Flood Impact Assessment

for

Charles Street Square

for Parramatta City Council, C/- Spackman Mossop Michaels and Lahz Nimmo Architects

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Contents

Report Details

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Introduction

Northrop Consulting Engineers have prepared a Flood Impact Assessment for the proposed development located at Charles Street Square, Parramatta, NSW herein referred to as "the subject site".

This study has been prepared to inform the City of Parramatta Council about potential flood behaviour impact due to the proposed development. The Assessment has given a consideration to the following legislation, policies, guidelines and studies:

- Parramatta Local Environmental Plan 2011, Section 6.3 – Flood Planning.
- City of Parramatta Floodplain Risk Management Policy, 2014.
- City of Parramatta Council Development Control Plan, Section 2.4.2.1 – Flooding, 2011.
- Australian Rainfall and Runoff 2019 (AR&R 2019).
- Australian Rainfall and Runoff 1987 (ARR1987) and subsequent updates.
- NSW State Flood Policy.
- NSW Government Floodplain Development Manual (NSW Government, 2016).
- Floodplain Risk Management Guide (OEH, 2015).
- Upper Parramatta River Catchment Floodplain Risk Management Study and Plan (Bewsher Consulting, 2003).
- Lower Parramatta River Floodplain Risk Management Study and Plan – Volume 1 – Main Report (SKM, 2005).
- Lower Parramatta River Floodplain Risk Management Study and Plan – Volume 2 – Planning (SKM, 2005).

The flood modelling discussed herein has been prepared using data from the following studies and models, used under a licence agreement for this project:

- Lower Parramatta River Floodplain Risk Management Study – Flood Study (SKM, 2005).

Contained herein is a description of the subject site, a summary of the available information used to inform the development of the study, an outline of the methodology used in undertaking this assessment, and a discussion of the results.

Locality Description

Subject Site

The subject site is adjacent to the Parramatta River channel and fully or partially contains the following properties/ lots:

- Lot 1/DP804131.
- Lot 2/DP532539.
- Lot 2/DP869816.
- Lot 2/DP869820.
- Lot 1/DP1172250.
- Lot 1/DP506760.
- Public Road Reserves (Crown Roads).

The subject site is approximately 3,600m^2 in size and includes Charles Street Square and the Parramatta Ferry Wharf. The existing land use is commercial, industrial, recreational and tourist related.

The subject site topography is steep with elevations ranging from 1.60 metres AHD to 7.60 metres AHD – existing landform contours are shown overleaf on **Figure 1**. Typical land cover over the subject site is concrete pavement, grassed areas and trees.

The Charles Street Weir is located adjacent to the site which is a concrete weir with an approximate length of 22 metres and a width of 1.5 metres. At the top of the weir is a pathway which is accessible to the public. When built, the initial purpose of the weir was to act as a freshwater storage zone and to encourage large vessels travelling through the river to turn back downstream to avoid the then shallow, rocky upper reaches of the river.

Today the weir acts as a recreational reserve and continues to separate the upstream fresh water from the brackish water downstream, dividing the fresh and saline ecological habitats in the area. The weir also prevents the fresh water derived from the upper reaches of the catchment from draining away during low tide, maintaining the trafficability and aesthetics of the river in the area. Consequently, in heavy rainfall, Parramatta River Channel can potentially be quickly flooded in the upstream reaches of the weir.

Two scenarios have been considered as a part of this assessment as outlined below.

Existing Case

The existing case includes the latest approved Parramatta Ferry Wharf development including the following features (refer to **Figure 1**):

- Construction of new concrete ferry platform.
- Demolition of the existing concrete ferry platform.
- Construction of new ferry pontoon and gangway.

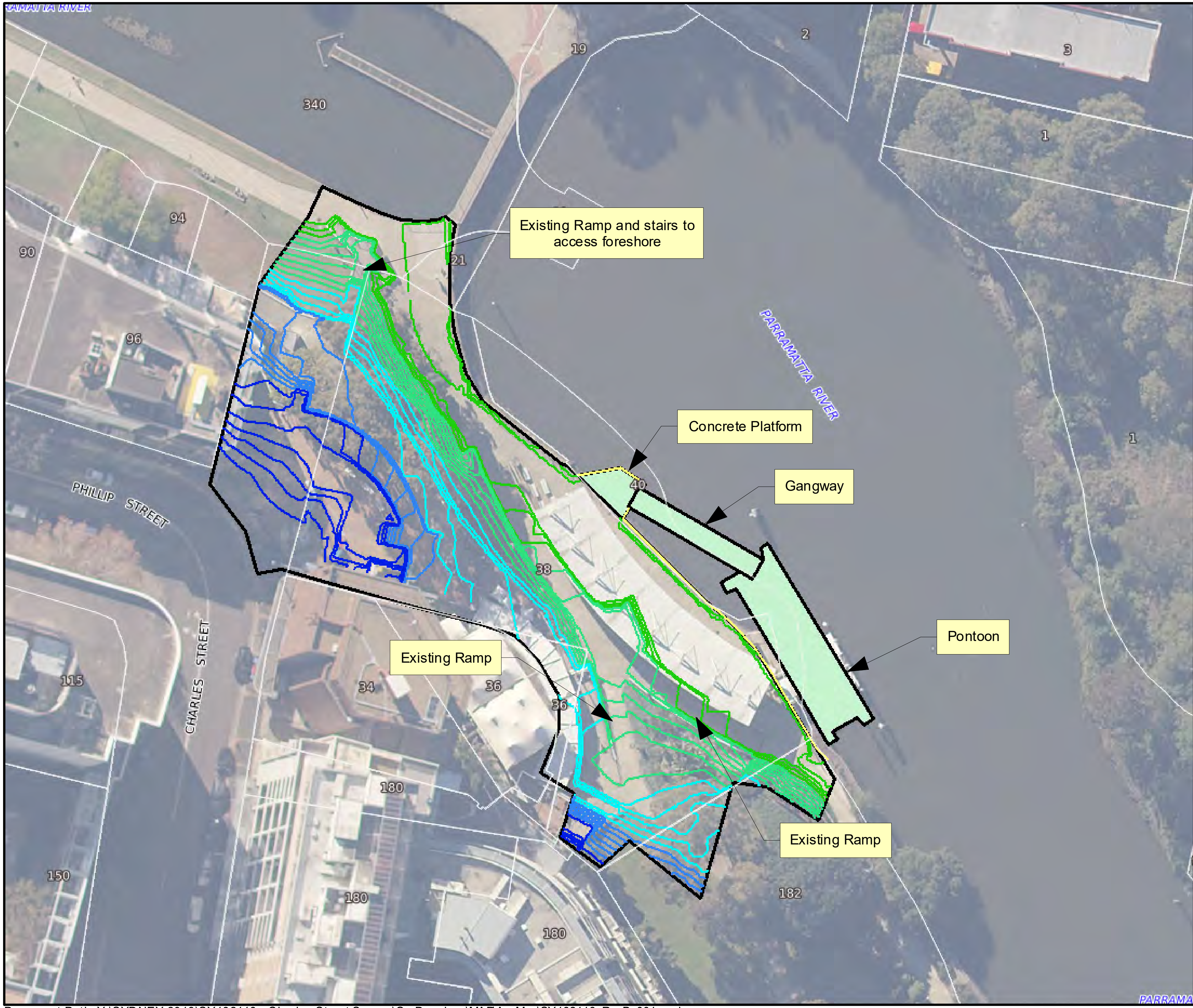
Proposed Development

The proposed upgrades to Charles Street Square and the Ferry Wharf will improve access from the Parramatta River foreshore to the City. The area is a major gateway to downstream suburbs via the Parramatta River and through the ferry services.

To improve access, amenity and legibility for ferry commuters the following upgrades are proposed (refer to **Figure 2** depicting the proposed development features and post-development landform contours):

- New Ramps with Balustrade.
- New Stairs.
- Seating Terraces.
- New Ferry Kiosk.
- New Shelter.
- Extended Concrete Pavement Area.

The proposed development takes into consideration a balance of cut and fill volumes to minimise loss of floodplain storage and maintain flow conveyance during flood events. The change in elevation across the development is presented in the cross sections shown on Figures 1 – 8 in Appendix 2.



Legend

Elevation (mAHD)

- 1.6 - 2.6
- 2.6 - 4.0
- 4.0 - 5.0
- 5.0 - 6.2
- 6.2 - 7.6
- Wire Balustrade
- Project Boundary
- Wharf Structures
- Cadastre

Figure 1

Existing Conditions

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

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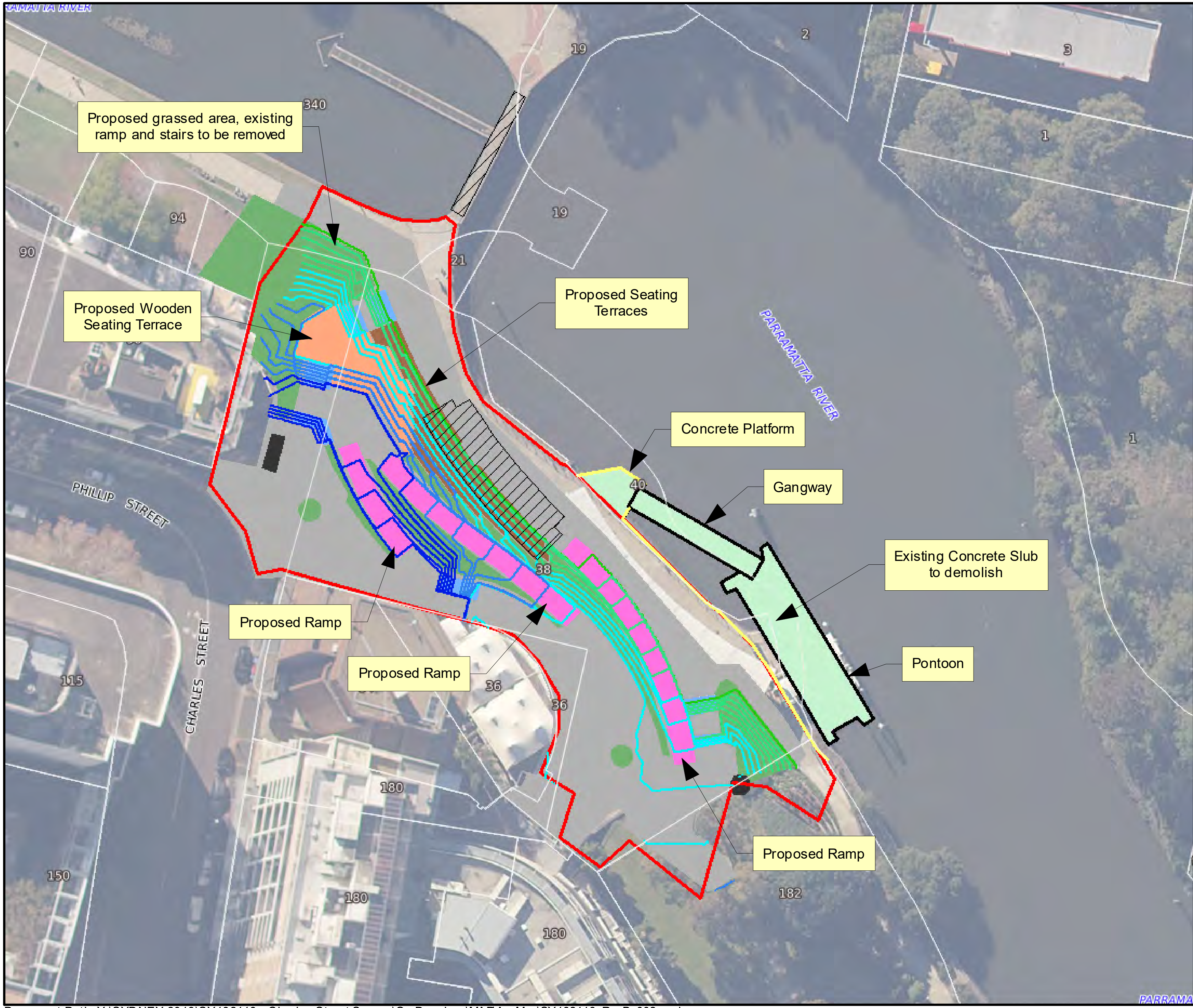

Figure 2
Proposed Development and Landform

Date 27 May 2020

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Methodology

This flood impact assessment was undertaken using the following procedure:

- Desktop review of previous investigations/flood studies including the Upper Parramatta River Catchment Floodplain Risk Management Study and Plan (Bewsher Consulting, 2003) and Lower Parramatta River Floodplain Risk Management Study – Flood Study (SKM, 2005).
- Setup a two-dimensional TUFLOW hydraulic model for both the existing and the proposed conditions to assess flooding behaviour during both scenarios.
- Compare the results for the existing and proposed scenarios to review the development impact on the existing flood behaviour across the floodplain, the subject site and adjacent properties

A description of the modelling, including parameters and assumptions used in the development of this study are contained herein.

2D TUFLOW Model Setup

This hydraulic assessment was undertaken using the TUFLOW hydrodynamic modelling software. The following provides a summary of the parameters used in the development of the two-dimensional flood model. The TUFLOW model extent and topography are shown on **Figure 3** overleaf.

Digital Terrain Model

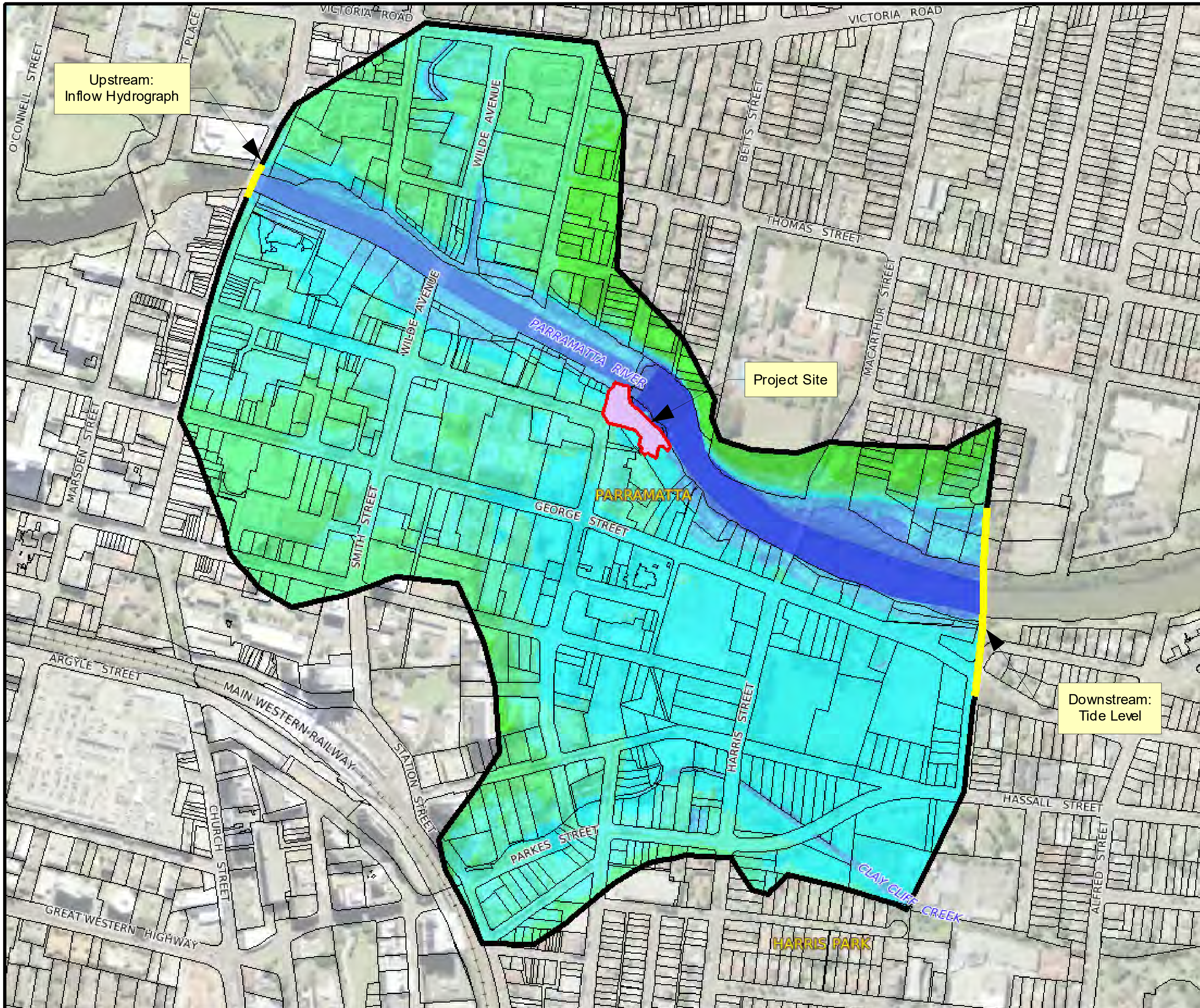
The digital terrain model was developed from a combination of the following datasets:

- LiDAR elevation data, 1m resolution raster interpolated from ground classified points. The LiDAR survey is dated by May 2011 and sourced from Geoscience Australia.
- Bathymetric elevations along Parramatta River were interpolated from cross sections extracted from the existing 1D Mike11 hydraulic model provided by Parramatta Council.
- Existing landform geodetic survey of Parramatta foreshore area (partially covers the subject site) provided by Parramatta Council as 3D contour lines. Date of survey is October 2013.
- Proposed development ground levels were created based on the latest architectural design drawings provided by Spackman Mossop Michaels and Lahz Nimmo Architects.

A TUFLOW model terrain grid size of 1.5 metres x 1.5 metres was adopted for all modelled cases. The Charles Street Weir structure, existing and proposed sheds and balustrades were included into the model as flow constrictions (2D TUFLOW features) by using elevation shapes and form losses.

2D Model Domain Extent

The upstream model boundary extends to the Church Street Bridge to the west while, the downstream boundary is located approximately 300 metres downstream of Macarthur Street Bridge to the east. The model extents include most of the Parramatta CBD area (for the PMF modelling scenarios). Terrain elevations range from approximately -3.3 metres to 16 metres AHD.



Legend

- Inflow/Outflow
- Proposed Development
- Tuflow Model Extent
- Cadastre

Terrain

Elevation, mAHD

- -3.3 - -1.32
- -1.31 - 1.57
- 1.58 - 4.54
- 4.55 - 7.13
- 7.14 - 9.18
- 9.19 - 11.62
- 11.63 - 16.11

Figure 3

Tuflow Model Extent and Topography

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Adopted Boundary Conditions

Upstream and downstream boundary conditions were sourced from the one-dimensional Mike11 model of the *Lower Parramatta River Flood Study (SKM, 2005).*

Inflow hydrographs include the 1%, 5%, 20% AEP flood events and PMF with a critical storm duration of 9 hours (refer to **Figure 4**).

Outlet head boundary conditions were entered in the model as follows (refer to **Figure 4**):

1. Fixed Water Levels for 1%, 5%, 20% AEP representing the ocean tide.
2. Dynamic Water Levels for the 1% and 5% AEP Lower Parramatta River Catchment Flooding.

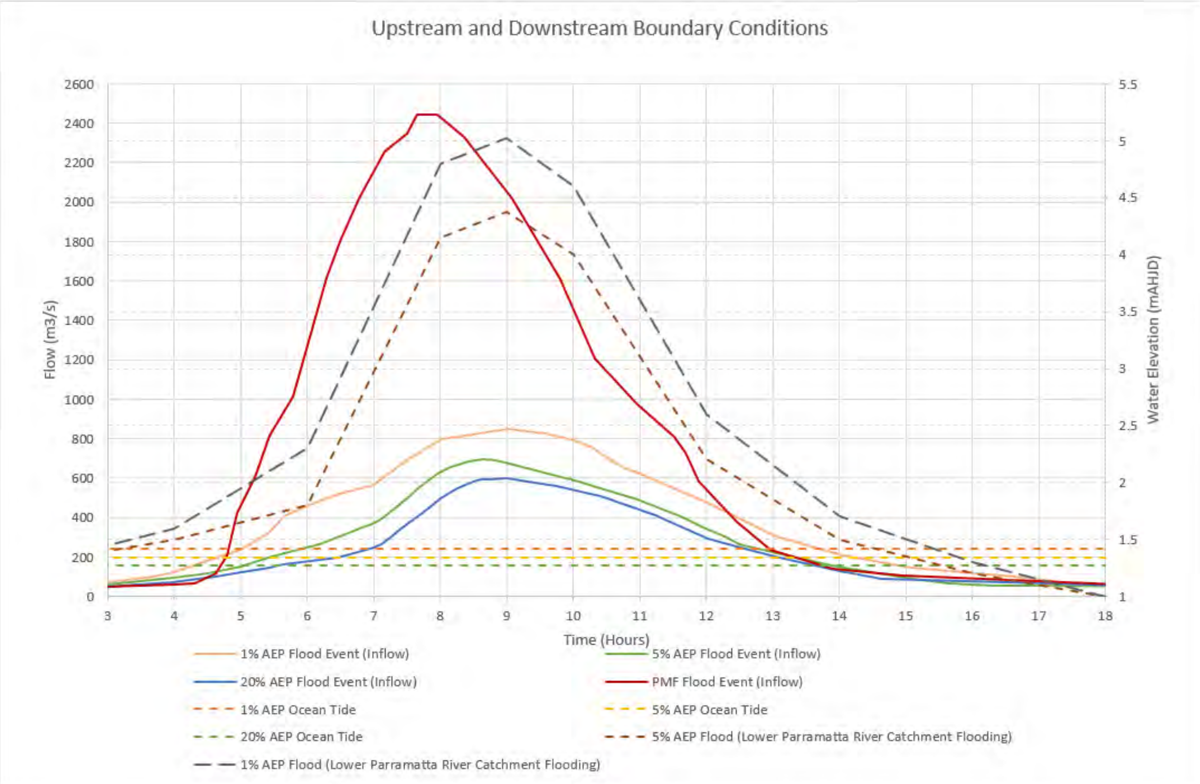


Figure 4 – Modelled Upstream and Downstream Boundary Conditions

The downstream tailwater initial condition was assumed as a riverbank half full flow condition with a water level of 0.8 metres AHD.

Surface Roughness and Building Representation

Surface Manning's n roughness values adopted in this flood impact assessment are listed in the **Table 1** below. The adopted values are based on typical land use within the model extent.

Table 1 - Manning's n Roughness

Land Use	Manning's n Roughness
Turf, Urban areas	0.040
Concrete pavement, Sealed roads	0.020
River Channel	0.025
High/Dense Vegetation	0.090
Pontoon	0.500
Wooden Terrace	0.900
Ticket Booth & Automated Toilets	0.900

All buildings located within the model extent have been modelled as inactive areas ("glass wall"), effectively assuming 100% blockage, forcing flows around them.

Modelled Scenarios

All modelled scenarios are listed in the **Table 2** below:

Table 2 – Modelled Scenarios

Scenario ID	Local (Upstream) Catchment Flood	Downstream Flooding	Landform
1	1% AEP	5% AEP Ocean Tide	Existing
2	1% AEP	5% AEP Ocean Tide	Proposed
3	5% AEP	20% AEP Ocean Tide	Existing
4	5% AEP	20% AEP Ocean Tide	Proposed
5	20% AEP	20% AEP Ocean Tide	Existing
6	20% AEP	20% AEP Ocean Tide	Proposed
7	PMF	1% AEP Ocean Tide	Existing
8	PMF	1% AEP Ocean Tide	Proposed
9	1% AEP	5% AEP Lower Parramatta Catchment Flooding (sensitivity)	Existing
10	1% AEP	5% AEP Lower Parramatta Catchment Flooding (sensitivity)	Proposed
11	1% AEP	1% AEP Lower Parramatta Catchment Flooding (sensitivity)	Existing
12	1% AEP	1% AEP Lower Parramatta Catchment Flooding (sensitivity)	Proposed

It is acknowledged using ocean tide levels will produce lower flood levels downstream of the Charles Street Weir than reported in the Council flood study. These have been chosen as it will produce a larger impact from the proposed development on flood behaviour. Sensitivity cases have also been considered with a dynamic tailwater condition for flooding of the surrounding river tributaries.

Modelling Results

The following is a summary of the flood results for the existing and the proposed scenarios as well as a brief discussion regarding the change in flood behaviour resulting from the proposed development.

Validation with Previous Flood Study/ Modelling

Modelled maximum water elevations during the existing scenario were compared with the flood modelling results from the *Lower Parramatta River Flood Study (SKM, 2005)*. The results are presented in the below **Table 3**.

Table 3 – Maximum Water Elevations at Charles St Weir

Flood Event	Downstream Conditions	Northrop Model	Previous Flood Study (2005)	Difference
PMF	1% AEP Ocean Tide	9.16m AHD (Middle of channel)	10.14m AHD	-0.92m
1% AEP	5% AEP Ocean Tide	5.30m AHD (Middle of channel)	5.50m AHD	-0.20m
5% AEP	20% AEP Ocean Tide	4.83m AHD (Middle of channel)	5.24m AHD	-0.41m
20% AEP	20% AEP Ocean Tide	4.51m AHD (Middle of channel)	4.93m AHD	-0.42m
1% AEP (sensitivity)	5% AEP Lower Parramatta River Catchment Flooding	5.42m AHD (Middle of channel)	5.50m AHD	-0.08m
1% AEP (sensitivity)	1% AEP Lower Parramatta River Catchment Flooding	5.53m AHD (Middle of channel)	5.50m AHD	+0.03m

The current Northrop modelled water elevations are lower for all flood events with the smallest difference of -0.20 metres observed during the 1% AEP and the highest difference of -0.92 metres observed during the PMF. The difference can be explained by modelling approach (two-dimensional versus one-dimensional hydrodynamic) and topography details (the current model uses latest LiDAR data and surveys).

For comparison purposes, the model was also run with tail water conditions consistent with the Lower Parramatta River Catchment flood study. The results show 30-80mm difference between the two models at the weir.

There is an insignificant difference in peak flows for both the current Northrop and previous models for all flood events.

The analysis indicates that the Northrop model appropriately represents current conditions and is considered suitable for the purposes of the flood impact assessment.

Water Elevations, Velocity – Existing v Proposed

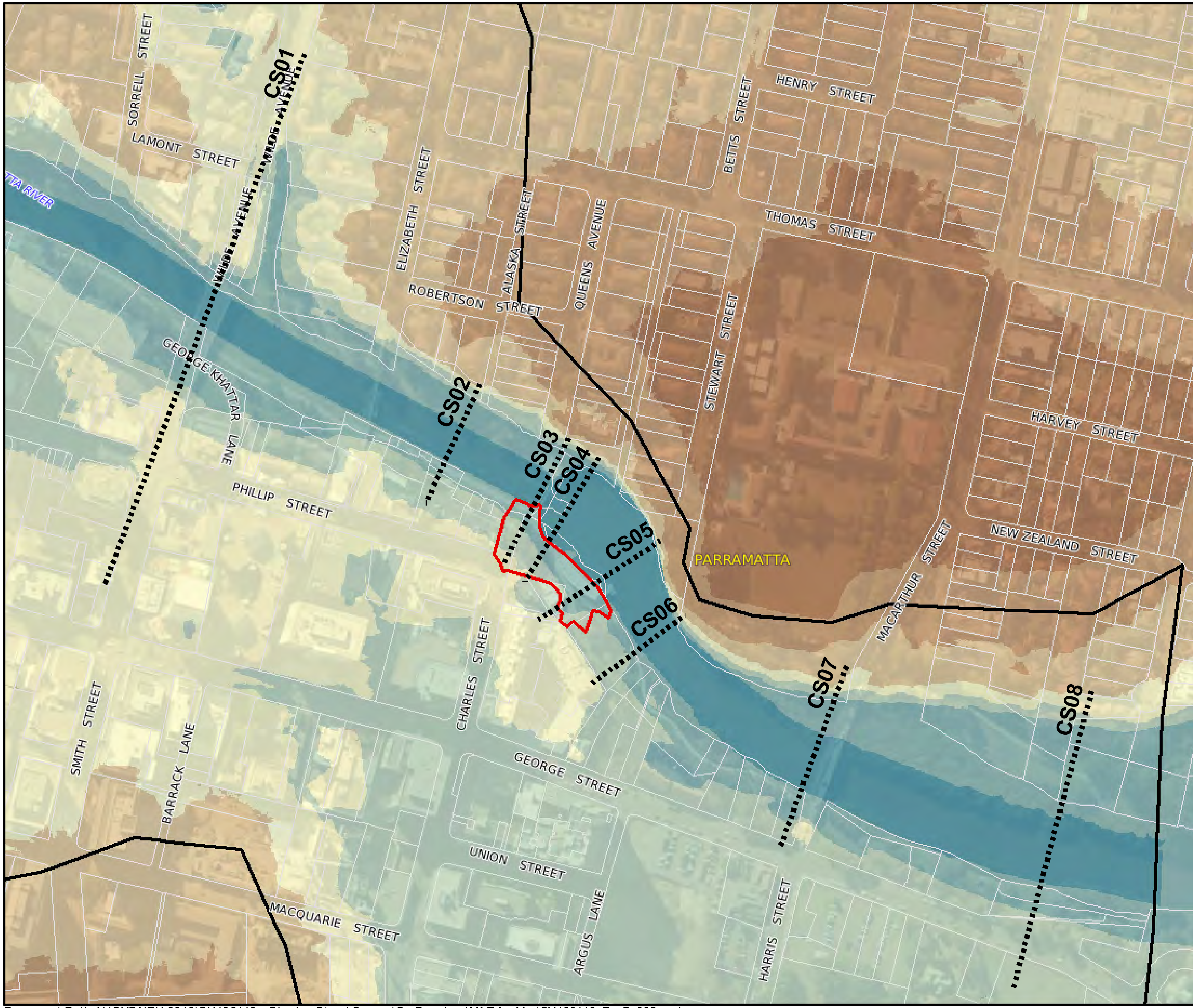
Modelled water elevations (hydrographs) for both the existing and the proposed conditions for the model cross sections (refer to **Figure 5**) are presented in Appendix 3 Figures 1 - 8. Maximum modelled water elevations, energy grades (hydraulic gradients), flow, velocity and result differences are presented in Appendix 4, Tables 1 to 4. The results for the two sensitivity tests are also presented in Appendix 4, Tables 1 to 4.

The analysis for the flood impact scenarios indicates that the 1% AEP water elevations for the proposed conditions will decrease approximately by 0.03-0.07 metres for upstream reaches of the Charles Street Weir and increase approximately by 0.01-0.07 metres within 100 metres downstream of the weir. For 5% and 20% AEP events water elevations decrease by 0.04-0.09 metres upstream of the weir and increase by 0.04-0.08 metres downstream of the weir. These changes only result in a minor change in the flood extents (as shown in Figures 7, 14, 21 and 28 of Appendix 1) and are not expected to create a significant adverse impact.

The modelling also indicates that a minor change in energy grades is expected for the flood impact scenarios. Generally, a minor increase is observed upstream of the weir which changes to a decrease as flows spill over the weir and finally an increase is observed as flows then continue downstream of the weir. The increase in energy grade upstream of the weir is expected to be due to the water levels becoming lower as flows begin to “drain out” towards the weir crest, drawing down the tail water level between the cross sections and increasing the energy grade. As flows spill over the weir, a decrease in water level is observed upstream but an increase is observed downstream. This results in a decrease in the energy grade due to the relative change in the head difference when compared to the existing case. Moving downstream of the weir, an increase in water levels is observed at the base of the weir. As these flows continue to equalise downstream, an increase in the energy grade is observed due to similar tailwater conditions pre-to-post.

A similar scenario occurs for the velocity whereby, an increase in the head difference (or energy grade) is typically observed upstream, leading to an increase in the flow velocity between cross sections. A decrease in the energy grade is observed at the weir, leading to a decrease in the energy grade and an increase in the energy grade is observed downstream while an increase in velocity is also observed.

The reduced water levels upstream of the weir are expected to be due to the removal of the existing access ramp and stairs on the western part of the subject site (refer to Appendix 2, Figure 2: Cross Section 1). Additional flows are then allowed to drain out which results in an increase at the base of the weir. The topographic changes in this area are also presented in plan in Appendix 2, Figure 1 [A2].



Legend

- Cross Sections
- Tuflow Model Extent
- Proposed Development
- Cadastre

Terrain (mAHD)

- -3.30 - 0.37
- 0.37 - 4.24
- 4.24 - 7.33
- 7.33 - 9.94
- 9.94 - 12.94
- 12.94 - 16.42
- 16.42 - 21.35

Figure 5
Model Cross Section Locations

Date 27 May 2020

Job Name
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Parramatta

Job Number SY182116 **Rev** B

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0 40 80 120 Meters

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Flood Maps (Maximum Depth, Elevation, Velocity, Hazard, Elevation Difference)

The modelled maximum water depth, velocity, hazard and depth difference maps are presented in Appendix 1 Figures 1-42 for both the existing and the proposed conditions. Figures 7, 14, 21, 28, 35, 42 present the change in water elevation with consideration to the spatial variability of maximum modelled water elevations changes.

The modelled maximum flood hazards are based on the AR&R 2019 hazard categories, see **Figure 6** for description.

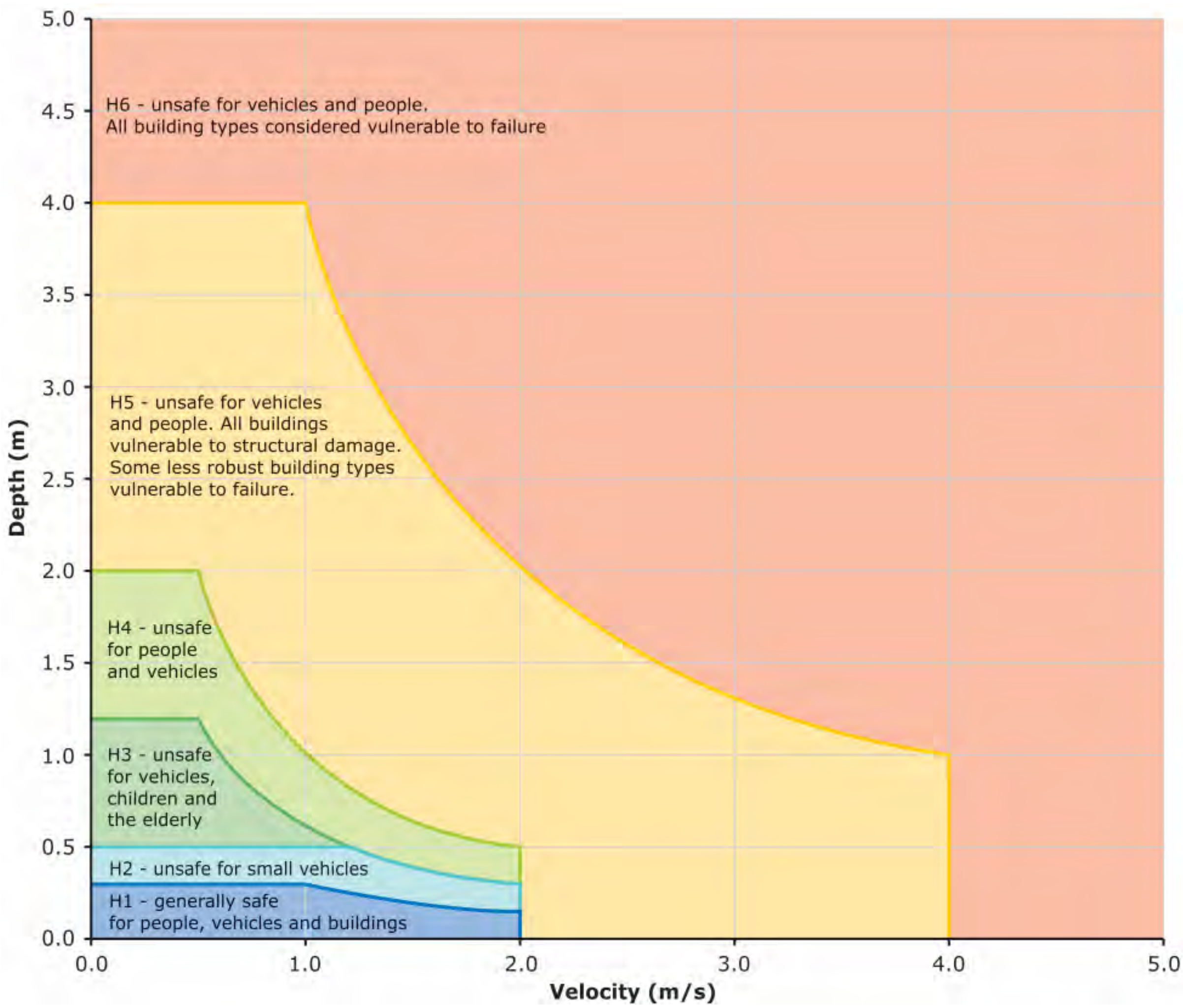

Figure 6 - Flood Hazard Categories (AR&R 2019, Book 6 - Chapter 7)

The modelling indicates that there are no changes in flood hazards in the properties surrounding the subject site. The analysis indicates that due to the proposed development landform modification there is a change in flood hazard within the subject site, see **Table 4** below.

