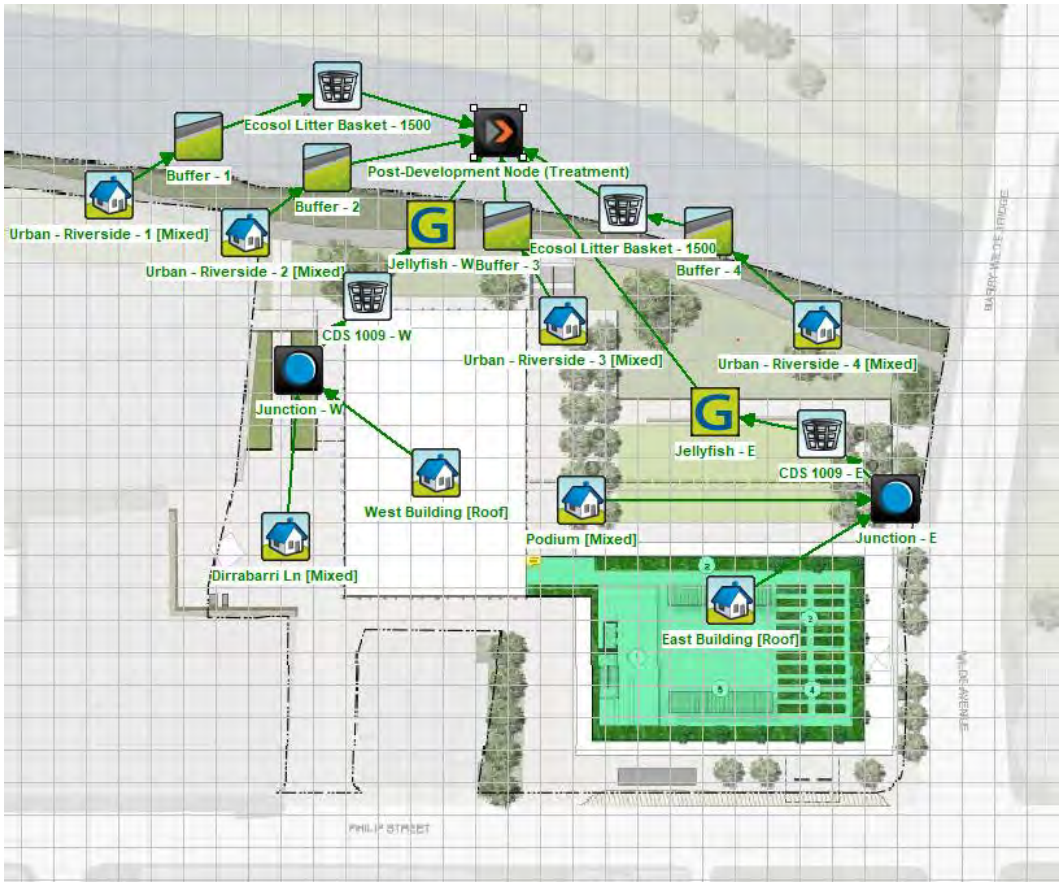


Figure 32: Arup preliminary WSUD assessment, extracted from MUSIC modelling software

The preliminary proposed WSUD strategy for treating runoff from the development site includes the following technologies:

- GPT units plus either raingardens (approximately 400 m^2 equivalent to 2% of the site area) and/or tertiary treatment proprietary units (one such example is the Jellyfish filter device manufactured by OceanProtect) for treating runoff from the East and West Building roofs as well as the Podium and Dirrabarri Lane paved areas; and
- Landscape buffer strips as well as litter baskets to capture suspended solids and gross pollutants for the remaining external areas adjacent to the Parramatta River.

Treatment is assessed against the 3-month ARI (or 4EY, exceedances per year) equivalent stormwater flows. For the purposes of a preliminary assessment, consideration has been given to implementing the Jellyfish filter device. With this strategy we are able to demonstrate it is practical to achieve the Council pollution reduction targets as shown in Figure 33 as follows.

Total Suspended Solids	88%	>85%
Total Phosphorus	68%	>60%
Total Nitrogen	47%	>45%
Gross Pollutant	93%	>90%

Figure 33: Results from the preliminary MUSIC modelling assessment (left column) illustrating pollutant reduction percentages realised presented alongside CoPC targets (right column) demonstrating targets can be achieved

The MUSIC software does not permit numerical modelling of hydrocarbon and oil capture. However, the GPT units can be specified to achieve effective capture and containment of the anticipated hydrocarbons and oils yields running off from the paved/car par areas. It is also noted that in the pre-developed condition there is a public car park which is likely to generate substantially greater quantities of hydrocarbons and oils than the post-development condition which does not include car parking.

Beyond SSDA, further discussions with the project team, City of Parramatta Council's engineering representatives and Powerhouse are required to develop the water quality strategy. As the Powerhouse Parramatta design develops a WSUD strategy will be selected and the MUSIC modelling presented in this report will be updated to check the compliance of the preferred approach with the CoPC water quality pollutant reduction targets.

9.4 Operation and Maintenance Considerations

Upon confirmation of the stormwater design, the stormwater network and associated elements will be divided between the following stakeholders for ownership. Their anticipated items for ownership are preliminary at this stage and will be further discussed and confirmed in subsequent stages of the project.

9.4.1 City of Parramatta Council:

- Existing Parramatta River and associated stormwater network outlets into the river;
- Trunk stormwater infrastructure (Dirrabarri Lane and Wilde Avenue networks), associated pits and water quality items within pits; and
- Stormwater infrastructure within the public domain road corridor (Phillip Street and Wilde Avenue) excluding private stormwater service connections into the trunk network.

9.4.2 Powerhouse / INSW:

- All stormwater services, pumps, tanks, water quality devices and any others within the building;
- Stormwater service connections from the building to the trunk network; and
- Landscaping elements.

It may be noted CoPC shall be provided with the required easements and appropriate maintenance access to their assets within the Powerhouse Parramatta property boundaries.

The operation and maintenance plan shall consider the maintenance action items, frequency of action, responsible owner and procedures for following items:

- Pipes/culverts/connections/outlets;
- First flush devices;
- Tanks (structure, storage, outlets and other elements);
- Pumps;
- Pits (surface inlet, grate, structure, chamber, inlets/outlets); and
- GTPs, Pit filter baskets, media-filled cartridges and/or other filtration devices.

The maintenance activities of many of these possible drainage and treatment products will depend on the product manufacturer's specific maintenance requirements. The detailed stormwater operation and maintenance will be further discussed with Powerhouse operators and refined during the design development.

Once the stormwater drainage design is more developed and the specific requirements for the products is known a meeting with CoPC and Powerhouse operators to agree ownership and responsibility is recommended, from which the operational and maintenance strategy can be developed.

10 Conclusion and Recommendations

The report has assessed the flooding and stormwater impacts and requirements of the proposed Stage 1 SSDA application associated with Powerhouse Parramatta. The following list provides a brief summary of the key conclusions of our work and recommendations for the development:

- Our assessment of the pre-development site conditions has identified there is a risk of mainstream flooding from the Parramatta River and overland flow flooding in areas generally to the south of the development site;
- A key element of our strategy to manage flood risk is the use of the undercroft spaces and external spaces that are at similar levels to the riverbanks to contain flood storage;
- This is intended to maintain the existing flood storage provision and flow conveyance available on site when the river is in flood;
- Likewise, adjustments to the finished terrain levels and new stormwater infrastructure are recommended to manage overland flows;
- Proposed buildings will be established at a finished floor level above the minimum flood planning levels (FPLs) determined by the CoPC DCP to offer flood protection to the Powerhouse and exhibition spaces;
- With this approach the Powerhouse Parramatta project has been developed such that there would be no substantial modification to the existing flood behaviour upstream or downstream of the site whilst protecting new building assets (and the museum collection) from flooding risk;
- New stormwater infrastructure will be required to service the site as part of the flood risk mitigation strategy and replace existing drainage assets impacted by the development;
- On site detention is not recommended for the development given its location on the banks of the Parramatta River meaning that rainwater and runoff can be conveyed offsite rapidly into the river before the peak of river. Similarly, a substantial volume of flood storage volume is being offered as part of the undercroft design to mitigate flooding impacts; and
- Water quality measures can be used to implement an effective WSUD strategy to reduce the quantity of pollutants draining off the development site into the river and thereby satisfy CoPC's DCP requirements.

Based on the works completed to date, the design development of the following infrastructure components will be integral to the success of the flood risk mitigation and stormwater management strategy described in this report:

- Proposed ground levels and aerial extents of undercroft and external spaces adjacent to the Parramatta River;
- Proposed ground levels and the detailing of kerbing and gutters in Dirribarri Lane and their relationship these elements within Phillip Street;

- Establishing the building finished floor levels at an appropriate elevation;
- The network configuration, reticulation, size, invert levels, inlet provision and detailing of proposed stormwater drainage infrastructure together with connections to the existing retained Council owned stormwater infrastructure;
- Surface finishes, surface drainage, roof drainage and connections to the proposed stormwater infrastructure; and
- The integration of stormwater quality treatment technologies and devices into the external works and stormwater infrastructure.

When designed appropriately and in concert, the above elements will deliver an effective, integrated stormwater and flood risk management system.

11 Limitations and Further Work

11.1 Limitation and Risks

Given the pre-development flooding and stormwater conditions on the Powerhouse Parramatta development site, significant effort has been given to developing the comprehensive flood modelling and design work presented in this report to as high a standard as possible. Nevertheless, there are some residual limitations and risks associated with the work which will be given further consideration as the design develops:

- Survey information – there are known information gaps associated with the existing stormwater system including invert levels, pipe sizes and the condition of existing drains within and surrounding the site. Assumptions have been made and ongoing site investigation work will help us close these gaps together with any supplementary information that can be provided by CoPC to assist with the development of the proposed stormwater design strategy;
- The proposals layout, levels and built form of the undercroft areas, external areas and roads/footpaths are still at an early stage of design development. Further development will be undertaken as development proposals evolve including the design of tie-ins with the surrounding existing terrain. We note that the flood maps presenting the 1% AEP event with climate change indicates some local afflux effects which we believe are a result of the preliminary nature of the terrain design and which require refinements;
- The Arup flood model does not currently account for all recent developments within the Parramatta CBD catchment (such as Parramatta Square, currently in construction) or proposed changes due to major future infrastructure projects (such as Parramatta Light Rail). The patterns of both pre- and post- development overland flood flow behaviour may change as a result of these developments; and
- The Arup flood model has not been comprehensively calibrated against measured data or other flood models. As discussed in Section 8.2 it would

be ideal to use a current, calibrated and CoPC adopted flood model but at this time the forthcoming Cardno flood model is in public consultation and is not being made available. When this model is available, calibration checks using the ARR2019 hydrological methods would be useful to validate the Arup modelling work.

11.2 Further Work

This report presents the work that has been completed in relation to stormwater and flood risk management at a relatively early stage of the project lifecycle. Beyond the SSDA submission further works will be required to develop the strategies presented. Specific items that will receive attention include:

- The driveway entry into the East Building from Wilde Avenue needs further design development along with consideration of drainage measures to mitigate/eliminate any flood risk;
- Reviewing the stormwater pits and pipes information included in the Arup flood model against Council stormwater data provided on 23/3/2020;
- Coordinate and integrate building downpipe connections with proposed stormwater systems;
- Where possible, optimise the layout, dimensions and hydraulic capacity of proposed stormwater pits and pipes networks whilst continuing to achieve the design intent;
- Develop the 3d design of proposed stormwater and utility services, verify space proofing and with consideration to existing retained utilities such as the Sydney Water sewer;
- Evaluate flood modelling scenarios whereby both pit and pipe systems are substantially blocked to identify and manage any associated risks;
- Discuss and confirm the on-site detention (OSD) strategy and principles with CoPC and the design team;
- Develop the Water Sensitive Urban Design (WSUD) strategy with the design team, INSW and Powerhouse with consideration to the CoPC pollutant reduction targets;
- Ongoing coordination of the landscape and building architectural designs with respect to stormwater, flooding and flood evacuation; and
- Develop the evacuation strategy including any warning systems, through ongoing discussions with INSW, Powerhouse, SES in coordination with pedestrian modelling and undercroft design proposals.

12 Reference Documents

Research and investigation presented in this report is based on information from a wide range of sources which include:

- 330 Church Street Parramatta, Flood and Stormwater Management Report by Mott MacDonald, dated December 2011;
- Architectural Building design - MKG Powerhouse Parramatta, revision No. 7, dated 01/04/2020;
- Architectural Landscape design - McGregor Coxall Powerhouse Parramatta reference 0792BRS, revision C, dated 02/04/2020;
- Australian Disaster Resilience Guideline 7-3 Flood Hazard (AIDR) 2017;
- Australian Rainfall and Runoff 1987;
- Australian Rainfall and Runoff 2019;
- Bureau of Meteorology – The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method, June 2003;
- City of Parramatta Council Local Environmental Plan (LEP) 2011;
- City of Parramatta Council Development Control Plan (DCP) 2011;
  - Part 2.4.2 Water Management
  - Part 2.4.3 Soil Management
- City of Parramatta Floodplain Risk Management Policy 2014;
- City of Parramatta Development Engineering Design Guidelines, dated June 2018;
- Flood modelling input information provided by City of Parramatta Council;
  - Mike11 Draft 8, received 11 March 2020
  - Mike11 Draft 9, received 19 March 2020
- NSW Water Management Act 2000;
- NSW Floodplain Development Manual 2005;
- NSW DP&E Secretary's Environmental Assessment Requirements (SEARs) reference: SSD-10416 dated: 10 February 2020
- Parramatta River Flood Study, Final Draft by Cardno, dated 10 December 2019;
- Riverbank Precinct Master Plan, Drainage and Flooding Study by Cardno, dated 9 March 2016;
- The New Museum, Parramatta, Flood Study Final version 6 by TTW, dated November 2016, and accompanying TUFLOW model;
- Upper Parramatta River Catchment Trust – On-site Stormwater Detention Handbook Fourth Edition, dated December 2005;
- Developer Handbook for Water Sensitive Urban Design, Blacktown City Council, dated November 2013;
- Water Sensitive Urban Design Technical Guidelines for Western Sydney, Draft, UPRCT, dated 7 November 2003;
- Draft NSW MUSIC Modelling Guidelines, Sydney Metropolitan Catchment Management Authority, dated August 2010.

Appendix A | City of Parramatta Council Stormwater & Flood Risk Planning Provisions

Table 9 presents a summary of how the Arup stormwater and flood risk management strategy addresses the provisions of relevant City of Parramatta Council planning documents as described in the development control plan (DCP 2011), engineering guidelines and associated policies and third party reference material:

Table 9: City of Parramatta Council policies and technical guidelines

Policy or Guideline	Where Addressed

City of Parramatta Council Local Environmental Plan 2011
• 6.3 Flood Planning
  • Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:
  • (a) is compatible with the flood hazard of the land, and
  • (b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and
  • (c) incorporates appropriate measures to manage risk to life from flood, and
  • (d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses, and
  • (e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.
	This is addressed in Section 8 of the report

City of Parramatta Council – Development Control Plan (2011); The purpose of the DCP is to Supplement the Parramatta LEP 2011 and provide more detailed provisions to guide the development
• 2.4.2.1 Flooding
  • P.1 New development should not result in any increased risk to human life.
  • P.2 The additional economic and social costs which may arise from damage to property from flooding should not be greater than that which can reasonably be managed by the property owner, property occupants and general community.
  • P.3 New development should only be permitted where effective warning time and reliable access is available
	These matters are addressed in Section 8 of the report

Policy or Guideline	Where Addressed
for the evacuation of an area potentially affected by floods to an area free of risk from flooding. Evacuation should be consistent with any relevant flood evacuation strategy where in existence. • P.4 Development should not adversely increase the potential flood affectation on other development or properties, either individually or in combination with similar developments that are likely to occur within the same catchment. • P.5 New developments must make allowances for motor vehicles to be relocated to an area • with substantially less risk from flooding, within an effective warning time. • P.6 New developments must provide an evacuation plan detailing procedure that would be in place for an emergency (such as warning systems, signage or evacuation drills). • P.7 Flood mitigation measures associated with new developments should not result in significant impacts upon the amenity of an area by way of unacceptable overshadowing of adjoining properties, privacy impacts (e.g. by unsympathetic house raising) or by being incompatible with the streetscape or character of the locality (including heritage). • P.8 Proposals for raising structures must provide a report from a suitably qualified engineer demonstrating that the raised structure will not be at risk of failure from the forces of floodwaters. • P.9 Development is to be compatible with any relevant Floodplain Risk Management Plan, Flood Studies, or Sub-Catchment Management Plan. • P.10 Development must not divert flood waters, nor interfere with floodwater storage or the natural function of waterways. • P.11 Filling of land up to 1:100 Average Recurrence Interval (ARI) (or flood storage area if determined) is not permitted. Filling of and above 1:100 ARI up to the Probable Maximum Flood (PMF) (or in flood fringe) must not adversely impact upon flood behaviour. • P.12 New development must consider the impact of flooding resulting from local overland flooding whether it is a result of Local Drainage or Major Drainage. • P.13 Where hydraulic flood modelling is required, flow hazard categories should be identified and adequately addressed in the design of the development. • P.14 Council strongly discourages basement car parks on properties within the floodplain. Where site conditions require a basement car park on a property within the floodplain, development applications must provide a detailed hydraulic flood study and design demonstrating that the proposed basement car park has	

Policy or Guideline	Where Addressed

been protected from all flooding up to and including the PMF event. An adequate emergency response and evacuation plan must also be provided where basement car parks are proposed in the floodplain.
• 3.3.6.1 Stormwater Drainage
  • P.1 WSUD principles are to be integrated into the development through the design of stormwater drainage, on-site detention and landscaping and in the orientation of the development rather than relying on 'end of pipe' treatment devices prior to discharge.
  • P.2 Operating practices and technology are to be employed to prevent contamination of stormwater.
  • P.3 Development is to be sited and built to minimise disturbance of the natural drainage system.
  • P.4 Impervious surfaces are to be minimised and soft landscaping used to promote infiltration and reduce stormwater run-off.
  • P.5 WSUD elements should be located and configured to maximise the impervious area that is treated.
  • P.6 Adequate provision is to be made for the control and disposal of stormwater run-off from the site to ensure that it has no adverse impact on Council's stormwater drainage systems, the development itself, or adjoining properties. Stormwater drainage design criteria are to be in accordance with Council's Stormwater Disposal Policy and current Design and Development Guidelines.
  • P.7 On-site detention (OSD) will be required as outlined in the Upper Parramatta River Catchment Trust On-Site Detention Handbook, subject to compliance with Council's Stormwater Disposal Policy and current Design and Development Guidelines.
  • P.8 Stormwater, including overland flows entering and discharging from the site, must be managed. The site drainage network must provide the capacity to safely convey stormwater run-off resulting from design storm events listed in Council's Design and Development Guidelines.
  • P.9 Council will generally not permit the construction of stormwater drainage lines through public reserves.
  • P.10 The design and location of stormwater drainage structures, such as detention and rainwater tanks, is to be in accordance with Council's Stormwater Disposal Policy and current Design and Development Guidelines.
  • P.11 Run-off entering directly to waterways or bushland is to be treated to reduce erosion and sedimentation, nutrient and seed dispersal.
  • P.13 For developments required to prepare a WSUD strategy as identified in Table 3.3.6.1.3, those developments must achieve pollution reduction targets
	These matters are addressed in Section 9 of the report

Policy or Guideline	Where Addressed
identified in Table 3.3.6.1.1 and prepare a WSUD Strategy as outlined in Appendix 7. • P.14 All development must consider the WSUD measures listed in Tables 3.3.6.1.2 in order to achieve water quality and quantity targets. • P.15 Pollution load reduction as defined in Table 3.3.6.1.1 is to be determined preferably through the Model for Urban Stormwater Improvement Conceptualisation (MUSIC), using suitable modelling parameters for Parramatta / Western Sydney. Pollution load reduction may also be determined by an equivalent, widely accepted model or methodology.	
City of Parramatta Council – Engineering Design Guidelines (2018) • The CoPC engineering design guidelines specify the technical requirements, specifications and standards of undertaking the following civil items associated with development: • Drainage; • On Site Detention (OSD); • Water Sensitive Urban Design (WSUD); and • Managing Watercourses and Overland Flow Flooding.	These matters are addressed in Section 9 of the report
City of Parramatta Council's Floodplain Risk Management Policy (2014) • The primary objective of the Parramatta Floodplain Risk Management Policy is to encourage measures that: "Reduce or eliminate the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and reduce private and public losses resulting from floods." The Policy establishes Parramatta City Council's strategic approach to floodplain risk management for the whole Parramatta Local Government Area (LGA). Details about specific flood management rules are described in a separate document, specifically the Local Environmental Plan and the Development Control Plan.	These matters are addressed in Section 8 of the report
Upper Parramatta River Floodplain Risk Management Study and Plan by Bewsher dated 2003; • This document is meant to bring together, and place in appropriate context, all past, current and proposed future activities related to the reduction of flood risk in the catchment. The Study has investigated what can be done to minimise the effects of flooding in the Upper Parramatta River catchment and recommended a strategy in the form of a draft Floodplain Risk Management Plan for local councils to adopt.	These matters are addressed in Section 8 of the report

