NORTHROP

Flood Impact Assessment

for

143a Stoney Creek Road, Beverly Hills

for Cambridge Unit Developments

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Acronyms

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ALS	Airborne Laser Survey (LiDAR)
DCP	Development Control Plan
FERP	Flood Emergency Response Plan
FPL	Flood Planning Level
GRC	Georges River Council
LGA	Local Government Area
LiDAR	Light Detection and Ranging (also see ALS)
m	Measure of length / height / distance (metres)
m AHD	Meters above Australian High Datum
m^3/s	Measure of flow rate (cubic metres per second)
NSW	New South Wales
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RoG	Rainfall on Grid
TUFLOW	A 1D and 2D hydraulic modelling software

		Date
Prepared by	LG	17/12/2020
Checked by	GB	17/12/2020
Admin	BBR	17/12/2020

Introduction

Northrop Consulting Engineers Pty Ltd (Northrop) have been engaged by Cambridge Unit Developments to prepare a Flood Impact Assessment for the proposed Health Services Facility located at 143a Stoney Creek Road, Beverly Hills, herein referred to as the subject site.

The Overland Flow Flood Study for Hurstville, Mortdale and Peakhurst Wards (SMEC, 2016) has identified the site to be impacted by flooding during both the 1% AEP and PMF design storm events. Initial liaison with Council confirmed that the subject site is flood prone, and that a Flood Impact Assessment will be required.

This Flood Impact Assessment aims to review the impact the proposed facility has on the existing flood behaviour within the subject site and adjacent properties.

Legislation, Policies and Guidelines

This assessment has been prepared with consideration to the following legislation, policies and guidelines.

- Hurstville Local Environmental Plan (2012).
- Hurstville Development Control Plan (2018).
- Australian Rainfall and Runoff 2016 (AR&R 2016).
- Australian Rainfall and Runoff 1987 (ARR1987) and subsequent updates.
- NSW Flood Prone Land Policy.
- NSW Government Floodplain Development Manual (NSW Government, 2005).
- Water Management Act 2000 (NSW Government, 2016).

Relevant Reports and Documents

This report is to be read in conjunction with the following reports and documents:

1. Detailed survey drawings prepared by LTS Lockley – Further stormwater details added from laser scan issue dated the 5 of April 2020.
2. Civil engineering drawings prepared by Northrop Consulting Engineers – DA revision dated 9 of December 2020 (ref 200410 DAC01.01 to DAC07.01).
3. Architectural drawings prepared by Rothelowman – DA Amendments issue dated 23 of November 2020.

The flood information discussed herein has been prepared based on the following study and model, used under a licence agreement for this project:

4. Overland Flow Flood Study for Hurstville, Mortdale and Peakhurst Wards, prepared by SMEC in 2016 herein referred to as the “HMPW Overland Flow Flood Study (SMEC, 2016)” or the “original model (SMEC, 2016)”.

Contained herein is a description of the subject site and proposed development, a summary of the modelling methodology and a discussion of the results.

Locality and Proposed Development

Subject Site

The subject site is located on the south western corner of the intersection of Stoney Creek Road and Cambridge Street, Beverly Hills. It includes the parcel of land at 143a Stoney Creek Road, otherwise known as Lot 3, DP1205598. The subject site is located within the Hurstville portion of the Georges River Council (GRC) Local Government Area (LGA). The location of the subject site and general vicinity is presented in **Figure 1** shown overleaf.

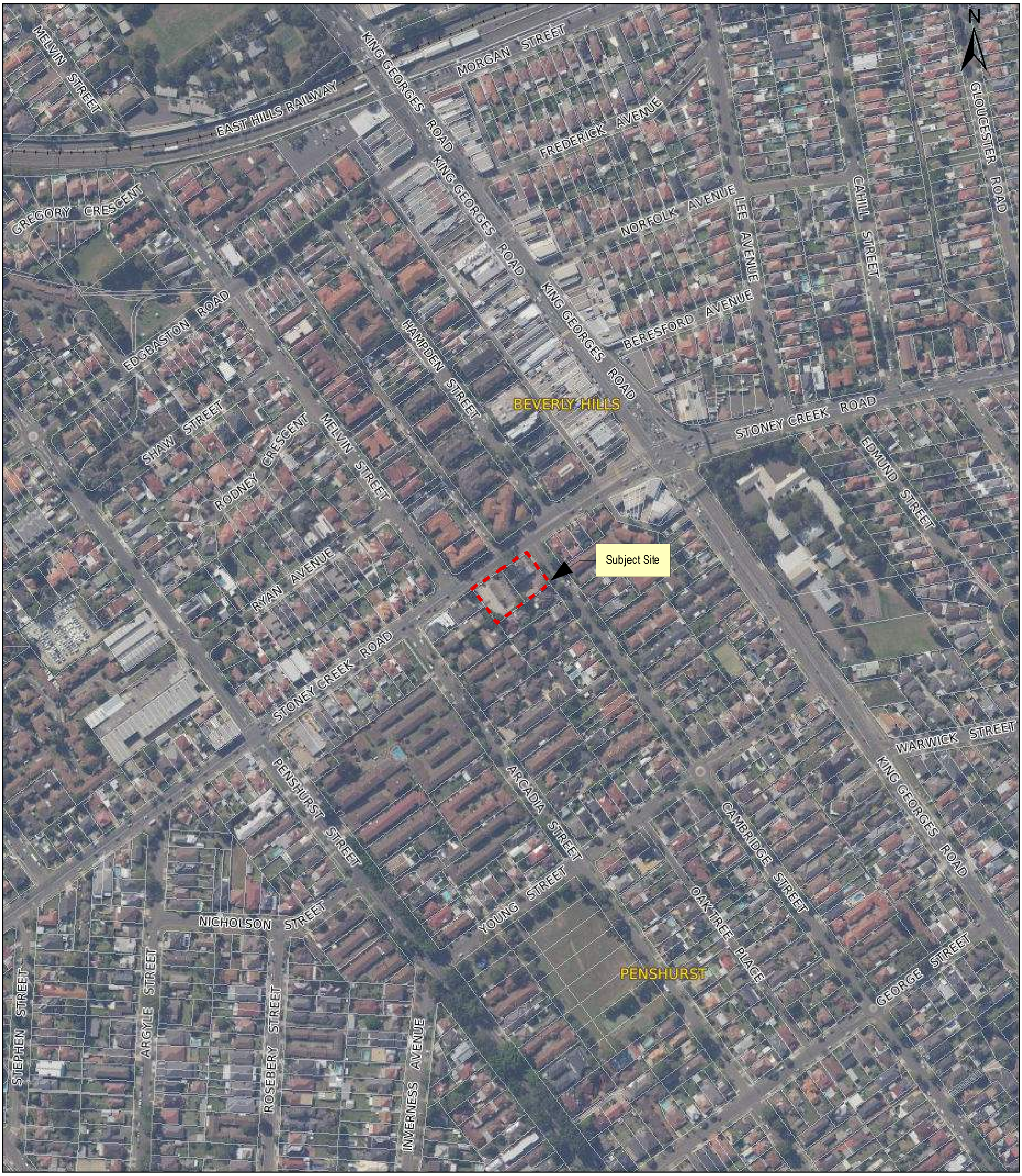
The current land-use is a single storey commercial facility and its associated carparking and landscaping. Detailed survey suggests the ground surface is relatively flat across the site with elevations generally ranging from 29.9m AHD to 30.25m AHD.

In its current state, the site is bordered by a series of brick landscaped walls around the northern and eastern boundaries, which detailed survey suggests has a variable top of wall height ranging from approximately 30.1-30.31m AHD. A green palisade fence sits on top of the brick landscaped wall and extends in excess of 1.5m above the brick wall.

Around the southern and western boundaries, a kerb and landscaped brick wall is observed with a 1.8m high Colourbond metal fence sited on top. Detailed survey suggests top of wall elevations range from 30.30m AHD to 30.45m AHD. There are two high landscaped brick walls around the site boundary; one located in the south-eastern corner of the subject site and the second extending approximately half-way along the western boundary. Detailed survey suggests that these two walls have a top elevation of 32.07m AHD and 32.01m AHD respectively.

Access to the existing facility is via the driveway off Cambridge Street, located in the south-eastern corner of the subject site.

An existing Sydney Water 1.981m wide by 1.219m high Reinforced Concrete Box Culvert (RCBC) and associated easement traverses the site. It extends from the southern boundary (in a north-easterly direction across the subject site), which then continues beneath Stoney Creek road to the north.