Table 4 – Area under H3 (Equal or Higher) Flood Hazard within the Subject Site

Flood Event	Existing conditions (m^2)	Proposed conditions (m^2)	Difference (m^2)	Difference (%)
1% AEP and 5% ocean tide	702	847	+145	+21
5% AEP and 20% ocean tide	541	664	+123	+23
20% AEP and 20% ocean tide	488	616	+128	+26
1% AEP – sensitivity, 5% Lower Parramatta River catchment flood	1539	1546	+7	+0.5
1% AEP – sensitivity, 1% Lower Parramatta River catchment flood	2233	2093	-140	-6

The area under the flood hazard category H3 and higher for the proposed development will increase by up to approximately 21-23% for 1%, 5% and 20% AEP flood events. The analysis also indicates that the area under the flood hazard category H3 and higher will decrease by approximately 12% for 1% AEP flood event (sensitivity) which is expected to be due to the higher downstream water level conditions. Given the sensitivity analysis best represents the entire river system during the flood, it is considered the flood hazard marginally decreases during the 1% AEP event.`

Downstream Conditions Sensitivity

The sensitivity modelling for 1% AEP Flood events indicates that the magnitude of water elevation change will be reduced under higher outlet water head (refer to Appendix 3 Figures 7 and 8).

Out of Bank Flooding: Tractive (Bed Shear) Stress and Velocity

Out of bank flooding velocity and tractive stress were analysed against reference stability threshold criteria (refer to **Table 5**) for both the existing and the proposed conditions. Bed shear stress (or tractive stress) is a measure of the erosive potential of flows within a watercourse. Bed shear stress is determined from both the depth of flow and energy loss within a given section of watercourse. Bed shear stress together with water velocity provides an accurate means of estimating the erosive potential within a watercourse.

Table 5 – Velocity and Tractive (Bed Shear) Stress Thresholds

Bed Material or Cover Type	Velocity (m/s)	Tractive Stress (N/m2)
Fine Colloidal Sand (dispersive)	0.50	1.400
Fine Gravels	0.76	3.600
Stiff Clay	1.40	12.50
Short Native and Bunch Grass	1.20	45.50
Graded Silts to Cobbles	1.22	20.60
100mm Cobbles	2.10	63.90
Concrete	6.10	957.6

Source: Stability Thresholds for Stream Restoration materials (US Army Engineers and Research Development Centre, 2001)

The attached Figure 1 of Appendix 5 demonstrates that during 1%, 5% and 20% AEP flood events, out of bank maximum flow velocities for the proposed conditions are slightly higher than the existing case at the locations upstream and downstream of the weir but remain within the stability thresholds for typical surfaces in the floodplain. Reductions in velocity are observed over the weir which is expected to be due to the modified cross section and reduced head difference when compared to the existing case.

Similarly Figure 2 of Appendix 5 demonstrates that during 1%, 5% and 20% AEP flood events, out of bank maximum tractive stress for the proposed conditions are slightly higher but also remain within stability thresholds.

Flood Extents

There are insignificant changes in flood extent for all flood impact events. The changes are mainly localised within the subject site and occur due to the proposed landform modifications. The flood extent boundaries are presented in Appendix 1 Figures 7, 14, 21 and 28.

Flood Durations

There are no changes in flood durations for all flood events for the proposed conditions.

Discussion

The proposed development has been assessed based on the requirements set out in Section 2.4.2.1 of the Parramatta Council Development Control Plan (DCP). The aforementioned flood behaviour and following **Figure 7** identifies the subject site to be located within a high flood hazard zone. As such, the following controls apply to the proposed development.

Figure 7 - Flood Risk Precinct (as per Council's online Web Map Service).

Floor Levels

The Parramatta Council DCP, in Particular Table 2.4.2.1.2 suggests floor levels are to be placed at an elevation equal to or greater than the 20-year ARI flood level plus freeboard of 500mm. This is roughly equivalent to the 5% AEP design storm event previously discussed.

A small ferry kiosk is proposed as part of the development. This structure will have a transient use and is not considered a 'habitable' room as defined by the Floodplain Development Manual. To comply with this definition, the kiosk is not to be used for the storage of valuable items including important records and valuable possessions. As a result, no minimum floor level applies to this structure.

Building Components

As per the requirements set out in Table 2.4.2.1.2 of Parramatta Council's DCP, the proposed development is to incorporate flood compatible finishes below the 1% AEP plus 500mm to allow for easy maintenance in the event of a very rare flood. Services such as power lines, telecoms and any electrical components sited below the 1% AEP + 500mm must be waterproofed.

Structural Soundness

Certification that the proposed structures can withstand the forces of floodwater, debris and buoyancy up to and including a 100-year ARI flood level plus a freeboard of 500mm is required as discussed in Table 2.4.2.1.2 of Parramatta Council’s DCP.

Failure during more extreme events should also be taken into consideration whereby, the proposed development should not create floating debris that may cause damage to other assets further downstream.

Each structure will need to be designed to withstand flooding during the Flood Planning Level event and full immersion conditions, with consideration to waterborne debris, hydrostatic and hydro-dynamic forces, flotation and scour.

Flood Affectation

The impact that the proposed development on the existing flood behaviour is discussed herein.

This investigation concludes that the proposed development is not expected to result in a significant adverse impact within adjacent private properties. Figures 7, 14, 21 and 28 of Appendix 1 demonstrate only minor changes to the flood extents as a result of the proposed development.

Evacuation Management and Design

As set out in Table 2.4.2.1.2 of Parramatta Council’s DCP, a Site Emergency Flood Response Plan will be required where the site is affected by the 100-year ARI flood level. An Emergency Flood Response Plan will reduce the risk to life by educating operators on the flood risk prior the onset of very rare to extreme rainfall, outlining evacuation and response procedures and by identifying areas of refuge.

The storage of goods and valuable items will be required at a level above the 100-year ARI flood level plus freeboard. Similar to above, any materials contained within the New Ferry Kiosk will be transient in nature and are not expected to be held on-site for a prolonged period of time.

The formalisation of the public open space area will also provide greater opportunity for management of this area to prevent items stored at ground level from becoming hazardous during a flood event.

Conclusion

A flood impact assessment has been undertaken for the proposed development at Charles Street Square, Parramatta, NSW.

It is concluded that the proposed development will not result any significant adverse impact to the existing flood behaviour within the properties surrounding the subject site.

We commend our findings to Council for their review.

Should you have any queries regarding this correspondence, please feel free to contact the undersigned on (02) 4943 1777.

Prepared by:

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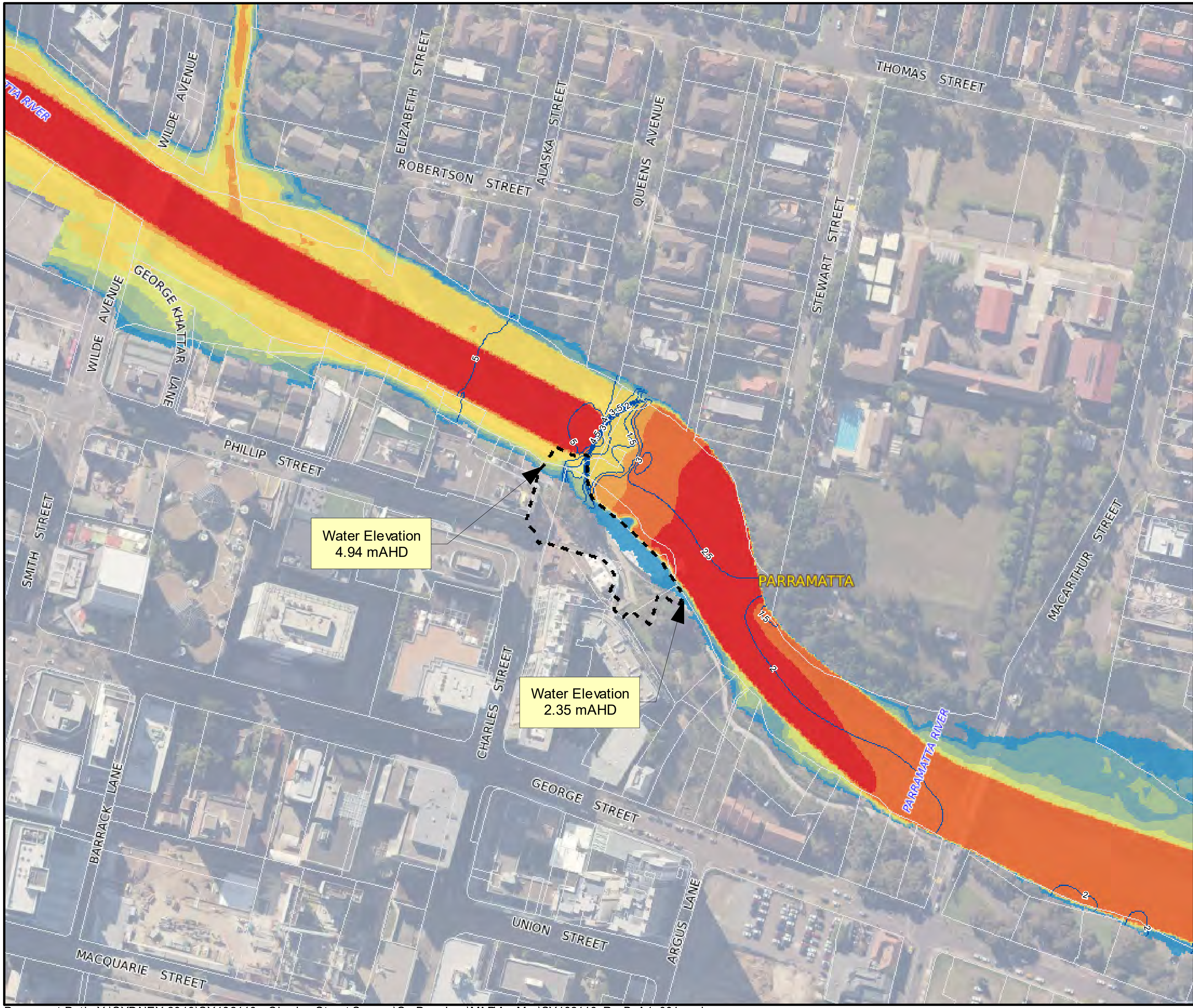
BEng (Civil)(Hons) MIEAust Member SIA FMA CPEng NER RPEQ

Appendix 1 – Flood Maps (Maximum Modelled Depth, Velocity, Hazard, Depth Difference)



Legend

- Proposed Development
- Cadastre
- Water Levels (mAHD)

Water Depth (m)

- 0 - 0.5
- 0.51 - 1
- 1.01 - 1.5
- 1.51 - 2
- 2.01 - 3
- 3.01 - 4
- 4.01 - 5
- 5.01 - 6

Figure 1 [A1]

Modelled Max Water Depth and Elevations
1% AEP Flood Event
Existing Scenario

Date 27 May 2020

Job Name
Charles Street Square
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N

0 30 60 90 Meters

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email newcastle@northrop.com.au ABN 81 094 433 100

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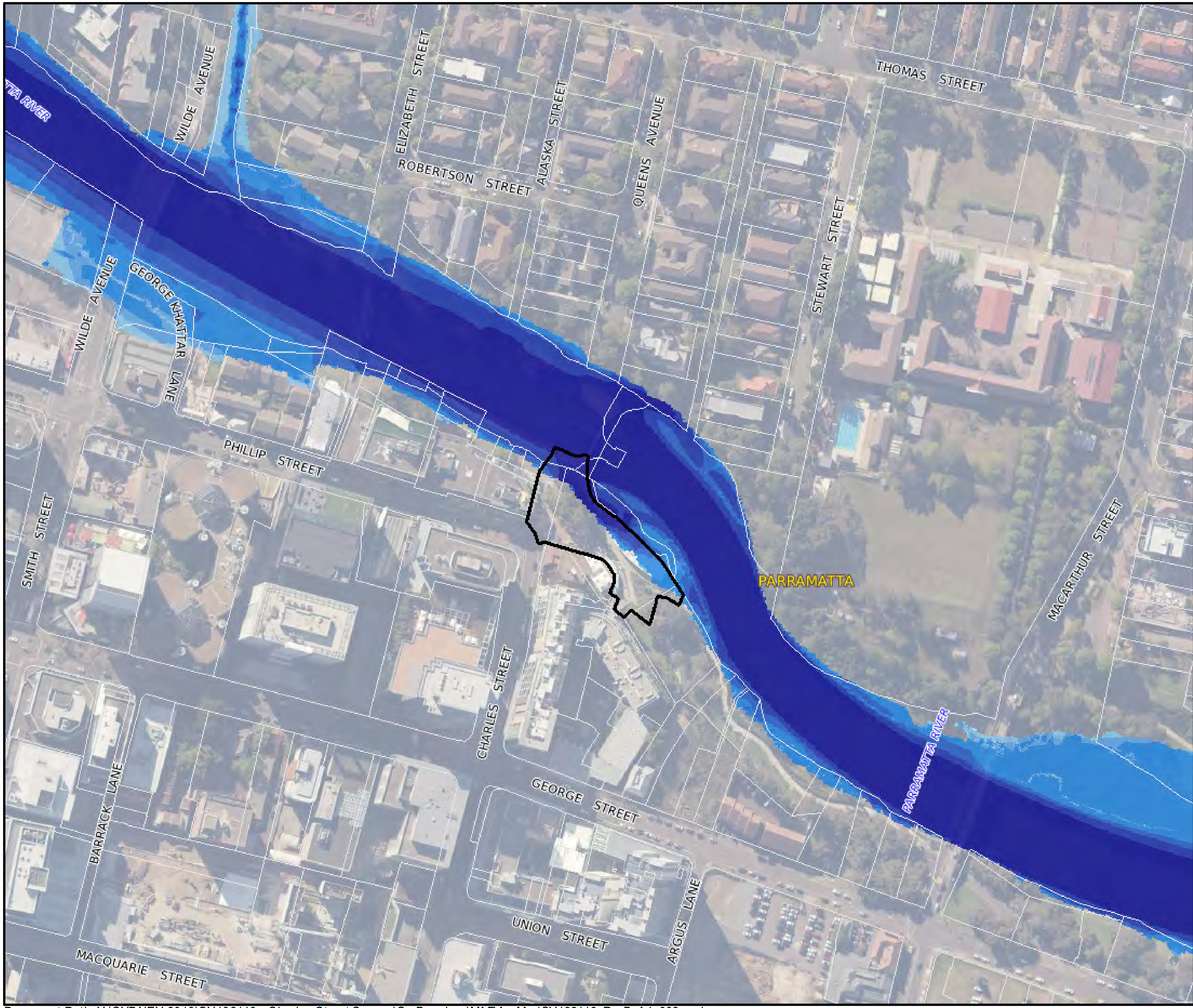

Legend

Proposed Development

Cadastre

Velocity (m/s)

0.01 - 0.01
0.02 - 0.05
0.06 - 0.1
0.11 - 0.5
0.51 - 1
1.01 - 2
2.01 - 9

Figure 2 [A1]

Modelled Max Flow Velocity
1% AEP Flood Event
Existing Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

NORTHROP

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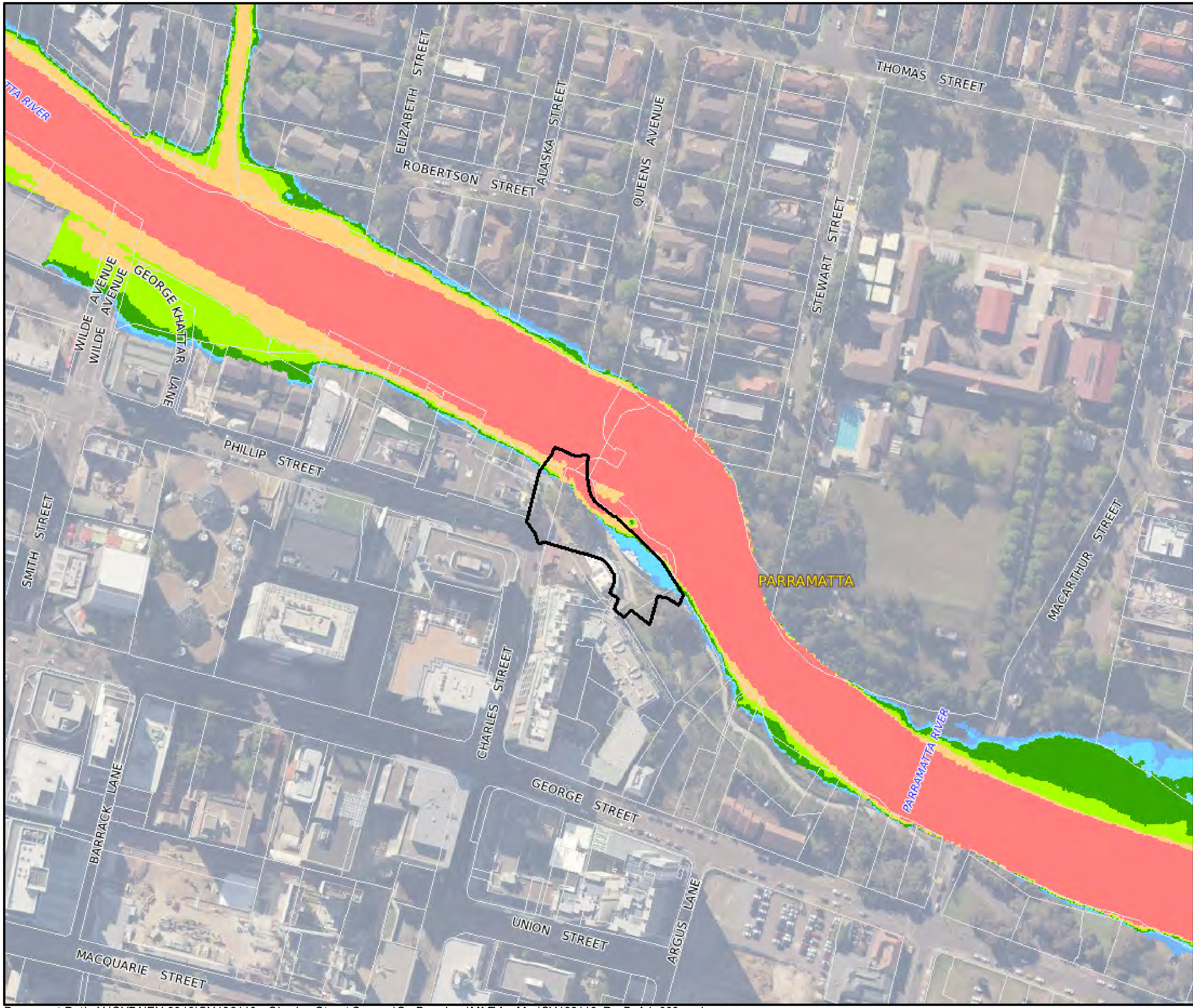

Legend

Proposed Development

Cadastre

Hazard Category

H1

H2

H3

H4

H5

H6

Figure 3 [A1]

Modelled Max Flood Hazard
1% AEP Flood Event
Existing Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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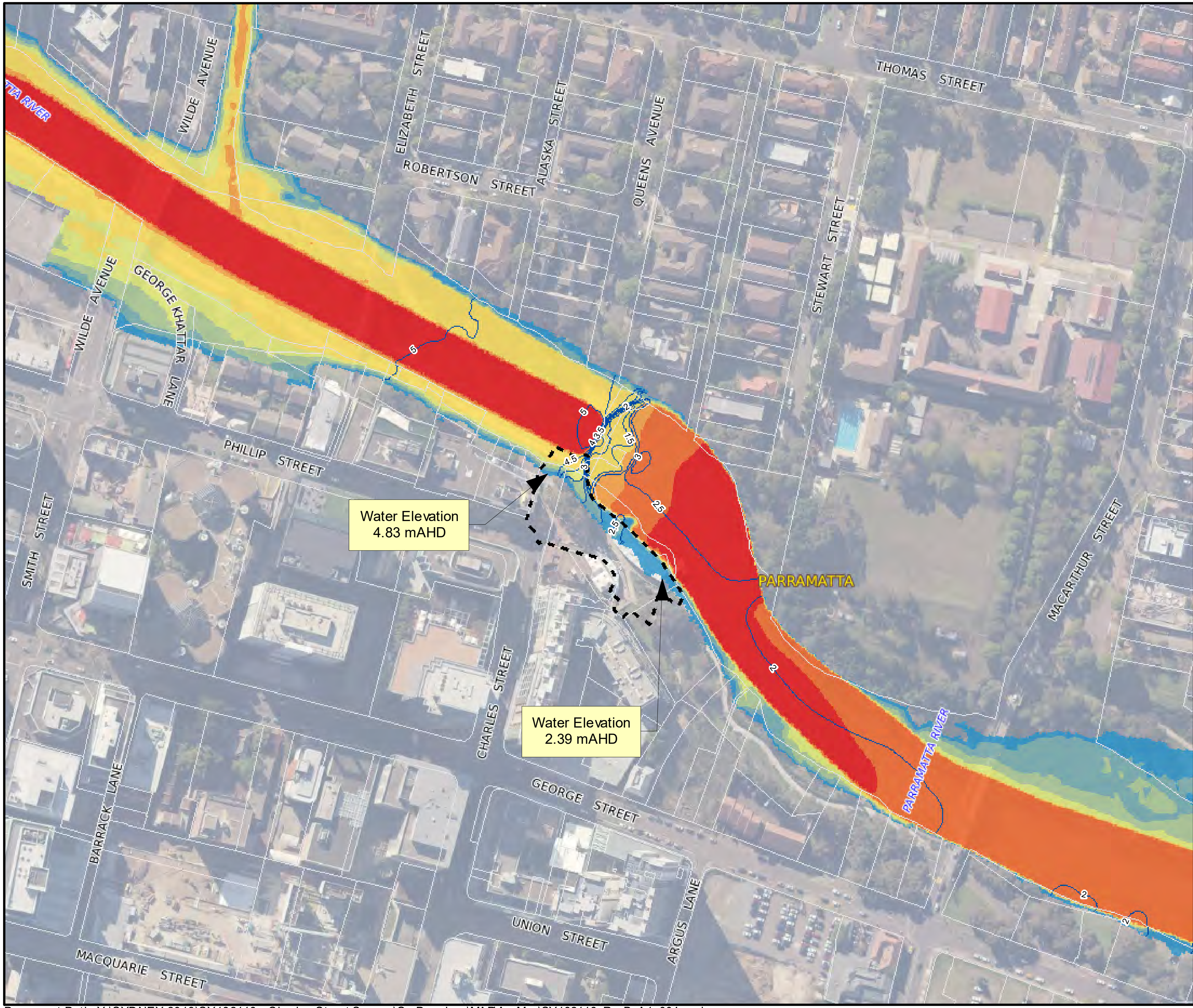

Legend

Proposed Development

Cadastre

Water Levels (mAHD)

Water Depth (m)

- 0 - 0.5
- 0.51 - 1
- 1.01 - 1.5
- 1.51 - 2
- 2.01 - 3
- 3.01 - 4
- 4.01 - 5
- 5.01 - 6

Figure 4 [A1]

Modelled Max Water Depth and Elevations 1% AEP Flood Event Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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Legend

Proposed Development

Cadastre

Velocity (m/s)

0.01 - 0.01

0.02 - 0.05

0.06 - 0.1

0.11 - 0.5

0.51 - 1

1.01 - 2

2.01 - 9

Figure 5 [A1]

Modelled Max Flow Velocity
1% AEP Flood Event
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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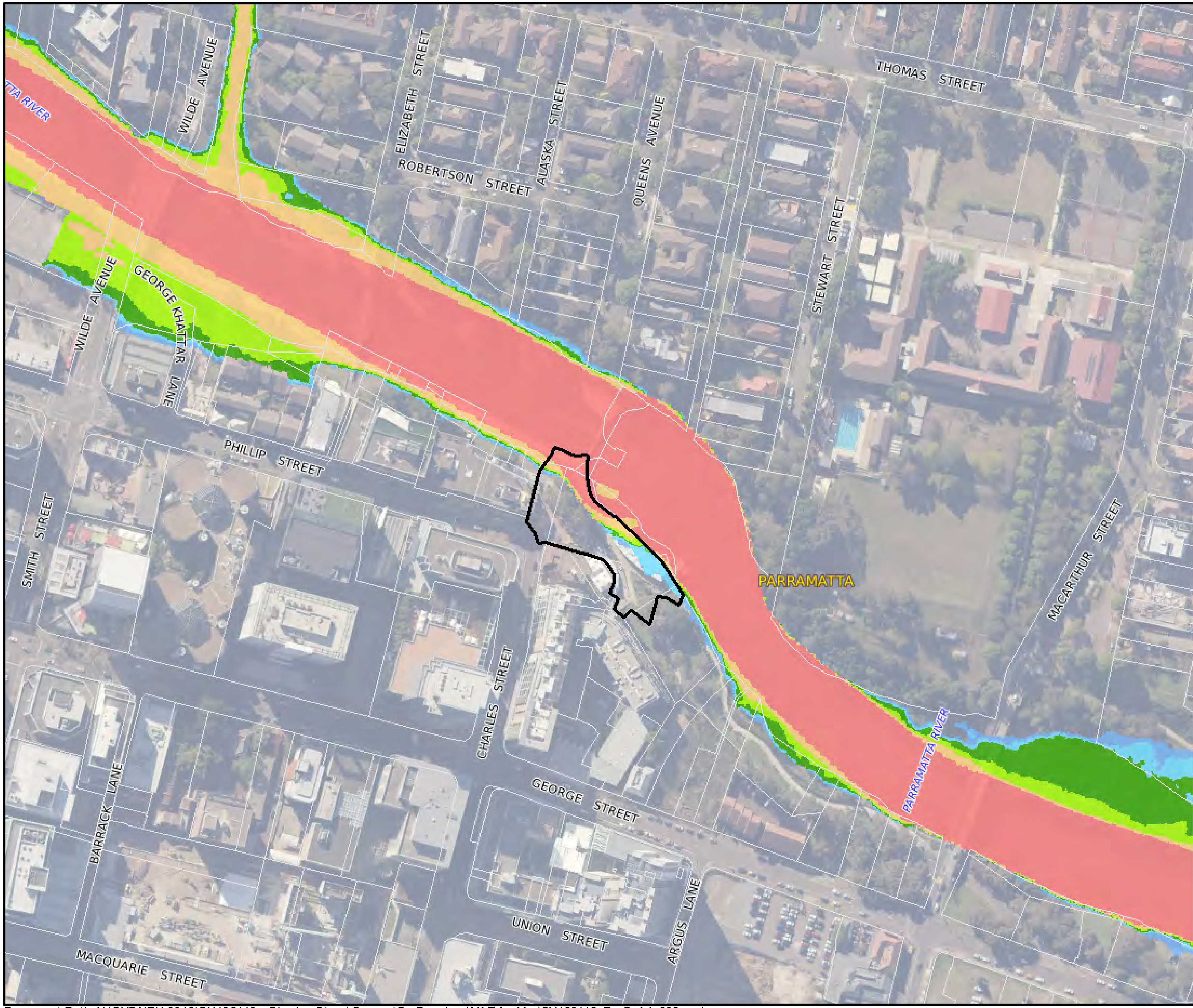

Legend

Proposed Development

Cadastre

Hazard Category

H1

H2

H3

H4

H5

H6

Figure 6 [A1]

Modelled Max Flood Hazard
1% AEP Flood Event
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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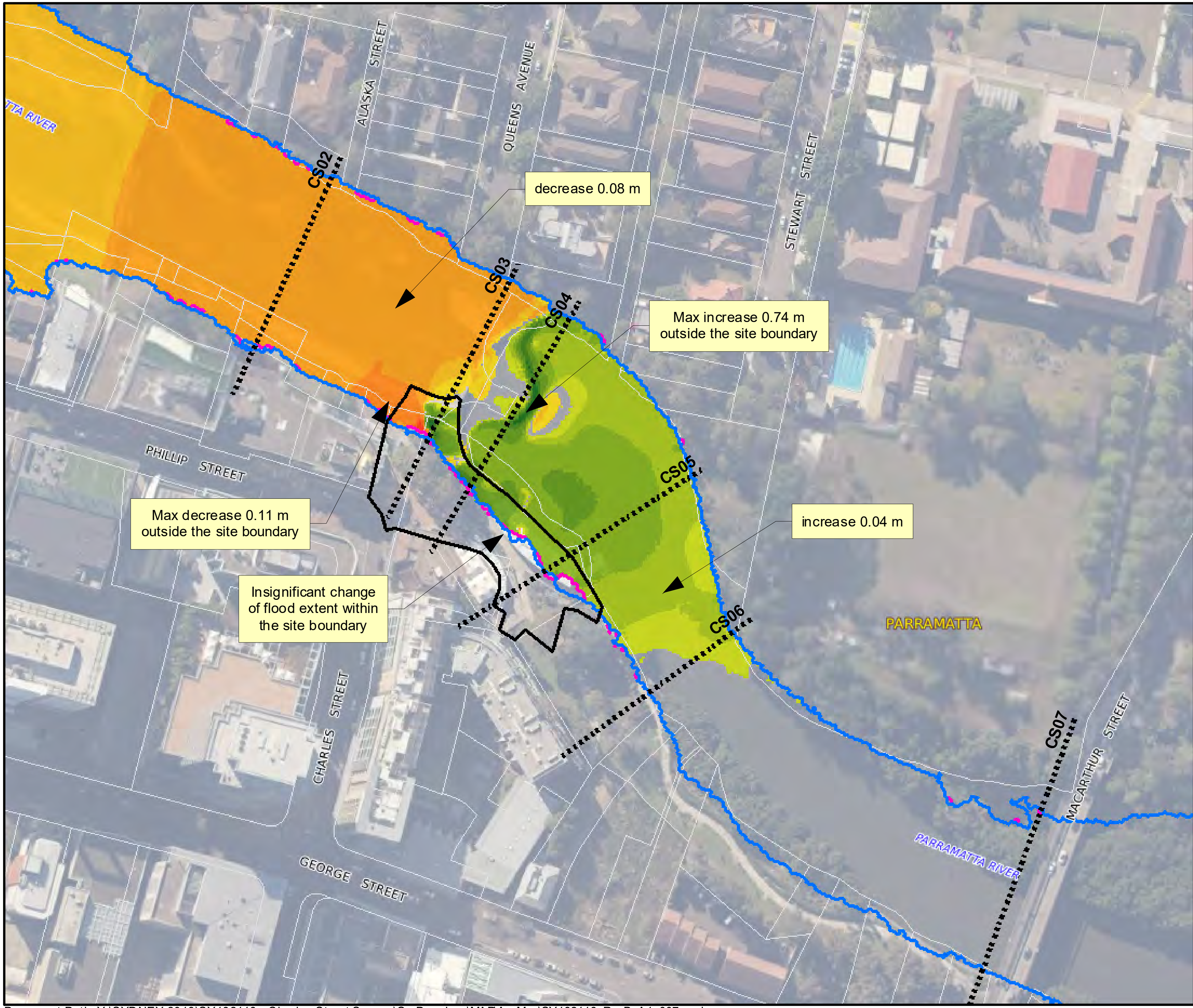

Legend

- Cross Sections
- Proposed Development
- Food Extent (Existing)
- Flood Extent (Proposed)
- Cadastre

Difference (m)

- <-0.499
- -0.499 - -0.300
- -0.299 - -0.100
- -0.099 - -0.050
- -0.049 - -0.030
- -0.029 - -0.010
- Less than +/- 10mm
- 0.011 - 0.030
- 0.031 - 0.050
- 0.051 - 0.100
- 0.101 - 0.300
- 0.301 - 0.500
- >0.500

Figure 7 [A1]