Appendix B | Flood Modelling Figures

Legend

- TUFLOW Model Boundary
- MIKE11 Boundary Conditions
- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- River/Creek
- Post-Development Pipes
- Pre-Development Pipes

Issue	Date	By	Chkd	Appd
1	3/04/2020	AA	NC	DC

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Museum of Applied Arts & Sciences

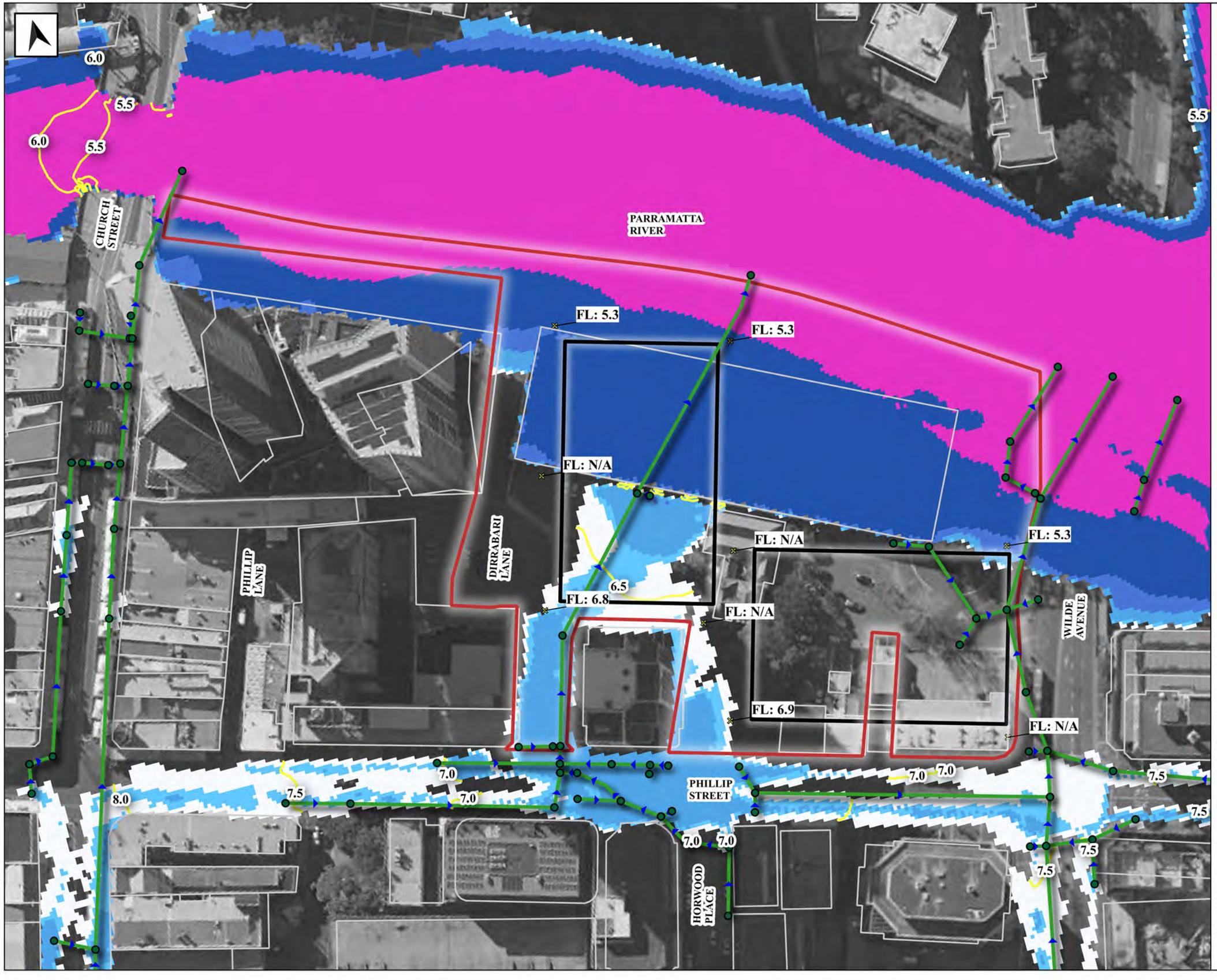
Powerhouse Parramatta

Model Setup

Scale at A3 **1:6000**

Job No	Figure Status	Issue
273467	**Preliminary**	**1**

Figure No **EP.0-S**



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- 8.0 Peak Flood Level (mAHD)
- Flood Level (mAHD)
- Pre-development Pits
- Pre-development Pipes

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00- 2.00
- > 2.00

Issue	Date	By	Chkd	Appd
1	3/04/2020	AA	NC	DC

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Pre-development
Peak Flood Depths and Levels 5% AEP

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
E1.0-5D	1

PARRAMATTA RIVER

CHURCH STREET

PHILLIP LANE

DIRRABARI LANE

PHILLIP STREET

HORWOOD PLACE

WILDE AVENUE

FL: 5.7

FL: 5.7

FL: 6.9

FL: N/A

FL: 5.7

FL: 6.9

FL: 6.9

FL: 7.0

FL: N/A

Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- 8.0 Peak Flood Level (mAHD)
- Flood Level (mAHD)
- Pre-development Pits
- Pre-development Pipes

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.10
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Issue	Date	By	Chkd	Appd
1	3/04/2020	AA	NC	DC

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Powerhouse Parramatta

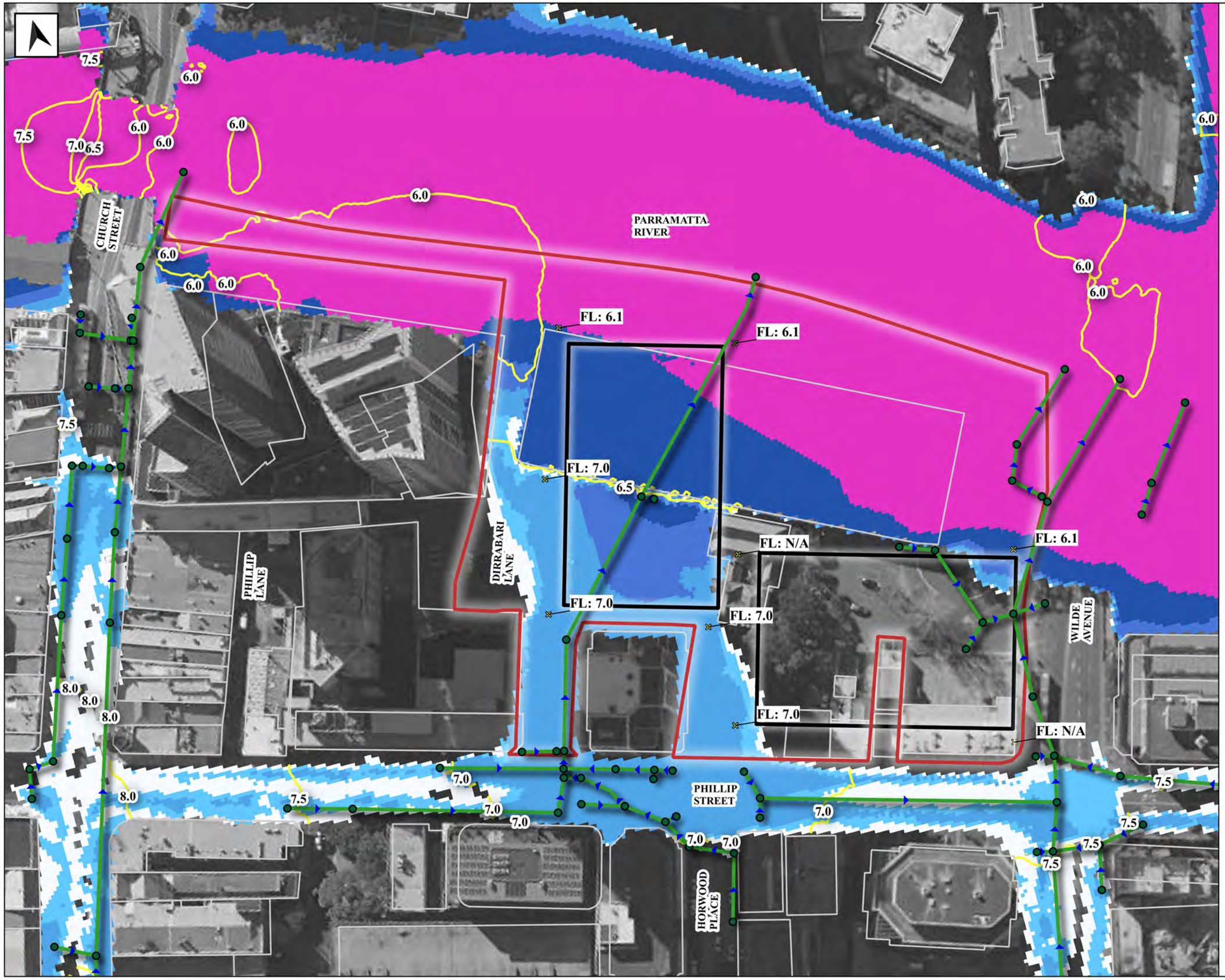
Pre-development
Peak Flood Depths and Levels 1% AEP

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
E1.0-1D	1



Legend

- Development Site Boundary
- Powerhouse Building Outline
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- 8.0 Peak Flood Level (mAHD)
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- Pre-development Pipes

Peak Flood Depth (m)

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Issue	Date	By	Chkd	Appd
1	3/04/2020	AA	NC	DC

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Pre-development
Peak Flood Depths and Levels 1% AEP & Cilmate Change

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
E1.0-1ccD	1

Legend

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Issue	Date	By	Chkd	Appd
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Powerhouse Parramatta

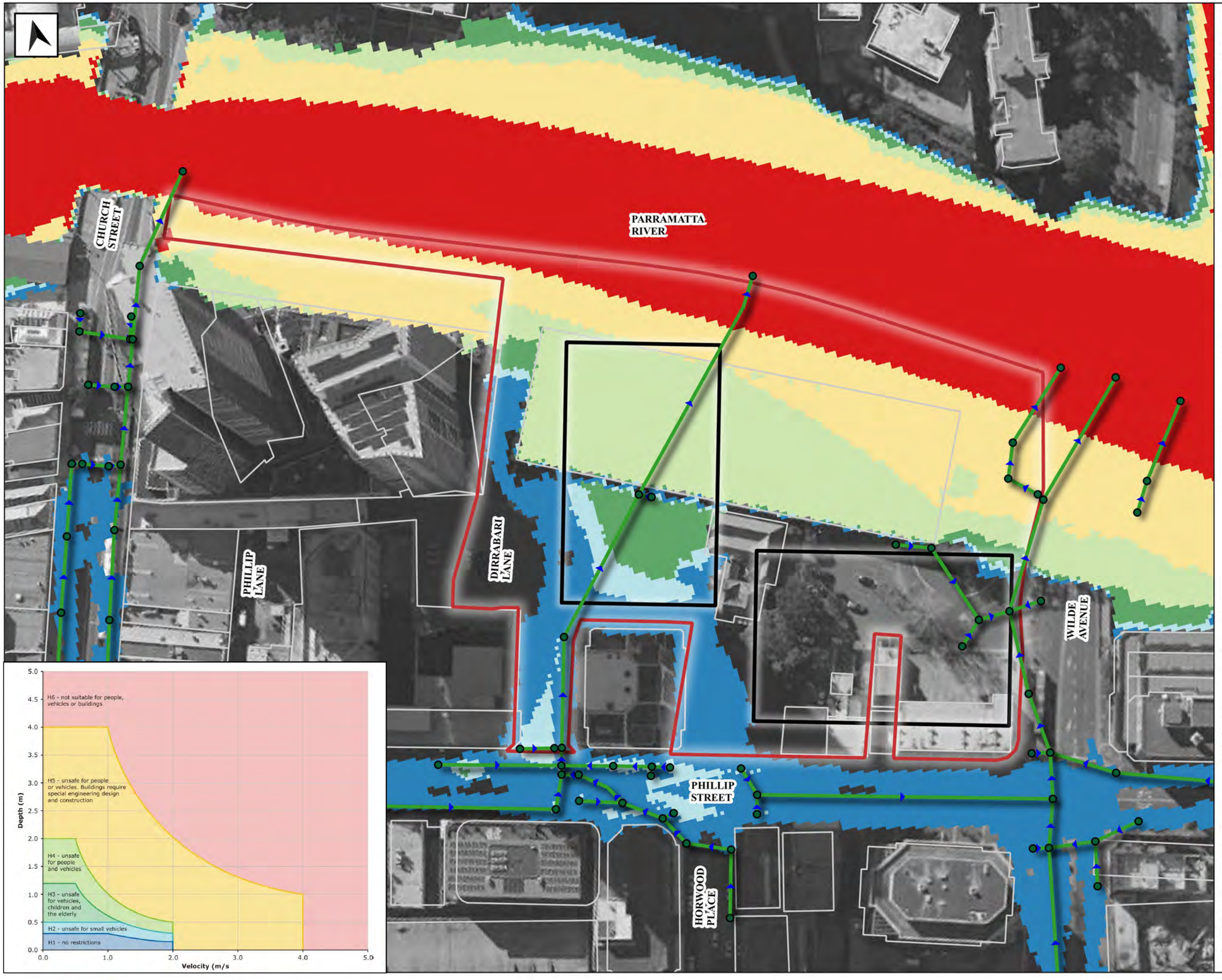
Pre-development
Peak Flood Depths and Levels PMF

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
E1.0-PMFD	1



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Pre-development Pits
- Pre-development Pipes

Flood Hazard Category

(Australian Management Institute, 2014)

- H1
  Relatively benign flow conditions.
  No vulnerability constraints.
- H2
  Unsafe for small vehicles.
- H3
  Unsafe for all vehicles, children and the elderly.
- H4
  Unsafe for all people and all vehicles.
- H5
  Unsafe for all people and all vehicles.
  Buildings require special engineering design and construction.
- H6
  Unconditionally dangerous.
  Not suitable for any type of development or evacuation access.
  All building types considered vulnerable to failure.

Issue	Date	By	Chkd	Appd
1	3/04/2020	AA	NC	DC

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Powerhouse Parramatta

Pre-development
Hydraulic Hazard 1% AEP

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
E1.0-1H	1

CHURCH STREET

PARRAMATTA RIVER

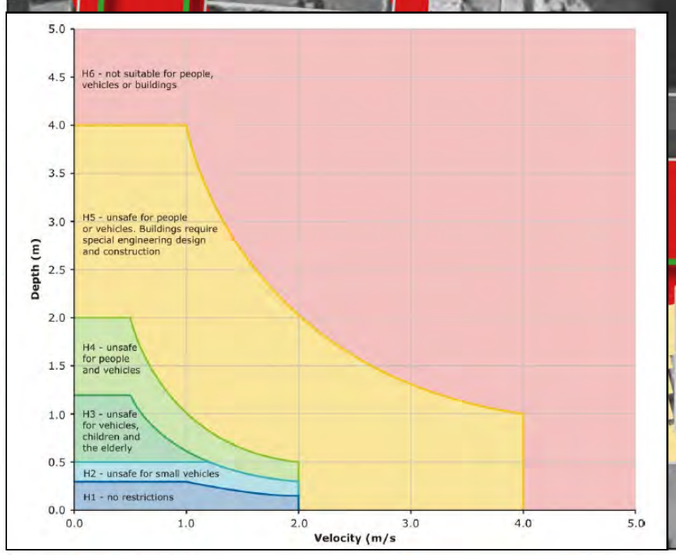
PHILLIP LANE

DIRRABARI LANE

PHILLIP STREET

HORWOOD PLACE

WILDE AVENUE



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  Unsafe for all people and all vehicles.
- H5
  Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6
  Unconditionally dangerous.
  Not suitable for any type of development or evacuation access.
  All building types considered vulnerable to failure.

Issue	Date	By	Chkd	Appd
1	3/04/2020	AA	NC	DC

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Powerhouse Parramatta

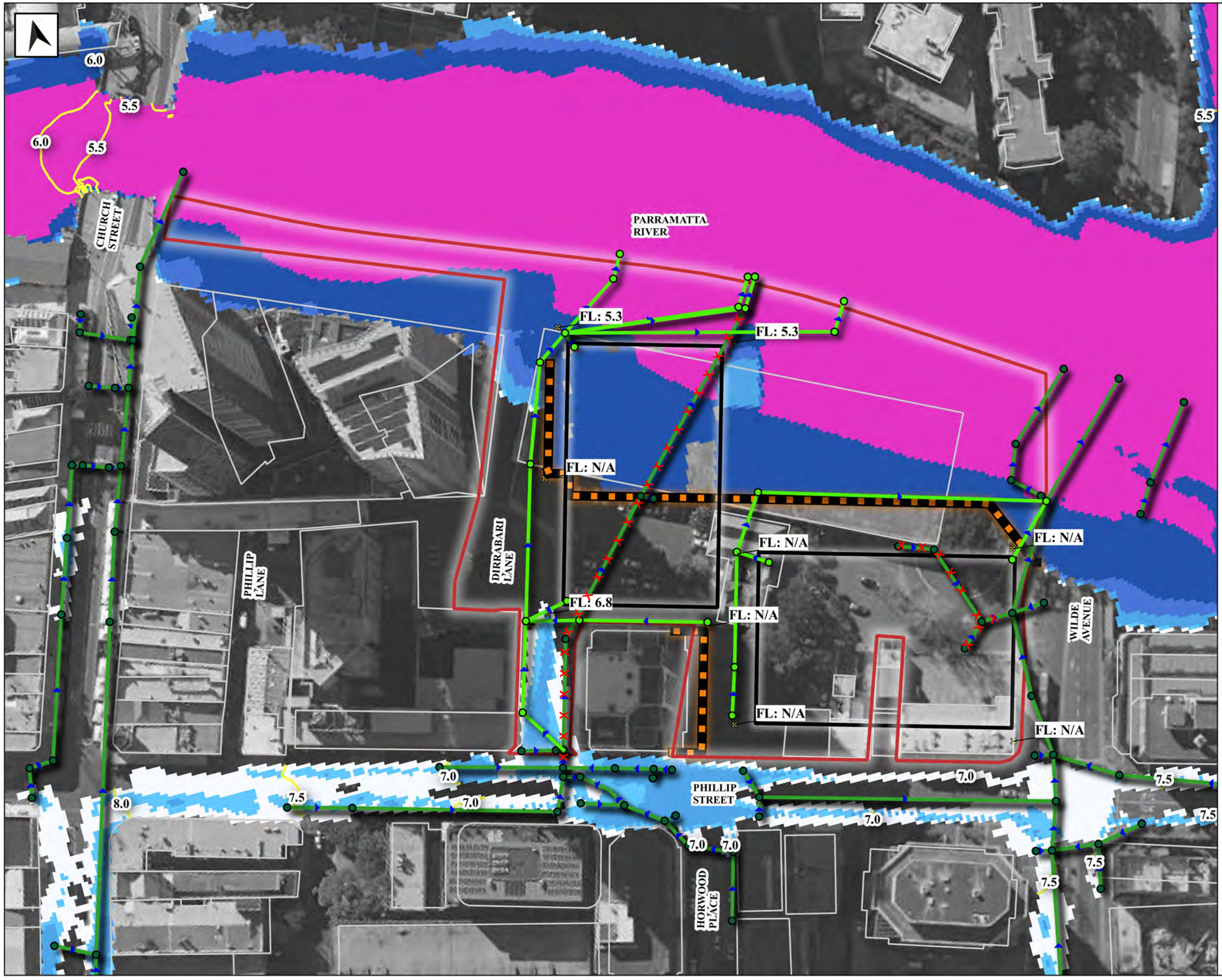
Pre-development
Hydraulic Hazard 1% PMF

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
E1.0-PMFH	1



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- 8.0 Peak Flood Level (mAHD)
- Flood Level (mAHD)
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Peak Flood Depth (m)

- <= 0.05
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Issue	Date	By	Chkd	Appd
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Powerhouse Parramatta

