NSW Planning, Industry & Environment
4 Parramatta Square
12 Darcy Street
PARRAMATTA NSW 2154

121007/parrapowerhse_reportwmawater

8 February 2021

Attention: Mr. M Jennejohn
Senior Planning Officer, Key Sites Assessments

Re: Independent Flooding Assessment
SSD 10416: Powerhouse Parramatta
Review of Flooding Aspects

1 INTRODUCTION

On 2 June 2020, the Department of Planning, Industry and Environment NSW (the DPIE) received a State Significant Development (SSD) application for the Powerhouse Parramatta. The project is located at 30B, 34, 36-38, 40, 42 and 44-54 Phillip Street, Parramatta and seeks development consent for:

- site preparation works including demolition, relocation and retention of existing structures and tree removal;
- construction, operation and use of the Powerhouse Parramatta;
- construction of an undercroft / flood mitigation infrastructure;
- open space and public domain works, vehicular access, infrastructure works and signage zones.

An Environmental Impact Statement (EIS) including a Flood Risk and Stormwater Management Report was prepared and this was exhibited in June/July 2020. In response to the exhibition the DPIE received:

- flooding and overland flow advice from the City of Parramatta Council;
- flooding advice from the Department's Environment, Energy and Science Group (EES);
- a submission from Australian Unity including a Review of Flood Impact Assessment prepared by Molino Stewart;
- 17% of the 1269 public submissions raising concerns about flooding.

In response, the Applicant provided further flood advice in September 2020 within its Response to Submissions (RtS). The RtS was referred to Council, EES and placed on its website. The DPIE received further advice/submissions from several sources, including the following which referenced flood-related aspects of the development:

- City of Parramatta Council;
- Powerhouse Museum Alliance including a RtS flood review prepared by Molino Stewart;
- EES group;
- Australian Unity.

The DPIE engaged WMAwater Pty Ltd in December 2020 to provide independent advice as to:

- the technical adequacy of the Applicant's assessment of flooding impacts;

WMAwater Pty Ltd
DIRECTORS
M K Babister, RPEQ
R W Dewar
E J Askew
F L N Ling, RPEQ
SENIOR ASSOCIATES
R Hardwick Jones
M E Retallick
ASSOCIATES
E M Harrison
ABN 14 600 315 053
Level 2, 160 Clarence St, SYDNEY NSW 2000
Phone: 02 9299 2855 Fax: 02 9262 6208
Email: enquiry@wmawater.com.au
Website: wmawater.com.au

- the appropriateness and effectiveness of the Applicant's approach to flood management and mitigation, in particular:
  - the construction of an undercroft for flood conveyance;
  - assumptions about debris blockage and stormwater drainage system performance;
  - flood impacts to surrounding properties;
  - protection of the museum collection; and
  - evacuation and emergency response management.
- consideration of the advice provided by City of Parramatta Council, EES and specialist flood advice within submissions, in particular areas of conflict or concern with the proposal;
- the adequacy of the Applicant's responses to the flooding issues raised in submissions;
- the flooding impacts on the site and surrounding sites, including management and mitigation measures to ensure acceptable impacts;
- recommendations for conditions for the construction and operation of the project should the DPIE recommend approval.

2 WMA WATER PTY LTD

WMAwater is a specialist water engineering consultancy with over 35 years' experience undertaking Flood Studies and Floodplain Risk Management studies across NSW under the Floodplain Development Manual and emerging national best practice. We are recognised experts in the field with capabilities across modelling, policy and planning, emergency response management, concept design and costing, and consultation and engagement.

We have offices in Sydney, Hobart, Geelong and Brisbane with over 30 well qualified staff. We work exclusively in this Flood Study / Floodplain Risk Management field with the majority of our work from Councils or sections of the respective State Governments. Our website provides further details of our experience and history.

This letter has been prepared by R W Dewar BSc, MEngSci, MIEAust CPEng Member No 477618 who has been a Director of WMAwater since inception of the company in 1983 and Rhys Hardwick Jones who has worked at WMAwater since 2006 and is a Technical Director. CVs of these two staff members were provided to the DPIE.

3 SCOPE OF WORK

The scope of work of this review included:

- Preparation of a peer review report for SSD-10416 (including consideration of the Reports as listed in the Table 1) in respect to the Flood Impact Assessment prepared for the site and proposed development;
- Involvement in video conference meetings with the DPIE and the Applicant and review of subsequent submitted reports.

Table 1: Listing of Reports to be Reviewed

Document Ref. No.	Revision No.	Title/Description
PHM-ARP-CIV-REP-0001	2 dated 22 April 2020	Appendix O of the EIS: Flood Risk and Stormwater Management Report
PHM-ARP-REP-CE-0003	16 September 2020	Appendix J of the RtS: Flood Risk and Stormwater Management Addendum
n/a		Attachment F of Additional information Technical Note prepared by Arup for Infrastructure NSW – Flood Risk Assessment for Inclusion of St Georges Terrace Building into Powerhouse at Parramatta Site
n/a		City of Parramatta submission dated 21 July 2020
n/a		City of Parramatta submission dated 12 November 2020
DOC20/457448		EES submission dated 18 June 2020
n/a		EES RtS submission
Submission by URBIS on behalf of Australian Unity Fund July 2020 & Appendix C: Review of Flood Impact Assessment Prepared by Molino Stewart	Molino letter report dated 27 July 2020	32 Phillip Street – EIS
Submission to Applicant's Response to Submissions' made on behalf of the landowners of 32 Phillip Street, Parramatta	10/11/2020	32 Phillip Street – RtS
1194 Parramatta Powerhouse Museum RtS Review – Flood_v1.1.docx	1.1 dated 17/11/2020	Parramatta Powerhouse RtS Review – Flood prepared by Molino Stewart Pty Ltd for the Powerhouse Museum Alliance and accompanying letter 'Response from Molino Stewart and Kylie Winkworth for Powerhouse Museum Alliance'.

4 APPROACH

WMAwater undertook the following work (listed chronologically):

- Initial video conference with DPIE on 18th December 2020;
- Review of all reports listed in Table 1 by WMAwater;
- Preparation and provision of a Memo entitled *Summary of Flooding Issues For Review* (included as Appendix A) on 11th January 2021 to DPIE. It was subsequently provided to the Applicant;
- Video conference with DPIE to discuss the above Memo on 13th January 2021;
- Video conference with DPIE and Applicant to discuss the above Memo on 18th January 2021;
- Various telephone calls / emails and provision of additional information by the Applicant;
- Video conference with DPIE on 25th January 2021 to discuss the use and design of the undercroft and obtain feedback on adequacy of the other responses from Arup to questions/issues raised;

- Various telephone calls / emails and receipt / review of additional information by the Applicant;
- Preparation and submission of this letter report on 8 February 2021.

5 ISSUES CONSIDERED IN THIS REVIEW

5.1 Discussion of Flood-Related Issues

The flood-related issues raised in the submissions are discussed further in the following sections.

5.1.1 Undercroft Area

The undercroft is the area beneath the building floor (at approximately RL 3 mAHD whilst the floor level of the Museum floor above is at RL 7.5 mAHD, derived from the overland flood 1% AEP flood level + 0.5 m). The intention of the undercroft is to allow the continued passage of floodwaters through the site in a manner similar to the flow that can occur through the existing carpark. The area cannot be fully enclosed as the exclusion of this area from the floodplain would cause an increase in flood levels on surrounding lands.

Council has suggested removal of the undercroft and reconfiguration of the bank. This approach of having the building floor on piers above the floodwaters and creating an undercroft is commonly used to enable development on floodplains. However, it would be against best practice in floodplain management to allow this area to be used as a permanent building floor space as it does not comply with the minimum floor level requirements of RL 7.5m AHD. Given the proposed building layout of the Museum it is difficult to see how it is possible to replicate this loss of floodplain conveyance and storage without having an undercroft area for flood mitigation purposes.

A further issue is that undercroft areas can potentially be used for anti-social activities and thus it is preferable if access can be prevented. Documentation in the RtS proposed a screen (to prevent access) which could be retracted (to allow the area to be inundated) during a flood. In theory, this retractable screen could work, although Parramatta City Council raised significant concerns with this approach (letter of 12/11/2020). WMAwater agrees with these Council concerns (included in Appendix A). Our recommendation is to retain the undercroft as an area of floodplain with no approval for permanent or temporary building floor space use by the Museum and have it enclosed by a fixed grille (e.g. security fencing or other permanent bars that prevent access but allow floodwaters to pass through). Further details are provided in Section 6.1 and Appendix B.

