



Waterloo Estate (South) Planning Proposal

Flooding Stormwater Climate Change

Department of Planning (NSW)

04 November 2021

➔ **The Power of Commitment**

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Printed date	17/11/2021 7:20:00 PM
Last saved date	17 November 2021
File name	https://projectsportal.ghd.com/sites/pp15_05/waterloosouthfloaddr/ProjectDocs/12555493_REP-Waterloo South Floodings Stormwater Climate Change.docx
Author	Rainer Berg / Rod Towner
Project manager	Rod Towner
Client name	Department of Planning (NSW)
Project name	Waterloo South - Flood Drainage Assessment
Document title	Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change
Revision version	Rev 0
Project number	12555493

Document status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	Draft	Rainer Berg	Rod Towner	iConnect	Rainer Berg	iConnect	17/11/2021
S4	Final	Rainer Berg	Rod Towner		Rainer Berg		17/11/2021
[Status code]							
[Status code]							
[Status code]							

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1. Introduction

1.1 Background

The Minister for Planning appointed the Secretary of Planning, Department of Planning, Industry and Environment (DPIE) as the Principal Planning Authority (PPA) for the Waterloo Estate (South) Planning Proposal (the Planning Proposal). On 27 April 2021 the PPA lodged the Planning Proposal with the Deputy Secretary for Gateway Determination. The Planning Proposal (Cos 2021) submitted was the one prepared by the City of Sydney and endorsed by the Central Sydney Planning Committee and Council.

The Planning Proposal contains a mix of affordable housing, social housing, and market housing. The Planning Proposal area also contains private land holdings with most of the land being in the ownership of the Land and Housing Corporation.

The Planning Proposal follows an earlier NSW Land and Housing Corporation (LAHC) planning proposal request (May 2020) to change the planning controls for Waterloo Estate (South). The request included a Planning Justification Report, an Urban Design and Public Domain study and technical studies. The 27 April 2021 Planning Proposal includes masterplan amendments, principally limited to the treatment of George Street development near the intersection with McEvoy Street. DPIE have acknowledged that the rest of the site remaining as per the LAHC masterplan proposal.

The 27 April 2021 Planning Proposal Gateway Determination recommended that an amendment to the Sydney Local Environment Plan (LEP 2012), to facilitate the development of Waterloo Estate (South), should proceed subject to several conditions. Of these conditions the following two surface water matters were to be addressed:

- Condition 10: Climate Change Mitigation and Adaptation - An addendum report to address storm events and flooding with the amended proposal.
- Condition 17. Water Quality, Flooding and Stormwater - A new report to address stormwater management and flooding from overland flow, associated with the amended proposal. In addition, to address Ministerial Direction 4.3.

1.2 Purpose of this report

This report provides a review of the Planning Proposal with respect to stormwater and flooding, providing a new Stormwater Management and Flooding report as required by the Gateway Determination. The following matters were agreed with DPIE and are the basis of this report:

- Given the project is a review of the LAHC Planning Proposal submission, GHD will generally adopt the overall LAHC Stormwater Management and Flooding strategy and adjust the strategy to respond to the City of Sydney masterplan amendments around George and McEvoy streets.
- GHD will reference much of the work undertaken by LAHC and adopt the LAHC strategy developed for much of the site.
- DPIE will procure and make the TUFLOW, DRAINS and MUSIC models compiled by the LAHC available, and these models would be used for simulation of existing conditions, without the need for model configuration. All model inputs such as hydrology and model parameters were to be accepted at face value without amendment.
- GHD will address the requirements of the DPIE Study Requirements, Nominated State Significant Precinct – Waterloo Revised March 2018 as per Table A.1 in Appendix A.

1.3 Limitations

This report has been prepared by GHD for Department of Planning (NSW) and may only be used and relied on by Department of Planning (NSW) for the purpose agreed between GHD and Department of Planning (NSW).

GHD otherwise disclaims responsibility to any person other than Department of Planning (NSW) arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (throughout this report). GHD disclaims liability arising from any of the assumptions being incorrect.

2. Existing Conditions and Derived Constraints

2.1 Location

2.1.1 Waterloo Estate

The Waterloo Estate is located south-west of the Sydney CBD in the suburb of Waterloo (Figure 2.1). It is located within the City of Sydney Local Government Area (LGA). Waterloo Estate is situated approximately 500 m south of Redfern Station. The Waterloo Estate comprises land bounded by Cope, Phillip, Pitt, and McEvoy Street, including an additional area bounded by Wellington, Gibson, Kellick and Pitt Streets. It has an approximate gross site area of approximately 18.9 ha. Waterloo Estate currently comprises predominantly social housing dwellings owned by LAHC, private dwellings, a small group of shops and community uses on the corner of Wellington and George Streets. Several commercial properties are located on the south-east corner of Cope and Wellington Streets.

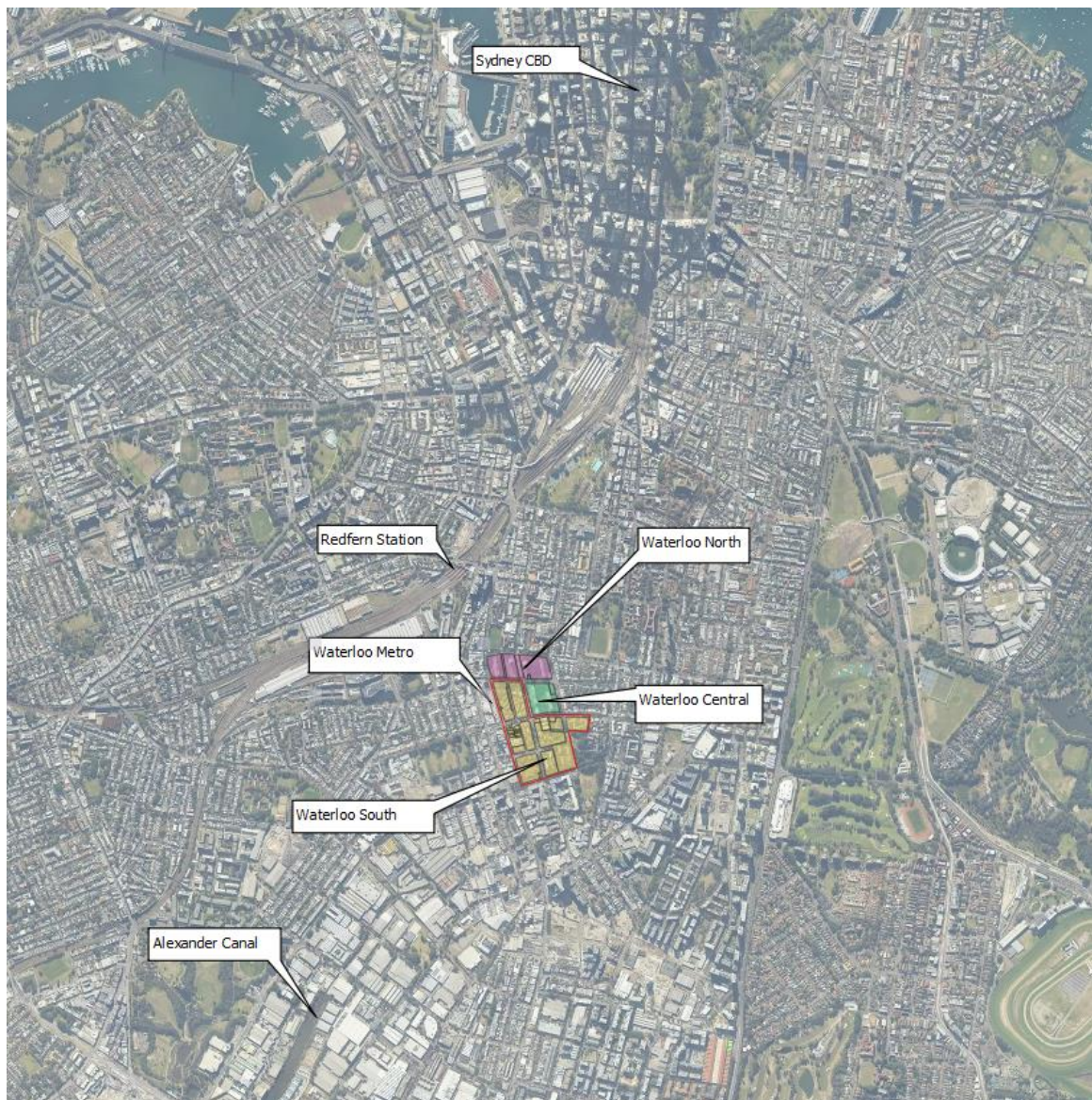


Figure 2.1 Waterloo Estate Location (Source Metro Maps)

2.1.2 Waterloo Estate (South)

Referring to Figure 2.2, Waterloo Estate (South) includes land bounded by Cope, Raglan, George, Wellington, Gibson, Kellick, Pitt, and McEvoy Streets. The approximate precinct area is 12.3 ha (being the larger portion of the Estate).

LAHC (2020) reports that Waterloo South is predominantly walk up flat buildings constructed in the 1950s and '60s, and mid-rise residential flat buildings (Drysdale, Dobell & 76 Wellington Street) constructed in the 1980s. Listed Heritage Items within Waterloo South include the Duke of Wellington Hotel, Electricity Substation 174 on the corner of George and McEvoy Streets, the terrace houses at 229-231 Cope Street and the Former Waterloo Pre-School at 225-227 Cope Street. The State Heritage listed 'Potts Hill to Waterloo Pressure Tunnel and Shafts' passes underneath the precinct.



Figure 2.2 Waterloo Precincts (source Metro Maps)

2.2 Catchment and Drainage

Referring to Figure 2.3, the Waterloo Estate is located within the much larger (approximately 550 ha) Sheas Creek catchment draining to the Alexandra Canal and the Cooks River. The location of the Estate within the Sheas Creek catchment is at the catchment 'head' and is separated from the adjacent Redfern Park catchment, by a ridge line east of Pitt Street. This overland flow path separation from the Redfern Park catchment was confirmed in LAHC 2020 and has been adopted as a basis of all current assessments.

In this location two smaller catchments drain to the stormwater systems and roadways bounding the site and would discharge through the site at times of rare to extreme flood events. These catchments and the larger Sheas Creek catchments are fully developed with a range of uses.

Since the Estate is located at the head of the catchment, minor flooding could be expected. This would likely be due to the stormwater system being surcharged, with overland flooding conveyed by the local roads.

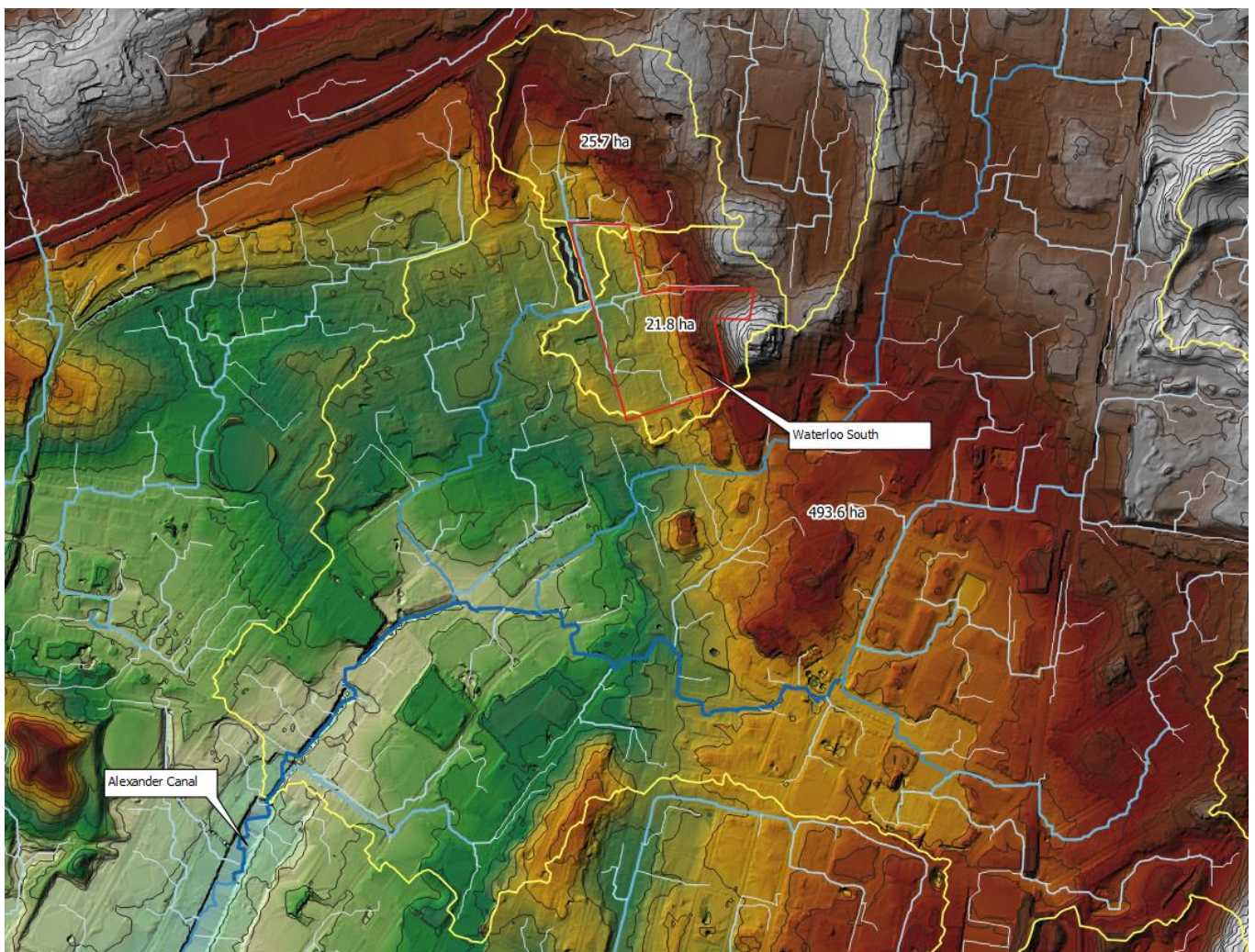


Figure 2.3 Catchments

The existing site is serviced by a local trunk drainage network (Figure 2.4) owned by Sydney Water Corporation. This drainage network drains to Shea Creek and Alexandra Canal. Overland flow is routed by kerb and gutter to inlet pits located in the local roads.

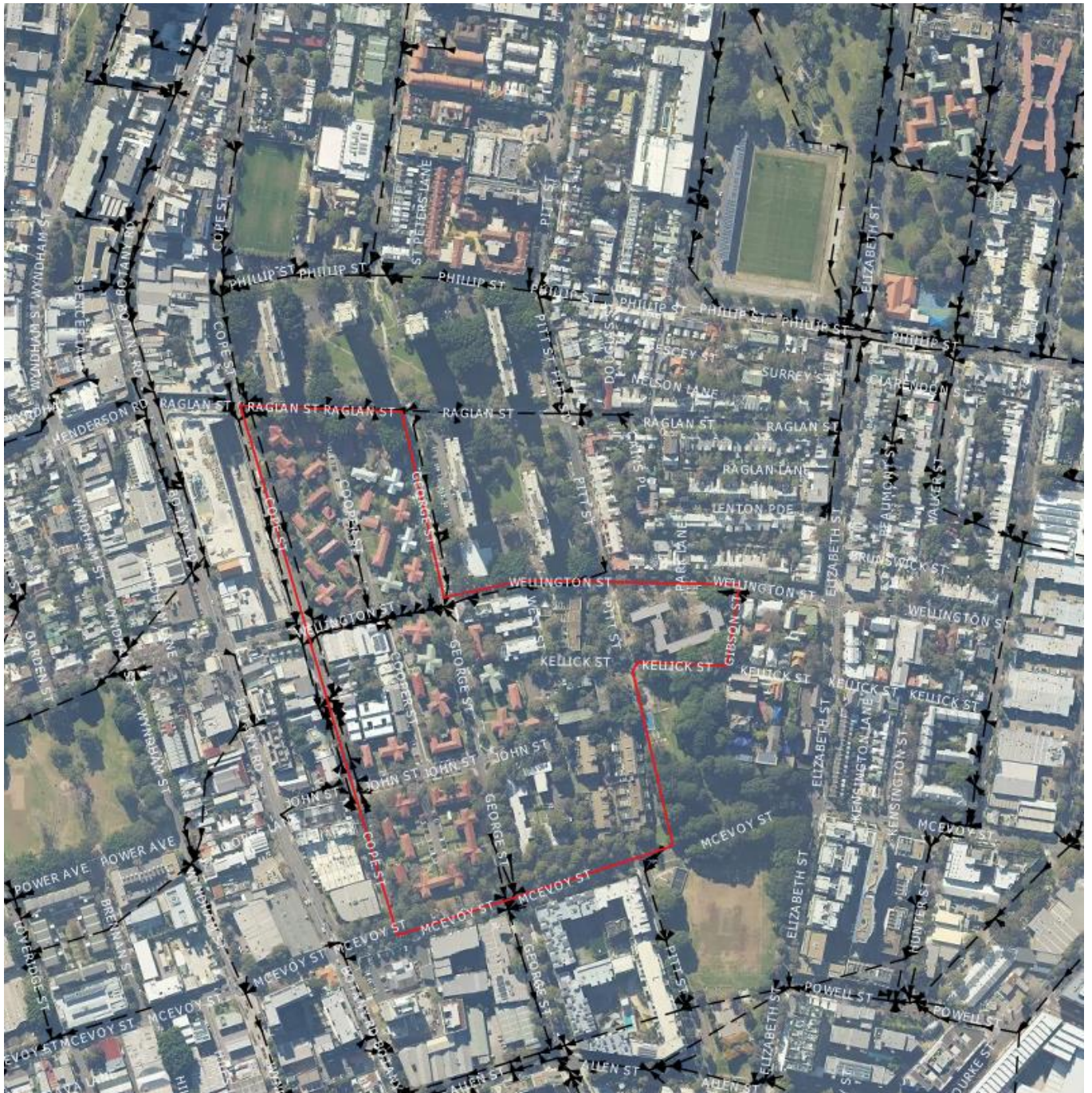


Figure 2.4 Existing Trunk Drainage Network

3. Waterloo Estate (South) Masterplan

The proposed Waterloo Estate (south) Masterplan dated 21 October 2021 is provided in Appendix B. With relevance to flooding and stormwater management, the plan provides for several overland flow paths as shown in Figure 3.1. The plan also suggests locations for car park entry to buildings (Figure 3.2), and documents that some buildings have residential tenancies at ground floor. Other buildings are shown to have commercial tenancies at ground floor. Car parking entries and type of tenancy, subject to overland flooding, will need careful consideration with respect to building floor levels and measures to prevent flood water ingress.



Figure 3.1 Proposed Stormwater Management (Source Hassall, 2021)

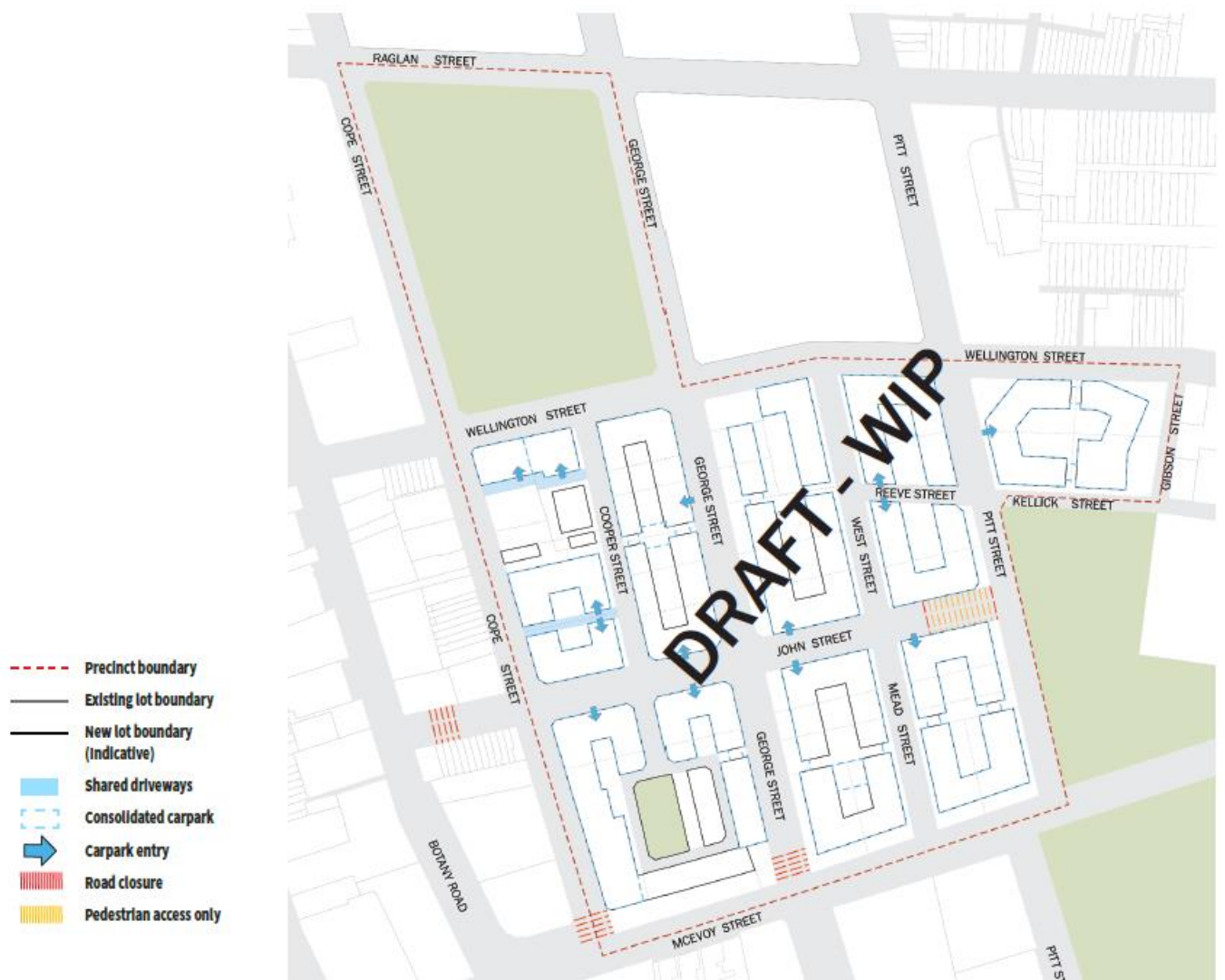


Figure 3.2 Proposed car parking entries (Source Hassell, 2021)

4. Design Criteria and Environmental Objectives

4.1 General

In March 2018 DPIE issued the Study Requirements, Nominated State Significant Precinct – Waterloo (DPIE, 2018). The list of requirements relevant to flood and stormwater management are tabulated in Appendix A. These requirements form the basis of the investigations undertaken in this report and are considered in developing the climate change mitigation and adaptation, stormwater, and flooding management strategies.

4.2 City of Sydney

4.2.1 DCP 2012

The City of Sydney Development Control Plan (DCP 2012) details guidelines, requirements, and controls for managing stormwater and flooding. Key requirements are provided in Section 3. 7 of the DCP:

- A site-specific flood study should be prepared to support the development of the site.
- The connection to the existing stormwater network is not to reduce the capacity of that infrastructure by more than 10%.
- Post development run-off from impermeable surfaces is to be managed by stormwater source measures that contain frequent low-magnitude flows; maintain the natural balance between run-off and infiltration; remove some pollutants prior to discharge into receiving waters; prevent nuisance flows from affecting adjacent properties; and enable appropriate use of rainwater and stormwater.
- The stormwater quality management approach will involve integrating WSUD techniques in the proposed stormwater drainage system. Stormwater quality requirements are as follows:
 - Reduce the baseline and annual pollutant load for litter and vegetation larger than 5 mm by 90%.
 - Reduce the baseline annual pollutant load for total suspended solids by 85%.
 - Reduce the baseline annual pollutant load for phosphorus by 65%.
 - Reduce the baseline annual pollutant load for total nitrogen by 45%.

4.2.2 Interim Floodplain Management Policy

In terms of flooding, the City of Sydney have developed an Interim Floodplain Management Policy with the following requirements to manage flood risk:

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

The Interim Floodplain Management Policy - Table 4 (reproduced in Table 4.1) describes the permissible minimum building floor levels and below ground development requirements for development.

Table 4.1 City of Sydney Interim Floodplain Management Policy - Table 4

Development Type		Type of Flooding	Flood Planning Level	Comments
Residential	Habitable rooms	Mainstream flooding (flood depth greater than 0.25 m 250mm)	1% AEP / 100-year ARI flood level + 0.5 m	Mainstream flooding occurs where the local drainage flooding criteria cannot be satisfied.

Development Type		Type of Flooding	Flood Planning Level	Comments
		Local drainage flooding (less than 250mm flood depth less than 0.25 m)	1% AEP / 100-year ARI flood level + 0.5 m or two times the depth of flow with a minimum of 0.3 m above the surrounding surface if the depth of flow in the 1% AEP 100 year ARI flood is less than 0.25 m	
	Non-habitable rooms such as a laundry or garage (excluding below-ground car parks)	Mainstream or local drainage flooding	1% AEP / 100-year ARI flood level	Mainstream flooding occurs where the local drainage flooding criteria cannot be satisfied.
Industrial or commercial	Retail Floor Levels	Mainstream or local drainage flooding	Merits approach presented by the applicant with a minimum of the 1% AEP / 100-year ARI flood. The proposal must demonstrate a reasonable balance between flood protection and urban design outcomes for street level activation.	Mainstream flooding occurs where the local drainage flooding criteria cannot be satisfied.
Below ground garage/car park	All other belowground car parks	Mainstream or local drainage flooding	1% AEP / 100-year ARI flood level + 0.5 m or the PMF (whichever is the higher).	The below ground garage/car park level applies to all possible ingress points to the car park such as vehicle entrances and exits, ventilation ducts, windows, light wells, lift shaft openings, risers, and stairwells

4.2.3 Alexandra Canal Floodplain Risk Management Study and Plan

The City of Sydney commissioned the Floodplain Risk Management Study and Plan for the Alexandra Canal Catchment to define the existing flooding behaviour and associated hazards, and to investigate possible management options to reduce flood damage and risk and make recommendations for options to be adopted as part of the plan. The tasks were undertaken alongside community consultation to ensure that community concerns were addressed.

Measures available for the management of flood risk were categorised according to the way in which the risk is managed. Various options for flood risk management were identified and assessed. The Plan has taken the prioritised measures from the study and developed an implementation plan for Council.

4.3 Sydney Water Corporation

Sydney Water Corporation is the responsible authority for the local trunk drainage network. LAHC (2020) approached Sydney Water Corporation as part of the earlier LAHC planning proposal request, for applicable minimum onsite detention and permissible site discharge requirements, for the entire estate. Sydney Water Corporation advised LAHC, that properties which must have onsite detention systems include (but are not limited to):

- All commercial, industrial, and special use (e.g., community, education, recreational) buildings or structures.
- Town houses, villas, home units or other strata subdivisions. These may use a single onsite detention system for the total site area if located on common property and the body corporate is responsible for maintenance.
- Dual occupancy lots. Each lot within the dual occupancy must have its own onsite detention system. Each individual lot owner is responsible for maintenance.
- Sealed sporting facilities (e.g., tennis, basketball courts, etc).

Since the Waterloo Estate (South) Planning Proposal forms part of the entire estate, and in the interest of timing, Sydney Water Corporation was not approached for revised onsite detention and permissible site discharge requirements. To this end the controls advised for the entire estate were factored by contributing catchment area, as tabulated below.

Table 4.2 *Sydney Water Corporation Stormwater Quantity Controls*

Location	Contributing Catchment Area	Minimum Onsite Detention	Permissible Site Discharge
Waterloo Estate (North, central & South)	*181,000 m ²	2,900 m ³	5,944 l/s
Factored requirements for Waterloo Estate (South)	123,000 m ²	1,970 m ³	4,039 l/s

Note *: It is acknowledged that the Waterloo Estate total area is 189,000 m². This figure was referenced in Sydney Water Corporation correspondence with LAHC (2020) and has been adopted for the purpose of factoring.

4.4 NSW Flood Prone Land Policy

The Floodplain Development Manual and NSW Flood Prone Land (NSW Government, 2005) policy concerns the management of flood-prone land within NSW. It provides guidelines in relation to the management of flood liable lands, including any development that has the potential to influence flooding, particularly in relation to increasing the flood risk to people and infrastructure. Activities of the project which require the management of flood risk would be subject to consideration under the Floodplain Development Manual.