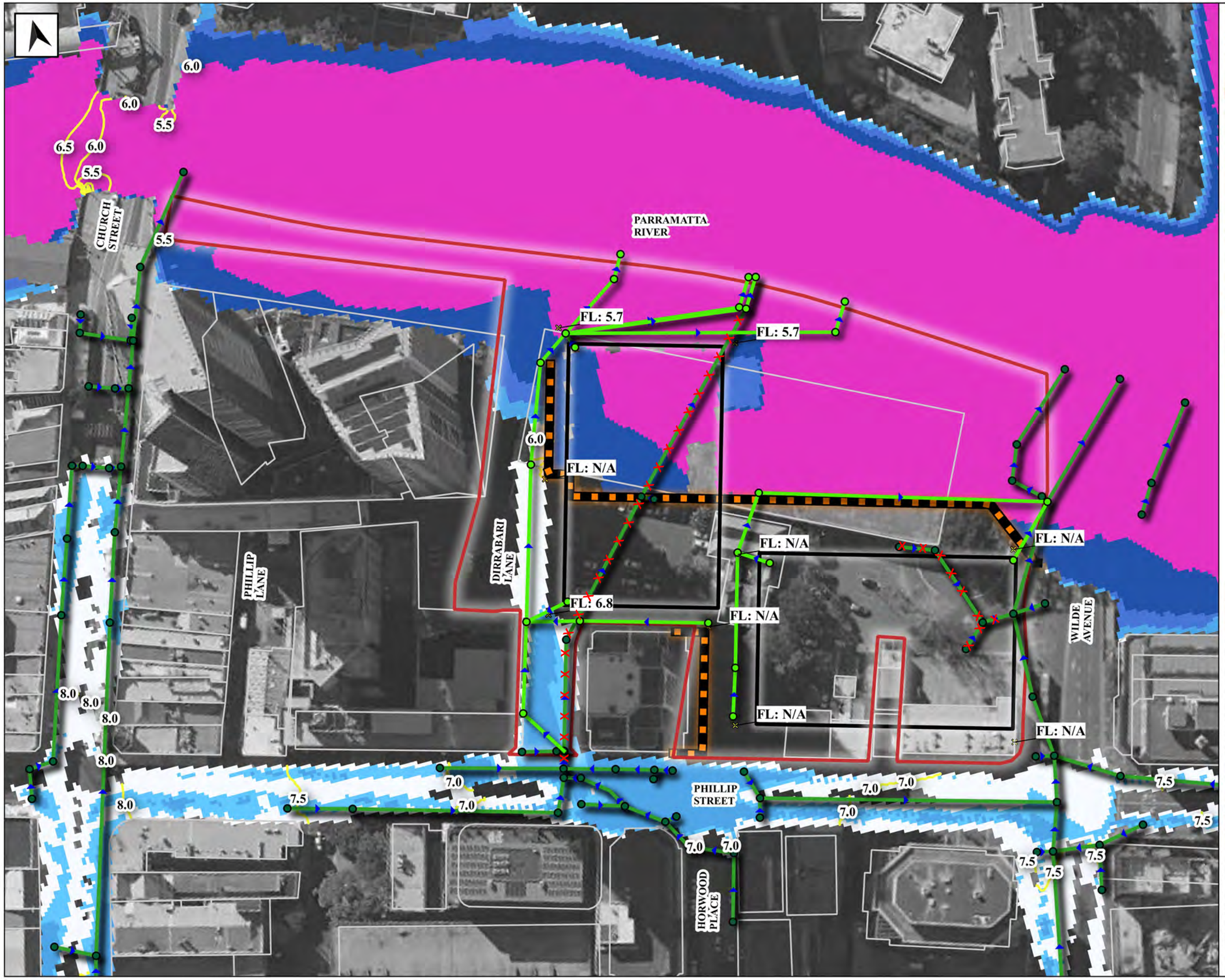
Post-development
Peak Flood Depths and Levels 5% AEP

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
P1.0-5D	1



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Powerhouse Parramatta

Post-development
Peak Flood Depths and Levels 1% AEP

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
P1.0-1D	1

PARRAMATTA RIVER

CHURCH STREET

PHILLIP LANE

DIRRABARI LANE

PHILLIP STREET

HORWOOD PLACE

WILDE AVENUE

FL: 6.0

FL: 6.1

FL: N/A

FL: 6.9

Legend

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Post-development
Peak Flood Depths and Levels 1% AEP & Cilmate Change

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
P1.0-1ccD	1

Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- 8.0 Peak Flood Level (mAHD)
- Flood Level (mAHD)
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00- 2.00
- > 2.00

Issue	Date	By	Chkd	Appd
1	3/04/2020	AA	NC	DC

ARUP
Level 5, 151 Clarence St
Sydney, NSW 2000
Tel +61 2 9320 9320 Fax +61 2 9320 9321
www.arup.com

Client

Powerhouse Parramatta

Post-development
Peak Flood Depths and Levels PMF

Scale at A3 1:1000

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
P1.0-PMFD	1

CHURCH STREET

PARRAMATTA RIVER

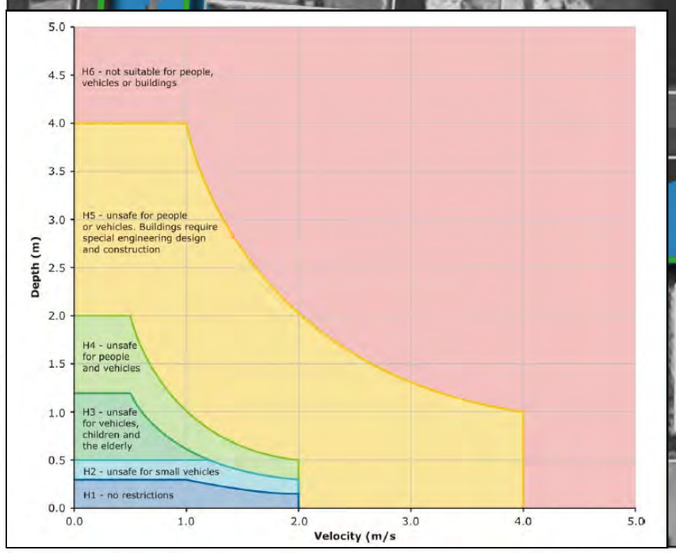
PHILLIP LANE

DIRRABARI LANE

PHILLIP STREET

HORWOOD PLACE

WILDE AVENUE



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Flood Hazard Category

(Australian Management Institute, 2014)

- H1
  Relatively benign flow conditions.
  No vulnerability constraints.
- H2
  Unsafe for small vehicles.
- H3
  Unsafe for all vehicles, children and the elderly.
- H4
  Unsafe for all people and all vehicles.
- H5
  Unsafe for all people and all vehicles.
  Buildings require special engineering design and construction.
- H6
  Unconditionally dangerous.
  Not suitable for any type of development or evacuation access.

Issue	Date	By	Chkd	Appd
1	3/04/2020	AA	NC	DC

ARUP

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www.arup.com

Client

Infrastructure New South Wales

Museum of Applied Arts & Sciences

Powerhouse Parramatta

Post-development
Hydraulic Hazard 1% AEP

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
P1.0-1H	1

CHURCH STREET

PARRAMATTA RIVER

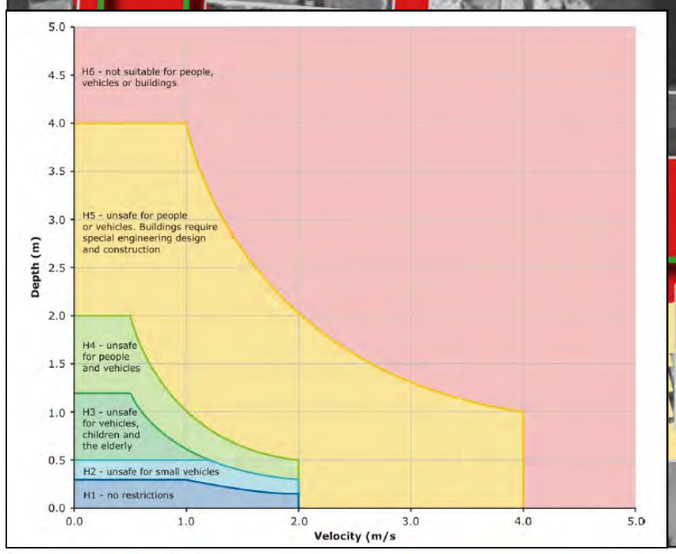
PHILLIP LANE

DIRRABARI LANE

WILDE AVENUE

PHILLIP STREET

HORWOOD PLACE



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Flood Hazard Category

(Australian Management Institute, 2014)

- H1
  Relatively benign flow conditions.
  No vulnerability constraints.
- H2
  Unsafe for small vehicles.
- H3
  Unsafe for all vehicles, children and the elderly.
- H4
  Unsafe for all people and all vehicles.
- H5
  Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
- H6
  Unconditionally dangerous.
  Not suitable for any type of development or evacuation access.

Issue	Date	By	Chkd	Appd
1	3/04/2020	AA	NC	DC

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Sydney, NSW 2000
Tel +61 2 9320 9320 Fax +61 2 9320 9321
www.arup.com

Client

insw Infrastructure New South Wales

Museum of Applied Arts & Sciences

Powerhouse Parramatta

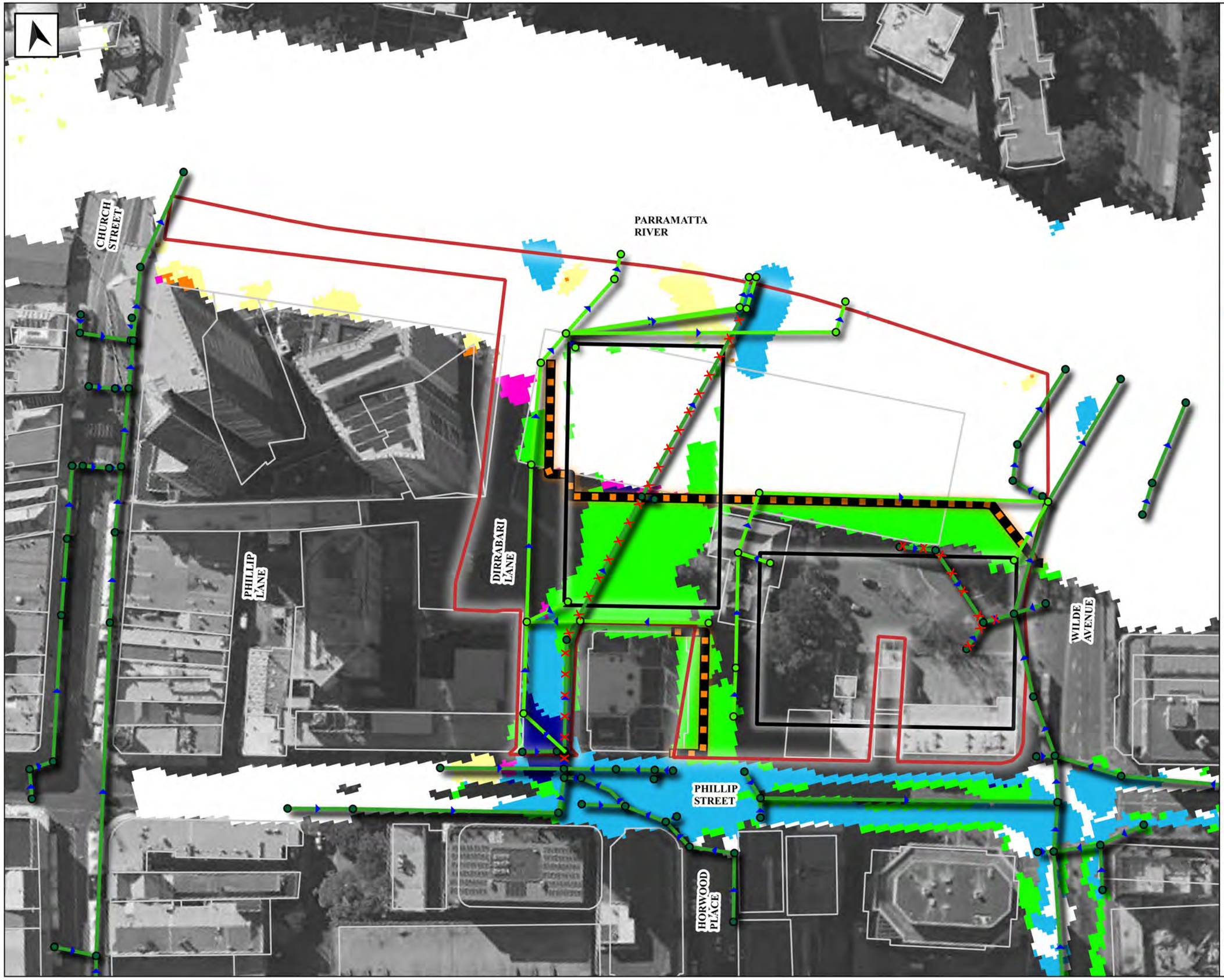
Post-development
Hydraulic Hazard PMF

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
P1.0-PMFH	1



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Peak Level Flood Afflux (m)

- <= -0.10
- -0.10 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- > 0.10
- Previously Flooded Area
- Newly Flooded Area

Note: *This figure has been produced by comparing the proposed development flooding levels presented in* ***Figure P1.0-5D*** *with the levels as presented in* ***Figure E1.0-5D****.*

Flooding impacts report changes in peak flood levels (mAHD). Note this is not the same as peak water depth.

Issue	Date	By	Chkd	Appd
1	3/04/2020	AA	NC	DC

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Client

Infrastructure New South Wales

Museum of Applied Arts & Sciences

Powerhouse Parramatta

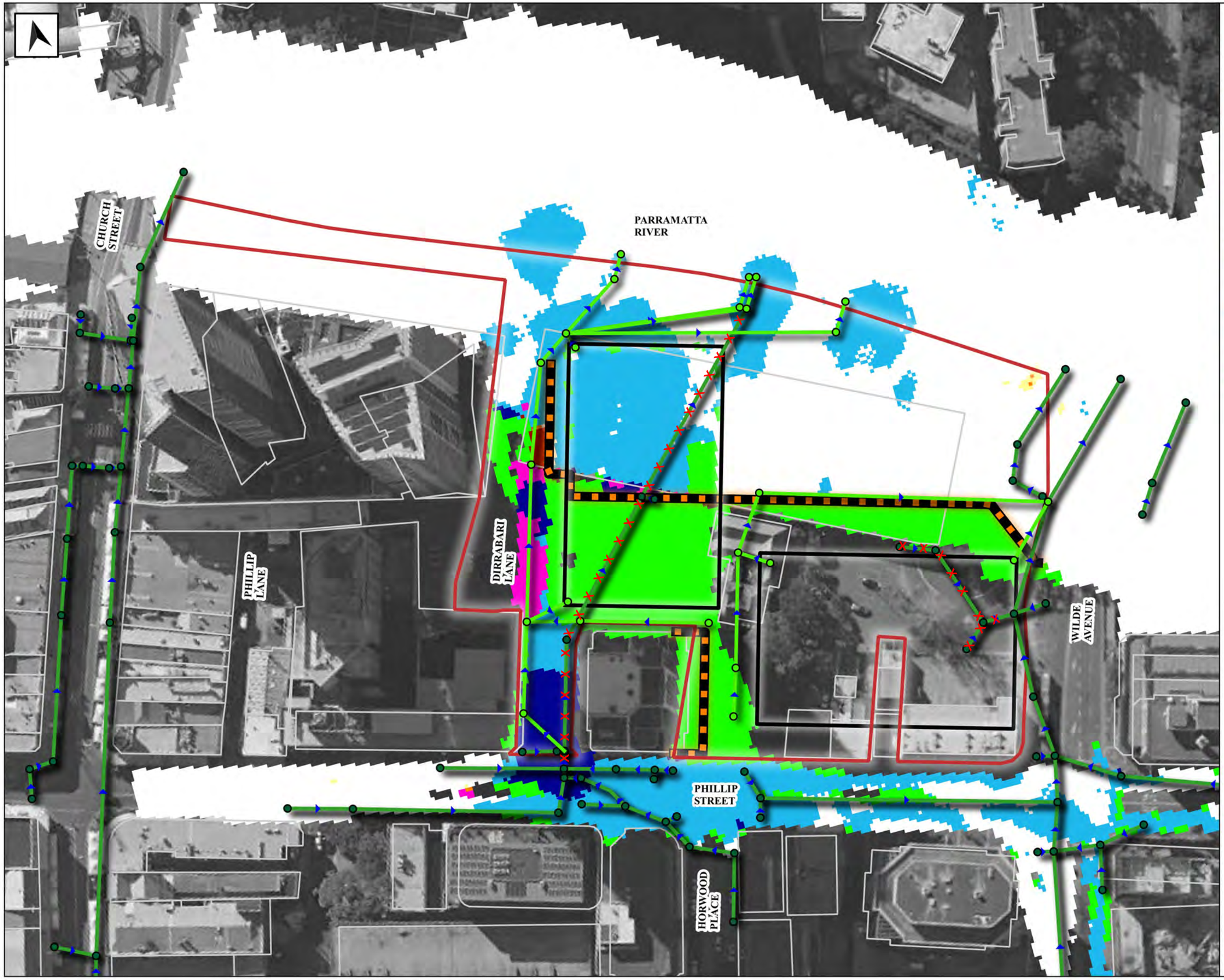
Post-development
Peak Flood Level Afflux
5% AEP

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
P1.0-5A	1



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Peak Level Flood Afflux (m)

- <= -0.10
- -0.10 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- > 0.10
- Previously Flooded Area
- Newly Flooded Area

Note: *This figure has been produced by comparing the proposed development flooding levels presented in* ***Figure P1.0-1D*** *with the levels as presented in* ***Figure E1.0-1D****.*

Flooding impacts report changes in peak flood levels (mAHD). Note this is not the same as peak water depth.

Issue	Date	By	Chkd	Appd
1	3/04/2020	AA	NC	DC

ARUP

Level 5, 151 Clarence St
Sydney, NSW 2000
Tel +61 2 9320 9320 Fax +61 2 9320 9321
www.arup.com

Client

Powerhouse Parramatta

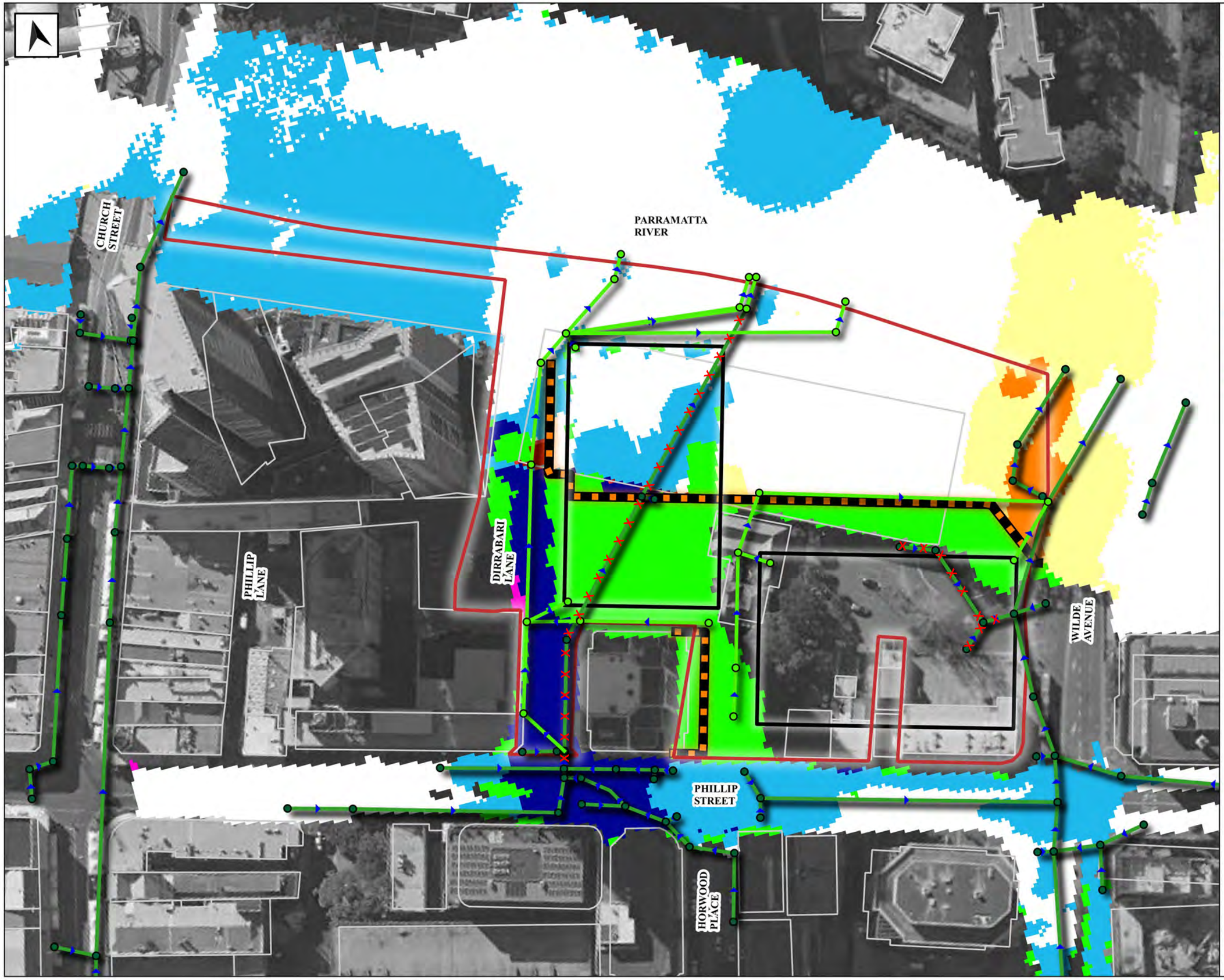
Post-development
Peak Flood Level Afflux
1% AEP

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
P1.0-1A	1



Legend

- Development Site Boundary
- Powerhouse Building Outline
- Existing Building Outlines
- Post-development Retaining Wall
- Pre-development Pits
- Pre-development Pipes
- Redundant Pits
- Redundant Pipes
- Post-development Pits
- Post-development Pipes

Peak Level Flood Afflux (m)

- <= -0.10
- -0.10 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- > 0.10
- Previously Flooded Area
- Newly Flooded Area

Note: *This figure has been produced by comparing the proposed development flooding levels presented in* ***Figure P1.0-1ccD*** *with the levels as presented in* ***Figure E1.0-1ccD****.*

Flooding impacts report changes in peak flood levels (mAHD). Note this is not the same as peak water depth.