Legend

Subject Site

Cadastre

0 62.5 125 250

Meters 1:5,000

Figure 1 [A]

Subject Site Locality

Data Source: LPI

143 Stoney Creek Road, Beverly Hills

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The Proposed Development

The proposed development is shown below in **Figure 2.** It includes a three storey Health Services Facility and its associated basement carpark and landscaping. Similar to the existing case, vehicular access is proposed in the south-eastern corner of the site, off Cambridge Street. The internal driveway extends parallel with the southern boundary before ramping down into three levels of basement carparking below.

It is proposed to re-direct the existing Sydney Water 1.981x1.219m RCBC and easement around the eastern boundary of the subject site, to avoid the proposed development. A new 2.1m wide by 1.29m high RCBC is proposed, with a maximum bend radius of 6m (as per initial advice provided by Sydney Water).

A flood storage chamber is also proposed beneath the ground floor level and western portion of the driveway which is intended to increase the available flood storage on the subject site. The flood storage chamber is sandwiched between the Ground Floor Level and Basement Level 1. The storage chamber has an invert level of 28.7m AHD and a maximum height of approximately 2.2 meters.

The inclusion of the flood storage chamber provides in excess of 2000m^3 of flood storage beneath the building before flows begin to overtop the landscaped walls along the northern and eastern boundaries. Low flows and flood water captured within the flood chamber is to discharge into the Sydney Water culvert through a series of Floor Waste pits and dual 225mm uPVC pipes. The chamber is intended to capture flood water before it continues onto Cambridge and Stoney Creek Road to the east and north respectively.

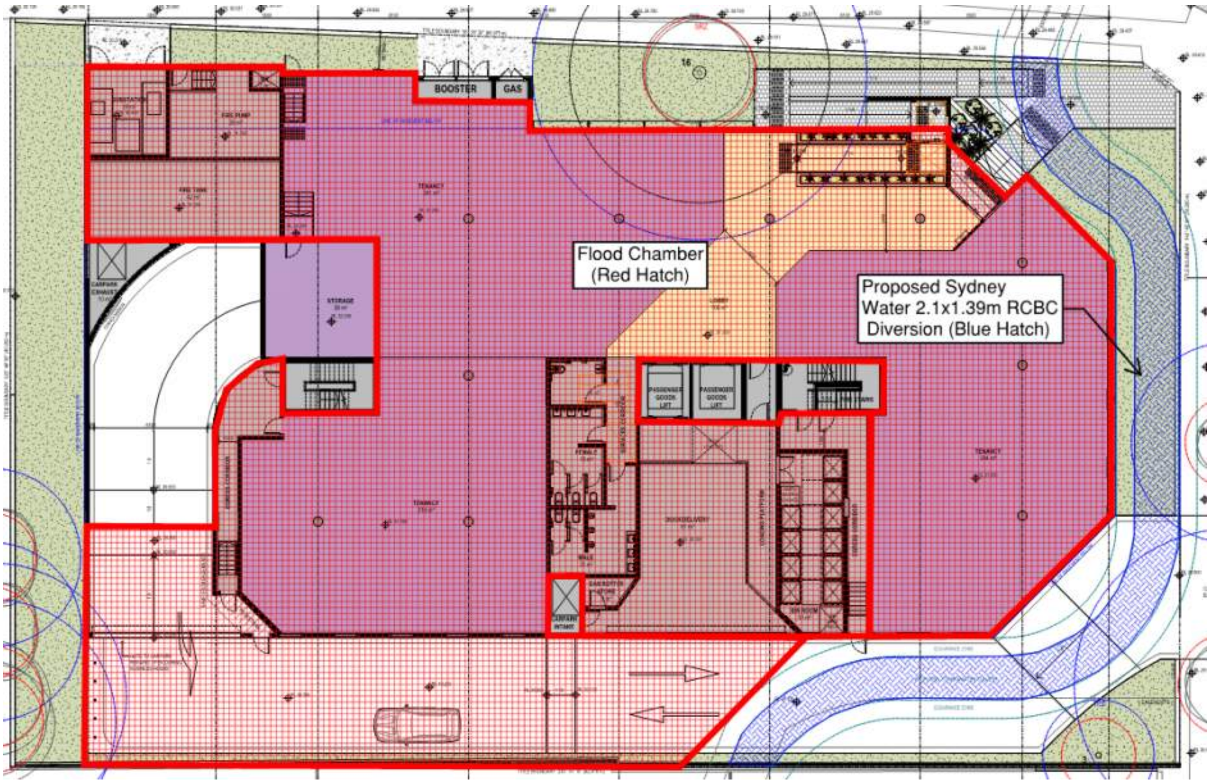

Figure 2 - Proposed Ground Floor Plan of the Health Services Facility (refer to Architectural Drawings for Details)

Methodology

This flood impact assessment was undertaken using the following procedure:

- Desktop review of previous investigations including the HMPW Overland Flow Flood Study (SMEC, 2016).
- Desktop review of available information including design plans, survey data, stormwater infrastructure and latest aerial imagery.
- Liaison with Georges River Council officers to obtain a copy of HMPW Overland Flow Flood Study (SMEC, 2016) model files.
- Create an “Existing Case” flood model by updating the HMPW Overland Flow Flood Model (SMEC, 2016) to include detailed survey and recent aerial imagery.
- Modify the Existing Case flood model to include the proposed development and create the “Developed Case” flood model.
- Compare the results of the Existing and Developed case flood models to review the impact the proposed development has on the existing flood behaviour on-site and in adjacent properties.

The results of the assessment have been reported herein.

Regional Flood Model Updates

The HMPW Overland Flow Flood Model (SMEC, 2016) has been provided by GRC under a license agreement for use in this study. The HMPW Overland Flow Flood Study (SMEC, 2016) covers the catchments of Hurstville, Mortdale and Peakhurst Wards and is a two-dimensional combined hydrological and hydraulic TUFLOW model. The hydrological model is Rainfall on Grid (RoG) with initial and continuing rainfall losses accounted for at the model surface through variable land-use types.

The HMPW Overland Flow Flood Model (SMEC, 2016) has been updated to include information captured on site through detailed survey, review of aerial imagery and by site photos to create the latest Existing Case model. The updated Existing Case model was then modified to include the proposed development. The following section identifies the changes made to the original model (SMEC, 2016).

Two-Dimensional Grid Extent and Size

A grid size of 2m has been adopted for the study which remains un-changed from what was used in the original model (SMEC, 2016). The 2m grid size was considered appropriate for the purposes of the study and is typically used for urban areas. Similarly, a timestep of 0.5 seconds has been adopted which also remains un-changed from what was used in the original model (SMEC, 2016). In addition, no changes were made to the model extent for the purposes of this study.

Terrain

Existing Case

Figure A1 of Appendix A presents the updated existing case topography. The original model terrain was updated to include the latest detailed survey. Landscaped walls have been excluded from the model following feedback received from Council.

The terrain around the upstream side of existing building has been raised to represent the flow obstruction generated by the walls around the building while, the downstream walls have been removed to enable storage within the building. This is consistent with the methodology used to model buildings both onsite and elsewhere in the original model (SMEC, 2016). Similarly, the terrain beneath the existing building was raised to a level of 30.26m AHD to match the existing case finished floor level presented in the detailed survey.

Developed Case

Figure A2 of Appendix A presents the modelled developed case topography. During the developed case scenario, a model surface (which includes the flood chamber) was created using the 12d software and overlayed the detailed survey. Openings into the basement, such as the stairwells, exhaust vents and the basement driveway ramp were raised above the flood level to represent exclusion of flow into these areas.

Land-use and Losses

Existing Case

The updated land-use and surface roughness for the existing case model is presented in **Figure A3** of Appendix A. For the existing case, surface roughness has been updated based on observations from the detailed survey and aerial imagery. Hardstand areas across the subject site have been modelled using a variable roughness as shown in the following Table 1. Landscaped areas across the subject site have also been modelled using the variable roughness presented in Table 2. Similarly, the existing case building has been modelled with a roughness of 0.025. All of the values are consistent with those modelled for Roads, Shrubs and Buildings in the original model (SMEC, 2016) respectively.

Table 1 - Hardstand Surface Roughness

Flow Depth (m)	Manning's Roughness (*n*)
0.00	0.017
0.04	0.017
0.10	0.021
0.15	0.018
100	0.018

Table 2 - Landscaped Surface Roughness

Flow Depth (m)	Manning's Roughness (*n*)
0.00	0.137
0.30	0.137
1.00	0.077
1.50	0.047
100	0.047

Fences sited on top of landscaped walls around the boundary have been entered into the model manually through a series of flow constriction polylines. A blockage factor of 50% was applied to fences, which is consistent with the assumptions made in the original model (SMEC, 2016), both on the subject site and around lot boundaries elsewhere in the model.

Developed Case

Figure A4 of Appendix A presents the developed case land-use and surface roughness. During the developed case scenario, hardstand areas, including the flood storage chamber and driveway, have been modelled in a similar manner to roads elsewhere in the model. Similarly, landscaped areas were modelled as shrubs.