On 14 July 2021 the Minister of Planning issued Ministerial Direction 4.3 under Section 9.1(2) of the Environmental Planning and Assessment Act 1979. The objectives of this direction are to ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005, and to ensure that the provisions of a local environmental plan that apply to flood prone land are commensurate with flood behaviour and include consideration of the potential flood impacts on and off the subject land.

The direction applies to all relevant planning authorities that are responsible for flood prone land and when a planning proposal authority prepares a planning proposal that creates, removes, or alters a zone or a provision that affects flood prone land. Amongst several directives, a planning proposal must include provisions that give effect to and are consistent with the Considering flooding in land use planning Guideline (DPIE, 2021).

4.5 Australian Rainfall and Runoff 2019

Australian Rainfall and Runoff (ARR, 2019) is the primary technical publication for stormwater and hydrological estimates and design considerations. The current publication was the result of several years of updates to the previous version of Australian Rainfall and Runoff (Engineers Australia, 1987). The technical analysis and development of the hydrologic and hydraulic models, including the management and flooding at the site must consider this guideline.

ARR 2019 documents climate change assessment processes based on projected changes from Global Climate Models (GCMs) and can be explored for four Representative Concentration Pathways (RCP's) for greenhouse gas and aerosol concentrations that were used to derive the GCMs. The use of RCPs 4.5 and 8.5 are recommended by the ARR 2019 guidelines for the assessment, with RCP 8.5 generally accepted as the high-emissions scenario which is frequently referred to as "business as usual", suggesting that is a likely outcome, if society does not make concerted efforts to cut greenhouse gas emissions. The ARR 2019 Data Hub provides the Interim Climate Change Factors as listed in Table 4.3 below.

Table 4.3 *Interim Climate Change Factors – Waterloo Estate*

Year	RCP 4.5	RCP6	RCP 8.5
2030	0.869 (4.3%)	0.783 (3.9%)	0.983 (4.9%)

Year	RCP 4.5	RCP6	RCP 8.5
2040	1.057 (5.3%)	1.014 (5.1%)	1.349 (6.8%)
2050	1.272 (6.4%)	1.236 (6.2%)	1.773 (9.0%)
2060	1.488 (7.5%)	1.458 (7.4%)	2.237 (11.5%)
2070	1.676 (8.5%)	1.691 (8.6%)	2.722 (14.2%)
2080	1.810 (9.2%)	1.944 (9.9%)	3.209 (16.9%)
2090	1.862 (9.5%)	2.227 (11.5%)	3.679 (19.7%)

5. Supporting Simulations

Numerical modelling was used to assess the flooding and stormwater management. Noting the purpose of this report outlined in Section 1.2, the TUFLOW flood model developed by LAHC was simulated for existing conditions and for developed conditions representing the Planning Proposal.

All modelling should be considered as preliminary and would need to be updated during later stages with more detailed studies, when information on landform, development footprints and other matters are further defined.

5.1 Flood Simulations

5.1.1 Model Amendments

The TUFLOW model compiled for the LAHC planning proposal request (May 2020) was updated. The updates and basis of the simulation results are as follows:

- The Planning Proposal building layout within the Waterloo Estate (South) boundary was configured in the model. Buildings were represented as “switched off” model domains. All buildings, beyond the Waterloo Estate (South) boundary were adopted as existing conditions, after confirmation with DPIE.
- The assumptions on roughness with the model was updated to conform with the Planning Proposal layout and intended land use types.
- The LAHC hydrology was adopted without change for Waterloo Estate (South). It is acknowledged that this may include a marginally higher runoff for the precinct, however this should provide a slightly conservative flood level scenario. For Water Estate (North and Central) the existing conditions hydrology was used.
- The proposed pervious and deep planting areas were configured in the model.
- The simulated events were the 1 in 20 AEP 60 minute; 1 in 100 AEP 60 and 90 minutes; and the PMF 30 and 45 minutes. These were the critical events identified by LAHC at the Waterloo Estate.
- Climate change was simulated for a 10% and 20% increase in rainfall intensity in the 1 in 100 AEP event. This was achieved by factoring the hydrology as per the LAHC approach. This approximately corresponds to the 2090 RCP 4.5 and 8.5 scenarios.
- The LAHC design stormwater network was adopted for the Waterloo Estate (South) precinct without change. The LAHC design stormwater network proposed a number of pipe upgrades, for example in Wellington Street. These have been retained without amendment and it is acknowledged that some pipe alignments will require rerouting given new building locations. The Waterloo North and Central estates LAHC design stormwater networks were reset to the existing stormwater networks as consistent with the revised Planning Proposal. This required removal of the LAHC stormwater networks under the Village Green. The design of the stormwater network will need to be undertaken during ensuing stages of the project.
- Stormwater detention volumes were adopted as follows:
 - For the Waterloo Common the LAHC modelled 350 m³ was retained, which is consistent with the volume now proposed to be provided in this location (refer Section 6.3).
 - For the Village Green the detention storage was omitted. This is conservative with relation to flood levels as detention storage is to be provided in this location (or alternative lot-based detention – refer Section 6.3).

5.1.2 Existing Conditions Flooding

Existing conditions flood maps are provided in Appendix C. Table 5.1 lists general observations.

Figure 5.1 shows a plot of the rate of overland flood water rise in Wellington Street, which is considered representative for the site. It shows that flood waters rise rapidly in the space of 30 min for all events simulated. Equally, flood water recedes rapidly after the flood event. This would suggest that there is insufficient time for flood evacuation and a shelter in place flood response would be more appropriate.

Table 5.1 Existing Conditions Flood Mapping

Maps Number	Discussion
C01, C04, C07 Flood depth and level	In the 1 in 20 AEP flood, the trunk drainage system in the roads is already surcharged, with many of storm discharges being conveyed as overland flows primarily within the roads and kerbs. The roads therefore the primary means of stormwater overflow conveyance throughout the Estate and can be designated as the 'floodway' hydraulic category. The flood maps show deeper pooling water at the intersection of George and McEvoy streets, with a general north-western conveyance of flood water from south-eastern catchments towards the intersection of Cope Street and John Street. Flood water pooling additionally occurs along Cope Street, between Wellington and John Street, as north-eastern overland flows are directed to the mid-block drainage channel between Botany and Cope Street. Flood depths in and around Waterloo Estate (south) roads are approximately 50 mm to 150 mm depending on location, increasing to 500 to 600 mm at the intersection of George and McEvoy streets where flood waters pool. Along Cope Street, between Wellington and John Street where flood waters pool, flood depths are in the order of 600 mm to 900 mm. It is noted, as shown in Figure 5.2, the overland flooding flows are significantly greater than the flows conveyed by the trunk stormwater system. This would suggest that there is limited flood mitigation that can be achieved using the trunk stormwater system upgrades. However, this would vary across the estate and would need to be reviewed at detailed design stage. In the 1 in 100 AEP flood, similar conveyance as described above is noted. Flood depths in and around Waterloo Estate (south) roads are approximately 100 mm to 200 mm depending on location, increasing to 550 to 600 mm at the intersection of George and McEvoy streets where flood waters pool. Along Cope Street, where flood waters pool, flood depths are in the order of 1200 mm. In the PMF flood, wide spread flooding is noted in the roads surrounding the Waterloo Estate (South) precinct. Flood depths are approximately 200 mm to 300 mm in the roads approaching Cope Street, with the deepest flood waters near the intersection of Wellington and Cope Street. Near the intersection of George and McEvoy streets, where flood waters pool, flood depths are approximately 800mm deep. Along Cope Street, where flood waters pool, flood depths are in the order of 1.5 to 2.0 mm.
C02, C05, C08 Flood Velocity	Since most of the overland flood conveyance is within the roadways, greater in the roads compared to the lots. Typically flood velocities in the 1 in 20 AEP event are in the order of 1 to 1.5 m/s. In the 1 in 100 AEP event these increase to 1.5 to 2 m/s, particularly in steeper roads. In a PMF many streets exhibit flood velocities of 2 to 2.5 m/s, with steeper sections of Raglan and Wellington Street exhibiting flood velocities above 3 m/s.
C03, C06, C09 Flood Hazard	In the 1 in 20 AEP flood, the majority of the roadways would be designated as Hazard H1, being '<i>relatively benign flow conditions with no vulnerability constraints</i>'. The exception is the pooling areas described above, where flood hazard is elevated. Along Cope Street, where flood waters pool, flood hazard is designated as H3 '<i>Unsafe for all vehicles, children and the elderly</i>'. At the intersection of George and McEvoy streets where flood waters pool, the flood hazard is H2 '<i>Unsafe for small vehicles</i>'. In the 1 in 100 AEP flood the majority of the roadways would remain designated as Hazard H1, being '<i>relatively benign flow conditions with no vulnerability constraints</i>'. The exception is Cope Street where the flood hazard is elevated to H2 '<i>Unsafe for small vehicles</i>'. Along Cope Street, where flood waters pool, flood hazard is designated as H3 '<i>Unsafe for all vehicles, children and the elderly</i>'. At the intersection of George and McEvoy streets where flood waters pool, the flood hazard is elevated to H3 '<i>Unsafe for all vehicles, children and the elderly</i>' in some locations. In a PMF, many of the road's exhibit H5 food hazard, "<i>being unsafe for all people and all vehicles</i>".

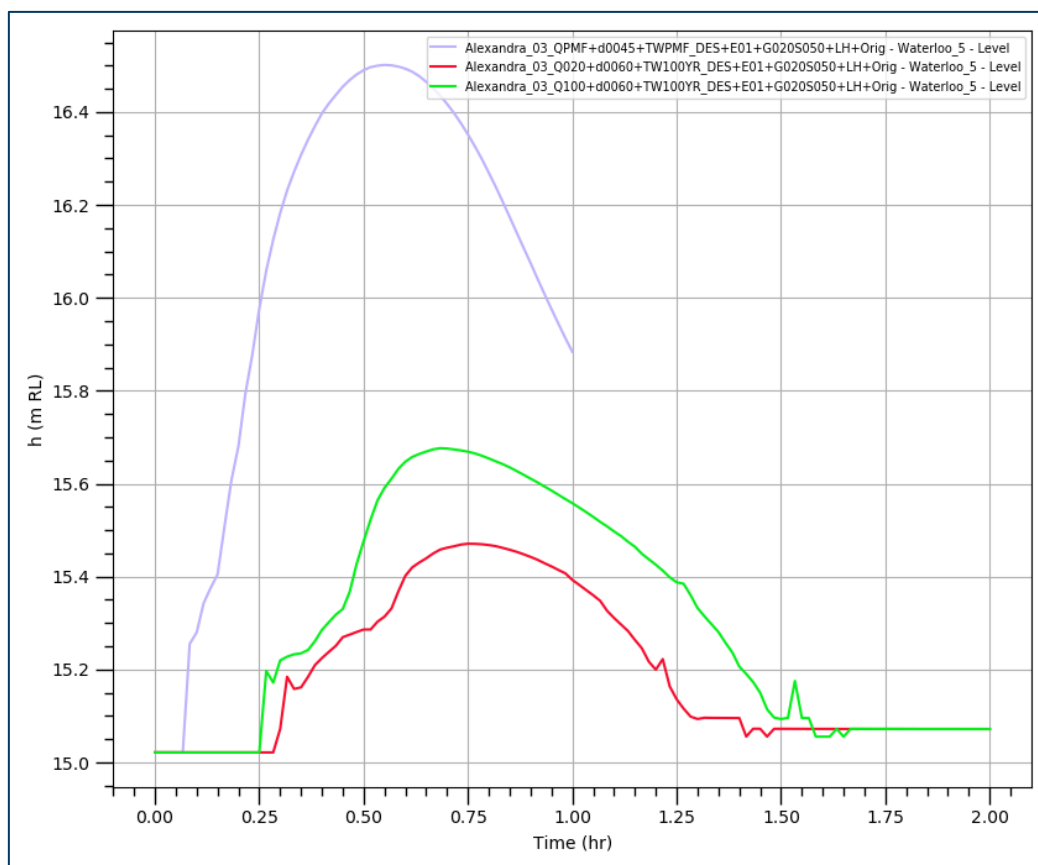


Figure 5.1 Rate of Rise – Wellington Street

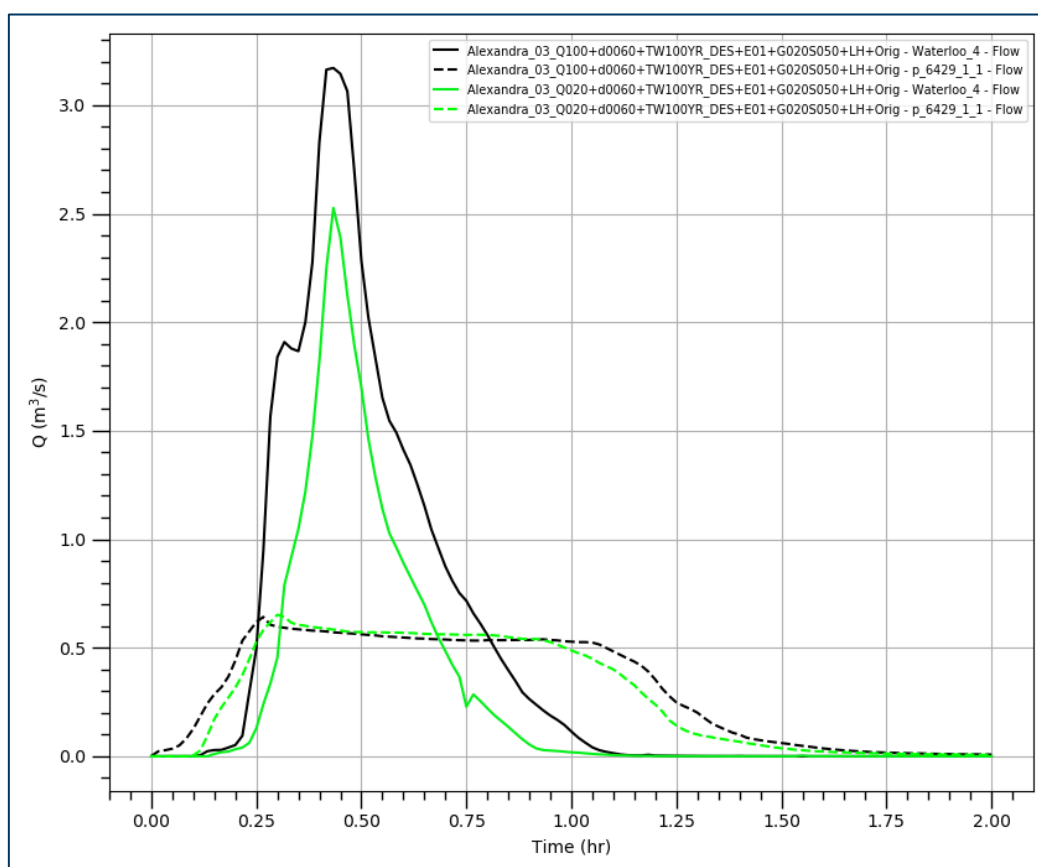


Figure 5.2 Wellington Street - trunk (dashed) versus overland (solid) flood flows

5.1.3 Developed Conditions Flooding

Existing conditions flood maps are provided in Appendix C. Table 5.2 lists general observations. In terms of the intersection of McEvoy and George Street, where flood levels are increased by approximately 55 mm as proposed buildings along the western edge of George Street obstruct the overland flood flows, it is considered possible that these impacts could be reduced with future detailed design of the local drainage system and the detention basin proposed beneath Waterloo Common.

At a qualitative level, cumulative impacts associated with the future development of Waterloo Estate (north and Central) are considered to be manageable on the basis that the Village Green provides opportunities for future management of flood flows. This was demonstrated in the LAHC planning proposal request (May 2020) which included additional flood detention within the Village Green together with an upgraded trunk drainage network in that location. Stormwater quality management would adopt a similar approach as documented in Section 6.

Table 5.2 *Developed Conditions Flood Mapping*

Maps Number	Discussion
C10, C13, C16 Flood depth and level	In the 1 in 20 AEP flood, for developed conditions, flood levels are similar to existing conditions for much of the roads surrounding the Waterloo Estate (South) precinct. There are minor changes in flood level in some areas as discussed further in under Flood Impact - Development. In the 1 in 100 AEP flood, the same is noted for much of the site, with exception of the intersection of George and McEvoy Streets, where there is a minor increase in flood levels. These matters discussed under Flood Impact – Development, below.
C11, C14, C17 Flood Velocity	For developed conditions flood velocities are similar to existing conditions.
C12, C15, C18 Flood Hazard	For developed conditions flood velocities are similar to existing conditions.
C19 and C20 Flood Impact - Development	In the 1 in 20 AEP flood, the Planning Proposal generally does not increase flood levels, beyond the site boundary. The exception are a few isolated locations along Cope Street which are attributed to modelling instabilities. In the area of Wellington Street and Botany Road, flood levels are marginally reduced by approximately 30 mm. This is attributed to the LAHC design stormwater network in this location which has been adopted for the present flood modelling. Within the precinct there are a number of locations behind buildings, where flood levels are shown to increase. This is also attributed to the configuration of the stormwater network, which will be designed under future project stages. In the 1 in 100 AEP flood, observations are similar to the 1 in 20 AEP flood, with the exception of the intersection of McEvoy and George Street. Here, flood levels are increased by approximately 55 mm, as proposed buildings along the western edge of George Street obstruct the overland flood flows. It is noted that the increases in flood levels are mostly within the precinct boundary, with a small area along the northern road verge of McEvoy Street affected and a small overflow to the in the vicinity of George Street to the southern McEvoy Street verge. Beyond these areas, buildings are not affected in this location.
C21, C22, C23 DCP triggers	Figure C21 has been prepared to identify the “type of flooding” as defined by City of Sydney Interim Floodplain Management Policy - Table 4 (Section 4.2). These show the areas of mainstream flooding and local drainage flooding as defined. Figure C22 and C23, has been prepared to identify the “below ground garage/car park” flood planning levels as defined by City of Sydney Interim Floodplain Management Policy - Table 4 (Section 4.2). The figures provide the envelope flood levels of the maximum, when comparing the 1 in 100 AEP flood plus 0.5m and the PMF flood.

5.1.4 Climate Change

The assessment of climate change risk was undertaken using the flood model 1 in 100 AEP event to determine potential climate change impacts. For the purposes of the assessment, the RCP 4.5 and RCP 8.5 climate change scenarios have been simulated for the 2090 planning horizon. This was achieved by simulating rainfall intensity increases of 10 % and 20% respectively, which approximately correspond to the estimates in Table 4.3. These increases were implemented in the flood model by factoring the inflow hydrology by 10% and 20%. Table 5.3 and Table 5.4 summarise the climate change impacts.

Table 5.3 *Climate Change Assessment*

Maps Number	Discussion
C24, C27 Flood depth and level	These figures provide the 10% and 20% increased rainfall intensity flood levels and depths. The chances are discussed under 'Climate Change Impact' below. The changes are between 30 and 100 mm and are difficult to discern on the flood mapping.
C25, C28 Flood Velocity	These figures provide the 10% and 20% increased rainfall intensity flood velocities. The changes are minor and are difficult to discern on the flood mapping.
C26, C29 Flood Hazard	These figures provide the 10% and 20% increased rainfall intensity flood hazard. The changes are minor and are difficult to discern on the flood mapping.
C30 to C33 Climate Change Impact	Climate change impact flood mapping has been prepared, compared to existing conditions flood mapping and to design conditions flood mapping. Under the 10% increase in rainfall scenario (RCP4.5), flood depths catchment wide increase by approximately 20 mm to 30 mm in areas where flood conveyance is unobstructed. In areas, where pooling can occur, such as trapped low points, flood impacts are increased to 50 mm to 100mm, due to the increased flood volumes. In the precinct, at the George and McEvoy streets intersection where flood waters pool, flood levels are simulated to increase by approximately 30 mm. Along Cope Street, where flood waters pool, flood levels are simulated to increase by a similar magnitude. Under the 20% increase in rainfall scenario (RCP8.5), flood depths catchment wide increase by approximately 30 mm to 40 mm in areas where flood conveyance is unobstructed. In areas, where pooling can occur, such as trapped low points, flood impacts are increased to 100 mm to 200mm, due to the increased flood volumes. In the precinct, at the George and McEvoy streets intersection where flood waters pool, flood level is simulated to increase by approximately 50 mm. Along Cope Street, where flood waters pool, flood levels are simulated to increase by approximately 75 mm.

Table 5.4 *Flood Level Increase compared to Design Flood Level*

Location	Flood Level (mAHD)	Flood level Increase (m)		Flood Level (mAHD)	
		10% Climate Change	20% Climate Change	10% Climate Change	20% Climate Change
Intersection George and McEvoy Streets	16.89	0.03	0.05	16.92	16.95
Cope Street between John and Wellington Street	15.64	0.03	0.08	15.67	15.72

5.2 Stormwater Management

As outlined in Section 6 stormwater management, with respect to both detention and stormwater quality is addressed by:

- Provision of a per unit catchment area detention volume specified by Sydney Water Corporation.
- Provision of general per unit catchment area stormwater quality treatment measures, confirmed based on MUSIC modelling undertaken for the previous LAHC assessment.

As such, further stormwater modelling was not deemed necessary at this stage. Detailed stormwater modelling is recommended in subsequent detailed design stages.

6. Stormwater and Flood Management Strategy

The following sections outline the proposed stormwater and flood management strategy developed based on the revised precinct layout, identified criteria, and supporting simulations.

6.1 General

6.1.1 Water Sensitive Urban Design (WSUD) Principles

Water usage and water conservation along with maintaining the health of the surrounding environment are important considerations of any proposed development.

In general, the Water Sensitive Urban Design (WSUD) principles for stormwater and flood management at the site should aim to retain as much stormwater as possible on site, transport as little stormwater as possible to receiving waters, 'lose' as much stormwater as possible along the treatment train and slow the transmission of stormwater to receiving waters. The treatment train should remove the pollutants of concern to the relevant treatment standards.

6.1.2 Objectives

In applying the above principles, key planning and design objectives are generally:

- Integrate stormwater treatment into the landscape by incorporating multiple-use corridors that maximise the visual and recreational amenity of the development.
- Protect water quality draining from the development.
- Reduce runoff and peak flows from developments by employing local or regional detention measures, minimising impervious areas and maximising re-use.
- Add value, while minimising drainage infrastructure development costs.
- Flood management, flow management and flow attenuation.

6.1.3 Waterloo Estate (South) Opportunities

General opportunities for Water Sensitive Urban Design (WSUD) at the Waterloo Estate site include:

- Maximise source control measures in preference to end of line treatment measures.
- Maintain and re-establish vegetation along public open spaces and develop multi-use corridors.
- Preserve and restore existing valuable elements of the stormwater drainage system.
- Manage the quality and quantity of stormwater at or near the source, which will involve a significant component of public education and community involvement.
- At source water quality treatment measures such as localised bio-retention areas or proprietary devices.

6.2 Stormwater Quality Management

6.2.1 Operational

As outlined in Section 4.2 a stormwater quality management approach, integrating Water Sensitive Urban Design (WSUD) measures, is recommended for integration in the proposed stormwater drainage system. These measures aim to reduce the stormwater quality impacts to downstream systems associated with urban catchments with the benefit of improving the amenity and environmental outcomes of the proposed works. The pollutant reduction requirements (Section 4.2) are generally industry standard and should be satisfied in the proposed stormwater quality management strategy.

Since stormwater is primarily collected in existing trunk underground drainage networks, in the order of 1 to 2 m below the ground surface, the provision of regional 'end of pipe' stormwater quality control measures is not considered feasible for the Waterloo Estate Precinct. These systems are often better suited to 'greenfield' developments. Therefore, the provision of 'at-source' water quality treatment is considered better suited for the Waterloo Estate Precinct. Accordingly, a suite of varied at-source treatments dependent on the land use at each location, are recommended across the precinct. Given the planning proposal stage of the project, detailed final identification of each water quality treatment feature is not possible since this is dependent on ensuing precinct design.

The recommendations of LAHC (2020) are therefore supported, which proposed:

- In private domain areas, stormwater quality targets are to be achieved by employing on-lot measures as required, which will be developed in the detailed design stage.
- In public domain areas, the following stormwater quality treatment measures are proposed:
 - Raingardens within some open space areas, collecting runoff from adjacent pavement areas.
 - Streetside tree pits and verge raingardens, subsequently discharging to the underground drainage network.
 - Proprietary underground stormwater quality devices where space limitations exist.

Through MUSIC water quality modelling, LAHC (2020) found that the water quality treatment targets outlined in Section 4.2 can generally be satisfied with the provision of:

- Bio-filtration treatment areas with a surface area that are 2 % of the contributing catchment areas.
- Bio-filtration treatment areas with a surface area that are 4 % of the contributing catchment areas, in cases where 10 % of the catchment area bypasses the treatment.

Bio-filtration treatment areas equivalent or greater to this would be provided within tree pits, or within road/open space raingarden areas. The MUSIC modeling also demonstrated that proprietary stormwater quality treatment devices could potentially satisfy pollutant reduction targets, in areas when bio-filtration cannot be accommodated.

6.2.2 Construction Phase

Construction phase water quality impacts will be managed through the implementation of Soil and Water Management Plans detailing stormwater management strategies in accordance with 'Soils and Construction, Managing Urban Stormwater' (Landcom 2004). Specific strategies may include:

- Material management practices.
- Stockpile practices.
- Topsoil practices.
- Erosion control practices (earth sediment basins, straw bales, sediment fences, turbidity barriers, stabilised site accesses, diversions and catch drains).

Monitoring, including visual inspections and water quality sampling, will be required as part of any development consent to ensure that management strategies are working effectively.

6.3 Stormwater Quantity Management

Sydney Water Corporation, the responsible authority for the local trunk drainage network, advised LAHC (2020) on onsite detention and permissible site discharge requirements for the entire Waterloo Estate. This advice has been factored for the Waterloo Estate (South) precinct in Section 4.3. Based on this advice a stormwater detention volume of 1,970 m³ and 4,039 l/s permissible site discharge is required for the precinct.

Subject to the future design and layout of the trunk drainage stormwater network within the precinct the following is proposed:

- 1620 m² as underground storage located underneath the Village Green.
- 350 m² as underground storage located underneath the Waterloo Common.

The underground storage in the Waterloo Common would receive flows from upgradient areas conveyed directly into the storage, depending on the trunk stormwater network alignment. It must be noted that site topography, may limit the depth of the detention storage to 0.5m. The available area at the Waterloo Common is approximately 1000 m² and therefore up to 500 m³ may be available at this location.

Based on site topography, conveyance of flows from the lowest portion of the site at the western perimeter to the Village Green, may be feasible with the construction of deep culverts. However, this would be subject to future detailed design considerations. Further the available area at the Village Green is substantial for a much larger detention facility. A larger facility may be required if this location is also used to detain flows from the future Waterloo Estate (North) and Waterloo Estate (Central) precincts. These matters are to be considered in future detailed design. If this is unfeasible, on-lot detention may be provided as an alternative in consultation with Sydney Water Corporation.

Permissible site discharge requirements as stipulated in Section 4.3 would need to be complied with during detailed design.

6.4 Flooding and Flood Risk Management

Development and land-use in flood prone areas at the Waterloo Estate (South) should be in accordance with City of Sydney DCP 2012, the City of Sydney Interim Floodplain Management Policy, the NSW Floodplain Development Manual, and the Ministerial Direction 43. In assessing the flood risk, consideration needs to be given to the full range of risks to people and property, for a full range of flood events up to and including the PMF. The following flood risk management guidelines should be adopted:

- ▶ Future design stages within the precinct should be supported by further detailed flood studies to define the flood and flood impacts. The flood studies should provide the relevant information to inform assessments against guidelines such as the City of Sydney DCP 2012 and Interim Floodplain Management policy, the NSW Floodplain Development Manual 2015, and the Ministerial Direction 4.3.
- ▶ The City of Sydney DCP 2012 flood controls for residential, industrial, commercial, and below ground garages/ car parks, as listed in Table 4.1, should be adopted together with other controls documented in the City of Sydney Interim Floodplain Management Policy. In addition, controls recommended in the Alexandra Canal Floodplain Risk Management Study and Plan should be adopted in particular with reference to Critical Facilities.
- ▶ For development in flood prone areas development must not lead to a significant increase in flood levels, flood damages, flood behaviour or flood hazard at the site or elsewhere. Provision of adequate and acceptable compensating works to offset flood impacts and lower flood risk must be provided.
- ▶ Emergency Response Measures Recommended for Implementation under the Alexandra Canal Floodplain Risk Management Study and Plan should be considered. These include, amongst others, EM3 - Prepare a Local Flood Plan, EM 5 Public Awareness and Education and EM6 – Flood Warning Signs at Critical Locations.
- ▶ Flood response planning must be provided up to the PMF level. Given the short duration of inundation and rapid rate of rise, 'a shelter in place' flood response is the preferred approach compared to flood evacuation. This would reduce unnecessary vehicular and pedestrian movements during flood events. The flood response plan must ensure flood information is available to current and future occupants and visitors to buildings and flood prone areas of the precinct. Operational flood emergency response plans are recommended for individual buildings which nominate appropriate muster areas and sheltered spaces, flood response triggers and evacuation routes if appropriate.