Issue	Date	By	Chkd	Appd
1	3/04/2020	AA	NC	DC

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www.arup.com

Client

Infrastructure New South Wales

Museum of Applied Arts & Sciences

Powerhouse Parramatta

Post-development
Peak Flood Level Afflux
1% AEP & Cilmate Change

Scale at A3 **1:1000**

0 25 50 m

Job No	Figure Status
273467	Preliminary

Figure No	Issue
P1.0-1ccA	1

Appendix C | Flood Risk Modelling - Technical Approach and Analysis

Following discussion with CoPC (refer Appendix G |) and recognising the limitations associated with the Parramatta River flood models available (refer Appendix E |), it has become imperative that a new flood model needs to be developed as part of the flood assessment herein. This has been undertaken to provide a more robust and reliable simulation of the flood behaviour for the development site, utilising up-to-date information and following AR&R guidelines. This model (refer herein as the Arup Powerhouse Flood Model) adopts the MIKE11 model Parramatta River flow and tailwater hydrographs as the boundary conditions, provides simulation of both overland flow and mainstream flood behaviour, as well as addresses limitations found in the other flood models.

The approach undertaken is the development of a DRAINS hydrological model coupled with a 1D/2D (One-dimensional and two-dimensional) TUFLOW hydraulic model that simulates both mainstream flooding from the Parramatta River as well as overland flow flooding within the Parramatta CBD catchment. Both software packages are industry standard and widely used in Australia for undertaking flood assessments.

Input data incorporated into the flood model are as follows:

- Use of most recent LiDAR survey (dated June 2019) sourced from NSW Spatial Services in the development of the Digital Elevation Model (DEM) of the Parramatta River catchment;
- Incorporation of detailed topographic survey of the development site undertaken by LTS Lockley;
- Inclusion of Council stormwater pits and pipes network based on CoPC flood maps issued on 22 July 2016;
- Incorporation of Parramatta River bathymetry derived from the MIKE11 model river cross-sections;
- Use of updated building footprints based on survey, recent aerial photos and Open Street Map;
- Use of land use information sourced from NSW Spatial Services to develop surface roughness for the hydraulic model; and
- Incorporation of proposed building footprint and surface tin which have been developed based on building design by MKG (dated 1 April 2019) and landscape design by McGregor Coxall (dated 2 April 2019).

It is important to note that the ARR87 hydrology has been adopted for the current assessment since the model boundary conditions are based on the MIKE11 flows which have been derived using ARR87. For subsequent design stage, sensitivity runs will be undertaken adopting the ARR2019 hydrology and the changes to the

predicted flood behaviour will be assessed. Experience from other Sydney based projects have shown that the peak flood levels would reduce when the ARR2019 hydrology is adopted when compared to those developed using ARR87 hydrology.

The development of the DRAINS hydrological model and TUFLOW hydraulic model is described as follows:

Hydrological Model – DRAINS

The DRAINS software has been used to develop the hydrological model for the current flood assessment. This software package has been widely used in Australia for deriving flood hydrographs from rainfall hyetographs for urban catchments. The input data required as part of the DRAINS model setup are as follows:

- Definition of sub-catchments, i.e. sub-catchment area, impervious fraction, flow length and slope, roughness;
- Rainfall losses based on the ILSAX model and values recommended by the DRAINS manual; and
- Definition of design rainfall storms based on Intensity-Frequency-Duration (IFD) curves obtained from Bureau of Meteorology (BOM).

Delineation of sub-catchments has been undertaken based on the digital elevation model (DEM) as well as the stormwater pits and pipes network, as shown in Figure 34. The area of each sub-catchment has been determined using a GIS software package, and the corresponding flow length and equal area slope have been determined using the DEM. The impervious fraction for each sub-catchment has been estimated based on land use types as well as using recent aerial photography available. Most of the sub-catchments within Parramatta CBD are highly urbanised and almost fully impervious.

The DRAINS model has been used to generate runoff hydrographs for the Parramatta CBD sub-catchments, which also serve as inflow boundary conditions in the TUFLOW hydraulic model.

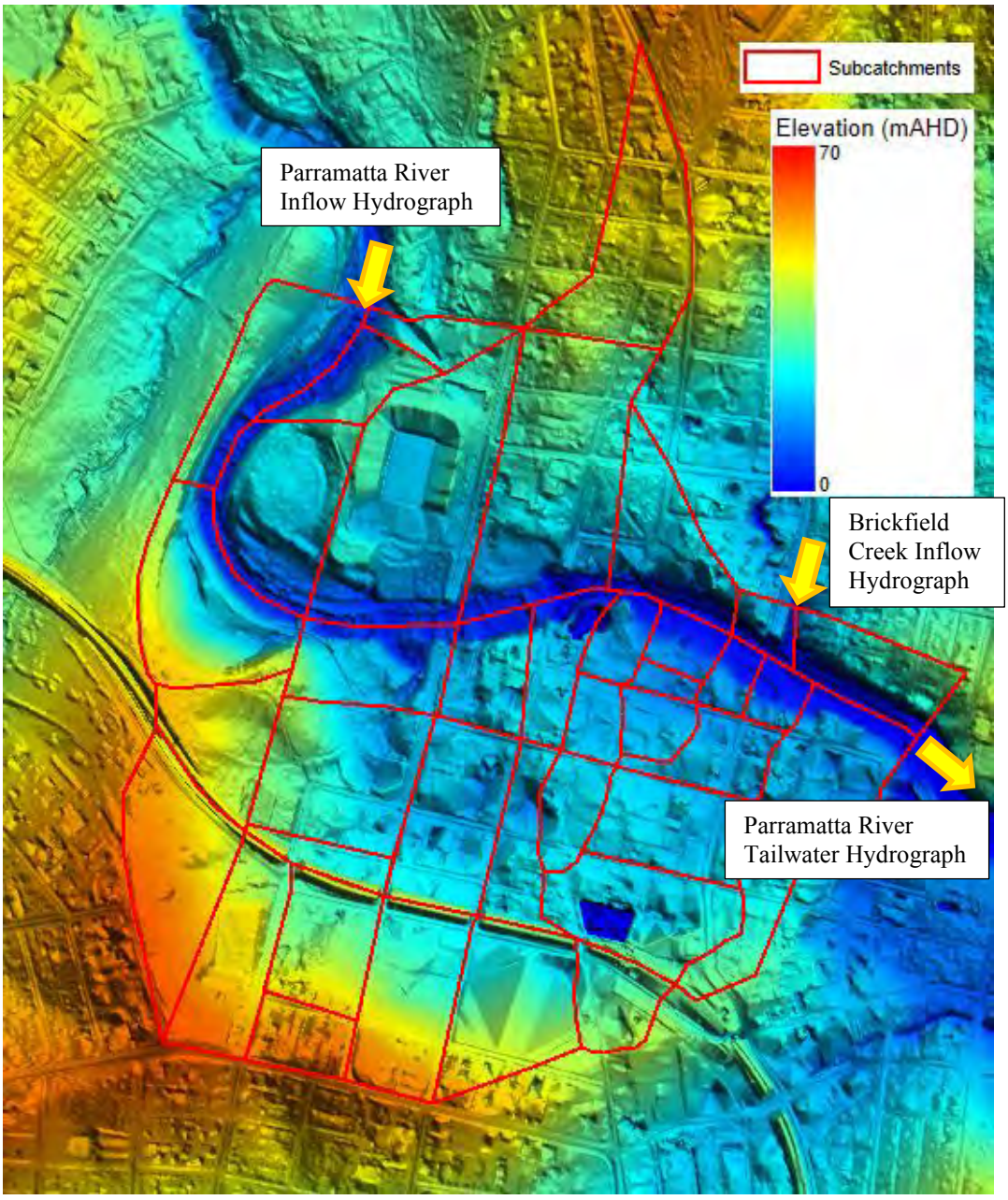

Figure 34: Delineation of sub-catchments and locations of boundary conditions for flood models

Hydraulic Model - TUFLOW

TUFLOW has been utilised to develop a 1D/2D hydraulic model for the current flood assessment. The software allows the linkage of 1D stormwater network with 2D domain and has been widely employed in various flood studies in Australia. The input data required as part of the TUFLOW model setup are as follows:

- Digital Elevation Model (DEM) – development of a 2 m fine grid based on LiDAR and topographic survey with sufficient resolution to represent catchment features and resulting in reasonable model run times;
- Incorporation of breaklines to represent gutter invert, top of kerb and retaining walls;
- Inclusion of 1D stormwater pits and pipes network, with details such as pipe layout and sizes, invert levels informed by survey. For stormwater network not covered by the survey, the pipe layout and sizes have been informed by the CoPC flood maps while the invert levels have been estimated assuming a standard cover and minimum pipe gradient of 0.5%;
- Derivation of inlet rating curves for the pits located within the development site and the use of a generic curve for those located outside the site boundary;
- Defining surface roughness based on values adopted in previous studies and industry standard (refer Table 10);

Table 10: Adopted Manning's 'n' roughness for different land use types

Land use type	**Manning's 'n' value**
Road, pavement, rail	0.02
Urban lot	0.05
Grass, light vegetation	0.03
Medium vegetation	0.045
Heavy vegetation	0.07
Creek, riverbed	0.035
Stormwater pipe (1D network)	0.015

- Schematisation of Parramatta River bridge structures based on information deduced from survey, site visit and Google Street View, including the Lennox Bridge portals;
- Introducing appropriate pit blockage factors and blockage of hydraulic structures, i.e. bridges, as per ARR2019 recommendations;
- Mainstream Parramatta River boundary conditions based on CoPC MIKE11 model and local catchment runoff based on inflows hydrographs generated using DRAINS (refer Figure 34). The latter have been applied

directly to the 1D stormwater pipes assuming the drainage system is limited by pipe capacity rather than pit capacity;

- Buildings have been modelled by "nulling" them out of the model domain since they serve as obstructions to flows; and
- Incorporation of Parramatta River bathymetry derived from the MIKE11 model river cross-sections to more accurately simulate river flow conveyance.

The TUFLOW model developed herein has been validated against the MIKE11 model results to provide confidence in the predicted flood behaviour. It is important to note that a like-for-like comparison has not been possible due to the difference in model inputs and modelling assumptions made. However, the general flood behaviour has been replicated by the model with the predicted flood levels found to be within the expected range of accuracy. Details of these are reported in the main section of this report.

The DRAINS and TUFLOW models developed herein have been used to simulate the 5% AEP, 1% AEP, 1% AEP with climate change (i.e. 20% rainfall increase) and PMF events, for both existing and post-development conditions.

In modelling the climate change scenario following ARR2019 recommendations, the 2090 RCP (Representative Concentration Pathways) 8.5 emission scenario was adopted cognisant of the Powerhouse Parramatta project would have a design life spanning more than 100 years. A 19.7% rainfall increase has been predicted for this scenario and this has been modelled herein for the 1% AEP event (rounded up to 20% rainfall increase). Sea level rise has not been modelled herein as it generally affects the tidal areas downstream of Charles Street Weir (Cardno, 2019) and not the development site. Further, the probability of a flood event occurring coincidentally with a high tide is generally low.

The critical storm durations for each AEP flood and each flooding mechanism (i.e. overland flow and mainstream flooding) have been ascertained. Details are provided in Table 11. The critical storm durations match those derived from previous flood studies. It is found that the critical storm duration for the overland flow flooding differs significantly from the mainstream flooding and there are implications for the flood risk management strategy proposed. For instance, the use of an on-site detention system to reduce post-development runoff may not be appropriate since attenuating the peak from the local overland flow flooding may exacerbate the peak mainstream flow which arrives much later.

Table 11: Critical storm duration (minutes) for the development site

Design Event (AEP)	**Existing Conditions**		**Post-Development Conditions**	
	Overland Flow Flooding @ Phillip Street	**Mainstream Flooding @ Parramatta River**	**Overland Flow Flooding @ Phillip Street**	**Mainstream Flooding @ Parramatta River**
5% AEP	30 + 60	540	30	540
1% AEP	90	540	30	540
1% AEP with 20% climate change	90	540	30	540
PMF	240	240	240	240

An overview of the model setup and the flood maps developed for both existing and post-development flood conditions are provided in Appendix C |.

Appendix D | Stormwater Management Plan

A1

CONNECTION INTO EXISTING STORMWATER NETWORK

EXISTING GROSS POLLUTANT TRAP (GPT) TO BE RETAINED

CONNECTION INTO EXISTING STORMWATER NETWORK

CONNECTION INTO EXISTING STORMWATER NETWORK

PROPOSED STORMWATER TO BE DESIGNED TO CROSS THE SYDNEY WATER TRUNK SEWER.

PARRAMATTA RIVER

EXISTING SYDNEY WATER TRUNK SEWER TO BE RETAINED

WILDE AVENUE

PROPOSED SURCHARGE PIT AND GRATE

PROPOSED WEST BUILDING

PROPOSED STORMWATER INLET PIT CHAMBER TO BE BUILT OUT TO ALLOW FOR DN1200 CULVERT TO CLEAR PROPOSED RETAINING WALL

PROPOSED SURCHARGE PIT AND GRATE

RECONSTRUCT EXISTING STORMWATER PIT

PROPOSED SURCHARGE PIT AND GRATE

TIE PROPOSED RETAINING WALL INTO EXISTING BRIDGE ABUTMENT

EXISTING COUNCIL STORMWATER DRAIN TO BE RETAINED, DEVELOPMENT PROPOSALS TO BE DEVELOPMENT TO CO ORDINATE WITH EXISTING INFRASTRUCTURE

DIRRIBARRI LANE

EXISTING GE BUILDING

RECONSTRUCT EXISTING STORMWATER PIT

PROPOSED EAST BUILDING

PHILLIP STREET

DP 1225807

NOTES:

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE ARUP STORMWATER FLOODING REPORT REFERENCE PHM-ARP-CIV-REP-0001.
2. THE INFORMATION CONTAINED IN THESE DRAWINGS PRODUCED BY ARUP IS SOLELY FOR USE OF INFRASTRUCTURE NEW SOUTH WALES FOR THE PURPOSE FOR WHICH IT HAS BEEN PREPARED. ARUP UNDERTAKES NO DUTY TO OR ACCEPTS NO RESPONSIBILITY TO ANY THIRD PARTY WHO MAY RELY UPON THIS DOCUMENT.
3. THIS STORMWATER PLAN IS A PRELIMINARY STRATEGY FOR THE PURPOSES OF SSDA AND WILL CHANGE SUBJECT TO FURTHER DESIGN DEVELOPMENT.
4. DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
5. DO NOT SCALE OFF DRAWINGS.
6. TOPOGRAPHICAL AND SERVICES SURVEY FOR THIS DESIGN IS SUPPLIED BY:
   LTS LOCKLEY
   SUITE 1 , LEVEL 1, 810 PACIFIC HIGHWAY,
   GORDON NSW 2072
   PHONE 1300 587 000
   FAX 02 9499 7760
   SURVEY REFERENCE: 41692011DT REVISION A DATED 12/03/20
7. SERVICES SHOWN ON THESE PLANS ARE LOCATED FROM SURVEY AND FIELD INVESTIGATION INFORMATION AND ARE NOT GUARANTEED TO BE COMPLETE OR CORRECT. ALL SERVICE LOCATIONS ARE TO BE VERIFIED BY THE CONTRACTOR PRIOR TO CONSTRUCTION.
8. DESIGN REFERENCES THE FOLLOWING FROZEN ARCHITECTURAL DESIGNS:
   LANDSCAPE - MCGREGOR COXALL POWERHOUSE PARRAMATTA REFERENCE 0792BRS; DATED 02/04/2020; REV C
   BUILDING - MKG POWERHOUSE PARRAMATTA DATED 01/04/20

LEGEND

- PROJECT BOUNDARY
- EXISTING MINOR CONTOUR
- EXISTING MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- PROPOSED MAJOR CONTOUR (CONTOUR LABELS FACE UPHILL)
- PROPOSED RETAINING WALL

EXISTING DRAINAGE

- EXISTING STORMWATER
- EXISTING STORMWATER TO BE REDUNDANT
- EXISTING STORMWATER INLET PIT
- EXISTING STORMWATER KERB INLET PIT
- EXISTING STORMWATER INFILL PIT
- EXISTING STORMWATER GRATED LINEAR DRAIN

PROPOSED DRAINAGE

- Ø300 STORMWATER PIPEWORK (FLOW DIRECTION AND NTERNAL PIPE DIAMETER)
- STORMWATER INSPECTION PIT
- GRATED PIT
- GRATED INLET PIT

SEWER

- EXISTING TRUNK SEWER

Issue	Date	
0	03.04.20	PRELIMINARY

ARUP

Level 5, 151 Clarence Street Sydney
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Client

Project Title
PARRAMATTA POWERHOUSE

Drawing Title
STORMWATER MANAGEMENT PLAN

Scale at A1	By / Chkd / Appd
NOT TO SCALE	MP/TT/DC

Role: CIVIL

Status: **PRELIMINARY**

Arup Job No	Rev
273467	**0**

SKETCH NO.
PMH-ARP-SKE-CE-000001

Do not scale

Appendix E | TTW Model Assessment

To undertake the flood risk assessment for the current Powerhouse Museum design as part of the SSDA submission, we have undertaken a review of previous flood studies and models to establish whether they are fit for purpose and suitable for use in the current assessment.

TTW undertook the previous flood assessment of the development site and the corresponding TUFLOW flood model has been reviewed. The model was found to be not suitable for use in the current flood risk assessment. The main reason being the flood flows utilised in the TTW model were based neither from Council's published flood study nor flood model.

Instead, estimated flows were used as input to produce flood levels that resemble those provided by City of Parramatta Council. The tabulated flood levels documented in the TTW flood report were instead based on levels published in previous studies and the flood model was used primarily for determining the development flood impacts rather than informing the Flood Planning Levels (FPLs).

The final draft Parramatta River Flood Study (2019) recently developed by Cardno on behalf of Council has also been reviewed. Whilst the report was made available, Council could not provide the corresponding flood model as the report has yet to undergo public exhibition.

Thus, the flood model results have not been formally adopted for the LGA. Initial review of the draft report undertaken by Arup nevertheless found that the reported flood flows for events such as the 1% AEP (used for informing the FPL) are significantly lower (i.e. up to 15%) than those determined in previous study.

The methodology adopted by the Cardno study is based on recently published Australian Rainfall & Runoff (ARR2019) guidelines unlike the previous study which is based on ARR1987. The reduced flows and resulting lower FPL would only be considered for formal endorsement by Council following the public exhibition which may not take place until the end of 2020.

Council, however, have indicated that the MIKE11 flood model developed as part of the previous flood study can be provided and used for the current assessment. The FPLs currently adopted by Council for the LGA were derived using this MIKE11 model, which are generally more conservative than the recent Cardno study.