5.1.2 Flood Impact Assessment and Potential Increases in Flood Levels on Surrounding Properties

A potential key issue with all developments on the floodplain is that if the proposed structure is larger than the existing structure on the site, floodwater can be displaced and flood levels on surrounding properties can increase. A flood impact assessment using computer models (e.g. TUFLOW), is usually undertaken in such circumstances to ensure that no significant impact (typically no greater than 10mm or 1cm) occurs outside the subject property.

In conclusion Arup completed this flood impact assessment using a best practice approach, with appropriate documentation provided in the reports listed in Table 1 and Appendix B.

The peak flood level impacts on surrounding properties are within acceptable limits with the exception of 330 Church Street where a retaining wall is recommended as a Condition of Consent (refer Section 6.2).

5.1.3 Assumed Blockages and Stormwater Performance

Flood impact assessments need to consider the potential for floating debris in floodwaters covering the inlets to the stormwater network, or the grilles and piers in the undercroft area. The nature of the blockage potential and effect will vary from event to event and location to location. There is no precise guidance on the parameters to adopt in the flood impact assessment.

Parramatta City Council's June 2018 Development Engineering Guidelines states (their Section 3.4) "For the purposes of risk assessment, it is to be assumed that there is no benefit from the piped system, i.e. 100% pipe blockage."

We accept that a sensitivity analysis 100% blockage should be analysed to assess whether a significant change in flood level results. However, this should not be adopted as a design criteria. 100% blockage of the pipe in Dirrabarrri Lane has been analysed and if it occurs it will increase flood levels and thus increase the frequency of inundation of the building floor by overland flood waters.

Typical blockage factors for design purposes under various stormwater and road drainage design guidelines are between 20% to 50% for kerb inlets (refer Section 7.5.2 Queensland Urban Drainage Manual – see below).

If blockage of kerb inlets is a concern, this could be mitigated by provision of extra kerb inlets, or larger inlet openings, to the proposed 900mm diameter pipe in Dirrabarrri Lane and this is recommended as a Condition of Consent in Section 6.2.

Analysis of the potential for blockage of the permanent grille around the undercroft was completed by Arup as documented in Appendix B, and WMAwater considers this analysis to be satisfactory.

7.5.2 Provision for blockage

Local authorities may nominate the percentage of 'design' blockage that is to be applied to the theoretical inflow capacity of inlets.

Where such guidance is not provided, the recommendations in Table 7.5.1 should be adopted. Where the invert of the kerb is depressed at the inlet the capacity of the inlet should be adjusted accordingly.

Table 7.5.1 – Provision for blockage at kerb inlets

Inlet type	Blockage factor	
	Design value [1]	Severe conditions [2]
Sag kerb inlets:		
Kerb inlet	20%	100 %
Grated	50 %	100%
Combination	[3]	100%
Continuous (on-grade) kerb inlets:		
Kerb inlet	20%	100%
Longitudinal bar grated	40%	100%
Transverse bar grate or longitudinal bar grate incorporating transverse bars	50%	100%
Combination	[4]	100%
Field (drop) inlets:		
Flush mounted	80%	100%
Elevated (pill box) horizontal grate	50%	100%
Dome screen	50%	100%
Open pipe inlets (blockage factors as per culverts)	Refer to Table 10.4.1	

Notes:

[1] Blockage factors applicable for the design of drainage structures.

[2] Maximum blockage factor considered during investigations into the consequences of storm in excess of the nominated major storm, or blockage in excess of 'design' values. Investigations into the likelihood of severe blockage may result in the nomination of a lower blockage value. Full blockage should only be considered in circumstances where suitable blockage material exists within the drainage catchment.

[3] At a sag, the capacity of a combination inlet (kerb inlet with grate) should be taken to be the theoretical capacity of the kerb opening with 100% blockage of the grate.

[4] On a continuous grade the capacity of a combination inlet should be taken to be 90% of the combined theoretical zero-blockage capacity of the grate plus kerb opening.

5.1.4 Protection of Museum Collection

Collections in museums are generally unique and may be irreplaceable. For all development including high value development such as museums, hospitals, power stations etc. it is physically impossible to completely eliminate all forms of risk (earthquakes, fire, tsunami, acts of vandalism/terrorism, etc.). Some level of residual risk remains where the likelihood is typically low, and the acceptability of the residual risk depends on the severity of the consequences. Residual risk may not be acceptable, even in unlikely circumstances, if the consequences are sufficiently catastrophic. For floods the probability of occurrence (the likelihood) can be reasonably accurately determined, and Arup have indicated that inundation of the proposed ground floor is a lower than 1 in 800 chance per year (including freeboard), or approximately a 1 in 12 chance over a 100 year period.

To determine whether the residual risk to the collection is acceptable, it will be necessary for the Museum curators to assess the consequences (e.g. the expected losses/damages that will occur from inundation above the ground floor level), and then determine whether those consequences are acceptable given the likelihood of occurrence described above. We propose that this should be addressed through the undertaking of a comprehensive flood damages assessment that includes consideration of the flood damage potential to individual items in the museum collection. This is provided as a Condition of Consent (Section 6.2).

The issue of flooding affecting the fire protection system has been raised and this is addressed as a Condition of Consent (Section 6.2). Flooding may also affect the electricity supply, this may be for a few hours or with significant flood damage may be for much longer. It is essential that there are adequate emergency generators and these are to be located above the PMF. A Condition of Consent (Section 6.2) is that adequate emergency generators should be designed to maintain climate control standards as specified by the curators of the collection.

5.1.5 Evacuation

There are two broad approaches to managing the well being of people in a flood. The first is to evacuate people in advance from the area that will flood. This presents significant difficulty in smaller urban catchments, as there may be risk to life issues in evacuating (intense rainfall, submerged roads, fallen trees etc.). The alternate is “shelter in place” which means people stay where they are above flood waters and under cover until the flood passes. This can pose risks relating to isolation and lack of critical supplies if the duration of flooding is greater than a few hours.

Our recommendation for addressing the above is the development of a Flood Emergency Management Plan to be maintained and implemented by the museum operators. This Plan would sit alongside similar plans (e.g. fire, pandemic etc.) and any other disaster or risk management planning that is required to run such a facility.

5.1.6 Flooding Issues During Construction

There is a significant risk of flooding during the construction phase and a report on the potential flood risk and associated issues is therefore required and is provided as a Condition of Consent (Section 6.2).

6 OUTCOMES

The outcomes of our review have been divided into two sections; firstly those where an adequate response or design amendment has been provided and secondly those that could be included and addressed later as a Condition of Consent for the development.

6.1 Adequate Response / Design Amendment

1. The undercroft area is available for the passage of floodwaters but should have a permanent grille on all sides to prevent entry of all persons (refer Appendix B for details). The space is not suitable as a permanent building floor use and must not be used as such. The use of the undercroft area by the Museum or others for a temporary function must comply with the same City of Parramatta requirements as for other temporary usage of land within the City.
2. A flood impact assessment of the proposed grille around the undercroft has been prepared by Arup and is attached as Appendix B, in accordance with best practice. WMAwater considers that the flood impacts in the 5% AEP and 1% AEP events for the proposed grille are within acceptable limits.
3. Provision of on-site accommodation will increase the number of persons staying overnight within the floodplain. This issue can be addressed by provision of a detailed Flood Emergency Management Plan.

4. To understand the magnitude of impacts for rarer floods, Arup prepared flood impact maps for the 1 in 1000 AEP flood and the Probable Maximum Flood (PMF). From these figures the changes in flood level for the 1 in 1000 AEP flood on private property outside the site are less than 10 mm except for a few small areas. One is adjacent to 330 Church Street and another is a small area in Phillip Street (which is likely to be due to modelling noise). The impacts for the PMF are less than 10 mm for areas along the Parramatta River. However, the project would result in impacts in the order of 50mm in the Parramatta CBD in the PMF event. Flood depths for the PMF in these streets would already be in the order of 2m to 4m, and WMAwater considers that these impacts in the PMF are within acceptable limits.
5. The consideration of cumulative impacts is addressed by assuming that all similar developments on the Parramatta River floodplain in the vicinity of the project would meet the same requirements as applied to this project of no adverse impacts for flood events up to the 1% AEP flood. This development also results in no significant adverse impacts for flood events up to the 1% AEP flood. Hence, the cumulative impact of this project and other future or imminent developments on the floodplain is likely to also result in no adverse impacts in the 1% AEP event.
6. Arup provided further details on the blockage and other factors adopted to simulate the restriction of flow in both overland and mainstream areas to the satisfaction of WMAwater.