Max Water Elevation Difference
1% AEP Flood Event
Proposed minus Existing

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 20 40 60 Meters

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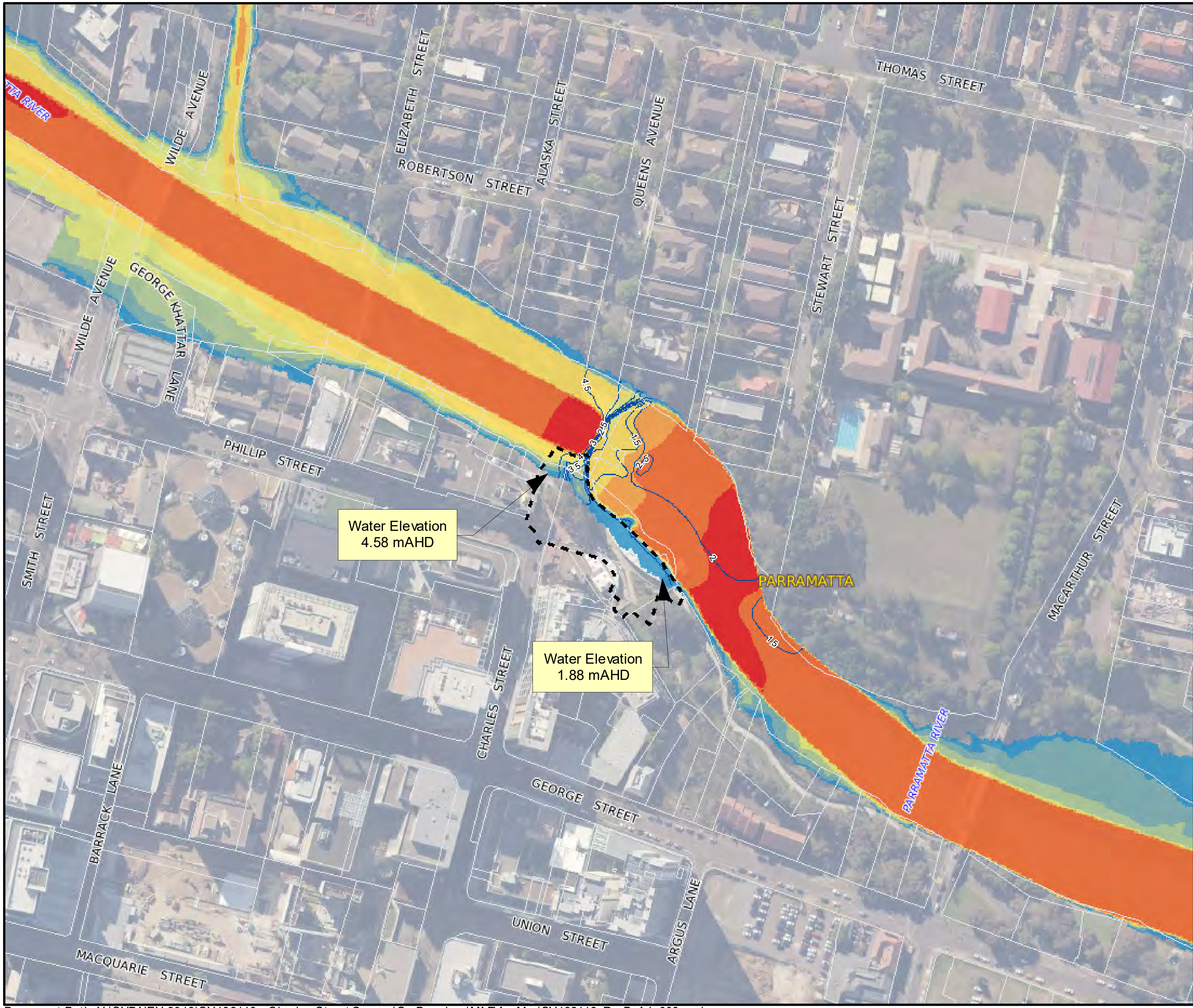

Legend

Proposed Development
Cadastre
Water Levels (mAHD)

Water Depth (m)

- 0 - 0.5
- 0.51 - 1
- 1.01 - 1.5
- 1.51 - 2
- 2.01 - 3
- 3.01 - 4
- 4.01 - 5
- 5.01 - 6

Figure 8 [A1]

Modelled Max Water Depth and Elevations
5% AEP Flood Event
Existing Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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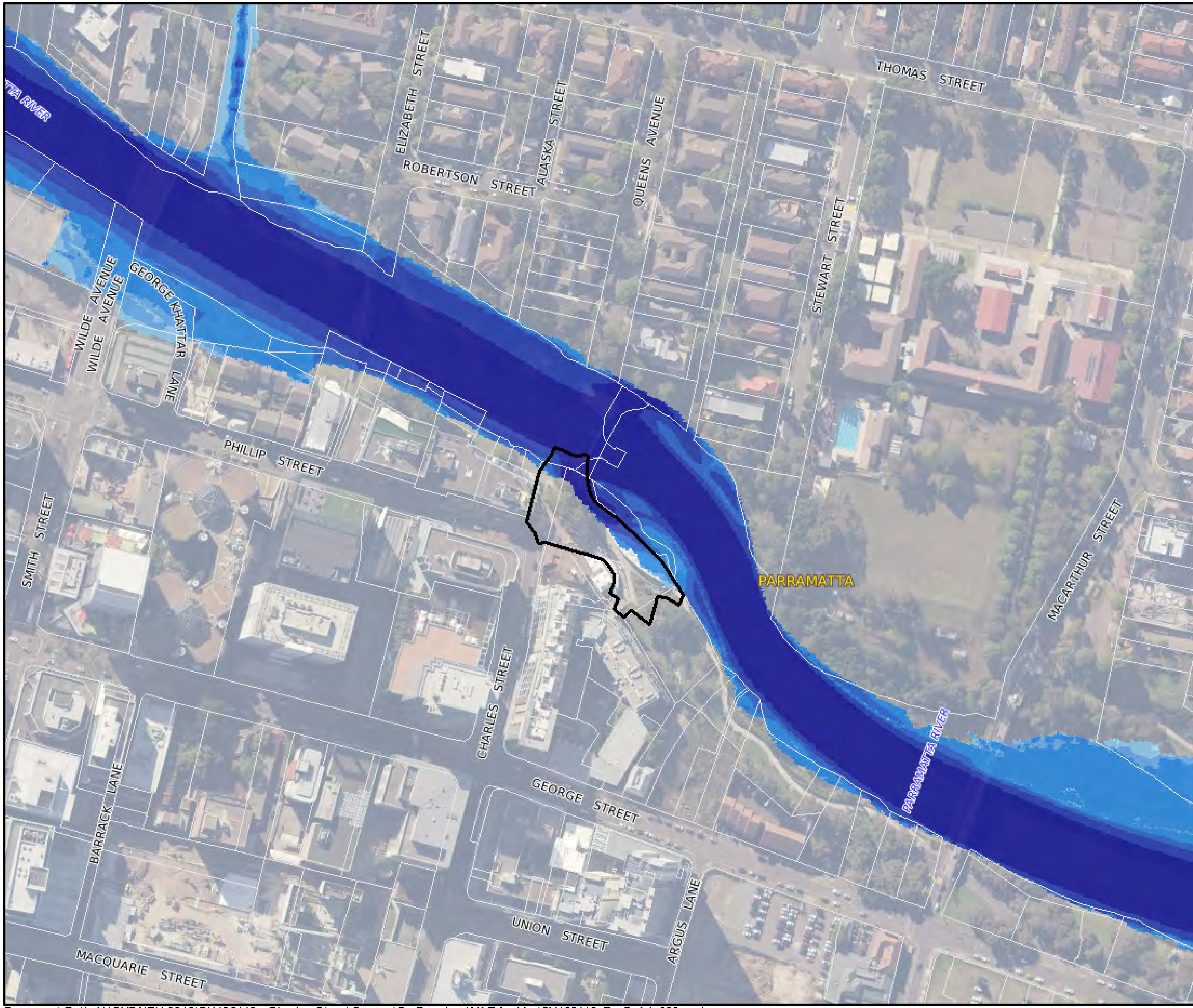

Legend

Proposed Development

Cadastre

Velocity (m/s)

0.01 - 0.01

0.02 - 0.05

0.06 - 0.1

0.11 - 0.5

0.51 - 1

1.01 - 2

2.01 - 9

Figure 9 [A1]

Modelled Max Flow Velocity
5% AEP Flood Event
Existing Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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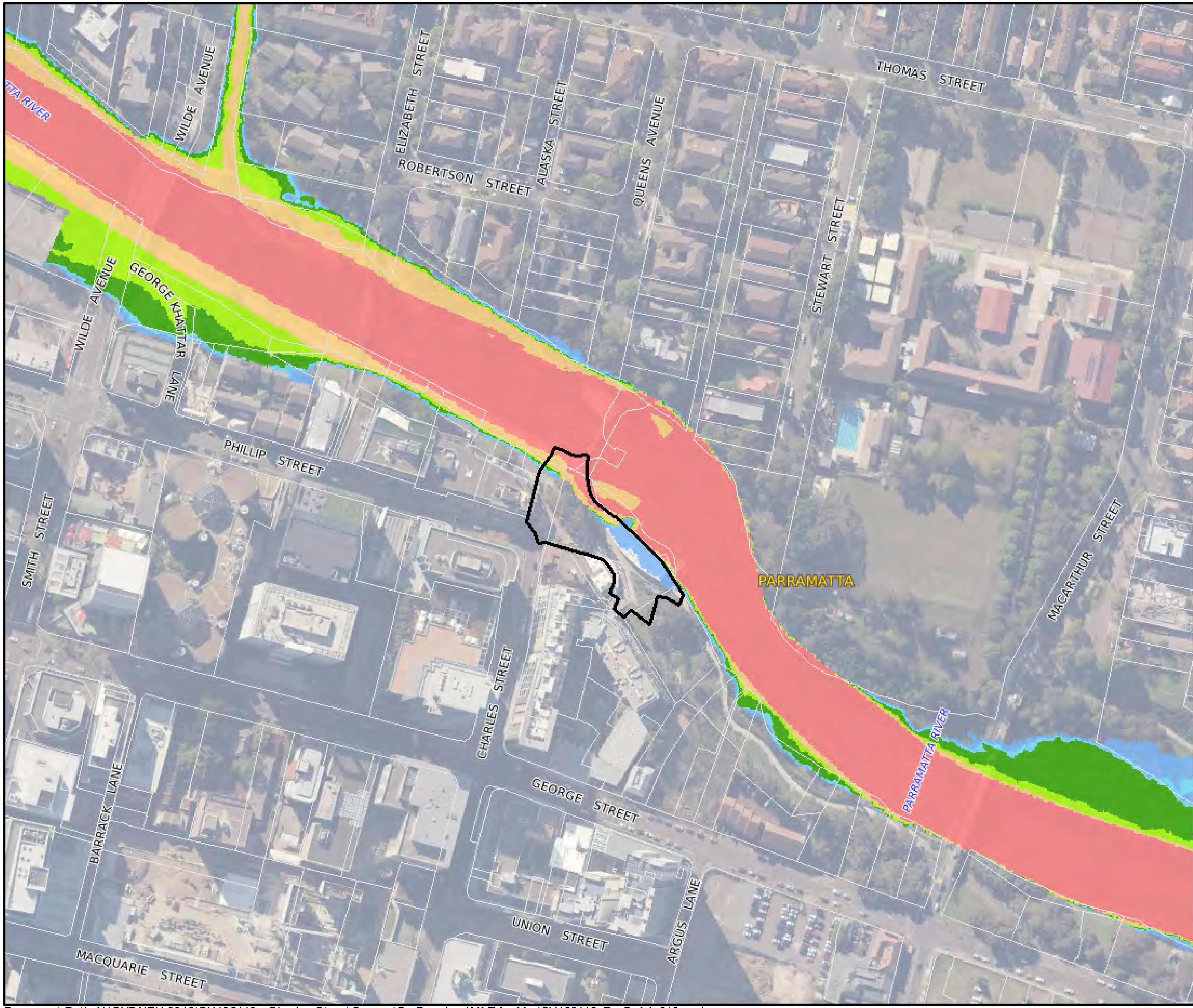

Legend

Proposed Development

Cadastre

Hazard Category

H1

H2

H3

H4

H5

H6

Figure 10 [A1]

Modelled Max Flood Hazard
5% AEP Flood Event
Existing Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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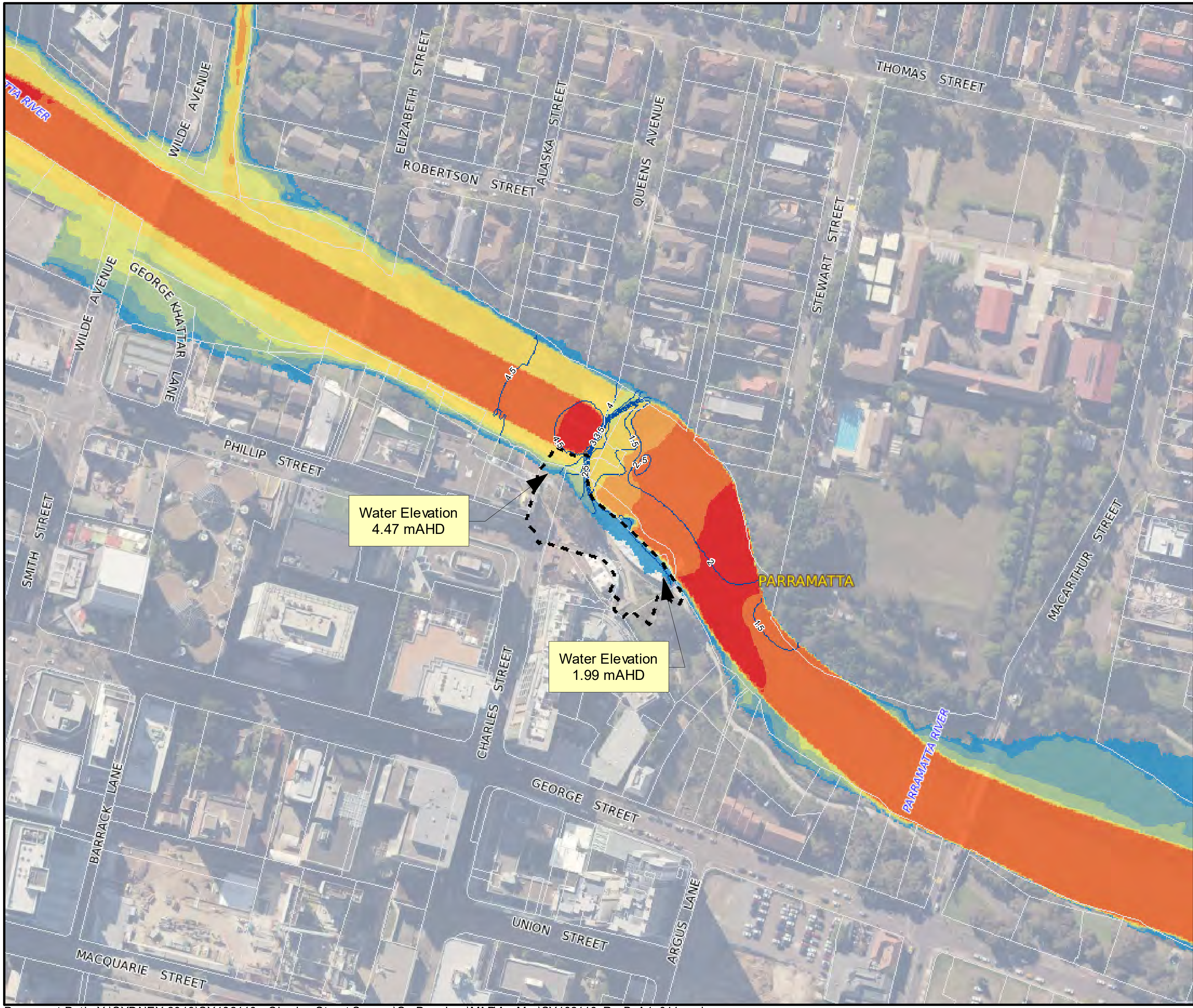

Legend

Proposed Development

Cadastre

Water Levels (mAHD)

Water Depth (m)

- 0 - 0.5
- 0.51 - 1
- 1.01 - 1.5
- 1.51 - 2
- 2.01 - 3
- 3.01 - 4
- 4.01 - 5
- 5.01 - 6

Figure 11 [A1]

Modelled Max Water Depth and Elevations
5% AEP Flood Event
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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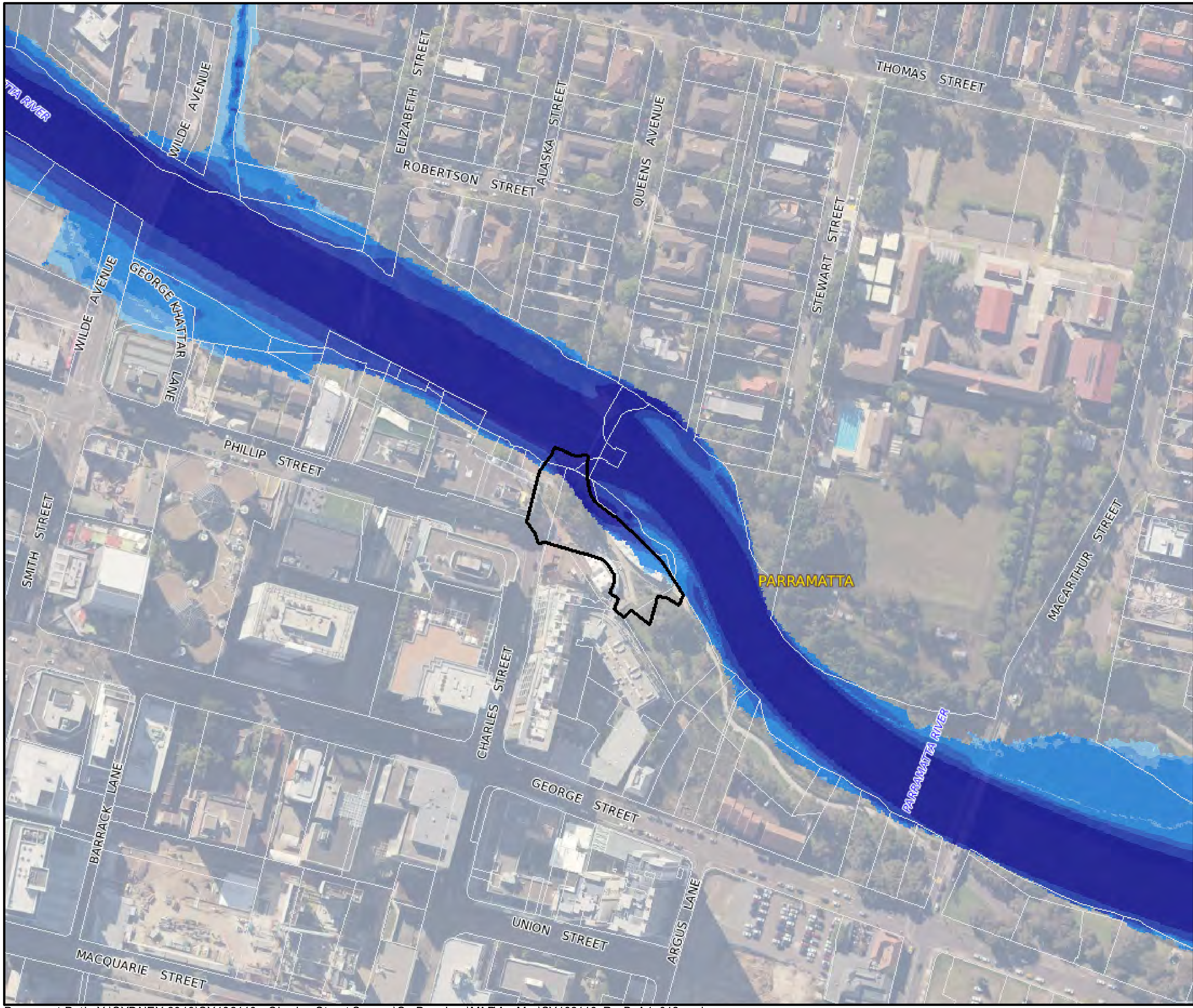

Figure 12 [A1]

Modelled Max Flow Velocity
5% AEP Flood Event
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

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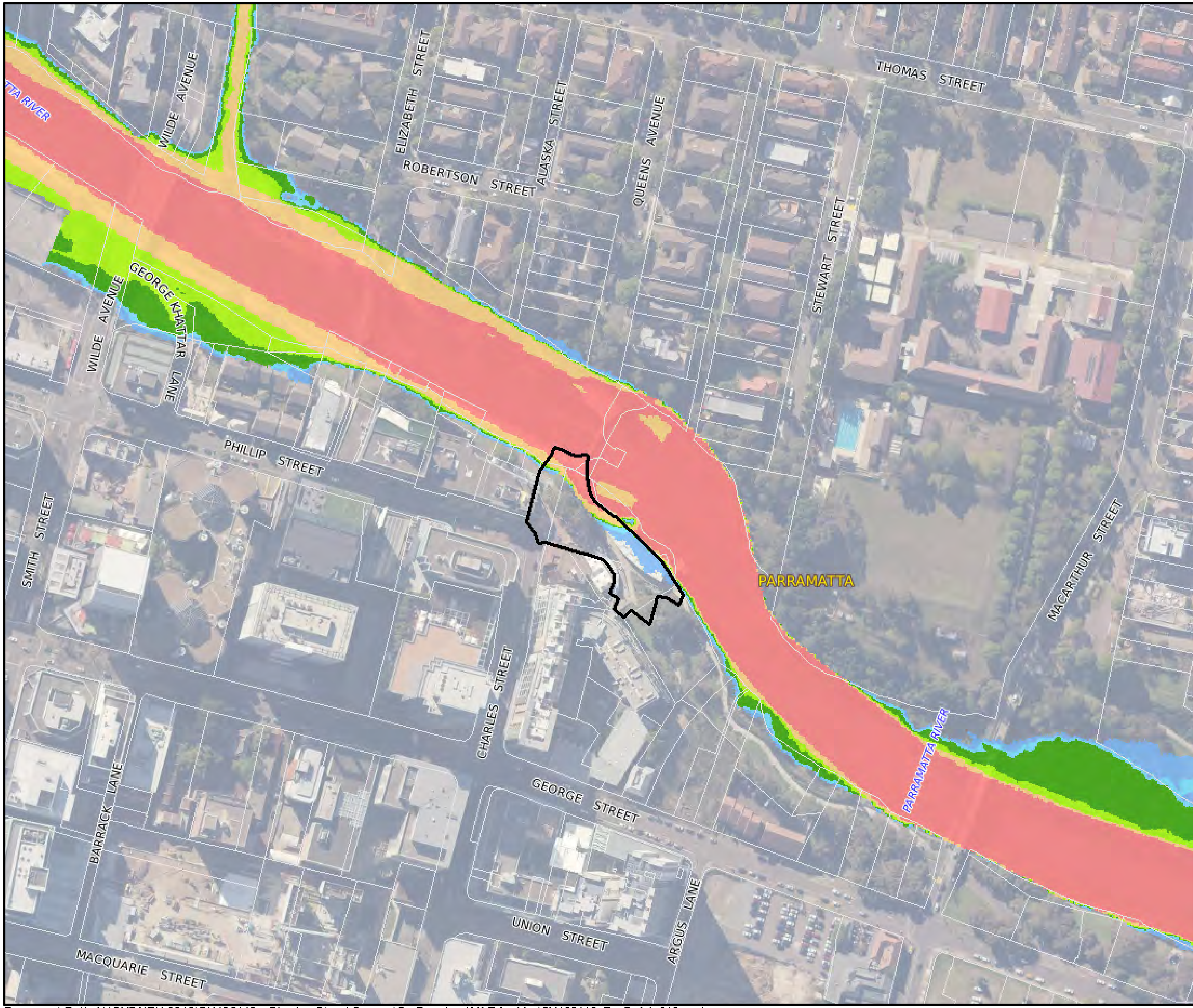

Legend

Proposed Development

Cadastre

Hazard Category

H1

H2

H3

H4

H5

H6

Figure 13 [A1]

Modelled Max Flood Hazard
5% AEP Flood Event
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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Legend

- Cross Sections
- Proposed Development
- Food Extent (Existing)
- Flood Extent (Proposed)
- Cadastre

Difference (m)

- <-0.499
- -0.499 - -0.300
- -0.299 - -0.100
- -0.099 - -0.050
- -0.049 - -0.030
- -0.029 - -0.010
- Less than +/- 10mm
- 0.011 - 0.030
- 0.031 - 0.050
- 0.051 - 0.100
- 0.101 - 0.300
- 0.301 - 0.500
- >0.500

Figure 14 [A1]

Max Water Elevation Difference
5% AEP Flood Event
Proposed minus Existing

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 20 40 60 Meters

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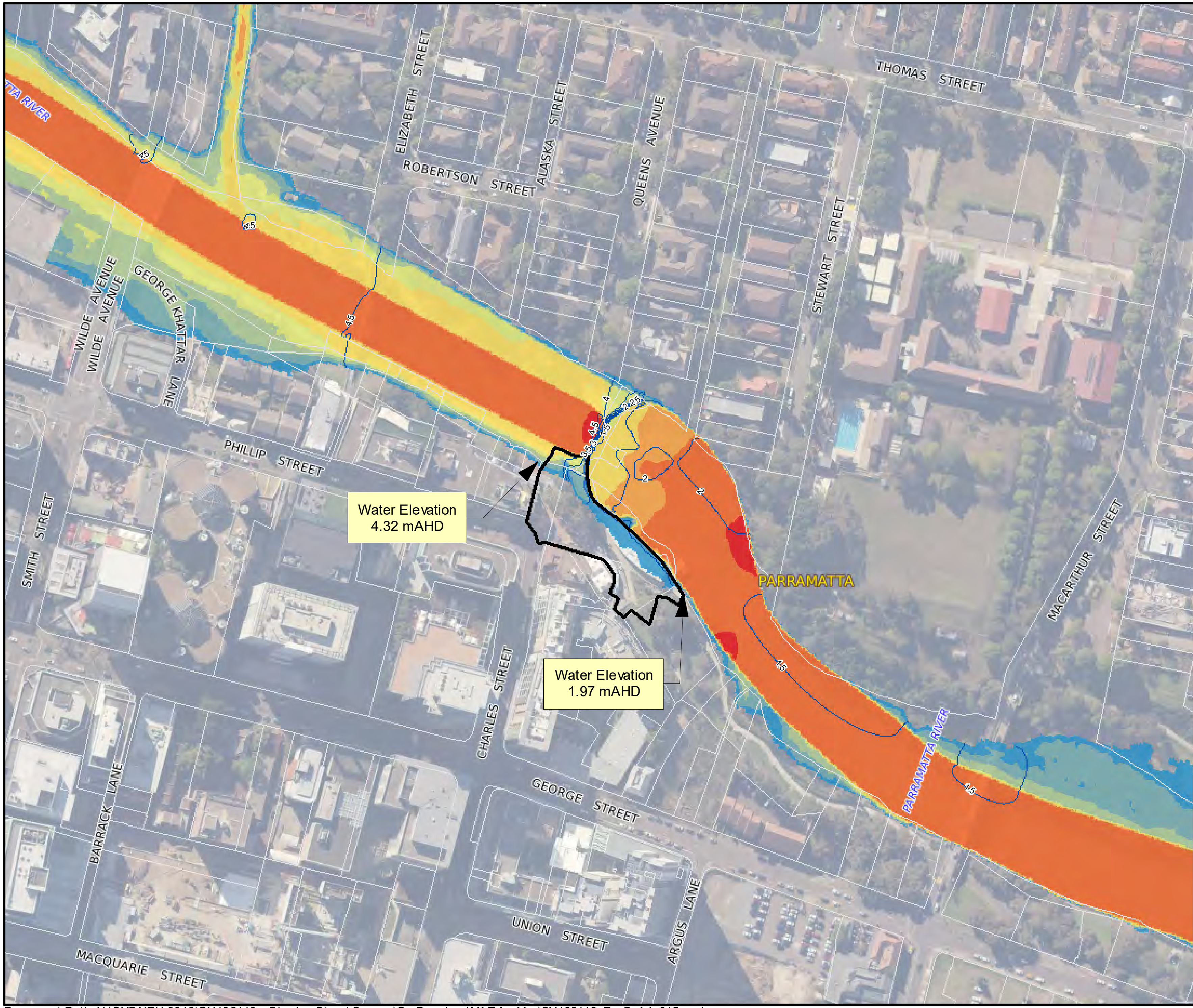

Legend

Proposed Development

Cadastre

Water Levels (mAHD)

Water Depth (m)

- 0 - 0.5
- 0.51 - 1
- 1.01 - 1.5
- 1.51 - 2
- 2.01 - 3
- 3.01 - 4
- 4.01 - 5
- 5.01 - 6

Figure 15 [A1]

Modelled Max Water Depth
20% AEP Flood Event
Existing Scenario

Date 29 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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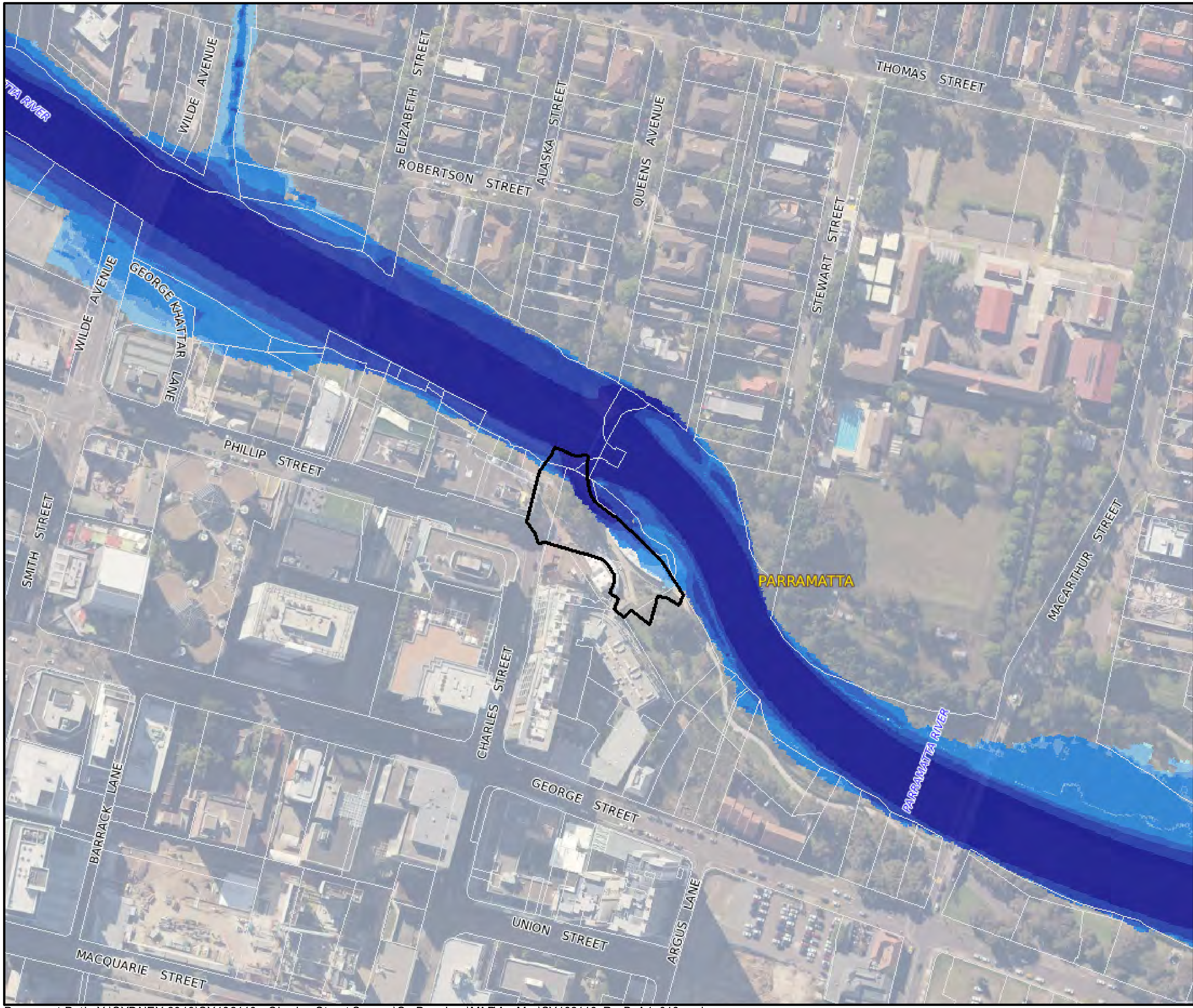

Legend

Proposed Development

Cadastre

Velocity (m/s)

- 0.01 - 0.01
- 0.02 - 0.05
- 0.06 - 0.1
- 0.11 - 0.5
- 0.51 - 1
- 1.01 - 2
- 2.01 - 9

Figure 16 [A1]

Modelled Max Flow Velocity
20% AEP Flood Event
Existing Scenario

Date 28 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

NORTHROP

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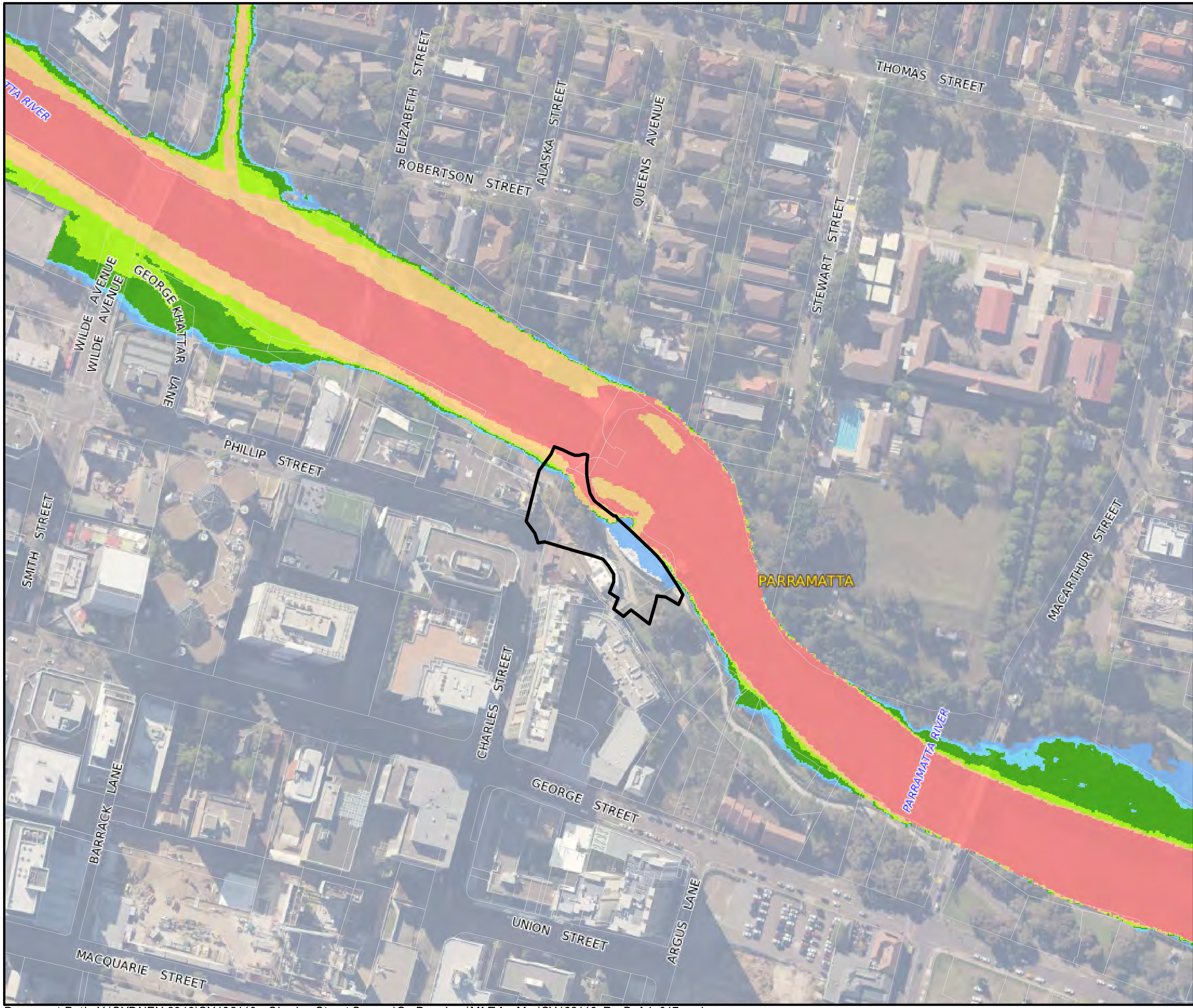

Legend

Proposed Development

Cadastre

Hazard Category

H1

H2

H3

H4

H5

H6

Figure 17 [A1]