In view of the TTW model limitations and the decision by Council not to provide the Cardno (2019) flood model, we propose the following flood modelling approach be undertaken to assess FPL compliance and to determine flood impacts and any mitigation works required for the development site, utilising the best available data obtained to date:

a) Using the TTW flood model as a guide, develop an Arup TUFLOW model covering a reasonable extent of the study area to facilitate the flood risk assessment;

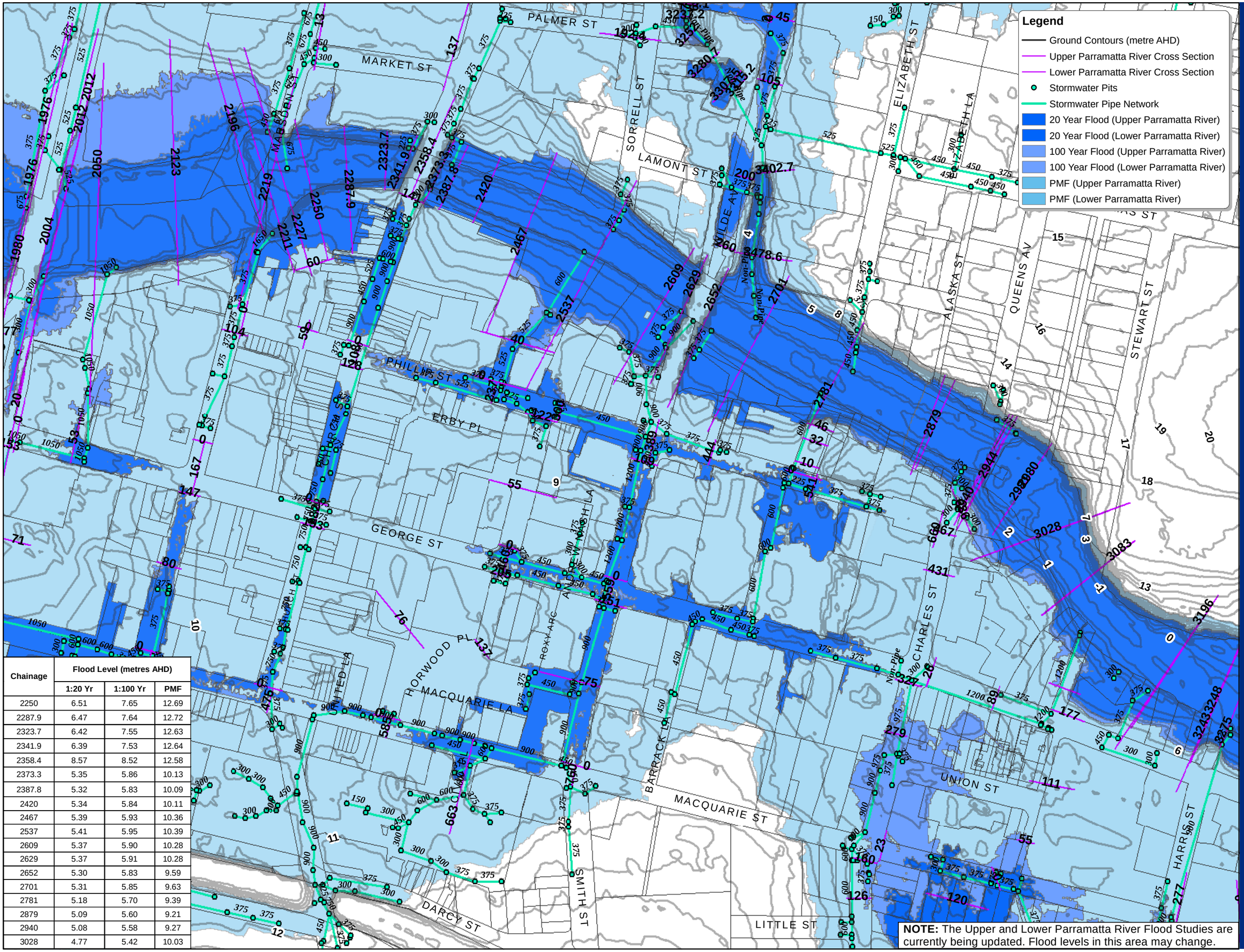
b) Adopt Council's MIKE11 model flow hydrographs as input for the flood model; and

c) Incorporate up-to-date site data including ground survey, stormwater pits and pipes data, existing building outlines which more accurately represent existing site conditions.

This approach would be based on best practice and avoid the risk associated with utilising Cardno flood results (with lower FPL), which may or may not be endorsed by Council following public exhibition later this year.

Arup recommended INSW adopt the approach to develop a bespoke TUFLOW model for the Powerhouse Museum site to minimise the risks identified above.

City of Parramatta Council Flood Map



Chainage	Flood Level (metres AHD)		
	1:20 Yr	1:100 Yr	PMF
2250	6.51	7.65	12.69
2287.9	6.47	7.64	12.72
2323.7	6.42	7.55	12.63
2341.9	6.39	7.53	12.64
2358.4	8.57	8.52	12.58
2373.3	5.35	5.86	10.13
2387.8	5.32	5.83	10.09
2420	5.34	5.84	10.11
2467	5.39	5.93	10.36
2537	5.41	5.95	10.39
2609	5.37	5.90	10.28
2629	5.37	5.91	10.28
2652	5.30	5.83	9.59
2701	5.31	5.85	9.63
2781	5.18	5.70	9.39
2879	5.09	5.60	9.21
2940	5.08	5.58	9.27
3028	4.77	5.42	10.03

NOTE: The Upper and Lower Parramatta River Flood Studies are currently being updated. Flood levels in this area may change.

N

1:3,000

Maps Updated and Published by Information Systems, Parramatta City Council

Base data supplied from NSW Department of Lands
Projection - Map Grid of Australia (MGA94)
Data - Geocentric Datum of Australia (GDA94)

Printed
22/07/2016

NOTE: The Upper and Lower Parramatta River Flood Studies are currently being updated. Hydraulic hazard extents in this area may change.

Council Hydraulic Hazard Map

City of Parramatta Council

N

1:3,000

Maps Updated and Published by Information Systems, Parramatta City Council

Base data supplied from NSW Department of Lands
Projection - Map Grid of Australia (MGA94)
Data - Geocentric Datum of Australia (GDA94)

Legend

- Ground Contours (metre AHD)
- Upper Parramatta River Cross Section
- Lower Parramatta River Cross Section
- Stormwater Pits
- Stormwater Pipe Network
- High Hazard (Lower Parramatta River)
- High Hazard (Upper Parramatta River)
- Low Hazard (Upper Parramatta River)
- Low Hazard (Lower Parramatta River)

Printed
22/07/2016

Appendix F | City of Parramatta Council Flood Plan (From TTW Flood Report (2016))

Appendix G | Correspondence with City of Parramatta Council

The summary of correspondence between Arup and City of Parramatta Council flooding and stormwater engineering team prior to the publication of this report of is provided in Table 12:

Table 12: Summary of correspondence with CoPC

Date	From	To	Description
26/02/20	Arup (Terrence Tang)	CoPC (Peter Sirianni)	Initial Contact with City of Parramatta Council and request for latest Parramatta flood model information.
04/03/20	Arup (Terrence Tang)	CoPC (Peter Sirianni)	Email to confirm phone call discussion between Arup and CoPC to clarify: • CoPC will not be releasing the latest Parramatta Flood Study by Cardno as it is currently still under development and is expected to be publicly available next year. • The current Mike11 CoPC flood model shall be adopted for the purposes of SSDA.
11/03/20	CoPC (Peter Sirianni)	Arup (Terrence Tang)	Version 8 Mike11 Parramatta flood models provided to Arup by CoPC.

18/03/20	CoPC (Peter Sirianni)	Arup (Terrence Tang)	CoPC have clarified the following with respect to stormwater and flood information provided by CoPC:
			• 2016 CoPC flood map (from TTW's report) is still the most current to date.
			• Version 8 of Mike11 model will be adopted for the purposes of the SSDA. Version 9 of Mike11 model will be considered as part of our assessment.
			• ARR1987 will be followed for the SSDA submission. Due to time constraints, ARR2019 will not be assessed, however CoPC will have the opportunity to raise this as a comment during SSDA review and Arup will subsequently undertake the ARR2019 assessment then.
			• The following flood events will be undertaken for SSDA:
			  • 5% AEP
			  • 1% AEP
			  • 1% AEP + climate change

Date	From	To	Description
			• Probable Maximum Flood (PMF)
19/03/20	CoPC (Peter Sirianni)	Arup (Terrence Tang)	Version 9 Mike11 flood models provided to Arup from CoPC.
23/03/20	CoPC (Jeffrey Chan)	Arup (Terrence Tang)	Digitized Parramatta stormwater network plans provided to Arup from CoPC.

Copies of relevant e-mail correspondence between Arup and CoPC are also appended by way of further detail.

Terrence Tang

From: Jeffrey Chan <JChan@cityofparramatta.nsw.gov.au>
Sent: Monday, 23 March 2020 2:59 PM
To: Terrence Tang; Peter Sirianni
Subject: [External] RE: New Powerhouse Museum - Flood information and Parramatta Council input
Attachments: GISdata_20200323.zip

Hi Terrence,

(You may try to download QGIS to view the SHP files.)

The **Invert Levels** will be under one of the attribute columns. Refer to these column name and Peter should be able to assist.

Kind Regards,

Jeffrey Chan
Team Leader LIS & GIS | Survey & Spatial
(02) 98068257
City of Parramatta
316 Victoria Road, Rydalmere NSW 2116
PO Box 32, Parramatta, NSW 2124
cityofparramatta.nsw.gov.au

From: Terrence Tang <Terrence.Tang@arup.com>
Sent: Monday, 23 March 2020 12:47 PM
To: Jeffrey Chan <JChan@cityofparramatta.nsw.gov.au>; Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hi Jeff,

Thank you for letting me know - please send through the GIS files and we will try to work out on our end.

Thanks,

Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
Level 5, 151 Clarence Street, Sydney NSW 2000 Australia
t: +61 02 9320 9320 d: +61 02 9320 9297
www.arup.com

From: Jeffrey Chan <JChan@cityofparramatta.nsw.gov.au>
Sent: Monday, 23 March 2020 12:42 PM
To: Terrence Tang <Terrence.Tang@arup.com>; Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Subject: [External] RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hi Terrance,

Unless you are able to accept GIS files, there invert levels will not appear in CAD.

Kind Regards,

Jeffrey Chan
Team Leader LIS & GIS | Survey & Spatial
(02) 98068257
City of Parramatta
316 Victoria Road, Rydalmere NSW 2116
PO Box 32, Parramatta, NSW 2124
cityofparramatta.nsw.gov.au

From: Terrence Tang <Terrence.Tang@arup.com>
Sent: Monday, 23 March 2020 11:27 AM
To: Jeffrey Chan <JChan@cityofparramatta.nsw.gov.au>; Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hi Jeff,

Thanks for sending these over.

I hope you don't mind if I bring up two things:

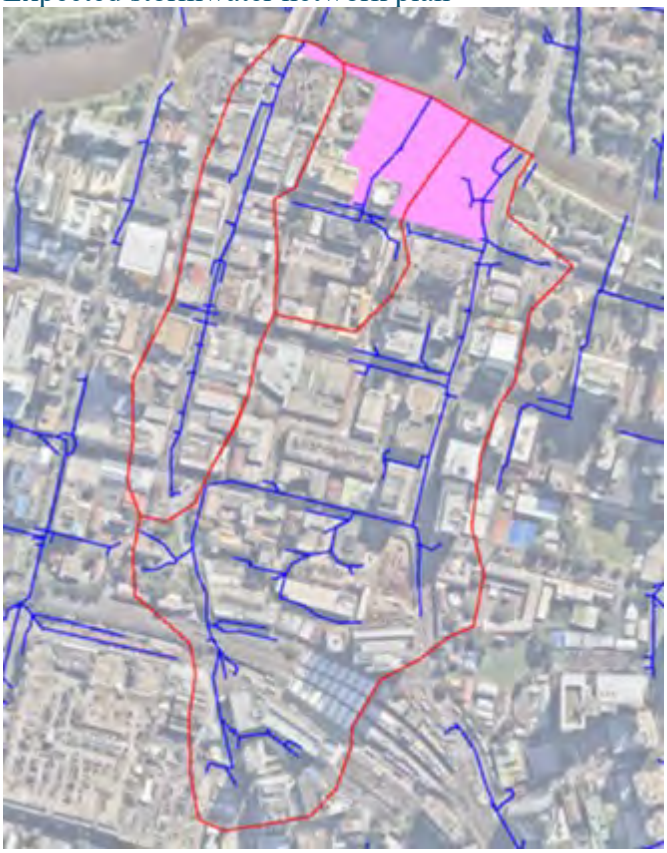
1. The plan provided seems to only cover one catchment area, would you be able to send over the stormwater networks for the other two areas, please? Please refer to snapshots at bottom of this e-mail.
2. The plans don't seem to indicate pipe sizes or invert levels. Is it possible to include this information in the CAD drawings?

Feel free to contact me if you have any issues.

Thank you,
Terrence

Stormwater plans provided

Expected stormwater network plan



Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
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t: +61 02 9320 9320 d: +61 02 9320 9297
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From: Jeffrey Chan <JChan@cityofparramatta.nsw.gov.au>
Sent: Monday, 23 March 2020 10:00 AM
To: Terrence Tang <Terrence.Tang@arup.com>; Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Subject: [External] RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hi Terrance,

Please see attached for DWG (stormwater assets).

Kind Regards,

Jeffrey Chan
Team Leader LIS & GIS | Survey & Spatial
(02) 98068257
City of Parramatta
316 Victoria Road, Rydalmere NSW 2116
PO Box 32, Parramatta, NSW 2124
cityofparramatta.nsw.gov.au

From: Terrence Tang <Terrence.Tang@arup.com>
Sent: Friday, 20 March 2020 10:50 AM
To: Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>; Jeffrey Chan <JChan@cityofparramatta.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hi Peter and Jeffrey,

Please see attached CAD drawing for the extents of the three stormwater networks (purple "STORMWATER CATCHMENT BOUNDARY" layer). The CAD file is in MGA coordinates.

Thank you for your help – any issues please get a hold of me.

Thanks,

Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
Level 5, 151 Clarence Street, Sydney NSW 2000 Australia
t: +61 02 9320 9320 d: +61 02 9320 9297
www.arup.com

From: Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Sent: Friday, 20 March 2020 9:40 AM
To: Terrence Tang <Terrence.Tang@arup.com>
Cc: Jeffrey Chan <JChan@cityofparramatta.nsw.gov.au>
Subject: [External] FW: New Powerhouse Museum - Flood information and Parramatta Council input

Hello Terrence,

Could you please arrange request below.

Regards,

Peter Sirianni | **Senior Engineer Catchment Management**
City of Parramatta
PO Box 32, Parramatta NSW 2124
☎ (02) 9806 8254
✉ **psirianni@cityofparramatta.nsw.gov.au**
Links | **www.cityofparramatta.nsw.gov.au**

STORMWATER

CITY OF PARRAMATTA

From: Jeffrey Chan <JChan@cityofparramatta.nsw.gov.au>
Sent: Friday, 20 March 2020 9:37 AM
To: Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hi Peter,

Can you please ask the consultant to send the catchment extent files in CAD format? It would be more accurate to extract the pits/pipes this way.

Kind Regards,

Jeffrey Chan
Team Leader LIS & GIS | Survey & Spatial
(02) 98068257
City of Parramatta
316 Victoria Road, Rydalmere NSW 2116
PO Box 32, Parramatta, NSW 2124
cityofparramatta.nsw.gov.au

Terrence Tang

From: Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Sent: Thursday, 19 March 2020 11:01 AM
To: Terrence Tang
Subject: [External] RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hello Terrence,

I have re zipped and uploaded.

Regards,

Peter Sirianni | Senior Engineer Catchment Management
City of Parramatta
PO Box 32, Parramatta NSW 2124
☎ (02) 9806 8254
✉ **psirianni@cityofparramatta.nsw.gov.au**
Links | www.cityofparramatta.nsw.gov.au

From: Terrence Tang <Terrence.Tang@arup.com>
Sent: Thursday, 19 March 2020 9:58 AM
To: Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hi Peter,

The version9 Mike11 model zip folder that was uploaded appears to be empty, would you mind checking, please?

Will we also be able to obtain the stormwater network plans (GIS) from CPC today as well?

Thanks,

Terrence Tang
Civil Engineer | NSW & ACT Transport

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Level 5, 151 Clarence Street, Sydney NSW 2000 Australia

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www.arup.com

From: Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Sent: Thursday, 19 March 2020 9:38 AM
To: Terrence Tang <Terrence.Tang@arup.com>
Subject: [External] RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hello Terrence,

I have uploaded.

Regards,

Peter Sirianni | **Senior Engineer Catchment Management**
City of Parramatta
PO Box 32, Parramatta NSW 2124
☎ (02) 9806 8254
✉ **psirianni@cityofparramatta.nsw.gov.au**
Links | **www.cityofparramatta.nsw.gov.au**

From: Terrence Tang <Terrence.Tang@arup.com>
Sent: Thursday, 19 March 2020 9:06 AM
To: Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Cc: Myfanwy McNally <MMcNally@cityofparramatta.nsw.gov.au>; Callantha Brigham <CBrigham@cityofparramatta.nsw.gov.au>; Jim Tsom <JTsom@cityofparramatta.nsw.gov.au>; Duncan Crook <Duncan.Crook@arup.com>; Nathan Cheah <Nathan.Cheah@arup.com>; Claire Moore <Claire.Moore@arup.com>; Enrico Zara <Enrico.Zara@arup.com>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hi Peter,

Does the new OneDrive link work for you? Please let me know if there are any issues.

Would you be able to have the Version9 Mike11 and stormwater networks plans in the OneDrive folder by mid-day today, please? It would be greatly appreciated.

Thank you,

Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
Level 5, 151 Clarence Street, Sydney NSW 2000 Australia
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www.arup.com

From: Terrence Tang
Sent: Wednesday, 18 March 2020 2:57 PM
To: 'Peter Sirianni' <PSirianni@cityofparramatta.nsw.gov.au>
Cc: Myfanwy McNally <MMcNally@cityofparramatta.nsw.gov.au>; Callantha Brigham <CBrigham@cityofparramatta.nsw.gov.au>; Jim Tsom <JTsom@cityofparramatta.nsw.gov.au>; Duncan Crook (Duncan.Crook@arup.com) <Duncan.Crook@arup.com>; 'Nathan Cheah (Nathan.Cheah@arup.com)' <Nathan.Cheah@arup.com>; Claire Moore (Claire.Moore@arup.com) <Claire.Moore@arup.com>; Enrico Zara (Enrico.Zara@arup.com) <Enrico.Zara@arup.com>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input [Filed 18 Mar 2020 14:56]

Hi Peter,

Thanks for the chat earlier, our clarifications below in red.

1. CPC to please confirm if the CPC flood maps (attached) supplied back in 2016 for TTW's flood report are still the most recent and will not have changed since 2016 print. – Maps attached to your email are still current. Information is from Draft 8 version (See response for item 4 below). These will remain current until Council has adopted the Parramatta River Floodplain Risk Management Study/Plan currently in progress. Noted.

2. CPC to provide us with the existing stormwater network plans (with sizes and levels) within the catchment extents (preferably in CAD, MGA coordinates) that indicate sizes and invert levels (refer to snapshot below; Pink – powerhouse development; Blue – existing stormwater assets; Red – catchment extents). – I will arrange for this to be forwarded separately. Please put files into Onedrive, updated link below:

https://arup-my.sharepoint.com/:f:/p/terrence_tang/EhvCMXO58SJMsLzPsj8QyvkB-DffOfhNh2p2maj3H7RlZQ?e=9sRilV

3. CPC to provide us with Version 9 Mike 11 flood models, please place in following folder: Link has expired. Please forward new link. No Mike-11 result files available. Noted. Please see updated OneDrive link above.

4. CPC to confirm which Mike11 version (8 or 9) we should be adopting for this development. – Draft 8 is the last official release/issue by the former Upper Parramatta River Catchment Trust and is the version used for the Upper Parramatta River Catchment Floodplain Risk Management Study and Plan which has been adopted by City of Parramatta Council. Draft 9 version was to be an update however it was never officially released/issued by the Trust. Assessment of the impact of the proposal should be carried out using 2d model. Based on this we will be adopting Version 8 at this time. We are currently undertaking the assessment using Tuflow.

5. Because the Mike11 models provided were done in accordance with ARR 1987, we are planning on undertaking this development to ARR 1987. CPC please confirm if this is OK. – Follow current guidance to utilise ARR 2019 and carry out sensitivity testing utilising ARR 1987. As discussed and based on our current time constraints, we will only have time to undertake the assessment to ARR 1987 for SSDA submission. However CPC will have the opportunity to raise this as a comment as part of the Powerhouse SSDA review and we can subsequently undertake it using ARR 2019 then.

6. Arup will be undertaking flood modelling or the following flood events. If CPC have any issues/comments with this please let us know. – No issue. Noted.
    - 1:20 year ARI
    - 1:100 year ARI

- 1:100 year ARI + CC
- PMF

Thank you,

Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
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t: +61 02 9320 9320 d: +61 02 9320 9297
www.arup.com

From: Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Sent: Wednesday, 18 March 2020 2:12 PM
To: Terrence Tang <Terrence.Tang@arup.com>
Cc: Myfanwy McNally <MMcNally@cityofparramatta.nsw.gov.au>; Callantha Brigham <CBrigham@cityofparramatta.nsw.gov.au>; Jim Tsom <JTsom@cityofparramatta.nsw.gov.au>
Subject: [External] RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hello Terrence,

Response below in green.

Regards,

Peter Sirianni | Senior Engineer Catchment Management
City of Parramatta
PO Box 32, Parramatta NSW 2124
☎ (02) 9806 8254
✉ **psirianni@cityofparramatta.nsw.gov.au**
Links | www.cityofparramatta.nsw.gov.au

From: Terrence Tang <Terrence.Tang@arup.com>
Sent: Tuesday, 17 March 2020 8:48 AM
To: Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Cc: Duncan Crook <Duncan.Crook@arup.com>; Claire Moore <Claire.Moore@arup.com>; Nathan Cheah <Nathan.Cheah@arup.com>; Jim Tsom <JTsom@cityofparramatta.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hi Peter,

Would you be able to respond to our queries below by today, please?

These items are critical for our flood modelling for the Powerhouse SSDA submission. We are under tight timeframes to deliver and response from CPC is affecting our program.