6.2 Conditions of Consent

1. The inlet structures to any proposed overland flow pipe are to be designed assuming 50% blockage in the kerb inlets.
2. Guidelines need to be developed on what use, if any, can be made of the undercroft area and how these are enforced. WMAwater considers that any permanent building floor use of the undercroft area, whether for operations or exhibits or storage, should be prohibited.
3. A suitable consultant is to undertake a detailed flood damages assessment to assess the likely intangible and tangible damages for the Museum across the full range of flood events. The assessment will review the acceptable probability of loss or damage to categories of Museum contents by the curators, taking into account their various values. This assessment is to be updated following each flood and before any significant changes to the operation of the Museum are undertaken.
4. A detailed Flood Emergency Management Plan is to be prepared by a suitable consultant covering all flood preparation, response and recovery operations for the full range of design flood events (i.e up to the PMF). This Plan is to be updated following each flood and before any future significant changes to the operation of the Museum are undertaken. The plan shall consider safe routes for all occupants and visitors to the site, including occupants of the on-site accommodation to travel from the accommodation areas on Levels 1 and 6 to the designated refuge areas within the building, all of which should be above the PMF level.
5. A report on the potential flood risk and associated issues during the construction period is to be prepared by a suitable consultant.
6. Arup are to confirm that results from a flood impact assessment based on the final design plans and at the final building certification stage are compatible with those provided at this time.
7. Further details have been provided on protection for 330 Church Street. This is to include a retaining wall to support the ramp connecting the southern end of Dirrabarri Lane to the

Parramatta River foreshore. The top of the retaining wall supporting the west end of the ramp, wraps around to the corner of 330 Church Street. The top of the wall is to be at the 1% AEP flood level plus 0.5m freeboard.

8. The fire system is to be designed to work at its full potential in a 1% AEP plus 0.5 m flood.
9. The emergency electricity generators are to be designed to maintain climate control standards as specified by the curators of the collection.
10. The buildings must be structurally designed to withstand water and debris loads in a PMF.

Should you have any questions or require further clarification regarding the above please do not hesitate to contact the undersigned.

Yours Sincerely,
WMAwater

R W Dewar
Director

Appendix A

SUMMARY OF FLOOD ISSUES – PROPOSED PARRAMATTA MUSEUM

Ranked in each category in approximate order of importance

Managing Risk to Life

1. Undercroft: would this approach of screens / evacuation be permitted for other commercial developments in the floodplain? Will this set a precedent that say a supermarket will suggest a similar approach? Generally, for new developments in the floodplain approval should not be reliant on measures which can potentially fail.
2. Is it acceptable to increase the number of persons staying overnight within the floodplain, many of whom may be children and people unfamiliar with the local flooding issues. This is a museum not a hotel and as such may not be equipped with professional staff on 24 hours duty to respond in an emergency.
3. Undercroft: evacuation process – is this acceptable? In theory this may work but in a real life situation unexpected issues will arise. Generally, for new developments in the floodplain approval should not be reliant on evacuation, particularly if the frequency of inundation is more regular than 10% AEP (evacuation may be required every two years because we don't know in advance exactly how big the flood will be when a warning is issued).
4. Undercroft: this area is subject to frequent inundation more regular than 10%AEP and as such is classified as H5 – the 2nd highest category (hazard classifications are divided into six categories which indicate the restrictions on people, buildings and vehicles – refer below):

   H1 - Generally safe for vehicles, people and buildings,
   H2 - Unsafe for small vehicles,
   H3 - Unsafe for vehicles, children and the elderly,
   H4 - Unsafe for people and vehicles,
   H5 - Unsafe for people or vehicles. Buildings require special engineering design and construction, and
   H6 - Unsafe for vehicles and people. All buildings types considered vulnerable to failure.

Flood Hazard	The potential for damage to property or risk to persons during a flood. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.

It is noted that the flood hazards on the riverbank level and undercroft area are high and early movement of people from these areas to safe locations is critical.

   Is it best practice to have the proposed uses for the undercroft area located in an H5 hazard category area?
5. Undercroft: how will the screens operate, and will they fail to open if used so infrequently? Will this mean that the surrounding buildings will experience greater flood levels and risk to life and will they then potentially take legal action against the museum?
6. Inundation of fire safety equipment below 2.5m AHD may compromise safety during a flood. Floods and fires can potentially occur together. Is there anything else in the basement that, if damaged, may affect the safety of occupants?
7. Loss of power in a flood will affect lifts needed to evacuate people. Generally, in a flood situation we assume loss of power.
8. What is the frequency of inundation of the floor at 7.5 m AHD – is this acceptable?
9. Undercroft: will this area encourage people to stay as with screens etc. they may consider it safe?

Increased Risk to Other Floodplain Users

1. Further details are required on the blockage and other form loss factors adopted to simulate the restriction of flow through the undercroft area. The Arup report does not provide enough information to assess the suitability of these assumptions. This is critical to ensure that surrounding properties do not experience increased flood levels and / or increased risk to life.
2. What is an appropriate blockage factor for overland flow assessment?
3. Failure of the operation of the undercroft screens will worsen the flooding on others.
4. More detail is needed on mitigation measures to protect 330 Church Street from increased flood impact if climate change occurs.

Acceptable Risk to the Museum's Collections

1. How will flooding affect the Museum's operations and the indirect and direct damages? There are several aspects to this, including damages to the undercroft area, damages to the ground floor, and secondary damages resulting from possible loss of power and closure for repairs.
2. Is the intent to use the undercroft for temporary exhibits? The flood report appears to assume a very basic concrete structure, but this would presumably be very dark and unsuitable for museum exhibits or operations. Will the undercroft require electrical connections and lighting? Has the damage and repair of this infrastructure been considered? Will there be other temporary or permanent infrastructure required in this space?
3. How will the moveable undercroft screens operate? Will they be damaged or require replacement if left closed, or if they are successfully opened but the operating mechanisms are submerged?
4. An objective assessment is required of an acceptable probability of loss or damage to categories of Museum contents taking into account their various values. It would be valuable to investigate the damages and implications for the Brisbane museum after the January 2011 flood.
5. What is an acceptable freeboard for mainstream and overland flooding?
6. The overland flow assessment is affected by the assumed blockage factor for the sub surface drainage system.
7. Is the emergency generator sufficient to maintain required climate control standards during extreme floods? There appears to be confusion about the standard required with different sources describing different requirements. Has the standard been confirmed with the curators of the collection?

Additional Information Required

1. The assessment of flood affectation in events larger than the 1% AEP up to the PMF is required according to Council's DCP (*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*). The modelling assumptions for the effect of the buildings on flow obstruction for more extreme events should be clarified.
2. Advice on potential cumulative impact assessment as required in Council's DCP (*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*).
3. Further details are required on the blockage and other factors adopted to simulate the restriction of flow through the undercroft area.
4. A flood damages (tangible and intangible) assessment should be undertaken to evaluate the potential loss across the range of flood events, including potential damages due to various scenarios of power outages and climate control failure.
5. Construction period flood risk assessment.

Appendix B

Technical Note

ARUP

To	WMA DPIE	4 February 2021	
Copies	Tom Kennedy	Reference number	273467
From	ARUP	File reference	Tech Note 3001
Subject	Powerhouse Parramatta – Undercroft Loss Factors and Afflux with Fixed Screen		

1 Introduction

DPIE, and their technical advisor WMA, has undertaken a review of the Stormwater Management Reports and responses to submissions. This is a second technical note prepared to provide supplementary information to address questions raised by DPIE and WMA.

2 Information Requested

2.1 Derivation of Blockage Factors within Undercroft

Further information was requested by DPIE's independent engineer in relation to how the flood model considered the proposed structures located within the undercroft. This information is presented in Appendix A.

2.2 Scenario A: Flood Impacts with Fixed Grille

The flood modelling carried out and documented in the Response to Submissions (and the EIS) included the assumption that retractable screens would not be in place during a flood.

However, the design may be altered to include a fixed grille. To quantify the impacts of that scenario, the flood model was simulated with a representation of a fixed grille.

This was represented in the TUFLOW model using rows of 2d_lfcshp (i.e. FLC) cells along the alignment of the proposed screen (see Figure 1 below).

