Redfern Place - Flood Assessment

Prepared for Hickory and Bridge Housing

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Project Number S23123
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Executive Summary

This report accompanies a detailed State Significant Development Application that seeks approval for a mixed-use development at 600-660 Elizabeth Street, Redfern (Redfern Place). The development proposes four buildings comprising community facilities, commercial/office, affordable/social/specialist disability housing apartments and new public links and landscaping.

The project site comprises Lot 1 in DP 1249145. It covers an area of approximately 10,850m^2. Part of the site currently accommodates the existing Police Citizens Youth Club (PCYC) (to be demolished and replaced). The remaining portion of the site is vacant with remnant vegetation.

The SSDA seeks approval for redevelopment of the site, including:

- Demolition of existing buildings.
- Tree removal.
- Bulk earthworks including excavation.
- Construction of a community facility building known as Building S1.
- Construction of two residential flat buildings (known as Buildings S2 and S3) up to 14 and 10 storeys respectively, for social and affordable housing.
- Construction of a five-storey mixed use building (known as Building S4) comprising commercial uses on the ground level and social and specialist disability housing above.
- Construction of one basement level below Buildings S2, S3 and part of S4 with vehicle access from Kettle Street.
- Site-wide landscaping and public domain works including north-south and east-west pedestrian through-site link.
- For a detailed project description refer to the Environmental Impact Statement prepared by Ethos Urban.

A flood assessment has been undertaken using the supplied flood model from City of Sydney to assess flood behaviour at the development and assess potential flood impact of the development on adjacent land, as well as changes to flood risk. The outcome of the assessment is to demonstrate the development is compliant with the conditions in the Planning Secretary's Environmental Assessment Requirements (SEARs), the City of Sydney Interim Floodplain Management Policy, the Sydney Local Environment Plan and the City of Sydney Development Control Plan. The flood assessment has been undertaken to include relevant provisions of the NSW Floodplain Development Manual. The SEARs have been addressed in the sections listed in Table 0-1.

Table 0-1: SEARs

Item	Requirement	Report Reference
15	Identify any flood risk on-site having regard to adopted flood studies, the potential effects of climate change, and any relevant provisions of the NSW Floodplain Development Manual	See Section 3.4, Section 4.2, Section 4.3, Section 4.4, Section 4.5, and Section 5.1
	Assess the impacts of the development, including any changes to flood risk on-site or off-site, and detail design solutions and operational procedures to mitigate flood risk where required	See Section 3.5, Section 5.4, Section 5.5, and Section 5.6.1.

1. Introduction

1.1 Purpose of Report

BG&E has been engaged by Hickory and Bridge Housing Ltd to prepare a flood assessment for the proposed mixed use state significant development at 600-660 Elizabeth Street Redfern NSW 2106, commonly referred to as Redfern Place. See the location of the site in Figure 1-1.

The aim of this report is to:

- Describe the updates made to the City of Sydney (CoS) flood model of the Alexandra Canal catchment.
- Understand existing flood risk to the site and identify additional flood risks to the future development
- Identify key development constraints regarding flooding
- Establish any flood mitigation measures required to minimise flood impacts to the development itself and the surrounding area
- Consider potential flood management and evacuation options for the site.

The assessment and report have been made in accordance with the SEARs relevant to the development, the CoS Interim Floodplain Management Policy which is applicable to all new developments within the CoS local government area and the Sydney Local Environment Plan (LEP).

1.2 Terminology

The frequency of a flood event is expressed in terms of its Annual Exceedance Probability (AEP); the probability of an event being equalled or exceeded within a year. Smaller magnitude events are described by Exceedances per Year (EY); the average number of times a year in which the event is likely to be equalled or exceeded. Previously flood probabilities have been described by the Average Recurrence Interval (ARI); that is the average time period between occurrences equalling or exceeding a given value. Some documents, such as Development Control Plans and Guidelines still refer to the ARI terminology.

For example, a 1% AEP event has a 1% chance (i.e. a 1 in 100 chance) of being equalled or exceeded in any one year and is equivalent to a 100-year Average Recurrence Interval (ARI) event. In the same way, a 5% AEP event is the equivalent of a 20-year ARI event.

1.3 Available Flood Data

1.3.1 Existing Flood Models

Redfern Place falls within the Alexandra Canal catchment as classified by CoS. A request for flood data was submitted to CoS on 2 November 2023 and a copy of the Alexandra Canal flood model and raw results from the "Alexandra Canal Catchment Flood Study Model Update – ARR2019 Hydrology" (WMAwater, September 2020) was provided on 27 November 2023. This study was commissioned by the CoS to update the model to reflect recent development and infrastructure renewal throughout the catchment while using current best practice design hydrology inputs (Australian Rainfall and Runoff 2019).

This study was adopted by CoS in September 2020 for flood planning purposes. Since this adoption CoS has updated the model to reflect 2023 conditions, this did not reflect a full Flood Study update but rather minor updates to the model. CoS provided a digital copy of the flood model and a full set of modelling results in geographic information system (GIS) format on the 27 November 2023. The Alexandra Canal catchment is in the south of the Sydney Central business district and drains to the Cooks River and ultimately Botany Bay. The catchment is 14 km^2 and the site is in the northern section of catchment which is the upper reaches as seen in Figure 1-1.

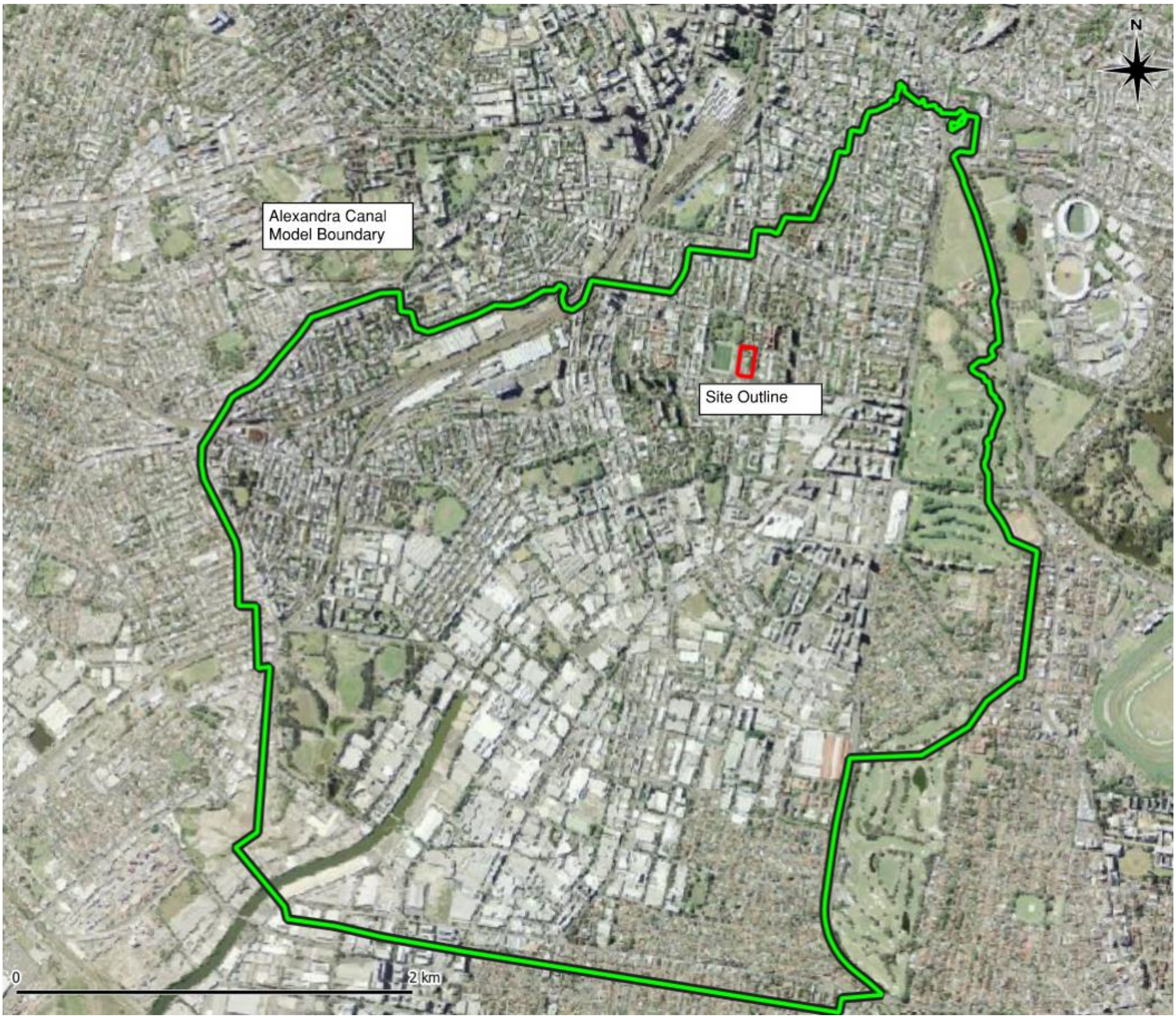


Figure 1-1: Redfern Place Location in CoS Model

1.4 Australian Rainfall and Runoff 2019

The Alexandra Canal Catchment Flood Study Model Update – ARR2019 Hydrology (WMAwater, September 2020) adopted by CoS was updated to Australian Rainfall and Runoff (ARR) 2019 utilising two separate models;

- DRAINS – a hydrologic model which can simulate a full storm hydrograph and develop hydrological inputs
- TUFLOW – a 1D/2D hydraulic modelling software for floodplain and urban drainage projects and is widely used across Australia and internationally.

While the results for each Annual Exceedance Event (AEP) was provided, the critical durations and temporal patterns were documented for each design storm event so the design storm could be simulated for any changes to the topography.

2. Site Summary

2.1 Existing Site Summary

At Redfern Place, currently the PCYC South Sydney is located in the southern portion of the lot with a basketball court on the eastern edge. The northern section of the lot is undeveloped grassland and trees. The site is surrounded by the local stormwater system with pipes on the western side of Elizabeth Street running south, pipes on the western side of Walker Street running south, pipes on the southern side of Kettle Street running east and pipes on the northern side of Phillip Street running east.

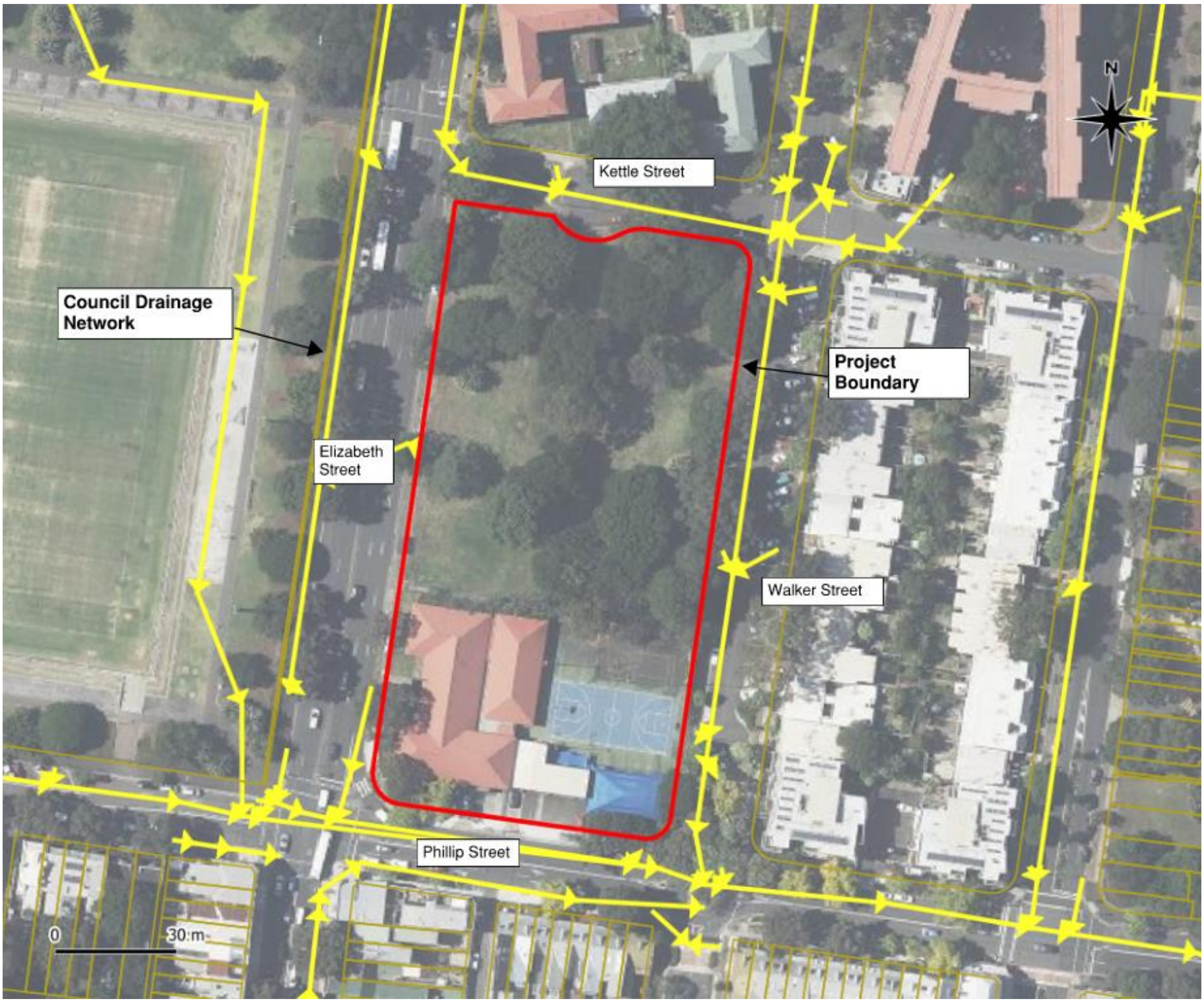


Figure 2-1: Existing Site Layout

2.2 Proposed Development

The project site comprises Lot 1 in DP 1249145. It has an area of approximately 10,850 m^2. Part of the site currently accommodates the existing Police Citizens Youth Club (PCYC) (to be demolished and replaced). The remaining portion of the site is vacant with remnant vegetation. The SSDA seeks approval for redevelopment of the site, including:

- Demolition of existing buildings.
- Tree removal.
- Bulk earthworks including excavation.
- Construction of a community facility building known as Building S1.
- Construction of two residential flat buildings (known as Buildings S2 and S3) up to 14 and 10 storeys respectively, for social and affordable housing.
- Construction of a five-storey mixed use building (known as Building S4) comprising commercial uses on the ground level and affordable housing above.
- Construction of one basement level below Buildings S2, S3 and part of S4 with vehicle access from Kettle Street.
- Site-wide landscaping and public domain works including north-south and east-west pedestrian through-site link.