Thank you,

Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
Level 5, 151 Clarence Street, Sydney NSW 2000 Australia
t: +61 02 9320 9320 d: +61 02 9320 9297
www.arup.com

From: Terrence Tang
Sent: Monday, 16 March 2020 12:07 PM
To: 'Peter Sirianni' <PSirianni@cityofparramatta.nsw.gov.au>
Cc: Duncan Crook (Duncan.Crook@arup.com) <Duncan.Crook@arup.com>; Claire Moore (Claire.Moore@arup.com) <Claire.Moore@arup.com>; Nathan Cheah <Nathan.Cheah@arup.com>; 'jtsom@parracity.nsw.gov.au' <jtsom@parracity.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input [Filed 16 Mar 2020 12:07]

Hi Peter,

As a matter of urgency, would you be able to provide input on the following, please:

1. CPC to please confirm if the CPC flood maps (attached) supplied back in 2016 for TTW's flood report are still the most recent and will not have changed since 2016 print. – Maps attached to your email are still current. Information is from Draft 8 version (See response for item 4 below). These will remain current until Council has adopted the Parramatta River Floodplain Risk Management Study/Plan currently in progress.

2. CPC to provide us with the existing stormwater network plans (with sizes and levels) within the catchment extents (preferably in CAD, MGA coordinates) that indicate sizes and invert levels (refer to snapshot below; Pink – powerhouse development; Blue – existing stormwater assets; Red – catchment extents). – I will arrange for this to be forwarded separately.

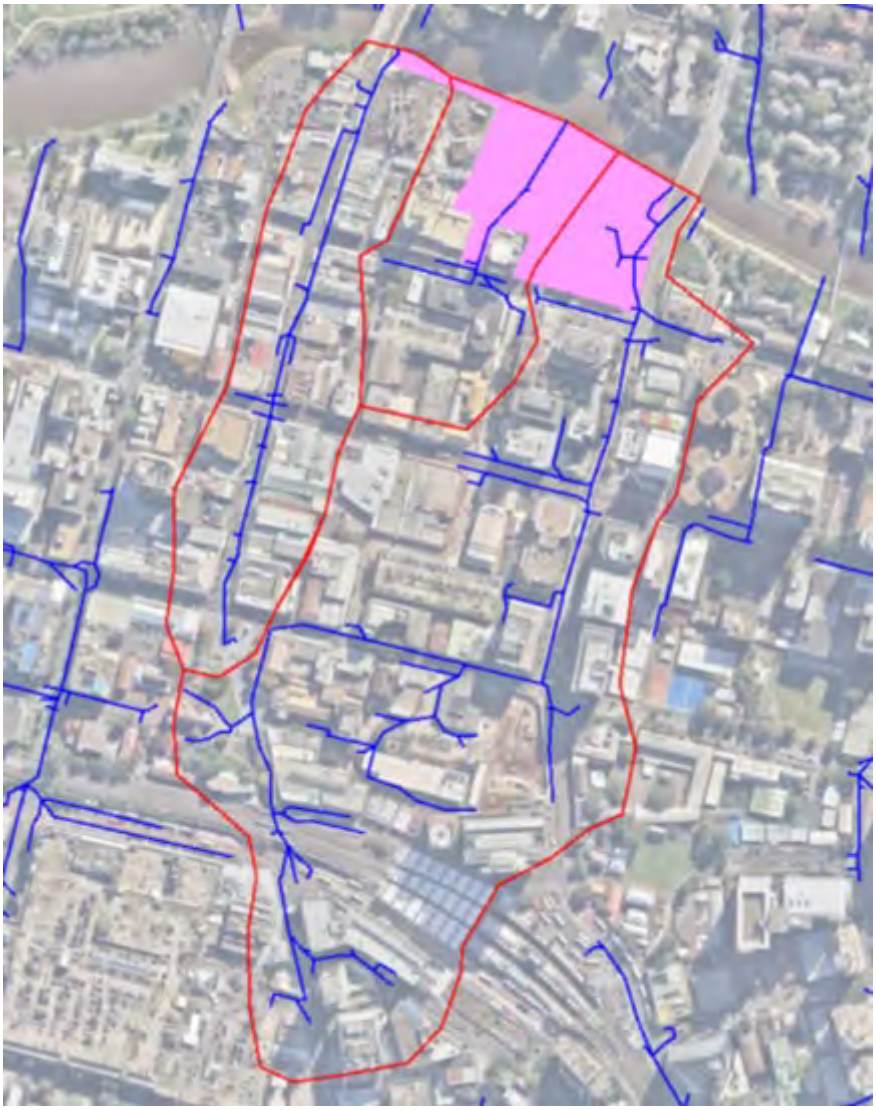
3. CPC to provide us with Version 9 Mike 11 flood models, please place in following folder: Link has expired. Please forward new link. No Mike-11 result files available.

https://arup-my.sharepoint.com/:f:/p/terrence_tang/EhvCMXO58SJMsLzPsj8QyvkB-DffOfhNh2p2maj3H7RlZQ?e=uKvbe1

4. CPC to confirm which Mike11 version (8 or 9) we should be adopting for this development. – Draft 8 is the last official release/issue by the former Upper Parramatta River Catchment Trust and is the version used for the Upper Parramatta River Catchment Floodplain Risk Management Study and Plan which has been adopted by City of Parramatta Council. Draft 9 version was to be an update however it was never officially released/issued by the Trust. Assessment of the impact of the proposal should be carried out using 2d model.

5. Because the Mike11 models provided were done in accordance with ARR 1987, we are planning on undertaking this development to ARR 1987. CPC please confirm if this is OK. – Follow current guidance to utilise ARR 2019 and carry out sensitivity testing utilising ARR 1987. Will undertake with 1987 for now due to time constraints, CPC to bring up 2019 as comment.

6. Arup will be undertaking flood modelling or the following flood events. If CPC have any issues/comments with this please let us know. – No issue.
    - 1:20 year ARI
    - 1:100 year ARI
    - 1:100 year ARI + CC
    - PMF



Thank you,

Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
Level 5, 151 Clarence Street, Sydney NSW 2000 Australia
t: +61 02 9320 9320 d: +61 02 9320 9297
www.arup.com

From: Terrence Tang
Sent: Friday, 13 March 2020 1:27 PM
To: 'Peter Sirianni' <PSirianni@cityofparramatta.nsw.gov.au>
Cc: Duncan Crook (Duncan.Crook@arup.com) <Duncan.Crook@arup.com>; Claire Moore (Claire.Moore@arup.com) <Claire.Moore@arup.com>; Nathan Cheah <Nathan.Cheah@arup.com>; 'jtsom@parracity.nsw.gov.au'

<jtsom@parracity.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input [Filed 13 Mar 2020 13:26]

Hi Peter,

Any chance we would be able to get a response on the items below soon, please?

Thank you,

Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
Level 5, 151 Clarence Street, Sydney NSW 2000 Australia
t: +61 02 9320 9320 d: +61 02 9320 9297
www.arup.com

From: Terrence Tang
Sent: Thursday, 12 March 2020 11:11 AM
To: 'Peter Sirianni' <PSirianni@cityofparramatta.nsw.gov.au>
Cc: Duncan Crook (Duncan.Crook@arup.com) <Duncan.Crook@arup.com>; Claire Moore (Claire.Moore@arup.com) <Claire.Moore@arup.com>; Nathan Cheah <Nathan.Cheah@arup.com>; 'jtsom@parracity.nsw.gov.au' <jtsom@parracity.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input [Filed 12 Mar 2020 11:10]

Hi Peter,

Thanks for the call earlier, summary of our request below:

1. CPC to please provide results of draft 8 Mike 11 model (file format ".res11") if available.

2. CPC to please provide independent review and comments (full list) of Cardno's flood study.

3. CPC to please confirm if the CPC flood maps (attached) supplied back in 2016 for TTW's flood report are still the most recent and will not have changed since 2016 print.

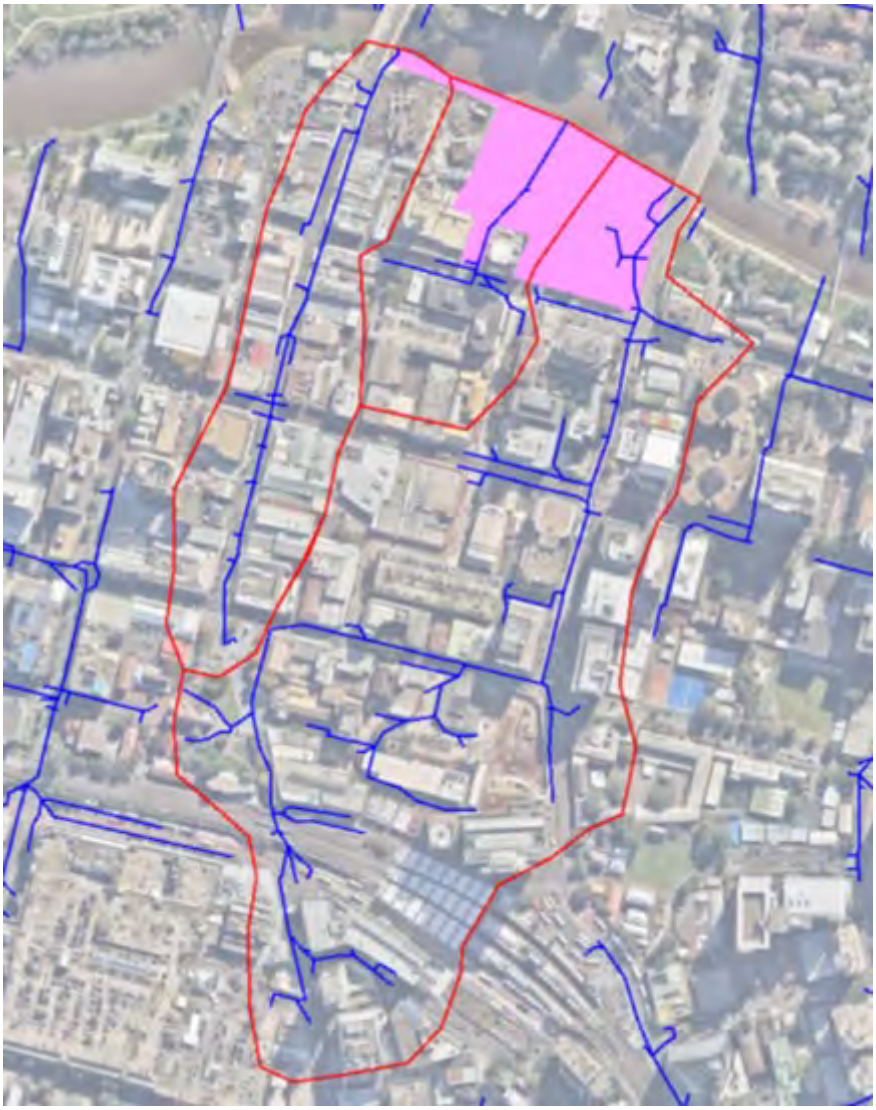
4. Existing stormwater asset network plans within the catchment extents (preferably in CAD, MGA coordinates) that indicate sizes and invert levels (refer to snapshot below; Pink – powerhouse development; Blue – existing stormwater assets; Red – catchment extents).

5. You mentioned GTK requested for Version 9 of Mike11, if you could also put this in the same folder that would be greatly appreciated.

https://arup-my.sharepoint.com/:f:/p/terrence_tang/EhvCMXO58SJMsLzPsj8QyvkB-DffOfhNh2p2maj3H7RlZQ?e=uKvbe1

6. Please confirm which Mike11 version (8 or 9) we should be adopting for this development.

Thank you,
Terrence



Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
Level 5, 151 Clarence Street, Sydney NSW 2000 Australia
t: +61 02 9320 9320 d: +61 02 9320 9297
www.arup.com

From: Terrence Tang
Sent: Wednesday, 11 March 2020 3:52 PM
To: 'Peter Sirianni' <PSirianni@cityofparramatta.nsw.gov.au>
Cc: Duncan Crook (Duncan.Crook@arup.com) <Duncan.Crook@arup.com>; Claire Moore (Claire.Moore@arup.com) <Claire.Moore@arup.com>; Nathan Cheah <Nathan.Cheah@arup.com>; 'jtsom@parracity.nsw.gov.au' <jtsom@parracity.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input [Filed 11 Mar 2020 15:52]

Hi Peter,

Thank you very much for sending through the information. We had an initial look – it would help us a lot if CPC could also provide us with:

1. Results of draft 8 Mike 11 model (file format ".res11") if available.

In addition – would CPC also be able to help clarify/provide the following information, please?

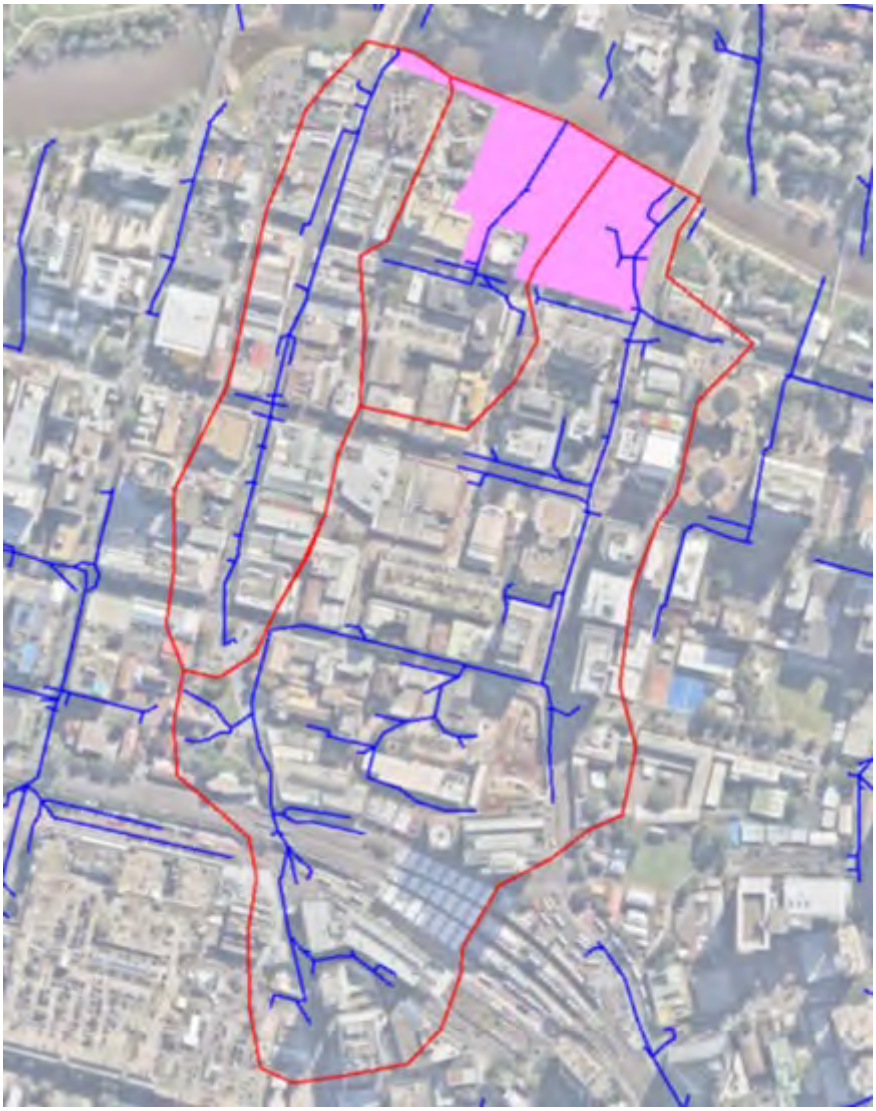
2. Independent review and comments of Cardno's flood study.

3. Confirm if the CPC flood maps (attached) supplied back in 2016 for TTW's flood report are still the most recent and will not have changed since 2016 print.

4. Existing stormwater asset network plans within the catchment extents (preferably in CAD, MGA coordinates) that indicate sizes and invert levels (refer to snapshot below; Pink – powerhouse development; Blue – existing stormwater assets; Red – catchment extents).

Please contact me at any time to further discuss if needed. Once again a response ASAP would be really appreciated.

Thank you,
Terrence



Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
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t: +61 02 9320 9320 d: +61 02 9320 9297
www.arup.com

From: Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Sent: Wednesday, 11 March 2020 12:23 PM
To: Terrence Tang <Terrence.Tang@arup.com>
Subject: [External] RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hello Terrence,

I have uploaded Draft 8 Mike11 files in .zip folder to the OneDrive folder as below. Please ignore other files. I had problem with uploading folders.
Please let me know if you have any problems.

Regards,

Peter Sirianni | **Senior Engineer Catchment Management**
City of Parramatta
PO Box 32, Parramatta NSW 2124
☎ (02) 9806 8254
✉ **psirianni@cityofparramatta.nsw.gov.au**
Links | **www.cityofparramatta.nsw.gov.au**

<a href="https://aus01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fsecure-web.cisco.com%2F1swq2mPlTo7r9Tqcv-HfPlZfXiLVWw_iD_lxcVKt3KOx3-JBwQaFFjUoS7kcnt1Ec8KagNhz8HFELyEw1SDVUJNCr_pHydv5wcxLveZ-I13lXGWBZbiLGdfFD2rPC1MaFyNbtMO3lm5yScCWr9F2hWnty3y3ekQ4Lttn2FueQh8_c7-s7Nsi0055t6zVtfGn7Rlp8RIrkg-5G8mYQrWGhL6CzFZOF9XVd8mfDo6R009BpWJooCSfey3M_y1_aFCvBdPbTs8RqObFb_99QH5ebyCVSZK912BAKnh1tFWRgA9UG2DWC16tvy4BlCyBdaXZnJ074CYxdEIYKF_6NE37F-Q%2Fhttps%253A%252F%252Faus01.safelinks.protection.outlook.com%252F%253Furl%253Dhttps%25253A%25252F%25252Fsecure-web.cisco.com%25252F17v85IAfvKtsHrfFMKhcDcI6_AimYMz93EWj3tC6e6amDRR-dO2DEipAhC84pb1AqucgMi1lNdvMGMOko9tylzjNgTc1mGfzGVtzmK_vZrcJOag-Z7rlr6rSEwuFTFcgm4_T_U8eCiv3fsuXG41DAjtt4iF4COA7mEfuawyrt-r1RUcqFskfL-z8xzRFWhVQA-xIvU9-Qi0ew01gwkqAv-h_eFn9ccBN0VS4CJm9_XtwCWSXSWJFs3cFe_kaAtNHRfiwLpwjnK-kKfoXbqu4EKXnrkhhRMwrY3Rk9W5Et-ld4xRETI512Xk4jIHQRU9xPZOQE04s0Zgc7VE-L6QgAQg%25252Fhttps%2525253A%2525252F%2525252Faus01.safelinks.protection.outlook.

Terrence Tang

From: Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Sent: Wednesday, 11 March 2020 12:23 PM
To: Terrence Tang
Subject: [External] RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hello Terrence,

I have uploaded Draft 8 Mike11 files in .zip folder to the OneDrive folder as below. Please ignore other files. I had problem with uploading folders.
Please let me know if you have any problems.

Regards,

Peter Sirianni | **Senior Engineer Catchment Management**
City of Parramatta
PO Box 32, Parramatta NSW 2124
☎ (02) 9806 8254
✉ **psirianni@cityofparramatta.nsw.gov.au**
Links | **www.cityofparramatta.nsw.gov.au**

From: Terrence Tang <Terrence.Tang@arup.com>
Sent: Wednesday, 11 March 2020 12:17 PM
To: Peter Sirianni <PSirianni@cityofparramatta.nsw.gov.au>
Cc: Duncan Crook <Duncan.Crook@arup.com>; Enrico Zara <Enrico.Zara@arup.com>; Claire Moore <Claire.Moore@arup.com>; Jim Tsom <JTsom@cityofparramatta.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input

Hi Peter,

I just left you a message on your mobile as well – but I wanted to follow-up with you on providing Arup with the flood models for the powerhouse project.

We are trying to achieve SSDA submission for our client, INSW, and we cannot start unless we have the Mike11 models. The project is under significant program timelines and we would like CPC to provide the flood models ASAP.

Thank you,

Terrence Tang

Civil Engineer | NSW & ACT Transport

Arup
Level 5, 151 Clarence Street, Sydney NSW 2000 Australia
t: +61 02 9320 9320 d: +61 02 9320 9297
www.arup.com

From: Terrence Tang
Sent: Tuesday, 10 March 2020 12:57 PM
To: 'psirianni@parracity.nsw.gov.au' <psirianni@parracity.nsw.gov.au>
Cc: Duncan Crook (Duncan.Crook@arup.com) <Duncan.Crook@arup.com>; Enrico Zara (Enrico.Zara@arup.com) <Enrico.Zara@arup.com>; Claire Moore (Claire.Moore@arup.com) <Claire.Moore@arup.com>; 'jtsom@parracity.nsw.gov.au' <jtsom@parracity.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input [Filed 10 Mar 2020 12:57]

Hi Peter,

Would CPC be able to advise us on when we would be able to obtain the information below, please?

The CPC current Mike11 model is the most urgent item, so even if you send that through first that would be greatly appreciated.