7. Assessment against DPIE Study Requirements, 2018 and Ministerial Direction 4.3

The proposed Stormwater and Flood Management Strategy was reviewed against the DPIE Study Requirements, 2018 and Ministerial Direction 4.3, as outlined in Table 7.1.

Table 7.1 Study Requirements Review

Requirement	Response
DPIE Study Requirements, 2018	
17.1. Provide an assessment of any potential impacts of the proposal on the hydrology and hydrogeology of the urban renewal precinct and adjoining areas, with particular focus on water quality, and to water quality targets in the City of Sydney DCP 2012:	Refer to Sections 6.2 and 6.3. Stormwater detention is to be provided in accordance with the requirements of Sydney Water Corporation. A water quality management approach is proposed, which indicating compliance with the City of Sydney water quality targets.
17.2. Provide a concept Stormwater Management Plan outlining the general stormwater management measures for the proposal, with particular emphasis on possible WSUD options.	Refer to Section 6 which includes potential WSUD measures.
17.3. Consider the effect of climate change and changing rainfall patterns and undertake a sensitivity analysis to address the risks and impacts.	Refer to Section 5.1.4
17.4. Provide a flood risk assessment developed in consultation with City of Sydney Council identifying flooding behaviours for existing and developed scenarios in order to outline the suitability of the land for proposed uses. Identify flooding characteristics i.e., flow, levels, extent, velocity, rate of rise, hydraulic and hazard categories, for the full range of flooding up to the probable maximum flood (PMF), for both mainstream and overland flow path.	Refer to Section 5.1 and supporting flood mapping in Appendix C
17.5. Consider the future cumulative flood risk impact across the entire Waterloo Precinct and adjoining land areas.	Refer to Section 5.1.3
17.6. Address the impact of flooding on future proposed development including flood risk to people and properties for key flood events including the 1% AEP and the probable maximum flood (PMF) event. The assessment is to address relevant provisions of the NSW Floodplain Development Manual (2005).	Refer to Section 5.1 and supporting flood mapping in Appendix C
17.7. Provide an assessment of possible impacts of the proposal on the flood behaviour (i.e., flow levels, extent, velocities, and duration of flooding) and any impact of the proposal on adjacent, downstream, and upstream areas.	Refer to Section 5.1 and supporting flood mapping in Appendix C
17.8. Provide concept level information on the impacts of future earthworks and filling of land within the proposal. This assessment is to be based on an understanding of staging and cumulative flood impacts.	The basis of this assessment is that no earthworks or filling of land is proposed.
17.9. Provide preliminary assessment on recommended flood management measures including mitigation works and development controls.	Refer to Section 6.4
17.10. Provide recommendations regarding the most appropriate emergency response strategy to manage risk to life.	Refer to Section 6.4
17.11. Provide concept level details of the drainage associated with the proposal, including stormwater drainage infrastructure and address the impact of stormwater flows on the site from other catchments.	The LAHC design stormwater network was adopted for the Waterloo Estate (South) precinct without change. The LAHC design stormwater network proposed a number of pipe upgrades, for example in Wellington Street. These have been retained without amendment and it is acknowledged that

Requirement	Response
	some pipe alignments will require rerouting given new building locations. The Waterloo North and Central estates LAHC design stormwater networks were reset to the existing stormwater networks as consistent with the revised Planning Proposal. This required removal of the LAHC stormwater networks under the Village Green. The design of the stormwater network will need to be undertaken during ensuing stages of the project.
17.12. In addition to securing an acceptable level of personal and property safety from flooding, the proposal is to ensure that measures to address flooding can achieve high quality urban design outcomes, including ground floor public – private domain engagement i.e., how ground floor retail can be entered at ground at footpath level, and promote water quality outcomes through measures such as water sensitive urban design (in the public and private domains).	Refer to Section 6. Urban design outcomes will require attention in future stages, when building configurations are further defined
17.13. Prepare an implementation plan for the concept Stormwater Management Plan and Flood Risk Assessment.	These will be prepared during future design stages of the project.
17.14. Demonstrate, through assessment against established criteria, how the proposed flooding and stormwater strategy achieves acceptable water quantity and quality outcomes, and in particular, promotes water sensitive urban design.	Refer to Section 6.
Ministerial Direction 4.3	
A planning proposal must include provisions that give effect to and are consistent with: (a) the NSW Flood Prone Land Policy, (b) the principles of the Floodplain Development Manual 2005, (c) the Considering flooding in land use planning guideline 2021, and (d) any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manual 2005 and adopted by the relevant council.	The documents listed in (a) to (c) have been adopted as the basis of the assessments in this report. The Alexandra Canal Floodplain Risk Management Study and Plan (CoS 2014) does not recommend any structural floodplain risk management works within the precinct area.
A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Environmental Protection Zones to a Residential, Business, Industrial or Special Purpose Zones.	To be determined by others
A planning proposal must not contain provisions that apply to the flood planning area which: (a) permit development in floodway areas, (b) permit development that will result in significant flood impacts to other properties, (c) permit development for the purposes of residential accommodation in high hazard areas, (d) permit a significant increase in the development and/or dwelling density of that land, (e) permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate, (f) permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent, (g) are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or	(a) Refer to Section 5.1.2. Roadways throughout the precinct are identified as floodways. (b) Refer to Section 5.1.3 (c) Refer to Section 5.1.3 (d) Refer to Section 5.1.3 (e) This matter is to be determined in future design stages (f) This matter is to be determined under future design stages (g) Given the simulated impacts of the proposal, increased requirement for government spending on emergency management services is unlikely. (h) This matter is to be determined in future design stages

Requirement	Response
(h) permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.	
A planning proposal must not contain provisions that apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply which: (a) permit development in floodway areas, (b) permit development that will result in significant flood impacts to other properties, (c) permit a significant increase in the dwelling density of that land, (d) permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate, (e) are likely to affect the safe occupation of and efficient evacuation of the lot, or (f) are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities.	Special flood considerations (SFC) are particular flood risk considerations that a consent authority must be satisfied with before granting consent to certain types of development that have been identified by councils and the state government as having a higher risk to life and warranting the consideration of the impacts of rarer flood events on land located outside the Flood Planning Area. These types of development require special flood considerations relating to the management of risk to life and the risk of hazardous industry/hazardous storage establishments to the community and the environment in the event of a flood. This matter is to be determined in future design stages when Special flood considerations (SFC) have been defined. In the meantime, controls recommended in the Alexandra Canal Floodplain Risk Management Study and Plan should be adopted in particular with reference to Critical Facilities.
For the purposes of preparing a planning proposal, the flood planning area must be consistent with the principles of the Floodplain Development Manual 2005 or as otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant Council.	The flood planning area is considered consistent with the principles of the Floodplain Development Manual 2005

8. Conclusions

- Several opportunities for management of stormwater quality, quantity and flooding exist at the Waterloo Estate (South) precinct, through the implementation the Waterloo Estate (South) Stormwater and Flood Management Strategy as documented in this report.
- The Waterloo Estate (South) Stormwater and Flood Management Strategy the following, which are recommended to be included in the design guide:
 - In private domain areas, City of Sydney DCP 2012 stormwater quality targets are to be achieved by employing on-lot measures as required, which will be developed in the detailed design stage.
 - In public domain areas, City of Sydney DCP 2012 stormwater quality targets are to be achieved by implementing stormwater quality treatment measures, which include:
 - Raingardens within some open space areas, collecting runoff from adjacent pavement areas.
 - Streetside tree pits and verge raingardens, subsequently discharging to the underground drainage network.
 - Proprietary underground stormwater quality devices where space limitations exist.
 - Construction phase water quality impacts will be managed through the implementation of Soil and Water Management Plans detailing stormwater management strategies in accordance with 'Soils and Construction, Managing Urban Stormwater' (Landcom 2004).
 - Stormwater detention requirements as stipulated by Sydney Water Corporation are to be adopted as follows. Subject to the future design and layout of the trunk drainage stormwater network within the precinct the following is proposed:
 - 1620 m² as underground storage located underneath the Village Green.
 - 350 m² as underground storage located underneath the Waterloo Common.
 - The City of Sydney DCP 2012 and Interim Floodplain Management Policy flood controls for residential, industrial, commercial, and below ground garages/ car parks should be adopted. In addition, controls recommended in the Alexandra Canal Floodplain Risk Management Study and Plan should be adopted in particular with reference to Critical Facilities. Emergency Response Measures Recommended for Implementation under the Alexandra Canal Floodplain Risk Management Study and Plan should be considered. Flood response planning must be provided up to the PMF level.
- The results of this assessment show, that with further future detailed design, the Waterloo Estate (South) Stormwater and Flood Management Strategy can meet the requirements of the Study Requirements, Nominated State Significant Precinct – Waterloo (DPIE, 2018), stormwater and flooding controls nominated by the City of Sydney, stormwater requirements pertaining to detention and site discharge nominated by Sydney Water corporation and requirements under the NSW Flood Prone Land Policy and Ministerial Direction 4.3.

9. References

- CoS 2021, Planning Proposal – Waterloo Estate (South) – Sydney Local Environmental Plan 2012 Amendment, City of Sydney, 2021.
- CoS 2014, Floodplain Risk Management Plan, Alexandra Canal Floodplain Risk Management Study and Plan W4948, Prepared for City of Sydney by Cardno, 20 May 2014.
- DPIE 2021, IRF21/2528, Gateway determination report – PP 2021 – 3265, Waterloo Estate (South) – Renewal of social housing under Communities Plus (total of 3060 dwellings and 18,000 sqm non-residential floorspace).
- LAHC 2020, Land and Housing Corporation planning proposal request (May 2020), Attachment B22, Water Quality, Flooding and Stormwater Study – Waterloo Estate (South) – Land and Housing Corporation, prepared by AECOM March 2020.
- DPIE 2018, Study Requirements, Nominated State Significant Precinct – Waterloo, March 2018.
- CRC for Catchment Hydrology, Music Model User Guide, April 2005.
- ARR 2019, Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) Australian Rainfall and Runoff: A Guide to Flood Estimation, © Commonwealth of Australia (Geoscience Australia), 2019.
- NSW Government, Floodplain Development Manual, 2005.
- Ministerial Direction 4.3, Minister of Planning, 14 July 2021.
- DPIE 2021, Considering flooding in land use planning Guideline, July 2021
- DCP 2012, City of Sydney Development Control Plan
- CoS 2014, City of Sydney, Interim Floodplain Management Policy
- Landcom 2004, Soils and Construction, Managing Urban Stormwater, March 2004.

Appendix A

Basis of Report and Clarification

Table A.1 *DPIE Study Requirements, Nominated State Significant Precinct – Waterloo Revised March 2018 - Water Quality, Flooding and Stormwater*

Requirement	Response
17.1. Provide an assessment of any potential impacts of the proposal on the hydrology and hydrogeology of the urban renewal precinct and adjoining areas, with particular focus on water quality, and to water quality targets in the City of Sydney DCP 2012:	Adopt and reference much of the work undertaken by LAHC. Respond to the CoS masterplan amendments around George and McEvoy streets.
17.2. Provide a concept Stormwater Management Plan outlining the general stormwater management measures for the proposal, with particular emphasis on possible WSUD options.	Adopt and reference much of the work undertaken by LAHC. Respond to the CoS masterplan amendments around George and McEvoy streets
17.3. Consider the effect of climate change and changing rainfall patterns and undertake a sensitivity analysis to address the risks and impacts.	Work from the reporting completed by LAHC and carry out additional assessment considering impacts of projected rainfall patterns due to climate change on the CoS masterplan, as identified in the revised modelling. Assess the risks to identify potential adaptation/mitigations for adoption by CoS.
17.4. Provide a flood risk assessment developed in consultation with City of Sydney Council identifying flooding behaviours for existing and developed scenarios in order to outline the suitability of the land for proposed uses. Identify flooding characteristics i.e., flow, levels, extent, velocity, rate of rise, hydraulic and hazard categories, for the full range of flooding up to the probable maximum flood (PMF), for both mainstream and overland flow path.	Adopt and reference much of the work undertaken by LAHC. Respond to the CoS masterplan amendments around George and McEvoy streets. To be updated with TUFLOW modelling.
17.5. Consider the future cumulative flood risk impact across the entire Waterloo Precinct and adjoining land areas.	Adopt and reference work undertaken by LAHC. No additional assessment to be undertaken.
17.6. Address the impact of flooding on future proposed development including flood risk to people and properties for key flood events including the 1% AEP and the probable maximum flood (PMF) event. The assessment is to address relevant provisions of the NSW Floodplain Development Manual (2005).	Adopt and reference much of the work undertaken by LAHC. Respond to the CoS masterplan amendments around George and McEvoy streets. To be updated with TUFLOW modelling.
17.7. Provide an assessment of possible impacts of the proposal on the flood behaviour (i.e., flow levels, extent, velocities, and duration of flooding) and any impact of the proposal on adjacent, downstream, and upstream areas.	Adopt and reference much of the work undertaken by LAHC. Respond to the CoS masterplan amendments around George and McEvoy streets. To be updated with TUFLOW modelling.
17.8. Provide concept level information on the impacts of future earthworks and filling of land within the proposal. This assessment is to be based on an understanding of staging and cumulative flood impacts.	Adopt and reference work undertaken by LAHC. No additional assessment to be undertaken.
17.9. Provide preliminary assessment on recommended flood management measures including mitigation works and development controls.	Adopt and reference much of the work undertaken by LAHC. Respond to the CoS masterplan amendments around George and McEvoy streets. To be updated with TUFLOW modelling.
17.10. Provide recommendations regarding the most appropriate emergency response strategy to manage risk to life.	Adopt and reference much of the work undertaken by LAHC. Respond to the CoS masterplan amendments around George and McEvoy streets. To be updated with TUFLOW modelling.
17.11. Provide concept level details of the drainage associated with the proposal, including stormwater drainage infrastructure and address the impact of stormwater flows on the site from other catchments.	Adopt and reference work undertaken by LAHC. No additional assessment to be undertaken.
17.12. In addition to securing an acceptable level of personal and property safety from flooding, the proposal is to ensure that measures to address flooding can achieve high quality urban design outcomes, including ground floor public – private domain engagement i.e., how ground floor retail can be entered at ground at footpath level, and promote water quality outcomes	Adopt and reference work undertaken by LAHC. No additional assessment to be undertaken.

Requirement	Response
through measures such as water sensitive urban design (in the public and private domains).	
17.13. Prepare an implementation plan for the concept Stormwater Management Plan and Flood Risk Assessment.	Adopt and reference work undertaken by LAHC. No additional assessment to be undertaken.
17.14. Demonstrate, through assessment against established criteria, how the proposed flooding and stormwater strategy achieves acceptable water quantity and quality outcomes, and in particular, promotes water sensitive urban design.	Adopt and reference much of the work undertaken by LAHC. Respond to the CoS masterplan amendments around George and McEvoy streets. To be updated with TUFLOW modelling.

Appendix B

Waterloo Estate (South) Masterplan

OPTION 4 REFERENCE PLAN

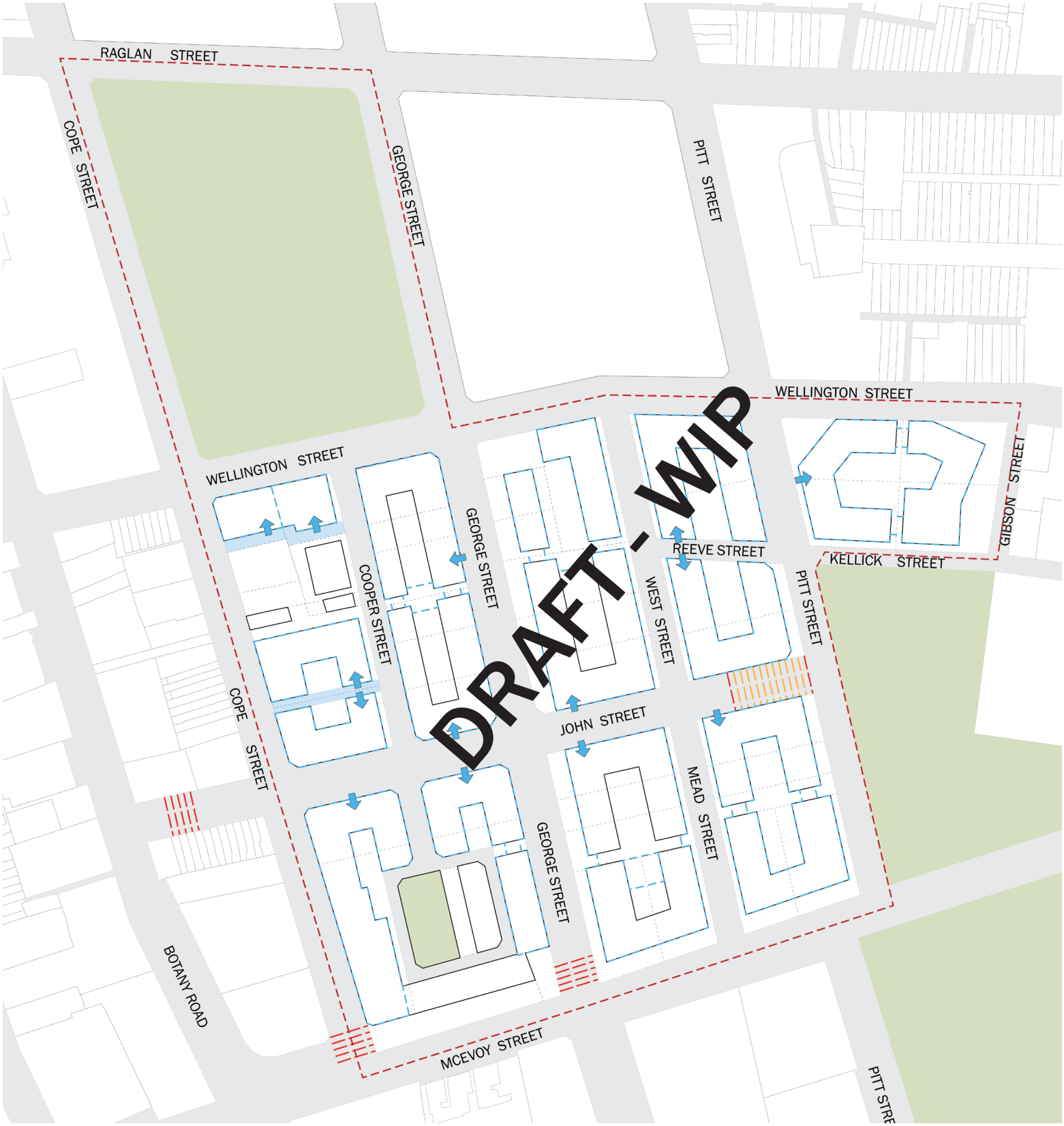


DRAFT CAR PARK ACCESS PLAN

This drawing provides a draft approach to car park access across the project area.

It is a draft work-in-progress. It requires further refinement with DPIE and should not be relied upon.

-  Precinct boundary
-  Existing lot boundary
-  New lot boundary (Indicative)
-  Shared driveways
-  Consolidated carpark
-  Carpark entry
-  Road closure
-  Pedestrian access only



Ground level soil and planting

Landscape areas and 'planting on structure' are to align in type, location and size with the areas as shown in the amended design proposal.



Competitive design process sites

The following design excellence strategy applies to all competitive design process sites in the amended Waterloo Estate (south) design proposal relating to 'Design excellence and competitive design processes' in Sydney DCP 2012.



Carpark locations

Vehicular access and egress points are to be located on the street frontages identified in the amended Waterloo Estate (south) design proposal.

- Precinct boundary
- Existing lot boundary
- New lot boundary (Indicative)
- Shared driveways
- Consolidated carpark
- Carpark entry
- Road closure
- Pedestrian access only



Stormwater

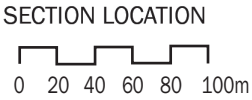
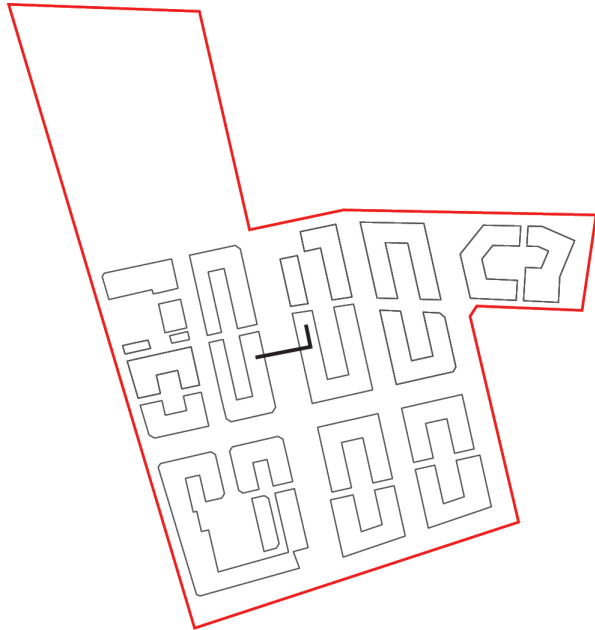
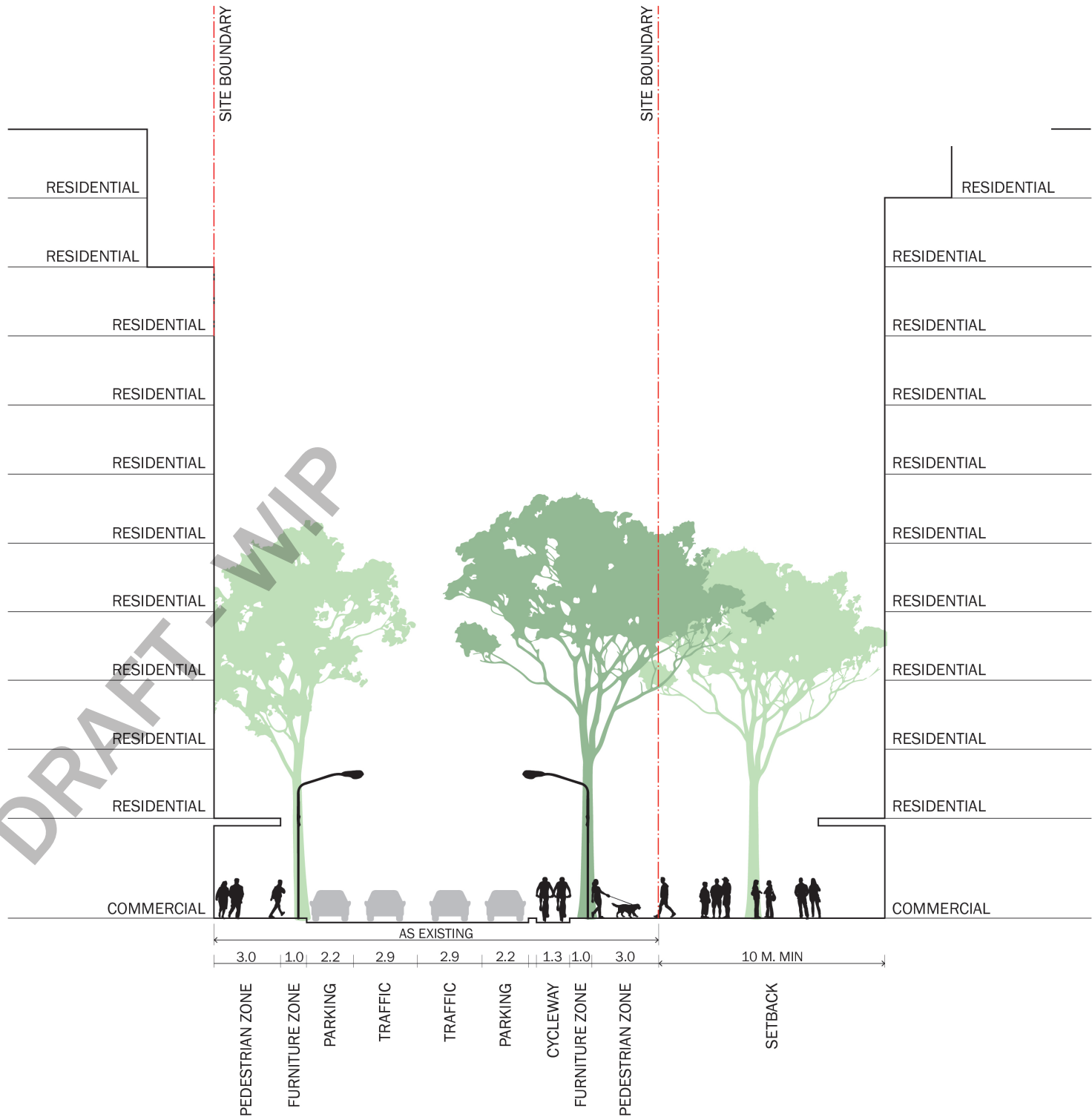
Stormwater is to be generally managed with the amended Waterloo Estate (South) design proposal in accordance with the City of Sydney Interim Floodplain Management Policy.

- Precinct boundary
- Existing lot boundary
- New lot boundary (Indicative)
- Open space with infiltration capacity
- Existing low point (ponding)
- Overland flow path
- Bio-swale



Street Cross Section - George Street

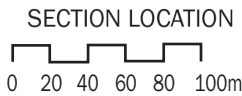
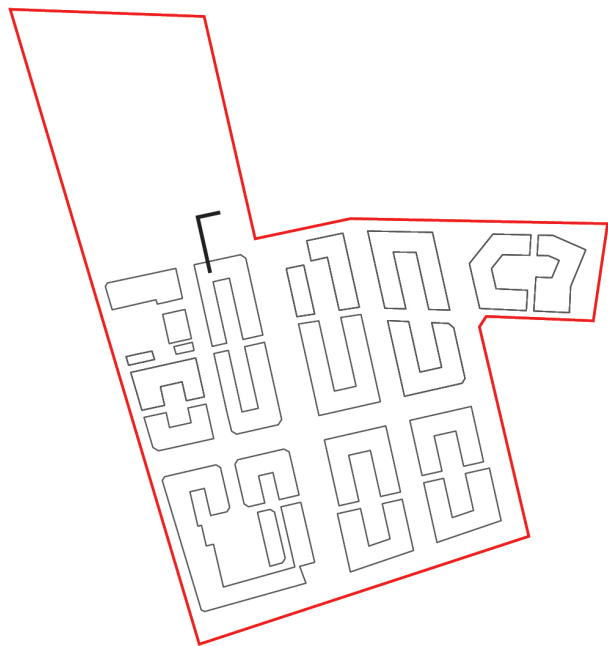
The street is to be designed in accordance with the indicative street specifications with the amended Waterloo Estate (South) design proposal.