Figure 2-2 shows the masterplan of the development. The architectural drawing of the masterplan can be seen attached in Appendix B.

Figure 2-2: Proposed Site Masterplan

3. Flood Modelling Methodology

3.1 Sources of Flooding

The major and only source of flooding for the site is overland flows from local catchments draining towards the Cooks River. Overland flows from the north of the site to the south along Walker and Elizabeth Street. Most of the catchment is fully developed and consists predominantly of medium to high density residential developments, commercial and industrial developments which contributes to the overland flows in area surrounding the site.

3.2 Flood Model Updates

The Alexandra Canal Catchment Flood Study Model Update – ARR2019 Hydrology (WMAwater, September 2020) was adopted by CoS for the purpose of flood planning and assessment. The Flood Study will have been through review process before adoption. Therefore use of CoS's model provides consistency between this assessment and CoS flood planning.

For the existing scenario a minor update was made to the model to better represent local ground conditions. Updates to the base model included the removal of a building footprint on Redfern Park that was no longer present in present conditions. Figure 3-1 shows the location the building footprint was removed. This was validated against recent aerial imagery and Google Street View.

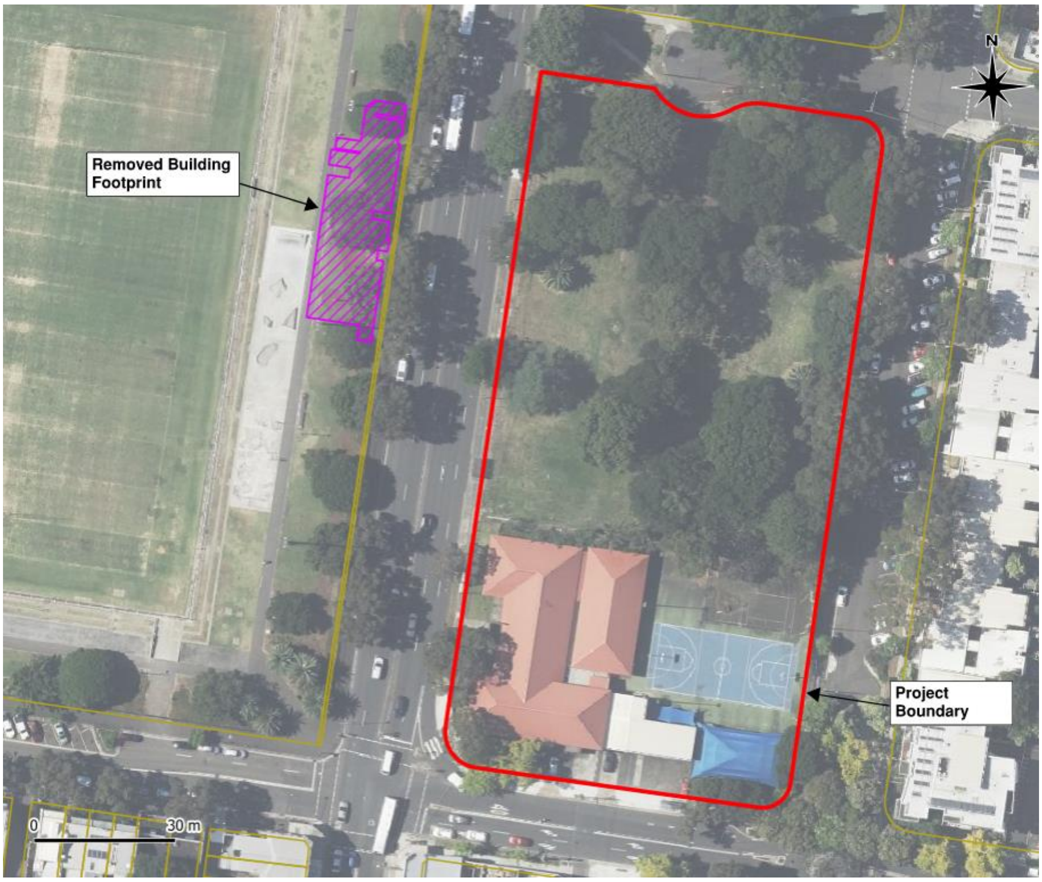


Figure 3-1: Removed Building Footprint

3.3 Flood Modelling Assumptions

In preparing this assessment the following assumptions were made:

- Flood modelling has been undertaken using Alexandra Canal Catchment Flood Study Model Update – ARR2019 Hydrology (WMAwater, September 2020). As this model is adopted by CoS for flood planning purposes, no changes have been made to the model parameters and assumptions, including blockage and catchment hydrology.
- Only the scenarios and critical storms listed in the memorandum included in the data handover of the Tuflow model have been run for the assessment. See Table 3-1 for the run simulations. The model was run for both the 'Current Day' and 'Ultimate Development' and the one resulting in the highest flood levels was adopted.

Table 3-1: Design Flood Simulations

Design Storm Event	Duration (minutes)	Temporal Pattern	Tailwater Condition	Blockage	Development Scenario
1% AEP	30	S05	1% AEP Tailwater	G020S050	CurDay And Rev Ultim
	60	S08	1% AEP Tailwater	G020S050	
PMF	90	n/a	1% AEP Tailwater	G020S050	

3.4 Methodology - Pre-Development Scenario

The results from the Alexandra Canal Catchment Flood Study Model Update – ARR2019 Hydrology (WMAwater, September 2020) was adopted including the alteration listed in Section 3.2 after rerunning the listed design flood simulations.

3.5 Methodology - Post-Development Scenario

The development was incorporated into the flood model by adjusting the DEM to incorporate the proposed finished floor levels (FFLs) of each building and the proposed landscaping levels. An outline of the finished floor levels can be seen in Figure 3-2. Refer to Appendix B for architectural plans with detailed FFLs of the proposed development and Appendix C for levels of the proposed landscaping.

Flood storage was applied in the development to replicate the loss of flood storage volume occurring from the development of the green space present in existing conditions. The flood storage was incorporated into the design to alleviate adverse impact on neighbouring properties and to lower the PMF level. The proposed design consists of one cavernous concrete flood storage structure located in the basement of the building under the southwest corner of the site. These storage areas of the basement would be sealed off from all other areas. The flood storage area would be connected the street stormwater network to ensure the area is kept dry until storm events, and flood louvres or vents are required along Elizabeth Street to convey surface runoff into the tank.

The ground level along the southern portion of Elizabeth Street against the site boundary where the flood storage is proposed is 30.45 m AHD. For the most efficient inflow into the storage tank the flood louvres or vents should be below 30.68 m AHD which is the ponded 1% AEP level at the corner of Phillip Street and Elizabeth Street. If it is not below this level a greater flow cross area connecting into the flood storage area may be required.

Flood storage was incorporated into the Tuflow model as shown in Figure 3-2. Flood storage is represented in the flood model by elevation vs. area tables which represent the capacity of the tanks. The size and inflow areas of the storage area is detailed in Table 3-2. An investigation to connect the proposed flood storage into the flood storage under Redfern Park was undertaken but could not be achieved due to limitations such as the cost of construction to join the storage areas under Elizabeth Street.

Table 3-2: Flood Storage Areas

Flood Storage	Total Available Storage Volume (m^3)	Base Level of Storage (m AHD)	Street Connection Level (m AHD)	Flow Area Connecting to Street
In the basement of the southwest corner of the site.	1600	29.35	30.45	0.90 m^2 from Elizabeth Street.

Figure 3-2: Plan Layout of Flood Storage and Finished Floor Levels

Refer to Appendix B and Appendix D for a more detailed markup of the proposed flood storage area.

4. Existing Flood Behaviour

The existing flood behaviour was assessed from City of Sydney's Alexandra Canal Catchment Flood Study Model Update – ARR2019 Hydrology (WMAwater, September 2020). CoS prepared the flood model under provisions to the Floodplain Development Manual (2005) (FDM). Including reference to flood planning levels, hydraulic and hazard categorisation, emergency response planning considered in the FDM.

4.1 Flood Behaviour

From the Alexandra Canal Catchment Flood Study Model Update – ARR2019 Hydrology (WMAwater, September 2020) the flood behaviour at the site was observed in the 1% AEP event and the Probable Maximum Flood (PMF). The south eastern corner of the site at Phillp Street and Walker Street intersection is a low point in the surrounding topography. This creates a ponding location near the site. As the site except for the PCYC is currently green space the site acts as additional an overland flow path and flood storage in flood events. Overland flows from the north to the south towards the low point at Phillp Street and Walker Street intersection. Flow breaks out of the gutters on the east side of Elizabeth Street and the west side of Walker Street to travel through the site. Mapping of the existing flood behaviour at the site can be seen in Appendix A and is discussed further below.

4.2 Flood Levels

Flood levels on Elizabeth and Walker Street are on grade until they reach the ponding point at the Phillp Street and Walker Street intersection. Kettle Street is primarily not flood affected apart from the intersections with Walker and Elizabeth Street. At Phillip Street it the overland flow grades from Elizabeth street to a low point near the intersection at Phillip and Walker Street. Here floodwaters pond reaching a consistent level of 30.67 mAHD along Phillip Street and parts of Walker Street. In the PMF this is seen to a greater extent with flood levels reaching 32.64 mAHD surrounding the whole building due to the ponding nature of floodwaters in this area. Figure 4-1 shows the flood levels for the PMF and 1% AEP and the flood depths for the 1% AEP. Flood mapping of the existing flood depths and levels can be seen in Appendix A Figure A1 and A4. Flood level contours cannot be seen in the PMF figure due to the constant water level surface.

Figure 4-1: Pre-development 1% AEP - Flood Depths and Levels

4.3 Flood Hazard

Flood hazard is defined by product of velocity and depth at a specific location. Thresholds have been set to act as indicators of flood hazard risks in a floodplain.

At Redfern Place in the 1% AEP event in Kettle Street and the northern sections of Walker Street and Elizabeth Street flood hazard is classified as H1 (generally safe for vehicles, people and buildings). Towards the south side of the site in Elizabeth Street and Walker Street the flood hazard transitions from H1 (generally safe for vehicles, people and buildings) to H2 (unsafe for small vehicles) and H3 (unsafe for vehicles children and the elderly). This is caused by increases in flood depths in these streets. Within the site itself there are flood hazard ratings up to H3 (unsafe for vehicles children and the elderly) due to ponding floodwaters. This can be seen in Figure 4-2.

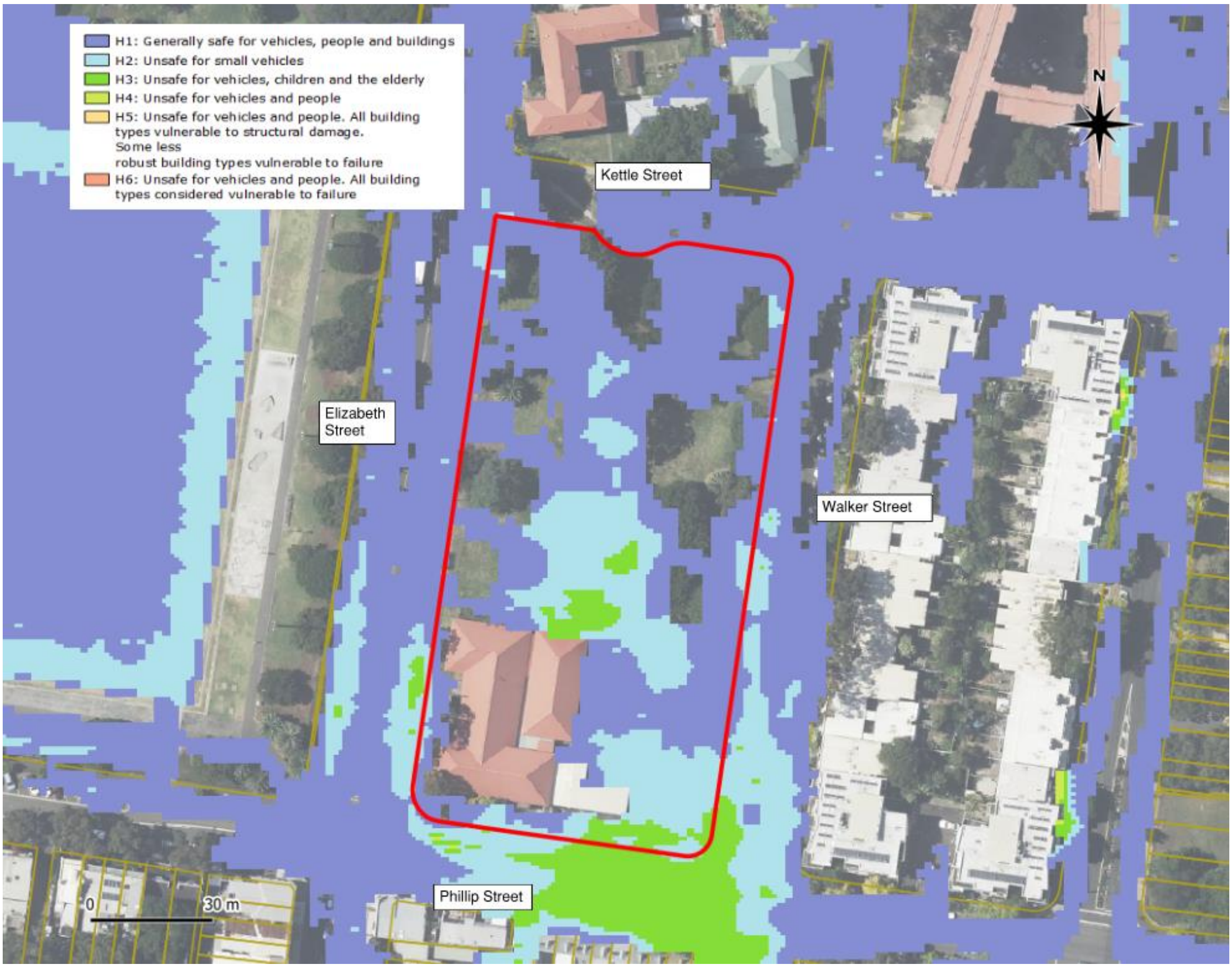


Figure 4-2: Pre-development 1% AEP Flood Hazard

In the PMF event flood hazard reaches H4 (unsafe for vehicles and people) and H5 (unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure). These flood hazard ratings in the PMF event is caused by the depths of flooding reaching up to 2.8 m at the corner of Phillip Street and Walker Street. Flood mapping of the existing flood hazard can be seen in Appendix A Figure A3 to A6.