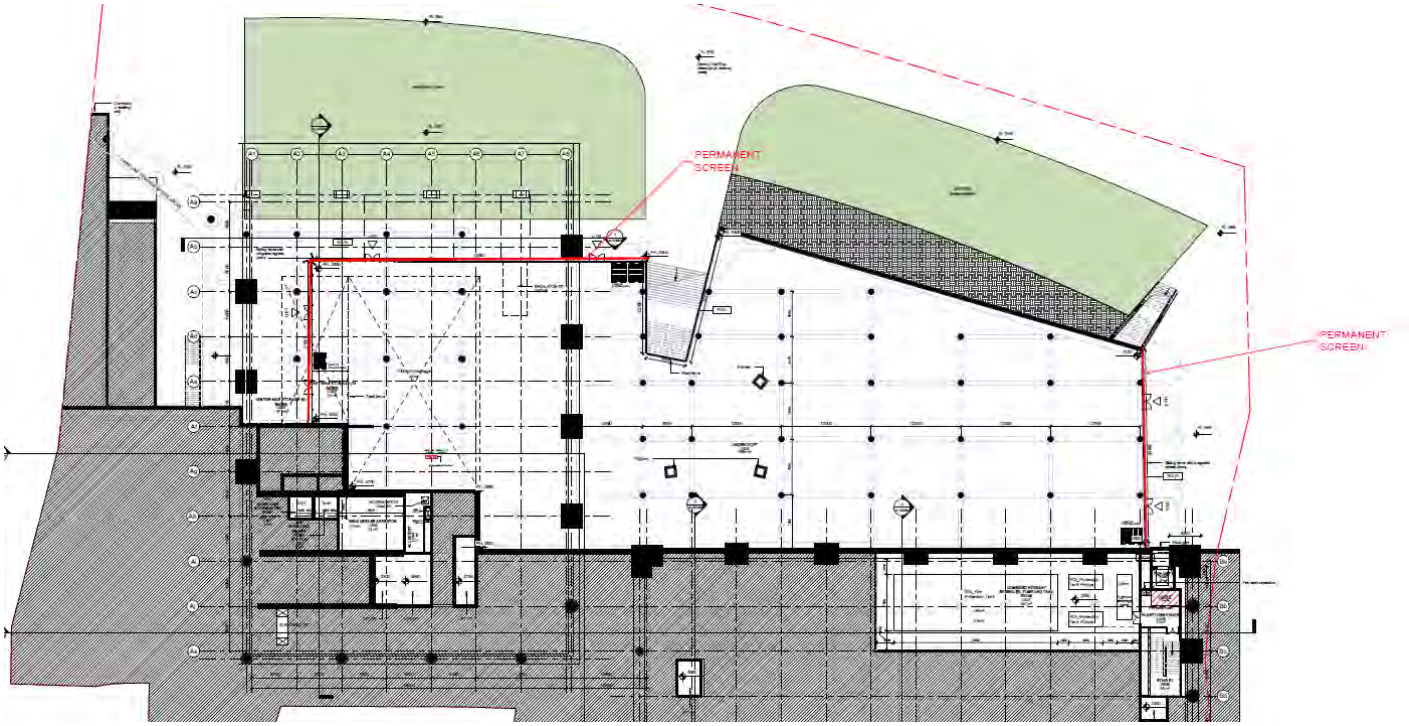


Figure 1: Alignment of Assumed Fixed Grille

A form loss coefficient was used to represent the fixed grille. This is a factor used to represent turbulence due to a partial obstruction. A form loss coefficient of 0.4 was used based on an assumed ratio of bar width to bar spacing of approximately 0.20 to 0.25 (i.e. 20% to 25%) depending on the profile of the bars. See Section 2.6 for examples of fencing with similar ratios.

As well, a 25% blockage factor was included to represent possible debris build-up on the screens which could account for a 0.5m deep debris mat in 3.3m deep water (undercroft level of 3.5mAHD and 1% AEP flood level of 6.8mAHD) plus another 10% debris build-up on submerged bars.

The flood afflux maps for this fixed grille scenario are presented as Drawings 1 and 4 for the 1% AEP and 5% AEP flood events respectively. The afflux was derived by comparing the flood levels with the fixed grille to the base case assuming that all cars are removed from the current car park prior to the flood event (i.e. the same base case as assumed in the EIS and RTS assessments).

This afflux map indicates that there would be afflux less than 10mm on all private property for this scenario with the following exceptions:

- 330 Church Street (the neighbouring Meriton apartments) – note that the potential impact of this afflux to result in inflows into the car park (via an air vent) will be mitigated through a landscaped bund to provide additional immunity to the car park than currently exists. This is discussed in the Response to Submissions Appendix J.
- Riverbank lawn of Museum Gardens Apartments building (fronting Sorrell St) on northern side of river. The areas impacted are lawns on the riverbank and riverbank vegetation as shown in Figure 2 below. The afflux at this location in this scenario are not high and in the order of 10mm to 14mm. The basement car park level of the neighbouring building is at

7.24mAHD which is 0.3m above the 1% AEP flood level. Hence, there is no impact of this afflux on habitable or utility areas of the properties.

Figure 2: Affected area of afflux between 10mm and 14mm

2.3 Scenario B: Flood Impacts with No Grille / Screen

The flood afflux presented in Response to Submissions Appendix J was based on a design that included retractable screens and it was assumed that these screens would be fully retracted prior to a flood event. Hence, that case represents no grille or screen in place (as per architectural image below in Figure 3).

Figure 3: Architectural Image of No Grille or Screen on upstream side

The flood afflux maps for this no grille / screen scenario are presented as Drawings 2 and 5 for the 1% AEP and 5% AEP flood events respectively.

This afflux map indicates that there would be afflux less than 10mm on all private property for this scenario with the following exceptions:

- 330 Church Street (the neighbouring Meriton apartments) – note that the potential impact of this afflux to result in inflows into the car park (via an air vent) will be mitigated through a landscaped bund to provide additional immunity to the car park than currently exists. This is discussed in the Response to Submissions Appendix J.
- Riverbank lawn of Museum Gardens Apartments building (fronting Sorrell St) on northern side of river. The areas impacted are lawns on the riverbank and riverbank vegetation as shown in Figure 3 below. The afflux at this location in this scenario are not high and in the order of 10mm to 12mm. The basement car park level of the neighbouring building is at 7.24mAHD which is 0.3m above the 1% AEP flood level. Hence, there is no impact of this afflux on habitable or utility areas of the properties.

2.4 Scenario C: Flood Impacts with Fully Blocked Grille / Screen

If the screens were unable to be retracted prior to a flood event, the screen would block flow. For the purposes of that scenario, it was conservatively assumed that this screen would block all flow through that enclosed part of the undercroft. The retractable screens in place is shown in Figure 4 below at the downstream end of the building.

Figure 4: Architectural Image of Retractable Screen on downstream side

The flood afflux maps for this fully blocked screen scenario are presented as Drawings 3 and 6 for the 1% AEP and 5% AEP flood events respectively.

This afflux map indicates that there would be afflux of up to 70mm in the river and on the properties adjoining the river.

2.5 Comparison of Flood Impacts

Table 1 and 2 present comparisons of the 1% AEP and 5% AEP flood afflux / impacts at 8 points along the northern bank of the Parramatta River. These 8 locations are shown on the afflux maps as points A to H.

Table 1: Comparison of 1% AEP Flood Impacts (m)

Location	Scenario A: Fixed Grille	Scenario B: No Grille / Screen	Scenario C: Fully Blocked Screen
A	-0.01	-0.03	0.07
B	-0.01	-0.02	0.07
C	-0.01	-0.02	0.07
D	0.01	0.00	0.07
E	0.01	0.00	0.07
F	0.01	0.01	0.02
G	-0.01	0.00	-0.05
H	-0.01	0.00	-0.08

Table 2: Comparison of 5% AEP Flood Impacts (m)

Location	Scenario A: Fixed Grille	Scenario B: No Grille / Screen	Scenario C: Fully Blocked Screen
A	-0.02	-0.03	0.05
B	-0.02	-0.03	0.05
C	-0.01	-0.02	0.05
D	0.01	0.00	0.06
E	0.02	0.01	0.06
F	0.02	0.02	0.02
G	0.00	0.00	-0.03
H	0.00	0.00	-0.07

2.6 Example Images of Possible Fixed Grilles

The fixed grille assumed in the flood impact assessment listed above are based on a grille with a ratio of bars to opening of between 20% and 25%. The flood impacts are not overly sensitive to this value. Below are images of typical security fences that have similar ratios.