Modelled Max Flood Hazard
20% AEP Flood Event
Existing Scenario

Date 28 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

NORTHROP

Newcastle

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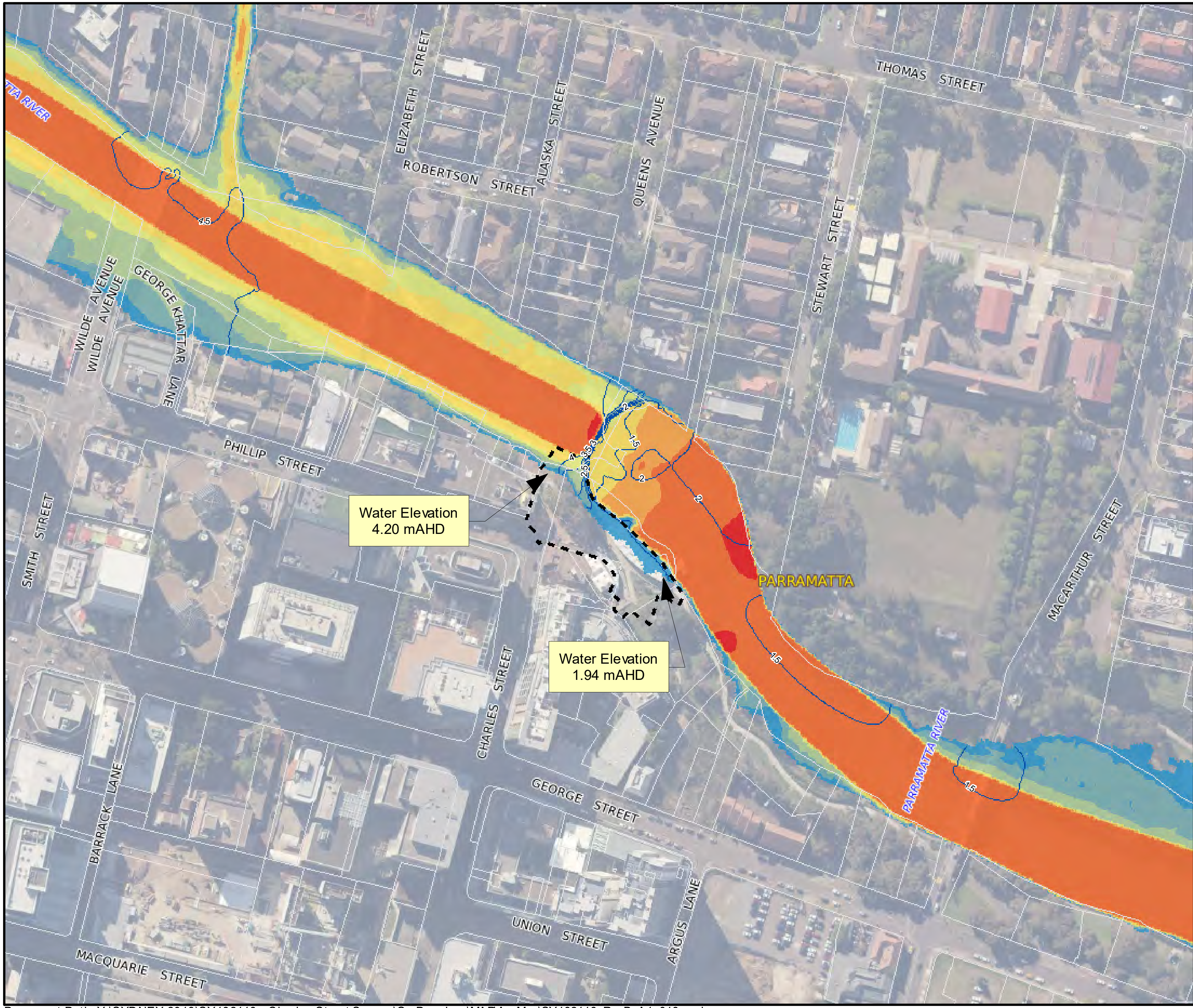

Figure 18 [A1]

Modelled Max Water Depth and Elevations
20% AEP Flood Event
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

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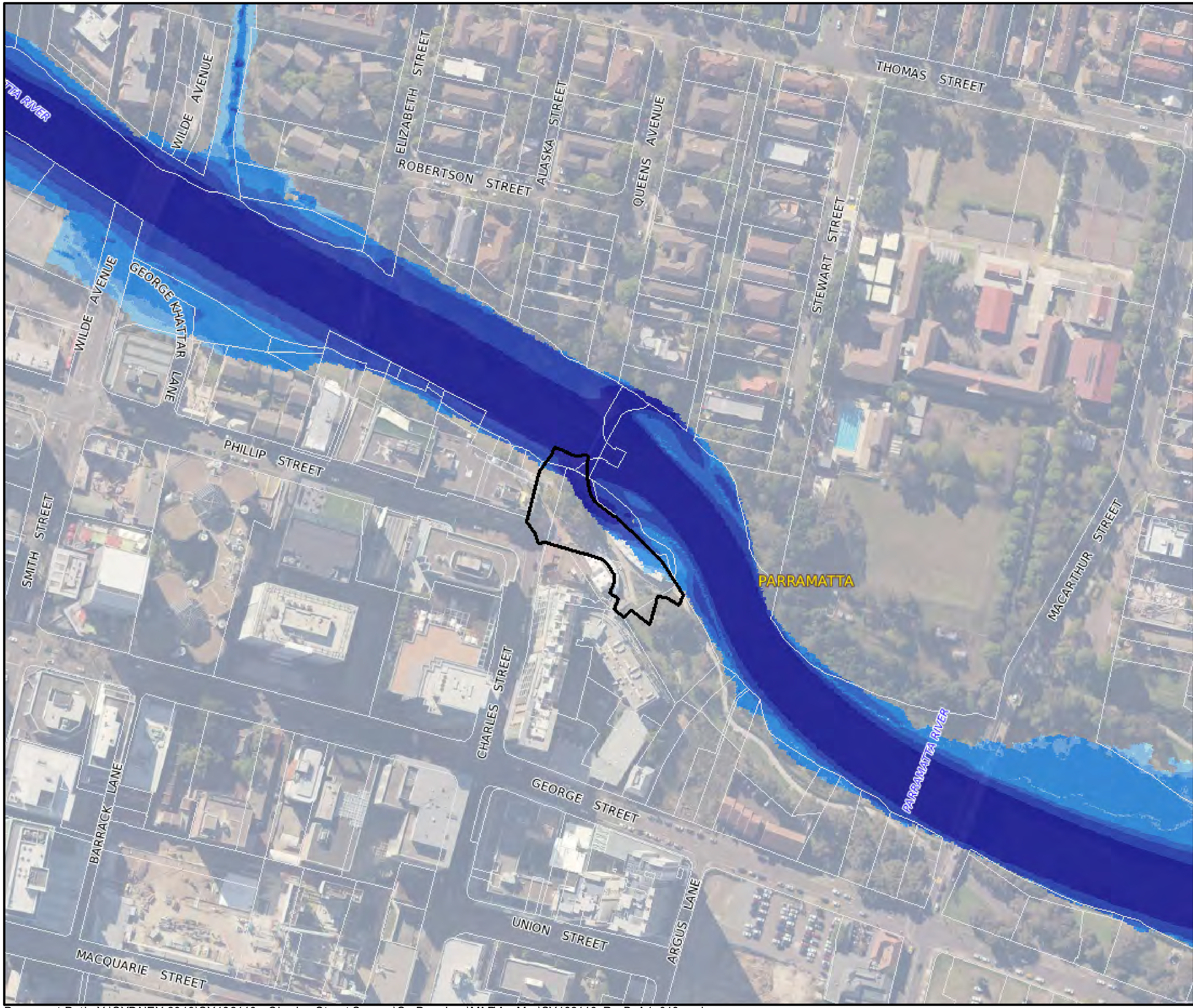

Legend

Proposed Development

Cadastre

Velocity (m/s)

0.01 - 0.01

0.02 - 0.05

0.06 - 0.1

0.11 - 0.5

0.51 - 1

1.01 - 2

2.01 - 9

Figure 19 [A1]

Modelled Max Flow Velocity
20% AEP Flood Event
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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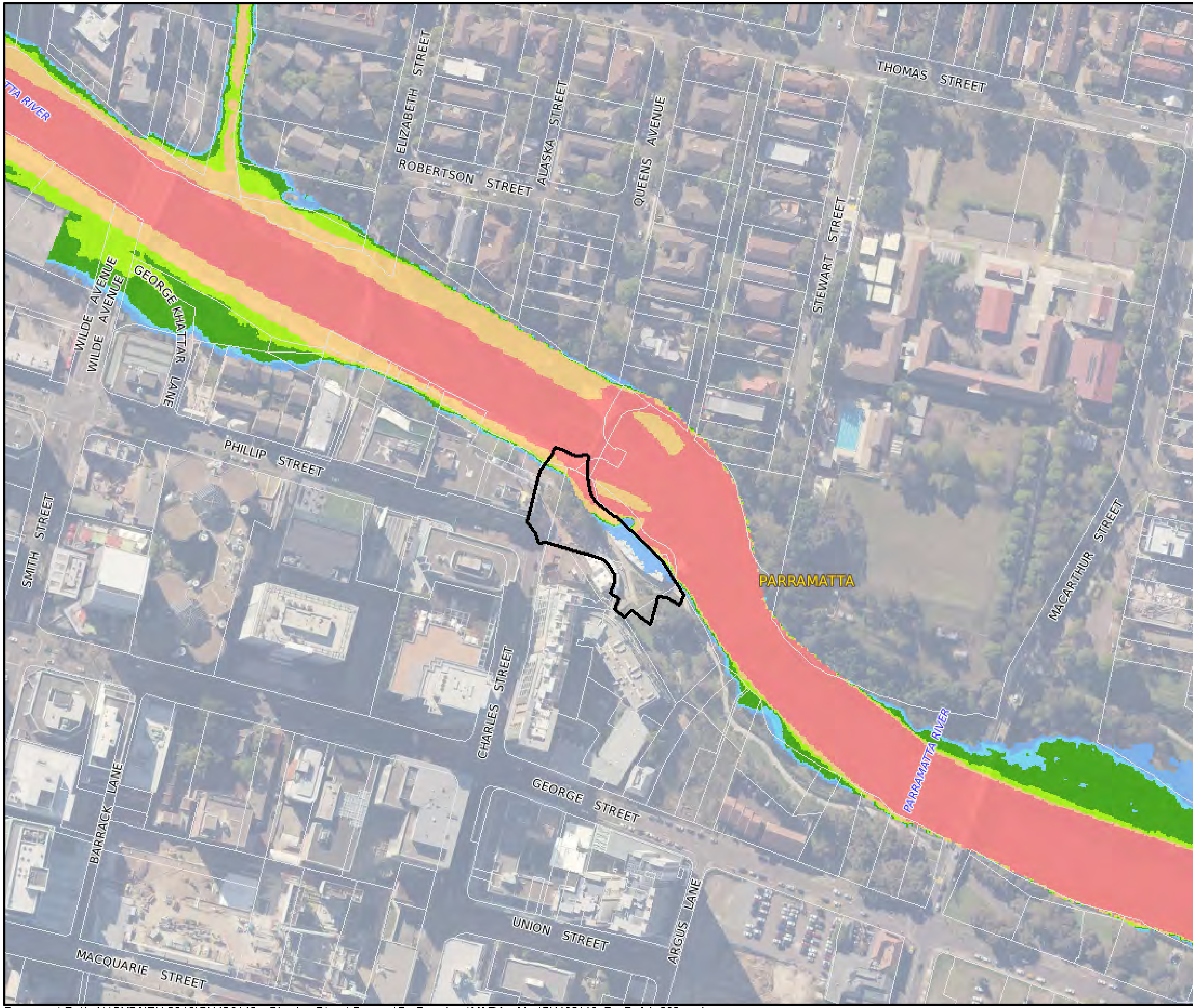

Legend

Proposed Development

Cadastre

Hazard Category

H1

H2

H3

H4

H5

H6

Figure 20 [A1]

Modelled Max Flood Hazard
20% AEP Flood Event
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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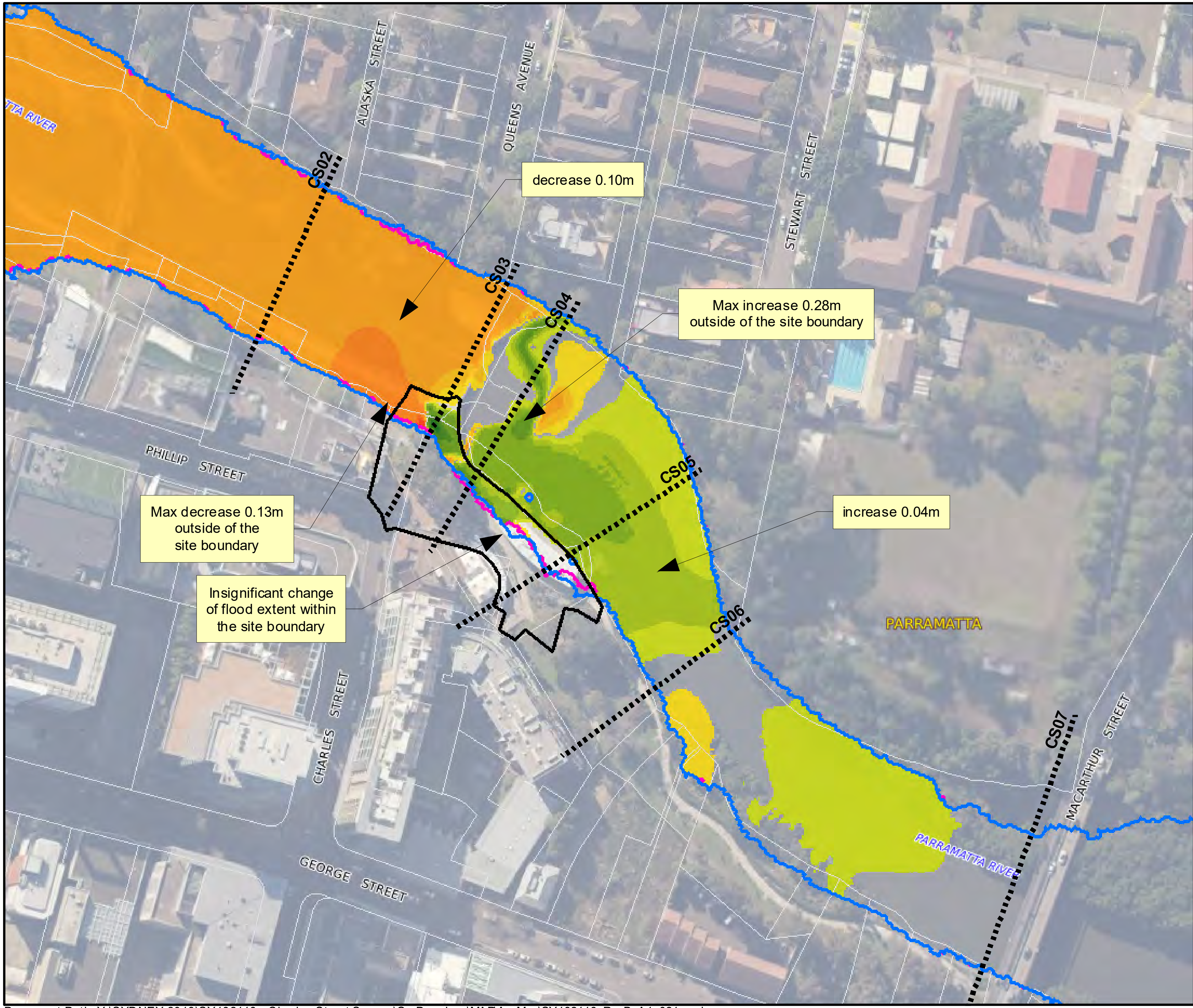

Legend

- Cross Sections
- Proposed Development
- Food Extent (Existing)
- Flood Extent (Proposed)
- Cadastre

Difference (m)

- <-0.499
- -0.499 - -0.300
- -0.299 - -0.100
- -0.099 - -0.050
- -0.049 - -0.030
- -0.029 - -0.010
- Less than +/- 10mm
- 0.011 - 0.030
- 0.031 - 0.050
- 0.051 - 0.100
- 0.101 - 0.300
- 0.301 - 0.500
- >0.500

Figure 21 [A1]

Max Water Elevation Difference
20% AEP Flood Event
Proposed minus Existing

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 20 40 60 Meters

NORTHROP

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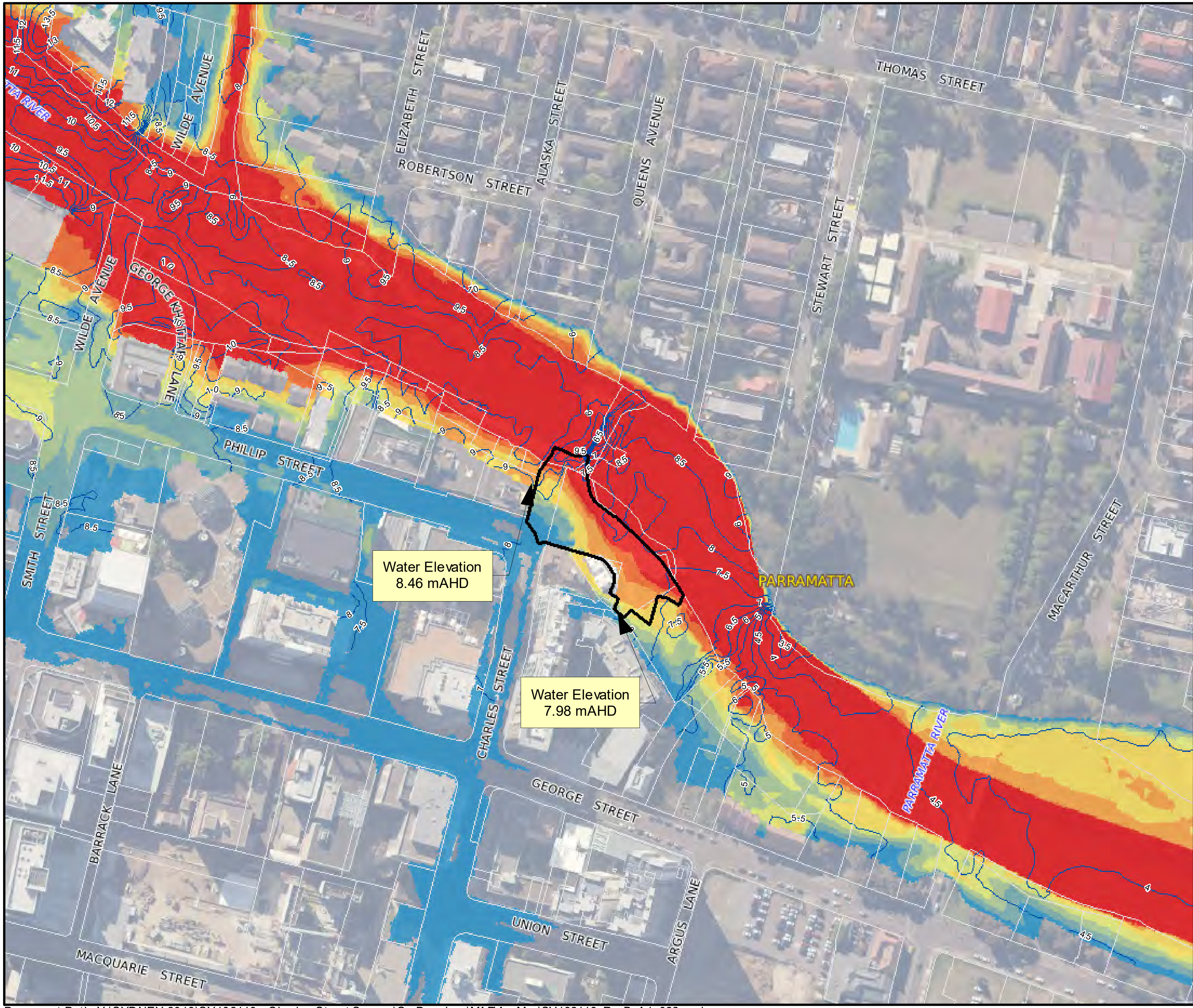

Legend

- Proposed Development
- Cadastre
- Water Levels (mAHD)

Water Depth (m)

- 0 - 0.5
- 0.51 - 1
- 1.01 - 1.5
- 1.51 - 2
- 2.01 - 3
- 3.01 - 4
- 4.01 - 5
- 5.01 - 6

Figure 22 [A1]

Modelled Max Water Depth and Elevations
PMF
Existing Scenario

Date 28 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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Ph (02) 4943 1777 Fax (02) 4943 1577
P.O Box 180, Charlestown NSW 2290
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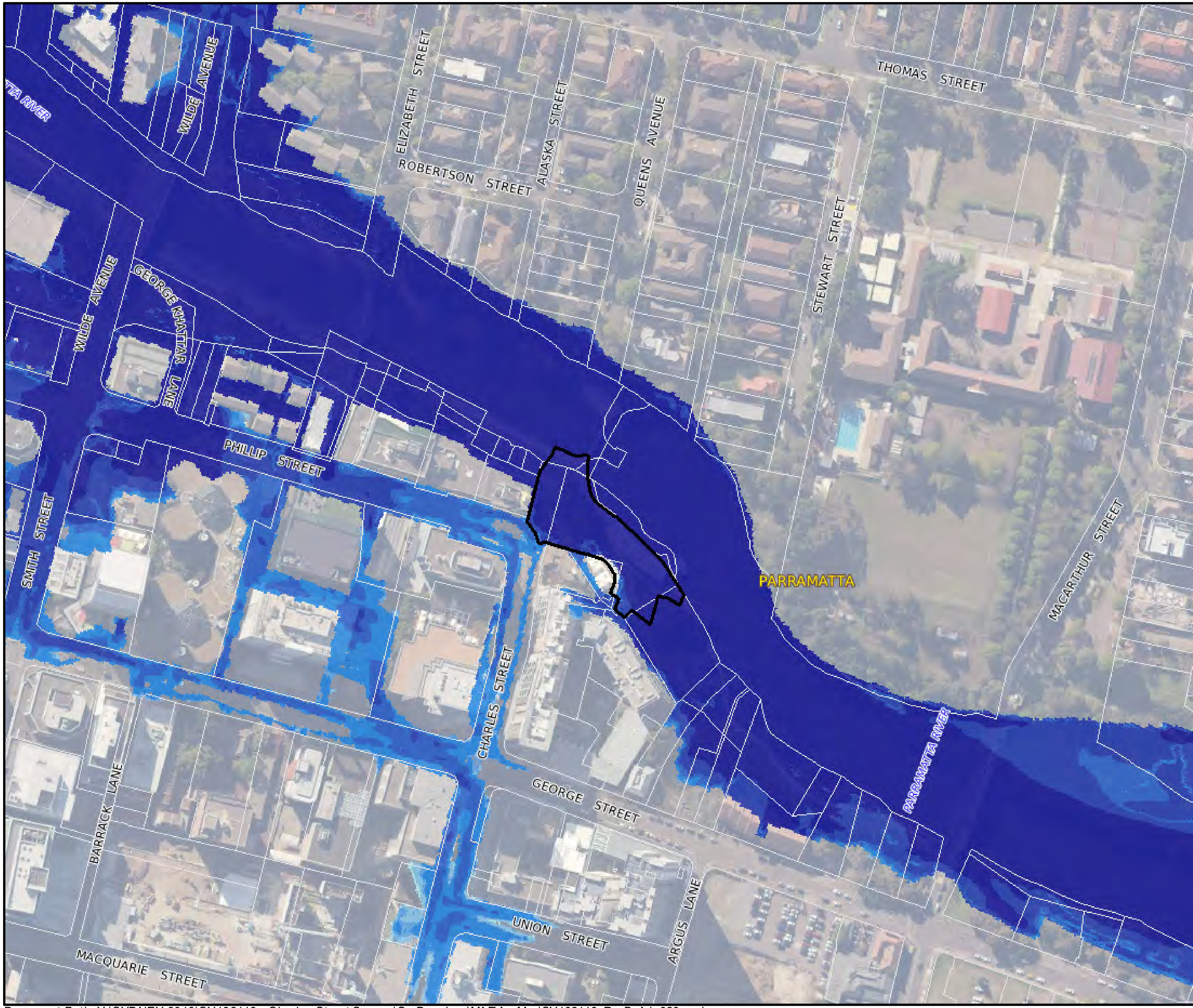

Legend

Proposed Development

Cadastre

Velocity (m/s)

- 0.01 - 0.01
- 0.02 - 0.05
- 0.06 - 0.1
- 0.11 - 0.5
- 0.51 - 1
- 1.01 - 2
- 2.01 - 9

Figure 23 [A1]

Modelled Max Flow Velocity
PMF
Existing Scenario

Date 28 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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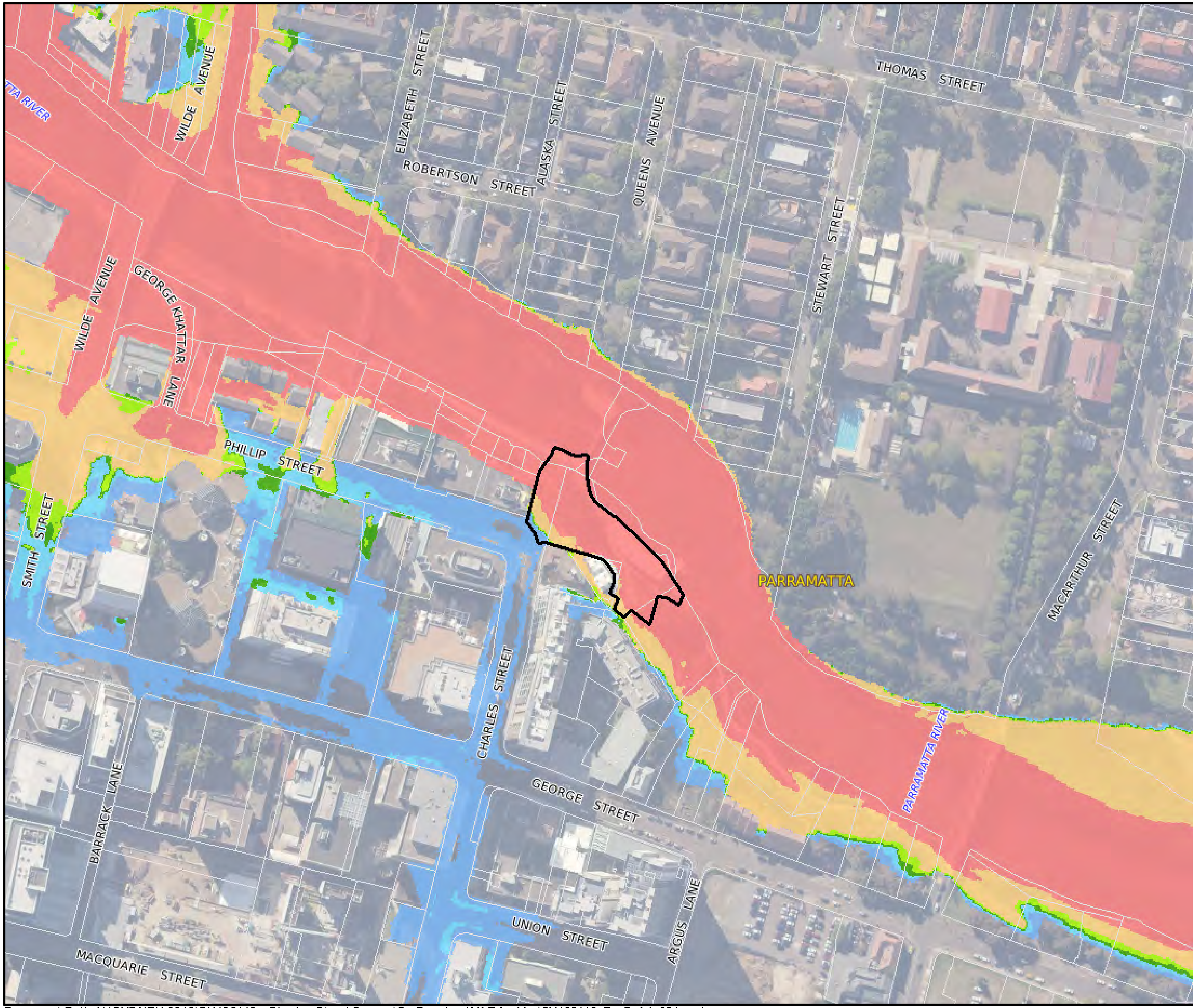

Legend

Proposed Development

Cadastre

Hazard Category

H1

H2

H3

H4

H5

H6

Figure 24 [A1]

Modelled Max Flood Hazard
PMF
Existing Scenario

Date 28 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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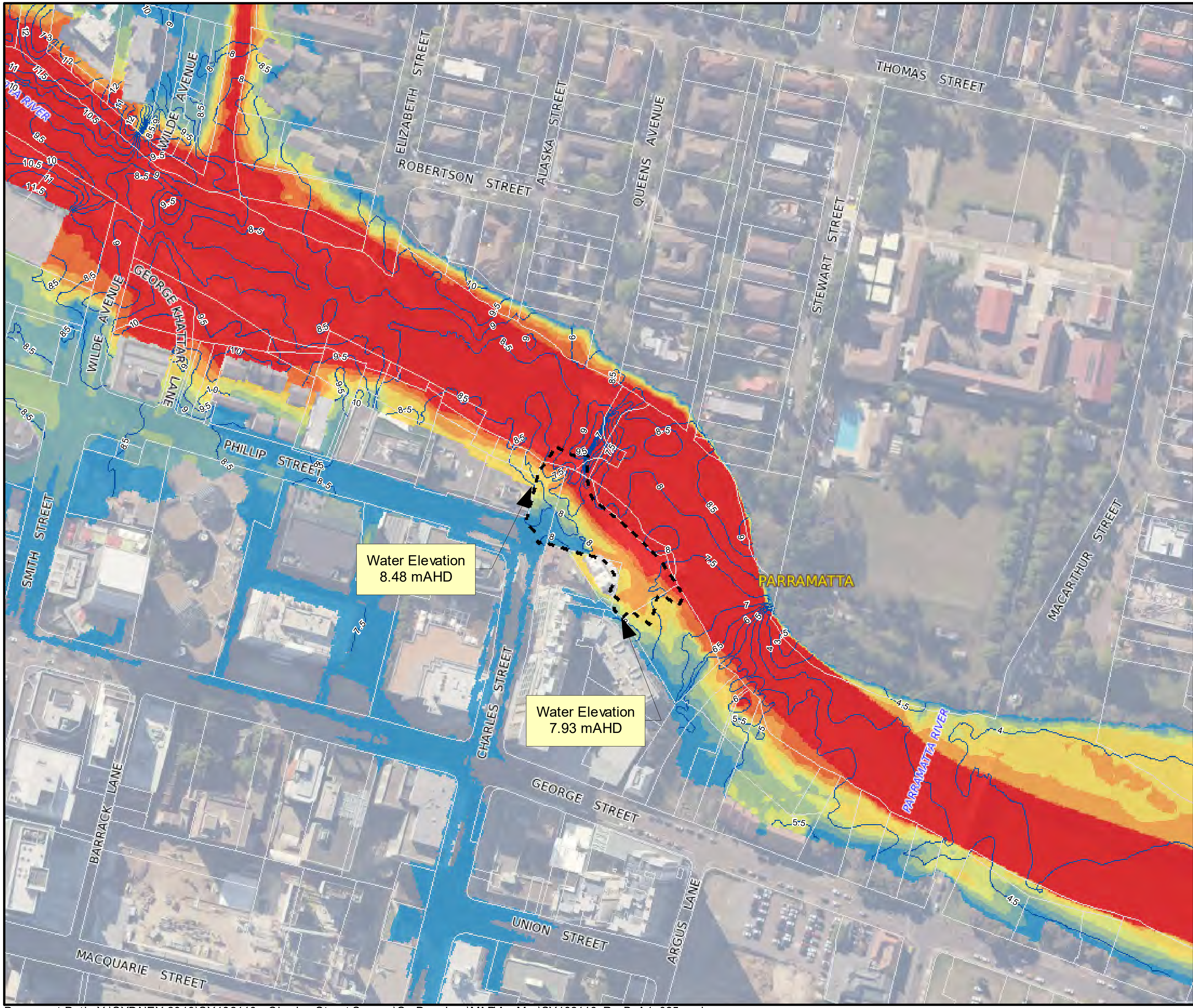

Legend

Proposed Development

Cadastre

Water Levels (mAHD)

Water Depth (m)

0 - 0.5

0.51 - 1

1.01 - 1.5

1.51 - 2

2.01 - 3

3.01 - 4

4.01 - 5

5.01 - 6

Figure 25 [A1]

Modelled Max Water Depth and Elevations
PMF
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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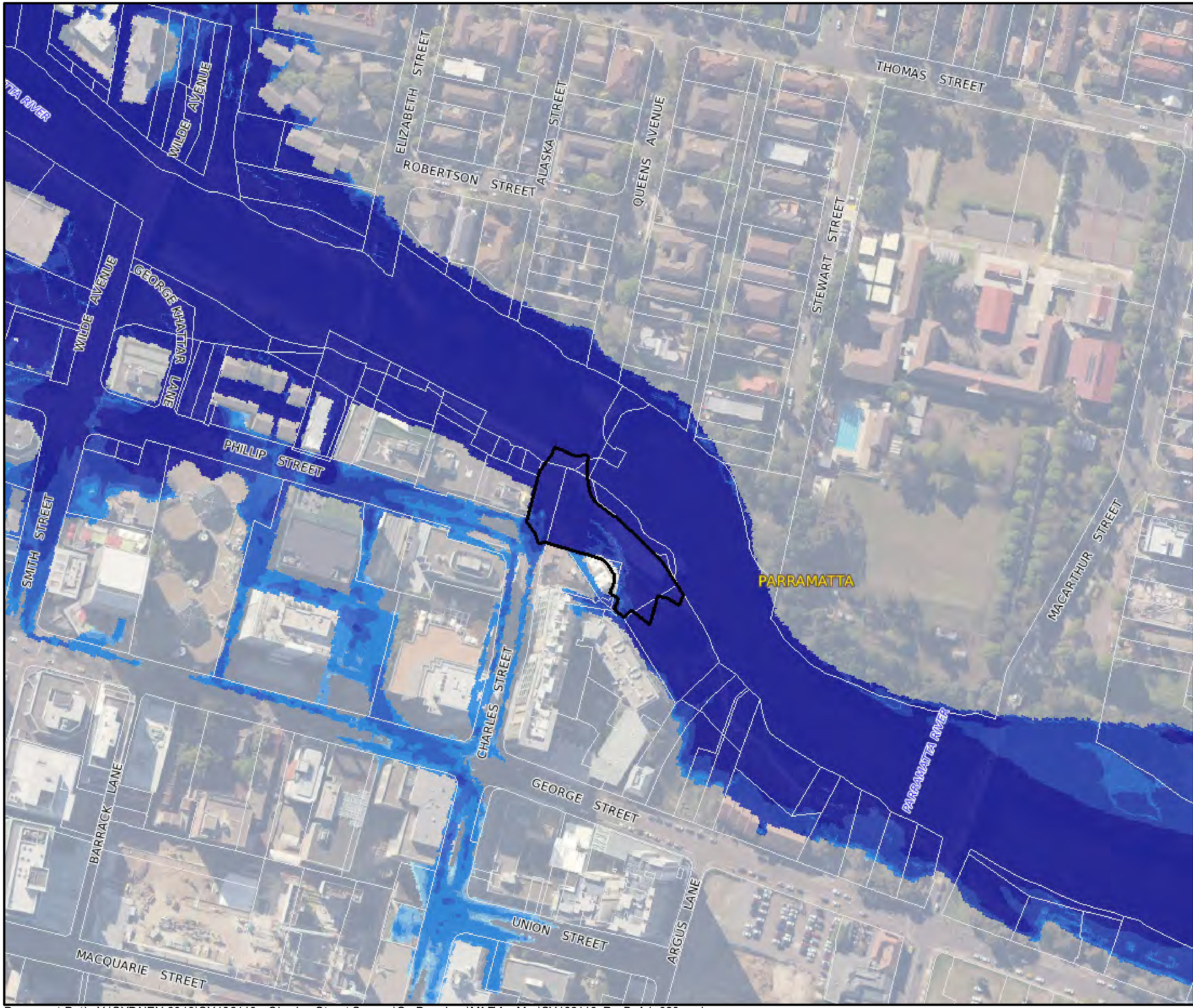