4.4 Hydraulic Categories

The Alexandra Canal Catchment Flood Study Model Update – ARR2019 Hydrology (WMAwater, September 2020) uses the 2005 NSW Government's Floodplain Development Manual classification of hydraulic categories. There a three categories;

- Floodways – areas of the floodplain where a significant discharge of water occurs during flood events. If blocked these areas would have a significant effect on flood flows, velocities and/or depths.
- Flood Storage – areas of importance for the temporary storage of floodwaters and if filled would increase flood levels due to the loss of flood attenuation.
- Flood Fringe – all remaining areas of the floodplain are classified as flood fringe.

At Redfern Place in the 1% AEP event the flooding on the site is classified as flood storage. On Phillip Street there are areas of floodway and on Elizabeth Street and Walker Street the hydraulic categories fluctuate between flood storage and flood fringe.

4.5 Climate Change

4.5.1 Rainfall Sensitivity

Climate change was assessed within the Alexandra Canal Catchment Flood Study Model Update – ARR2019 Hydrology (WMAwater, September 2020). Sensitivity analysis was undertaken by comparing the 0.5% APE and 0.2% AEP events with the 1% AEP event. These events are commonly used to assess an increase in rainfall intensity. The change in peak flood level at the corner of Phillip Street and Walker Street was assessed to be 0.07 m in the 0.5% AEP event and 0.17 m in the 0.2% AEP event. These increases correspond to increase catchment flows derived from rainfall intensity increases.

4.5.2 Sea Level Rise

The impact of sea level rise was assessed in the Alexandra Canal Catchment Flood Study Model Update – ARR2019 Hydrology (WMAwater, September 2020) for the years 2050 and 2100 respectively. The flood levels at the corner of Phillip Street and Walker Street are not impacted by the increase in sea level or tailwater levels with no increase in flood levels due to the elevation of the area above sea level.

5. Post-Development Flood Risk Assessment

5.1 Proposed Development

The proposed development design was developed through an iterative process to minimise flood impacts and work with the various development constraints. The development proposal fills a portion of the site to level the site and raise it appropriate FFLs to comply with CoS flood planning levels (FPLs).

The proposed development levels and drainage modifications were incorporated into the flood model and run for the range of flood events to assess potential impacts to the existing flood behaviour. Changes to the model are outlined in Section 3.5, mapping of the post development flood behaviour is included in Appendix A and is discussed in the following sections. Since CoS's flood model was prepared under the NSW Floodplain Development Manual (2005) the following sections are considered in reference to the Floodplain Development Manual.

5.2 Flood Storage

As the development is filling an area of land that is classified as 'Flood Storage' according to the NSW Floodplain Development Manual (2005). To manage the loss of flood storage from the development of Redfern Place flood storage has been implemented at the development to prevent adverse impacts on neighbouring properties in events up to and including the 1% AEP. The flood storage is proposed at the southwest corner of the site. Flood storage area is proposed as cavernous areas within the basement of the building that has inflows from the street. The storage system will be kept permanently dry with a connection to the stormwater system within the flood storage structure. More detail on the flood storage system is outlined in Section 3.5.

5.3 Flood Impact Assessment

As part of the CoS Interim Floodplain Management Policy (CoS, 2014) in the Development Provisions Performance Criteria the development must "not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties". Due to the development displacing the existing flow path travelling north to south through the site there are increases in the 1% AEP water levels on the northern section of the site and with the implementation of the flood storage there are decreases or no changes in the southern section. The increases in each area are listed below.

- Elizabeth Street
  - In the road corridor along the northern portion of the development there are increases of up to 30 mm on the road corridor in the 1% AEP event.
  - Along the southern portion of the development along Elizabeth Street there are decreases of up to 60 mm in the 1% AEP event on the road corridor.
- Kettle Street
  - Against the walls of the development there is increases of up to 370 mm in the 1% AEP event, these are within the project boundary.
  - There are increases of up to 250 mm within the road corridor in the 1% AEP event.
- Walker Street
  - On the road corridor at the northern section of the development there are increases in water levels of up to 75 mm in the 1% AEP event.
  - At the southern of the development on Walker Street there are no water level increases in the 1% AEP event
- Phillip Street
  - There is no significant change in flood levels (+/- 10 mm) on Phillip Street with the development in the 1% AEP event.

The increases that are present only occur in the road corridor and do not impact any neighbouring properties. Flood impacts for the 1% AEP are presented in the Figure A13 of Appendix A.

5.4 Change in Hazard

With the changes to the building footprint from the development there are minor changes to the hazard surrounding the site. The change in hazard surrounding the site is listed below.

- Kettle Street
  - There is increases form H1 to (Generally safe for vehicles, people and buildings) H2 (unsafe for small vehicles) and H3 (unsafe for vehicles children and the elderly) hazard however this is within the building footprint outside the lobby entrance to the building.
- Elizabeth Street
  - There is a increase from H1 (Generally safe for vehicles, people and buildings) to H2 (unsafe for small vehicles) on the northern corner of the site.
  - There is a decreases in both H1 (Generally safe for vehicles, people and buildings) to H2 (unsafe for small vehicles) and H2 (unsafe for small vehicles) to H3 (unsafe for vehicles children and the elderly) near the southern area of the site, near the entrance to the flood storage.
- Phillip Street
  - There minor decreases present on Phillip Street reducing the hazard to from H3 (unsafe for vehicles children and the elderly) to H2 (unsafe for small vehicles), and H4 (unsafe for vehicles and people) to H2 (unsafe for small vehicles).
- Walker Street
  - There are minor increases from H1 (Generally safe for vehicles, people and buildings) to H2 (unsafe for small vehicles).

Figure 5-1 and Figure 5-2 shows the pre and post development flood hazard in the 1% AEP event, and Table 5-1 outlines the extent these changes occur.

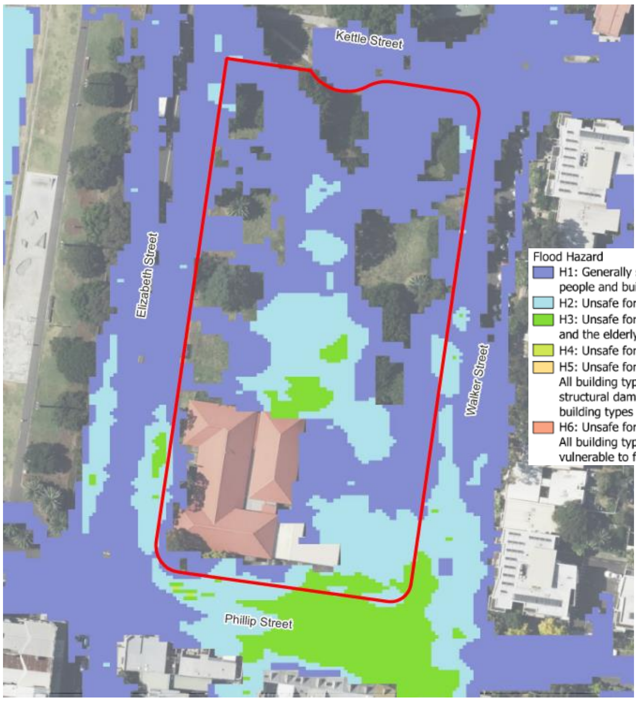


Figure 5-1: Pre Development Flood Hazard - 1% AEP Event

Figure 5-2: Post Development Flood Hazard - 1% AEP Event

Table 5-1: Change in Hazard Extent

Change in Hazard Outside Site Extent (from Pre to Post Development)	Area (m^2)
Decrease by 2 Categories	4
Decrease by 1 Category	282
Increase by 1 Category	92

Note all other model extent did not record a change in hazard.

These increases and decreases to the flood hazard do not make a significant difference to the flood behaviour Elizabeth Street is a dual carriageway with 3 lanes in each direction. In the development scenario both carriageways have areas of H1 (Generally safe for vehicles, people and buildings) and would be trafficable in a 1% AEP event. The extent of non-trafficable section has been reduced in the post development scenario. Walker Street is a one-way street with no access to Phillip Street for cars. In the post development scenario, the road is still trafficable with areas of H1 (Generally safe for vehicles, people and buildings) and not flood affected in a 1% AEP event.

Flood hazard for the proposed development are presented in Figure A9 and A12 of Appendix A. A change in flood hazard map for the 1% AEP event is seen in Figure A15 of Appendix A. There are no changes in flood hazard impacting surrounding residencies.

5.5 Flood Levels and Pad Levels

With the increased footprint from the development there is increases in the PMF level surrounding the site to 32.69 mAHD. The 1% AEP event flood levels remain consistent with the existing conditions with some areas of localised increases as mentioned in Section 5.3.

The proposed development pad levels have been set from the flood levels derived in the post-development modelling and the Cos Interim Floodplain Management Policy this is discussed further in Section 6. Figure 5-3 illustrates the FFLs and flood levels from the post-development modelling. Flood mapping of the post-development flood depths and levels can be seen in Figure A7 and A10 in Appendix A. Flood level contours cannot be seen in the PMF figure due to the flat-water level surface having no level change spatially at the site.

Figure 5-3: FFLs and Post Development Flood Levels (1% AEP Flood Depths)

5.6 Evacuation Planning / Flood Emergency Management

5.6.1 Shelter in Place

5.6.1.1 <u>Catchment Behaviour and Timing</u>

A shelter-in-place evacuation is suitable for the site as it has small critical durations for flooding. Critical durations for flooding in the area range between 30 to 60 minutes in the 1% AEP event and 90 minutes in the PMF. As the catchment draining to the site is relatively small and within an urban environment there is very little warning time to evacuate persons on site before road corridors become subject to high flood hazard.

In the PMF event on the northern side of Phillip Street at the southeast corner of the site the flood depths reach 1.0 m within 15 minutes of water being present in the street and reaches the peak depth of 2.68 m in 1.5 hours (level of 32.7 m AHD). In the 1% AEP event the rate of rise is not as severe taking approximately 40 mins from water being present in the street to reach the peak depth of 0.65 metres. In the 1% AEP event the total time for the storm event to occur and floodwaters to recede is 1 hour and 40 minutes, in the PMF this is 8.5 hours. This has been taken from the ponding location at the corner of the site on Phillip Street. At the north end of the site on Kettle Street the time is approximately 7 hours for the floodwaters to recede in the PMF. The timeseries of the floodwater depths at the southeast corner of the site in Phillip Street can be seen in Figure 5-4.

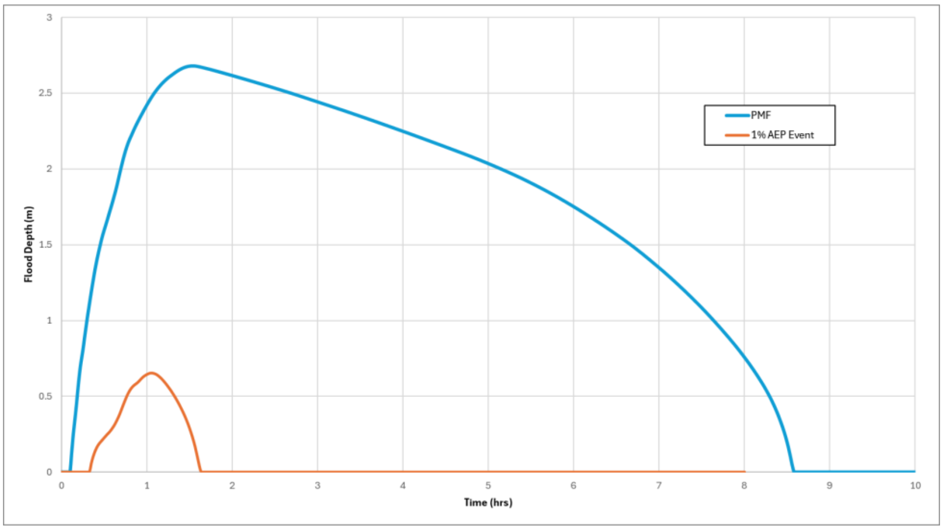


Figure 5-4: Timeseries of Flood Depths at Southeast Corner of Site in Phillip Street

Although the duration of inundation is greater than 6 hours in the PMF event, due to the fast rate of rise where floodwaters can go from 0 to 1 metre depths in 20 minutes it is safer for occupants to remain on flood free areas of the site than to leave the site and cross hazardous flood waters. In doing so this minimises pressure on emergency response services.