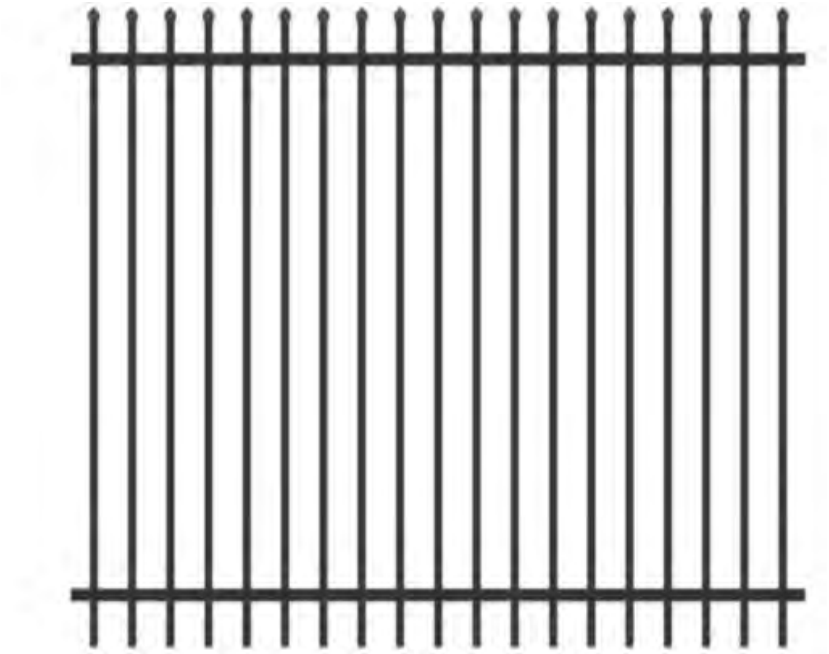


Figure 5: Typical Security Fence: 140mm spacing, 25mm poles, 18% blockage

Figure 6: Typical Security Fence: 150mm spacing, 25mm poles, 17% blockage

Figure 7: Typical Palisade Security Fence: 150mm spacing, 50mm poles, 33% blockage

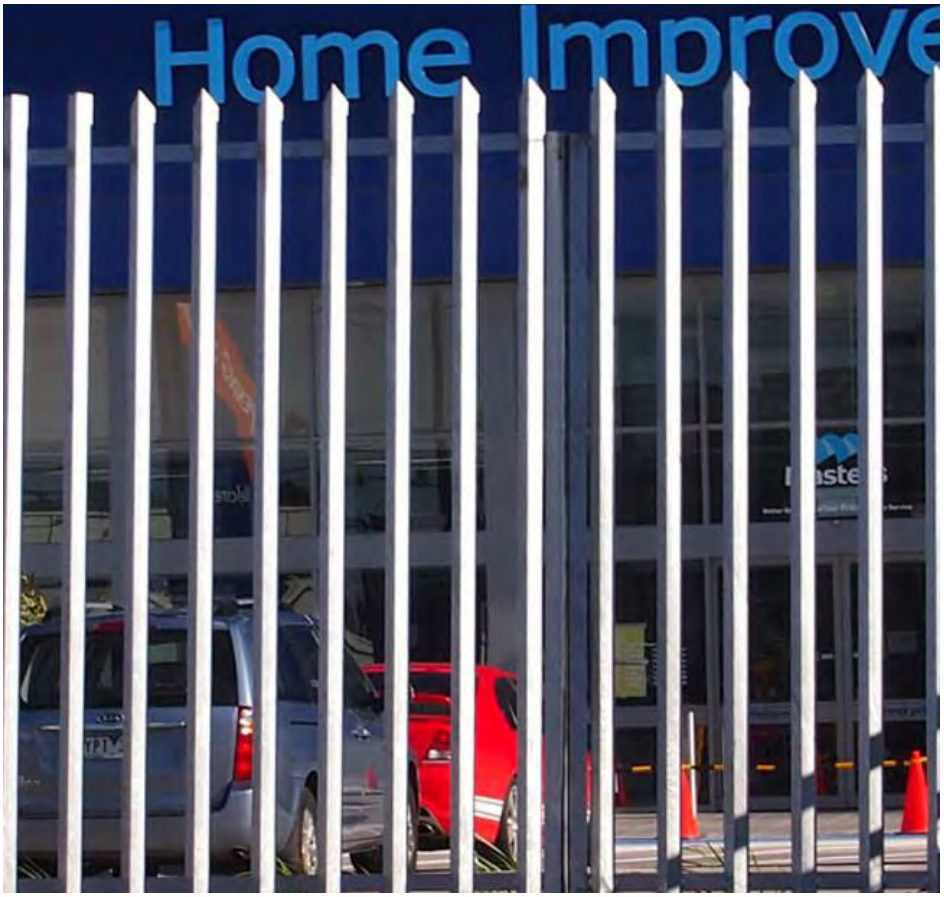


Figure 8: Heavy Duty Anti-ram / Anti-climb Security Fence: 150mm spacing, 50mm poles, 33% blockage

Appendix A: Derivation of Blockage Factors within Undercroft

Model files and a spreadsheet detailing how Flood Loss Coefficient's (FLC's) were calculated have been provided to DPIE and their independent engineer.

The proposed structural columns have been treated like a set of bridge piers and represented the losses accordingly using a distributed loss along the line of the columns (using a J value and appropriate k value).

The k values were derived from Figure 4.10 of Guide to Bridge Technology Part 8: Hydraulic Design of Waterway Structures (AustRoads, 2018).

J values (i.e. the ratio of pile with to pile spacings) were derived from the concept engineering drawings of the undercroft area (lower ground level).

The k values were then represented in the TUFLOW model at the nearest appropriate cell side using 2d_lfcshp files.

A graphical representation of the resulting cell side loss factors is presented in Figure A1 and Figure A2 below.

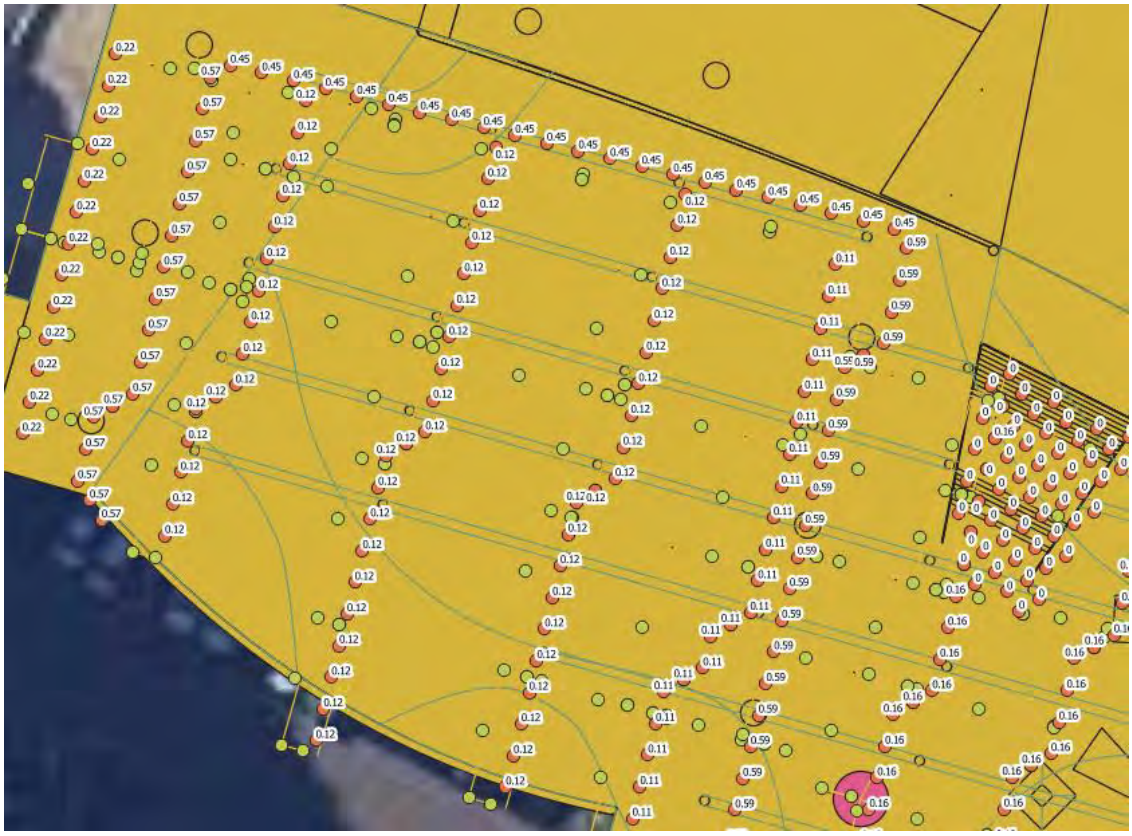


Figure A1: FLC values used for representation of piles / columns in undercroft (West Bldg)