Thank you,

Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
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From: Terrence Tang
Sent: Monday, 9 March 2020 12:07 PM
To: 'psirianni@parracity.nsw.gov.au' <psirianni@parracity.nsw.gov.au>
Cc: Duncan Crook (Duncan.Crook@arup.com) <Duncan.Crook@arup.com>; Enrico Zara (Enrico.Zara@arup.com) <Enrico.Zara@arup.com>; Claire Moore (Claire.Moore@arup.com) <Claire.Moore@arup.com>; 'jtsom@parracity.nsw.gov.au' <jtsom@parracity.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input [Filed 09 Mar 2020 12:06]

Hi Peter,

Thanks for the chat earlier. This is a reminder summary of information for CPC to provide to us ASAP, please:

- Please let us know who the main CPC contact for Powerhouse Museum will be.
- Would CPC be able to provide us with the Mike11 flood models, please? You may put the files in the OneDrive folder here: https://arup-my.sharepoint.com/:f:/p/terrence_tang/EhvCMXO58SJMsLzPsj8QyvkB-DffOfhNh2p2maj3H7RlZQ?e=uKvbe1
- Would CPC be able to provide us with the independent review of Cardno's flood study, please?

- As discussed – the CPC flood maps (attached) supplied back in 2016 for TTW's flood report are still the most recent and will not have changed since 2016 issue. Please let us know otherwise.

Thank you,

Terrence Tang
Civil Engineer | NSW & ACT Transport

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From: Terrence Tang
Sent: Friday, 6 March 2020 10:39 AM
To: 'psirianni@parracity.nsw.gov.au' <psirianni@parracity.nsw.gov.au>
Cc: Duncan Crook (Duncan.Crook@arup.com) <Duncan.Crook@arup.com>; Enrico Zara (Enrico.Zara@arup.com) <Enrico.Zara@arup.com>; Claire Moore (Claire.Moore@arup.com) <Claire.Moore@arup.com>; 'jtsom@parracity.nsw.gov.au' <jtsom@parracity.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input [Filed 06 Mar 2020 10:39]

Hi Peter,

Just as a kind reminder:

- Please let us know who the main CPC contact for Powerhouse Museum will be.
- Would CPC be able to provide us with the Mike11 flood models, please? You may put the files in the OneDrive folder here: https://arup-my.sharepoint.com/:f:/p/terrence_tang/EhvCMXO58SJMsLzPsj8QyvkB-DffOfhNh2p2maj3H7RlZQ?e=uKvbe1
- Would CPC be able to provide us with the independent review of Cardno's flood study, please?

Thank you,

Terrence Tang
Civil Engineer | NSW & ACT Transport

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From: Terrence Tang
Sent: Wednesday, 4 March 2020 3:37 PM
To: 'psirianni@parracity.nsw.gov.au' <psirianni@parracity.nsw.gov.au>
Cc: Duncan Crook (Duncan.Crook@arup.com) <Duncan.Crook@arup.com>; Enrico Zara (Enrico.Zara@arup.com) <Enrico.Zara@arup.com>; Claire Moore (Claire.Moore@arup.com) <Claire.Moore@arup.com>; 'jtsom@parracity.nsw.gov.au' <jtsom@parracity.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input [Filed 04 Mar 2020 15:37]

Hi Peter,

Thanks for the chat earlier, we appreciate your help on this.

A summary of what we discussed:

1. A single CPC point of contact will be nominated for the project in the next few days. Please let us know the contact and their details when confirmed.
2. CPC will not be releasing Cardno's flood models – we understand this is still under development and will be ready next year.
3. We understand the current Mike11 CPC flood model will be adopted for the Powerhouse SSDA design.
    a. Would CPC be able to send us the appropriate Mike11 CPC flood model (and confirming the version) for us to adopt, please? If you could send this to us as soon as possible that would be greatly appreciated. You may drag and drop the files into the following shared OneDrive folder: https://arup-my.sharepoint.com/:f:/p/terrence_tang/EhvCMXO58SJMsLzPsj8QyvkB-DffOfhNh2p2maj3H7RlZQ?e=uKvbe1

Thank you,

Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
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www.arup.com

From: Terrence Tang
Sent: Tuesday, 3 March 2020 3:47 PM
To: 'psirianni@parracity.nsw.gov.au' <psirianni@parracity.nsw.gov.au>
Cc: Duncan Crook (Duncan.Crook@arup.com) <Duncan.Crook@arup.com>; Enrico Zara (Enrico.Zara@arup.com) <Enrico.Zara@arup.com>; Claire Moore (Claire.Moore@arup.com) <Claire.Moore@arup.com>; 'jtsom@parracity.nsw.gov.au' <jtsom@parracity.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input [Filed 03 Mar 2020 15:47]

Hi Peter,

Thanks for the chat yesterday - I just left you a voicemail as you must be busy.

You mentioned you would be able to get back to us with a CPC contact for this project by next week, unfortunately we are getting pressure to start looking at the flooding for the site ASAP.

It would be greatly appreciated if you could get back to us as early as possible this week. In the initial instance, the priority items we are asking from CPC are:

1. CPC flood engineer contact for the project going forward; and
2. Cardno's latest flood model (which we understand is not yet formalised).

Thank you,

Terrence Tang
Civil Engineer | NSW & ACT Transport

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www.arup.com

From: Terrence Tang
Sent: Monday, 2 March 2020 2:17 PM
To: 'psirianni@parracity.nsw.gov.au' <psirianni@parracity.nsw.gov.au>
Cc: Duncan Crook (Duncan.Crook@arup.com) <Duncan.Crook@arup.com>; Enrico Zara (Enrico.Zara@arup.com) <Enrico.Zara@arup.com>; Claire Moore (Claire.Moore@arup.com) <Claire.Moore@arup.com>; 'jtsom@parracity.nsw.gov.au' <jtsom@parracity.nsw.gov.au>
Subject: RE: New Powerhouse Museum - Flood information and Parramatta Council input [Filed 02 Mar 2020 14:16]

Hi Peter,

I wanted to kindly follow-up with you to see if a flood engineer from CPC has been nominated to be involved in the Powerhouse Project? If so please let us know. We just had a meeting with iNSW and flooding is a significant item for the project which we are looking to discuss with CPC as early as possible.

Thank you and your help is appreciated,

Terrence Tang
Civil Engineer | NSW & ACT Transport

Arup
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www.arup.com

From: Terrence Tang
Sent: Wednesday, 26 February 2020 10:34 AM
To: 'psirianni@parracity.nsw.gov.au' <psirianni@parracity.nsw.gov.au>
Cc: Duncan Crook (Duncan.Crook@arup.com) <Duncan.Crook@arup.com>; Enrico Zara (Enrico.Zara@arup.com) <Enrico.Zara@arup.com>
Subject: New Powerhouse Museum - Flood information and Parramatta Council input

Hi Peter,

Thank you for the call earlier. As discussed - we are currently working on the initial stages of the new Powerhouse Museum development (our client is MAAS and iNSW) proposed at the existing Riverbank car park near the corner of Wilde Avenue and Phillip Street.

We would like to start the conversations with Parramatta Council (CPC) for this development early in the design process, particularly with flooding as this is a significant risk to the design. To date we understand there is the current Parramatta flood model (undertaken using Mike11) and a new flood model currently being undertaken by Cardno which we anticipate will be publicly available next year.

In order for us to undertake our flood modelling and initial design of the development would CPC be able to provide us with Cardno's new flood model to date, please? We understand this is still being worked on and will not be publicly available until next year. However any updated flood information in the interim will help us with the development design as we are trying to achieve project milestones this year.

Apologies if you are not the appropriate contact for this type of query, but if you would be able to discuss this internally within your team and let us know who would be the best contact going forward for this project that would be greatly appreciated.

Thank you,

Terrence Tang
Civil Engineer | NSW & ACT Transport

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Appendix H | Correspondence with Sydney Water

Terrence Tang

From: Stormwater <Stormwater@sydneywater.com.au>
Sent: Thursday, 19 March 2020 3:28 PM
To: Terrence Tang
Cc: Duncan Crook
Subject: [External] RE: Parramatta Powerhouse Museum - Sydney Water stormwater and flooding query

Terrence,

You proposal has impact on Sydney Water sewers which are located within your development site and may impact on other Sydney Water services such as water main. You need to discuss with Water Servicing Coordinator regarding likely requirements for your development due to Sydney Water services which are within your property or within the zone of influence of the Sydney Water assets or within the dig zone of Sydney Water's assets.

The following comments only related to Sydney Water's stormwater requirements:

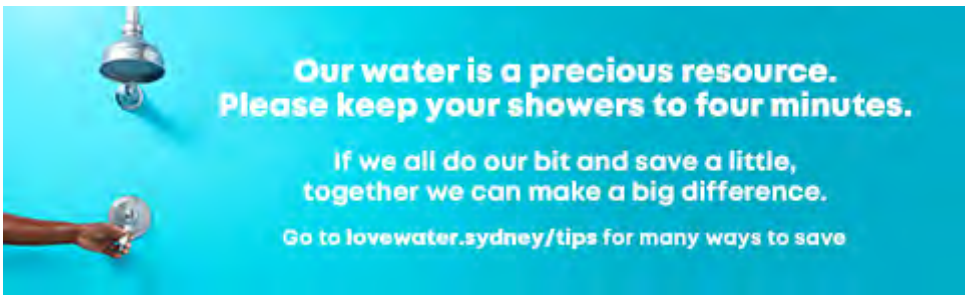
As there are no Sydney Water's stormwater assets within your development site or within 10m from your development boundary, there are no specific Sydney Water's stormwater requirements for the proposed development.

Best Regards

Jeya Jeyadevan
Senior Capability Assessor
Liveable City Solutions
Sydney Water, Level 13, 1 Smith Street, Parramatta NSW 2150

Sydney WATER

Ph 8849 6118
Mob 0409 318 827
jeya.jeyadevan@sydneywater.com.au



From: Terrence Tang <Terrence.Tang@arup.com>
Sent: Thursday, 19 March 2020 2:00 PM
To: Stormwater <Stormwater@sydneywater.com.au>
Cc: Duncan Crook <Duncan.Crook@arup.com>
Subject: Parramatta Powerhouse Museum - Sydney Water stormwater and flooding query

Hi Jeya,

Thank you for the chat earlier.

As discussed - We are currently undertaking the civil and stormwater design for the proposed Powerhouse Museum at Parramatta. Refer to link below and attached PDF markup for development details and plan.
http://www.infrastructure.nsw.gov.au/projects-nsw/new-powerhouse-museum/

We understand the stormwater and flooding scope for this project is within City of Parramatta Council's responsibility and that we do not affect Sydney Water owned assets.

However, would you be able to please review the intent of our development and advise if there may be any Sydney Water requirements for stormwater/flooding.

Thank you and we look forward to hearing from you,

Terrence Tang
Civil Engineer | NSW & ACT Transport

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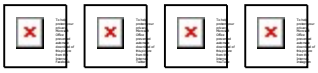
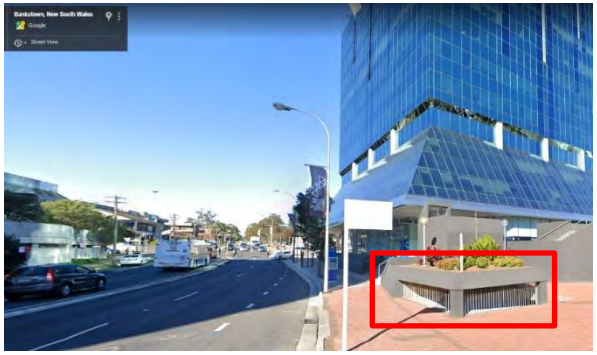


Appendix I | Mitigation Options Assessment

Table 13: Summary of the flood mitigation options considered by the Arup stormwater and flooding team in the development of the proposed Powerhouse Parramatta stormwater and flood risk management strategy as discussed in this report

Option	Opportunities	Considerations
1) Adjusting external ground plane design (Adopted)	• Locally lowering ground levels to encourage surface stormwater conveyance to the local stormwater infrastructure network or Parramatta River in an efficient manner.	• Matching into proposed building entryway finished floor levels and adjacent existing development levels while ensuring vehicle and pedestrian paths (gradients and clearances) are still adequate; and • Ensuring flooding is not made worse around existing developments.
2) Upgrading/augmenting existing Ø600mm trunk main along Dirrabarri Lane (Adopted)	• Proposing the existing Ø600mm to be redundant and an upsized Ø1200mm trunk main implemented further west along Dirrabarri Lane. • Utilizing existing smaller downstream connections for discharging into the river while avoiding any outlet connection works to the river channel wall; and • Implementing surcharge pits for overland flow into Parramatta River.	• Potential clash with existing Ø525 Sydney Water Sewer main.
3) Proposing additional trunk stormwater infrastructure between West and East Buildings (Adopted)	• Proposing stormwater trunk main to traverse through development in between the two proposed buildings and connection into the existing Ø900 trunk network on the east along Wilde Avenue. This increases the capacity of the stormwater network local to the development site.	• The new trunk main may have minimal longitudinal grade due to proposed ground levels and existing downstream invert levels; and • Further utilities coordination with other proposed assets running through the site; • Further hydraulic assessment required to check if existing Ø900mm network will be able to perform suitably with additional flows.
4) Proposing additional overland flow through east side of the development site by regrading the proposed levels (Not adopted)	• Regrading ground levels on east side of East Building to allow for new overland flow path (likely to be feasible but unlikely to be desirable from a public perception perspective); • Possibility to consider Wilde Avenue footpath as separate and higher walkway than East Building edge. Grade separation may be possible but this complicates pedestrian access to the River which is an aspiration of the design brief	• There is a high point of the site on this east area just before the Wilde Avenue bridge which is a constraint for ground level grading; • May require regrading of the Wilde avenue and Phillip Street intersection which is a significant additional scope of works; • Regrading the east area of the East Building is constrained between the East Building entryways and the existing Wilde Avenue road/footpath levels provided that it is only a small width; and • The presence of many existing utilities along this east face footpath.

Option	Opportunities	Considerations
5) Dramatically upgrading the existing drainage along Phillip Street (Not adopted)	• Potential for adding inlet pits and/or upsizing pipes; and • Allocating more water in the below ground storm infrastructure meaning a there is a reduction of surface water.	• This is considered as a costly solution; • Council asset; • Contains additional works outside of the project boundary requiring temporary closure and management of Phillip Street; • There are many services to consider along Phillip Street; and • The hydraulic performance is not confirmed and may not provide better results than the existing.
6) Proposing on-site detention (Not adopted)	• Providing additional water storage volume while meeting Council OSD requirements; and • Potential for stormwater reuse.	• Site peak discharge will need to be assessed against the Parramatta River flood event; • During a river flood event the in ground OSD will likely be inundated; • Sufficient space within the development will need to be allowed for to accommodate the OSD and this may conflict with other development features; and • An OSD will have cost implications which may not be feasible compared to the benefits it may have.
7) Proposing flow paths through the undercroft area with vertical inlets (Not adopted)	• Provide alternative flow paths via vertical inlets shown below where floodwaters can flow into under the building hidden from sight; and • Cater for major event flows mainly, i.e. 1% AEP and can be combined with the provision of on-site detention if required. • 	• Integration of this flow path with the building design; and • Need for space under the building.

Memorandum

ARUP

To	Tom Kennedy (INSW) Hannah Slater (INSW) Simon Pagett (INSW)	Date	27 April 2020
Copies	Angelica Giannoulatou (MK) Hiroko Kusunoki (MK) Nicolas Moreau (MK) Agnieszka Prusik (MK) Leigh Woodley (Gentons) Steven Toia (Gentons) Philip Coxall (McGregor Coxall) Miguel Serrao (McGregor Coxall) Michael Cowdy (McGregor Coxall) Josh Milston (JMT) Geoffrey Quach (Aver) Enrico Zara (Arup) Claire Moore (Arup)	Reference number	PHM-ARP-TCN-CE-0001
From	Terrence Tang, Duncan Crook (Arup)	File reference	C02
Subject	Parramatta Powerhouse: SSDA Erosion and Sediment Control Plan (ESCP)		

Introduction

This technical memorandum supports a State Significant Development (SSD) Development Application (DA) for the development of the Powerhouse Parramatta at 34-54 & 30B Phillip Street and 338 Church Street, Parramatta. The Powerhouse Parramatta is a museum (information and education facility) that has a capital investment value in excess of $30 million and as such the DA is submitted to the Minister for Planning pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

The purpose of this technical memorandum is to describe the erosion and sediment control plan for the proposed Parramatta Powerhouse development. Erosion and sediment control measures are a specific consideration of the broader construction management plan (CMP) that are designed to minimise the risk of scour, erosion and sedimentation. These risks are increased during necessary construction activities including demolition, land disturbance, cutting and filling.

Likewise, these risks are also increased when developing a site that is prone to overland flows and flooding. The Arup Powerhouse Parramatta Flood Risk and Stormwater Management report (reference: PHM-ARP-CIV-REP-0001) provides an assessment of the existing site conditions and identifies regions of the development site at risk from overland flows and flooding.

The purpose of this project specific erosion and sediment control plan (ESCP) is to:

- Reduce the risk of land degradation associated with vegetation removal, regrading and related construction activities;

- Control and reduce the risk of erosion of soil material;
- Control and contain sediment and other particulate materials together with soil nutrients near their source;
- Provide temporary drainage measures that will remain stable and operational in a significant storm event;
- Reduce the risk of sediment, construction materials and associated pollutants from being washed into downstream areas and receiving water courses thereby offering protection to these environments; and
- Inform the construction management plan including the site establishment, access and egress, material management to reduce the risk of disruption and damage to the development.

Erosion and Sediment Control Plan

The erosion sediment control plan (ESCP) proposals are illustrated in Appendix A. These drawings indicate two key phases of development representing distinct scenarios of the on-site activities that are likely to occur as part of the Powerhouse Parramatta development as follows:

1. Demolition phase: demolition of existing car park and building structures
2. Construction phase: site clearances, bulk earthworks and construction of proposed foundations

These two phases will generate different risk profiles in the context of erosion and sediment risk and require different responses.

Demolition Phase ESCP

During the demolition phase, the predominant activity will be demolition of existing structures and the sorting of materials arising from demolition. Demolition activities are likely to be undertaken at both the lower elevation, near to the Parramatta River and at the higher elevation closer to Phillip Street. The main land disturbances will be the removal or partial removal of existing pavements/slabs and vegetated areas as part of the demolition scope.

The Arup ESCP proposals described in the appended drawings set out the temporary stormwater management proposals for this phase. These measures include temporary sediment fences, channels and in-ground drainage that aim to manage surface runoff whilst minimising erosion. Surface water and overland together with any sediment that is transported across the site will be directed to two sediment basins located near the Parramatta River. This will allow settlement and containment of sediment with filtered, cleaner water pumped into the river.

Whilst this approach should be largely successful for smaller rainfall events and overland flow, one residual risk is the occurrence of a significant flood event that would cause the Parramatta River to burst its banks. In this scenario the sediment basins will quickly become filled with floodwater from the river and there is a risk of sediment in the basins being washed into the river itself. For this reason, regular inspection, maintenance and cleaning/emptying of the basins will be necessary following rainfall on the site to minimise the risk.

Construction Phase ESCP

During the construction phase more significant land disturbances are likely to occur including earthworks cut and fill, regrading of the site, excavation for utility services and foundations and the creation of temporary structures, ramps, works areas and circulation routes to enable construction. These activities are very likely to affect a significant proportion of the site with several construction work faces active at once.

The Arup ESCP proposals described in the appended drawings set out the temporary stormwater management proposals for this phase. There are similarities to the demolition phase with temporary sediment fences, channels, banks, straw bales and in-ground drainage that aim to manage surface runoff whilst minimising erosion. As with the previous phase, surface water and overland together with any sediment that is transported across the site will be directed to two sediment basins located near the Parramatta River. This will allow settlement and containment of sediment with filtered, cleaner water pumped into the river.

As with the demolition phase, the key risk is the Parramatta River flooding which at this stage could wash sediment captured in the basins into the river. Likewise, flooding of the river could pose a risk to active construction causing damage, a risk of materials, plant and equipment being washed into the river as well as direct risks to construction workers on site. To mitigate these risks, the construction team should implement special measures to monitor patterns of rainfall and other significant flows into the Parramatta River, upstream of the site. This information will enable proactive management of site activities and enable the construction team to minimise risks at periods of greater rainfall and flooding risk.

ESCP Development & Adaptation

This proposed ESCP and associated drawings have been prepared by the design team to be used as a guide by the construction team. It offers an overview of the key risks and one possible method of response that can mitigate these risks. However, the it will be construction team's responsibility to develop and adapt this erosion and sedimentation control plan. Changes may materialise for several reasons including ongoing design development, the preferred method/s of construction, and the sequencing of works on site.

It is the construction team's responsibility to take all steps necessary to protect the environment during the contract works and implement the necessary measures for the control of erosion and sedimentation. Such measures will need to meet the satisfaction of all administering bodies including the City of Parramatta Council, Infrastructure New South Wales, NSW Office of Water, Sydney Water, NSW Environmental Protection Authority and NSW Environment and Heritage. Likewise, there are relevant legislative provisions including the Protection of the Environment Operations Act 1997 and Protection of the Environment Operations (General) Regulation 2009 and associated guidelines which must be followed as part of the site works.