5.6.1.2 Access to Areas Above the PMF Level

All areas of the development have internal access to levels above the PMF level aside from two sections. The commercial area on the ground floor of the southwest building may not be able to access the residential levels above it. Should it not be able to, persons can evacuate and shelter in place in the PCYC structure which is directly to the north. One of the residential apartments on Walker Street does not have internal access to levels above the PMF. It will have to evacuate along Walker Street to the Kettle Street lobby entrance and shelter in place at the northeast building. A flood sensor may be required on Walker Street to trigger an alarm for this apartment to evacuate. This should be investigated as part of a flood emergency response plan, all the apartments will be managed by Bridge Housing with on site management provided. Outline of the buildings access to areas above the PMF level are shown in Figure 5-5.

Figure 5-5: Building Access to Areas Above the PMF Level

In the 1% AEP the flood hazard is up to H4 (unsafe for vehicles and people) outside the site, in the PMF outside the site the flood hazard reaches up to H5 (unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure). The building is recommended to be constructed with flood compatible materials to prevent damage from a flood event, CoS list flood compatible materials for each building component. This is recommended to be investigated in the flood emergency response plan and further stages of the design.

Most buildings within the development are residential apartments, for a shelter in place strategy these residents will be able to shelter within their own apartments with access to their own amenities, supplies and space for the shelter in place time required. The PCYC is recommended to have supplies for a shelter in place event stored on Level 1 and Level 2. As the PCYC is a community centre with a gymnasium and multipurpose rooms. It is expected to be able to provide enough space for patrons of the PCYC and the commercial level from the southwest building if required this should be investigated and documented in a flood emergency response plan.

6. Planning Considerations

This report has been prepared to consider the NSW Government's Floodplain Development Manual, City of Sydney's Interim Floodplain Management Policy (2014), the Sydney Local Environment Plan (LEP) (2012), CoS Development Control Plan (DCP) as well as the requirements of the SEARs.

6.1 SEARs

Compliance with the SEARs regarding flooding is summarised in Table 6-1.

Table 6-1: SEARs

Item	Requirement	Report Reference
15	Identify any flood risk on-site having regard to adopted flood studies, the potential effects of climate change, and any relevant provisions of the NSW Floodplain Development Manual	See Section 3.4, Section 4.2, Section 4.3, Section 4.4, Section 4.5, and Section 5.1
	Assess the impacts of the development, including any changes to flood risk on-site or off-site, and detail design solutions and operational procedures to mitigate flood risk where required	See Section 3.5, Section 5.4, Section 5.5, and Section 5.6.1.

6.2 City of Sydney Interim Floodplain Management Policy

The City of Sydney Interim Floodplain Management Policy provides direction with respect to how floodplains are managed within the Local Government Area (LGA) of the City of Sydney Council. The CoS uses this document to manage floodplains to ensure that new development will not experience undue flood risk; and existing development will not be adversely flood affected through increased damage or hazard as a result of any new development. This Policy applies to all new developments within the CoS.

Flood planning levels (FPLs) have been set following the CoS Interim Floodplain Management Policy. The applicable FPLs for the development are shown in Figure 6-1. As there are varying uses across the development the FPL differs for each building. Compliance with the development controls is specified in Table 6-2.

Table 6-2: Compliance with Flood Controls of Cos Interim Floodplain Management Policy

Building Zone	Building Use	Flood Levels (m AHD)	Flood Planning Level (m AHD)	FFL (m AHD)	Compliant
Residential Apartments without Basement Access	Residential – Habitable Rooms *1% AEP flood level + 0.5 m*	1% AEP: 31.03 PMF: 32.70	31.53	31.53	Yes
PCYC without Basement Access	Industrial or Commercial (Business, Retail) *Merits approach presented by the applicant with a minimum of the 1% AEP flood level*	1% AEP: 31.24 PMF: 32.70	31.24	31.5	Yes
Residential Apartments 1 with Basement Access	Residential with Access to Below Ground Garage / Car Park *1% AEP flood level + 0.5m or the PMF (whichever is higher).*	1% AEP: 30.67 PMF: 32.70	32.70	32.70	Yes
Residential Apartments 2 with	Residential with Access to Below Ground Garage / Car Park	1% AEP: 31.20 PMF: 32.70	32.70	32.70	Yes

Building Zone	Building Use	Flood Levels (m AHD)	Flood Planning Level (m AHD)	FFL (m AHD)	Compliant
Basement Access	*1% AEP flood level + 0.5m or the PMF (whichever is higher).*				
Commercial Building without Basement Access	Industrial or Commercial (Business) *Merits approach presented by the applicant with a minimum of the 1% AEP flood level*	1% AEP: 30.87 PMF: 32.70	30.87	32.10	Yes
Internal Lobby Entrance to Basement	Residential with Access to Below Ground Garage / Car Park *1% AEP flood level + 0.5m or the PMF (whichever is higher).*	1% AEP: n/a PMF: 32.7	32.70	32.70	Yes

Note 1: All lobby entrances that do not have basement access are used as transition zones and have no applicable FPL as they are being used to access areas of the building at the relevant FPL.
Note 2: Flood levels have been rounded up to the nearest 0.01 m

CoS Interim Floodplain Management Policy performance criteria also states a development must *"not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties".* As discussed in Sections 5.3 and 5.4 there is no significant change in flood behaviour that causes increases to flood affection of other development or properties.

Figure 6-1: Development FFLs

6.3 Sydney Local Environment Plan

Clause 5.21 of the Sydney LEP applies to the development

Clause	Comment	Report Reference
5.21 Flood Planning		
(1) (a) Minimise the flood risk to life and property associated with the use of land	The development has been designed to be compliant with the flood planning levels set out by CoS for the land use to minimise risk to property and life.	Section 6.2
(1) (b) to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change,	The development avoids area of high hazard flows and floodway. The increase in flood level results from climate change is negated by the most affected area of the development being designed to the PMF level.	Section 4.3, Section 4.4, Section 4.5
(1) (c) to avoid adverse or cumulative impacts on flood behaviour and the environment,	There are minimal changes to flood levels or hazard outside the development boundary. Where these do occur is in the road corridor directly outside the development not posing risks to neighbouring properties.	Section 5.3, Section 5.4

Clause	Comment	Report Reference
(1) (d) to enable the safe occupation and efficient evacuation of people in the event of a flood.	All of the buildings on the development have access to areas above the PMF. Either being the ground or 1st flood of the building.	Section 5.6.1
(2) (a) is compatible with the flood function and behaviour on the land, and	The development avoids area classed as floodway	Section 4.4
(2) (b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and	Flood storage within the development has been implemented to account for the loss of natural storage. This results in no impacts on neighbouring properties.	Section 3.5, Section 5.2, Section 5.3
(2) (c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and	There are no flood impacts to adversely affect safe occupation on neighbouring properties. Changes in flood hazard are minimal and only affect localised pockets surrounding the site. These small areas of increase will not adversely affect evacuation routes	Section 5.3, Section 5.4
(2) (d) incorporates appropriate measures to manage risk to life in the event of a flood, and	The development has been designed to be compliant with the flood planning levels set out by CoS for the land use to minimise risk to property and life. Flood storage within the development has been implemented to account for the loss of natural storage.	Section 6.2, Section 3.5, Section 5.2,
(2) (e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.	Flood mapping shows negligible change in flood velocities.	Velocity Mapping in Appendix A
(3) (a) the impact of the development on projected changes to flood behaviour as a result of climate change,	The maximum modelled increase in flood levels from the 1% AEP due to climate change is 0.17 m at the corner of Phillip and Walker Street. The building at this location has FFLs set to the PMF level (2.03 m above the 1% AEP level) to comply with the CoS Interim Floodplain Management Policy.	Section 4.5, Section 6.2
(3) (b) the intended design and scale of buildings resulting from the development,	The development has been designed to be compliant with the flood planning levels set out by CoS for the land use to minimise risk to property and life.	Section 6.2
(3) (c) whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood	All of the buildings on the development have access to areas above the PMF. Either being the ground or 1st flood of the building.	Section 5.6.1
(3) (d) the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion.	Climate change effects from Sea Level Rise were assessed and showed no increase on flood levels at the site due its location being high in the catchment. Coastal Erosion is not considered a risk due to the location of the development.	Section 4.5.2

6.4 City of Sydney Development Control Plan

Compliance with the development controls specifically related to flood planning are summarised in Table 6-3

Table 6-3: City of Sydney Development Control Plan

Control	Comment	Report Reference
3.7.1 Site Specific Flood Study		
When required by Clause 7.15 of Sydney LEP 2012, a site-specific flood study is to be prepared by a suitably qualified and experienced hydrologist in accordance with the NSW Floodplain Development Manual 2005, the NSW Coastal Planning Guideline: Adapting to Sea Level Rise, NSW Coastal Risk Management Guide: Incorporating Sea Level Rise Benchmarks In Coastal Risk Assessments and the NSW Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks In Flood Risk Assessments.	In the current version of the Sydney LEP Clause 7.15 has been repealed. Making this control not applicable.	n/a

7. Conclusions and Recommendations

7.1 Conclusions

- Flood modelling has been undertaken using the Alexandra Canal Catchment Flood Study Model Update – ARR2019 Hydrology" (WMAwater, September 2020). As this model is adopted by CoS for planning purposes no major changes have been made to the model parameters and assumptions
- Due to the proposed development increasing the building footprint and losing flood storage areas for the surrounding properties, on the site flood storage has been implemented to prevent adverse impacts on neighbouring properties. This has been designed with an outflow to the street stormwater infrastructure so the flood storage area is permanently dry so it is available to be used in a storm event.
- There is a possible increase in flood levels of 0.17 m in the 1% AEP event at the corner of Phillip Street and Walker Street due to climate change and increased rainfall intensity. As the southwest building is built to the PMF level to comply with CoS's Interim Floodplain Management Policy the risk from the increase in levels from climate change is minimised.
- The proposed development does not expose any resident to additional levels of risk or damage and does not increase flood hazard or levels on neighbouring properties.
- The finished floor levels for each building within the development have been set to comply with the CoS Interim Floodplain Management Policy.
- A shelter in place strategy is recommended during a PMF storm event and will mitigate risk to occupants of the site as all buildings have internal access to areas above the PMF level. Removing the risk of leaving the building and entering a flood event.
- The Redfern Place development complies with the CoS Interim Floodplain Management Policy and the Sydney LEP (2012) criteria.

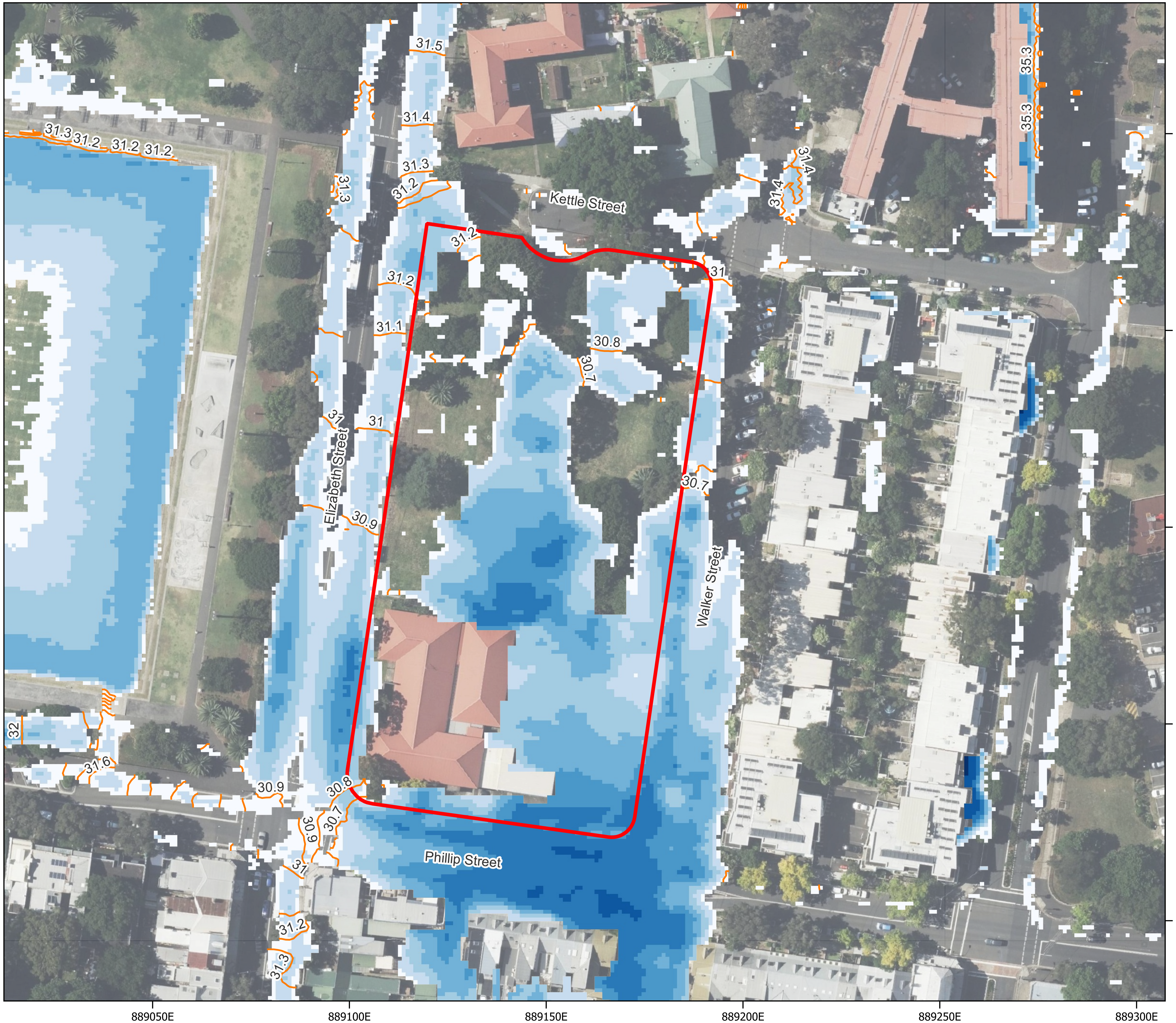
7.2 Recommendations

- It is recommended that a formal flood emergency response plan be undertaken for the development to document and include all measures required to be implemented to ensure the ongoing management of flooding risk in relation to the building.