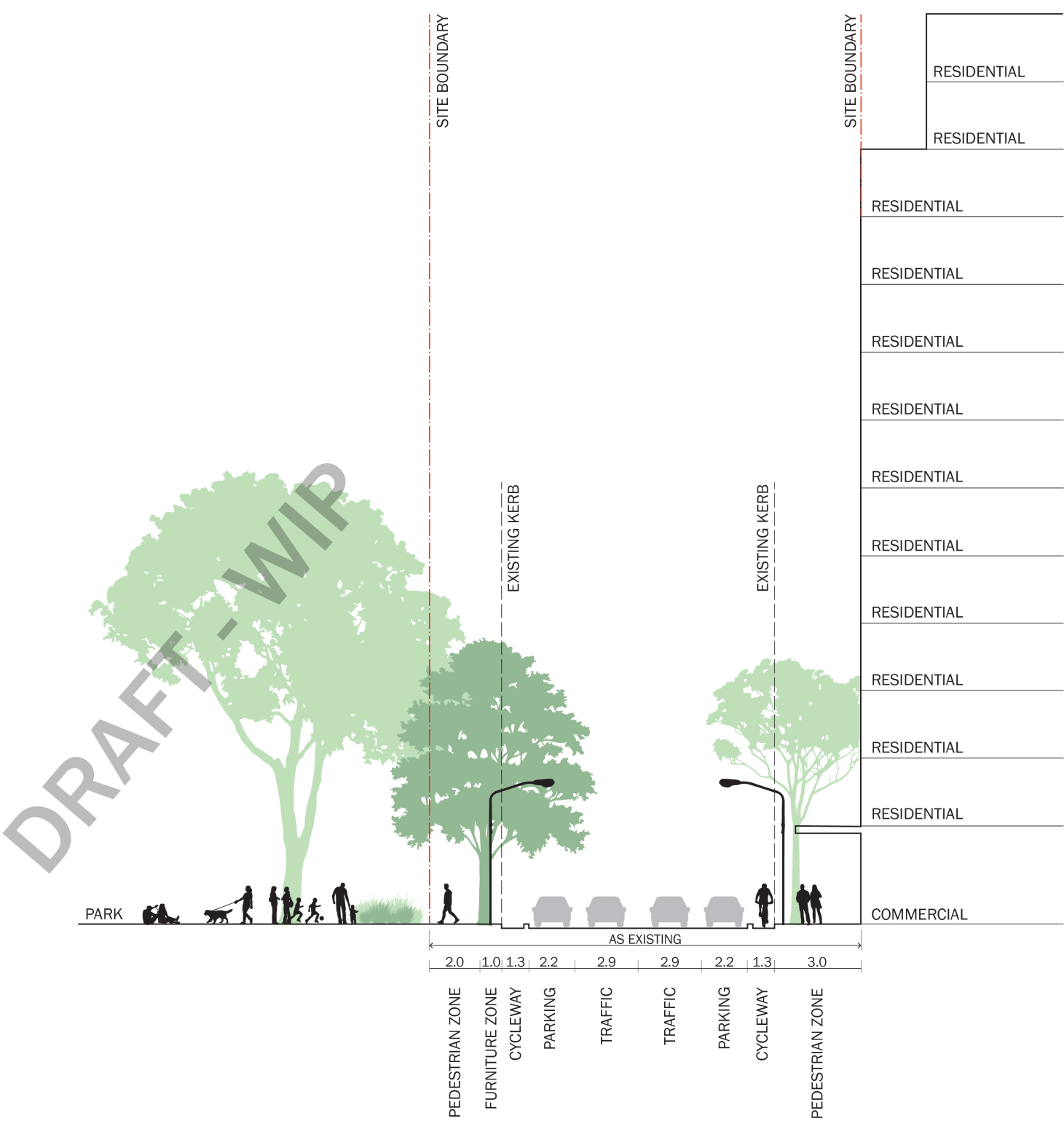
SCALE 1:250 @ A3

Street Cross Section - Wellington Street

The street is to be designed in accordance with the indicative street specifications with the amended Waterloo Estate (South) design proposal.



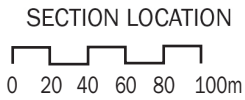
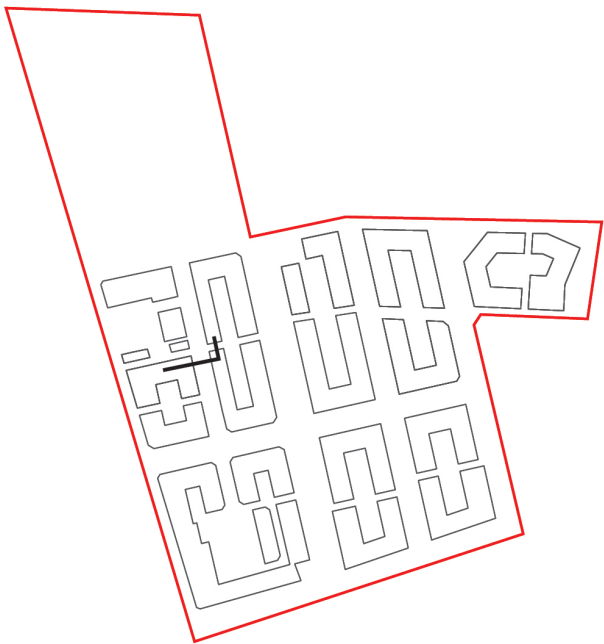
SCALE 1:250 @ A3



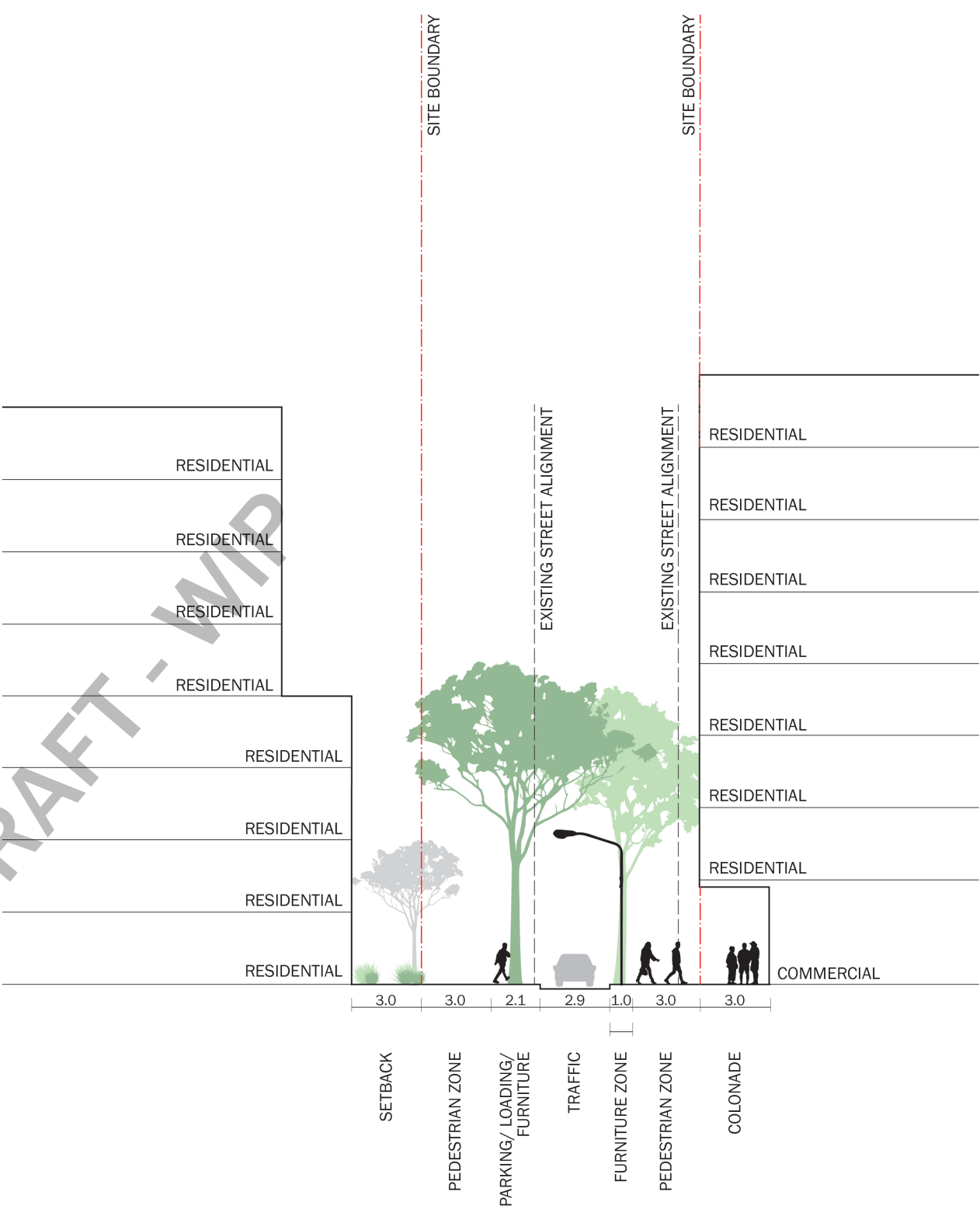
Section of Amendend Planning Proposal built form and surrounding context

Street Cross Section - Cooper Street North

The street is to be designed in accordance with the indicative street specifications with the amended Waterloo Estate (South) design proposal.



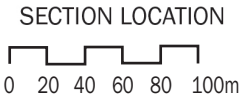
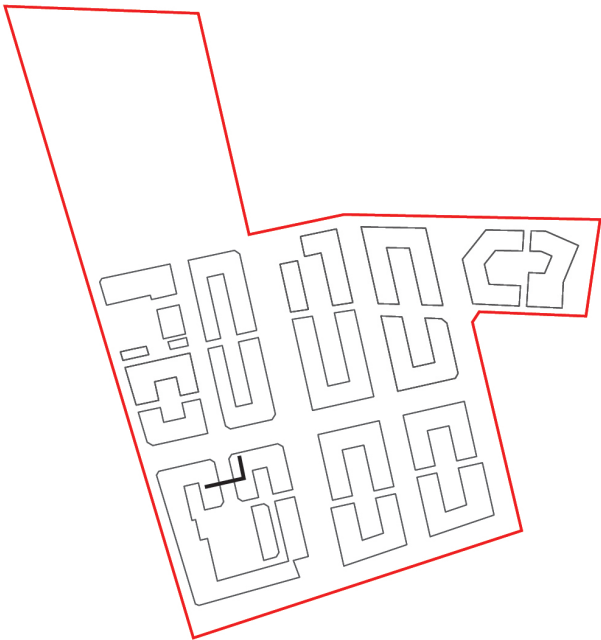
SCALE 1:250 @ A3



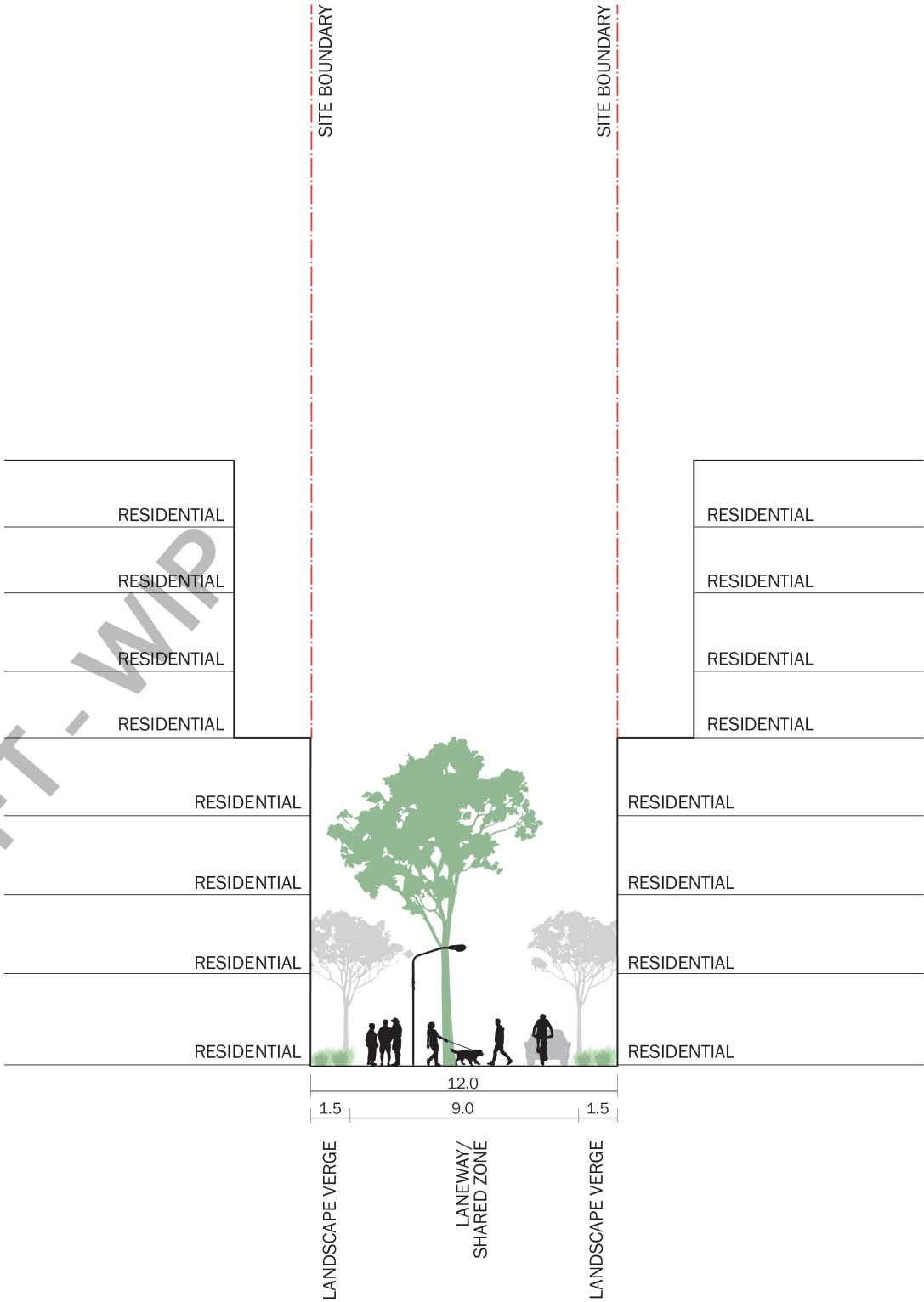
Section of Amendend Planning Proposal built form and surrounding context

Street Cross Section - Cooper Street South

The street is to be designed in accordance with the indicative street specifications with the amended Waterloo Estate (South) design proposal.



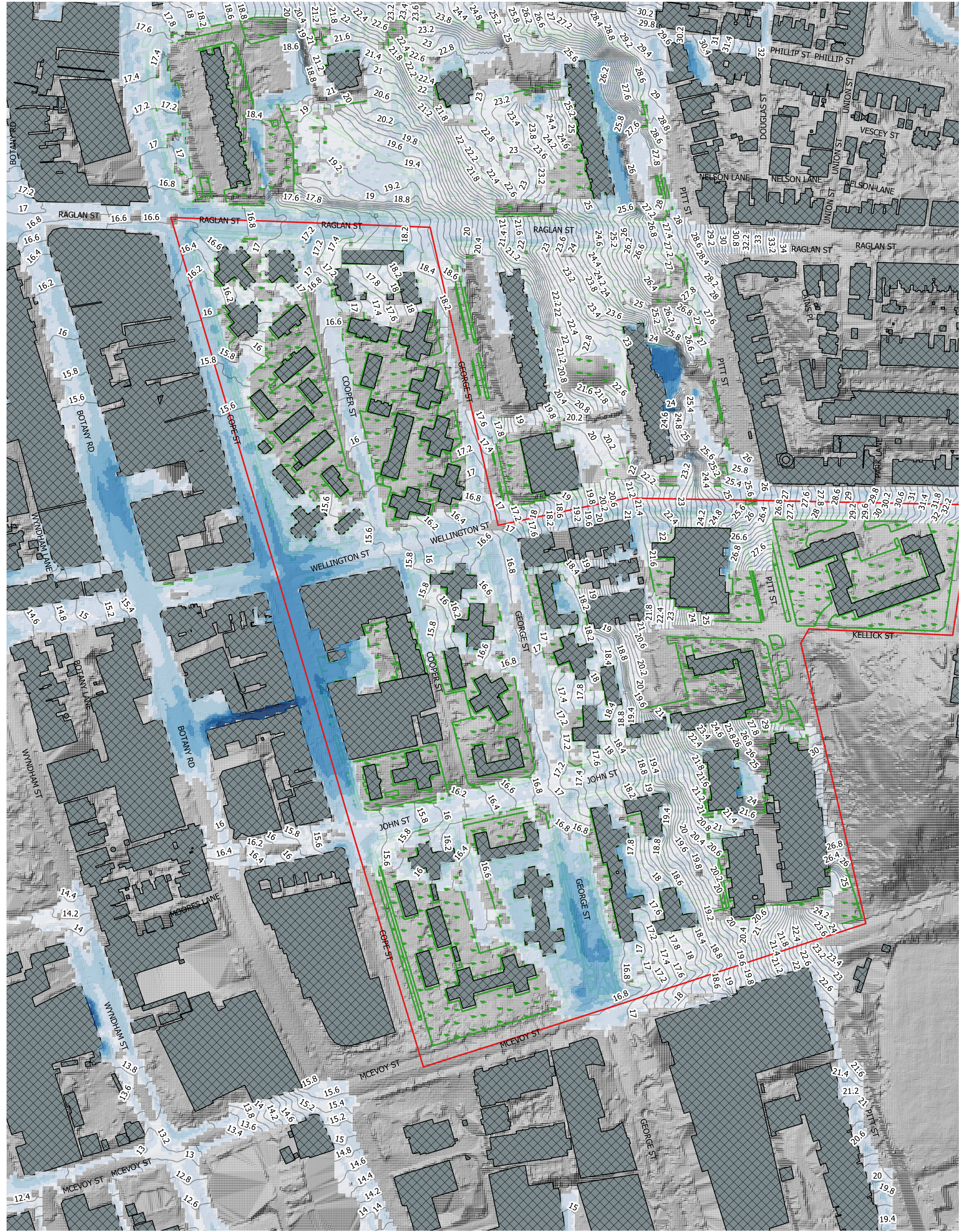
SCALE 1:250 @ A3



Section of Amendend Planning Proposal built form and surrounding context

Appendix C

Flood Mapping



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

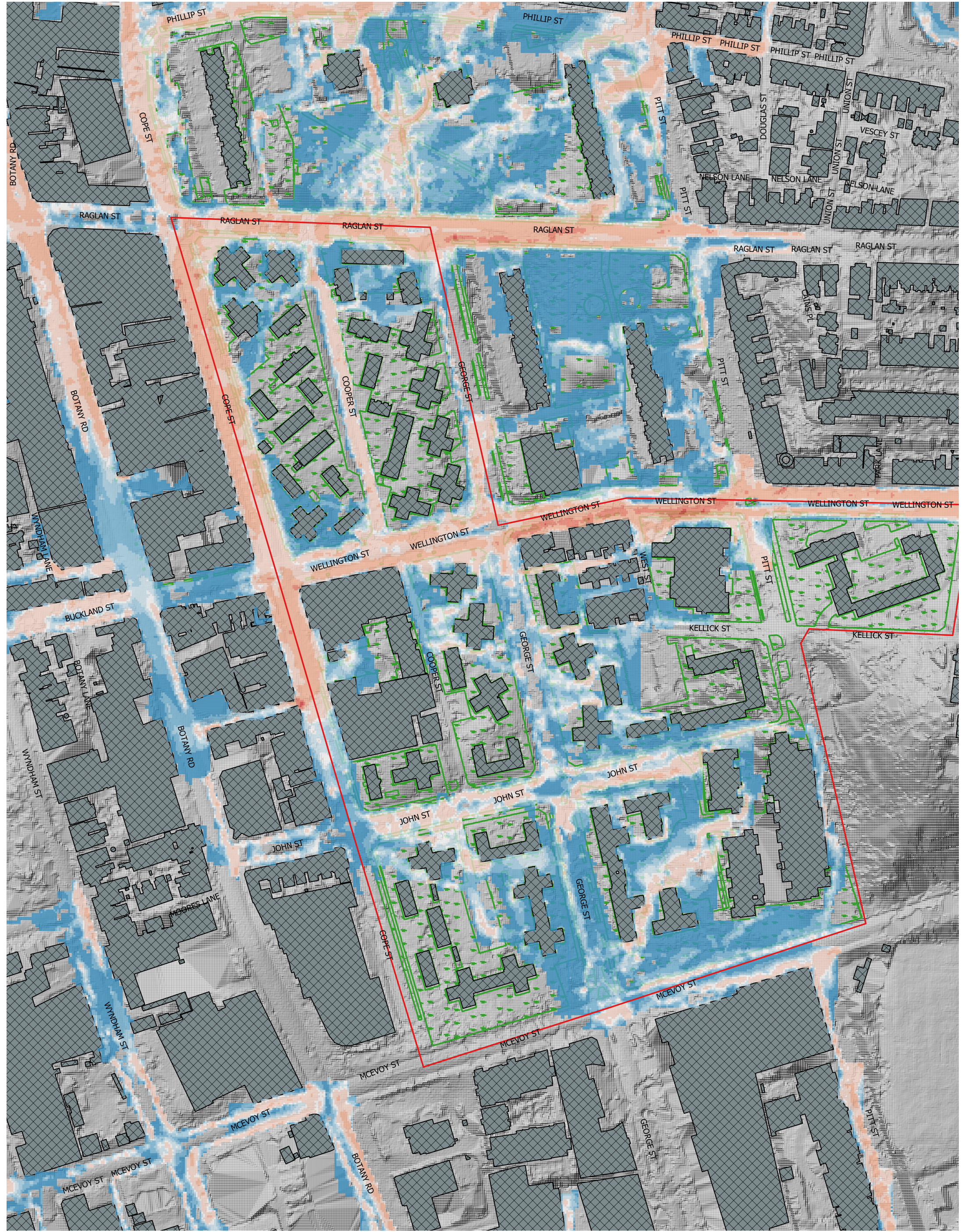
Level (mAHD)	0.5
Depth (m)	1
	2
	>2
	0.015
	0.1
	0.3



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Existing Conditions - 1 in 20 AEP

Job Number 12555493
Revision
Date Nov 2021

Figure C01



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

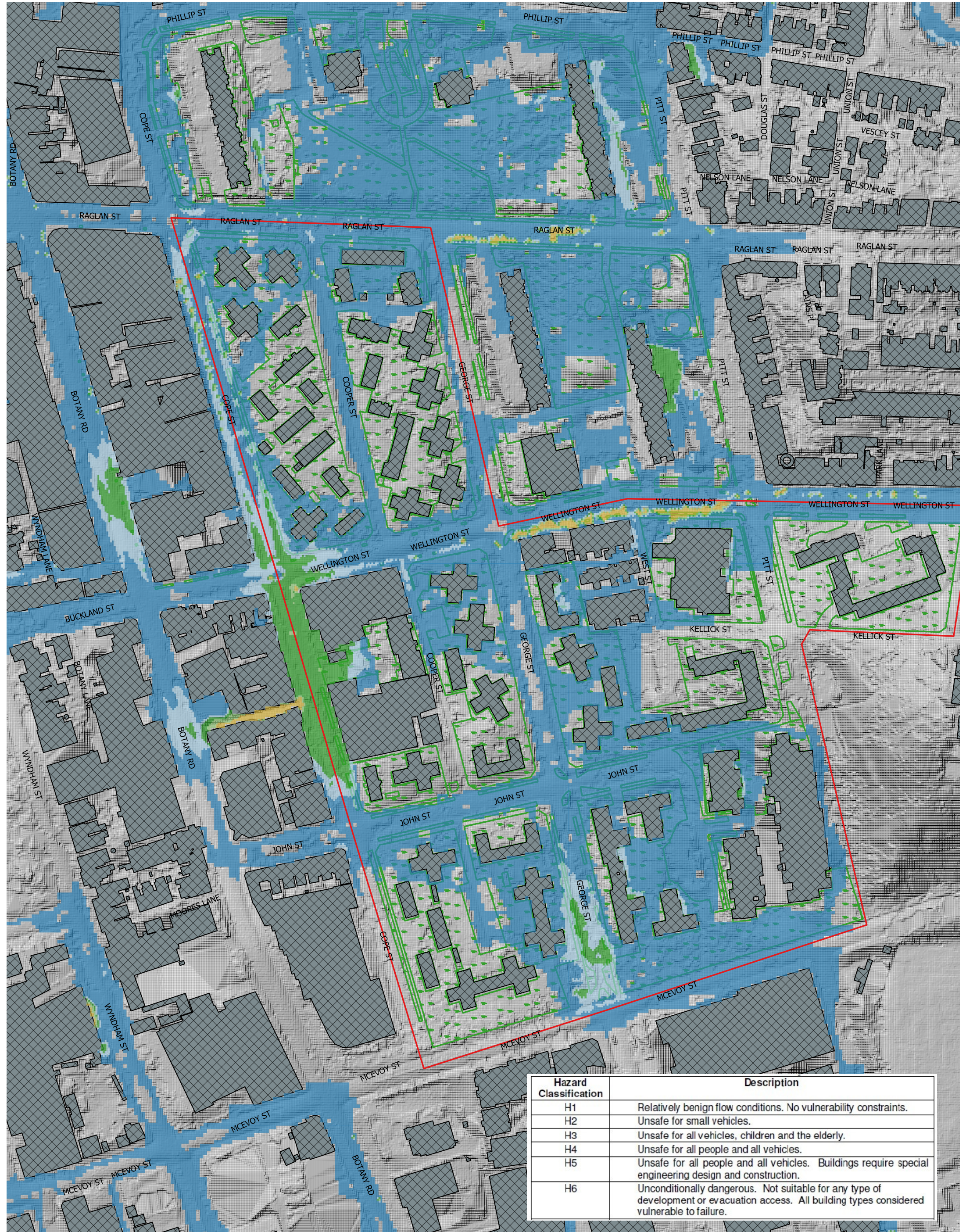
Velocity (m/s)	0.3-0.4	2.0-3.0
<0.1	0.4-0.5	3.0-5.0
0.1-0.2	0.5-1.0	>5.0
0.2-0.3	1.0-2.0	



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Existing Conditions - 1 in 20 AEP

Job Number 12555493
Revision
Date Nov 2021

Figure C02



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

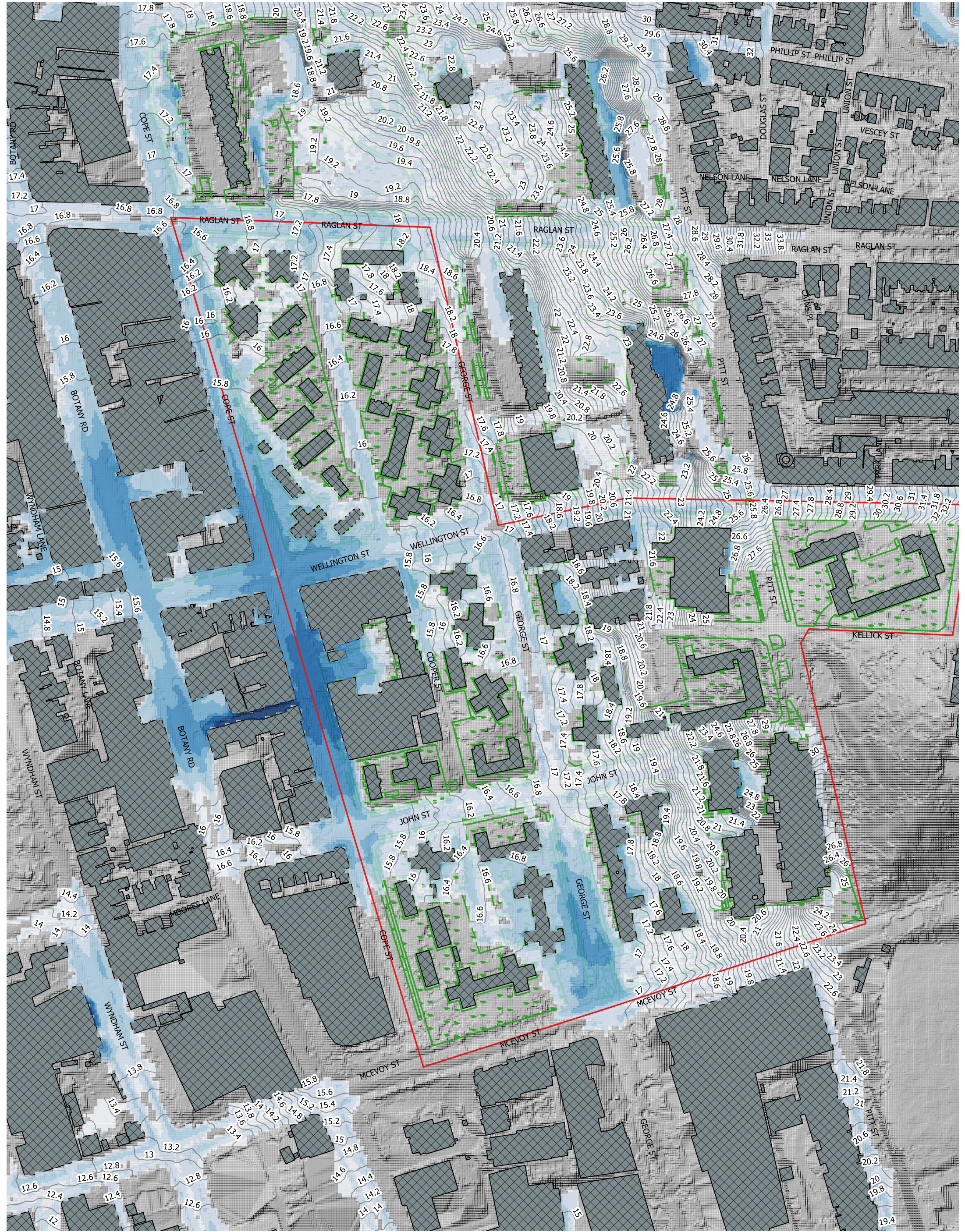
- Hazard
- H1
 - H2
 - H3
 - H4
 - H5
 - H6