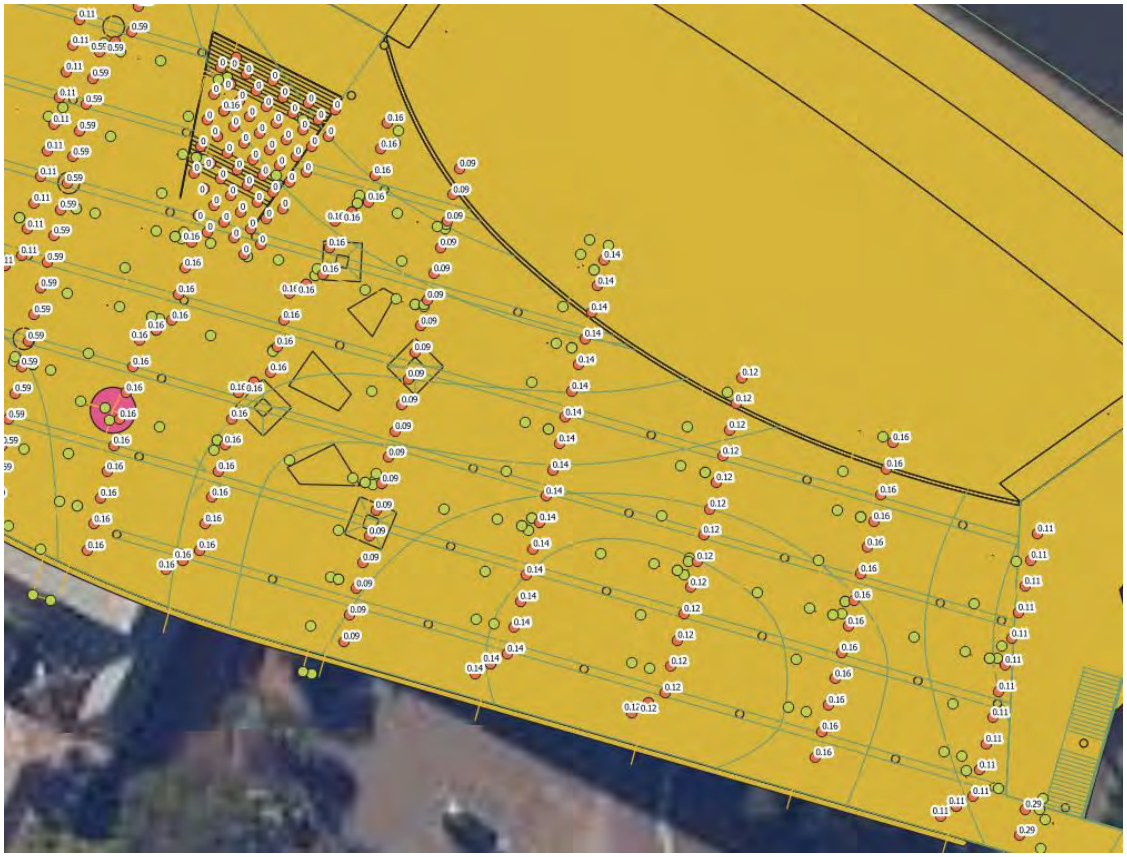
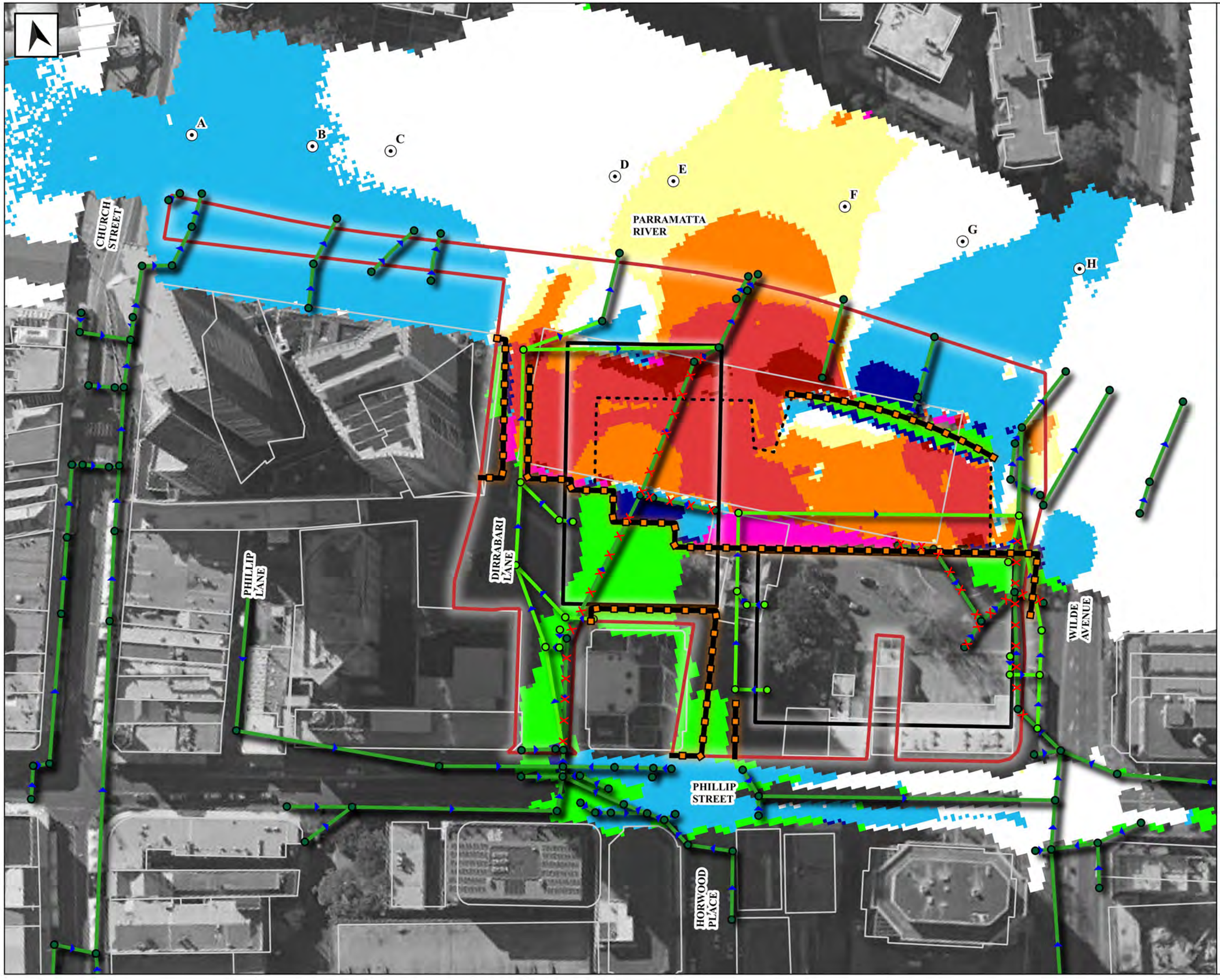


Figure A2: FLC values used for representation of piles / columns in undercroft (East Bldg)



Legend

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

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: *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	3/02/2021	AA	NC	EM