This flood assessment has shown that there are no adverse increase in flood levels causing risk to neighbouring properties, and does not place residents of the development to unacceptable levels of risk. This assessment was undertaken using CoS adopted flood model for the Alexandra Canal catchment which was developed in accordance with the Floodplain Development Manual.

Appendices

Appendix A - Flood Mapping



Legend

- Site Boundary
- Proposed Development Footprint

Flood Depths

- <= 0.05 (not shown)
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 0.75
- 0.75 - 1.50
- \> 1.50
- Water Level Contours 0.1 Intervals (m AHD)

0 20 40 60 m

N

DRAWN: SM
REVIEWED: IV
APPROVED: IV

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

BG&E

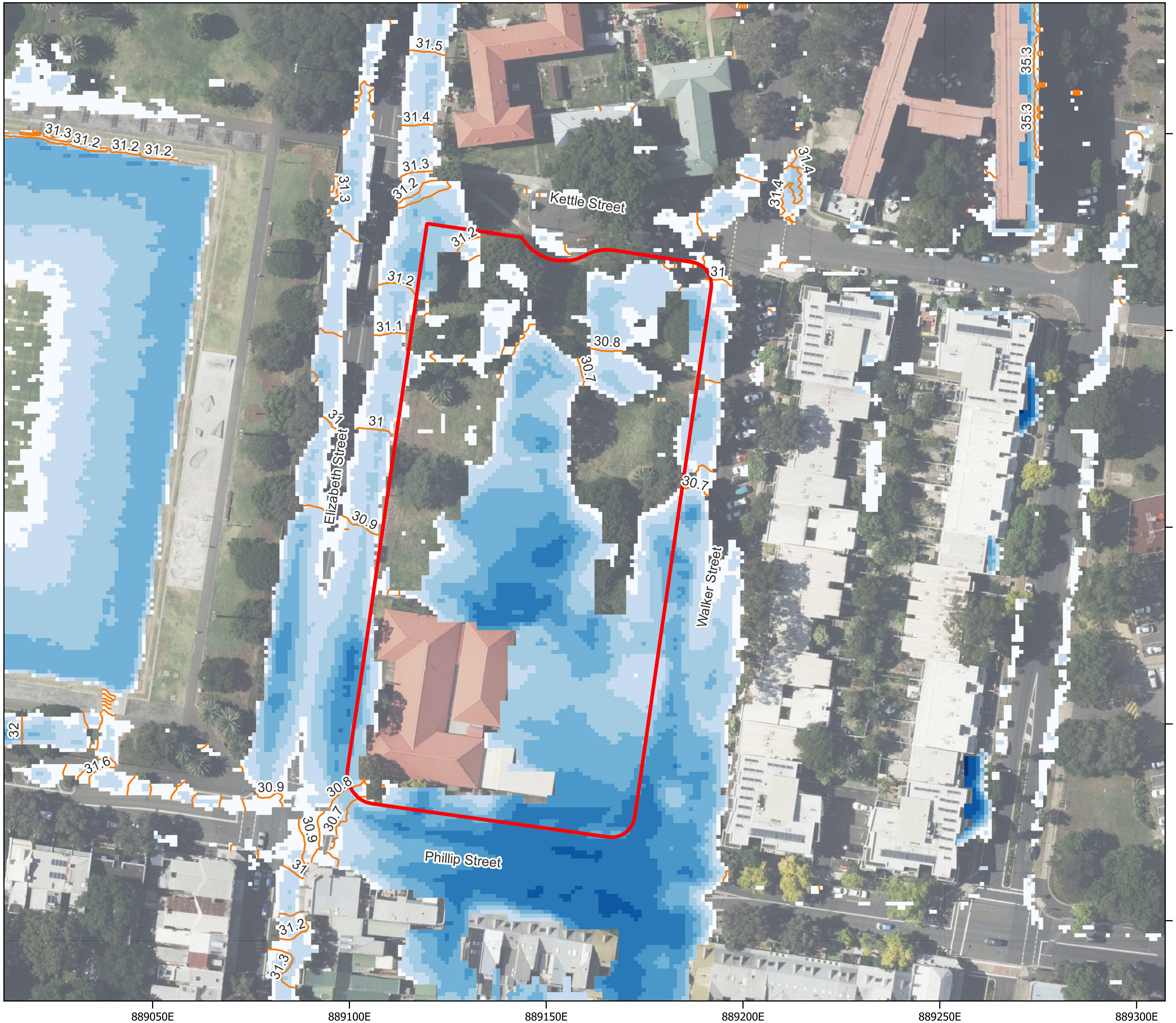
Redfern Place, 600-660 Elizabeth Street

Figure A1
Pre-Development Scenario
1% AEP Event
Peak Flood Depths with Water Level Contours

DATUM GDA 1994 MGA Zone 56

P:\BGE\SYD\S23123 REDFERN PLACE PROJECT, 600-660 ELIZABETH ST REDFERN\100 DRAW\100.9 Water\GIS\Wor\Alexandria Canal FS Results.qgz | Atlas

Aerial Imagery Source: NSW Sixmaps



Legend

- Site Boundary
- Proposed Development Footprint

Flood Depths

- <= 0.05 (not shown)
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 0.75
- 0.75 - 1.50
- > 1.50
- Water Level Contours 0.1 Intervals (m AHD)

0 20 40 60 m

N

DRAWN: SM
REVIEWED: IV
APPROVED: IV

BG&E

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

Redfern Place, 600-660 Elizabeth Street

Figure A1
Pre-Development Scenario
1% AEP Event
Peak Flood Depths with Water Level Contours

DATUM GDA 1994 MGA Zone 56

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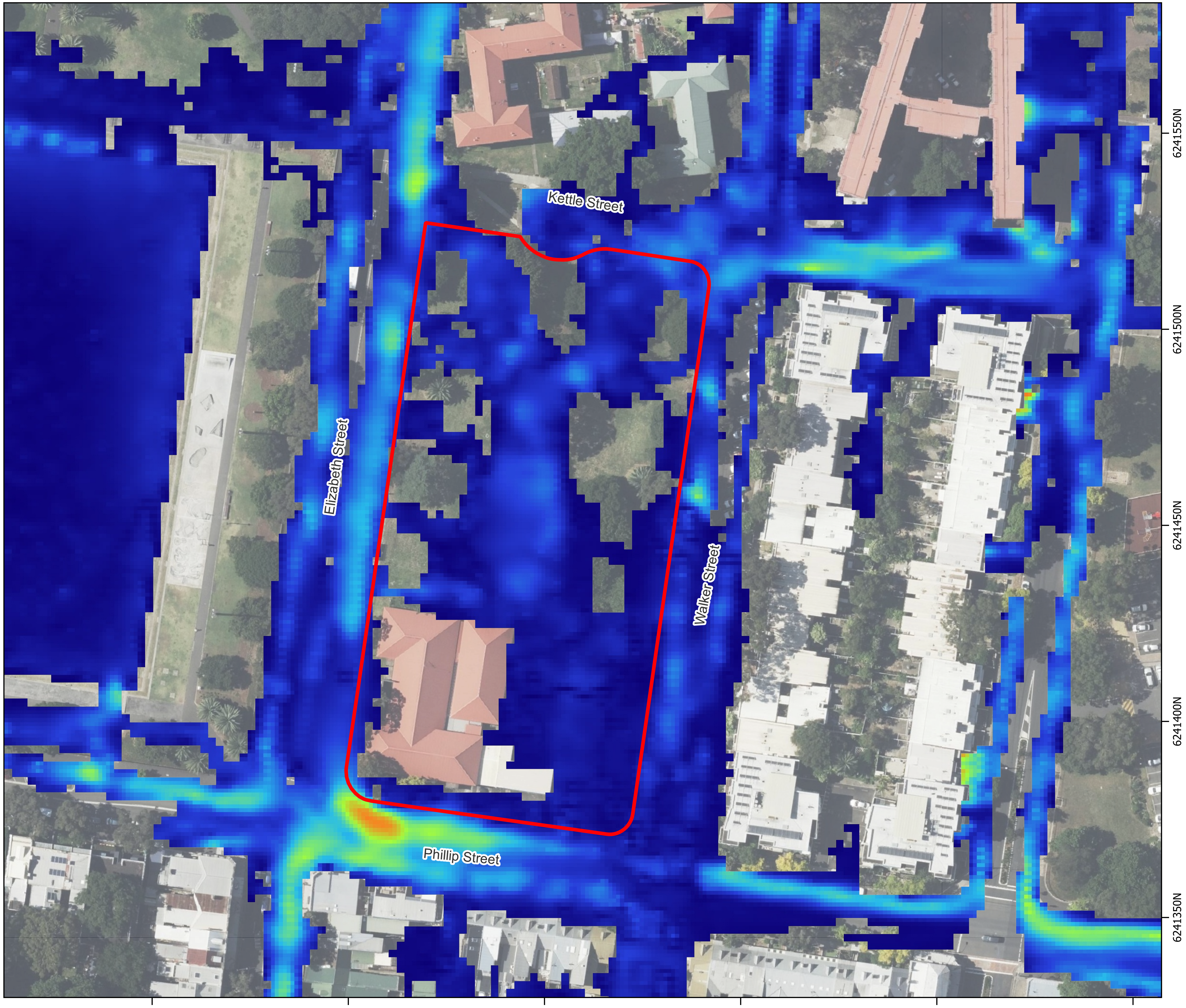
Aerial Imagery Source: NSW Sixmaps



Legend

- Site Boundary
- Proposed Development Footprint

Flood Velocities (m/s)

- 0.0
- 0.5
- 1.0
- 1.5
- 2.0
- 10.0

0 20 40 60 m

N

DRAWN: SM
REVIEWED: IV
APPROVED: IV

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

Redfern Place, 600-660 Elizabeth Street

Figure A2
Pre-Development Scenario
1% AEP Event
Peak Flood Velocity

DATUM GDA 1994 MGA Zone 56

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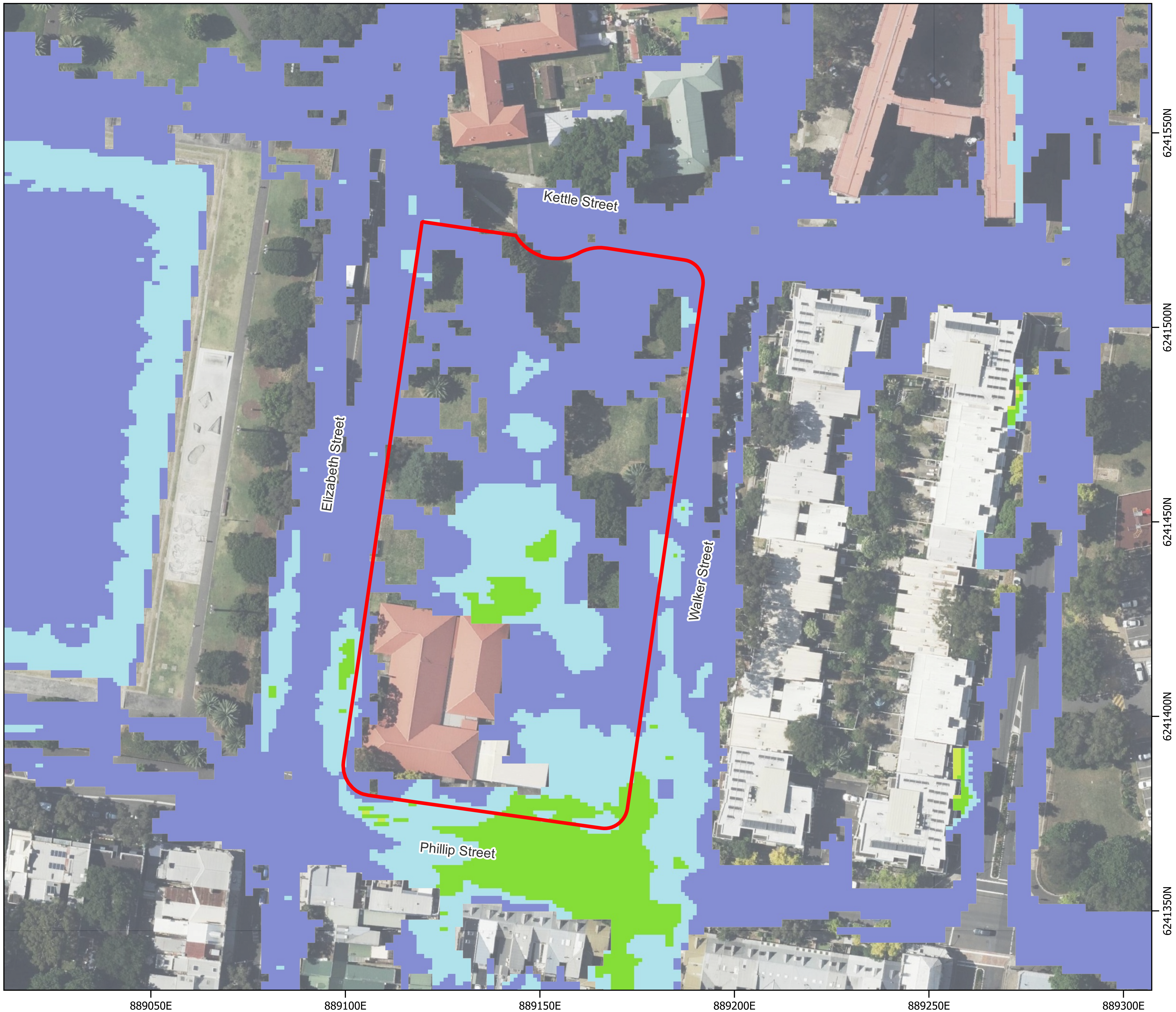
Aerial Imagery Source: NSW Sixmaps