Legend

Proposed Development
Cadastre

Velocity (m/s)

- 0.01 - 0.01
- 0.02 - 0.05
- 0.06 - 0.1
- 0.11 - 0.5
- 0.51 - 1
- 1.01 - 2
- 2.01 - 9

Figure 26 [A1]

Modelled Max Flow Velocity
PMF
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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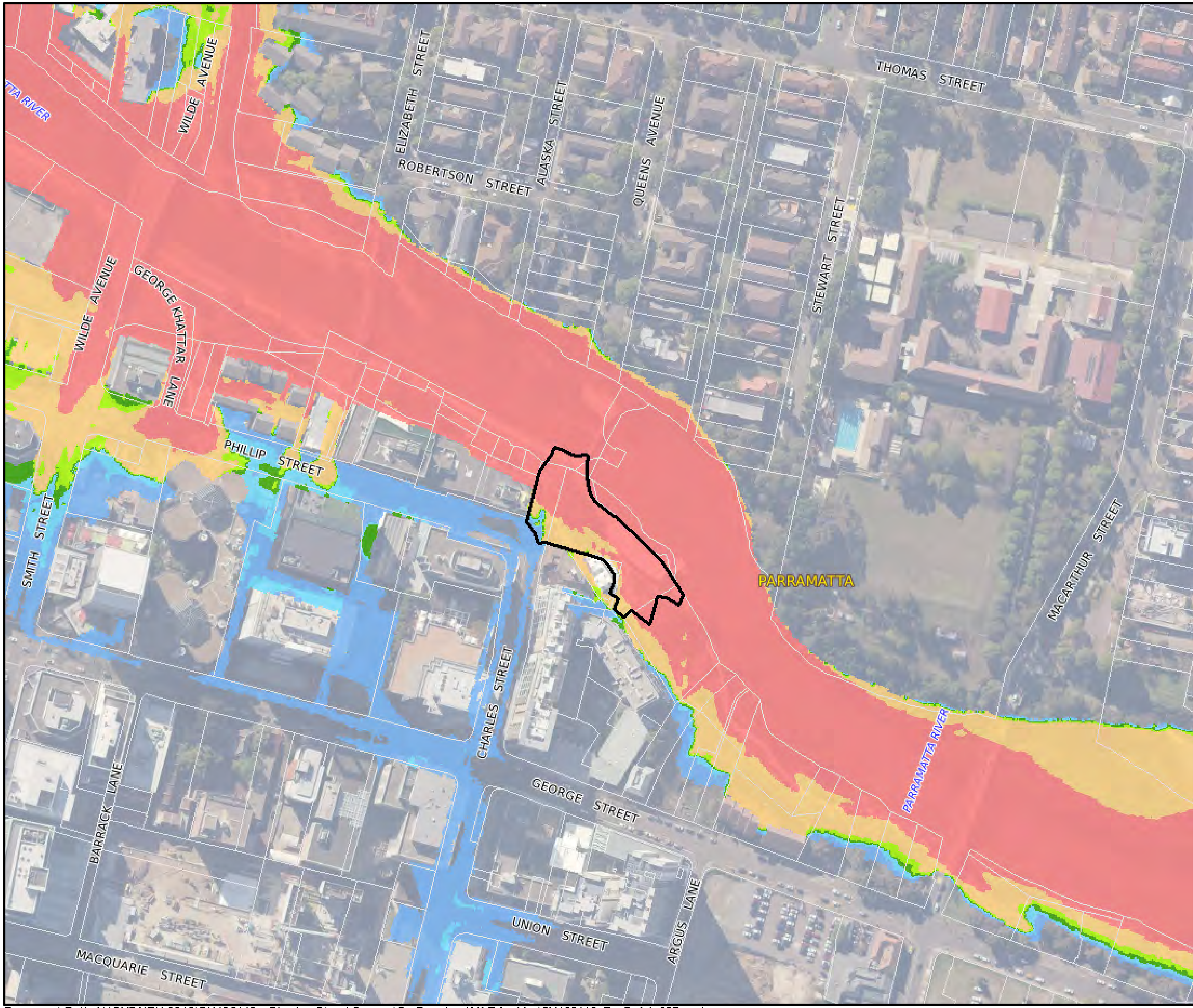

Figure 27 [A1]

Modelled Max Flood Hazard
PMF
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

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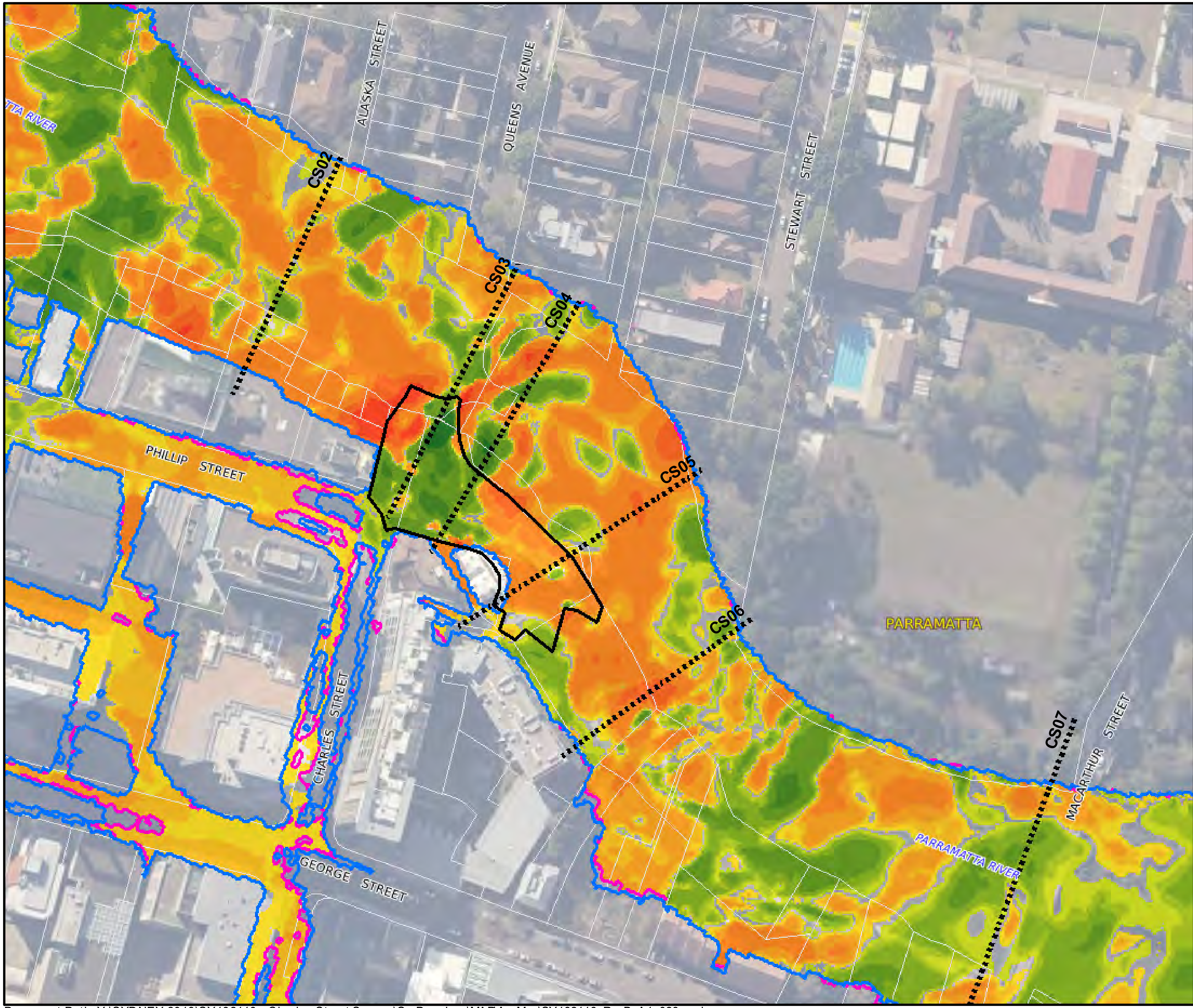

Legend

- Cross Sections
- Proposed Development
- Food Extent (Existing)
- Flood Extent (Proposed)
- Cadastre

Difference (m)

- <-0.499
- -0.499 - -0.300
- -0.299 - -0.100
- -0.099 - -0.050
- -0.049 - -0.030
- -0.029 - -0.010
- Less than +/- 10mm
- 0.011 - 0.030
- 0.031 - 0.050
- 0.051 - 0.100
- 0.101 - 0.300
- 0.301 - 0.500
- >0.500

Figure 28 [A1]

Max Water Elevation Difference PMF
Proposed minus Existing

Date 28 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 20 40 60 Meters

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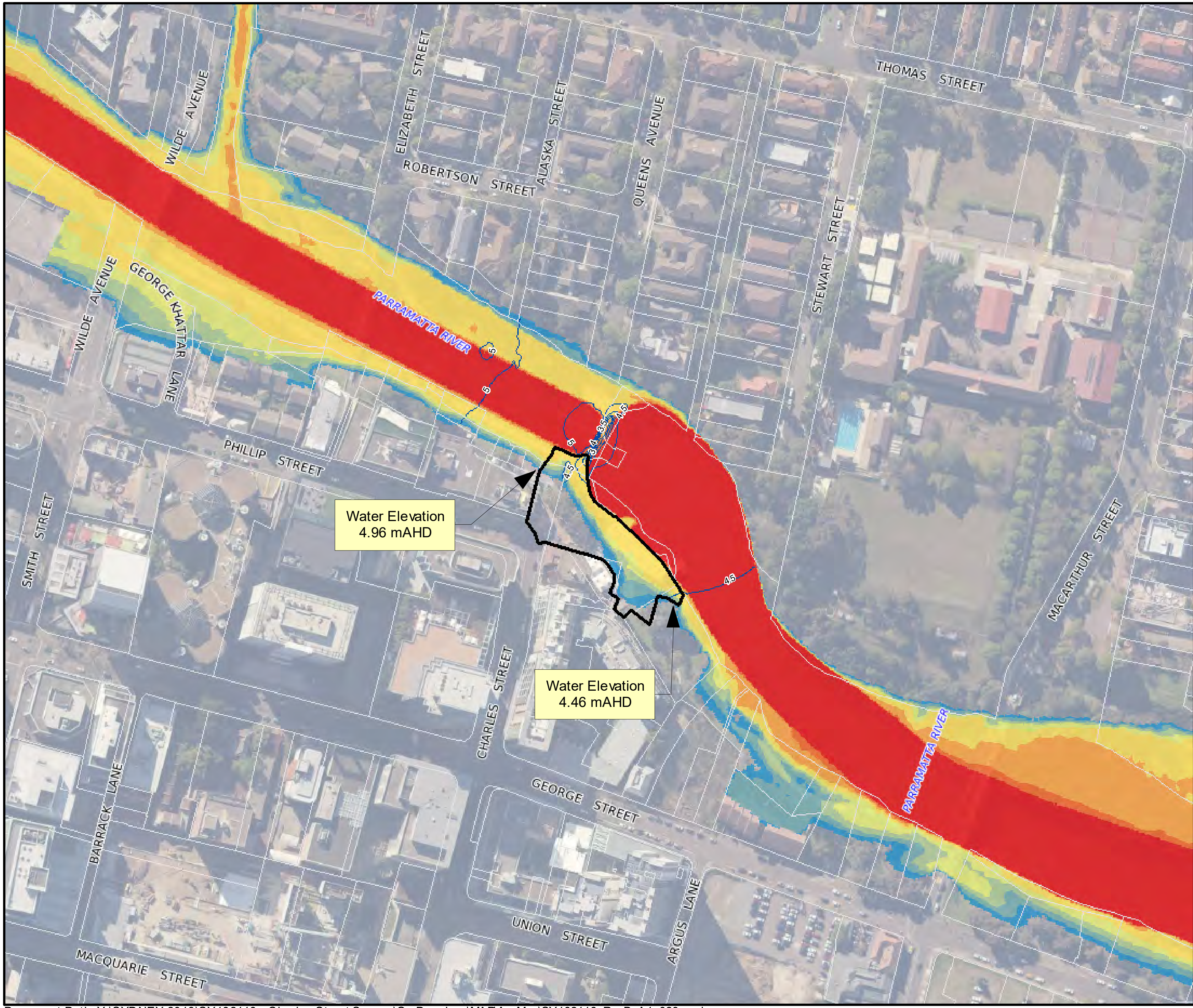

Legend

Proposed Development

Cadastre

Water Levels (mAHD)

Water Depth (m)

- 0 - 0.5
- 0.51 - 1
- 1.01 - 1.5
- 1.51 - 2
- 2.01 - 3
- 3.01 - 4
- 4.01 - 5
- 5.01 - 6

Figure 29 [A1]

Modelled Max Water Depth and Elevations
1% AEP Flood Event, Sensitivity - 5% AEP Lower Parramatta River Catchment Flooding
Existing Scenario

Date 28 May 2020

Job Name
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Parramatta

Job Number SY182116 **Rev** B

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0 30 60 90 Meters

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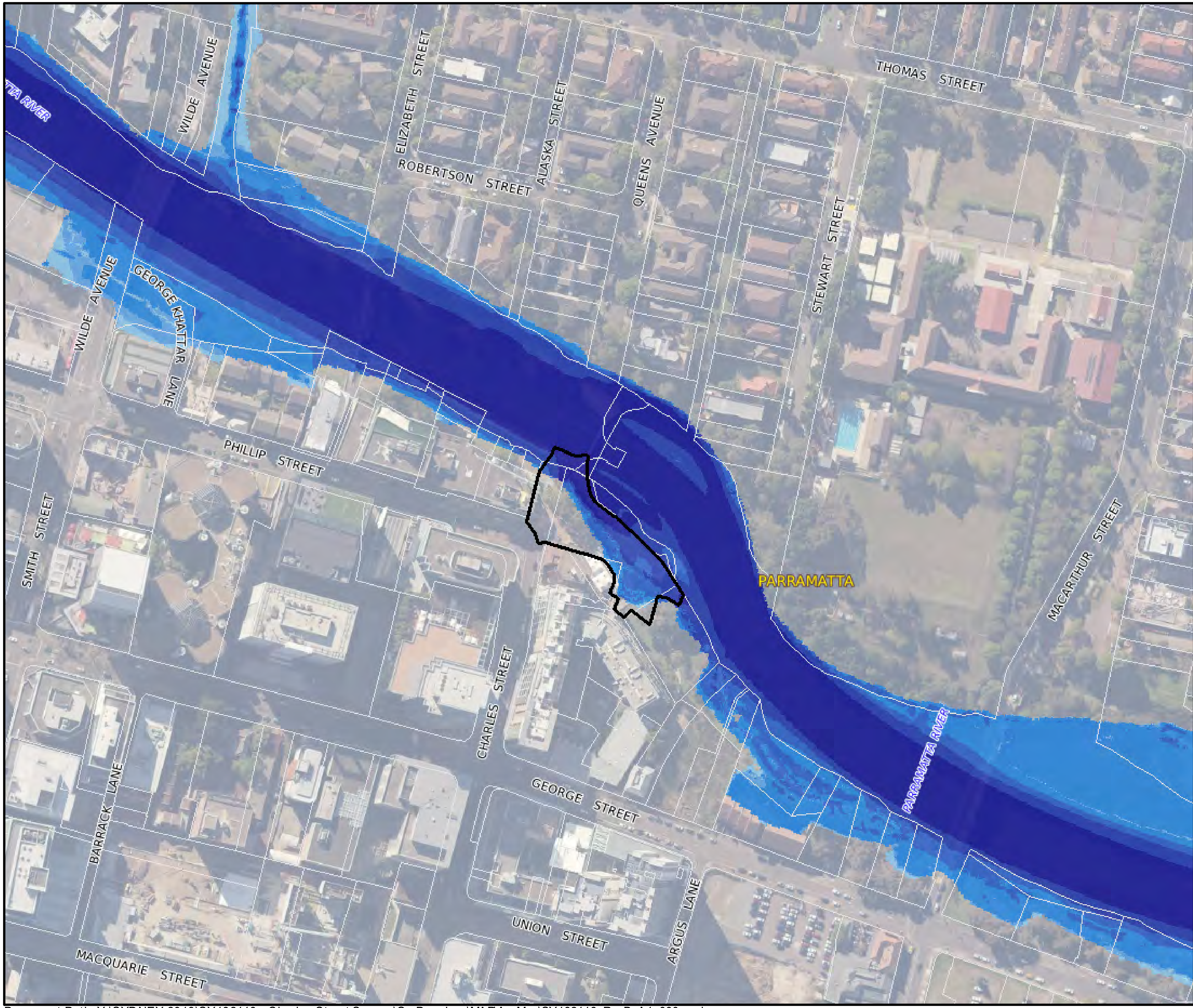

Legend

Proposed Development

Cadastre

Velocity (m/s)

0.01 - 0.01

0.02 - 0.05

0.06 - 0.1

0.11 - 0.5

0.51 - 1

1.01 - 2

2.01 - 9

Figure 30 [A1]

Modelled Max Flow Velocity
1% AEP Flood Event,
Sensitivity - 5% AEP Lower
Parramatta River Catchment
Flooding
Existing Scenario

Date 28 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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Legend

Proposed Development

Cadastre

Hazard Category

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

Figure 31 [A1]

Modelled Max Flood Hazard
1% AEP Flood Event,
Sensitivity - 5% AEP Lower Parramatta River Catchment Flooding
Existing Scenario

Date 28 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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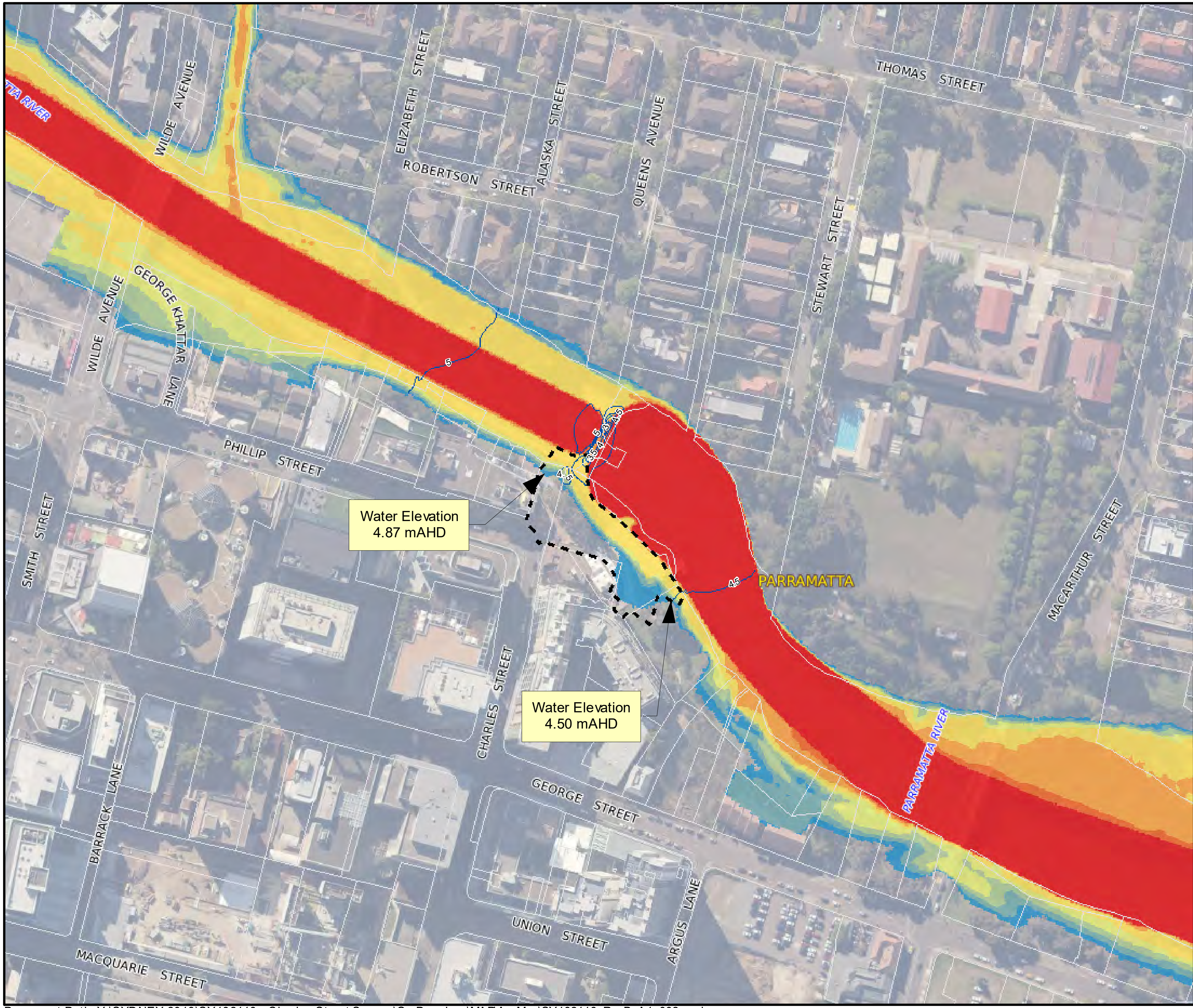

Legend

- Proposed Development
- Cadastre
- Water Levels (mAHD)

Water Depth (m)

- 0 - 0.5
- 0.51 - 1
- 1.01 - 1.5
- 1.51 - 2
- 2.01 - 3
- 3.01 - 4
- 4.01 - 5
- 5.01 - 6

Figure 32 [A1]

Modelled Max Water Depth and Elevations
1% AEP Flood Event
Sensitivity - 5% AEP Lower Parramatta River Catchment Flooding
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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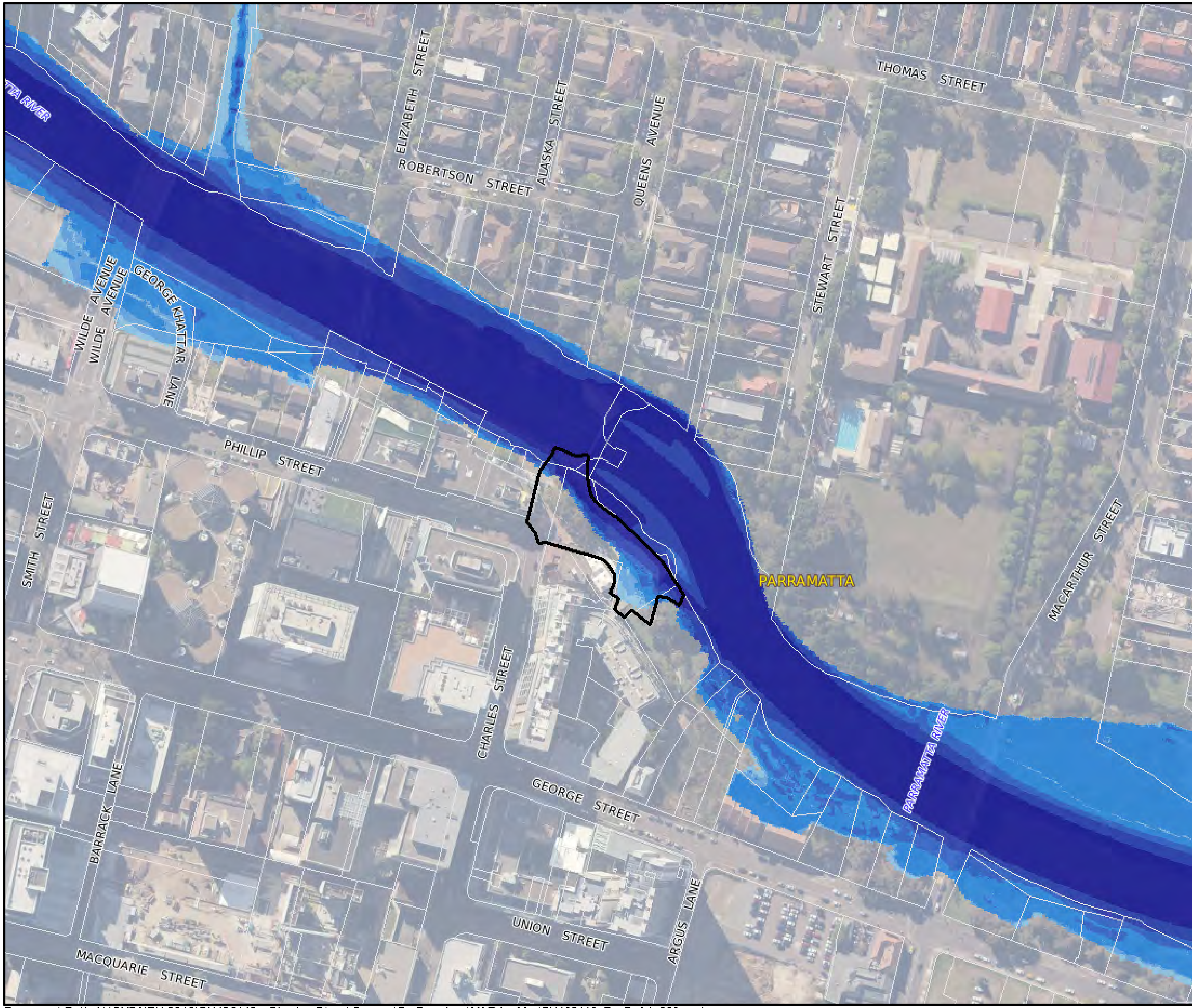

Legend

Proposed Development

Cadastre

Velocity (m/s)

- 0.01 - 0.01
- 0.02 - 0.05
- 0.06 - 0.1
- 0.11 - 0.5
- 0.51 - 1
- 1.01 - 2
- 2.01 - 9

Figure 33 [A1]

Modelled Max Flow Velocity
1% AEP Flood Event
Sensitivity - 5% AEP Lower
Parramatta River Catchment
Flooding
Proposed Scenario

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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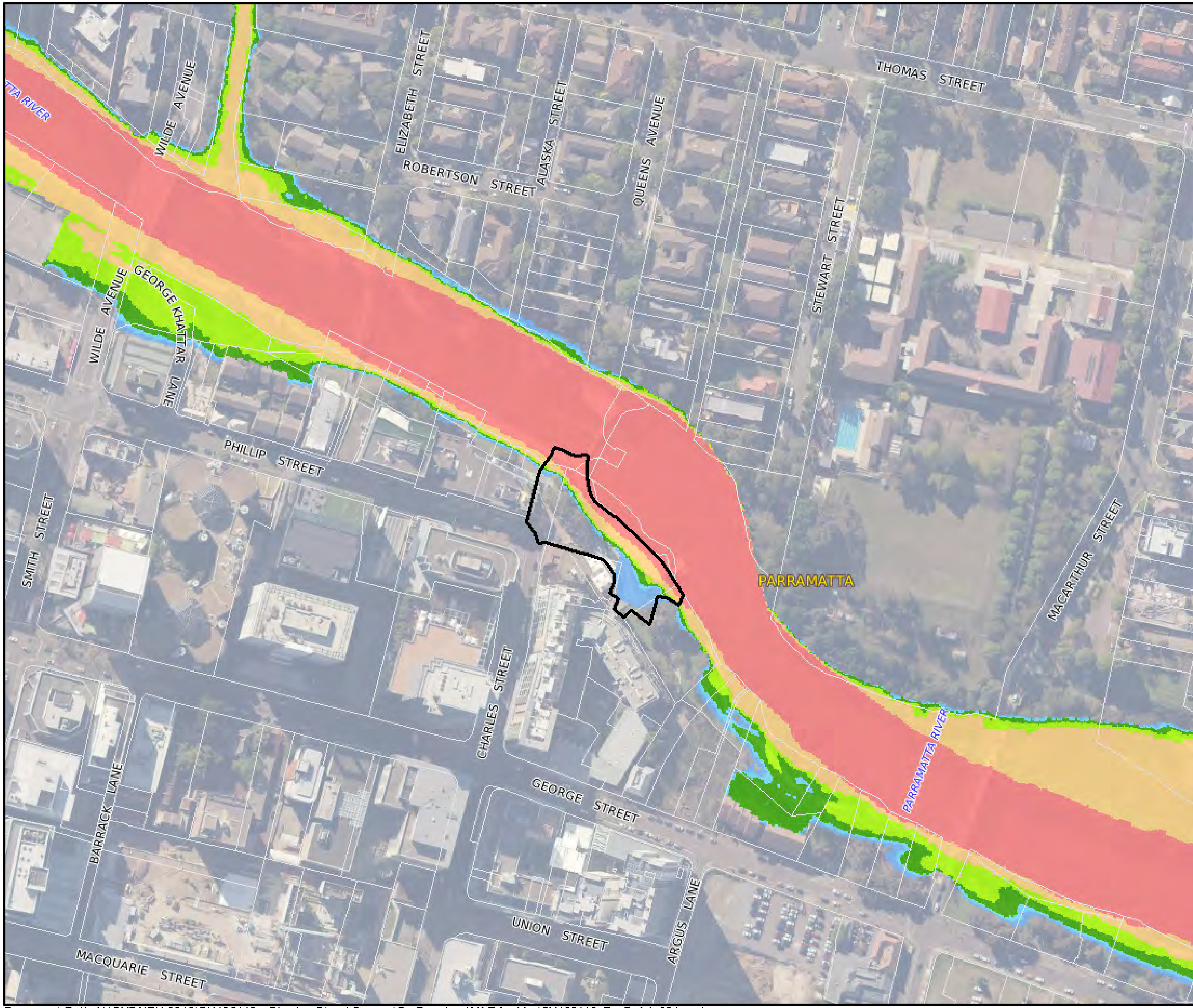

Legend

Proposed Development

Cadastre

Hazard Category

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

Figure 34 [A1]

Modelled Max Flood Hazard
1% AEP Flood Event
Sensitivity - 5% AEP Lower
Parramatta River Catchment
Flooding
Proposed Scenario

Date 27 May 2020

Job Name
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Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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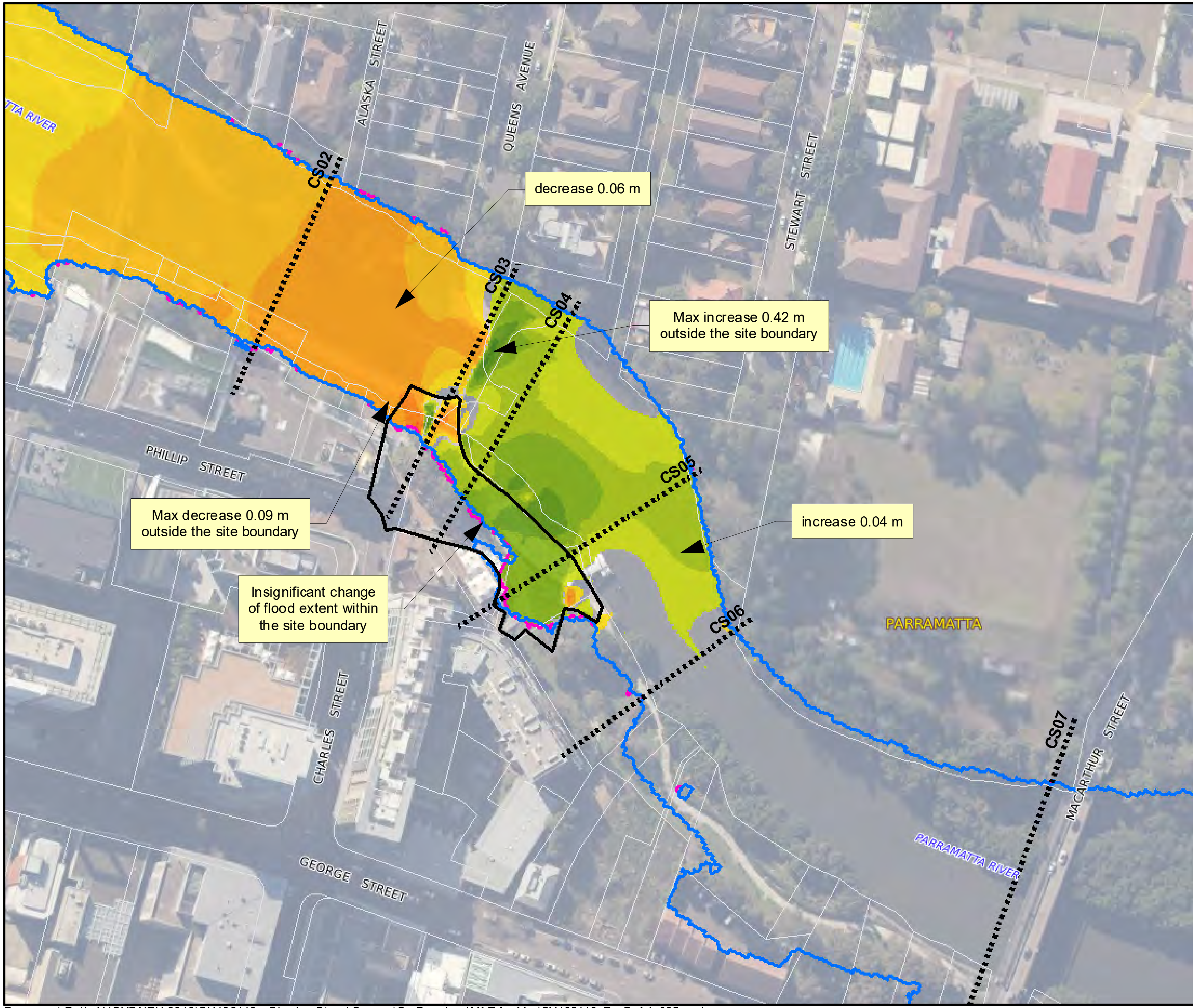

Legend

- Cross Sections
- Proposed Development
- Food Extent (Existing)
- Flood Extent (Proposed)
- Cadastre

Difference (m)

- <-0.499
- -0.499 - -0.300
- -0.299 - -0.100
- -0.099 - -0.050
- -0.049 - -0.030
- -0.029 - -0.010
- Less than +/- 10mm
- 0.011 - 0.030
- 0.031 - 0.050
- 0.051 - 0.100
- 0.101 - 0.300
- 0.301 - 0.500
- >0.500