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Existing Conditions - 1 in 20 AEP

Job Number 12555493
Revision
Date Nov 2021

Figure C03



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

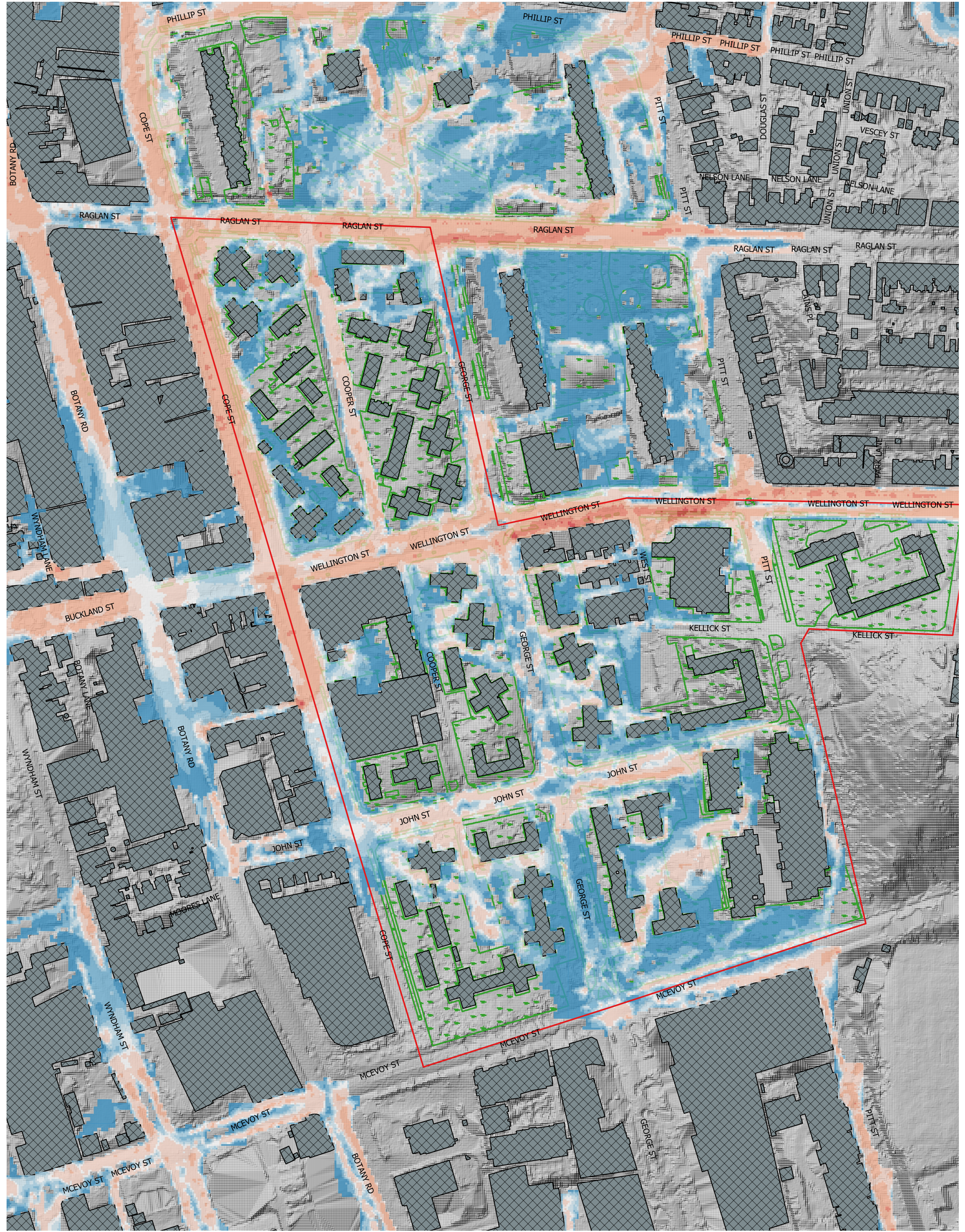
Level (mAHD)	0.5
Depth (m)	1
	2
	>2
	0.015
	0.1
	0.3



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Existing Conditions - 1 in 100 AEP

Job Number 12555493
Revision
Date Nov 2021

Figure C04



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

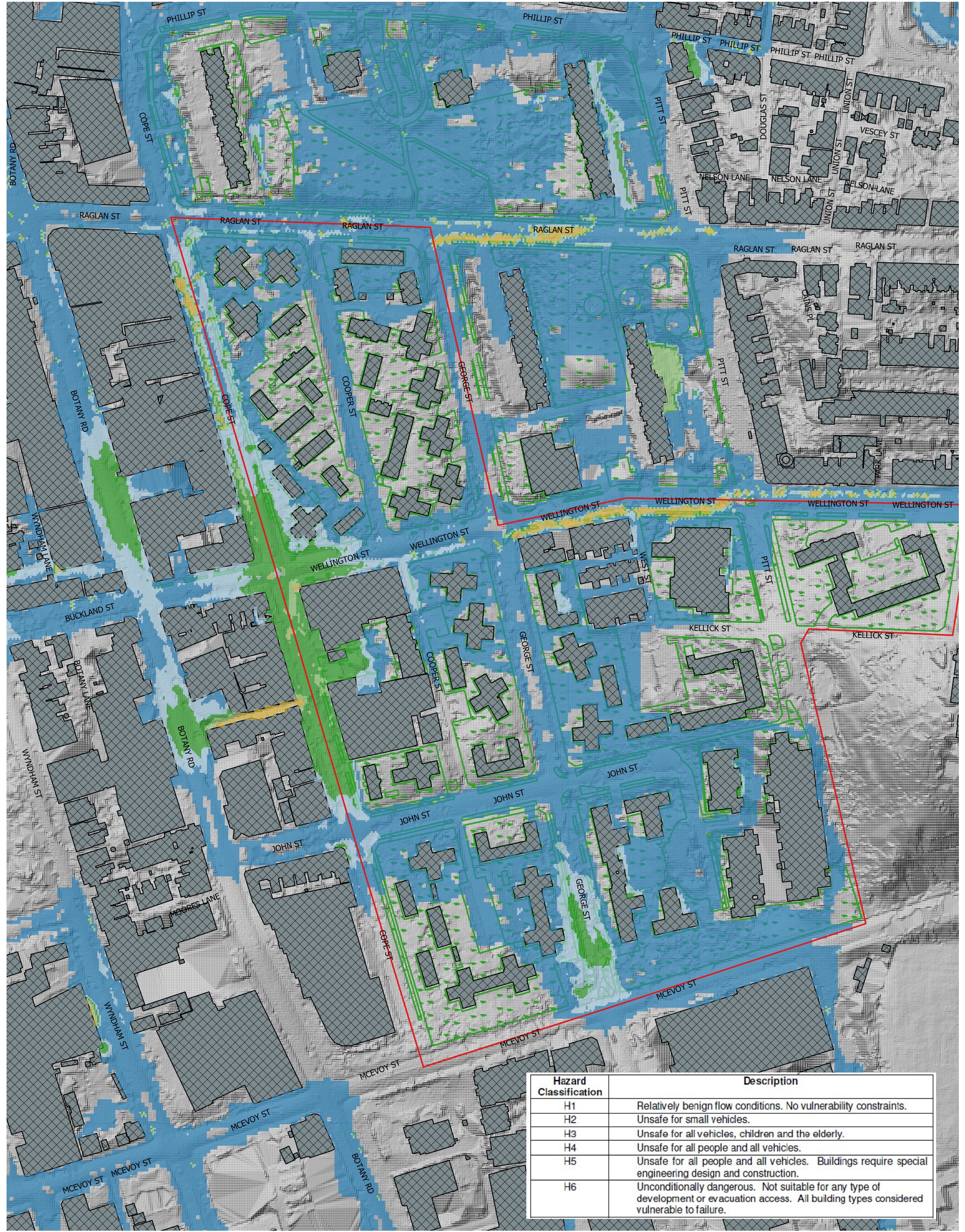
Velocity (m/s)		0.3-0.4	2.0-3.0
<0.1	0.4-0.5	3.0-5.0	
0.1-0.2	0.5-1.0	>5.0	
0.2-0.3	1.0-2.0		



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Existing Conditions - 1 in 100 AEP

Job Number 12555493
Revision
Date Nov 2021

Figure C05



Hazard Classification	Description
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.

Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

- Hazard

H1

H2

H3
- H4

H5

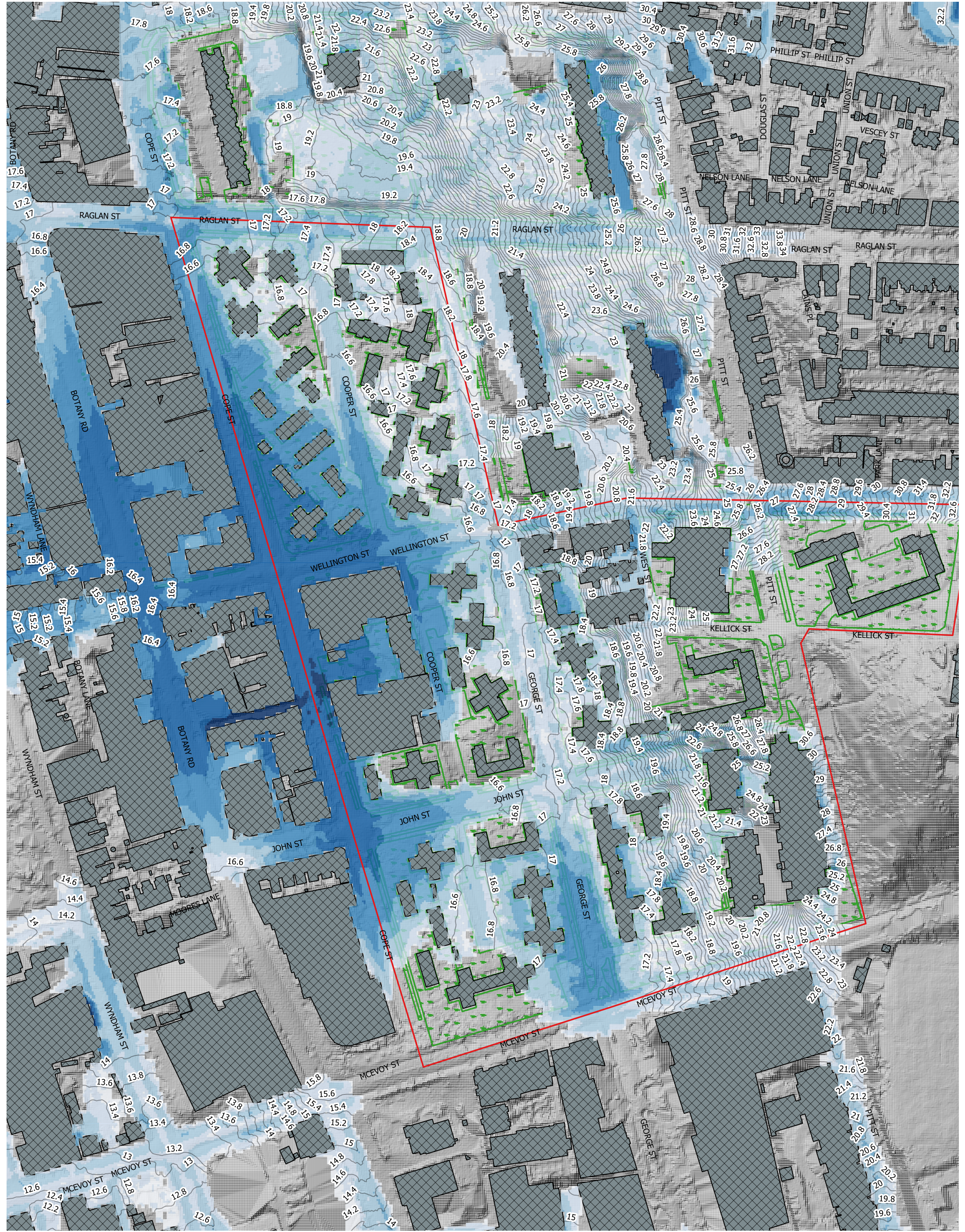
H6

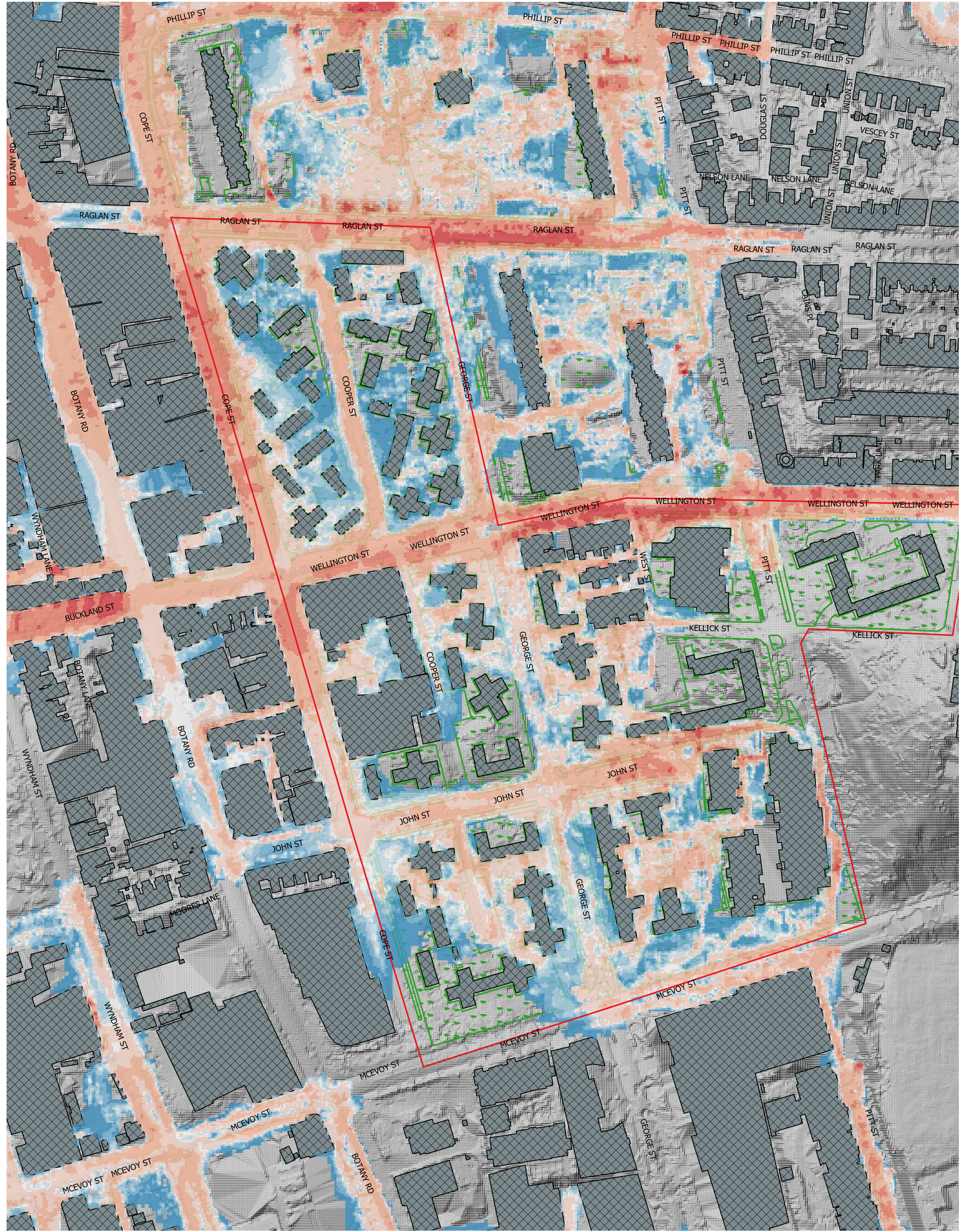


Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Existing Conditions - 1 in 100 AEP

Job Number 12555493
Revision
Date Nov 2021

Figure C06





Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

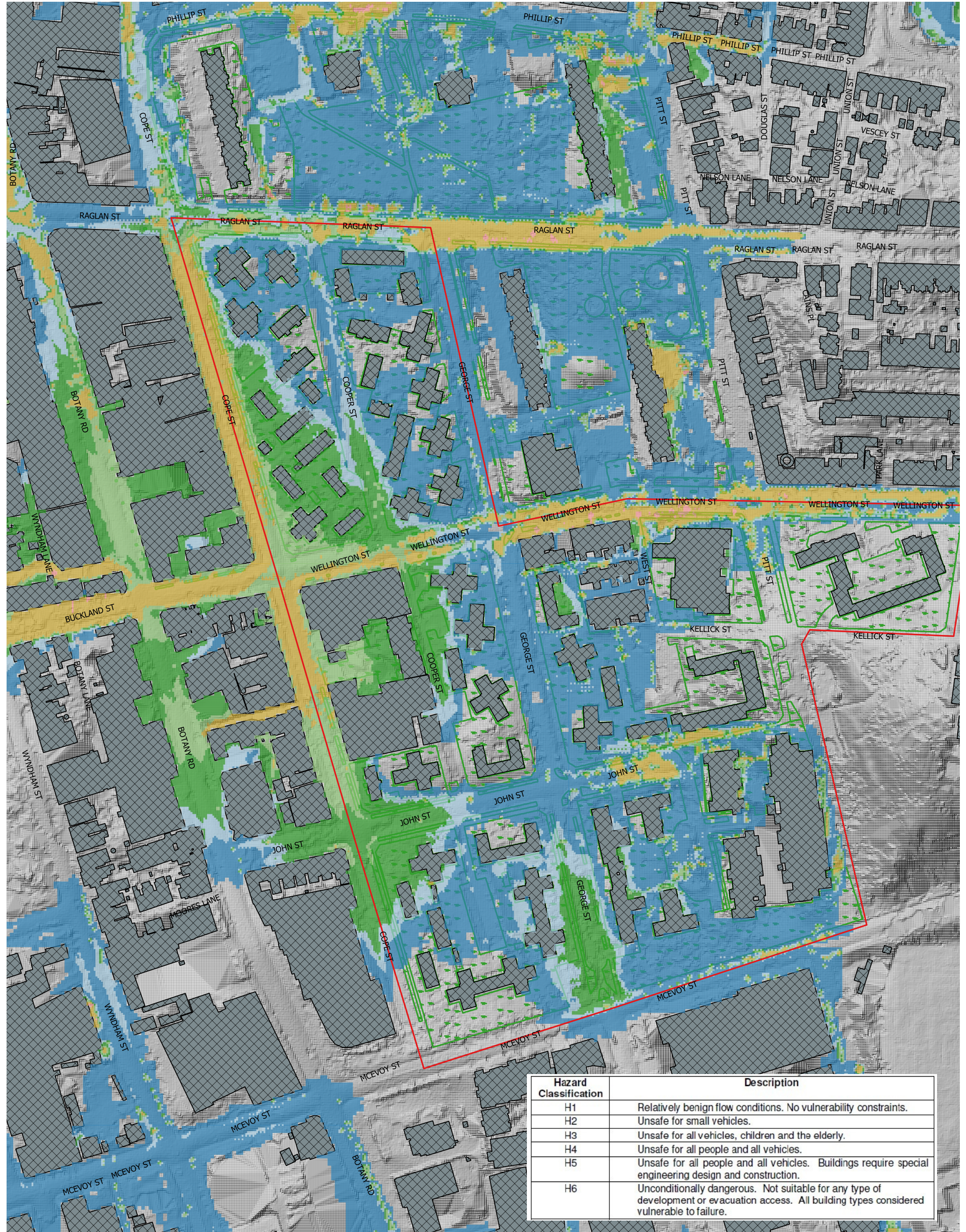
Velocity (m/s)	
 <0.1	 2.0-3.0
 0.1-0.2	 3.0-5.0
 0.2-0.3	 >5.0
 0.3-0.4	 1.0-2.0
 0.4-0.5	
 0.5-1.0	



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Existing Conditions - PMF

Job Number	12555493
Revision	
Date	Nov 2021

Figure C08



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

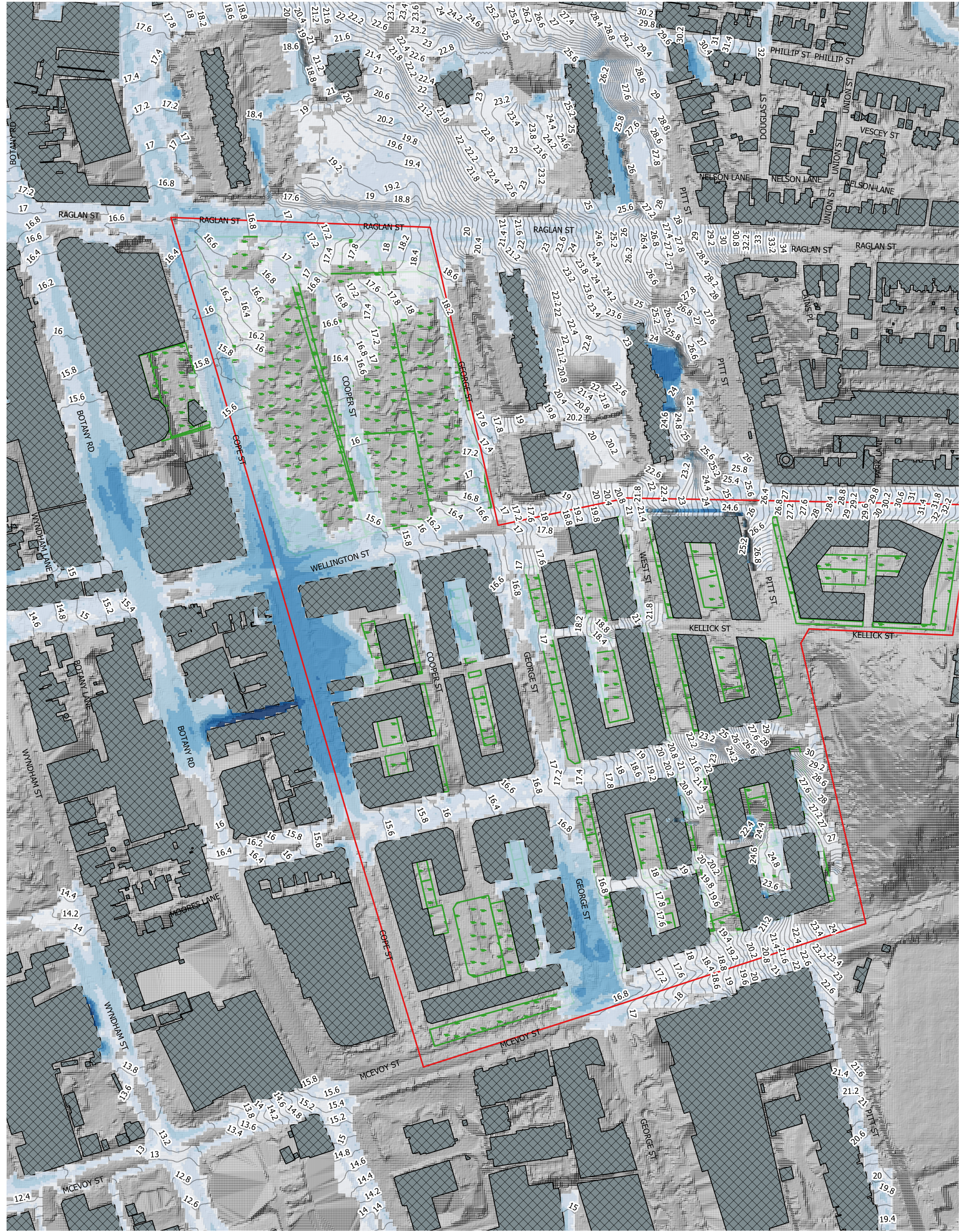
- Hazard
- H1
 - H2
 - H3
 - H4
 - H5
 - H6



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Existing Conditions - PMF

Job Number 12555493
Revision
Date Nov 2021

Figure C09



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

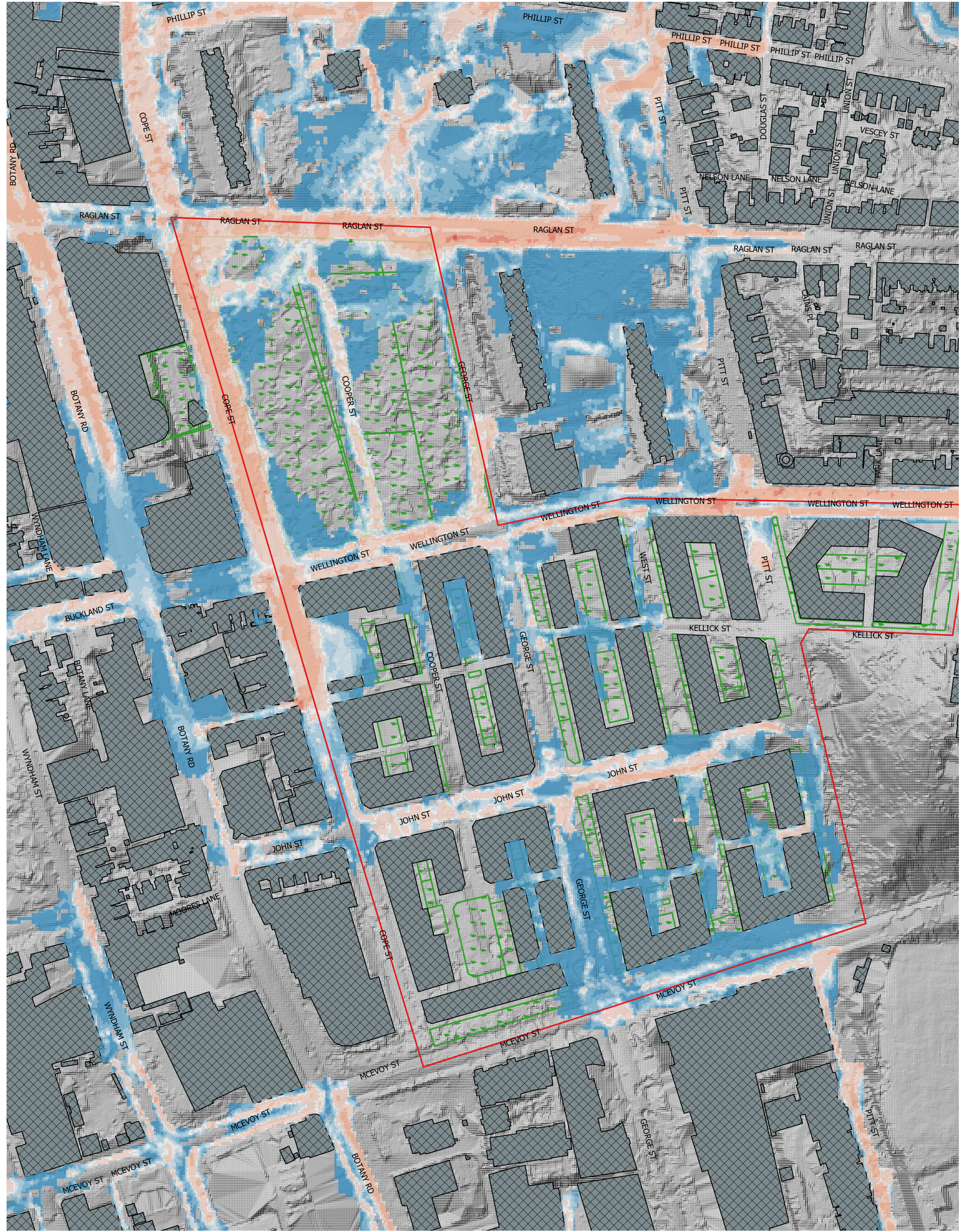
Level (mAHD)	0.5
Depth (m)	1
	2
	>2
	0.015
	0.1
	0.3