Legend

- Site Boundary
- Proposed Development Footprint

Flood Hazard

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

0 20 40 60 m

N

BG&E

DRAWN: SM
REVIEWED: IV
APPROVED: IV

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

Redfern Place, 600-660 Elizabeth Street

Figure A3
Pre-Development Scenario
1% AEP Event
Peak Flood Hazard

DATUM GDA 1994 MGA Zone 56

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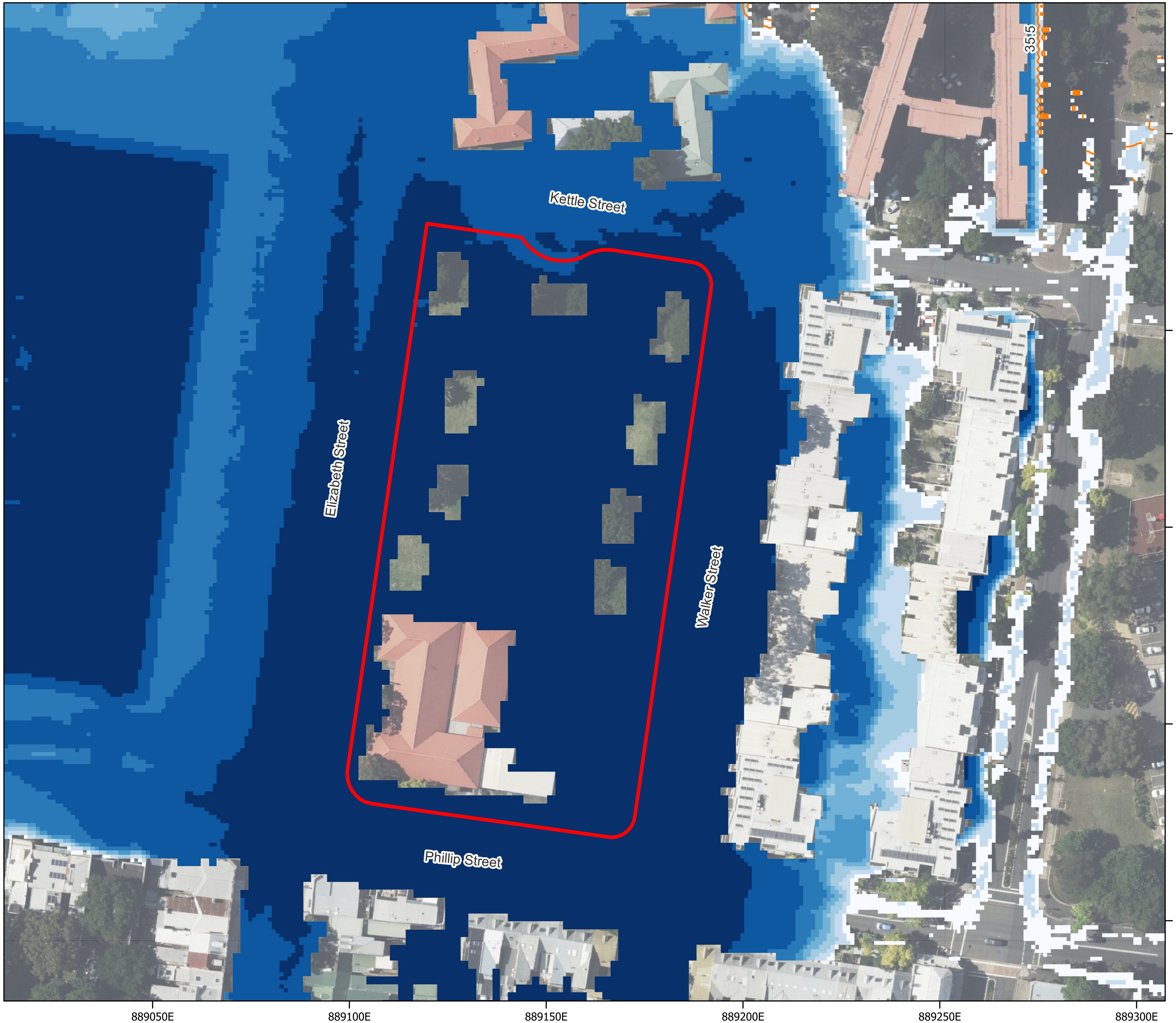
Aerial Imagery Source: NSW Sixmaps



Legend

- Site Boundary
- Proposed Development Footprint

Flood Depths

- <= 0.05 (not shown)
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 0.75
- 0.75 - 1.50
- > 1.50
- Water Level Contours 0.1 Intervals (m AHD)

0 20 40 60 m

N

DRAWN: SM
REVIEWED: IV
APPROVED: IV

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

BG&E

Redfern Place, 600-660 Elizabeth Street

Figure A4
Pre-Development Scenario
PMF
Peak Flood Depths with Water Level Contours

DATUM GDA 1994 MGA Zone 56

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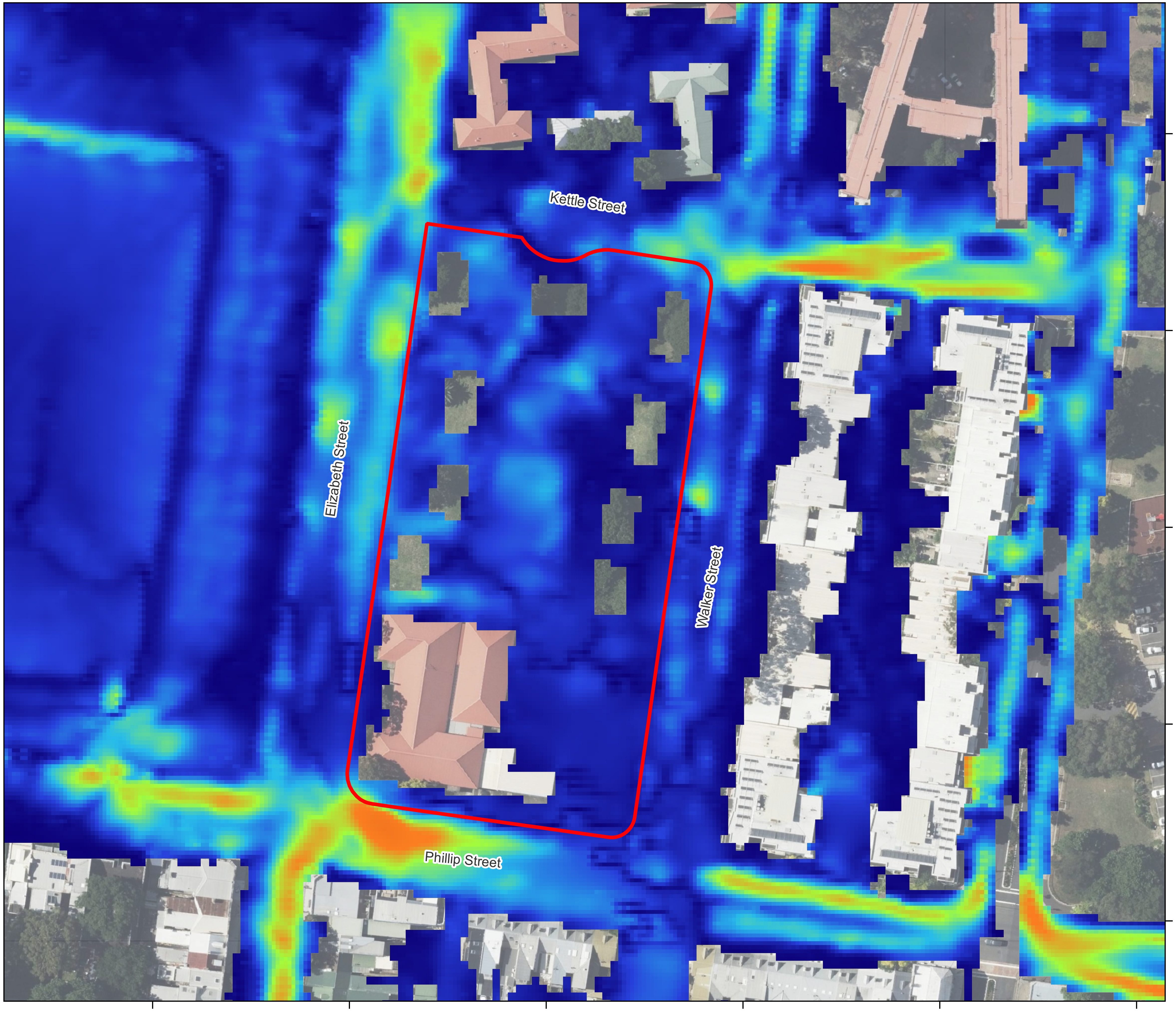
Aerial Imagery Source: NSW Sixmaps



Legend

- Site Boundary
- Proposed Development Footprint

Flood Velocities (m/s)

- 0.0
- 0.5
- 1.0
- 1.5
- 2.0
- 10.0

0 20 40 60 m

DRAWN: SM
REVIEWED: IV
APPROVED: IV

N

BG&E

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

Redfern Place, 600-660 Elizabeth Street

Figure A5
Pre-Development Scenario
PMF
Peak Flood Velocity

DATUM GDA 1994 MGA Zone 56

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Aerial Imagery Source: NSW Sixmaps

Legend

- Site Boundary
- Proposed Development Footprint

Flood Hazard

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

0 20 40 60 m

N

BG&E

DRAWN: SM
REVIEWED: IV
APPROVED: IV

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

Redfern Place, 600-660 Elizabeth Street

Figure A6
Pre-Development Scenario
PMF
Peak Flood Hazard

DATUM GDA 1994 MGA Zone 56

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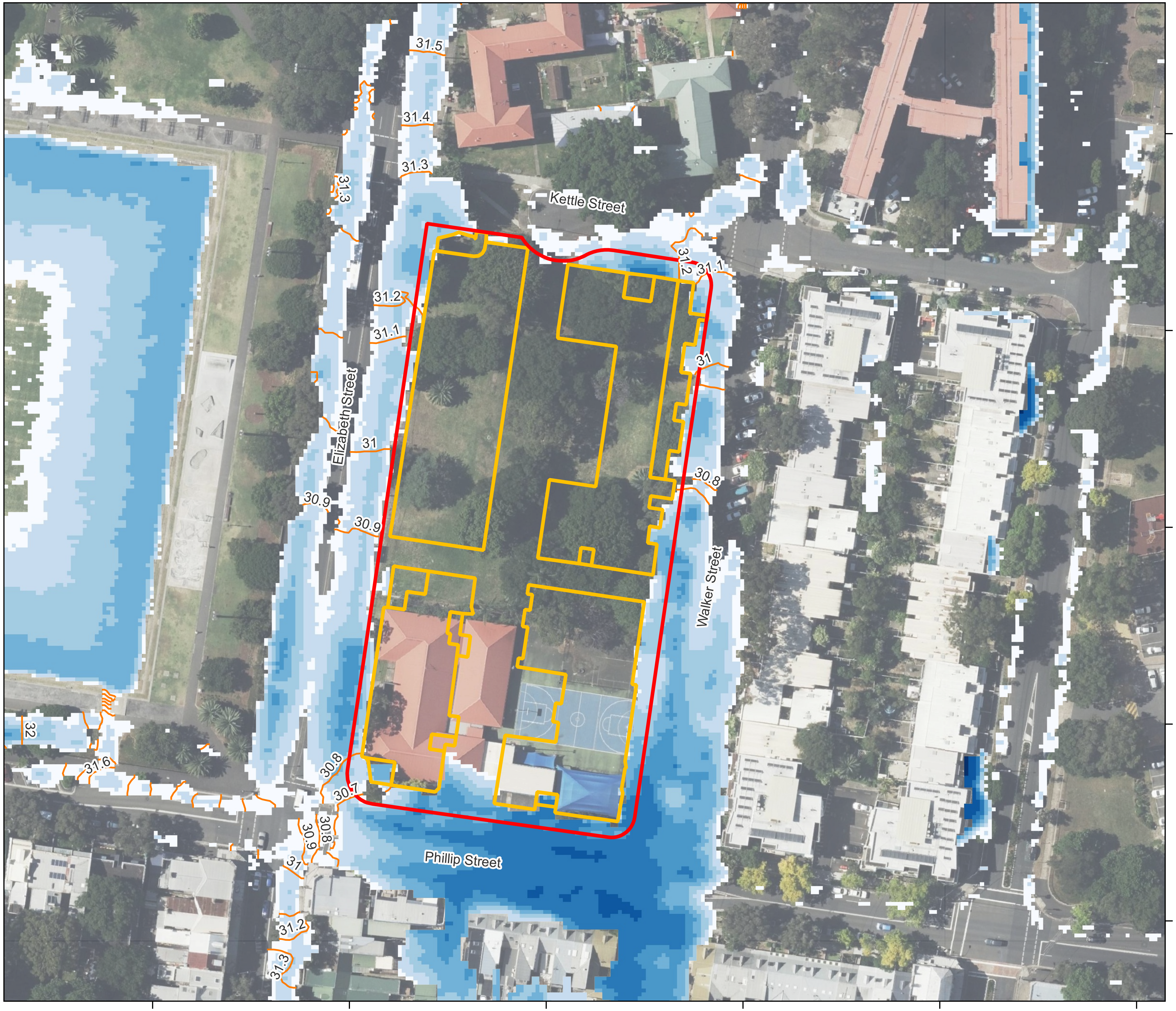
Aerial Imagery Source: NSW Sixmaps



Legend

- Site Boundary
- Proposed Development Footprint

Flood Depths

- <= 0.05 (not shown)
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 0.75
- 0.75 - 1.50
- > 1.50
- Water Level Contours 0.1 Intervals (m AHD)