Figure 35 [A1]

Max Water Elevation Difference
1% AEP Flood Event
Sensitivity - 5% AEP Lower
Parramatta River Catchment
Flooding
Proposed minus Existing

Date 27 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 20 40 60 Meters

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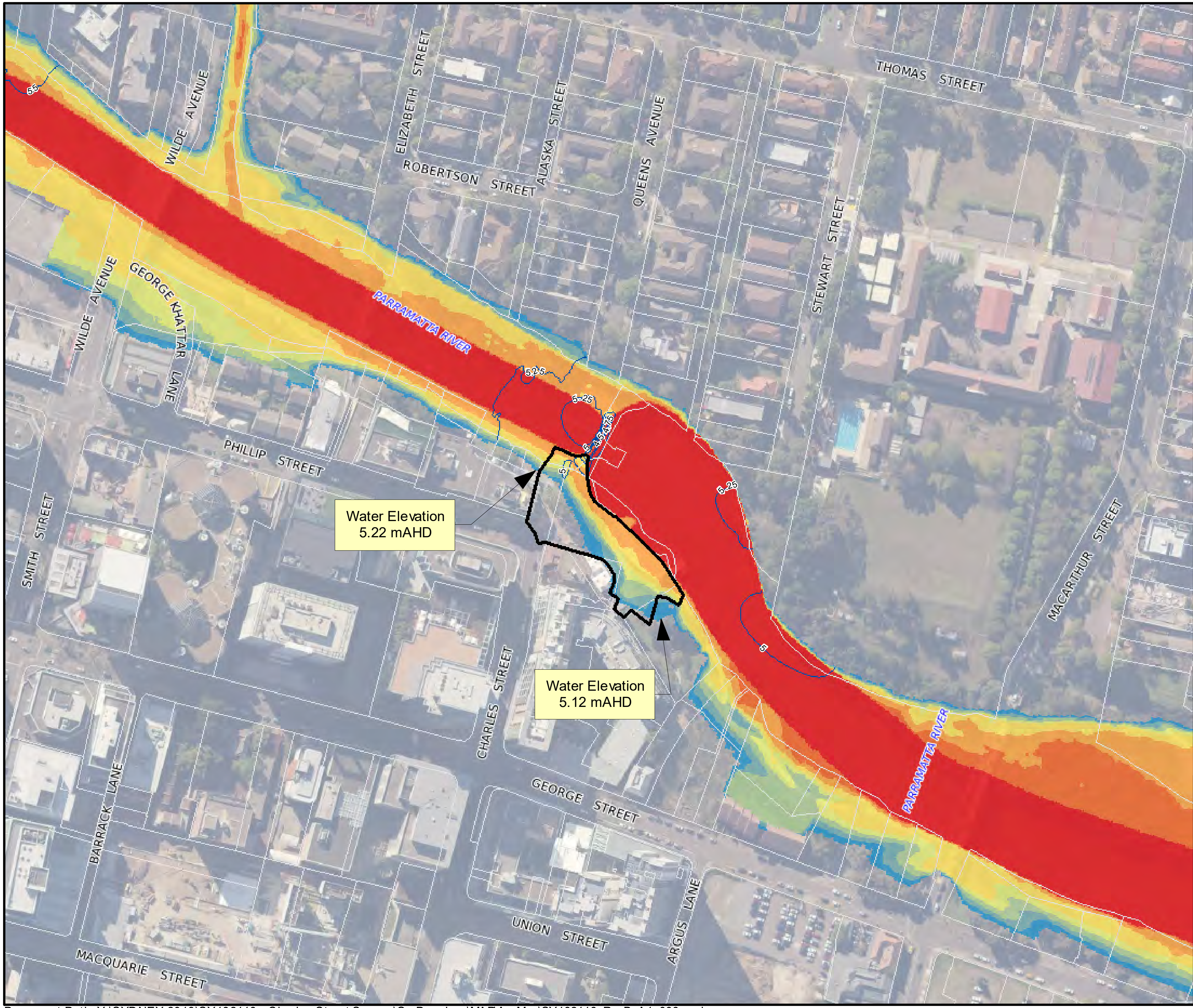

Legend

- Proposed Development
- Cadastre
- Water Levels (mAHD)

Water Depth (m)

- 0 - 0.5
- 0.51 - 1
- 1.01 - 1.5
- 1.51 - 2
- 2.01 - 3
- 3.01 - 4
- 4.01 - 5
- 5.01 - 6

Figure 36 [A1]

Modelled Max Water Depth and Elevations
1% AEP Flood Event,
Sensitivity - 1% AEP Lower Parramatta River Catchment Flooding
Existing Scenario

Date 28 May 2020

Job Name
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Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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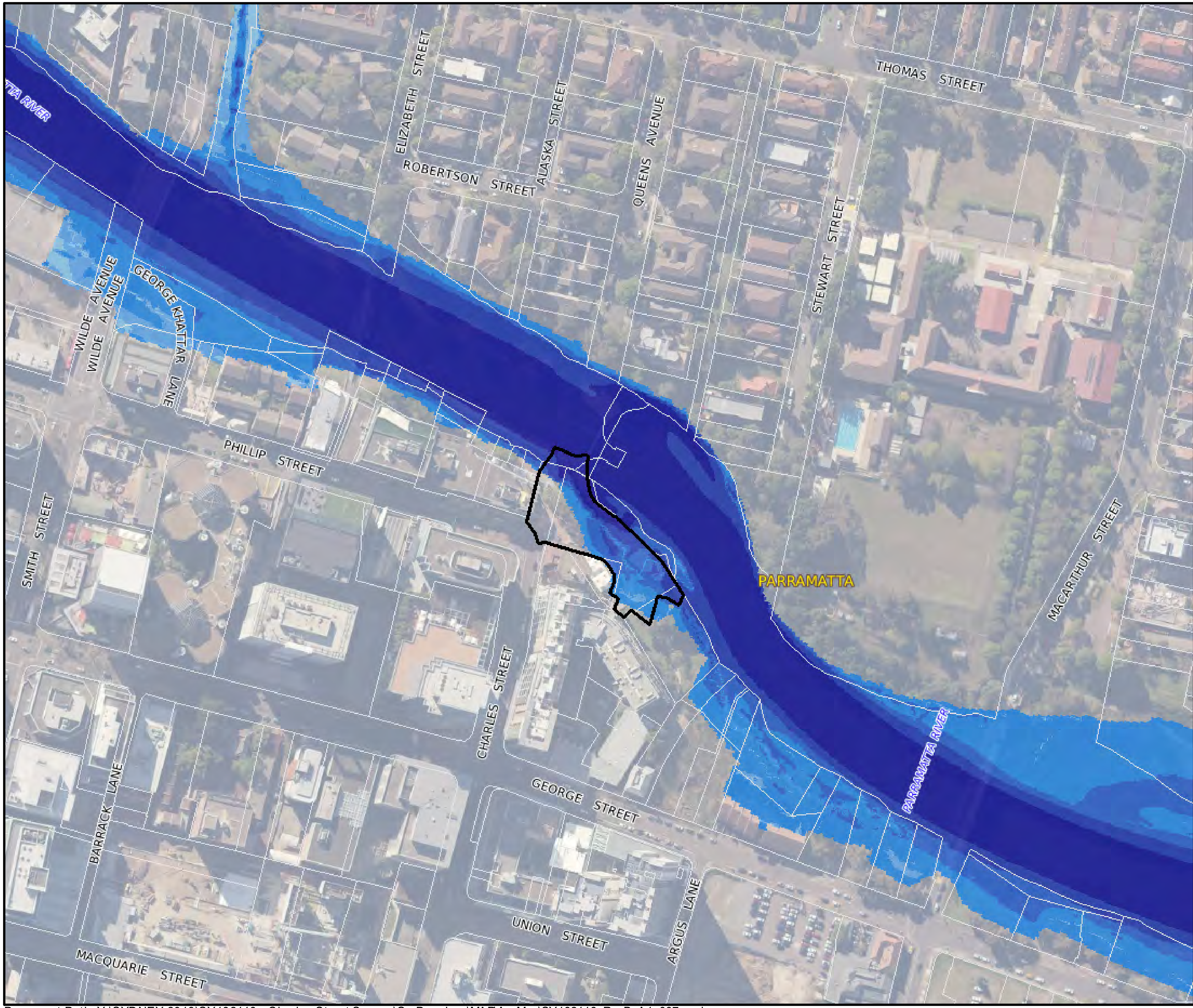

Legend

Proposed Development

Cadastre

Velocity (m/s)

- 0.01 - 0.01
- 0.02 - 0.05
- 0.06 - 0.1
- 0.11 - 0.5
- 0.51 - 1
- 1.01 - 2
- 2.01 - 9

Figure 37 [A1]

Modelled Max Flow Velocity
1% AEP Flood Event,
Sensitivity - 1% AEP Lower
Parramatta River Catchment
Flooding
Existing Scenario

Date 28 May 2020

Job Name
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Parramatta

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N

0 30 60 90 Meters

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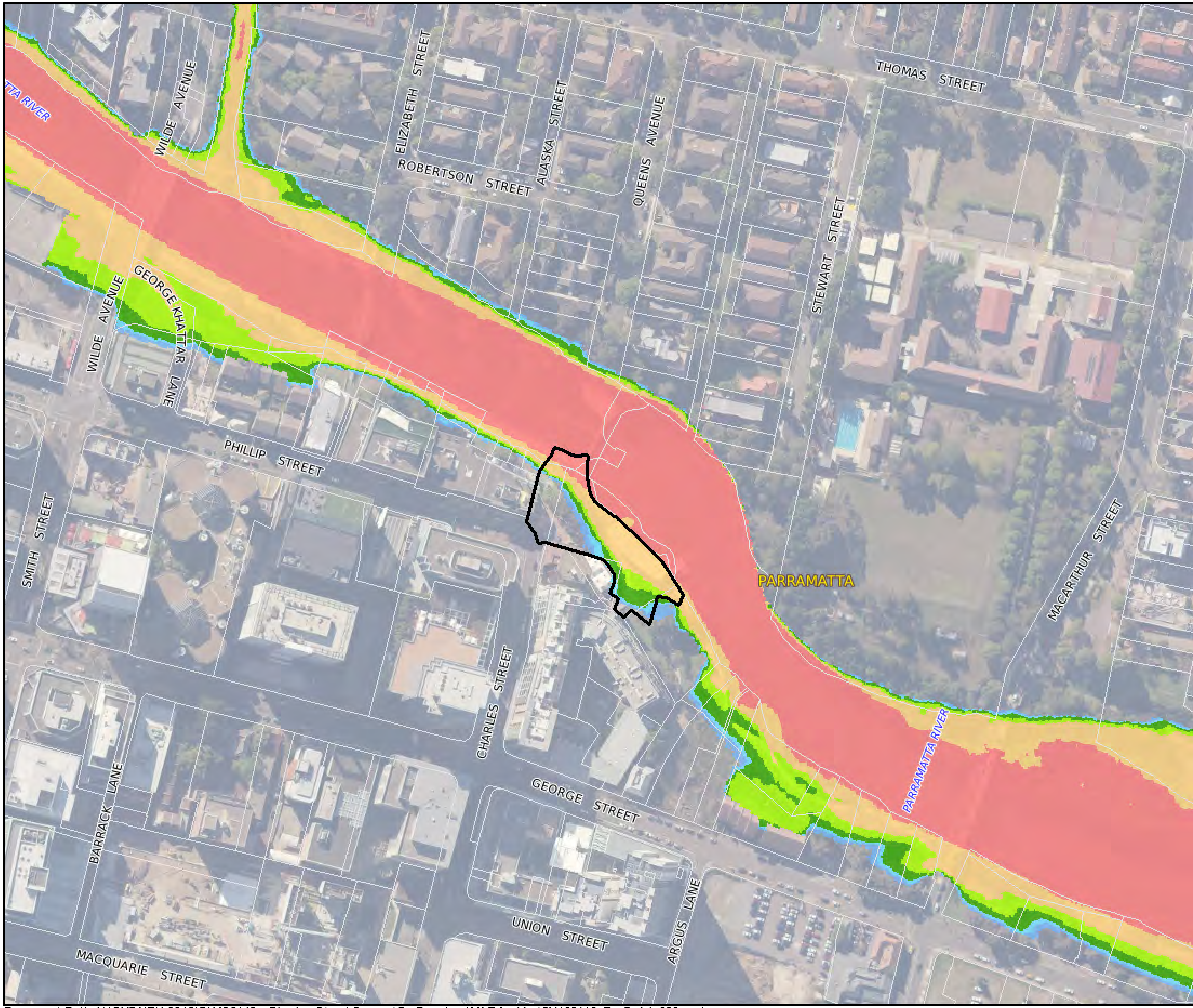

Legend

Proposed Development

Cadastre

Hazard Category

H1

H2

H3

H4

H5

H6

Figure 38 [A1]

Modelled Max Flood Hazard 1% AEP Flood Event, Sensitivity - 1% AEP Lower Parramatta River Catchment Flooding Existing Scenario

Date 28 May 2020

Job Name
Charles Street Square
Parramatta

Job Number SY182116 **Rev** B

N

0 30 60 90 Meters

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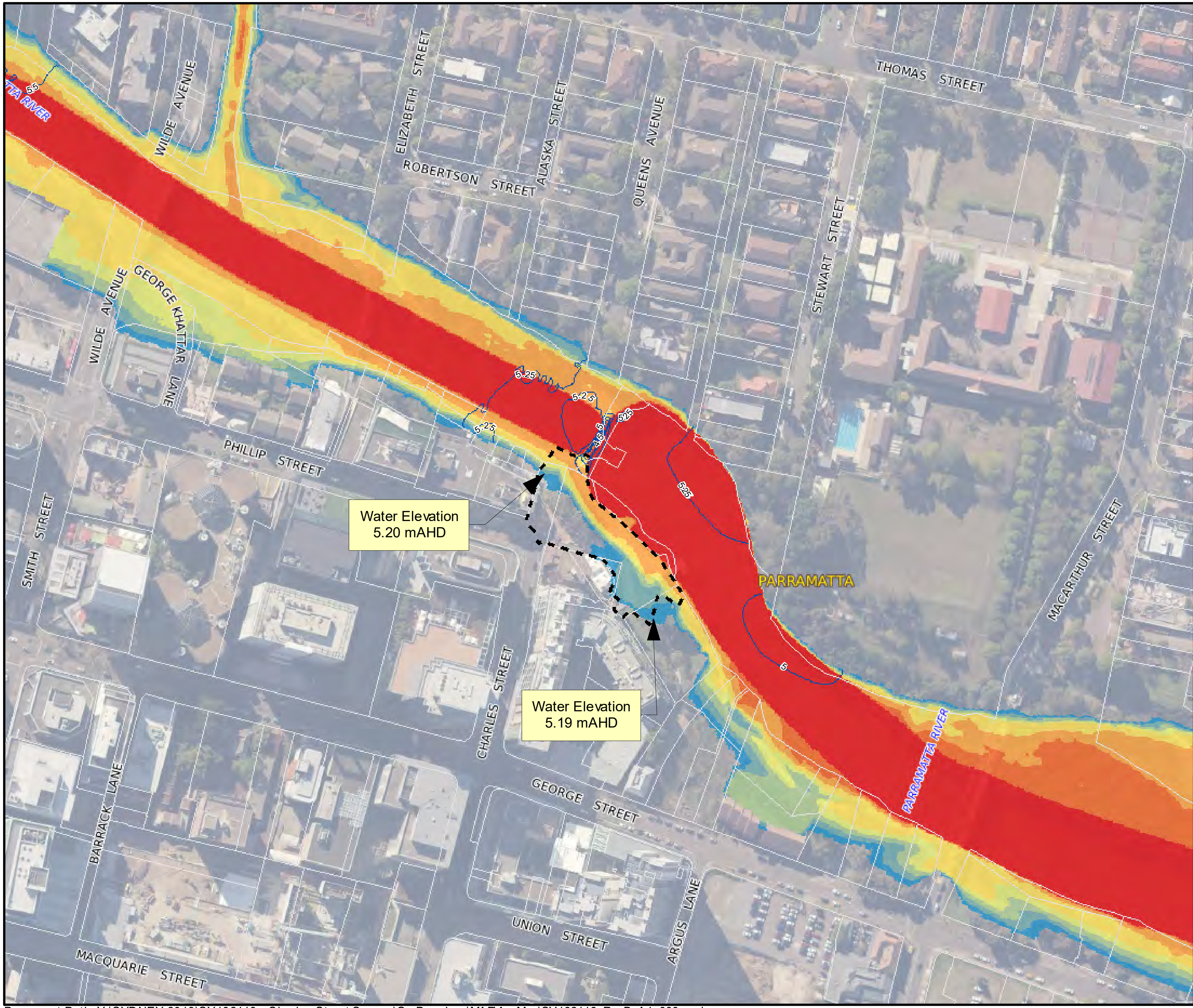

Legend

Proposed Development

Cadastre

Water Levels (mAHD)

Water Depth (m)

0 - 0.5

0.51 - 1

1.01 - 1.5

1.51 - 2

2.01 - 3

3.01 - 4

4.01 - 5

5.01 - 6

Figure 39 [A1]

Modelled Max Water Depth and Elevations
1% AEP Flood Event
Sensitivity - 1% AEP Lower Parramatta River Catchment Flooding
Proposed Scenario

Date 27 May 2020

Job Name
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Parramatta

Job Number SY182116 **Rev** B

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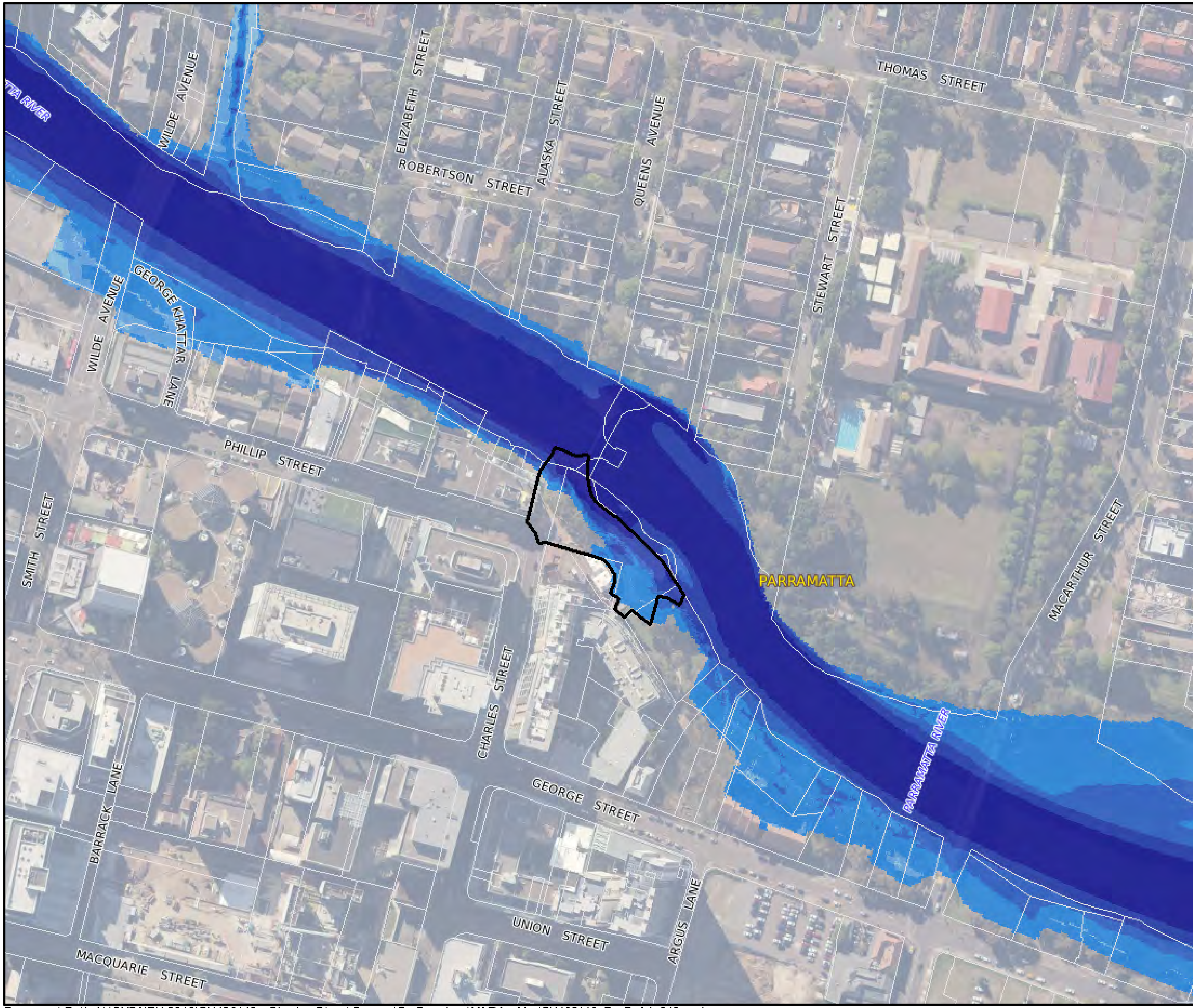

Legend

Proposed Development

Cadastre

Velocity (m/s)

0.01 - 0.01

0.02 - 0.05

0.06 - 0.1

0.11 - 0.5

0.51 - 1

1.01 - 2

2.01 - 9

Figure 40 [A1]

Modelled Max Flow Velocity
1% AEP Flood Event
Sensitivity - 1% AEP Lower Parramatta River Catchment Flooding
Proposed Scenario

Date 27 May 2020

Job Name
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Parramatta

Job Number SY182116 **Rev** B

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0 30 60 90 Meters

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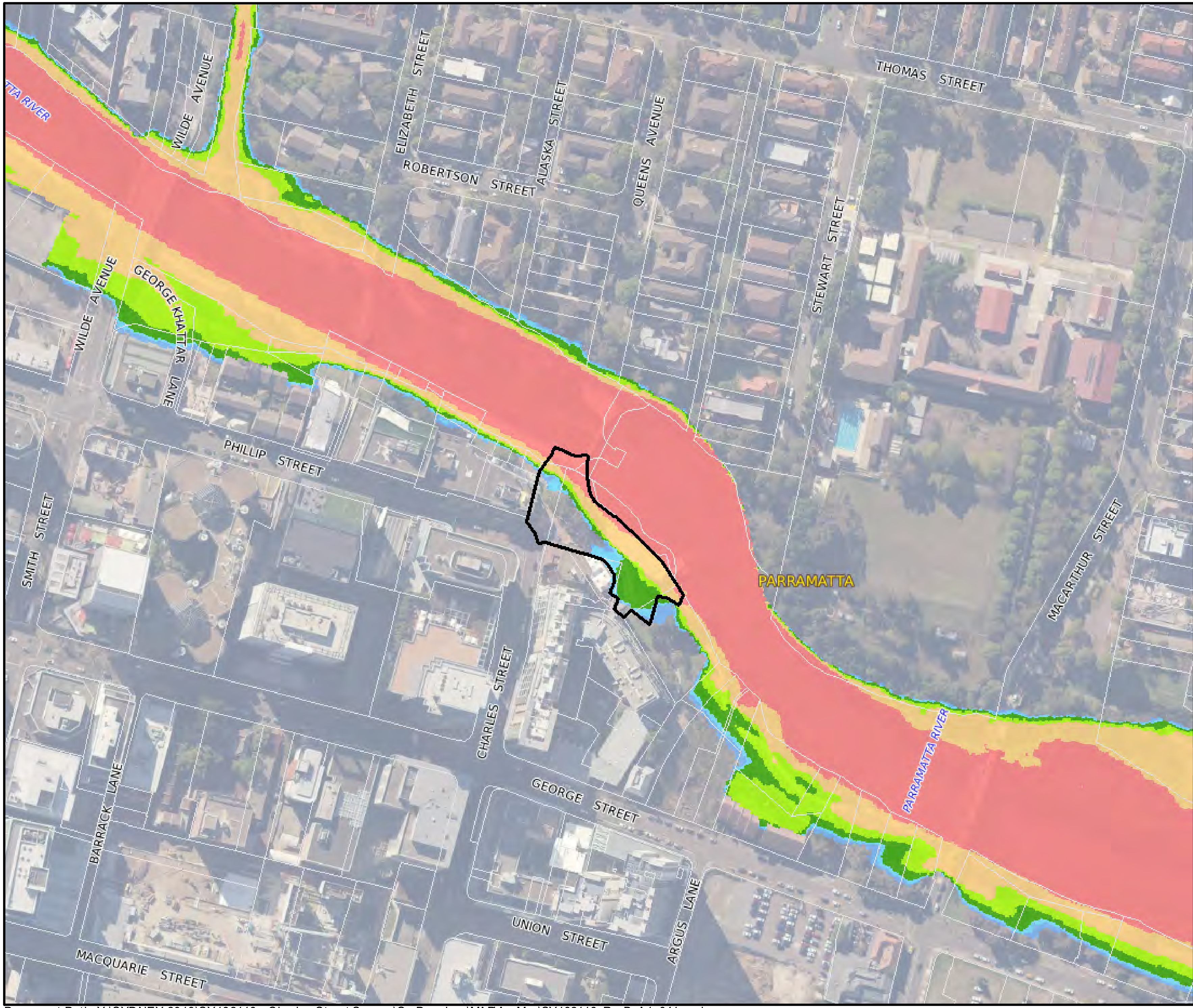

Legend

Proposed Development

Cadastre

Hazard Category

H1

H2

H3

H4

H5

H6

Figure 41 [A1]

Modelled Max Flood Hazard
1% AEP Flood Event
Sensitivity - 1% AEP Lower Parramatta River Catchment Flooding
Proposed Scenario

Date 27 May 2020

Job Name
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Parramatta

Job Number SY182116 **Rev** B

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0 30 60 90 Meters

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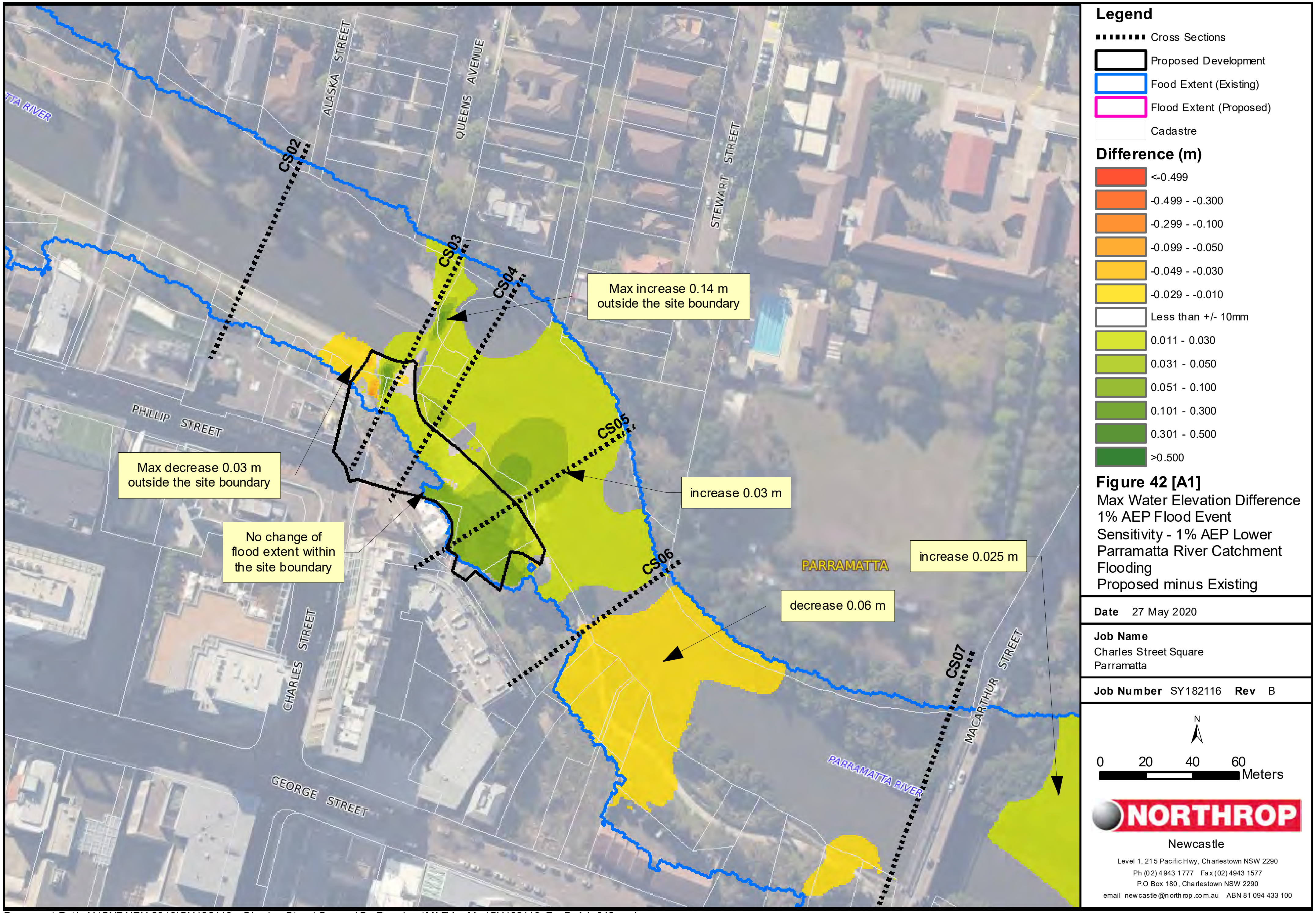

Figure 42 [A1]
Max Water Elevation Difference
1% AEP Flood Event
Sensitivity - 1% AEP Lower Parramatta River Catchment Flooding
Proposed minus Existing

Date 27 May 2020

Job Name
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Parramatta

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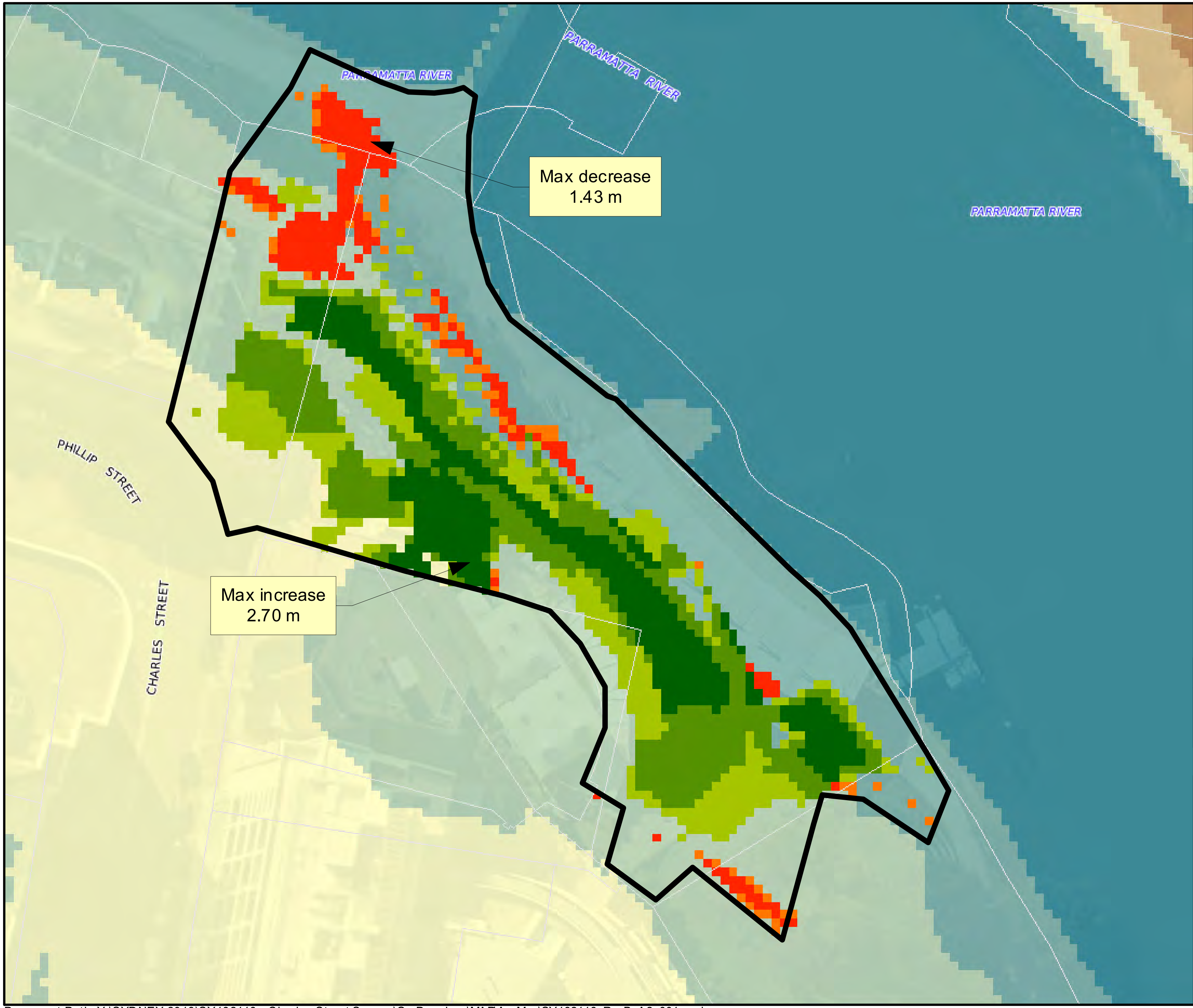
Appendix 2 – The Subject Site Landform Cross Sections (Existing v Proposed)



Legend

Proposed Development

Cadastre

Elevation Difference (m)

- -1.43 - -0.30
- -0.30 - -0.10
- -0.10 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 2.70

Terrain (mAHD)

- -3.30 - 0.37
- 0.37 - 4.24
- 4.24 - 7.33
- 7.33 - 9.94
- 9.94 - 12.94
- 12.94 - 16.42
- 16.42 - 21.35

Figure 1 [A2]

Landform Elevation Difference, Proposed minus Exisitng

Date 28 May 2020

Job Name
Charles Street Square
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Job Number SY182116 **Rev** B

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0 6.5 13 19.5 Meters

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Figure 2, Cross Section 1

Figure 3, Cross Section 2
Ground Elevation (mAHD)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
10
20
30
40
50
60
70
80
90
100
Distance (m)
Existing Landform
Proposed Landform
Weir Structure
Weir Pathway


Figure 4, Cross Section 3
Ground Elevation (mAHD)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
10
20
30
40
50
60
70
80
90
100
Distance (m)
Existing Landform
Proposed Landform