Similar to the existing case, boundary fences around the southern and eastern sides of the subject site where modelled with 50% blockage during the developed case which is consistent with the assumptions made in the original HMPW Overland Flow Flood Study (SMEC, 2016).

Rainfall losses remain un-changed to those used in the HMPW Overland Flow Flood Study (SMEC, 2016) with an initial and continuing loss of 1.0mm and 0mm/hr for Roads and 10mm and 2.5mm/hr for Shrubs respectively. All remaining land-use and surface roughness external to the subject site have been maintained as per the original HMPW Overland Flow Flood Study (SMEC, 2016)

Below Ground Stormwater Infrastructure

The existing Sydney Water 1.981x1.219m RCBC and inverts were updated in the existing case model based on detailed survey. It is noted a larger culvert cross section was assumed across the subject site in the original model (SMEC, 2016) when compared to what has been picked up by detailed survey. As such, the model cross section has been updated based on the detailed survey. A 50% blockage factor was included at the headwall upstream of the subject site by reducing the size of the culvert cross section.

Nearby pits and pipes were also updated in the existing case to match the detailed survey and observations made using aerial imagery and Google Street View.

The proposed diversion has been included in the model as a 2.1x1.29m RCBC. Additional form losses have been applied to the proposed culvert to represent head loss due to the bends.

Flood Chamber

The flood chamber has been represented in the model through the inclusion of a series of flow constrictions. **Figure A2** of Appendix A presents the flow constrictions, including polygons for the majority of the under-croft area and more perimeter polylines to allow for additional blockage where louvres (or similar) are proposed. A blockage factor of 10% has been applied beneath the building whereas, an increased factor of 20% has been considered where the chamber extends beneath the driveway, ramp and substation. Blockage in these areas has been included to represent supporting columns with additional supports expected for the driveway.

A slab thickness of 250mm with 150mm high kerb has been assumed for the driveway slab while a thickness of 300mm has been assumed for the building floor slab. A blockage factor of 100% has been applied to these elements representing a total obstruction to flow where flood water contacts the suspended slabs. Similarly, flows above the building floor level are also assumed 100% blocked, while flows above the driveway slab are assumed to pass over un-obstructed. An additional allowance for form loss has been applied to the flow constrictions within the flood chamber to allow for losses in momentum due to the columns within the flood chamber.

Blockage for louvres are shown in **Figure A2** to vary with generally 20% along the southern and western extent of the building and 50-70% along the northern and eastern extents. Similarly, **Figure A2** also shows a façade wall is proposed around the northern face of the building in an attempt to maintain the existing flow distribution across the boundary, post development. These will be designed during the detailed design and require a structural engineer to confirm they have the capacity to withstand flood forces and debris impact loads.

A total of twelve 150mm circular floor waste pits are proposed in the base of the flood chamber in order to drain stored flood water from the chamber. The inlet capacity rating curves for these floor waste pits suggest that only two would be sufficient to convey the required capacity through the proposed dual 225mm uPVC pipes due to the available head over the floor waste pits. This is equivalent to a blockage factor of approximately 85%.

The dual 225mm uPVC pipes are proposed from the floor wastes, connecting into the Sydney Water culvert. A one-way flap is also proposed at the connection to the Sydney Water Culvert to prevent back-flow into the chamber. Refer to the previously referenced Civil Engineering Drawings for additional details.

Results

Critical Duration

The critical duration for the subject site has been based on the information provided in the HMPW Overland Flow Flood Study report (SMEC, 2016). This suggests the 120-minute duration is critical for the 1% AEP, and the 60-minute duration is critical for the PMF.

Comparison with Regional Study

A comparison between the results from the original HMPW Overland Flow Flood Study (SMEC, 2016) and the updated Existing Case scenario has been prepared for the 1% AEP. The results are presented in the attached **Figure B1** of Appendix A.

Figure B1 of Appendix A shows a decrease in the properties west of the subject site which is expected to be due to the removal of a building that was modelled on the western portion of the site in the original model (SMEC, 2016). Similarly, an increase is observed upstream due to the updated culvert size and inclusion of blockage.

As a result, additional flow enters the subject site which leads to an increase in flood depths across the site when compared to the original HMPW Overland Flow Flood Study (SMEC, 2016). An increase is also observed downstream of the subject site which is expected to be commensurate with the decrease in the properties to the west and the increases observed upstream.

Existing Flood Behaviour

During the existing case, overland flow derived from the upstream catchment enters the subject site from the southern and western boundaries before continuing towards Cambridge Street via the driveway entrance and finally onto Stoney Creek Road as flows passes across the northern boundary. Overland flow continues in a north-easterly direction across Stoney Creek Road, and through the road network and the properties to the north.

Figure C1 and C3 of Appendix A presents the existing flood depths for the 1% AEP and PMF design storm events respectively. Flood depths for the 1% AEP range across the subject site between 100-500mm while, depths in the order of 600-1000mm are observed in the PMF. Similarly, the below Table 3 presents the corresponding existing flood elevations at each corner of the site.

Table 3 – Subject Site Existing Case 1% AEP Flood Levels

Reporting Point	1% AEP Flood Elevation (mAHD) (Refer to Figure C1 of Appendix A)	PMFFlood Elevation (mAHD) (Refer to Figure C3 of Appendix A)
North-Eastern Corner	29.93	30.38
North-Western Corner	30.38	30.87
South-Eastern Corner	30.37	30.78
South-Western Corner	30.47	30.90

Flood hazard has been assessed using the latest Australian Rainfall and Runoff 2019 guidelines, in particular **Figure 6.7.9** of Book 6 – Chapter 7, reproduced below as **Figure 3**. The flood hazard categories across the subject site and vicinity during the 1% AEP and PMF design storm events are presented in **Figure C2 and C4** of Appendix A respectively.

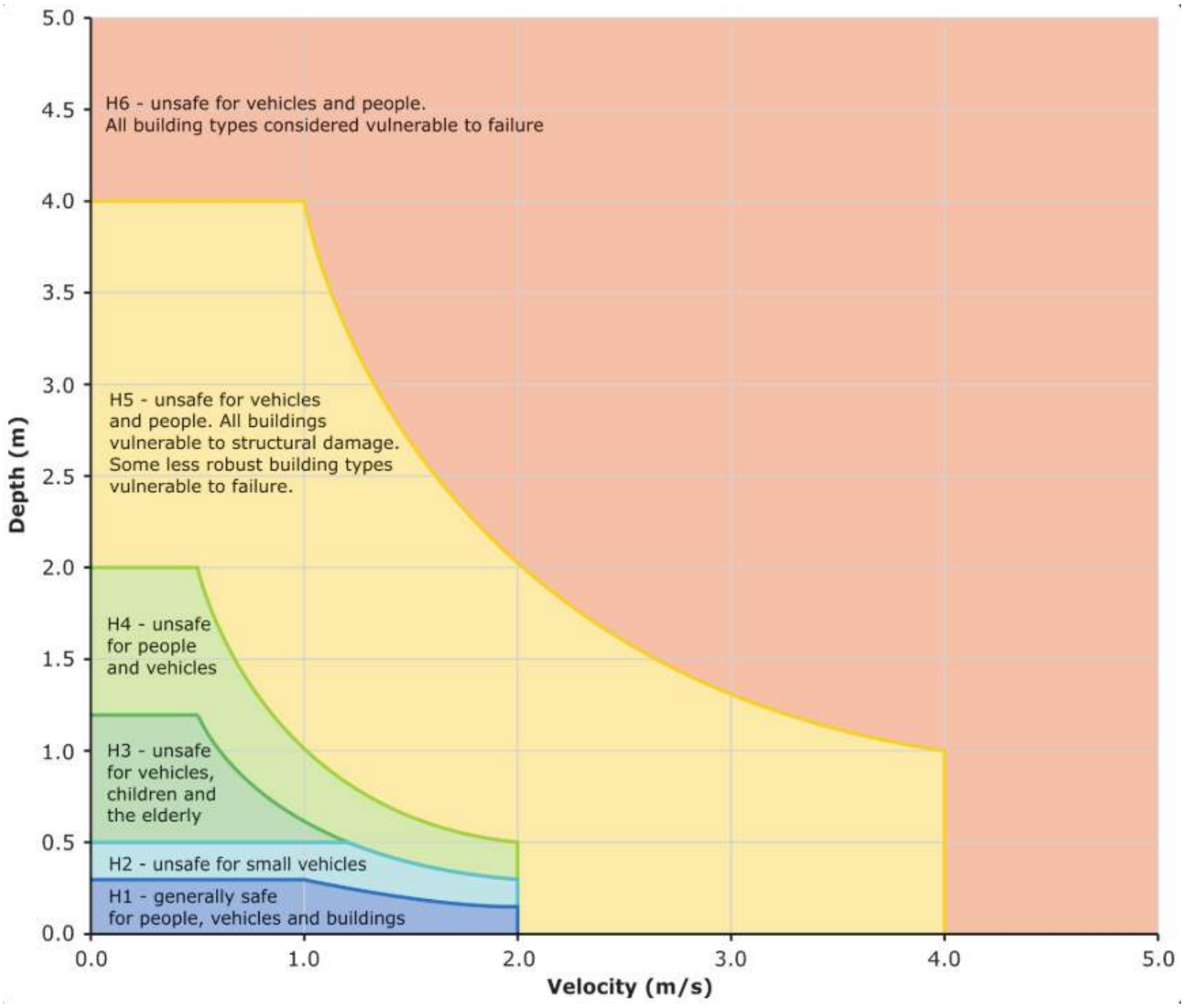

Figure 3 - Australian Rainfall and Runoff 2019 Flood Hazard Categories (Figure 6.7.9)

Figure C2 of Appendix A suggests flood hazard categories across the subject site during the 1% AEP design storm event are generally less than H2 with the exception of a portion of H3 observed along the northern boundary. During the PMF, Figure C4 shows flood hazard varies between H2 to H5 across the subject site.