The site is subject to both overland and river flooding and the construction team shall demonstrate their works will be properly managed in order to mitigate flood risks and protect the environment, the workforce, and the site works in the event of a flood.

Stormwater runoff will be managed on site and subsequently discharged into Parramatta River. The site works does not include modifications to the existing Parramatta River (i.e. channel bed, channel walls and outlet structures) as these elements are to be retained and protected during the duration of the site development works.

Supporting Documentation

The following Powerhouse Parramatta documentation has been reviewed in preparing this memorandum and the appended drawings:

- Building Architectural design – MKG Powerhouse Parramatta; dated 01/04/2020; revision No. 7
- Landscape Architectural design - McGregor Coxall Powerhouse Parramatta reference 0792BRS; dated 02/04/2020; revision C
- Construction Management plan – Aver, draft received 03/04/2020
- Landcom "Managing Urban Stormwater – Soils and Construction" Volume 1; 4th edition; dated March 2004

Memorandum

Appendix A

Sediment and Erosion Control Diagrams

A1

TEMPORARY CONNECTION FROM PERMANENT DRAINAGE INTO SEDIMENT BASIN PRIOR TO COMPLETION OF PERMANENT WORKS

SEDIMENT BASIN N0.1 VOLUME 188m³

SEDIMENT BASIN SUMP AND PUMP

PARRAMATTA RIVER

SEDIMENT BASIN N0.2 VOLUME 374m³

SEDIMENT BASIN SUMP AND PUMP

WILDE AVENUE

TEMPORARY STORMWATER DRAIN TO CONNECT TO PROPOSED PERMANENT DRAINAGE IF INSTALLED AT THIS STAGE.

TEMPORARY CAP DOWN STREAM OUTLET PIPE, CONSTRUCT TEMPORARY GRAVITY OUTLET TO SEDIMENT BASIN

CONTRACTOR TO MAINTAIN USE OF EXISTING DRAINAGE AS FAR AS PRACTICAL THROUGHOUT DEMOLITION PHASE AND PRIOR TO CONSTRUCTION AND COMMISSIONING OF NEW DRAINAGE LINE

CONSTRUCTION GATES (SECONDARY ACCESS)

RETAIN EXISTING DRAINAGE DURING CONSTRUCTION

CONSTRUCTION GATES (SECONDARY ACCESS)

PERMANENT DRAINAGE LINES MAY OPTIONALLY BE INSTALLED AS EARLY WORKS AT THIS STAGE AND COMMISSIONED TO MANAGE TEMPORARY STORMWATER DISCHARGE

DIRRIBARRI LANE

CONSTRUCTION EXIT

STOCKPILE AREA FOR DEMOLITION ARISINGS

CONTRACTOR TO INSTALL TEMPORARY DRAINAGE WHERE REQUIRED TO COLLECT LOCAL SITE RUNOFF

PHILLIP STREET

INSTALL TEMPORARY CONSTRUCTION ENTRY/EXIT AND TEMPORARY VEHICLE CROSSOVER ON PHILLIP STREET.

PROVIDE SEDIMENT CONTROL MEASURES TO EXISTING STREET KERB INLET PITS AND GRATES

NOTES

1. FOR SOIL AND WATER MANAGEMENT DETAILS AND NOTES REFER TO DRAWING No. PHM-ARP-SKE-CE-000004.
2. THIS DRAWING IS INDICATIVE ONLY AND ILLUSTRATES THE DESIGNERS' CONSIDERATIONS OF TEMPORARY SOIL AND WATER MANAGEMENT. THIS APPROACH MAY BE ADAPTED BY THE CONTRACTOR AT THEIR DISCRETION SUBJECT TO COMPLIANCE WITH GOOD PRACTICE AND 'THE BLUE BOOK'.
3. THIS SEDIMENT AND EROSION CONTROL PLAN DOES NOT TAKE INTO ACCOUNT DETAILED CONSTRUCTION STAGING. INTERIM SEDIMENT AND EROSION CONTROL MEASURES TO SUIT THE DETAILED STAGING OF THE WORKS ARE TO BE DETERMINED BY THE CONTRACTOR.
4. STOCKPILING AND STORAGE OF TOPSOIL AND TURF TO BE LOCATED AT INSW'S DISCRETION OR REMOVED OFF SITE.
5. EXISTING IN GROUND UTILITIES INDICATED ON THIS DRAWING IS REPRODUCED FROM DRAWINGS PREPARED BY LTS LOCKLEY AND ARUP ACCEPTS NO RESPONSIBILITY FOR ITS ACCURACY.
6. CONTRACTOR TO VERIFY THE LOCATION AND DEPTH OF INGROUND SERVICES BEFORE DISTURBING GROUND.
7. THE CONTRACTOR IS RESPONSIBLE FOR ANY AND ALL NECESSARY PROTECTIVE/DIVERSIONARY WORKS TOGETHER WITH ASSOCIATED APPROVALS WHICH SHOULD BE AGREED PRIOR TO WORKS COMMENCEMENT
   THE CONTRACTOR SHALL FAMILIARISE THEMSELVES WITH THE LOCAL STORMWATER FLOODING CONDITIONS AND RISKS PRIOR TO COMMENCING WORKS ON SITE. AN APPROPRIATE FLOOD RISK MANAGEMENT PLAN SHALL BE DEVELOPED FOR EACH STAGE OF THE PROJECT TO MINIMISE THE RISK OF FLOODING INJURING SITE STAFF OR MEMBERS OF THE PUBLIC, DAMAGING WORKS OR PLANT OR CARRYING MATERIALS OR DEBRIS DOWNSTREAM INTO THE RIVER. THE PROPOSED SYSTEMS MUST BE REVIEWED AND APPROVED BY INSW AND THEIR REPRESENTATIVES PRIOR TO COMMENCEMENT.
8. IMPLEMENT SEDIMENT TRAPS TO ALL EXISTING INLET PITS AND KERB INLET PITS AROUND THE DEVELOPMENT SITE.

LEGEND

- TEMPORARY CONSTRUCTION ACCESS
- STRAW BALES
- SEDIMENT FENCE
- DIVERSION BANK AND CHANNEL
- STORMWATER SUMP AND OUTLET
- TEMPORARY RISING MAIN
- TEMPORARY DRAINAGE PIPE
- TEMPORARY DRAINAGE PIT
- EXISTING STORMWATER TO BE REDUNDANT
- INLET SEDIMENT TRAP
- FABRIC STOCKING SEDIMENT TRAP
- CONTRACTOR'S COMPOUND
- STOCK PILE AREA
- SEDIMENT BASIN
- TEMPORARY SITE ENTRANCE
- OVERLAND FLOW DIRECTION

Issue	Date	
1	15.04.20	FOR SSDA
0	08.04.20	PRELIMINARY

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Client

Infrastructure New South Wales

Museum of Applied Arts & Sciences

Project Title

PARRAMATTA POWERHOUSE

Drawing Title

EROSION AND SEDIMENT CONTROL PLAN: DEMOLITION PHASE

Scale at A1	By / Chkd / Appd
NOT TO SCALE	MP/TT/DC

Role: CIVIL

Status: **FOR SSDA**

Arup Job No	Rev
273467	**1**

SKETCH NO.

PHM-ARP-SKE-CE-000002

Do not scale

A1

TEMPORARY CONNECTION FROM PERMANENT DRAINAGE INTO SEDIMENT BASIN PRIOR TO COMPLETION OF PERMANENT WORKS

SEDIMENT BASIN N0.1 VOLUME 188m³

SEDIMENT BASIN SUMP AND PUMP

PARRAMATTA RIVER

SEDIMENT BASIN N0.2 VOLUME 374m³

SEDIMENT BASIN SUMP AND PUMP

WILDE AVENUE

TEMPORARY EARTH RAMP TO ALLOW PLANT AND SITE STAFF TO TRANSITION BETWEEN LEVELS

MATERIAL SETDOWN AND STOCKPILE SITUATED AT LOWER SITE LEVELS ADJACENT TO RIVER, CONTRACTOR TO DEVELOP APPROPRIATE MANAGEMENT PLAN AND IMPLEMENT MEASURES TO MINIMIZE RISK OF FLOOD AFFECTATION

PERMANENT DRAINAGE LINES MAY OPTIONALLY BE INSTALLED AT THE BEGINNING OF THIS STAGE AND COMMISSIONED PRIOR TO EXCAVATION CUT/FILL AND CONSTRUCTION OF NEW BUILDINGS

TEMPORARY CAP DOWN STREAM OUTLET PIPE, CONSTRUCT TEMPORARY GRAVITY OUTLET TO SEDIMENT BASIN

EXISTING DRAIN RENDERED REDUNDANT

SUMP IN LIFT PITS AND EXCAVATION FOOTPRINT

CONSTRUCTION GATES (SECONDARY ACCESS)

RETAIN EXISTING DRAINAGE DURING CONSTRUCTION

PROPOSED ALIGNMENT OF RETAINING WALL

CONSTRUCTION GATES (SECONDARY ACCESS)

CONTRACTOR TO INSTALL TEMPORARY DRAINAGE WHERE REQUIRED TO COLLECT LOCAL SITE RUNOFF

SUMP IN BASEMENT LIFT CORES

SUMP IN LIFT CORE

CONTRACTOR TO INSTALL TEMPORARY DRAINAGE WHERE REQUIRED TO COLLECT LOCAL SITE RUNOFF

DIRRIBARRI LANE

EXISTING GE BUILDING

PHILLIP STREET

MAINTAIN TEMPORARY CONSTRUCTION ENTRY/EXIT AND TEMPORARY VEHICLE CROSSOVER ON PHILLIP STREET.

PROVIDE SEDIMENT CONTROL MEASURES TO EXISTING STREET KERB INLET PITS AND GRATES

NOTES

1. FOR SOIL AND WATER MANAGEMENT DETAILS AND NOTES REFER TO DRAWING No. PHM-ARP-SKE-CE-000004.
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3. THIS SEDIMENT AND EROSION CONTROL PLAN DOES NOT TAKE INTO ACCOUNT DETAILED CONSTRUCTION STAGING. INTERIM SEDIMENT AND EROSION CONTROL MEASURES TO SUIT THE DETAILED STAGING OF THE WORKS ARE TO BE DETERMINED BY THE CONTRACTOR.
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8. IMPLEMENT SEDIMENT TRAPS TO ALL EXISTING INLET PITS AND KERB INLET PITS AROUND THE DEVELOPMENT SITE.

LEGEND

- TEMPORARY CONSTRUCTION ACCESS
- STRAW BALES
- SEDIMENT FENCE
- DIVERSION BANK AND CHANNEL
- STORMWATER SUMP AND OUTLET
- TEMPORARY RISING MAIN
- TEMPORARY DRAINAGE PIPE
- TEMPORARY DRAINAGE PIT
- EXISTING STORMWATER TO BE REDUNDANT
- INLET SEDIMENT TRAP
- FABRIC STOCKING SEDIMENT TRAP
- CONTRACTOR'S COMPOUND
- STOCK PILE AREA
- SEDIMENT BASIN
- TEMPORARY SITE ENTRANCE
- OVERLAND FLOW DIRECTION
- TEMPORARY RAMPED ACCESS

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EROSION AND SEDIMENT CONTROL PLAN: CONSTRUCTION PHASE

Scale at A1	By / Chkd / Appd
NOT TO SCALE	MP/TT/DC

Role: CIVIL

Status: **FOR SSDA**

Arup Job No	Rev
273467	**1**

SKETCH NO.

PHM-ARP-SKE-CE-000003

Do not scale

EROSION AND SEDIMENT

ES1 ALL EROSION AND SEDIMENT CONTROL MEASURES TO BE IN ACCORDANCE WITH LANDCOM "SOILS AND CONSTRUCTION MANUAL VOLUME 1, MARCH 2004"

ES2 WORKS SHALL BE UNDERTAKEN IN THE FOLLOWING SEQUENCE:

(A) INSTALL AIR MONITORING EQUIPMENT, COMMENCE WITH PITS TO BE RETAINED.

(B) INSTALL EROSION AND SEDIMENT CONTROLS.

(C) STRIP AND STOCKPILE TOPSOIL AND CARRY OUT ALL BULK EARTHWORKS.

(D) UNDERTAKE REMAINING SITE WORKS IN ACCORDANCE WITH THE ENGINEERING PLANS.

(E) REMOVE SOIL AND WATER MANAGEMENT WORKS NOT REQUIRED FOR OTHER STAGES OF CONSTRUCTION ONCE UPSTREAM SURFACES ARE STABILISED TO THE SATISFACTION OF THE PROJECT MANAGER.

EROSION CONTROL MEASURES

EC1 CONTROLS AFFECTED BY WORKS ARE TO BE RE-ESTABLISHED PRIOR TO THE COMPLETION OF EACH DAYS WORK.

EC2 DUST CONTROL MEASURES SHALL BE IMPLEMENTED CONTINUOUSLY DURING CONSTRUCTION WORKS TO THE SATISFACTION OF THE PROJECT MANAGER.

SEDIMENT CONTROL MEASURES

SC1 DURING EARTHWORKS, CAR PARK WORKS, ROADWORKS, TEMPORARY DIVERSION BANKS SHOULD BE CONSTRUCTED TO LIMIT SLOPE LENGTH, WHERE POSSIBLE, IN ACCORDANCE WITH THE FOLLOWING:

RECOMMENDED MAXIMUM SPACING BETWEEN CROSS BANKS ON ALL ROADS.

SLOPE	MAXIMUM SPACING (m)
0 TO 1%	150
1 TO 3%	100
3 TO 5%	70
5 TO 10%	50
10 TO 17%	16

SC2 ALL STORMWATER PITS TO BE COVERED OR DROP INLET SEDIMENT TRAPS PROVIDED IN ACCORDANCE WITH DRAWING No. PHM-ARP-SKE-CE-000002 - 000003. KERB INLET SEDIMENT TRAPS ARE TO BE INSTALLED AFTER COMPLETION OF PAVING.

SC3 SEDIMENT TRAPS ARE TO BE MAINTAINED SUCH THAT:

(A) SEDIMENT IS REMOVED SUCH THAT NO LESS THAN 70% OF THE DESIGN CAPACITY REMAINS AT ANY ONE TIME.

(B) MATERIALS ARE REPLACED OR REPAIRED AS REQUIRED TO ENSURE SERVICEABILITY OF BOTH THE ELEMENT AND THE TRAP.

SC4 PERMANENT DRAINAGE STRUCTURES INCLUDING: PIPES, PITS ARE TO BE HANDED OVER IN A CLEAN CONDITION AT THE COMPLETION OF THE CONTRACT MAINTENANCE PERIOD.

SC5 FOLLOWING COMPLETION AND RESTORATION OF SITE, REMOVE ALL MATERIALS AND FILL DIVERSION DRAINS, WATERWAYS AND SEDIMENT TRAPS TO MATCH LEVELS OF THE PREVIOUSLY COMPLETED WORKS.

SC6 ALL TREES OTHER THAN THOSE IDENTIFIED FOR REMOVAL BY THE ARBORIST SHALL BE RETAINED UNLESS APPROVED FOR REMOVAL BY PROJECT MANAGER.

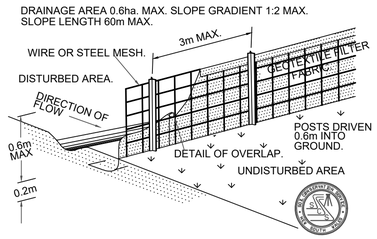
SC7 AN ACCESS POINT TO ALLOW MACHINE ENTRY / EXIT ARE TO INCLUDE A ROUNDED EARTH MOUND 0.3m HIGH WITH 10H:1V BATTERS.

SC8 THE CONTRACTOR SHALL PROVIDE A 0.4m WIDE TURF STRIP BEHIND ALL KERB AND GUTTER AT COMPLETION OF FOOTPATH FORMATION AND 1.0m WIDE AROUND ALL SURFACE INLET PITS.

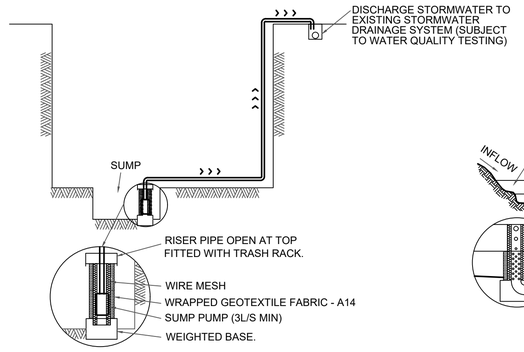
SC9 THE CONTRACTOR SHALL MAINTAIN A LOG BOOK DETAILING
- RECORDS OF ALL RAINFALL
- CONDITION OF SOIL AND WATER MANAGEMENT STRUCTURES
- ANY ADDITIONAL REMEDIAL WORKS REQUIRED
THE LOG BOOK SHALL BE MAINTAINED ON A DAILY BASIS AND BE MADE AVAILABLE TO ANY AUTHORISED PERSON UPON REQUEST. THE ORIGINAL LOG BOOK SHALL BE ISSUED TO THE PROJECT MANAGER AT THE COMPLETION OF THE WORKS.

SC10 THE CONTRACTOR SHALL AT ALL TIMES RESTRICT CONSTRUCTION EQUIPMENT MOVEMENT TO THE ESSENTIAL CONSTRUCTION AREAS.THE CONTRACTOR SHALL NOT EXTEND LAND DISTURBANCE BEYOND 2m FROM THE EDGE OF ANY ESSENTIAL CONSTRUCTION ACTIVITY.

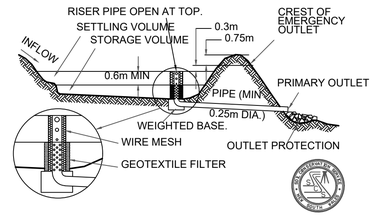
SC11 THE CONTRACTOR SHALL PROVIDE CATCH DRAINS AT THE BOTTOM OF ALL BATTERS AND DIVERT THE CATCH DRAINS AND ANY TAIL OUT DRAINS TO DRAIN TO THE NEAREST STORMWATER PIT.



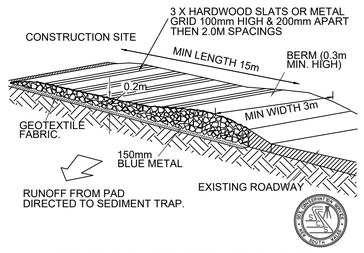
SEDIMENT FENCE



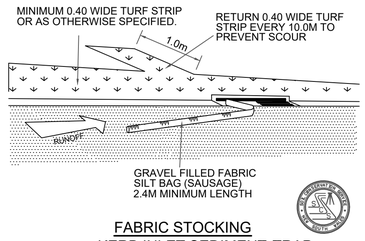
STORMWATER SUMP AND OUTLET



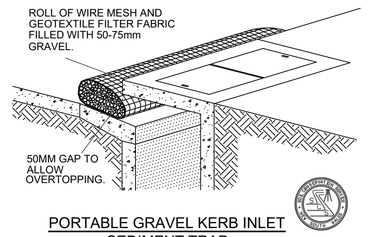
CROSS SECTION OF TYPICAL SEDIMENT BASIN



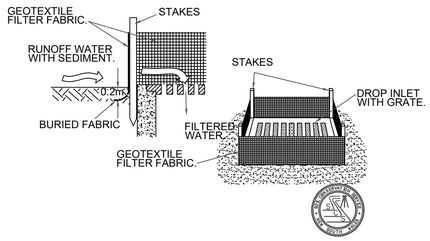
TEMPORARY CONSTRUCTION EXIT



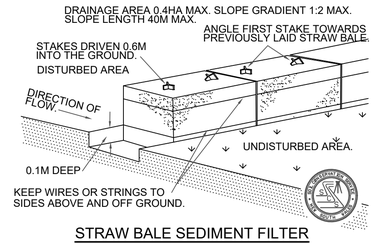
FABRIC STOCKING
KERB INLET SEDIMENT TRAP



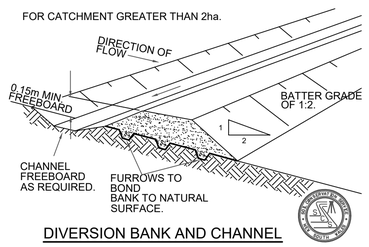
PORTABLE GRAVEL KERB INLET
SEDIMENT TRAP



GEOTEXTILE FILTER FABRIC DROP
INLET SEDIMENT TRAP



STRAW BALE SEDIMENT FILTER



DIVERSION BANK AND CHANNEL

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1	15.04.20	FOR SSDA
0		NOT ISSUED

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EROSION AND SEDIMENT CONTROL PLAN
GENERAL NOTES AND DETAILS

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Role: CIVIL

Status: **FOR SSDA**

Arup Job No	Rev
273467	**1**

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PMH-ARP-SKE-CE-000004

Appendix J | Erosion & Sediment Control Plan