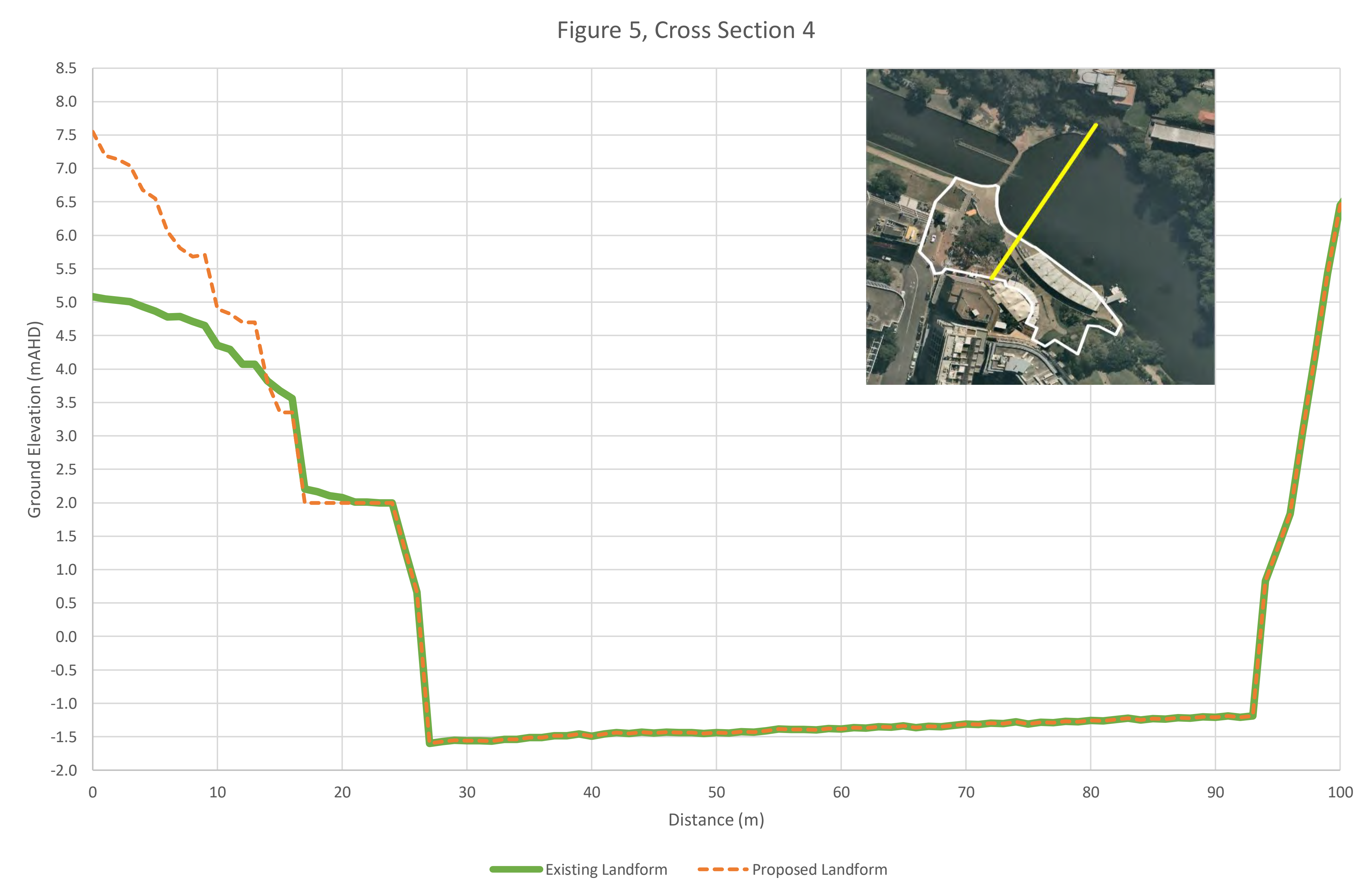


Figure 5, Cross Section 4
Ground Elevation (mAHD)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
10
20
30
40
50
60
70
80
90
100
Distance (m)
Existing Landform
Proposed Landform

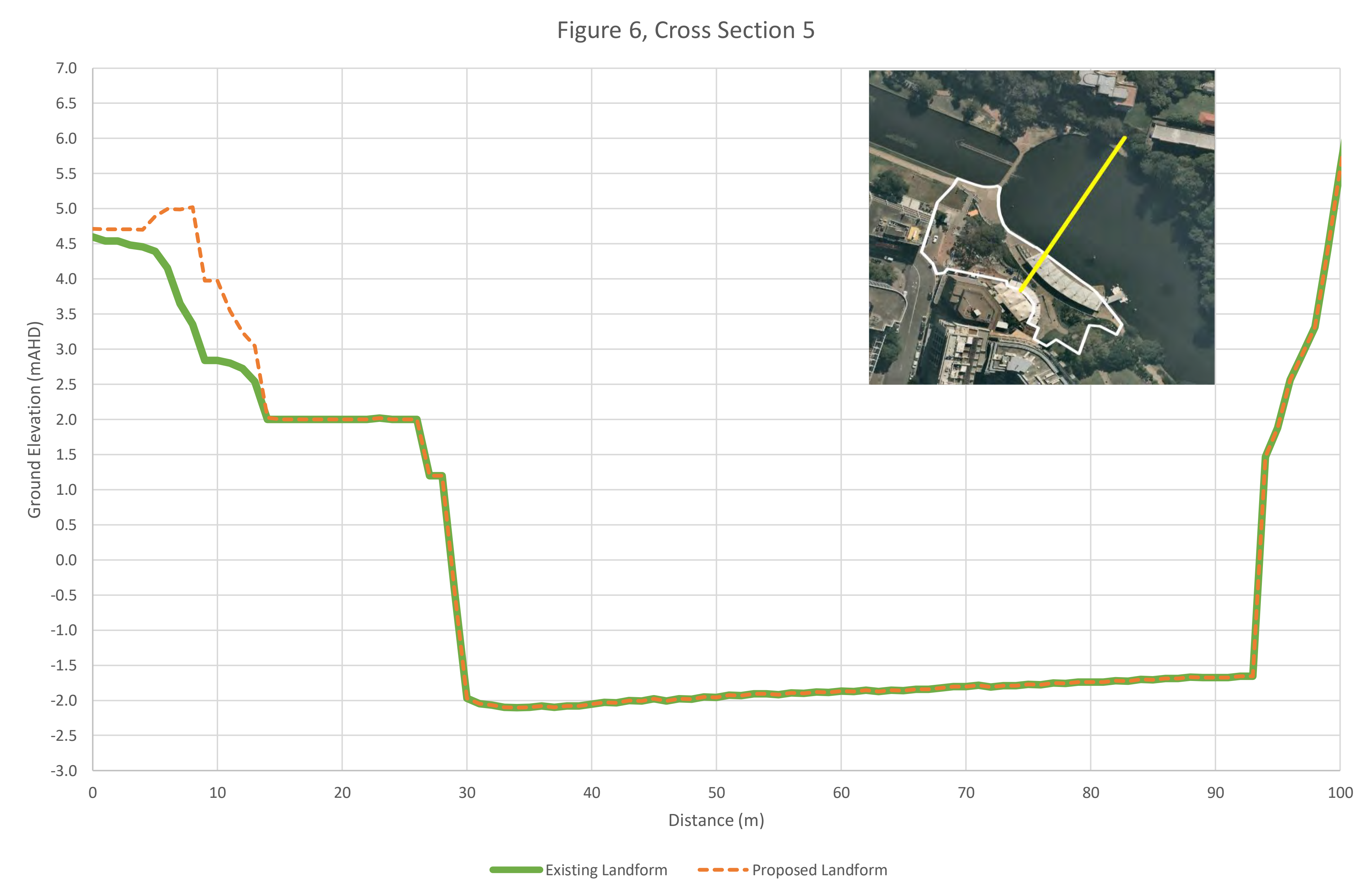


Figure 6, Cross Section 5
Ground Elevation (mAHD)
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0
10
20
30
40
50
60
70
80
90
100
Distance (m)
Existing Landform
Proposed Landform

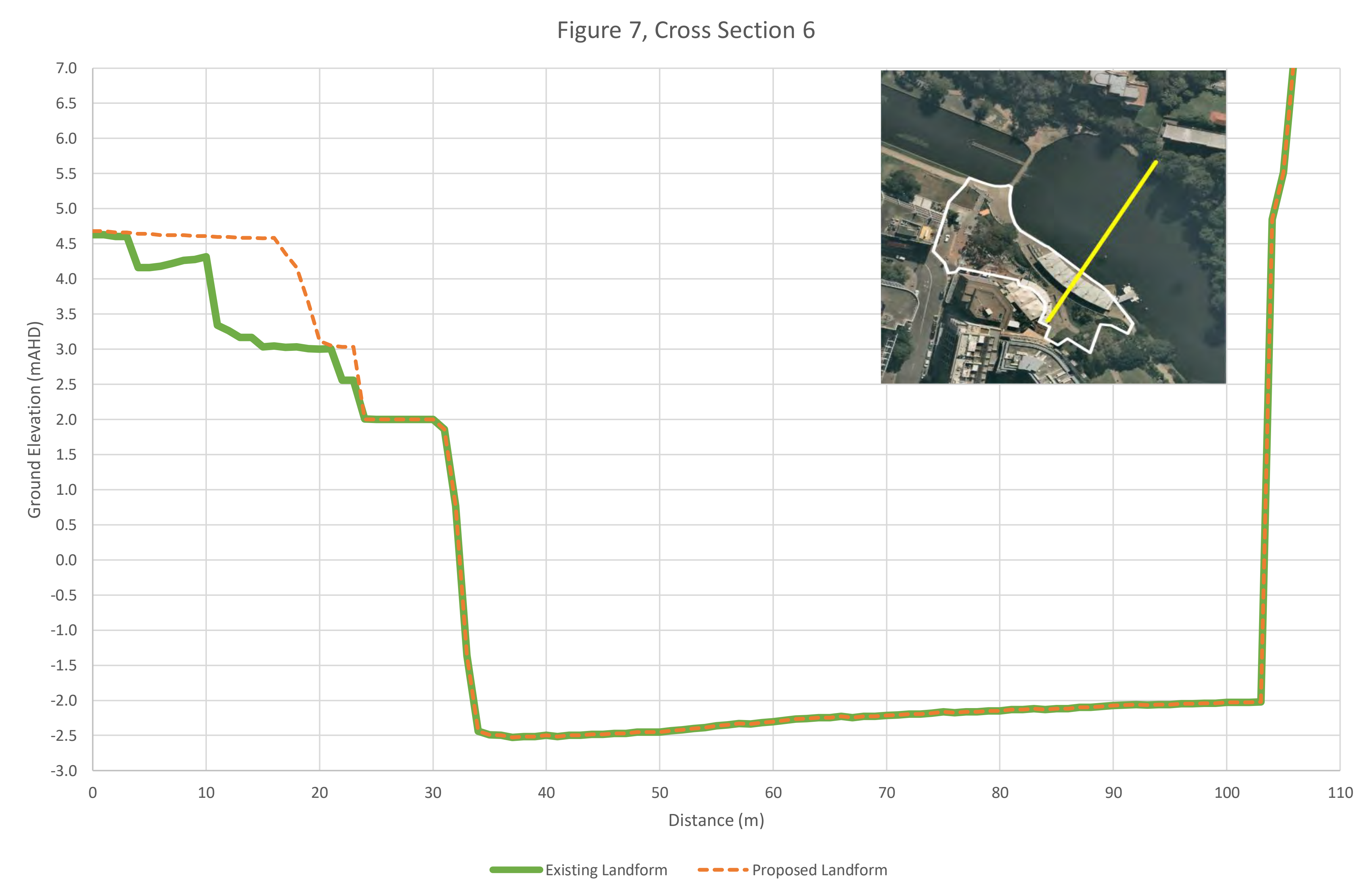


Figure 7, Cross Section 6
Ground Elevation (mAHD)
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0
10
20
30
40
50
60
70
80
90
100
110
Distance (m)
Existing Landform
Proposed Landform

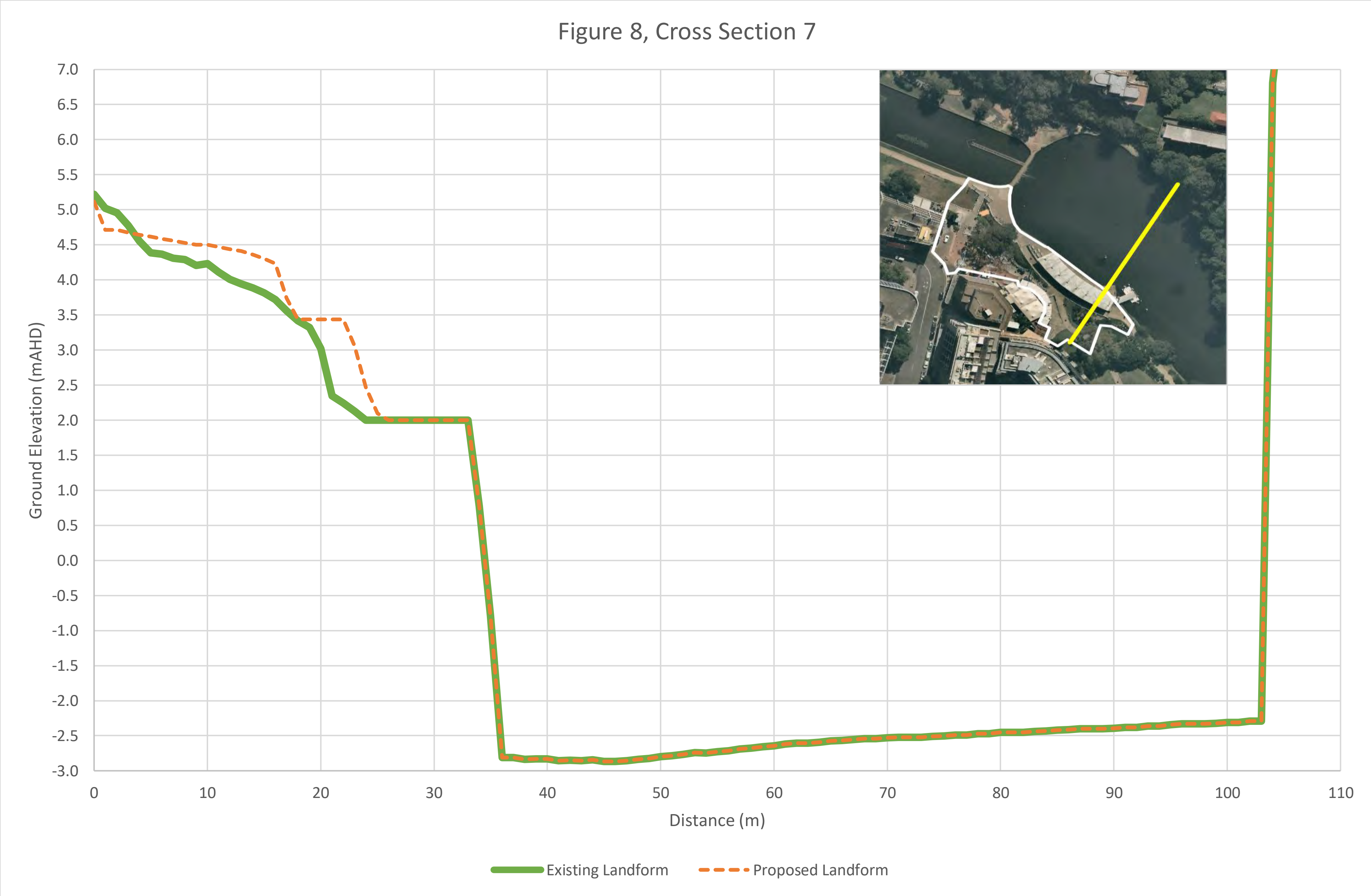


Figure 8, Cross Section 7
Ground Elevation (mAHD)
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0
10
20
30
40
50
60
70
80
90
100
110
Distance (m)
Existing Landform
Proposed Landform

Appendix 3 – Hydrographs (Modelled Water Elevations)

Figure 1: Water Elevations, CS01 (275 metres upstream of Charles St Weir - middle of the channel)

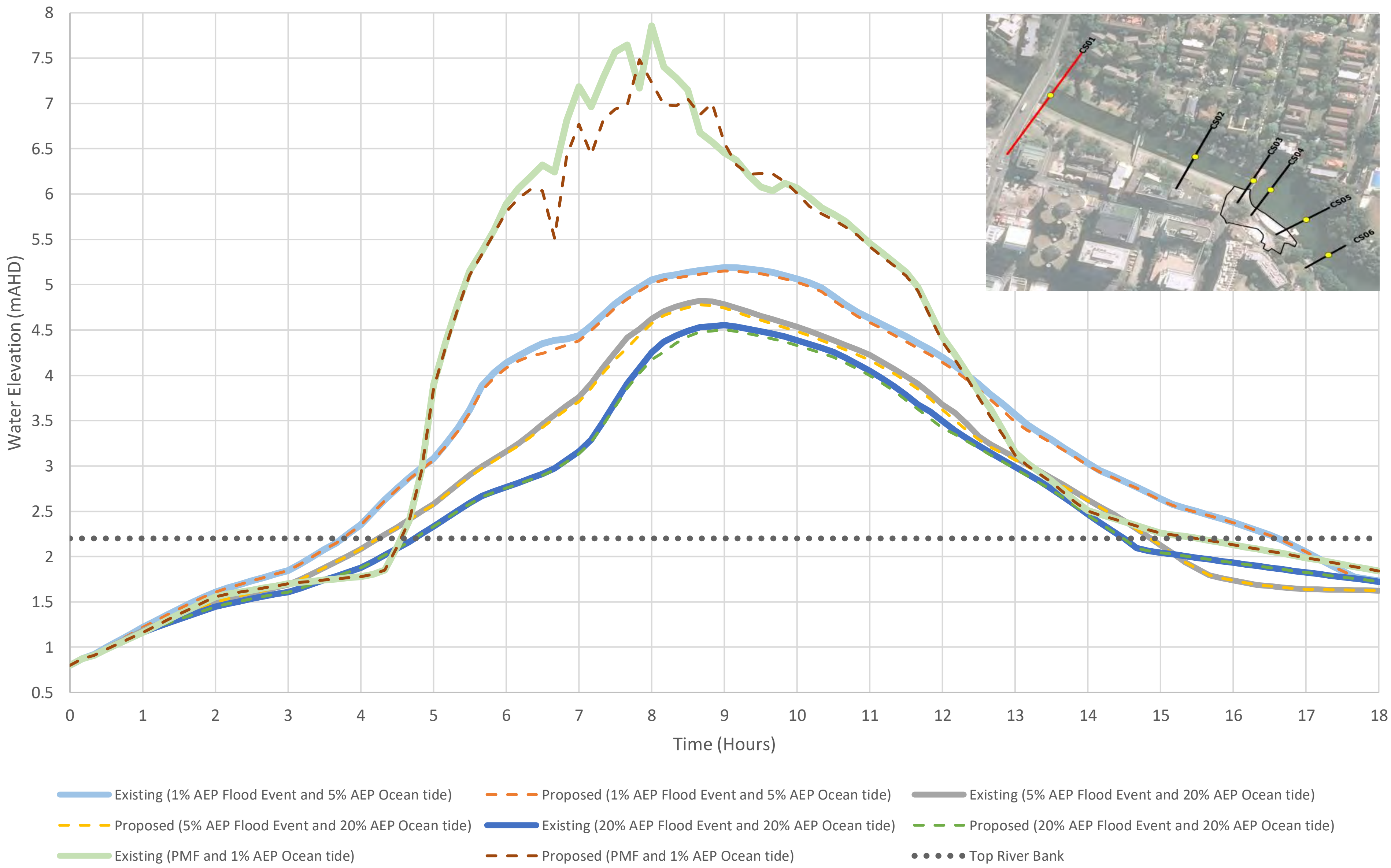
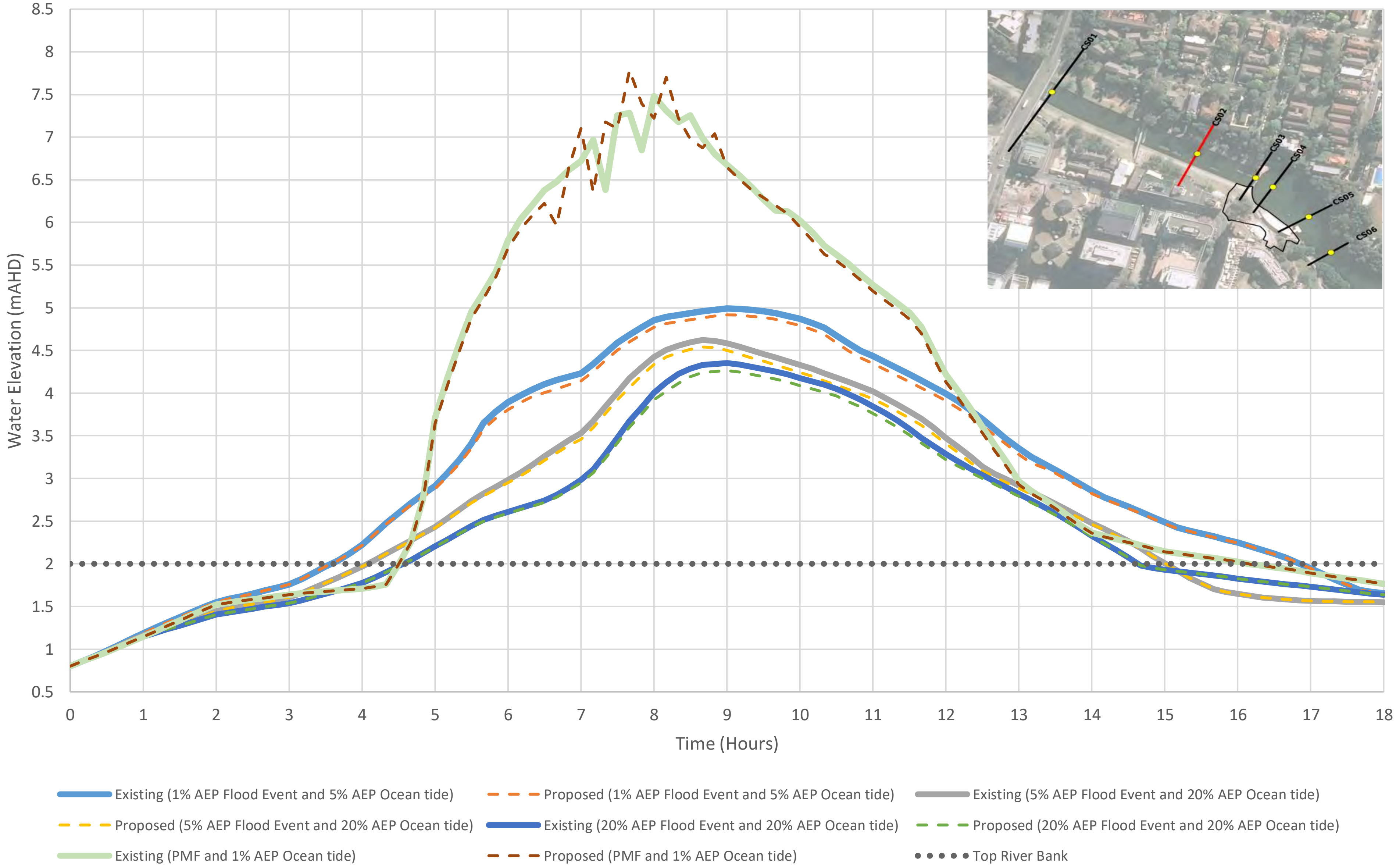


Figure 2: Water Elevations, CS02 (80 metres upstream of Charles St Weir - middle of the channel)



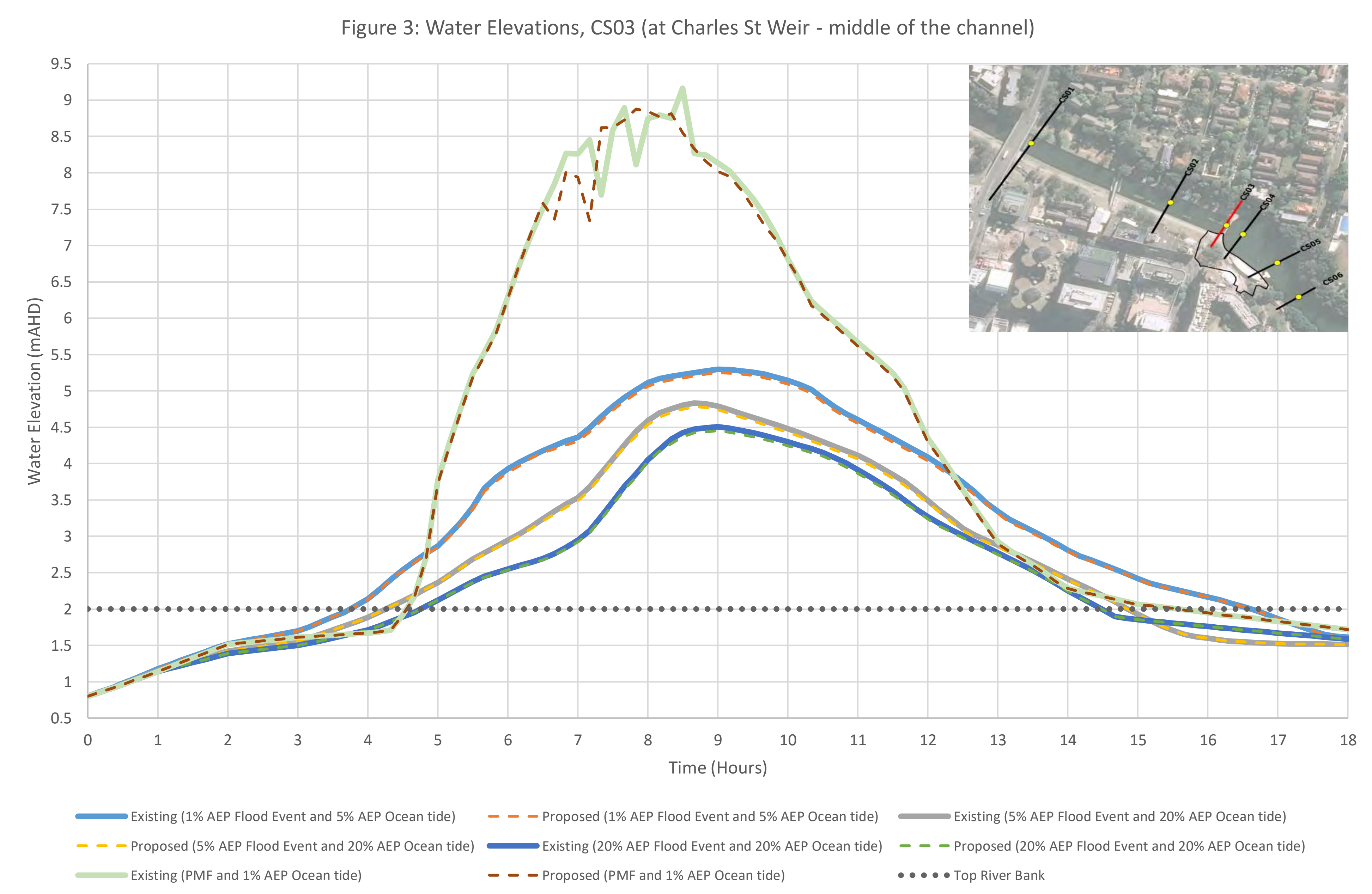


Figure 3: Water Elevations, CS03 (at Charles St Weir - middle of the channel)
Water Elevation (mAHD)
Time (Hours)
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
CS01
CS02
CS03
CS04
CS05
CS06
Existing (1% AEP Flood Event and 5% AEP Ocean tide)
Proposed (1% AEP Flood Event and 5% AEP Ocean tide)
Existing (5% AEP Flood Event and 20% AEP Ocean tide)
Proposed (5% AEP Flood Event and 20% AEP Ocean tide)
Existing (20% AEP Flood Event and 20% AEP Ocean tide)
Proposed (20% AEP Flood Event and 20% AEP Ocean tide)
Existing (PMF and 1% AEP Ocean tide)
Proposed (PMF and 1% AEP Ocean tide)
Top River Bank

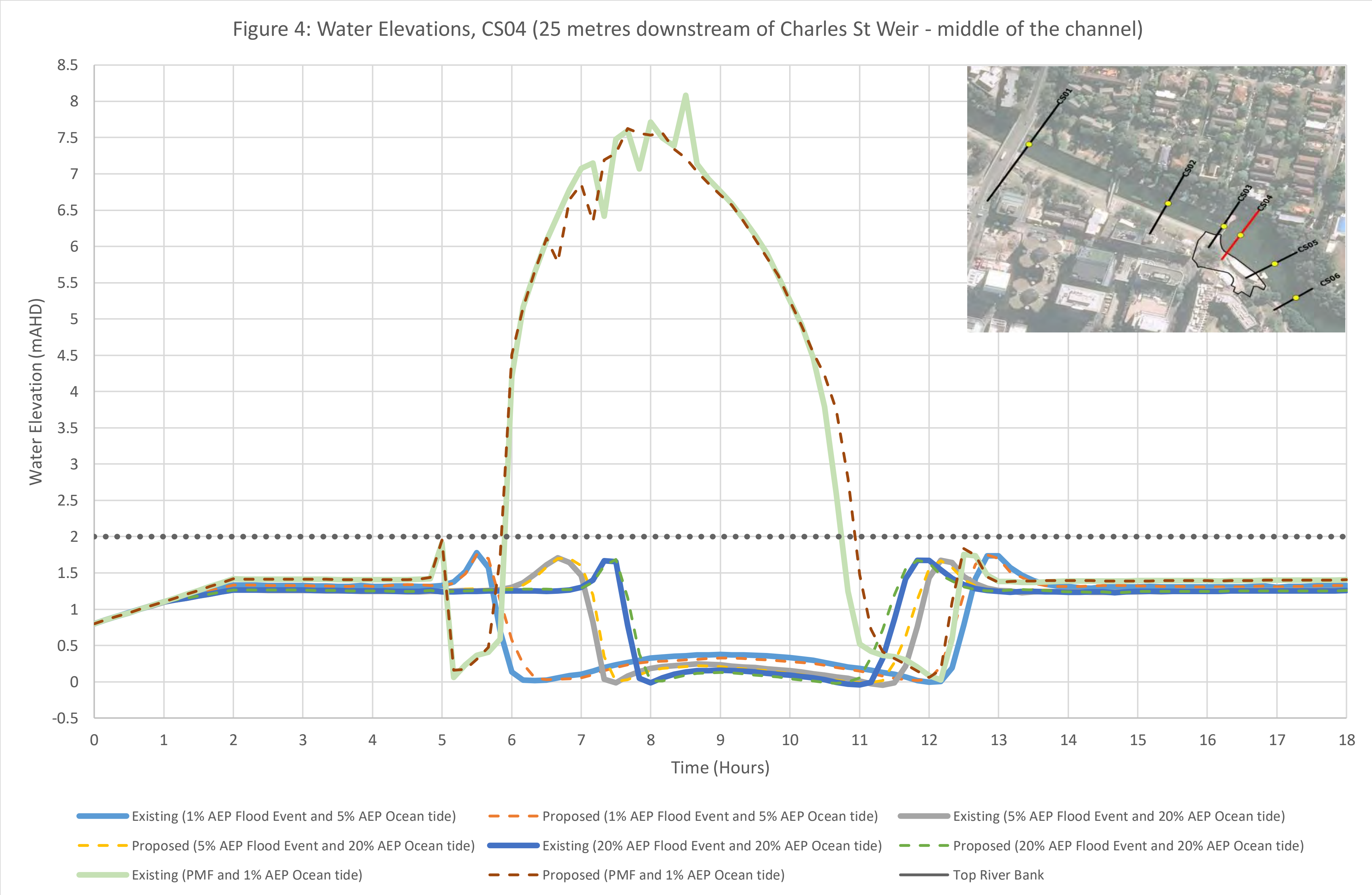
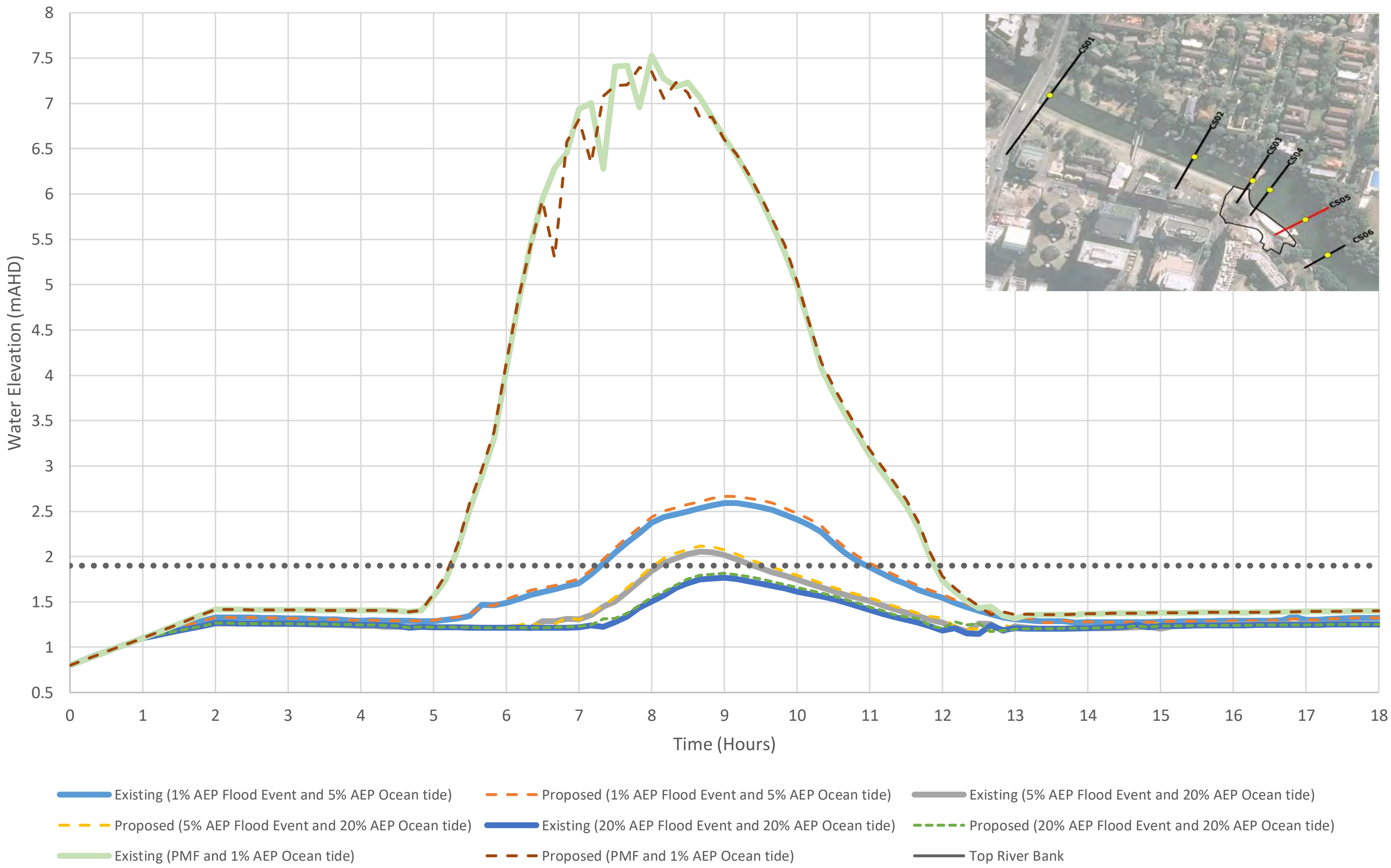