External to the subject site, patches of H5 hazard flow are observed in Cambridge Street and Stoney Creek Road during the 1% AEP. A patch of H3 and H4 hazard flow is observed at the driveway entrance to the subject site off Cambridge Street, suggesting evacuation from the site may not be safe during a major event under existing conditions. During the PMF, hazard conditions throughout the upstream properties and road network are largely H5.

Developed Flood Behaviour

Flow behaviour during the developed case is similar to that of the existing case. Stormwater derived from the upstream catchment enter the subject site from the western and southern boundaries. Overland flow that enters the site then spills into the proposed flood chamber beneath the building. Flood water stored in the chamber is proposed to be drained out via the proposed floor waste pits and the dual 225mm uPVC pipes. Similar to the existing case, flows that spill across the southern and western boundaries also travels in an easterly direction along the proposed driveway and towards Cambridge Street.

When full, overflow from the flood chamber spills into the landscaped areas along the northern and eastern boundaries. Flows then continue onto Cambridge Street and Stoney Creek Road.

Figure D1 and D3 of Appendix A presents the flood depths and elevations across the subject site during the developed case. Similarly, the below Table 4 presents the 1% AEP and PMF flood elevations at each corner of the subject site.

Table 4 - Developed Case Flood Levels

Reporting Point	1% AEP Flood Elevation (mAHD) (Refer to Figure D1 of Appendix A)	PMF Flood Elevation (mAHD) (Refer to Figure D3 of Appendix A)
North-Eastern Corner	29.92	30.40
North-Western Corner	30.25	30.66
South-Eastern Corner	30.22	30.73
South-Western Corner	30.38	30.94

Flood hazard during the developed case has also been considered with respect to the above **Figure 3, Figures D2 and D4** of Appendix A present the developed case flood hazard conditions during the 1% AEP and PMF design storm events respectively. During the 1% AEP, flood hazard within the driveway is limited to a maximum of H2 which **Figure 3** suggests is safe for large vehicles and pedestrians.

Flood hazard within the chamber is generally H4 with some patches of H5 during the 1% AEP and H5 with patches of H6 during the PMF design storm event. The chamber is proposed to exclude pedestrian access under normal operation with access permitted only for maintenance purposes. Under no circumstances should anyone attempt to enter the flood chamber during a flood event. Louvres (or similar) restrict access into the flood chamber around the building and are proposed to reduce the risk of someone entering and / or becoming trapped beneath the building during a flood event.

Development Impact

Figures E1 and E2 of Appendix A presents the impact of the proposed development during the 1% AEP **and PMF** design storm events respectively. With the introduction of the flood chamber beneath the building, an increase in the available flood storage on site is provided for the regional catchment. Under existing conditions, approximately 600m^3 of flood storage is available across the subject site while, during the developed scenario, in excess of 2000m^3 is provided. As a result, Figure E1 of Attachment 1 shows that during the 1% AEP design storm event, flood levels typically decrease across the subject site and within the adjacent properties.

A minor increase of up to approximately 68mm is observed in Stoney Creek Road during the 1% AEP design storm event which is expected to be due to a slight change in flow behaviour in this area when compared to the existing case. Similarly, an increase of up to approximately 46mm is observed in Cambridge Street which is also expected due to a minor change of flow behaviour across the subject site. These increases are generally contained in the road reserves and are not considered to adversely impact trafficability of these roads when compared to the existing conditions.

Figure E1 also shows an increase in the properties on the eastern side of Cambridge Street during the 1% AEP design storm event. This increase in less than 20mm and is located on the lowest side of these properties and is therefore not considered to create a significant adverse impact within these properties.

During the PMF, Figure E2 of Attachment 1 shows a decrease for the majority of the subject site and the surrounding properties. Similar to the 1% AEP, a minor localised increase of up to 63mm and 82mm is observed in Stoney Creek Road and Cambridge Street respectively which is expected to be due to a slight change in flow behaviour across the site.

In addition, increases are observed in the properties adjacent to the western boundary of the subject site and on the opposite side of Cambridge Street to the east. Generally, consideration to the PMF is given when reviewing risk to life and as such, a review of the change in hazard conditions in these areas has been considered. A comparison between the results presented in Figures C4 and D4 of Attachment 1 shows minimal change in the extent of the existing hazard conditions already observed in these properties under existing conditions. Furthermore, there is no escalation in hazard conditions that are already observed in these properties (i.e. H5 to H6). As such, the increased flood levels observed in these areas during the PMF are not considered to create a significant adverse impact to these properties.

Discussion

Flood Planning Levels

A minimum of the 1% AEP + 500mm or the PMF flood level is proposed as the Flood Planning Level for the proposed development. This is considered to provide a suitable level of protection to the development and is consistent with the requirements set out by the NSW Floodplain Development Manual (2005) for emergency response facilities and critical infrastructure. In this case, the PMF is the governing requirement with a maximum level in the south-western corner of the site of approximately 30.94m AHD. The ground floor is above this level with a Finished Floor Level of 31.2m AHD.

It is noted that the delivery dock area is sited below the 1% AEP flood level. This was required to enable vehicular access into the building while limiting flood impact to adjacent properties and has been raised to a minimum RL of 30.22m AHD following discussion with GRC. Positioning this area below the 1% AEP flood level is not considered to create in an increased risk to life within the facility as a step in the loading dock is proposed that will enable pedestrian access above the PMF flood level. Similarly, as recommended below, building elements located below the Flood Planning Level shall be structurally capable to withstand flood forces and facilitate easy cleaning.

Following initial liaison with Council, the basement carpark entry threshold is proposed to be set at a minimum of the 1% AEP level plus a freeboard of 300mm. This corresponds to a level of approximately 30.8m AHD. All other openings including the carpark intake and exhaust, basement carpark stairwells and lift shafts are positioned at or above the PMF flood level.

Building Components

The building shall be of robust construction and all structural components below the Flood Planning Level shall be flood compatible. Any building elements sited below the Flood Planning Level shall be constructed using elements that maintain strength and durability when wet, facilitate easy cleaning after inundation and capable of resisting the forces of floodwater, debris and buoyancy during an event.

The proposed louvers (or equivalent) surrounding the flood chamber are to be designed to withstand flood forces to prevent vehicles and pedestrians being washed into the flood chamber during a flood event. It is recommended certification of structural adequacy (by a qualified structural engineer) be required prior to issue of a Construction Certificate for this work.

Due to the type of building proposed, it is expected flood forces, debris impact loading and buoyancy will not be limiting in the design. This will need to be confirmed by structural engineers prior to Construction Certificate.

Safety and Evacuation

The proposed driveway has been raised to a level that minimises risk to life during a 1% AEP design storm event. Maximum of H2 hazard conditions have been achieved in the driveway and will reduce the risk of vehicles becoming buoyant and the risk to life within the subject site during a major event.

In addition, the proposed development provides refuge above the PMF level. This will facilitate vertical evacuation in the event of a rare or extreme flood event. As mentioned above, the building is to be designed to withstand flood forces and debris impact loads during a PMF event, which facilitates this approach. The provision for refuge above the 1% AEP and PMF is considered an improvement to the current conditions on site as there is limited opportunity for refuge during these events under existing flood scenarios.

The basement carpark entrance threshold level has been positioned in accordance with Council's requirements. All remaining building openings or penetrations leading to the basement are positioned at the PMF level. This will provide anyone that becomes trapped within the basement, during an event greater than the 1% AEP + 300mm, the opportunity for vertical evacuation (e.g. using emergency access stairs).