0 20 40 60 m

N

DRAWN: SM
REVIEWED: IV
APPROVED: IV

BG&E

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

Redfern Place, 600-660 Elizabeth Street

Figure A7
Post-Development Scenario
1% AEP Event
Peak Flood Depths with Water Level Contours

DATUM GDA 1994 MGA Zone 56

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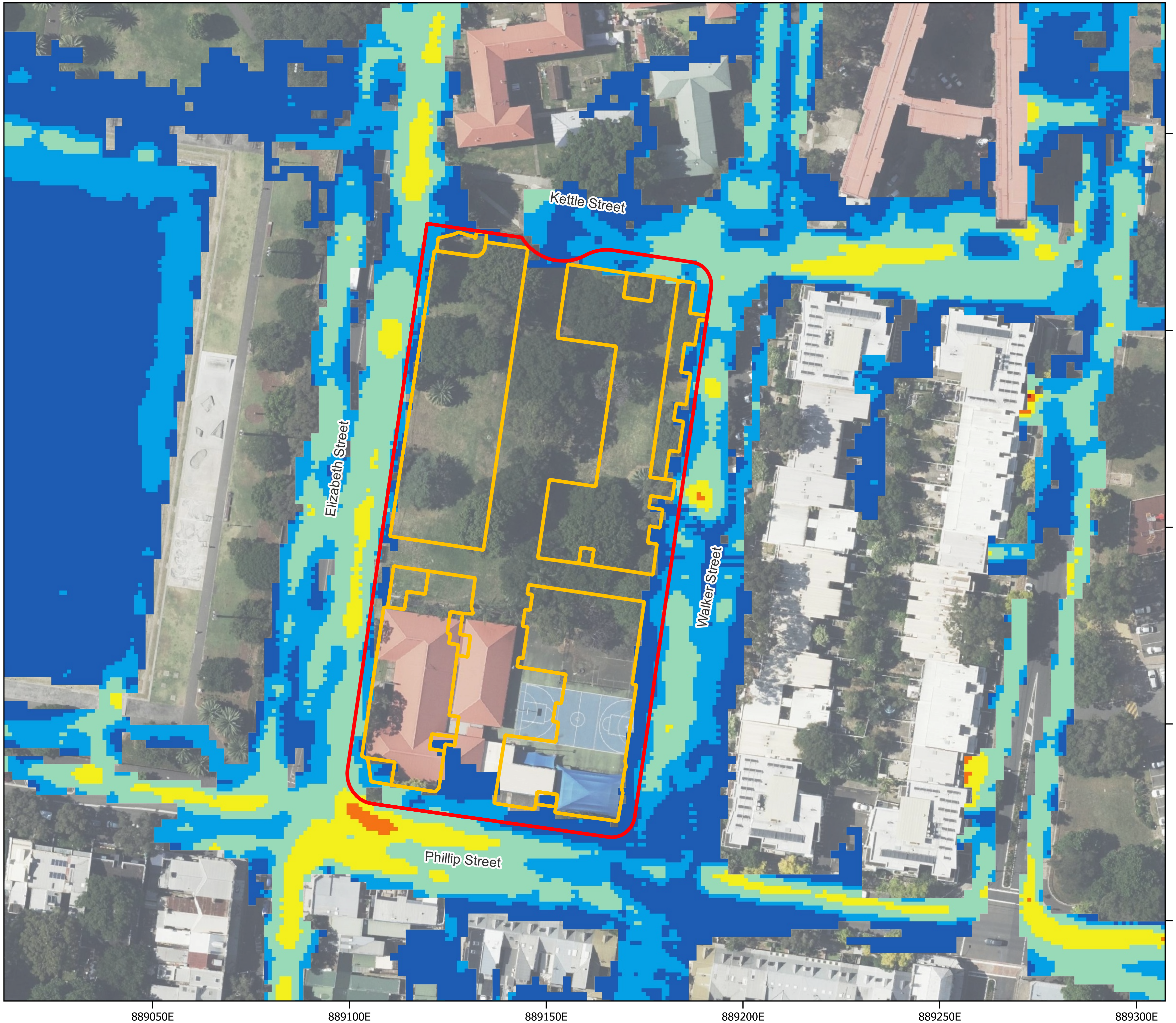
Aerial Imagery Source: NSW Sixmaps



Legend

Site Boundary
Proposed Development Footprint

Flood Velocities (m/s)

- 0.0
- 0.5
- 1.0
- 1.5
- 2.0
- 10.0

0 20 40 60 m

N

DRAWN: SM
REVIEWED: IV
APPROVED: IV

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

BG&E

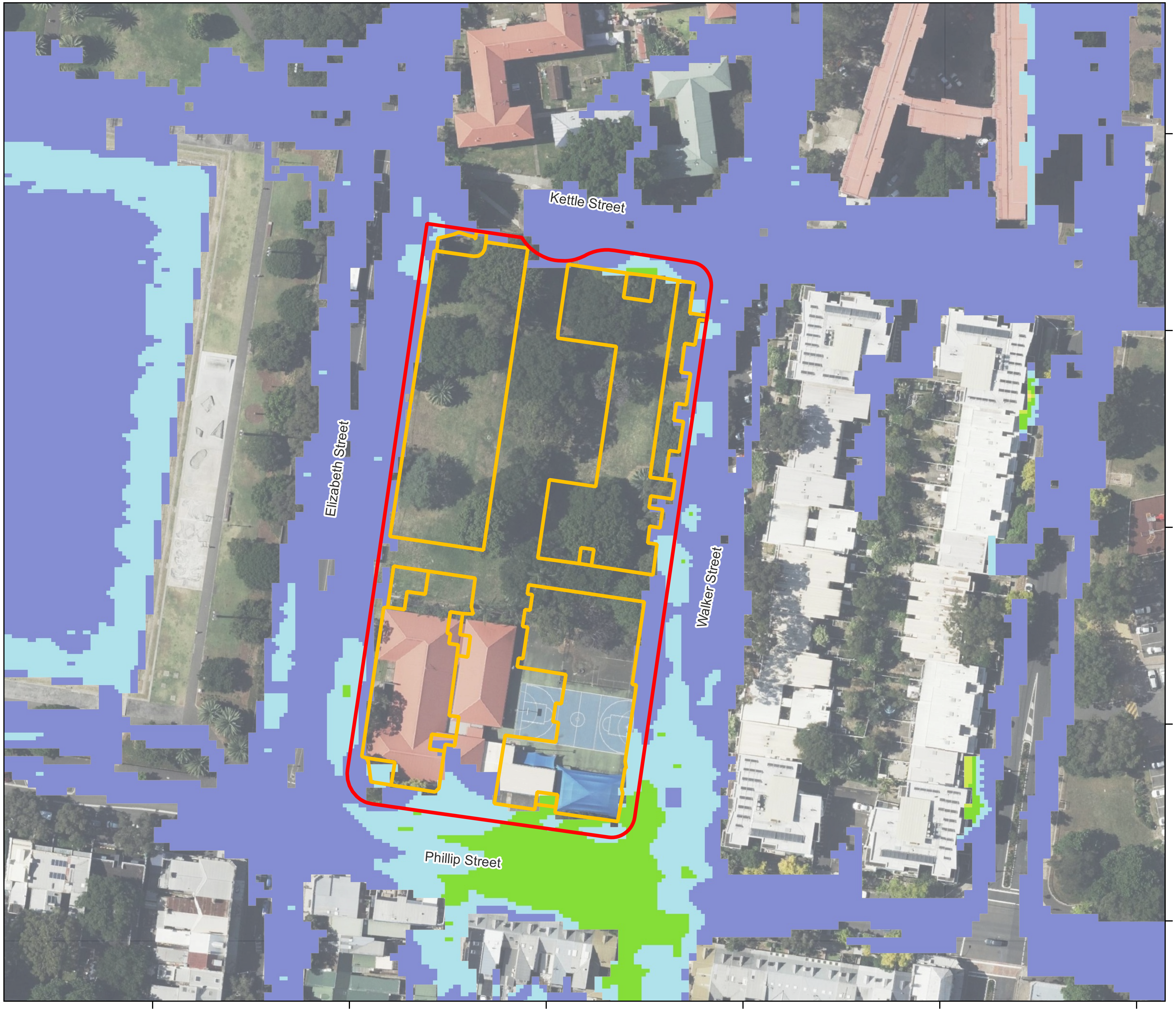
Redfern Place, 600-660 Elizabeth Street

Figure A8
Post-Development Scenario
1% AEP Event
Peak Flood Velocity

DATUM GDA 1994 MGA Zone 56

P:|BGE|SYD|S23123 REDFERN PLACE PROJECT, 600-660 ELIZABETH ST REDFERN|100 DRAW|100.9 Water|GIS|Wor|Alexandria Canal FS Results.qgz | Atlas

Aerial Imagery Source: NSW Sixmaps



Legend

Site Boundary
Proposed Development Footprint

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

0 20 40 60 m

N

DRAWN: SM
REVIEWED: IV
APPROVED: IV

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

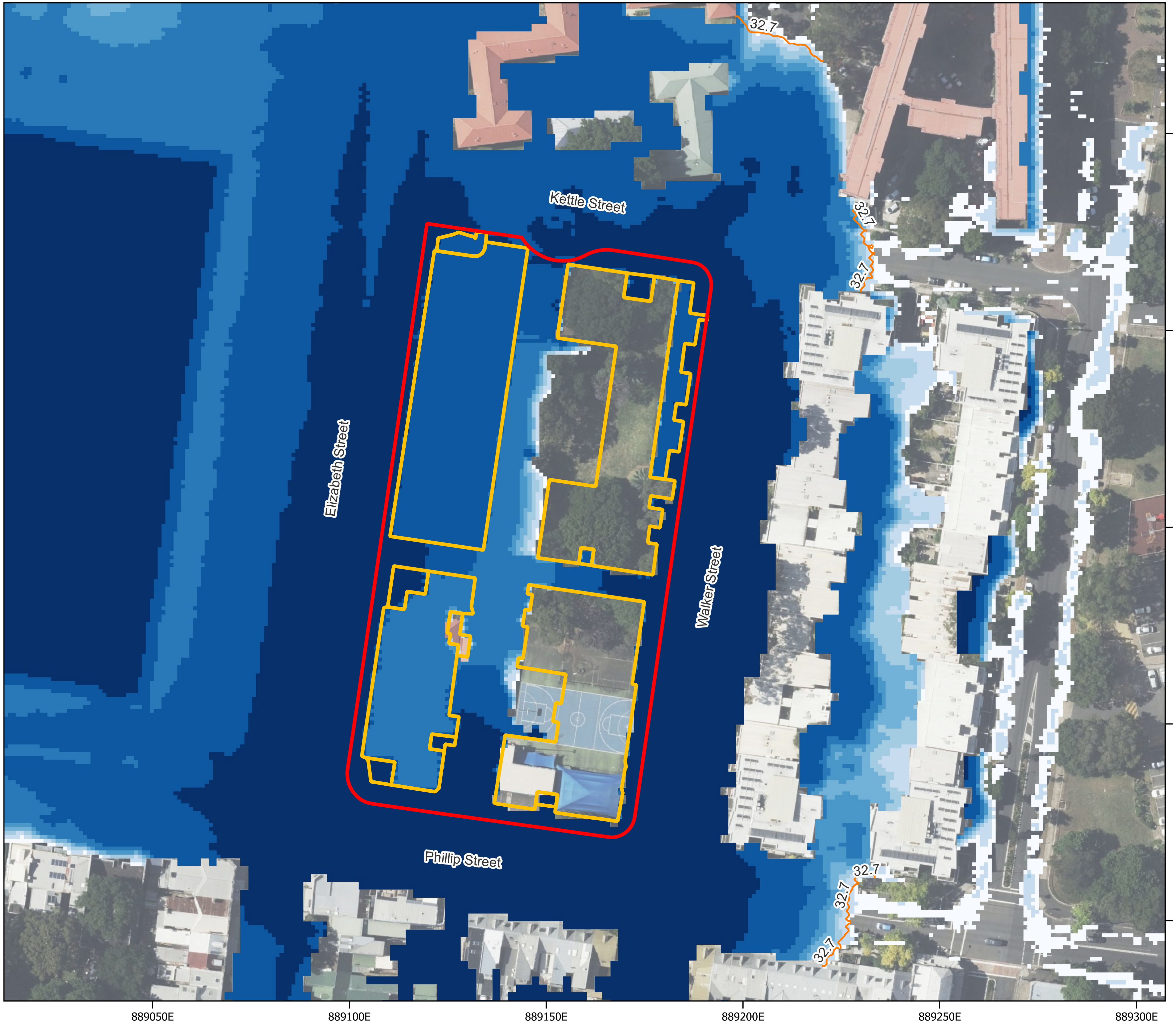
Redfern Place, 600-660 Elizabeth Street

Figure A9
Post-Development Scenario
1% AEP Event
Peak Flood Hazard

DATUM GDA 1994 MGA Zone 56

P:\BGE\SYD\S23123 REDFERN PLACE PROJECT, 600-660 ELIZABETH ST REDFERN\100 DRAW\100.9 Water\GIS\Wor\Alexandria Canal FS Results.qgz | Atlas

Aerial Imagery Source: NSW Sixmaps



Legend

- Site Boundary
- Proposed Development Footprint

Flood Depths

- <= 0.05 (not shown)
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 0.75
- 0.75 - 1.50
- > 1.50
- Water Level Contours 0.1 Intervals (m AHD)