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - 1 in 20 AEP

Job Number 12555493
Revision
Date Nov 2021

Figure C10



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

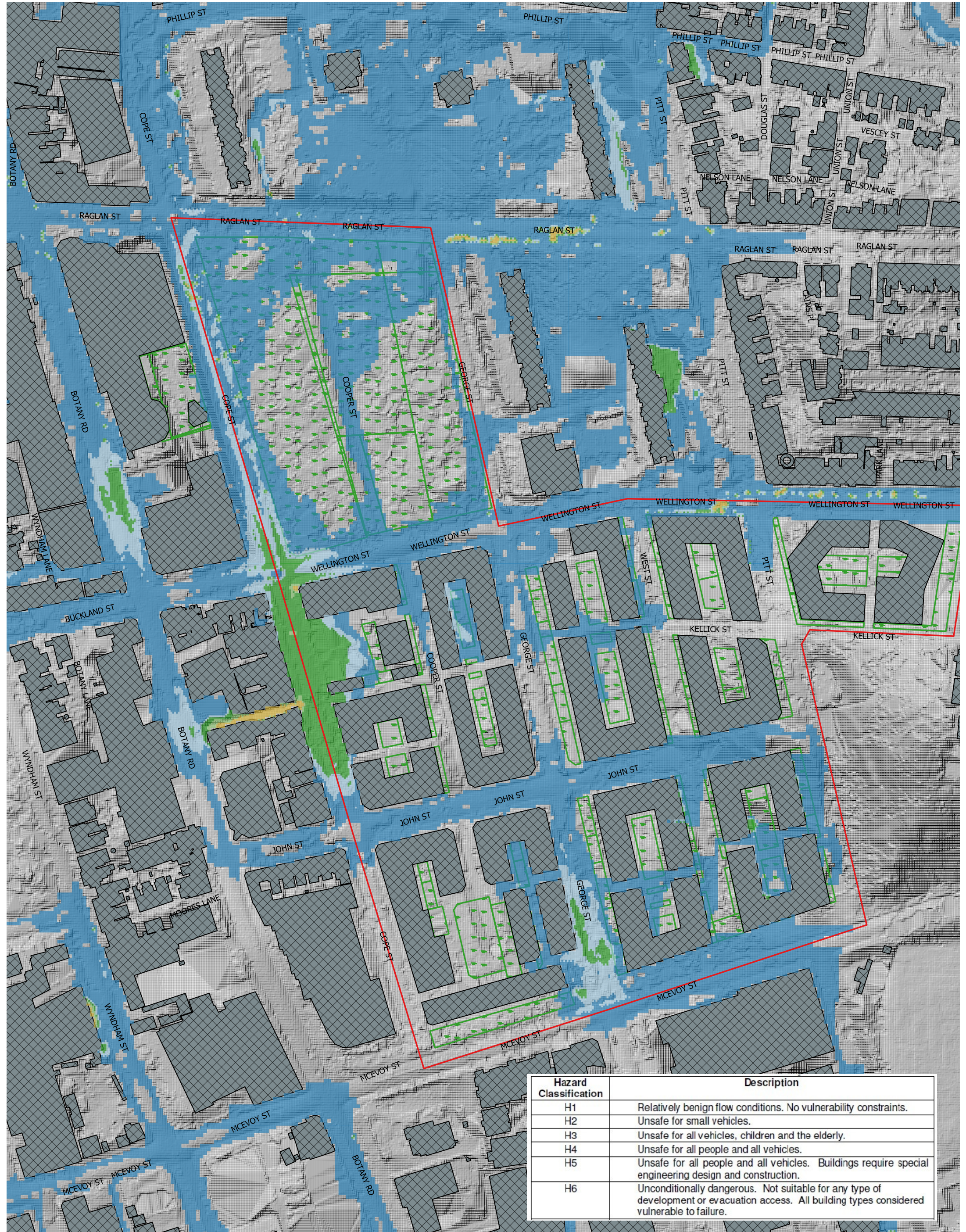
Velocity (m/s)	0.3-0.4	2.0-3.0
<0.1	0.4-0.5	3.0-5.0
0.1-0.2	0.5-1.0	>5.0
0.2-0.3	1.0-2.0	



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - 1 in 20 AEP

Job Number	12555493
Revision	
Date	Nov 2021

Figure C11



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

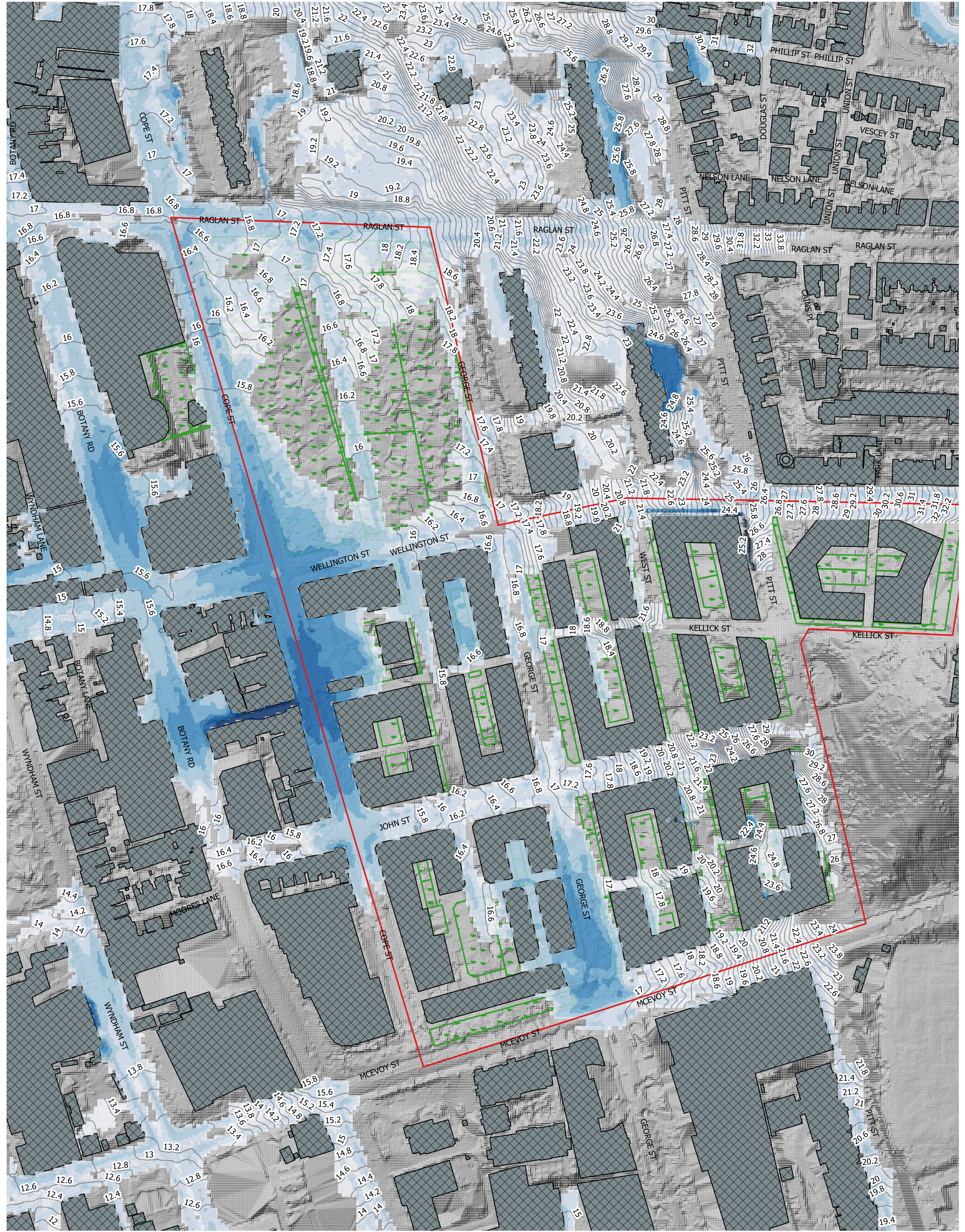
- Hazard
- H1
 - H2
 - H3
 - H4
 - H5
 - H6



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - 1 in 20 AEP

Job Number 12555493
Revision
Date Nov 2021

Figure C12



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

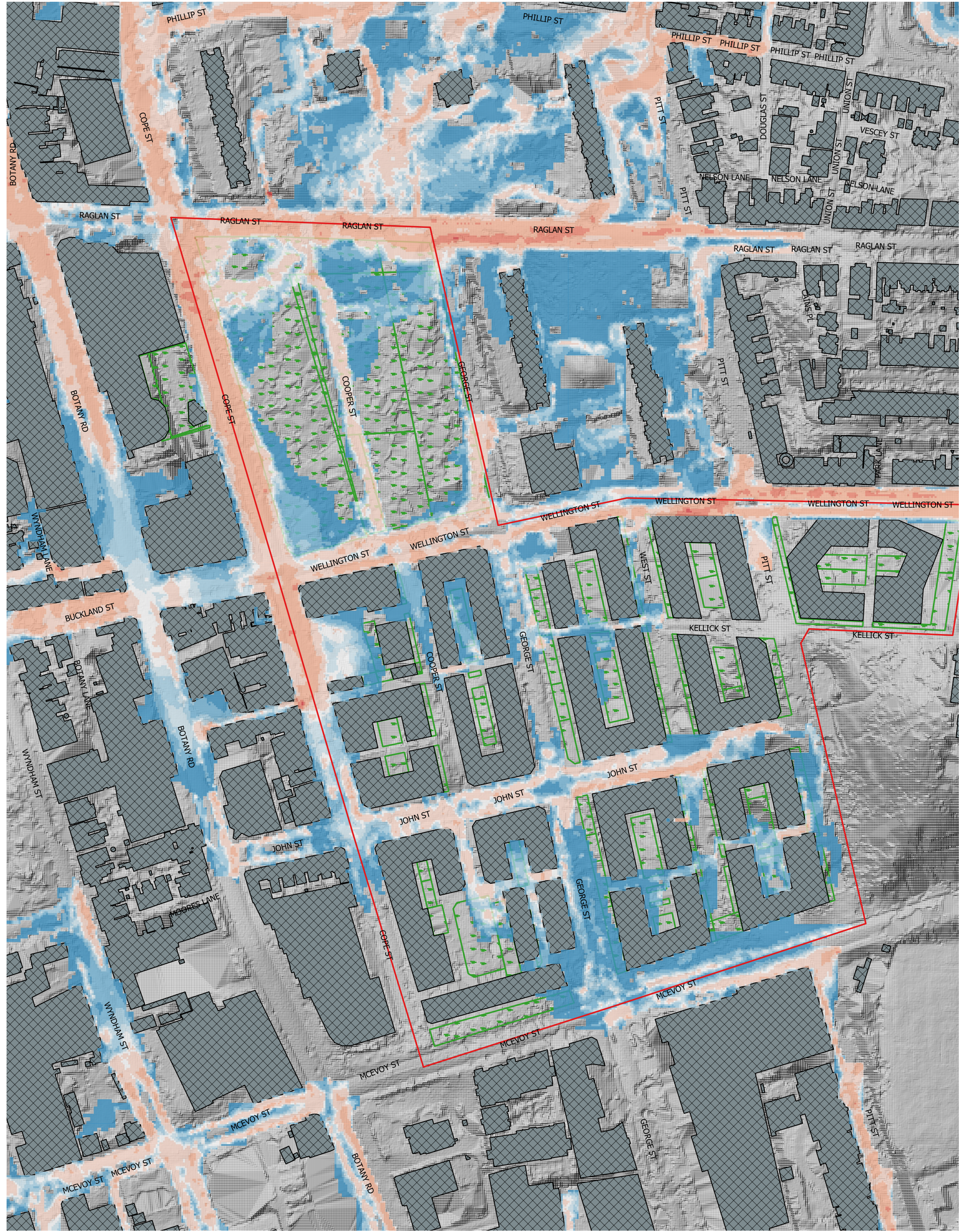
Level (mAHD)	0.5
Depth (m)	1
	2
	>2
	0.015
	0.1
	0.3



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - 1 in 100 AEP

Job Number 12555493
Revision
Date Nov 2021

Figure C13



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

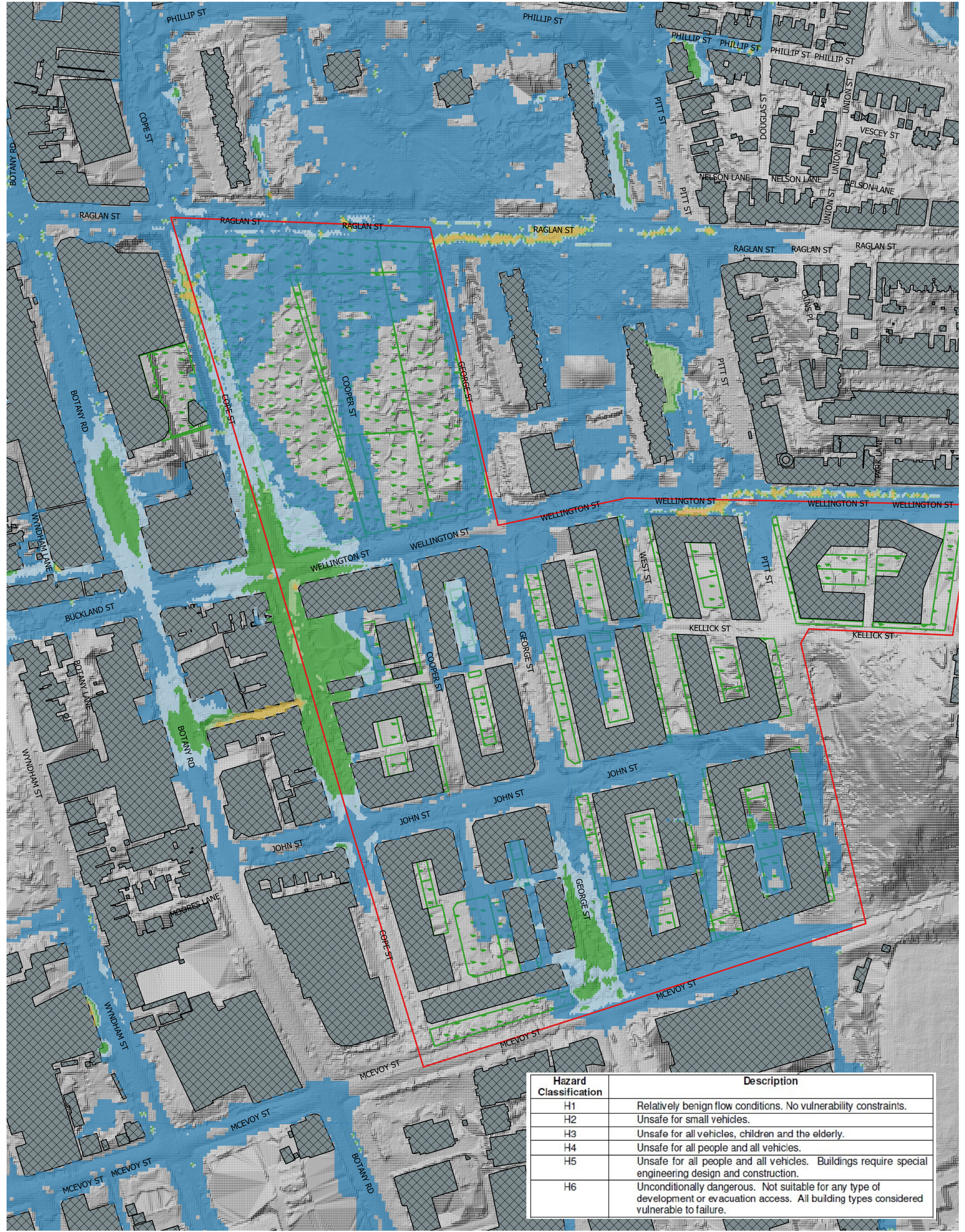
Velocity (m/s)		0.3-0.4	2.0-3.0
<0.1	0.4-0.5	3.0-5.0	>5.0
0.1-0.2	0.5-1.0		
0.2-0.3	1.0-2.0		



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - 1 in 100 AEP

Job Number 12555493
Revision
Date Nov 2021

Figure C14



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

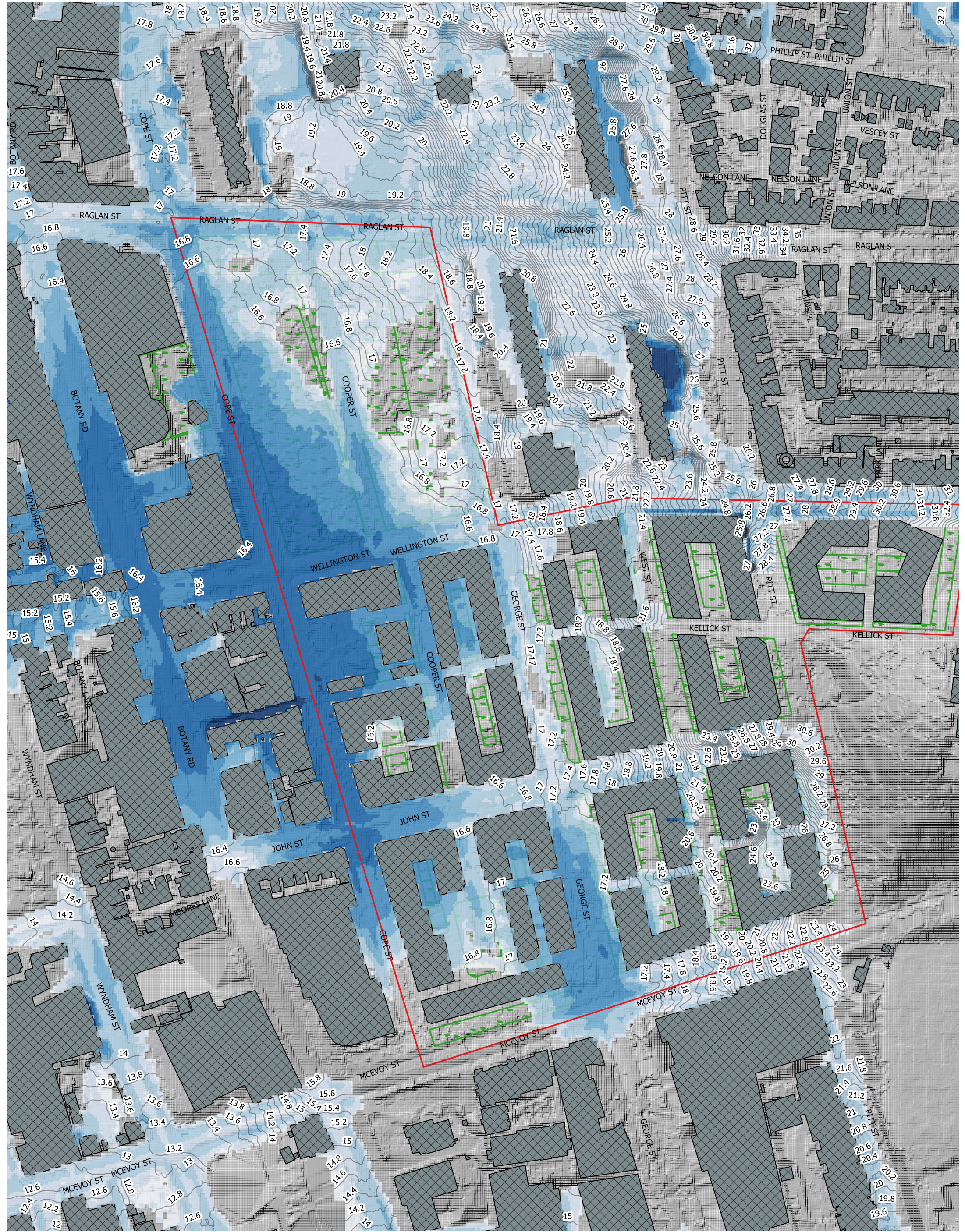
- Hazard
- H1
 - H2
 - H3
 - H4
 - H5
 - H6



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - 1 in 100 AEP

Job Number 12555493
Revision
Date Nov 2021

Figure C15



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

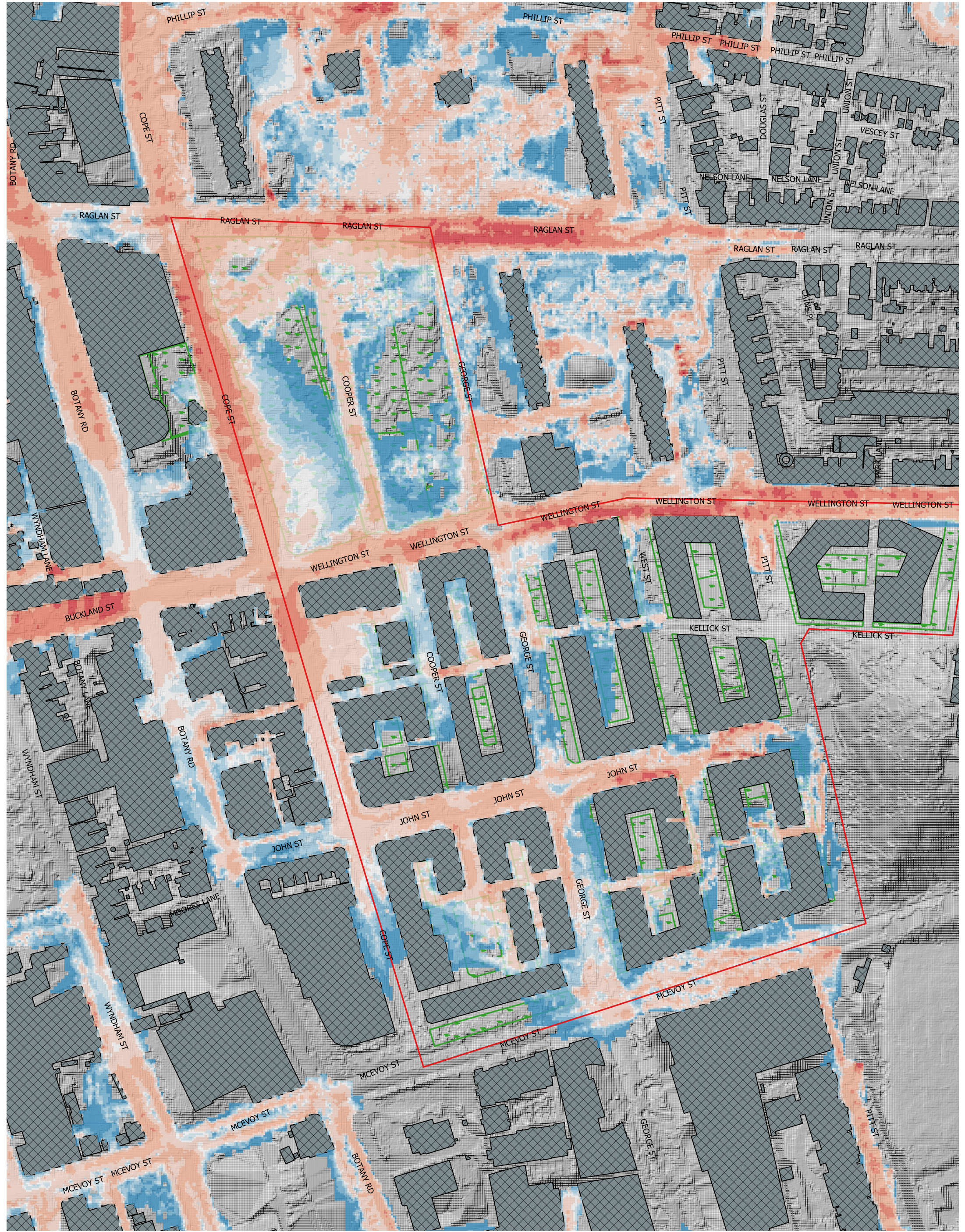
Level (mAHD)	0.5
Depth (m)	1
0.015	2
0.1	>2
0.3	



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - PMF

Job Number 12555493
Revision
Date Nov 2021

Figure C16



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

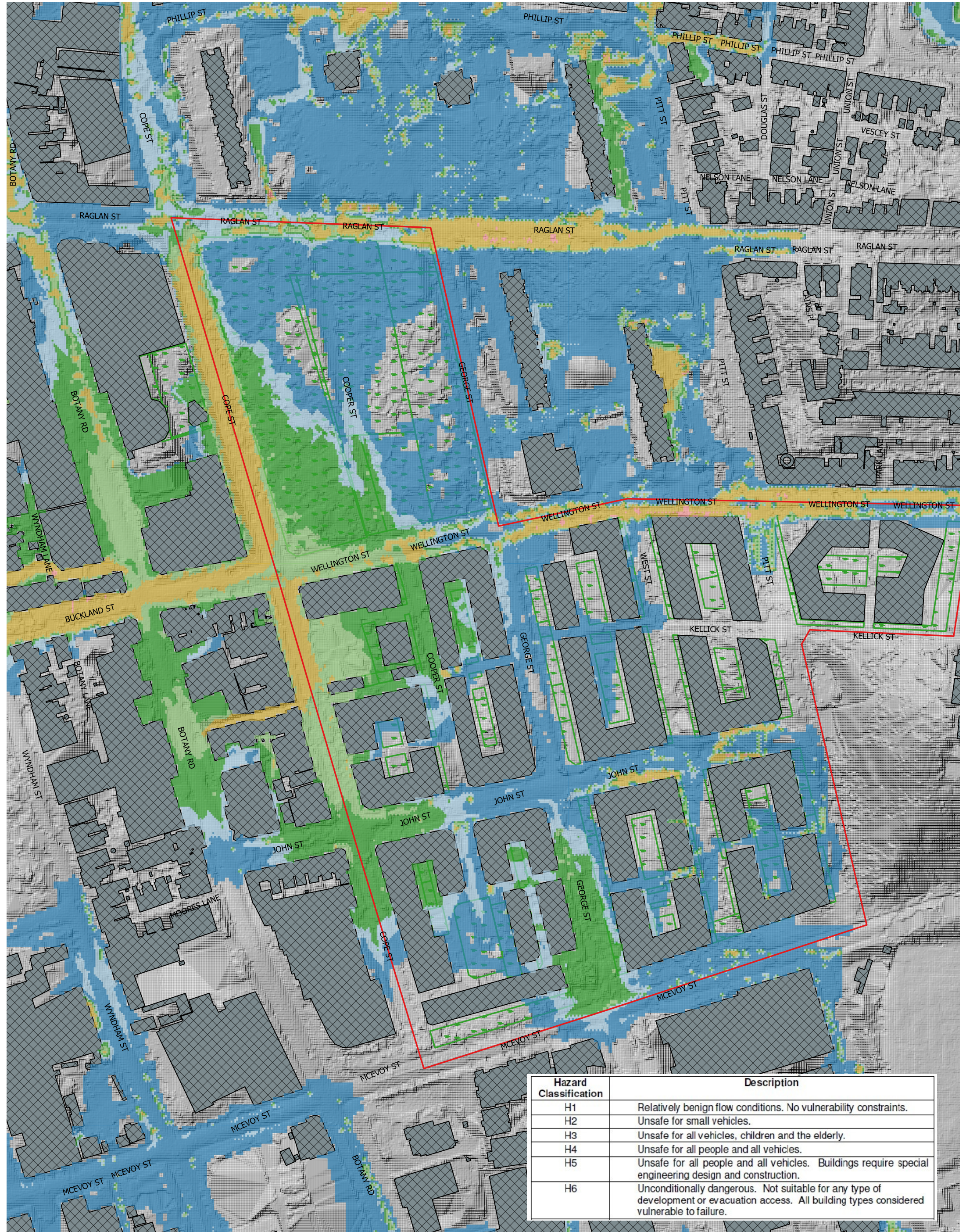
Velocity (m/s)	
 <0.1	 2.0-3.0
 0.1-0.2	 3.0-5.0
 0.2-0.3	 >5.0
 0.3-0.4	 5.0+
 0.4-0.5	
 0.5-1.0	
 1.0-2.0	