Access and egress to and from the subject site should not be attempted during the 1% AEP or less frequent events, as flood hazard conditions in excess of H2 are observed in Cambridge Street and Stoney Creek Road. During these events, vertical evacuation and refuge onsite should be sought following commencement of rainfall. With a critical duration of 2 hours during the 1% AEP and 60 minutes during the PMF design storm events, flood water is expected to rise and fall quickly over a period of a few hours. As such, the subject site is not expected to be cut off for a prolonged period of time.

It is recommended a Flood Emergency Response Plan (FERP) be prepared to assist in reducing the risk to life. This is intended to educate building occupants on the existing flood risk prior to the onset of rare to extreme rainfall. The FERP should outline the necessary response procedures and available areas of refuge within the building. This should be provided prior to Occupation Certificate. A Flood Emergency Response summary has been prepared for the subject site and is included as Appendix B.

Monitoring and Maintenance

Access to the flood chamber is to be provided with a minimum access opening of 600x900mm as per the requirements set out in AS3500.3. It is anticipated this can be achieved a number of ways such as access hatches from the suspended driveway, access hatches or grates through the louvres around the perimeter of the building or even through the temporary removal of the louvres. There are numerous opportunities to gain access to the flood chamber and it is anticipated this will be resolved during detailed design.

Some areas of the chamber are in excess of 1.2m deep and as such, step irons or a ladder will be required at access openings in accordance with the requirements set out by AS3500.3.

It is recommended that an operation and maintenance manual be developed for the flood chamber with scheduled inspections and cleaning performed to reduce the risk of blockage.

Conclusion

Northrop Consulting Engineers were engaged by Cambridge Unit Developments to prepare a Flood Impact Assessment for the proposed Health Services Facility located at 143a Stoney Creek Road, Beverly Hills.

It was found that the proposed development has no significant impacts on flood behaviour and affectation in the vicinity of the subject site. As a result, the proposed development is not considered to increase the existing level of hazard to persons or property within the subject site or in adjacent properties.

With the introduction of the proposed mitigation measures, (including the flood chamber and preparation of a Flood Emergency Response Plan), the proposed development is considered to improve the existing flood risk on site and make the site suitable for use.

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	Reviewed By
Laurence Gitzel	**Matt Richards**
Civil Engineer	Principal | Civil Section Manager
BEng (Civil)	

Limitation Statement

Northrop Consulting Engineers Pty Ltd (Northrop) has been retained to prepare this report based on specific instructions, scope of work and purpose pursuant to a contract with its client. It has been prepared in accordance with the usual care and thoroughness of the consulting profession for the use by Cambridge Unit Developments. The report is based on generally accepted practices and standards applicable to the scope of work at the time it was prepared. No other warranty, express or implied, is made as to the professional advice included in this report.

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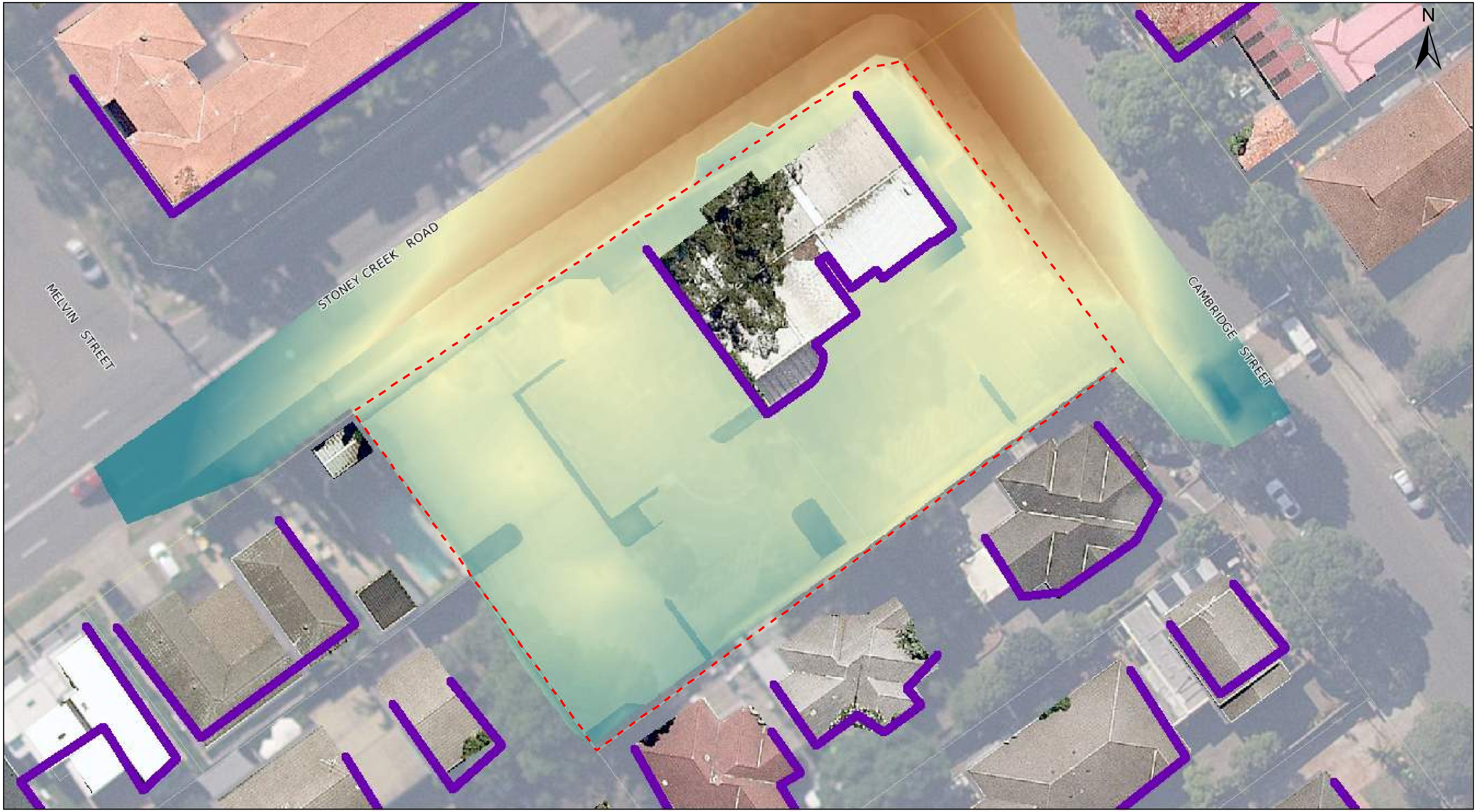
Document Register

Rev	Status	Prepared	Approved	Date
1	Draft for Client Review	LG	MR	27 May 2020
A	For Approval	LG	MR	28 May 2020
B	Re-Issued for Approval	LG	GB	16 December 2020

Appendix A – Figures



Legend

Subject Site
Building Walls
Cadastre

Detailed Survey (mAHD)

High : 30.71

Low : 29.20

0 5 10 20 Meters 1:500

Figure A1 [C]

Existing Case Terrain

143 Stoney Creek Road, Beverly Hills

NORTHROP

Data Source: LPI

4/11/2020 X:\PROJECTS\SYDNEY\2020 Jobs\BeverlyHills\TUFLOW\Figures\ArcMap\SY200410__A1[C].mxd

Legend

Building Walls
Facade Wall
Suspended Ramp

Flood Chamber Louvers

20% Blocked
50% Blocked
70% Blocked
Building Flow Constriction(Ground Level)

Design Surface (mAHD)

High : 32
Low : 28.7

0 5 10 20 Meters 1:500

Figure A2 [D]