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Client

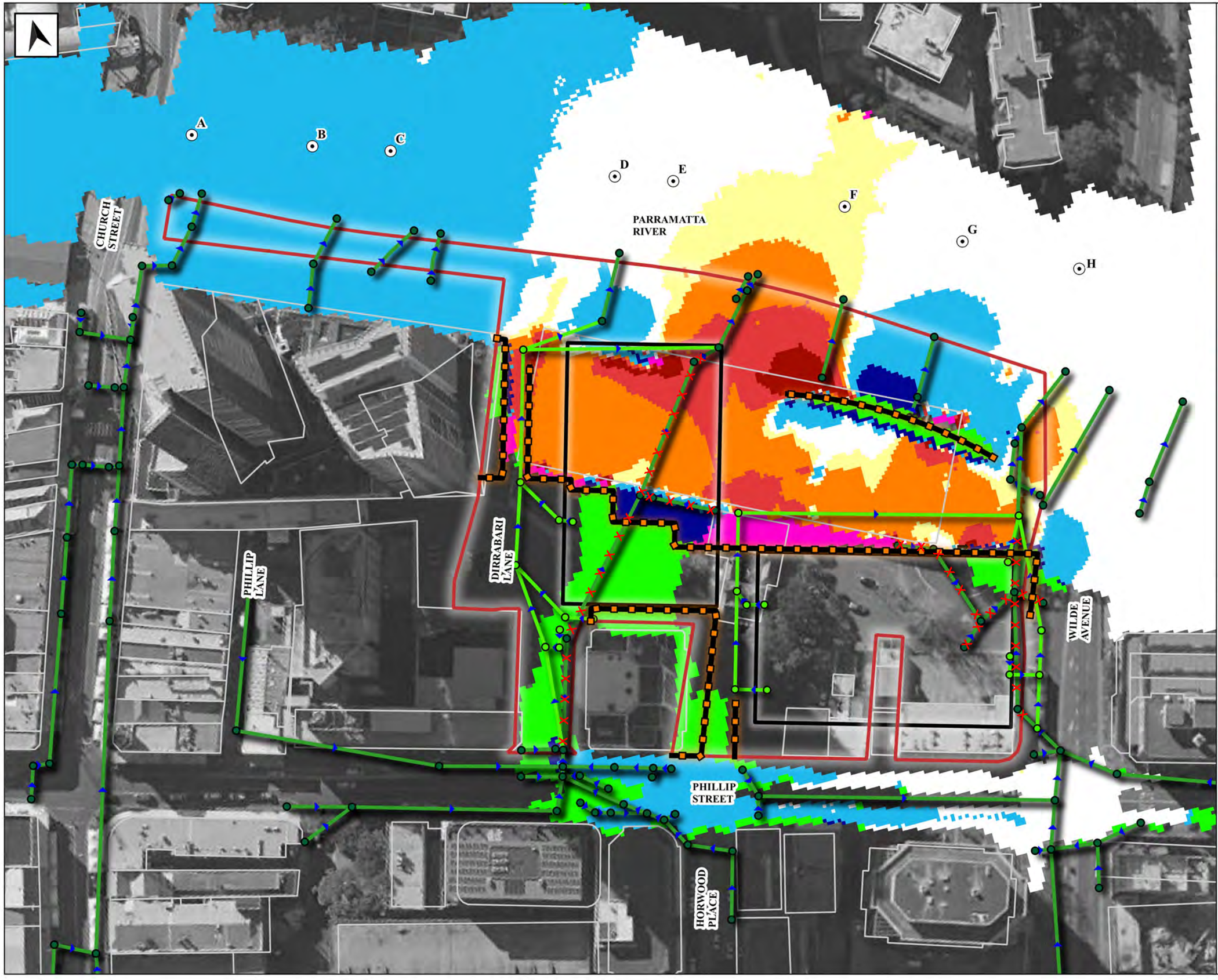
Powerhouse Parramatta

Post-development - River Flood
Fixed Grill, FLC=0.4 & BLKG=25%
Afflux
1% AEP (540 min)

Scale at A3
1:1000
0 25 50 m

Job No	Drawing Status
273467	Final

Drawing No	Issue
1	1



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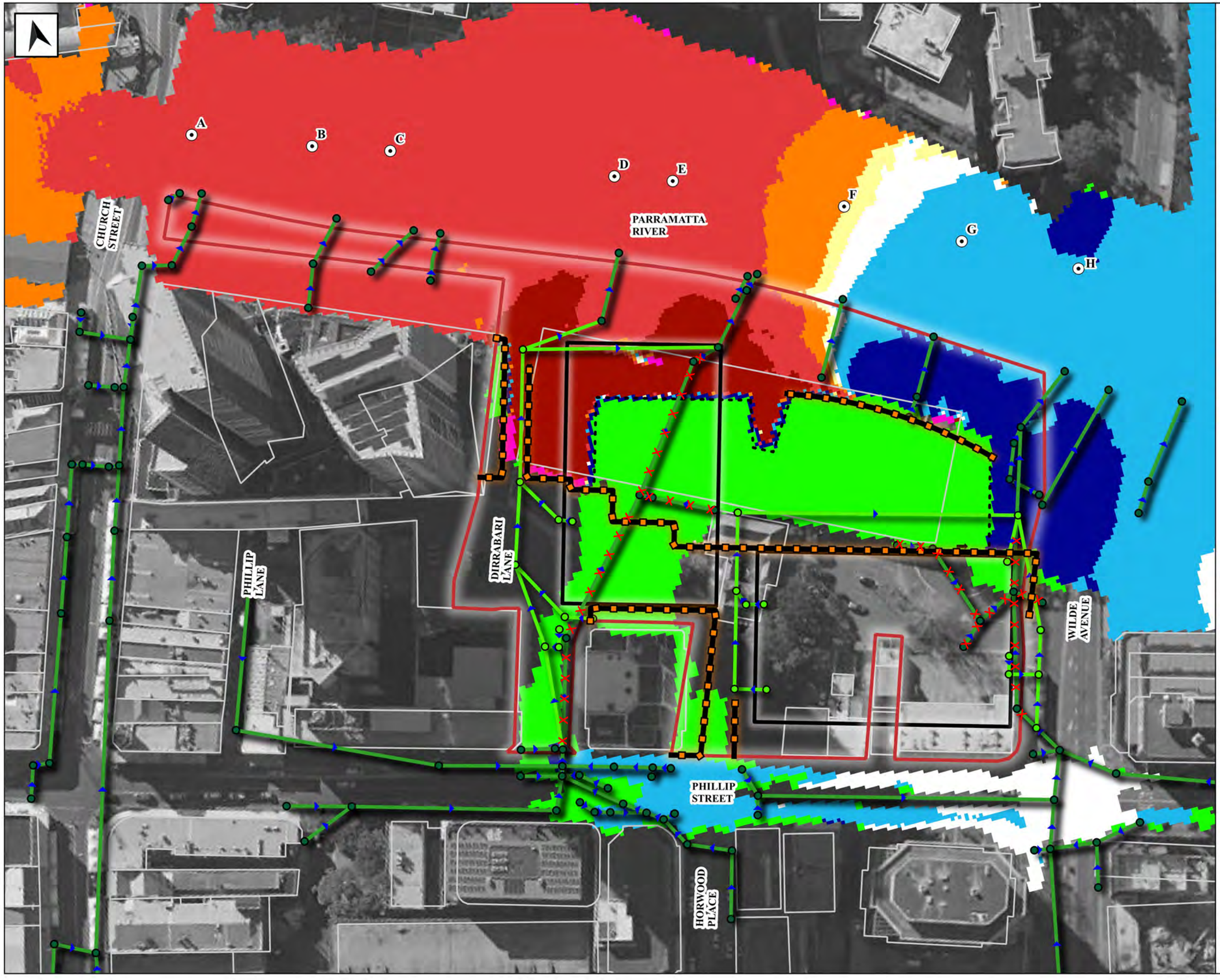
1% AEP (540 min)

Scale at A3
1:1000
0 25 50 m

Job No	Drawing Status
273467	Final

Drawing No	Issue
2	1



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Powerhouse Parramatta

Post-development - River Flood
Fixed Grill & Fully Blocked
Afflux
1% AEP (540 min)

Scale at A3
1:1000
0 25 50 m

Job No	Drawing Status
273467	**Final**

Drawing No	Issue
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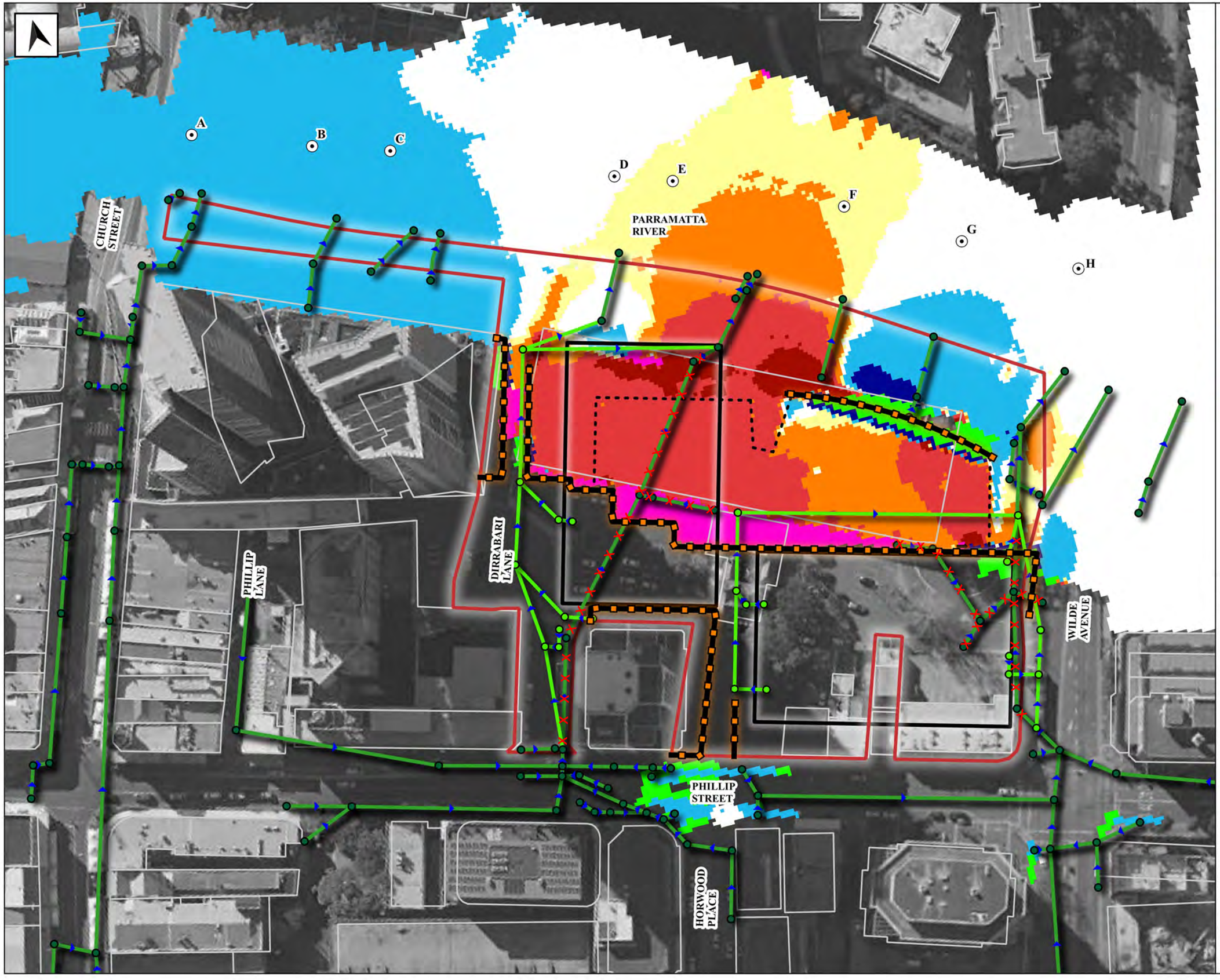