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - PMF

Job Number 12555493
Revision
Date Nov 2021

Figure C17



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

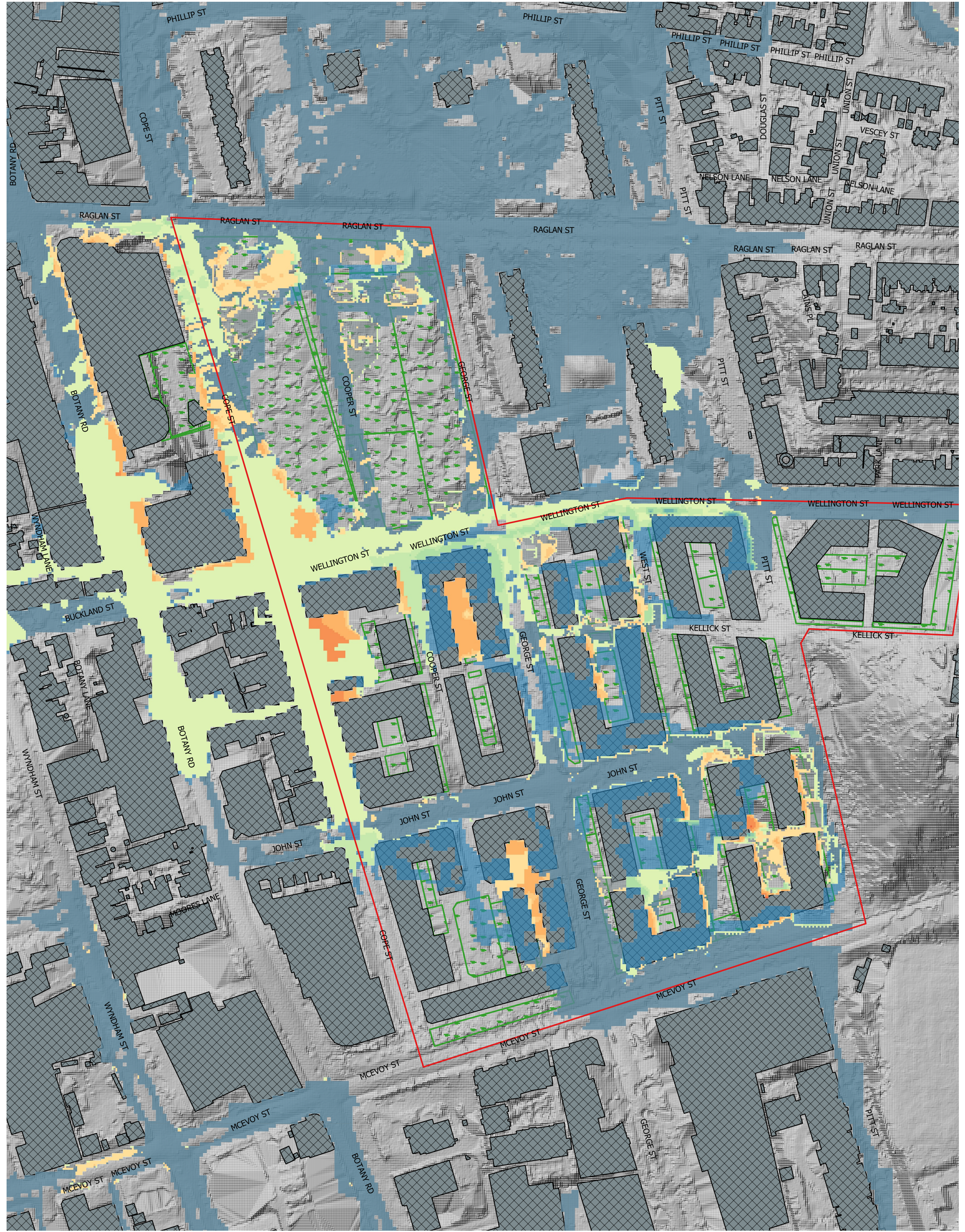
- Hazard
- H1
 - H2
 - H3
 - H4
 - H5
 - H6



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - PMF

Job Number 12555493
Revision
Date Nov 2021

Figure C18



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

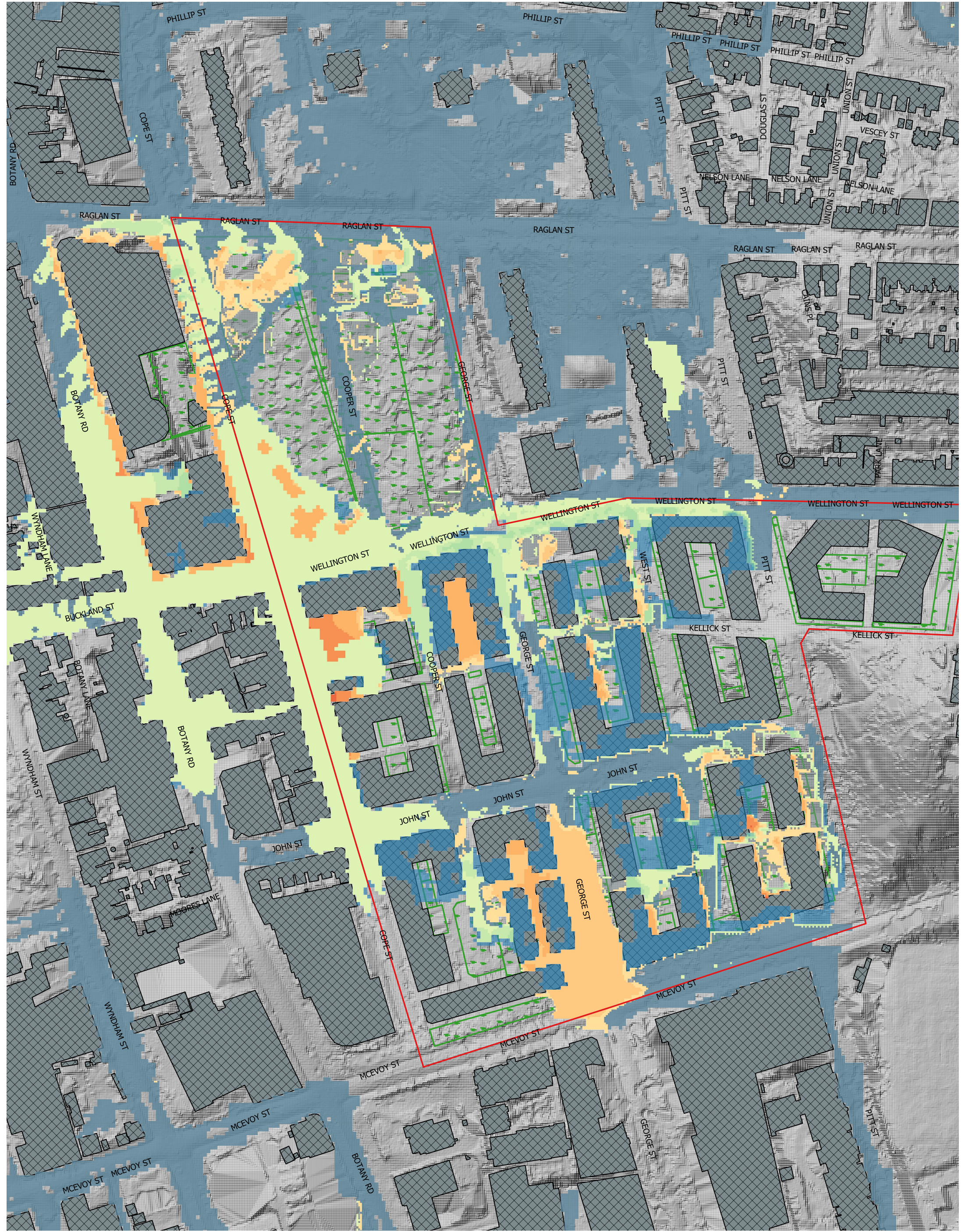
Impact (m)	-0.5	<0.01	1-2
<-2	-0.1	0.01-0.05	2-5
-2	-0.05	0.05-0.1	>5
-1	-0.01	0.1-0.5	
0	0.5-1		



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Flood Impact - 1 in 20 AEP

Job Number 12555493
Revision
Date Nov 2021

Figure C19



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

Impact (m)	-0.5	<0.01	1-2
<-2	-0.1	0.01-0.05	2-5
-2	-0.05	0.05-0.1	>5
-1	-0.01	0.1-0.5	
0	0.5-1		



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Flood Impact - 1 in 100 AEP

Job Number 12555493
Revision
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Figure C20



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

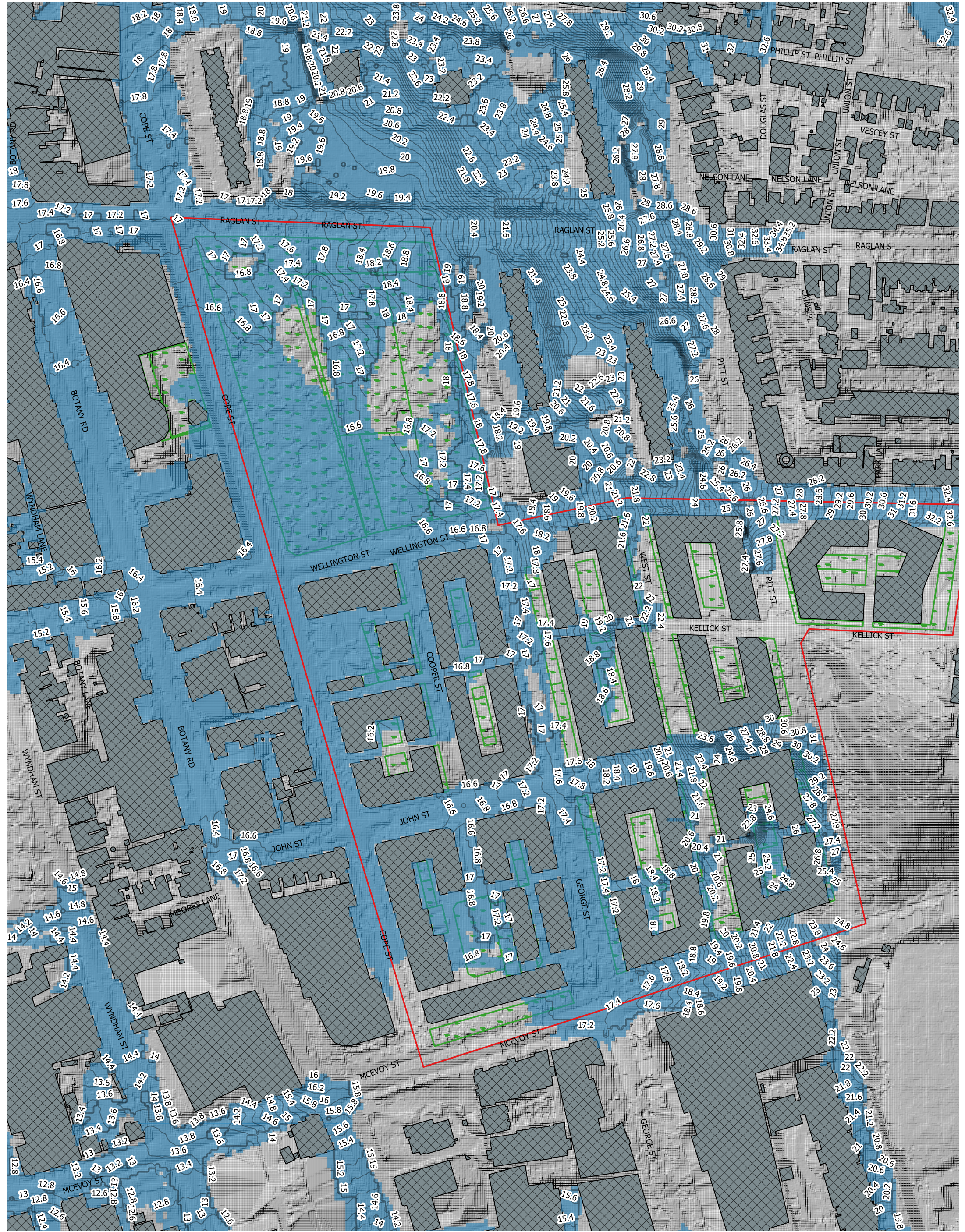
Flood Depth (m)
■ <0.25
■ >0.25



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - 100 AEP - DCP
250mm depth threshold

Job Number 12555493
Revision
Date Nov 2021

Figure C21



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

- Maximum flood level from 1 in 100AEP plus 0.5m and the PMF
- Flood Inundation

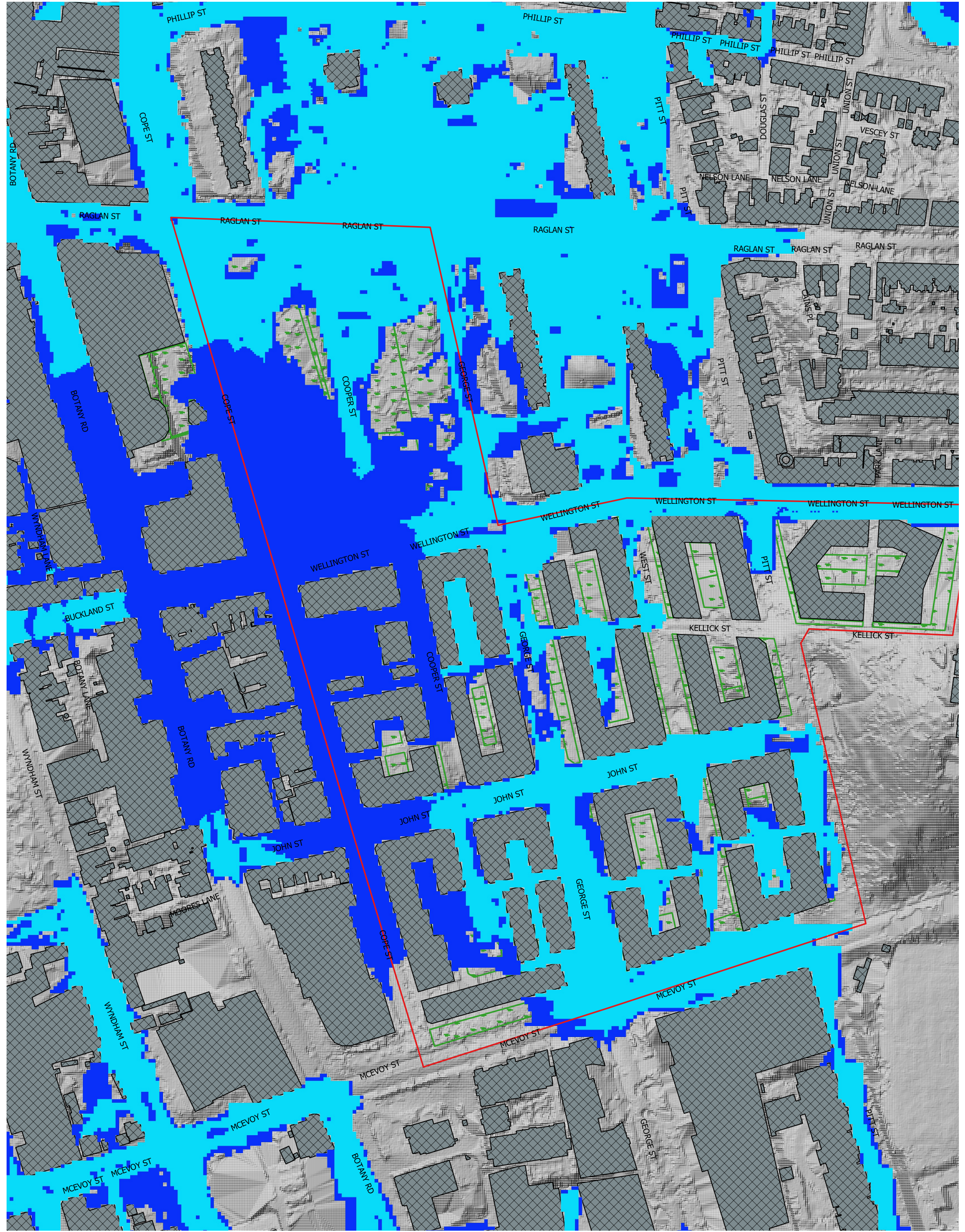


Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal

Job Number 12555493
Revision
Date Nov 2021

Flooding Assessment
Design Conditions - Envelope of 100
AEP+0.5m and PMF

Figure C22



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND



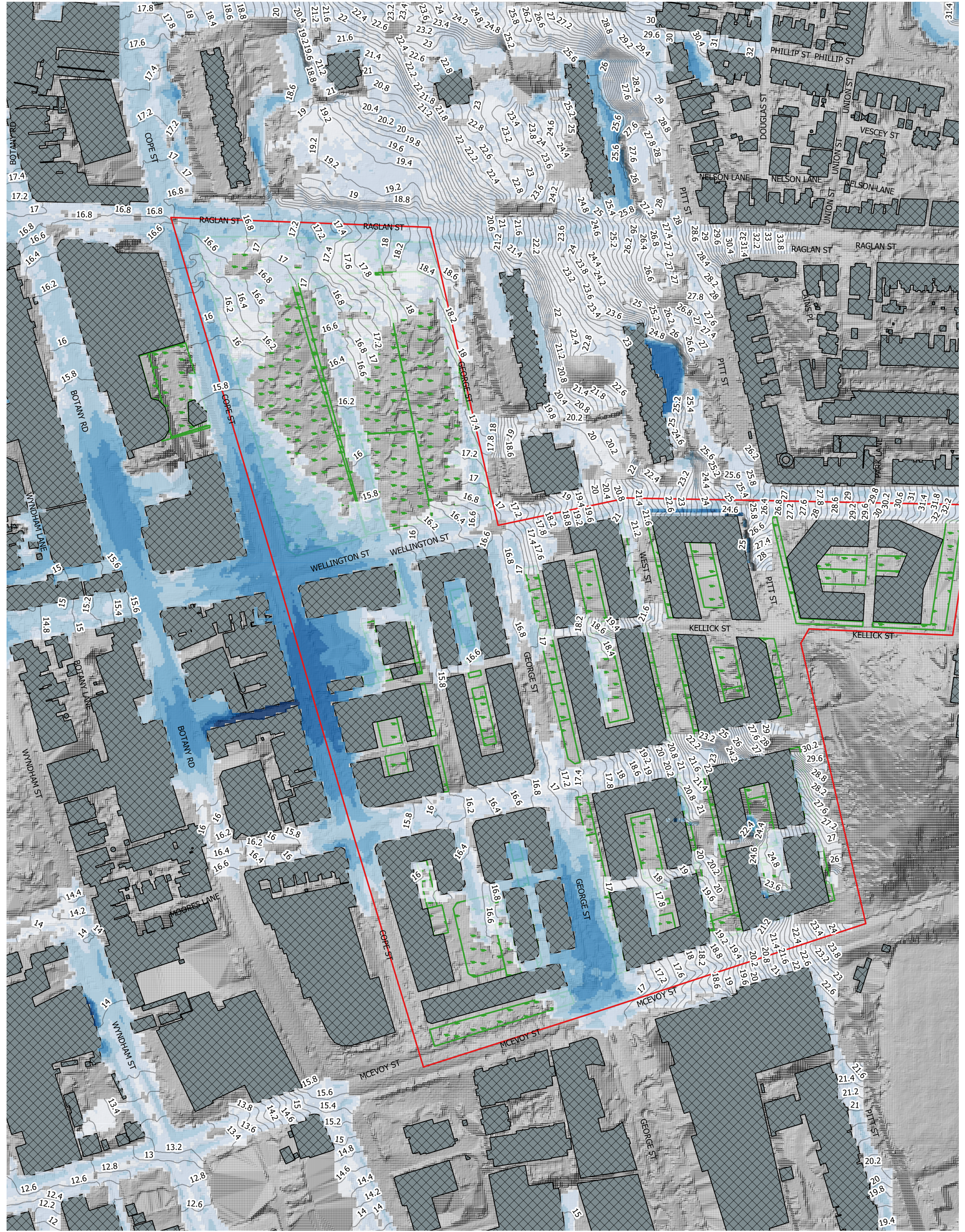
Governing Event for Maximum Flood Level
1 in 100 AEP plus 0.5m
PMF

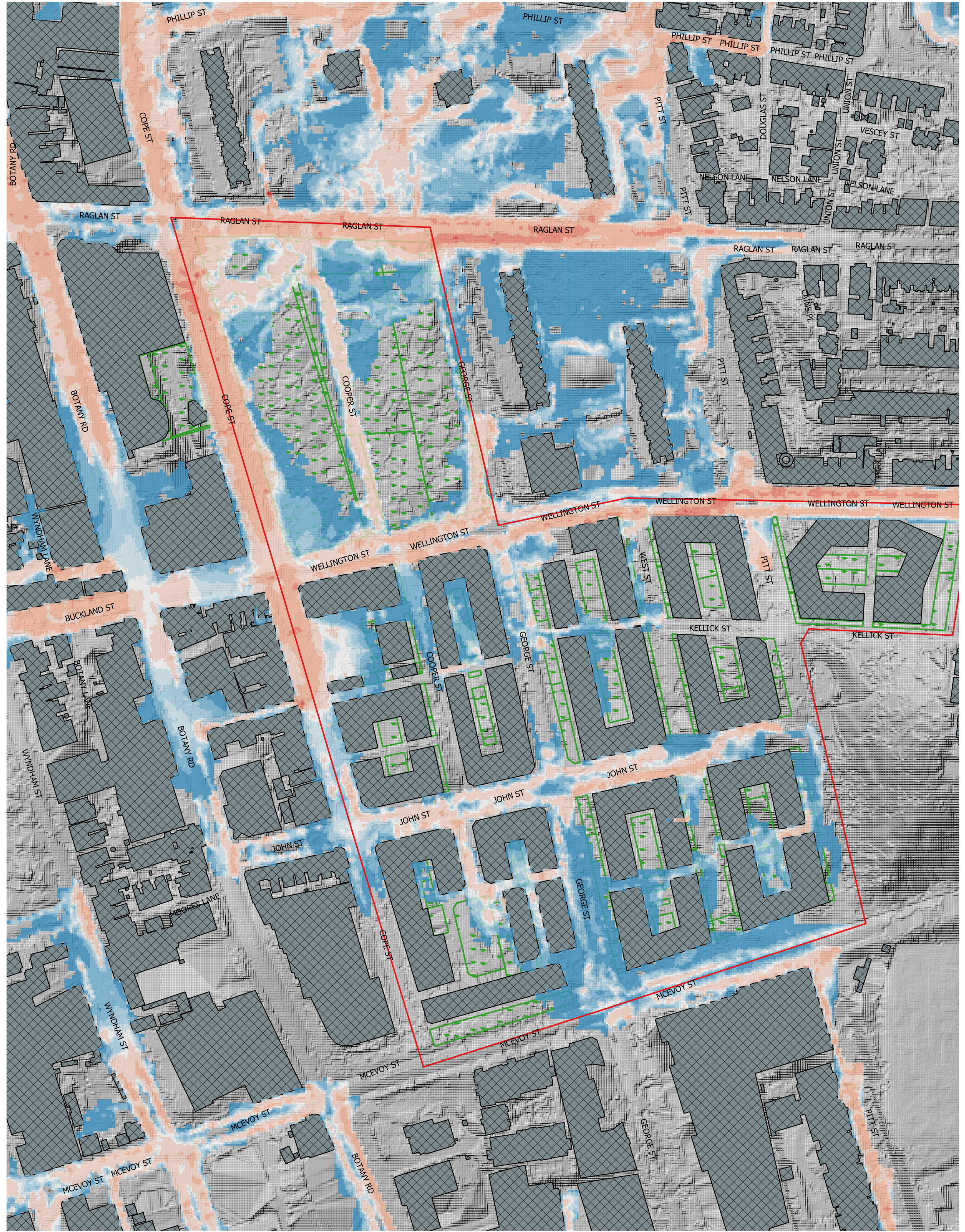


Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - Envelope of 100
AEP+0.5m and PMF

Job Number 12555493
Revision
Date Nov 2021

Figure C23





Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

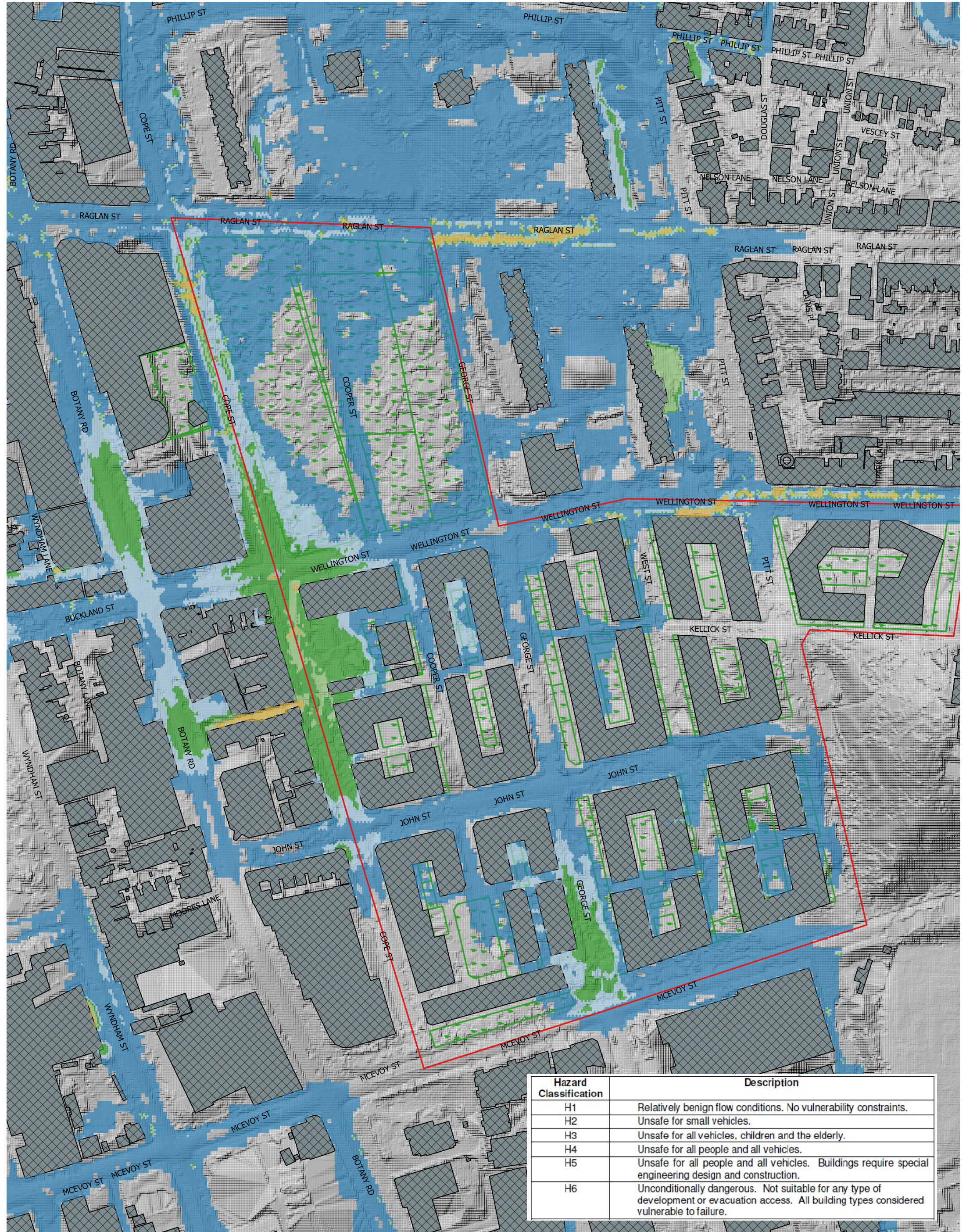
Velocity (m/s)	0.3-0.4	2.0-3.0
<0.1	0.4-0.5	3.0-5.0
0.1-0.2	0.5-1.0	>5.0
0.2-0.3	1.0-2.0	



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - 1 in 100 AEP Climate
Change (10% rainfall increase)