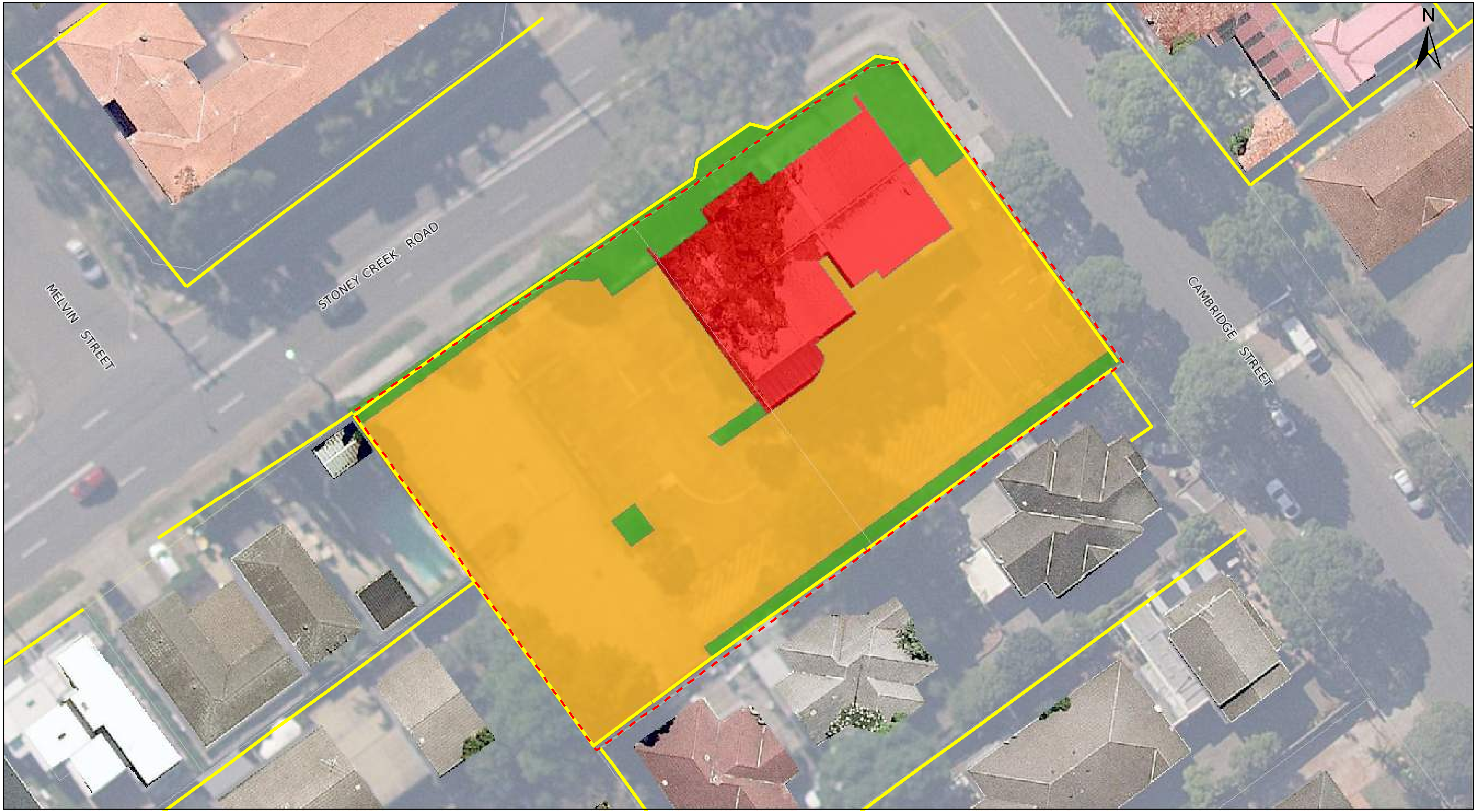
Developed Case Terrain

143 Stoney Creek Road, Beverly Hills

NORTHROP

Data Source: LPI

11/11/2020 X:\PROJECTS\SYDNEY\2020 Jobs\BeverlyHills\TUFLOW\Figures\ArcMap\SY200410__A2[D].mxd



Legend

- Subject Site
- Fences (50% Blocked)
- Cadastre

Land Use

- Building
- Concrete
- Vegetation

0 5 10 20 Meters 1:500

Figure A3 [B]

Existing Case Land use

143 Stoney Creek Road, Beverly Hills

NORTHROP

Data Source: LPI

4/11/2020 X:\PROJECTS\SYDNEY\2020 Jobs\BeverlyHills\TUFLOW\Figures\ArcMap\SY200410__A3[A].mxd

Legend

- Fences (50% Blocked)
- Cadastre
- Suspended Ramp
- Building Flow Constriction(Ground Level)

Land Use

- Concrete
- Vegetation

0 5 10 20 Meters 1:500

Figure A4 [C]

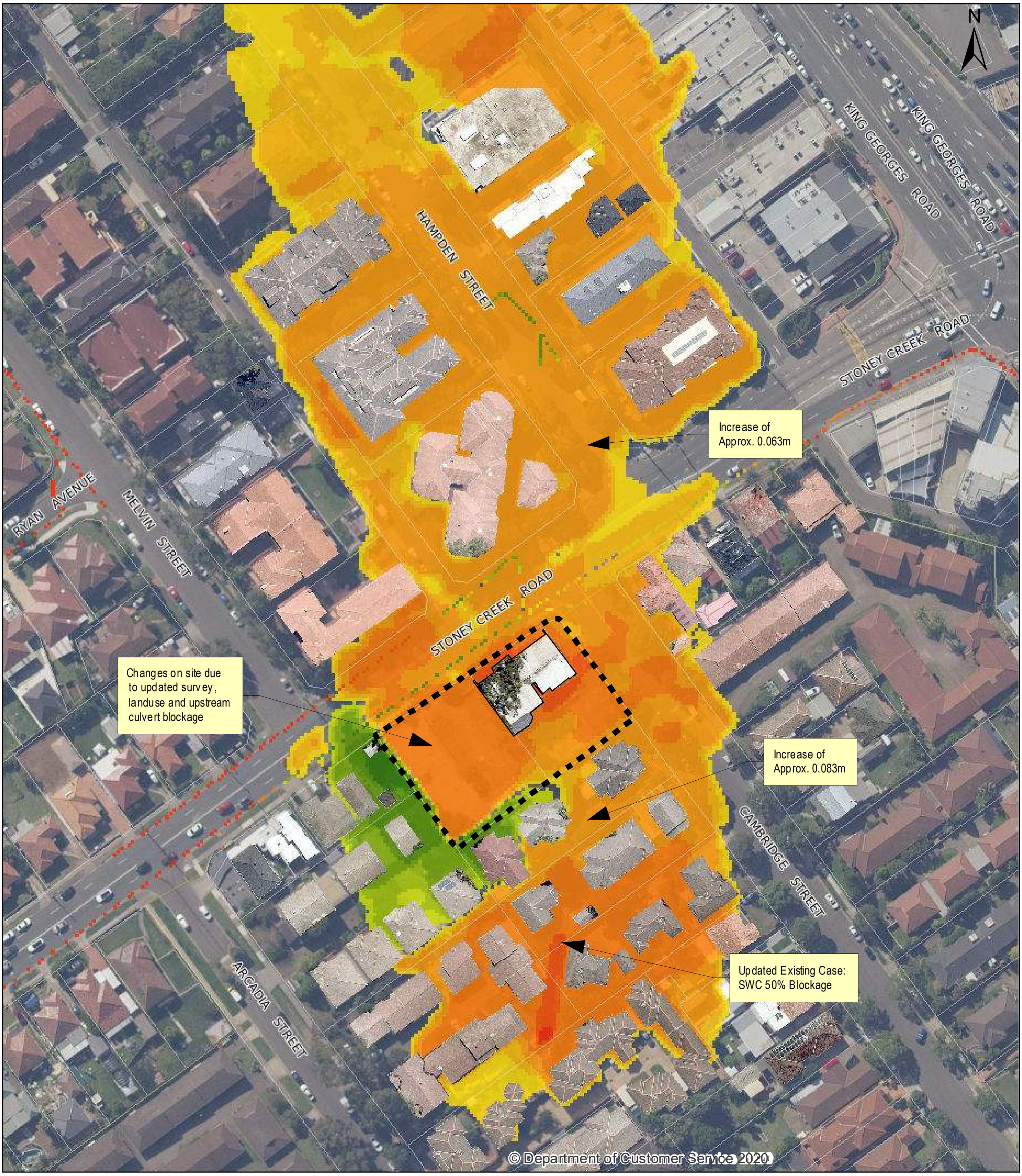
Developed Case Land use

143 Stoney Creek Road, Beverly Hills

NORTHROP

Data Source: LPI

11/11/2020 X:\PROJECTS\SYDNEY\2020 Jobs\BeverlyHills\TUFLOW\Figures\ArcMap\SY200410__A4[C].mxd



Legend

- Subject Site
- Existing Building
- Cadastre

Water Elevation 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

0 15 30 60 Meters 1:1,500

Figure B1 [B]