0 20 40 60 m

N

BG&E

DRAWN: SM
REVIEWED: IV
APPROVED: IV

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

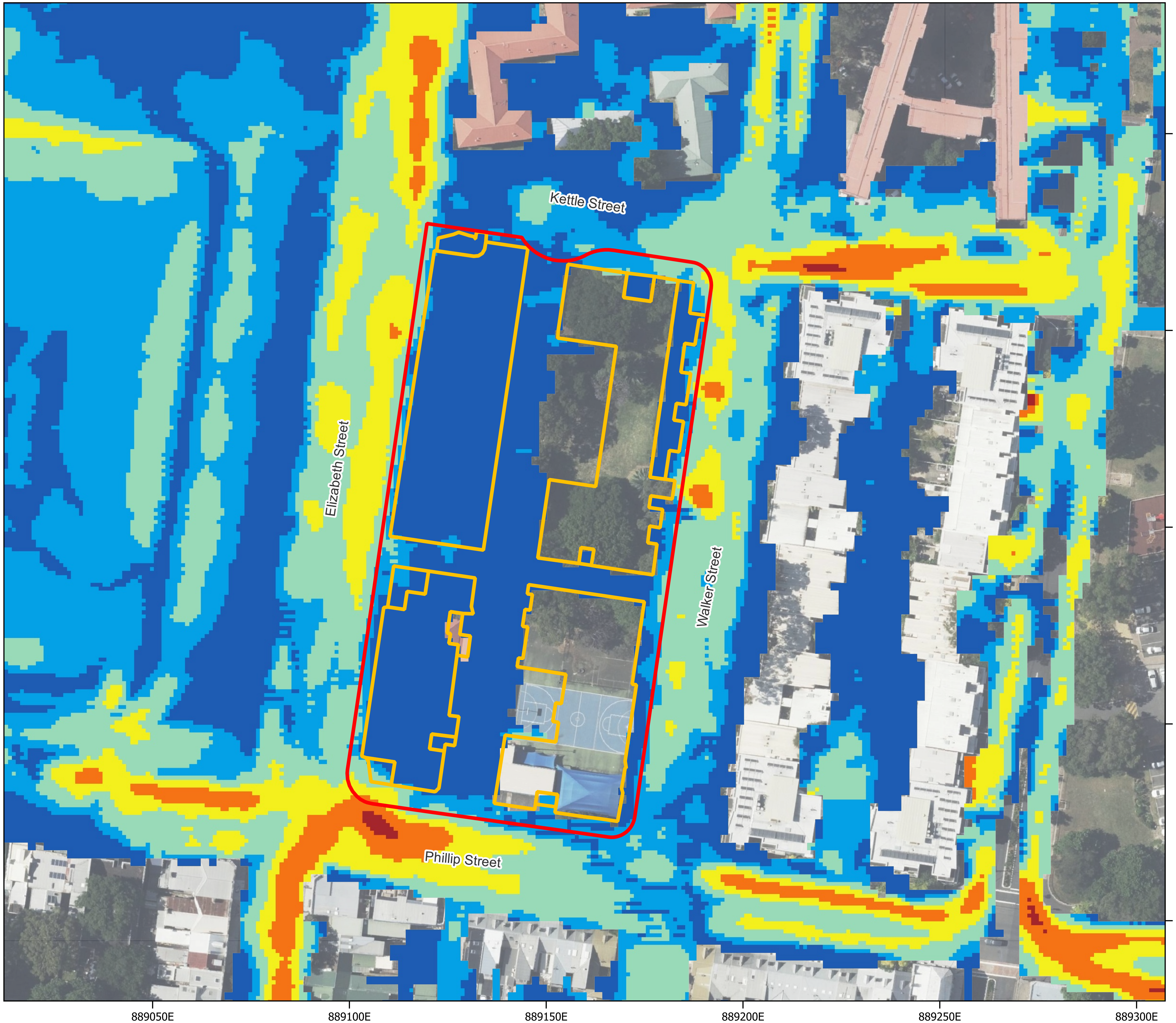
Redfern Place, 600-660 Elizabeth Street

Figure A10
Post-Development Scenario
PMF
Peak Flood Depths with Water Level Contours

DATUM GDA 1994 MGA Zone 56

P:\BGE\SYD\S23123 REDFERN PLACE PROJECT, 600-660 ELIZABETH ST REDFERN\100 DRAW\100.9 Water\GIS\Wor\Alexandria Canal FS Results.qgz | Atlas

Aerial Imagery Source: NSW Sixmaps



Legend

Site Boundary
Proposed Development Footprint
Flood Velocities (m/s)
0.0
0.5
1.0
1.5
2.0
10.0

0 20 40 60 m

DRAWN: SM
REVIEWED: IV
APPROVED: IV

N

BG&E

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

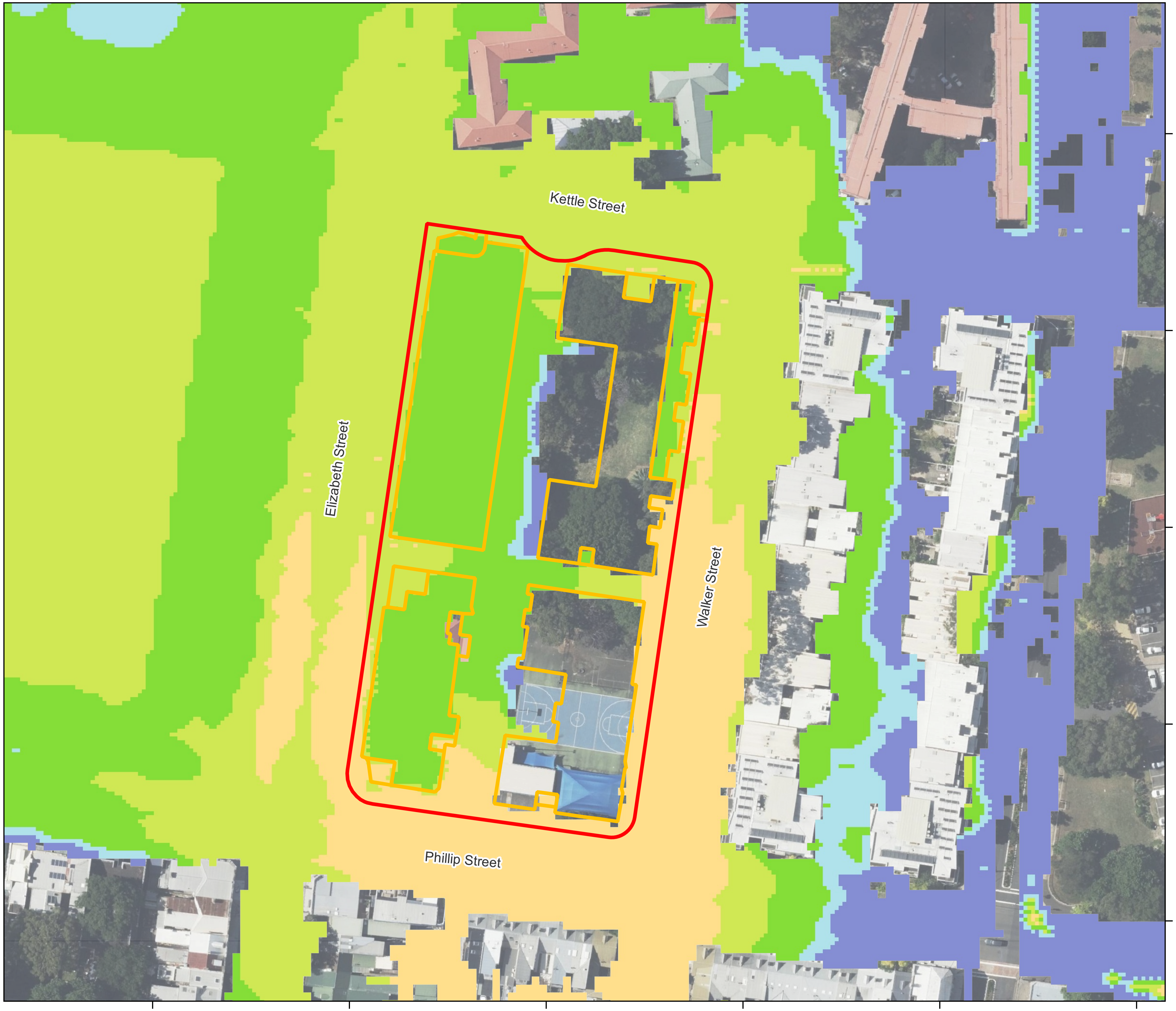
Redfern Place, 600-660 Elizabeth Street

Figure A11
Post-Development Scenario
PMF
Peak Flood Velocity

DATUM GDA 1994 MGA Zone 56

P:\BGE\SYD\S23123 REDFERN PLACE PROJECT, 600-660 ELIZABETH ST REDFERN\100 DRAW\100.9 Water\GIS\Wor\Alexandria Canal FS Results.qgz | Atlas

Aerial Imagery Source: NSW Sixmaps



Legend

- Site Boundary
- Proposed Development Footprint

Flood Hazard

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

0 20 40 60 m

N

DRAWN: SM
REVIEWED: IV
APPROVED: IV

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

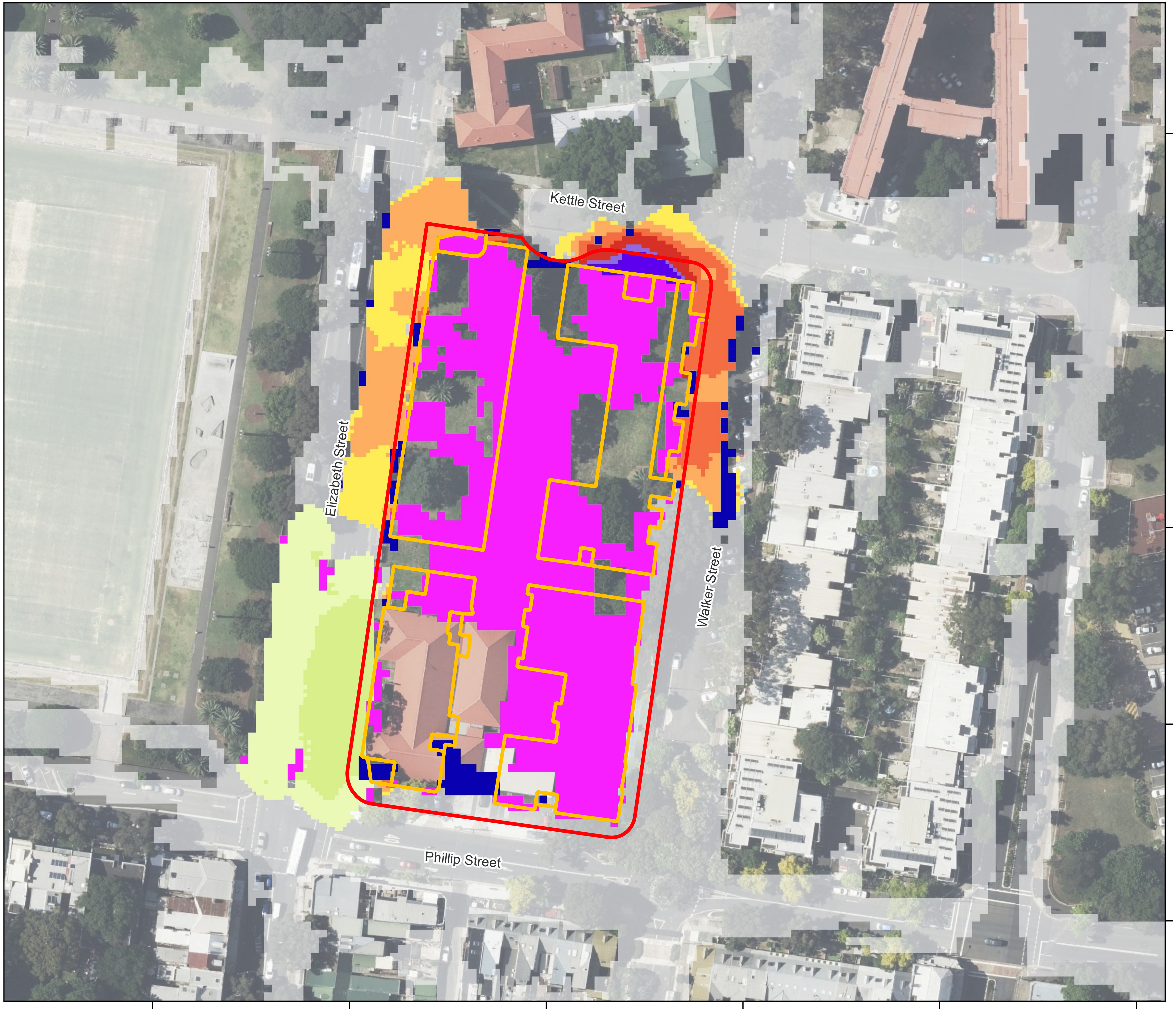
Redfern Place, 600-660 Elizabeth Street

Figure A12
Post-Development Scenario
PMF
Peak Flood Hazard

DATUM GDA 1994 MGA Zone 56

P:\BGE\SYD\S23123 REDFERN PLACE PROJECT, 600-660 ELIZABETH ST REDFERN\100 DRAW\100.9 Water\GIS\Wor\Alexandria Canal FS Results.qgz | Atlas

Aerial Imagery Source: NSW Sixmaps



Legend

- Site Boundary
- Proposed Development Footprint

Water Level Difference (m AHD)

- <= -0.25
- -0.25 - -0.20
- -0.20 - -0.15
- -0.15 - -0.10
- -0.10 - -0.05
- -0.05 - -0.01
- No significant change (+/- 0.01)
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.25
- > 0.25

- Was Wet Now Dry
- Was Dry Now Wet

0 20 40 60 m

N

DRAWN: SM
REVIEWED: IV
APPROVED: IV

DATE: 21/6/2024
PROJECT: Redfern Place, 600-660 Elizabeth Street
CLIENT: Hickory

BG&E

Redfern Place, 600-660 Elizabeth Street

Figure A13
Afflux Design Less Existing
1% AEP Event
Change in Water Levels

DATUM GDA 1994 MGA Zone 56

P:\BGE\SYD\S23123 REDFERN PLACE PROJECT, 600-660 ELIZABETH ST REDFERN\100 DRAW\100.9 Water\GIS\Wor\Alexandria Canal FS Results.qgz | Atlas

Aerial Imagery Source: NSW Sixmaps