Figure 4: Water Elevations, CS04 (25 metres downstream of Charles St Weir - middle of the channel)
Water Elevation (mAHD)
Time (Hours)
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
CS01
CS02
CS03
CS04
CS05
CS06
Existing (1% AEP Flood Event and 5% AEP Ocean tide)
Proposed (1% AEP Flood Event and 5% AEP Ocean tide)
Existing (5% AEP Flood Event and 20% AEP Ocean tide)
Proposed (5% AEP Flood Event and 20% AEP Ocean tide)
Existing (20% AEP Flood Event and 20% AEP Ocean tide)
Proposed (20% AEP Flood Event and 20% AEP Ocean tide)
Existing (PMF and 1% AEP Ocean tide)
Proposed (PMF and 1% AEP Ocean tide)
Top River Bank

Figure 5: Water Elevations, CDS05 (90 metres downstream of Charles St Weir - middle of the channel)



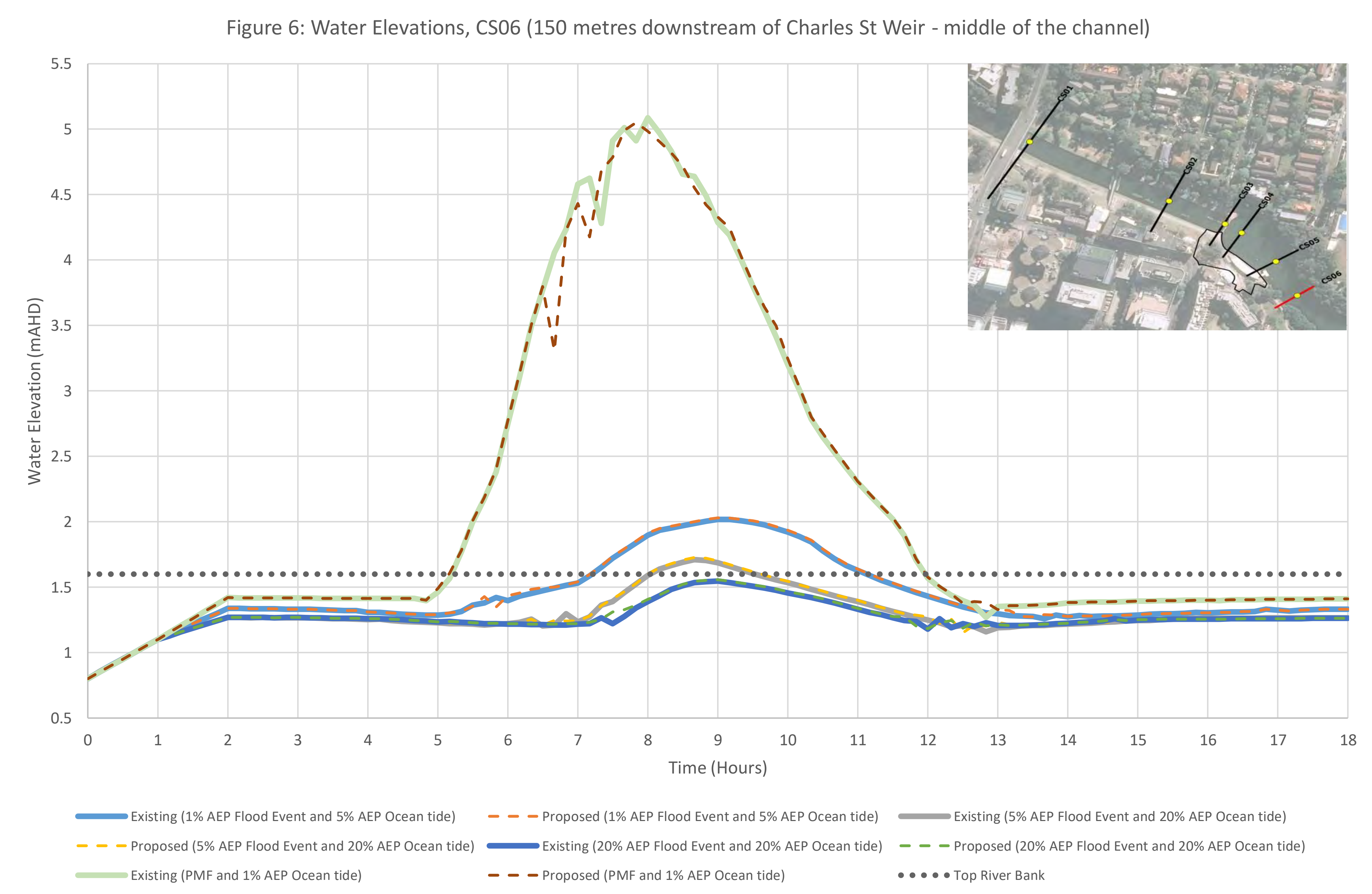


Figure 6: Water Elevations, CS06 (150 metres downstream of Charles St Weir - middle of the channel)
Water Elevation (mAHD)
Time (Hours)
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
CS01
CS02
CS03
CS04
CS05
CS06
Existing (1% AEP Flood Event and 5% AEP Ocean tide)
Proposed (1% AEP Flood Event and 5% AEP Ocean tide)
Existing (5% AEP Flood Event and 20% AEP Ocean tide)
Proposed (5% AEP Flood Event and 20% AEP Ocean tide)
Existing (20% AEP Flood Event and 20% AEP Ocean tide)
Proposed (20% AEP Flood Event and 20% AEP Ocean tide)
Existing (PMF and 1% AEP Ocean tide)
Proposed (PMF and 1% AEP Ocean tide)
Top River Bank

Figure 7: 1% AEP Flood Event (Downstream Flooding Conditions Sensitivity), CS02 (80 metres upstream of Charles St Weir - middle of the channel)

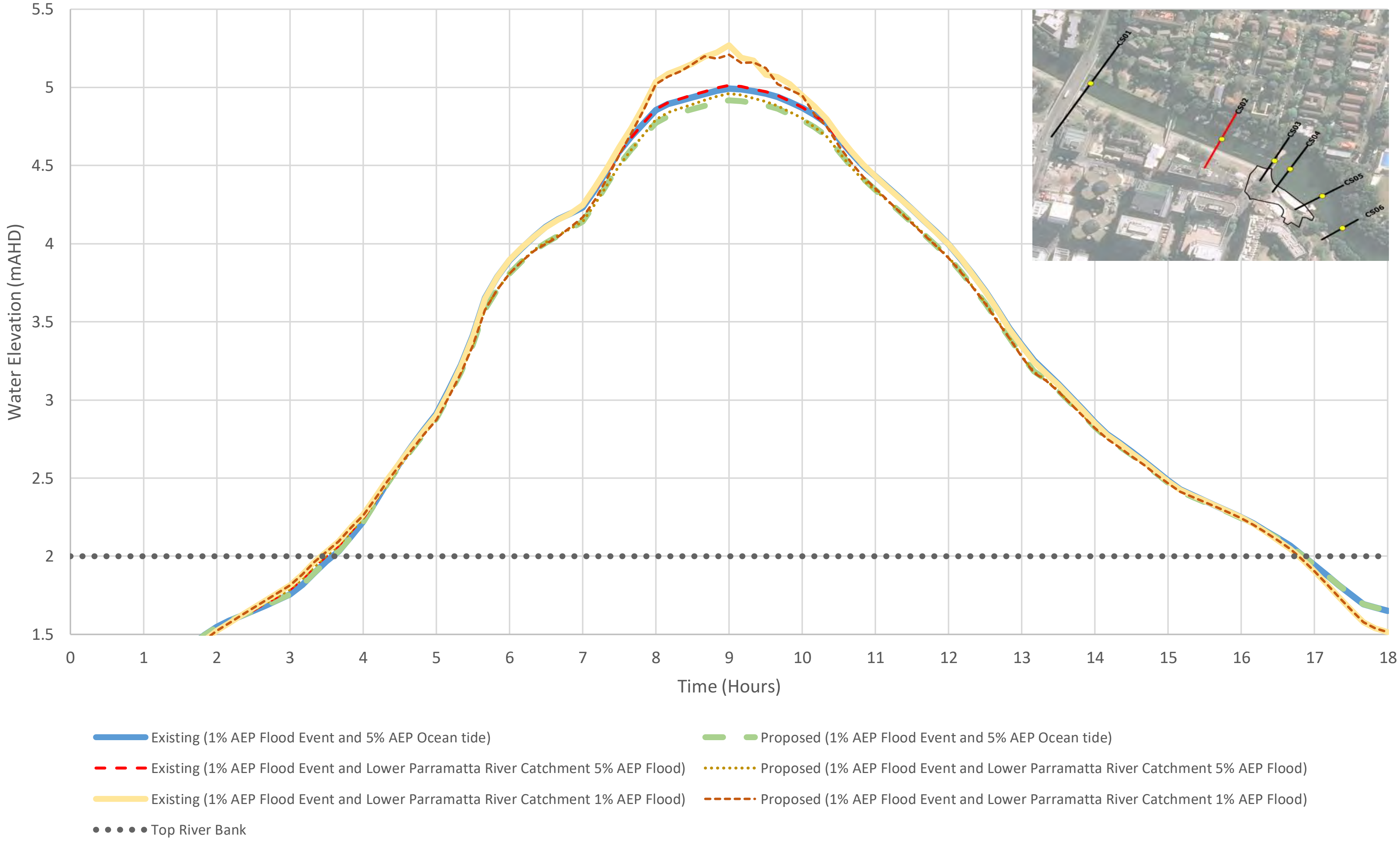
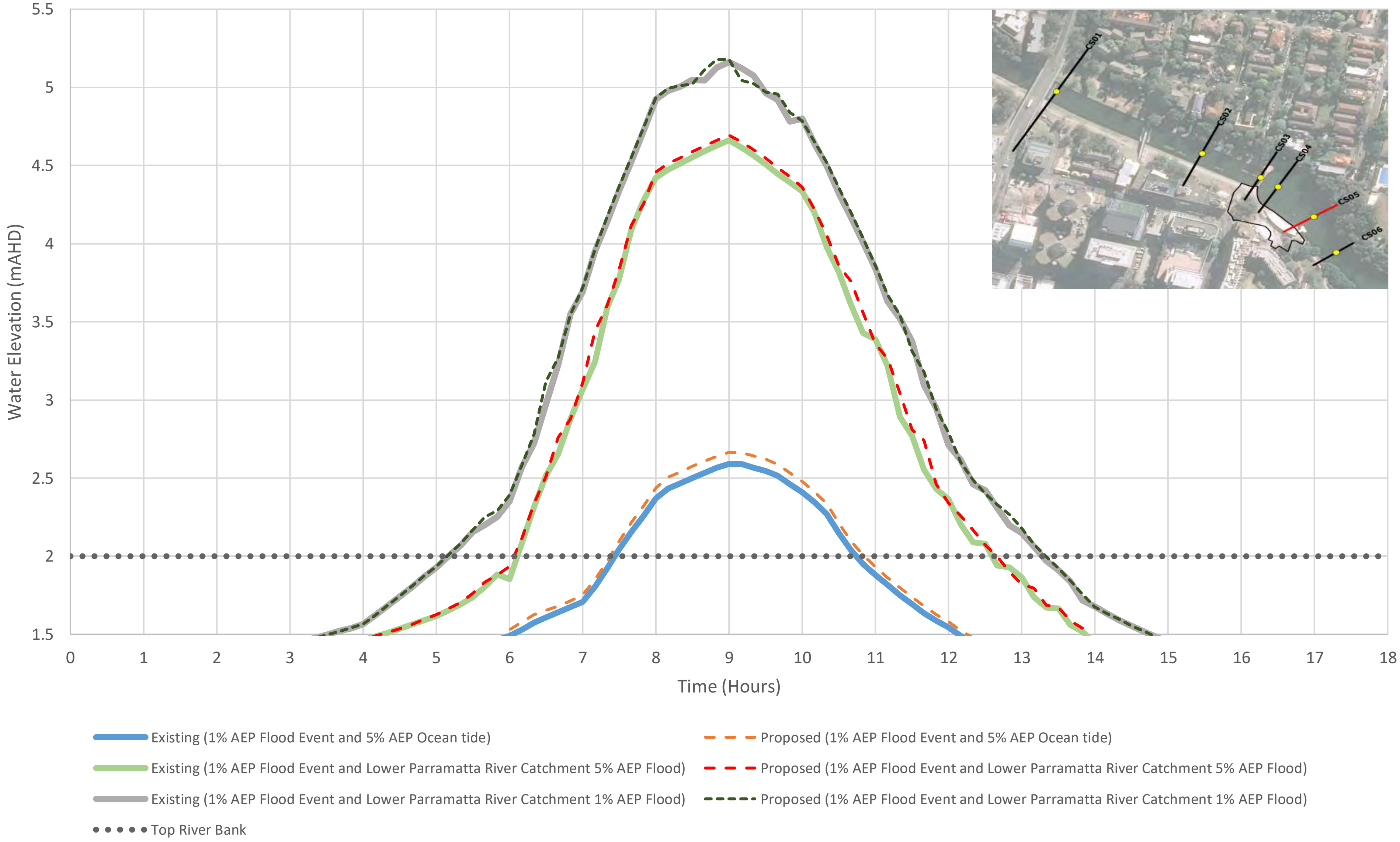


Figure 8: 1% AEP Flood Event (Downstream Flooding Conditions Sensitivity), CS05 (90 metres downstream of Charles St Weir - middle of the channel)



Appendix 4 – Hydraulic Modelling Results at Floodplain Cross Sections

Table 1: 1% AEP Flood Event, Hydraulic Modelling Results

Cross Section ID	Cross Section Location	Existing Scenario				Proposed Scenario				Difference						
		Mean Maximum Water Elevation (mAHD)	Energy Grade	Peak Flow (m3/s)	Mean Maximum Velocity (m/s)	Mean Maximum Water Elevation (mAHD)	Energy Grade	Peak Flow (m3/s)	Mean Maximum Velocity (m/s)	Water Level (m)	Energy Grade	Energy Grade (%)	Flow (m3/s)	Flow (%)	Velocity (m/s)	Velocity (%)
CS01	275 m u/s Weir	5.19		845.3	1.96	5.15		845.3	1.99	-0.04			0.0	0.00	0.03	1.51
CS02	80 m u/s Weir	5.00	0.0010	844.8	2.70	4.93	0.0011	844.8	2.90	-0.07	0.0002	13.64	0.0	0.00	0.20	6.90
CS03	Charles St Weir	4.62	0.0048	844.6	3.64	4.59	0.0043	844.6	3.53	-0.03	-0.0005	-11.76	0.0	0.00	-0.11	-3.12
CS04	25 m d/s Weir	2.23	0.0956	844.7	4.98	2.34	0.0900	845.0	4.66	0.11	-0.0056	-6.22	0.3	0.04	-0.32	-6.87
CS05	85 m d/s Weir	2.55	0.0053	844.4	2.34	2.62	0.0047	844.4	2.30	0.07	-0.0007	-14.29	0.0	0.00	-0.04	-1.74
CS06	150 m d/s Weir	2.02	0.0082	844.3	4.12	2.03	0.0091	844.3	4.11	0.01	0.0009	10.17	0.0	0.00	-0.01	-0.24
CS07	300 m d/s Weir	1.91	0.0007	844.1	2.88	1.91	0.0008	844.1	2.97	0.00	0.0001	8.33	0.0	0.00	0.09	3.03
CS08	500 m d/s Weir	1.89	0.0001	843.9	1.67	1.89	0.0001	843.9	1.70	0.00	0.0000	0.00	-0.1	-0.01	0.03	1.76

Table 2: 5% AEP Flood Event, Hydraulic Modelling Results

Cross Section ID	Cross Section Location	Existing Scenario				Proposed Scenario				Difference						
		Mean Maximum Water Elevation (mAHD)	Energy Grade	Peak Flow (m3/s)	Mean Maximum Velocity (m/s)	Mean Maximum Water Elevation (mAHD)	Energy Grade	Peak Flow (m3/s)	Mean Maximum Velocity (m/s)	Water Level (m)	Energy Grade	Energy Grade (%)	Flow (m3/s)	Flow (%)	Velocity (m/s)	Velocity (%)
CS01	275 m u/s Weir	4.82		696.0	1.77	4.78		696.0	1.78	-0.04			0.0	0.00	0.01	0.56
CS02	80 m u/s Weir	4.63	0.0010	695.8	2.57	4.54	0.0012	695.8	2.70	-0.09	0.0003	20.83	0.0	0.00	0.13	4.81
CS03	Charles St Weir	4.26	0.0046	695.8	3.37	4.26	0.0035	695.7	3.33	0.00	-0.0011	-32.14	0.0	-0.01	-0.04	-1.20
CS04	25 m d/s Weir	1.85	0.0964	695.7	4.74	1.93	0.0932	696.0	4.48	0.08	-0.0032	-3.43	0.3	0.04	-0.26	-5.80
CS05	85 m d/s Weir	2.05	0.0033	695.7	2.24	2.10	0.0028	695.5	2.14	0.05	-0.0005	-17.65	-0.1	-0.02	-0.10	-4.67
CS06	150 m d/s Weir	1.70	0.0054	695.6	3.71	1.71	0.0060	695.7	3.70	0.01	0.0006	10.26	0.0	0.00	-0.01	-0.27
CS07	300 m d/s Weir	1.66	0.0003	695.6	2.87	1.66	0.0003	695.5	2.87	0.00	0.0001	20.00	-0.1	-0.01	0.00	0.00
CS08	500 m d/s Weir	1.63	0.0002	695.2	2.42	1.63	0.0002	695.1	2.42	0.00	0.0000	0.00	-0.1	-0.01	0.00	0.00

Table 3: 20% AEP Flood Event, Hydraulic Modelling Results

Cross Section ID	Cross Section Location	Existing Scenario				Proposed Scenario				Difference						
		Mean Maximum Water Elevation (mAHD)	Energy Grade	Peak Flow (m3/s)	Mean Maximum Velocity (m/s)	Mean Maximum Water Elevation (mAHD)	Energy Grade	Peak Flow (m3/s)	Mean Maximum Velocity (m/s)	Water Level (m)	Energy Grade	Energy Grade (%)	Flow (m3/s)	Flow (%)	Velocity (m/s)	Velocity (%)
CS01	275 m u/s Weir	4.55		600.3	1.72	4.50		600.3	1.73	-0.05			0.0	0.00	0.01	0.58
CS02	80 m u/s Weir	4.36	0.0010	599.9	2.45	4.27	0.0012	599.9	2.58	-0.09	0.0002	17.39	0.0	0.00	0.13	5.04
CS03	Charles St Weir	3.99	0.0046	599.8	3.05	4.00	0.0034	599.8	3.11	0.01	-0.0013	-37.04	0.0	0.00	0.06	1.93
CS04	25 m d/s Weir	1.69	0.0920	599.7	4.36	1.75	0.0900	599.7	4.15	0.06	-0.0020	-2.22	-0.1	-0.01	-0.21	-5.06
CS05	85 m d/s Weir	1.81	0.0020	599.7	2.09	1.85	0.0017	599.7	1.99	0.04	-0.0003	-20.00	0.0	0.00	-0.10	-5.03
CS06	150 m d/s Weir	1.55	0.0040	599.6	3.34	1.55	0.0046	599.6	3.33	0.00	0.0006	13.33	0.0	0.00	-0.01	-0.30
CS07	300 m d/s Weir	1.53	0.0001	599.6	2.61	1.54	0.0001	599.5	2.62	0.01	-0.0001	-100.00	0.0	0.00	0.01	0.38
CS08	500 m d/s Weir	1.51	0.0001	599.4	2.12	1.52	0.0001	599.4	2.12	0.01	0.0000	0.00	0.0	0.00	0.00	0.00

Table 4: PMF, Hydraulic Modelling Results

Cross Section ID	Cross Section Location	Existing Scenario				Proposed Scenario				Difference						
		Mean Maximum Water Elevation (mAHD)	Energy Grade	Peak Flow (m3/s)	Mean Maximum Velocity (m/s)	Mean Maximum Water Elevation (mAHD)	Energy Grade	Peak Flow (m3/s)	Mean Maximum Velocity (m/s)	Water Level (m)	Energy Grade	Energy Grade (%)	Flow (m3/s)	Flow (%)	Velocity (m/s)	Velocity (%)
CS01	275 m u/s Weir	8.60		2584.5	4.57	8.53		2850.6	4.51	-0.07			266.2	9.34	-0.06	-1.33
CS02	80 m u/s Weir	8.73	0.0007	2611.2	8.00	8.70	0.0009	2553.9	8.07	-0.03	0.0002	23.53	-57.3	-2.25	0.07	0.87
CS03	Charles St Weir	8.61	0.0015	2552.7	7.07	8.72	0.0003	2561.4	6.63	0.11	-0.0013	-500.00	8.7	0.34	-0.44	-6.64
CS04	25 m d/s Weir	8.20	0.0164	2539.5	6.32	8.28	0.0176	2596.8	6.51	0.08	0.0012	6.82	57.3	2.21	0.19	2.92
CS05	85 m d/s Weir	8.05	0.0025	2445.4	4.51	7.93	0.0058	2418.4	4.53	-0.12	0.0033	57.14	-27.0	-1.12	0.02	0.44
CS06	150 m d/s Weir	6.20	0.0285	2432.7	7.35	6.08	0.0285	2424.6	7.31	-0.12	0.0000	0.00	-8.1	-0.33	-0.04	-0.55
CS07	300 m d/s Weir	4.26	0.0129	2490.3	5.56	4.25	0.0122	2448.8	5.57	-0.01	-0.0007	-6.01	-41.6	-1.70	0.01	0.18
CS08	500 m d/s Weir	3.99	0.0014	2464.9	3.89	4.04	0.0011	2470.2	3.98	0.05	-0.0003	-28.57	5.3	0.22	0.09	2.26

Table 5: 1% AEP Flood Event - Sensitivity - Lower Parramatta River Catchment Flood 5% AEP, Hydraulic Modelling Results

Cross Section ID	Cross Section Location	Existing Scenario				Proposed Scenario				Difference						
		Mean Maximum Water Elevation (mAHD)	Energy Grade	Peak Flow (m3/s)	Mean Maximum Velocity (m/s)	Mean Maximum Water Elevation (mAHD)	Energy Grade	Peak Flow (m3/s)	Mean Maximum Velocity (m/s)	Water Level (m)	Energy Grade	Energy Grade (%)	Flow (m3/s)	Flow (%)	Velocity (m/s)	Velocity (%)
CS01	275 m u/s Weir	5.20		845.2	1.96	5.17		845.2	1.97	-0.03			0.0	0.00	0.01	0.51
CS02	80 m u/s Weir	5.02	0.0009	844.6	2.65	4.97	0.0010	844.6	2.80	-0.05	0.0001	10.00	-0.1	-0.01	0.15	5.36
CS03	Charles St Weir	4.82	0.0025	844.5	3.38	4.81	0.0020	844.4	3.43	-0.01	-0.0005	-25.00	-0.1	-0.01	0.05	1.46
CS04	25 m d/s Weir	4.62	0.0080	844.5	2.91	4.65	0.0064	844.2	2.90	0.03	-0.0016	-25.00	-0.3	-0.03	-0.01	-0.34
CS05	85 m d/s Weir	4.65	0.0005	844.7	2.35	4.69	0.0007	843.6	2.38	0.04	0.0002	25.00	-1.1	-0.13	0.03	1.26
CS06	150 m d/s Weir	4.34	0.0048	844.4	3.14	4.34	0.0054	844.4	3.16	0.00	0.0006	11.43	0.0	0.00	0.02	0.63
CS07	300 m d/s Weir	4.41	0.0005	845.8	1.58	4.41	0.0005	845.9	1.56	0.00	0.0000	0.00	0.1	0.01	-0.02	-1.28
CS08	500 m d/s Weir	4.39	0.0001	849.1	0.98	4.39	0.0001	848.9	0.98	0.00	0.0000	0.00	-0.2	-0.03	0.00	0.00

Table 6, 1% AEP Flood Event - Sensitivity - Lower Parramatta River Catchment Flood 1% AEP, Hydraulic Modelling Results

Cross Section ID	Cross Section Location	Existing Scenario				Proposed Scenario				Difference						
		Mean Maximum Water Elevation (mAHD)	Energy Grade	Max Flow (m3/s)	Mean Maximum Velocity (m/s)	Mean Maximum Water Elevation (mAHD)	Energy Grade	Max Flow (m3/s)	Mean Maximum Velocity (m/s)	Water Level (m)	Energy Grade	Energy Grade (%)	Flow (m3/s)	Flow (%)	Velocity (m/s)	Velocity (%)
CS01	275 m u/s Weir	5.36		844.5	1.93	5.35		845.0	1.94	-0.01			0.5	0.05	0.01	0.52
CS02	80 m u/s Weir	5.28	0.0004	851.1	2.55	5.27	0.0004	851.4	2.57	-0.01	0.0000	0.00	0.3	0.03	0.02	0.78
CS03	Charles St Weir	5.20	0.0010	845.7	3.12	5.21	0.0007	852.6	3.22	0.01	-0.0003	-33.33	6.8	0.80	0.10	3.11
CS04	25 m d/s Weir	5.14	0.0024	845.5	2.53	5.17	0.0016	850.3	2.66	0.03	-0.0008	-50.00	4.8	0.57	0.13	4.89
CS05	85 m d/s Weir	5.16	0.0003	855.1	1.75	5.20	0.0005	852.0	1.76	0.04	0.0002	33.33	-3.2	-0.37	0.01	0.57
CS06	150 m d/s Weir	4.98	0.0028	860.2	2.69	4.98	0.0034	861.8	2.72	0.00	0.0006	18.18	1.6	0.19	0.03	1.10
CS07	300 m d/s Weir	5.08	0.0007	873.7	1.41	5.07	0.0006	856.6	1.41	-0.01	-0.0001	-11.11	-17.1	-2.00	0.00	0.00
CS08	500 m d/s Weir	5.07	0.0000	865.9	1.22	5.07	0.0000	879.3	1.22	0.00	0.0000	0.00	13.3	1.52	0.00	0.00

Appendix 5 – Modelled Velocity and Tractive (Bed Shear) Stress v Stability Thresholds

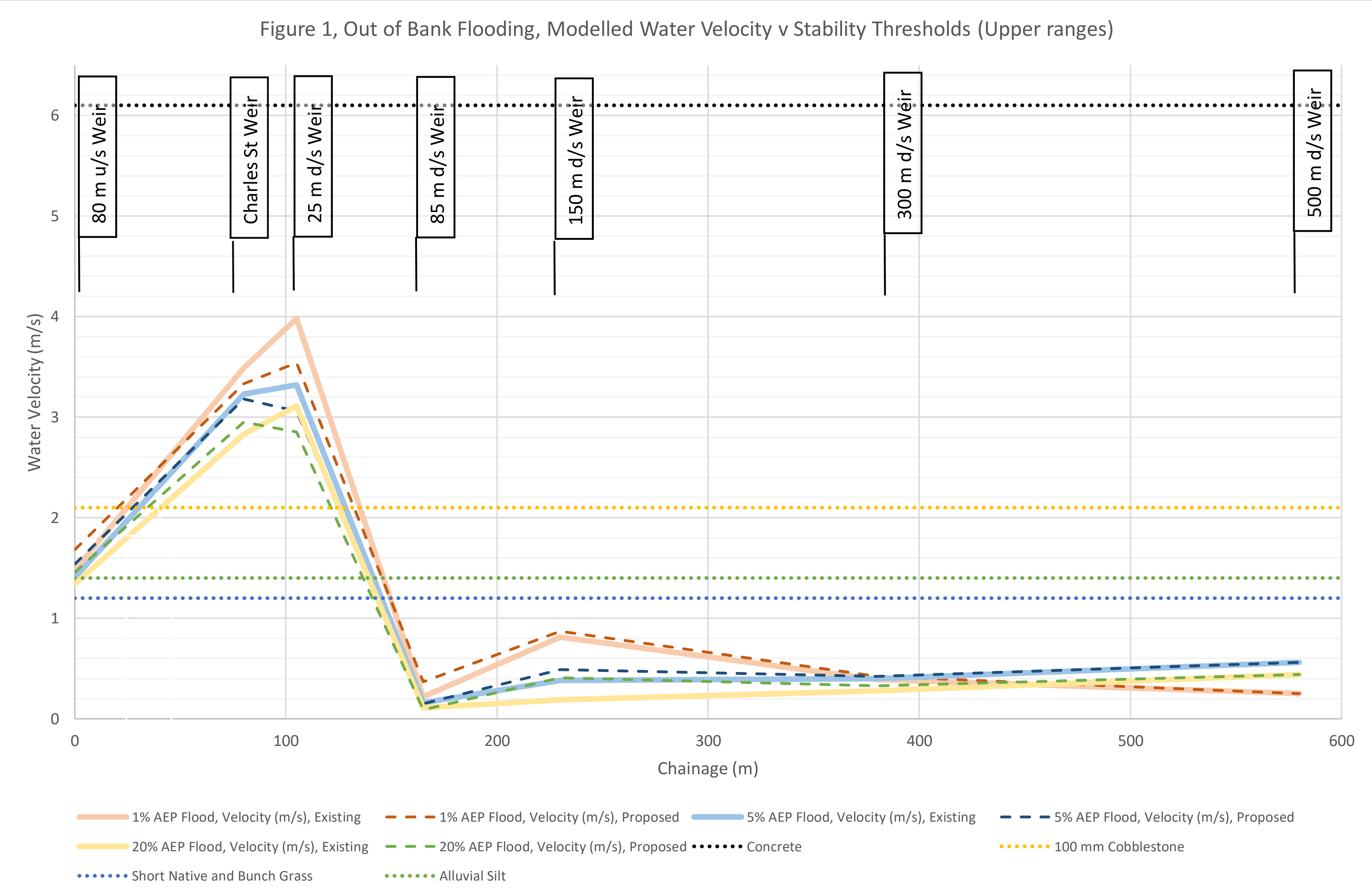


Figure 1, Out of Bank Flooding, Modelled Water Velocity v Stability Thresholds (Upper ranges)
80 m u/s Weir
Charles St Weir
25 m d/s Weir
85 m d/s Weir
150 m d/s Weir
300 m d/s Weir
500 m d/s Weir
Water Velocity (m/s)
0
1
2
3
4
5
6
Chainage (m)
0
100
200
300
400
500
600
1% AEP Flood, Velocity (m/s), Existing
1% AEP Flood, Velocity (m/s), Proposed
5% AEP Flood, Velocity (m/s), Existing
5% AEP Flood, Velocity (m/s), Proposed
20% AEP Flood, Velocity (m/s), Existing
20% AEP Flood, Velocity (m/s), Proposed
Concrete
100 mm Cobblestone
Short Native and Bunch Grass
Alluvial Silt

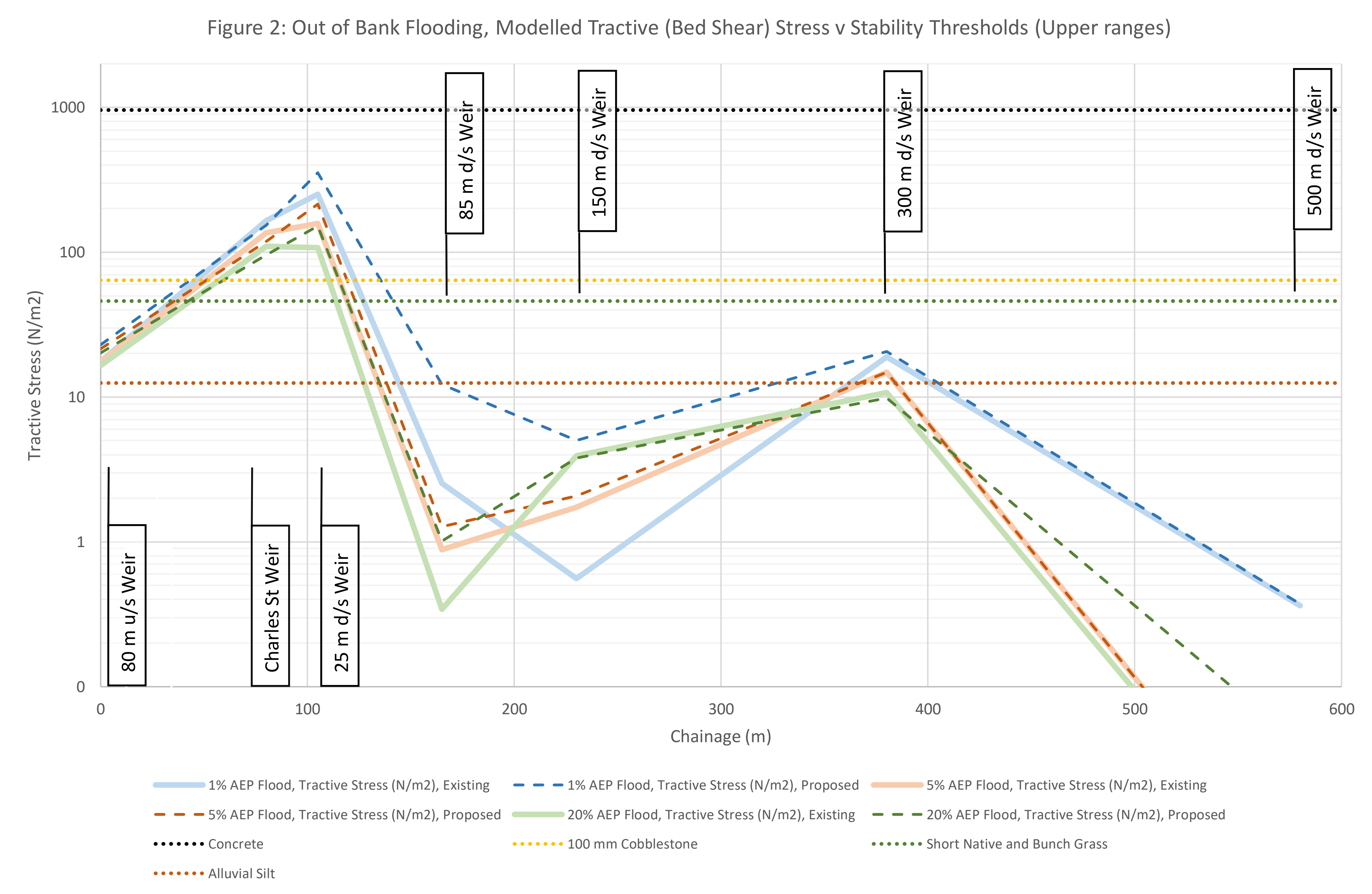


Figure 2: Out of Bank Flooding, Modelled Tractive (Bed Shear) Stress v Stability Thresholds (Upper ranges)
Tractive Stress (N/m2)
1000
100
10
1
0
0
100
200
300
400
500
600
Chainage (m)
85 m d/s Weir
150 m d/s Weir
300 m d/s Weir
500 m d/s Weir
80 m u/s Weir
Charles St Weir
25 m d/s Weir
1% AEP Flood, Tractive Stress (N/m2), Existing
1% AEP Flood, Tractive Stress (N/m2), Proposed
5% AEP Flood, Tractive Stress (N/m2), Existing
5% AEP Flood, Tractive Stress (N/m2), Proposed
20% AEP Flood, Tractive Stress (N/m2), Existing
20% AEP Flood, Tractive Stress (N/m2), Proposed
Concrete
100 mm Cobblestone
Short Native and Bunch Grass
Alluvial Silt