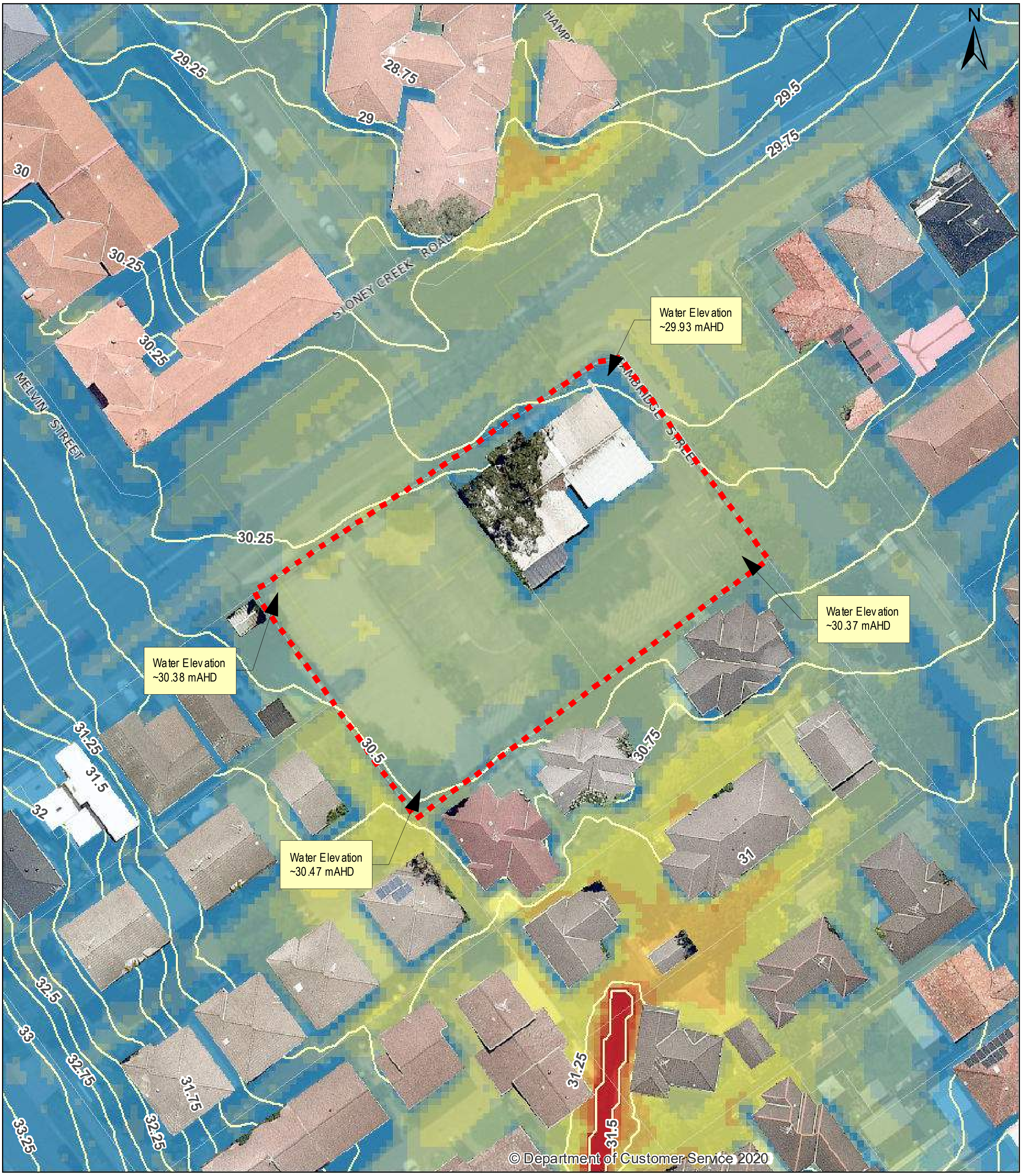
Updated Existing Case minus Original 1% AEP Flood Elevation Difference

Data Source: LPI

143 Stoney Creek Road, Beverly Hills

NORTHROP

10/11/2020 X:\PROJECTS\SYDNEY\2020 Jobs\Beverly Hills\TUFLOW\Figures\ArcMap\SY200410__B1[B]_v2.mxd



Legend

Subject Site
Water Levels
Cadastre

Depth(m)

- 0.00 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 0.7
- 0.7 - 0.9
- 0.9 - 1.1
- 1.1 - 1.3
- 1.3 - 1.5
- 1.5 - 1.7
- 1.7 - 2

0 5 10 20
Meters 1:750

Figure C1 [B]

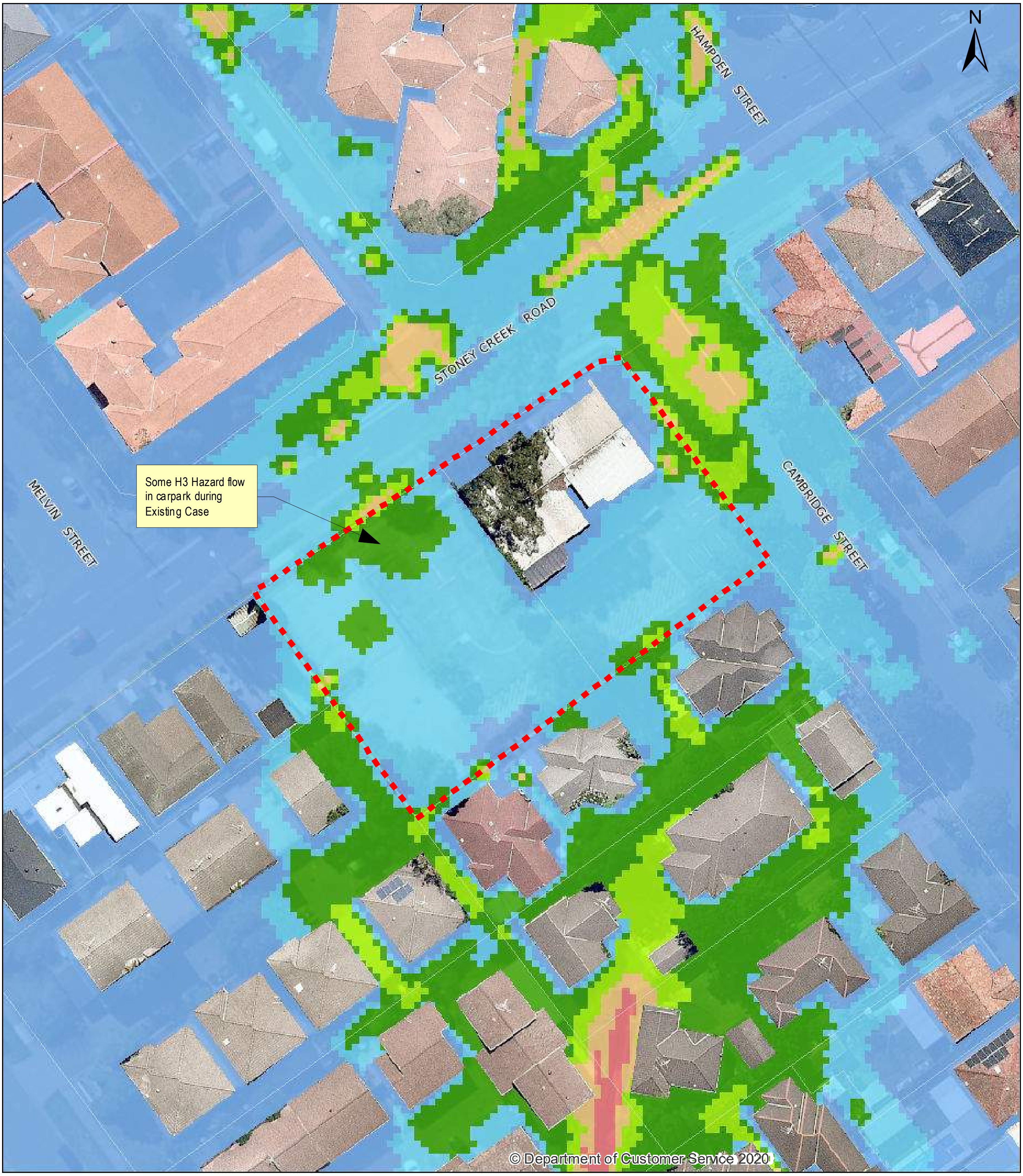
Existing Case
1%AEP Depth and
Elevation Contours

Data Source: LPI

143 Stoney Creek Road, Beverly Hills

NORTHROP

10/11/2020 \\ncl-nas3\FLOODING\PROJECTS\SYDNEY\2020 Jobs\BeverlyHills\TUFLOW\Figures\ArcMap\SY200410__C1[B].mxd



Legend

- Subject Site
- Cadastre

Hazard

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

0 5 10 20 Meters 1:750

Figure C2 [B]

Existing Case
1% AEP Flood Hazard
(ARR 2019)

Data Source: LPI

143 Stoney Creek Road, Beverly Hills

NORTHROP

10/11/2020 \\ncl-nas3\FLOODING\PROJECTS\SYDNEY\2020 Jobs\BeverlyHills\TUFLOW\Figures\ArcMap\SY200410__C2[B].mxd

Legend

Subject Site

Water Levels

Cadastre

Depth(m)

0.00 - 0.05
0.05 - 0.1
0.1 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.1
1.1 - 1.3
1.3 - 1.5
1.5 - 1.7
1.7 - 2