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1:1000
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Job No	Drawing Status
273467	Final

Drawing No	Issue
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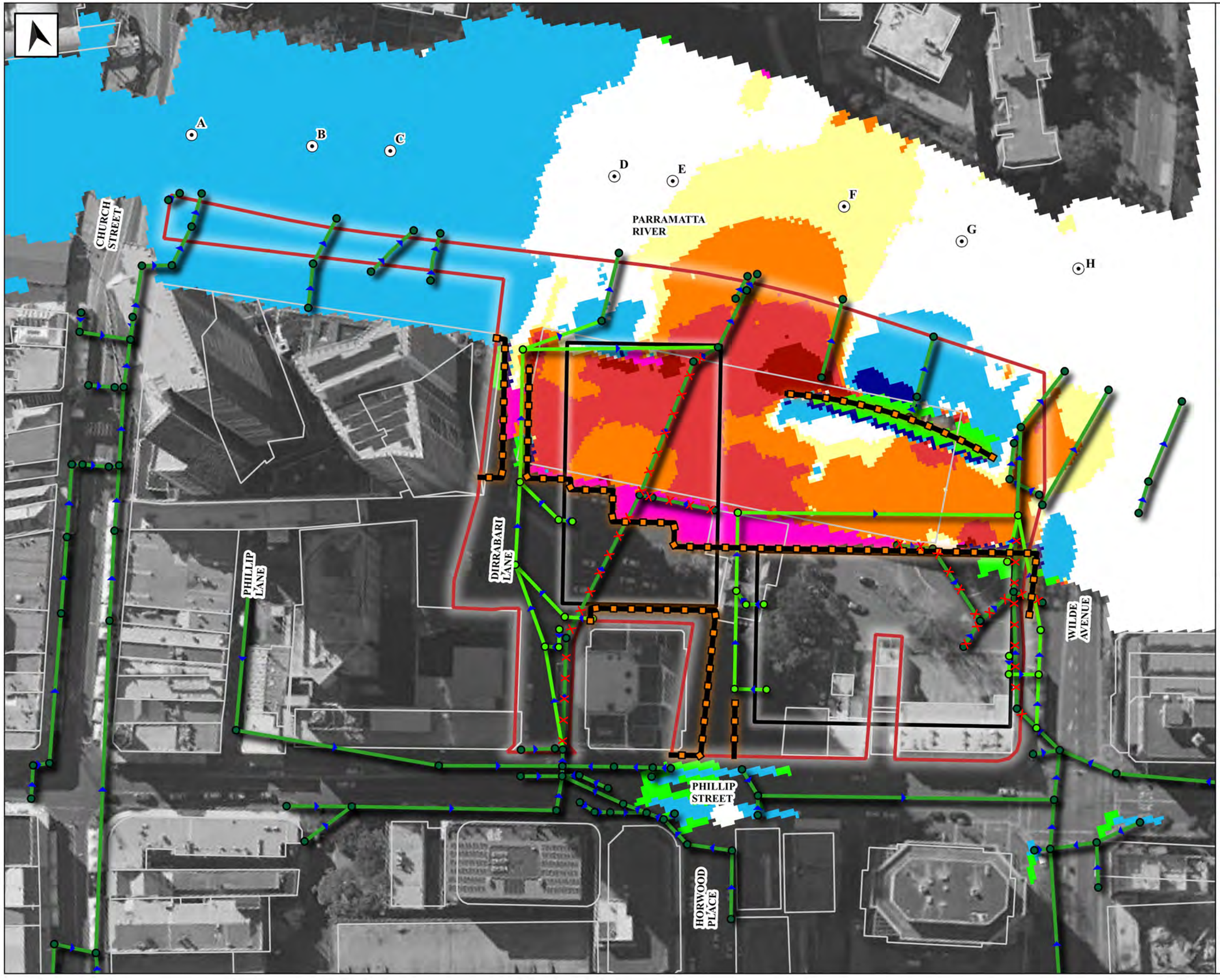

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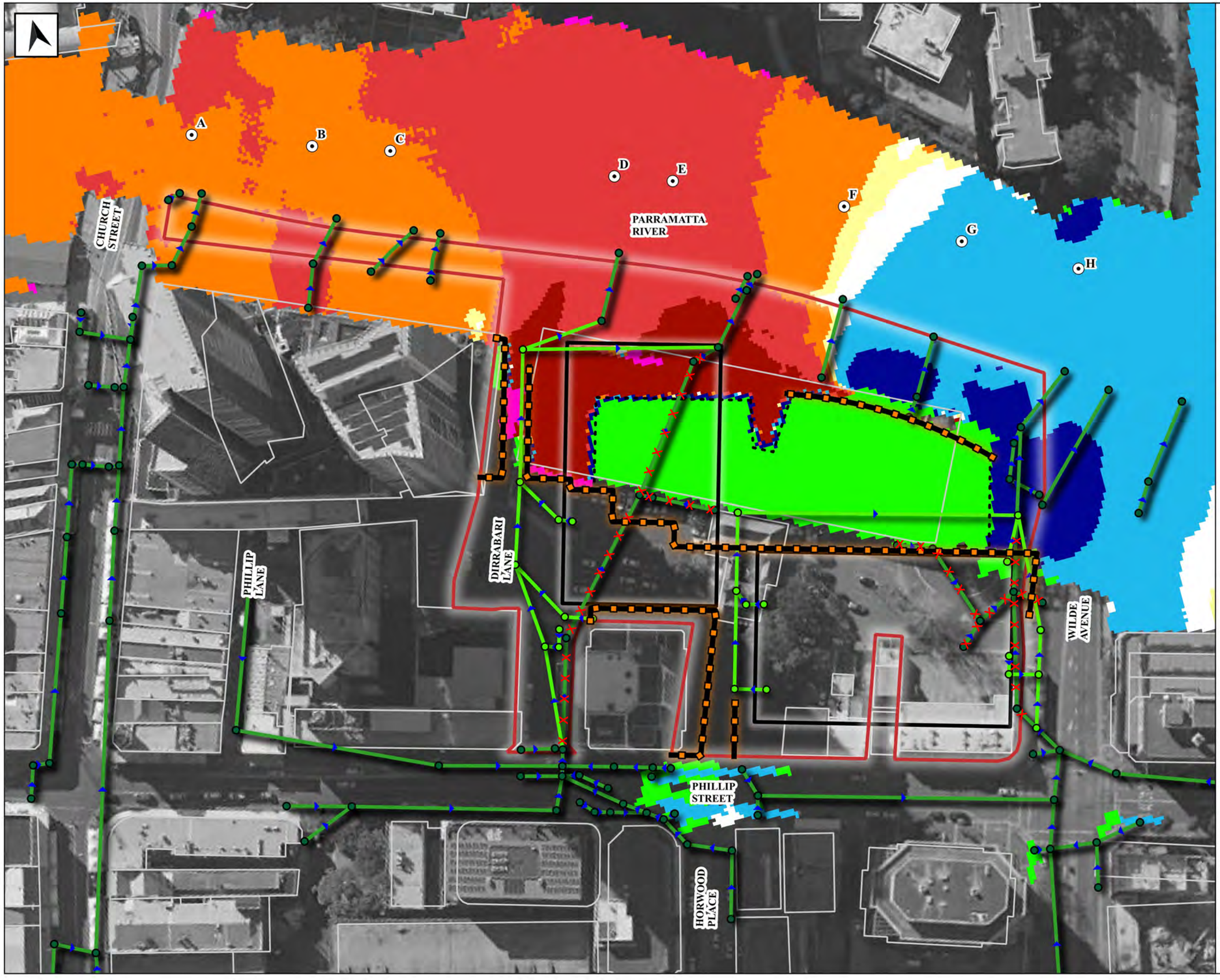
5	1



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Drawing No	Issue
6	1