Job Number 12555493
Revision
Date Nov 2021

Figure C25



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

- Hazard
- H1
 - H2
 - H3
 - H4
 - H5
 - H6

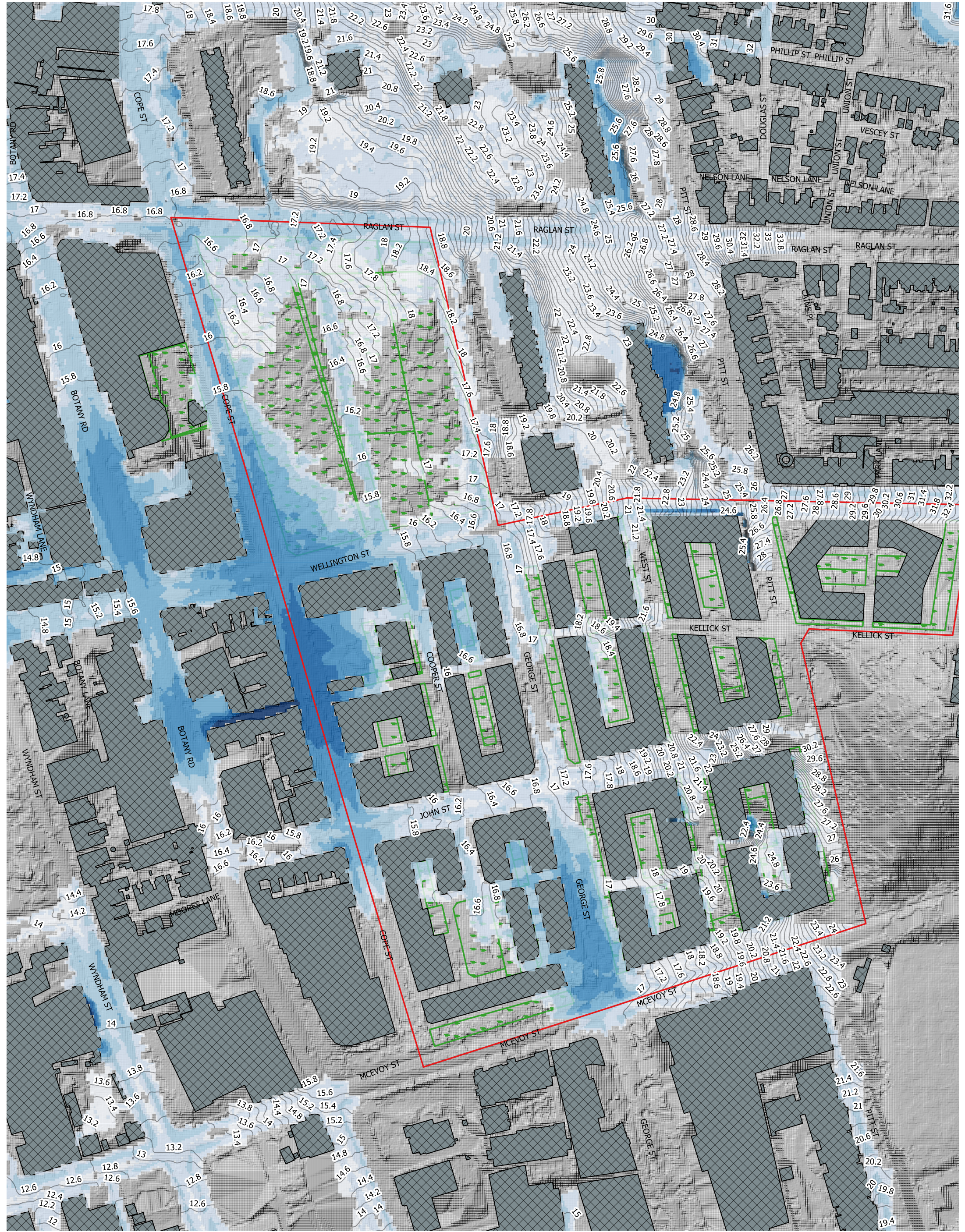


Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal

Flooding Assessment
Design Conditions - 1 in 100 AEP Climate Change (10% rainfall increase)

Job Number 12555493
Revision
Date Nov 2021

Figure C26



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

Level (mAHD)	0.5
Depth (m)	1
0.015	2
0.1	>2
0.3	

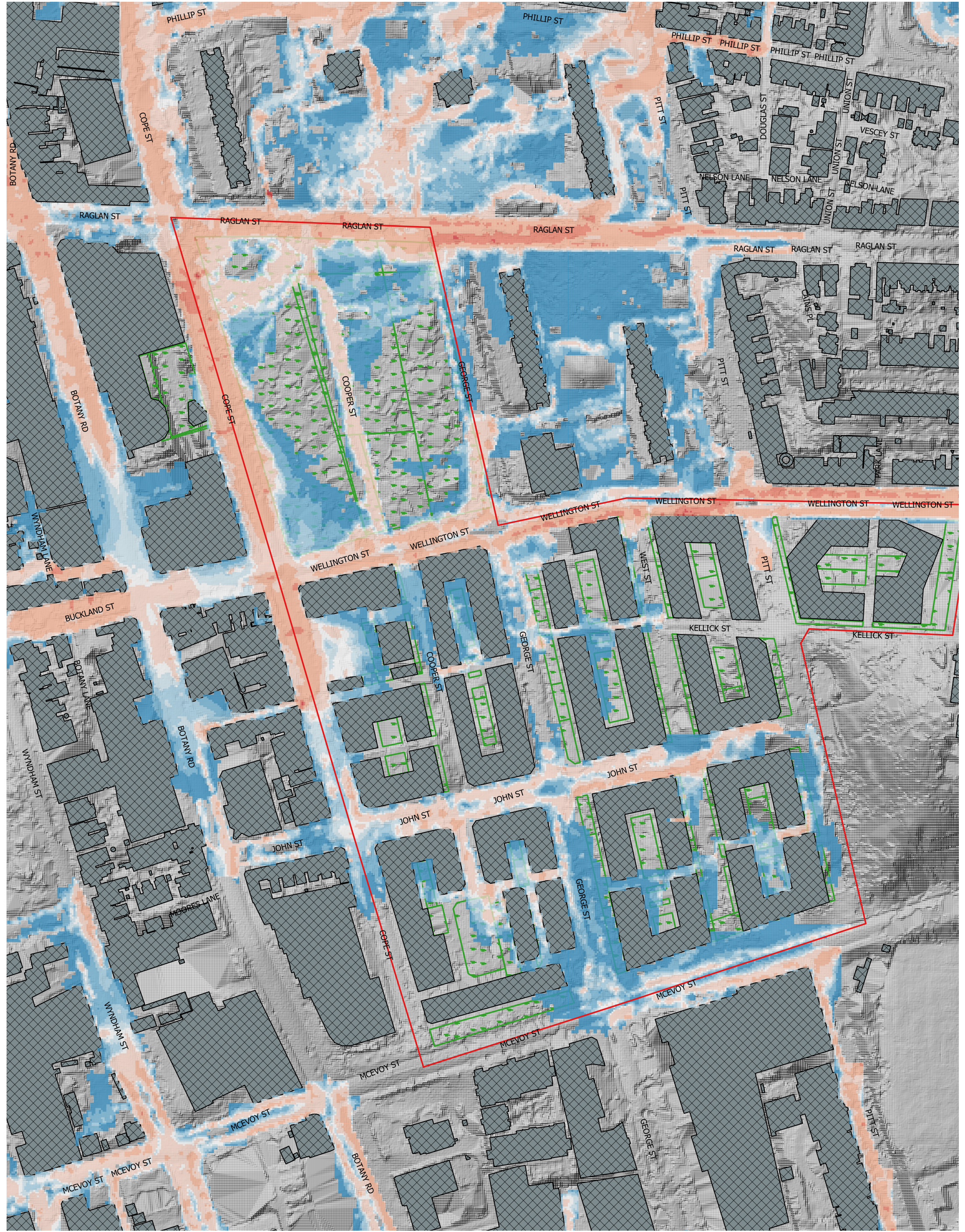


Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal

Flooding Assessment
Design Conditions - 1 in 100 AEP Climate
Change (20% rainfall increase)

Job Number 12555493
Revision
Date Nov 2021

Figure C27



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

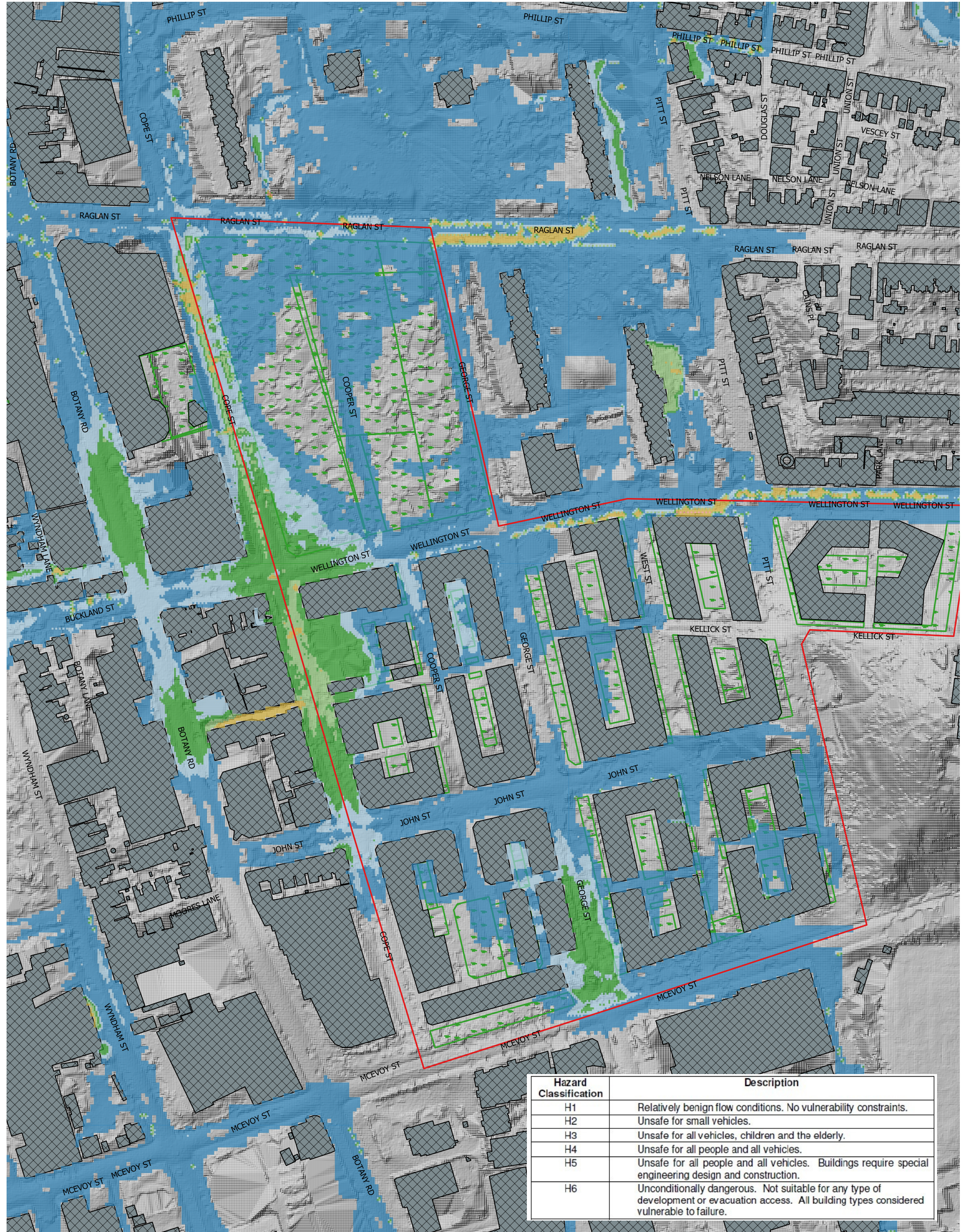
Velocity (m/s)		0.3-0.4	2.0-3.0
<0.1	0.4-0.5	3.0-5.0	>5.0
0.1-0.2	0.5-1.0		
0.2-0.3	1.0-2.0		



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal
Flooding Assessment
Design Conditions - 1 in 100 AEP Climate
Change (20% rainfall increase)

Job Number 12555493
Revision
Date Nov 2021

Figure C28



Hazard Classification	Description
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.

Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

- Hazard
- H1
 - H2
 - H3
 - H4
 - H5
 - H6

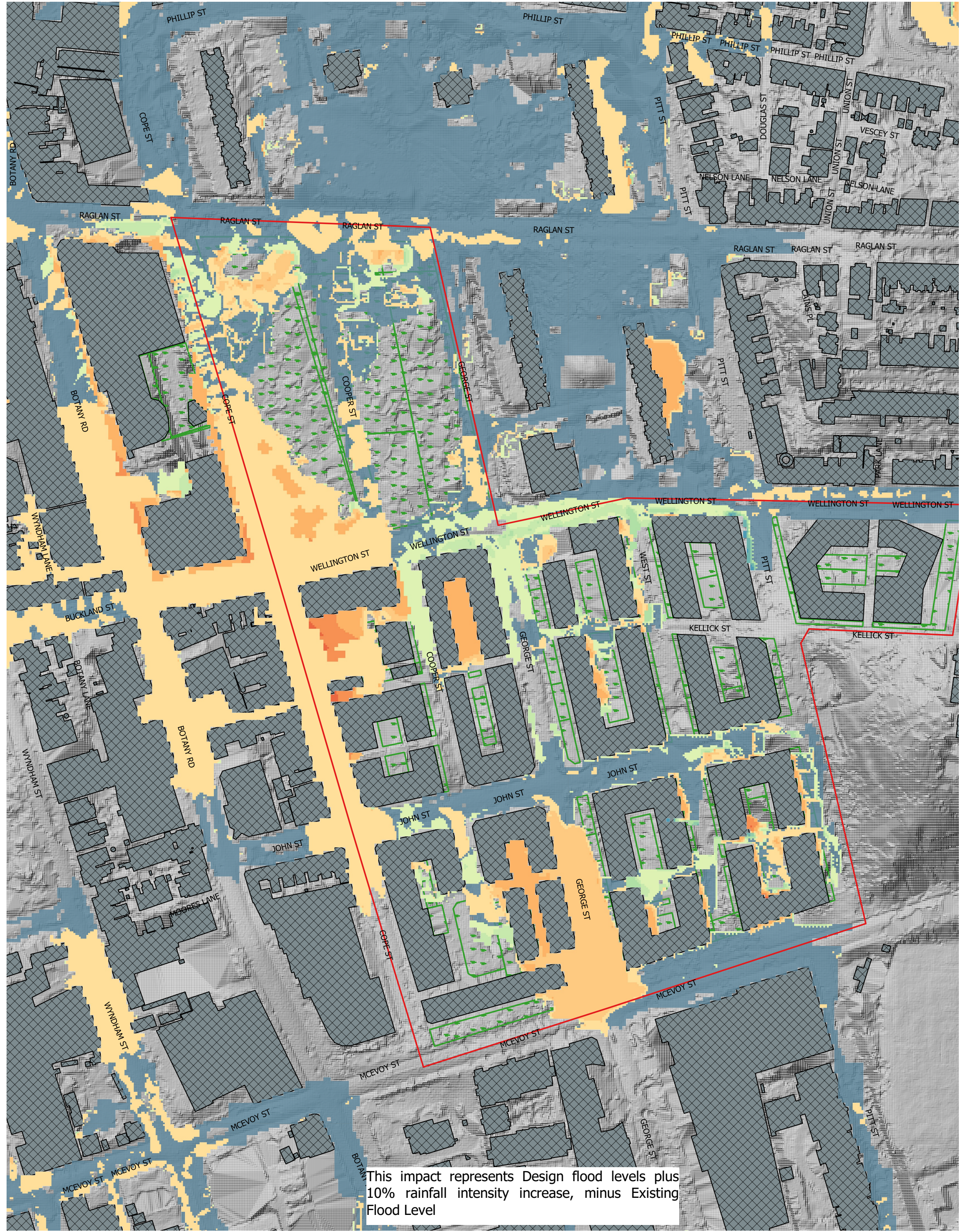


Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal

Flooding Assessment
Design Conditions - 1 in 100 AEP Climate
Change (20% rainfall increase)

Job Number 12555493
Revision
Date Nov 2021

Figure C29



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

Impact (m)	-0.5	<0.01	1-2
<-2	-0.1	0.01-0.05	2-5
-2	-0.05	0.05-0.1	>5
-1	-0.01	0.1-0.5	
0	0.5-1		

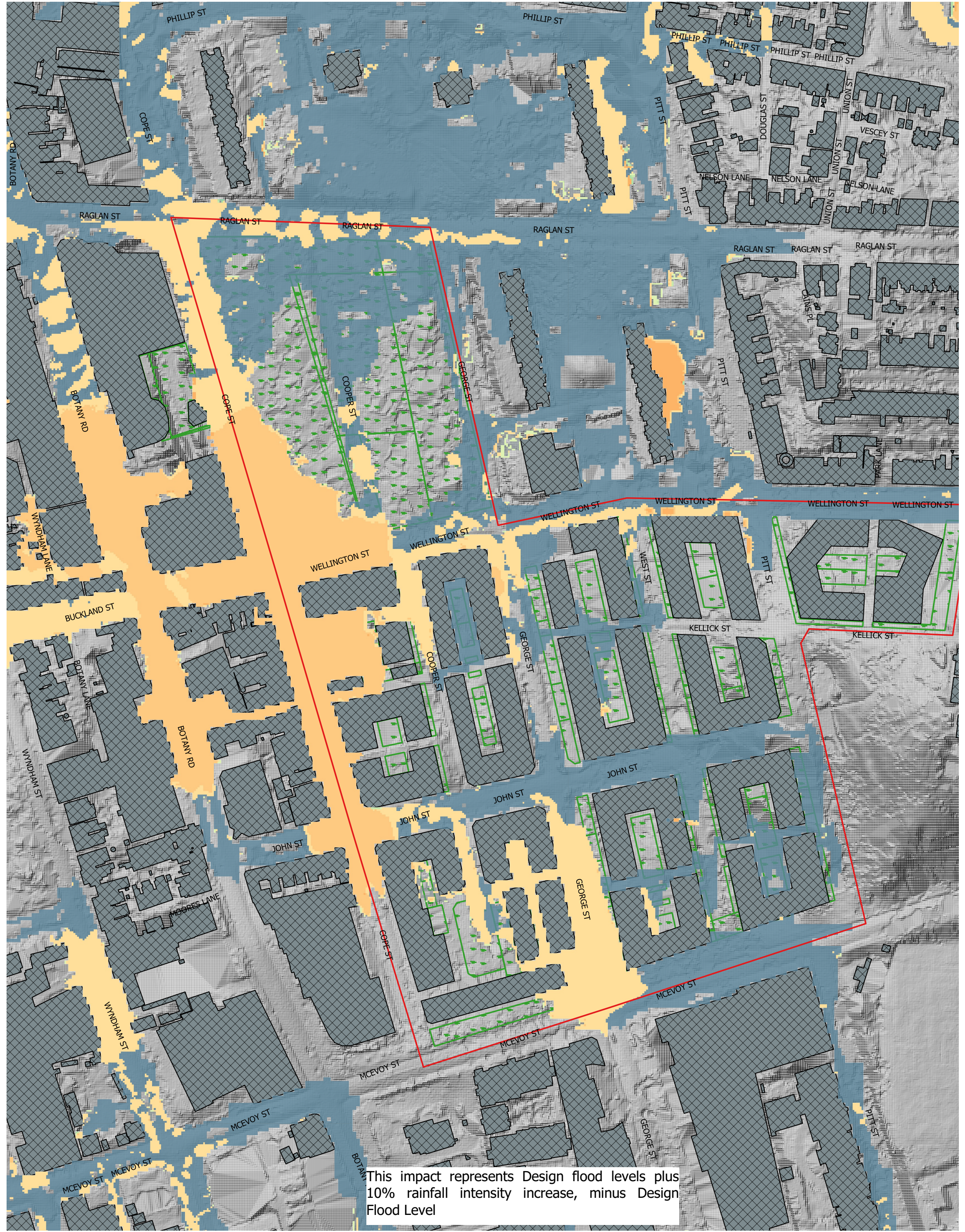


Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal

Flooding Assessment
Flood Impact - 1 in 100 AEP Design (10% rainfall increase on Existing)

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Figure C30



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

Impact (m)	-0.5	<0.01	1-2
<-2	-0.1	0.01-0.05	2-5
-2	-0.05	0.05-0.1	>5
-1	-0.01	0.1-0.5	
0	0.5-1		

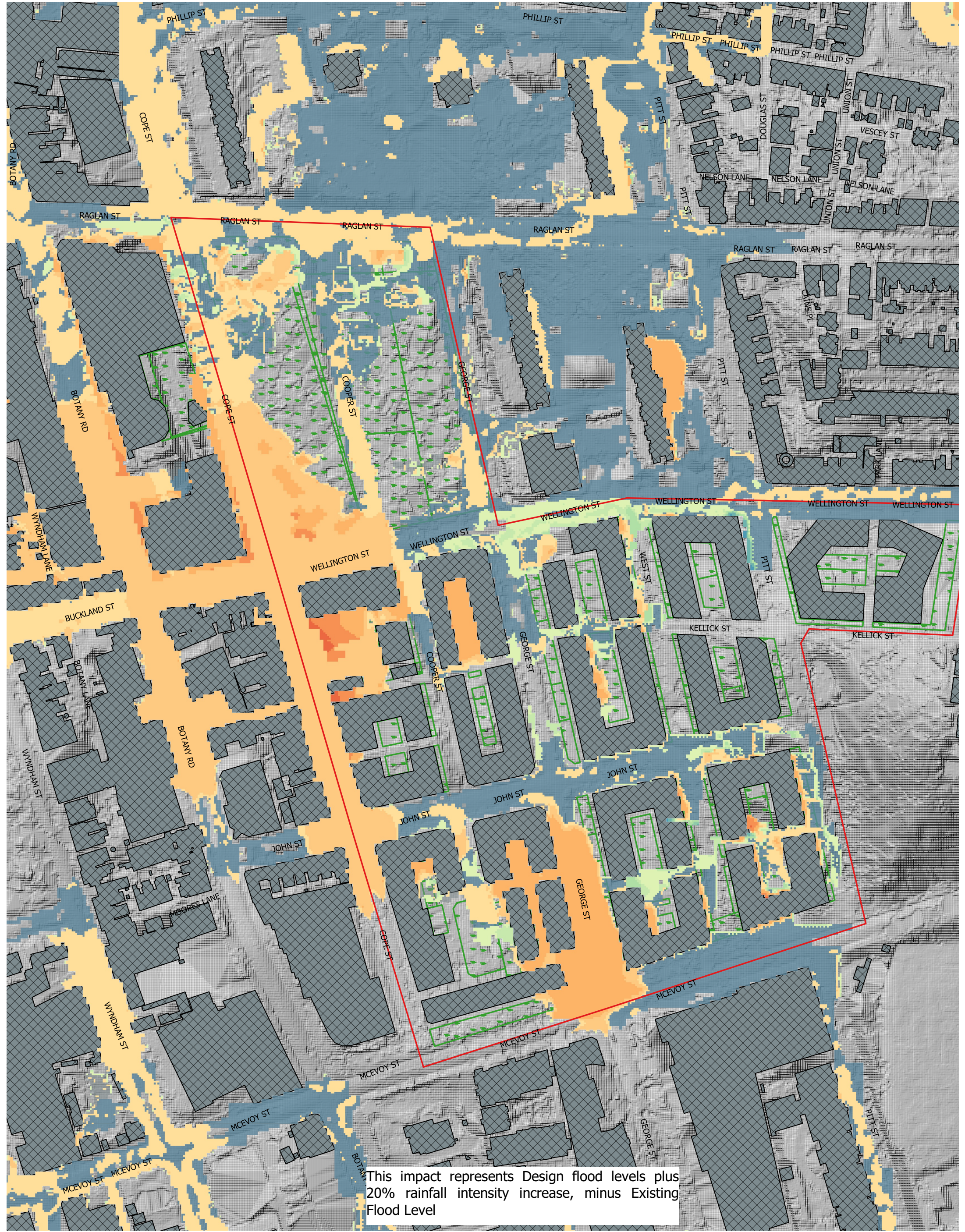


Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal

Flooding Assessment
Flood Impact - 1 in 100 AEP Design (10% rainfall increase on Design)

Job Number 12555493
Revision
Date Nov 2021

Figure C31



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

Impact (m)	-0.5	<0.01	1-2
<-2	-0.1	0.01-0.05	2-5
-2	-0.05	0.05-0.1	>5
-1	-0.01	0.1-0.5	
0	0.5-1		

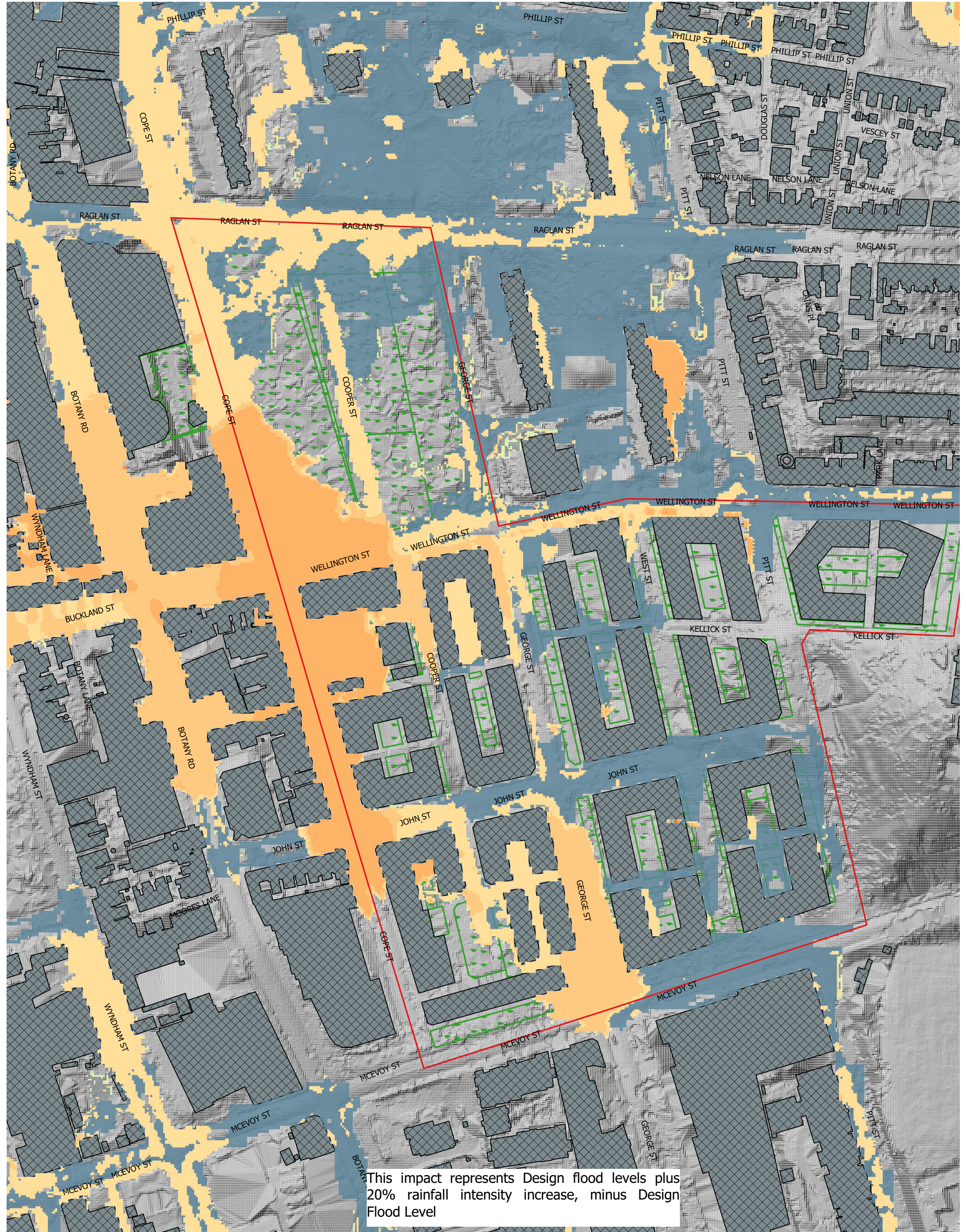


Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal

Flooding Assessment
Flood Impact - 1 in 100 AEP Design (20% rainfall increase on Existing)

Job Number 12555493
Revision
Date Nov 2021

Figure C32



Scale 2000

Paper Size A3

Map projection: Transverse Mercator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



LEGEND

Impact (m)	-0.5	-0.1	-0.05	-0.01	0	<0.01	0.01-0.05	0.05-0.1	0.1-0.5	0.5-1	1-2	2-5	>5
<-2													
-2													
-1													



Department of Planning
Waterloo Estate (South) Precinct - Planning Proposal

Flooding Assessment
Flood Impact - 1 in 100 AEP Design (20% rainfall increase on Design)

Job Number 12555493
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Figure C33



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