0 5 10 20
Meters 1:750

Figure C3 [B]

Existing Case PMF Depth and Elevation Contours

Data Source: LPI

143 Stoney Creek Road, Beverly Hills

NORTHROP

10/11/2020 \\ncl-nas3\FLOODING\PROJECTS\SYDNEY\2020 Jobs\BeverlyHills\TUFLOW\Figures\ArcMap\SY200410__C3[B].mxd

Legend

Subject Site

Cadastre

Hazard

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

0 5 10 20 Meters 1:750

Figure C4 [B]

Existing Case
PMF Flood Hazard
(ARR 2019)

Data Source: LPI

143 Stoney Creek Road, Beverly Hills

NORTHROP

10/11/2020 \\ncl-nas3\FLOODING\PROJECTS\SYDNEY\2020 Jobs\BeverlyHills\TUFLOW\Figures\ArcMap\SY200410__C4[B].mxd

Legend

- Subject Site
- Water Levels
- Ramp
- Building Flow Constriction
- Cadastre

Depth(m)

- 0.00 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 0.7
- 0.7 - 0.9
- 0.9 - 1.1
- 1.1 - 1.3
- 1.3 - 1.5
- 1.5 - 1.7
- 1.7 - 2

Design Surface (mAHD)

High : 32.0

Low : 28.7

0 5 10 20 Meters 1:750

Figure D1 [D]

Developed Case
1% AEP Depth and
Elevation Contours

Data Source: LPI

143 Stoney Creek Road, Beverly Hills

NORTHROP

10/11/2020 X:\PROJECTS\SYDNEY\2020 Jobs\Beverly Hills\TUFLOW\Figures\ArcMap\SY200410__D1[D].mxd

Legend

- Subject Site
- Building Flow Constriction
- Ramp
- Cadastre

Hazard

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

Design Surface (mAHD)

High : 32.0

Low : 28.7

0 5 10 20 Meters 1:750

Figure D2 [D]

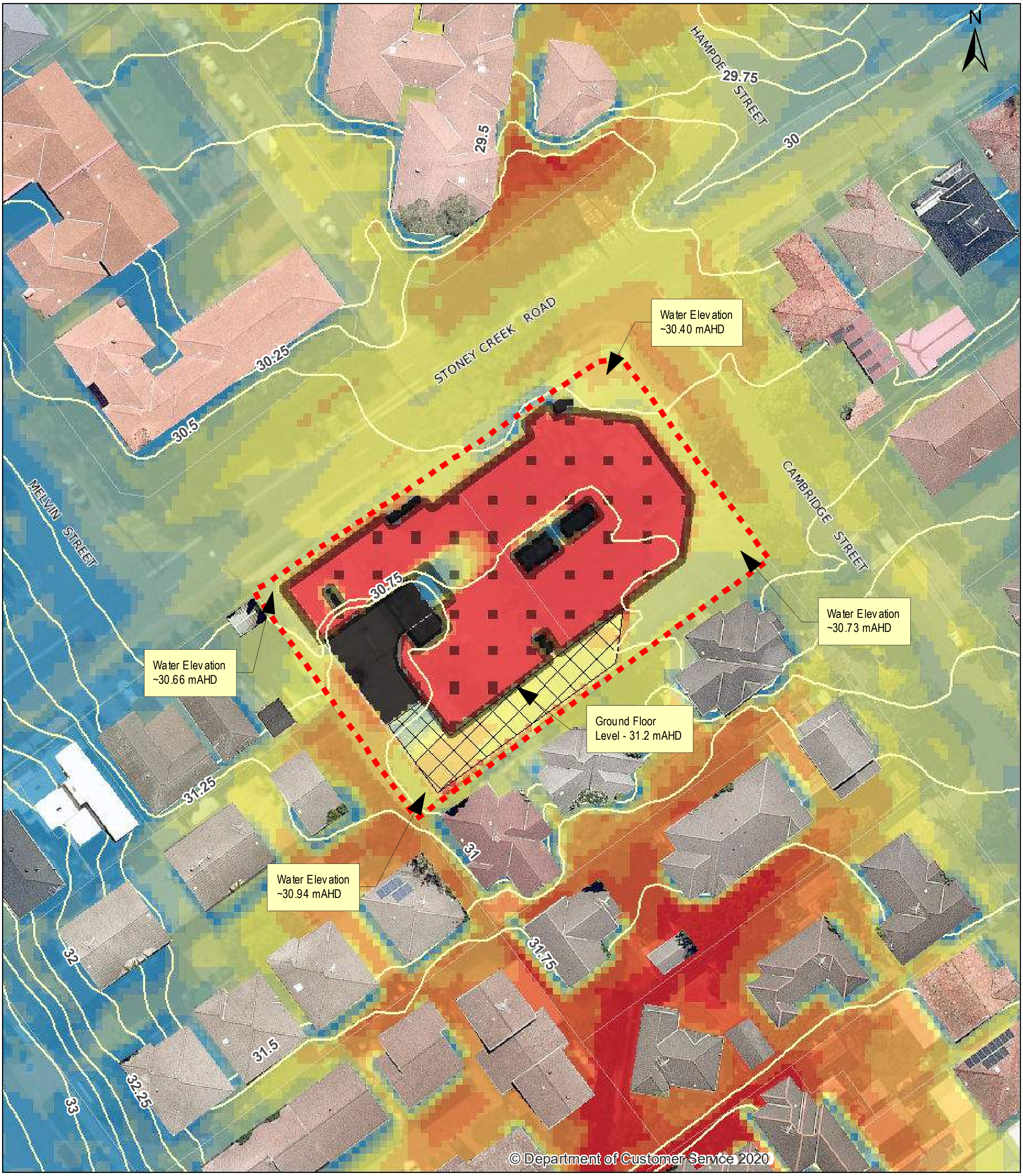
Developed Case
1% AEP Flood Hazard
(ARR 2019)

Data Source: LPI

143 Stoney Creek Road, Beverly Hills

NORTHROP

10/11/2020 \\ncl-nas3\FLOODING\PROJECTS\SYDNEY\2020 Jobs\BeverlyHills\TUFLOW\Figures\ArcMap\SY200410__D2[D].mxd



Legend

Subject Site

Water Levels

Ramp

Building Flow Constriction

Cadastre

Depth(m)

0.00 - 0.05

0.05 - 0.1

0.1 - 0.3

0.3 - 0.5

0.5 - 0.7

0.7 - 0.9

0.9 - 1.1

1.1 - 1.3

1.3 - 1.5

1.5 - 1.7

1.7 - 2

Design Surface (mAHD)

High : 32.0

Low : 28.7

0 5 10 20 Meters 1:750

Figure D3 [D]

Developed Case PMF Depth and Elevation Contours

143 Stoney Creek Road, Beverly Hills

NORTHROP

Data Source: LPI

10/11/2020 X:\PROJECTS\SYDNEY\2020 Jobs\Beverly Hills\TUFLOW\Figures\ArcMap\SY200410__D3[D].mxd

Legend

- Subject Site
- Building Flow Constriction
- Ramp
- Cadastre

Hazard

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

Design Surface (mAHD)

High : 32.0

Low : 28.7

0 5 10 20 Meters 1:750

Figure D4 [D]

Developed Case
PMF Flood Hazard
(ARR 2019)

143 Stoney Creek Road, Beverly Hills

NORTHROP

Data Source: LPI

10/11/2020 \\ncl-nas3\FLOODING\PROJECTS\SYDNEY\2020 Jobs\BeverlyHills\TUFLOW\Figures\ArcMap\SY200410__D4[D].mxd

Legend

- Subject Site
- Existing Building
- Cadastre

Water Elevation 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

0 12.5 25 50 Meters 1:1,000

Figure E1 [E]

Pre to Post Comparison 1% AEP Flood Elevation

Data Source: LPI

143 Stoney Creek Road, Beverly Hills

NORTHROP

6/11/2020 X:\PROJECTS\SYDNEY\2020 Jobs\BeverlyHills\TUFLOW\Figures\ArcMap\SY200410__E1[E].mxd

Legend

- Subject Site
- Existing Building
- Cadastre

Water Elevation 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

0 12.5 25 50 Meters 1:1,000

Figure E2 [E]

Pre to Post Comparison PMF Flood Elevation

143 Stoney Creek Road, Beverly Hills

NORTHROP

Data Source: LPI

6/11/2020 X:\PROJECTS\SYDNEY\2020 Jobs\BeverlyHills\TUFLOW\Figures\ArcMap\SY200410__E2[E].mxd

Appendix B – Flood Emergency Response Summary

The following provides as summary of the expected flood behaviour and the anticipated Flood Emergency Response including:

- A summary of the anticipated developed case flood depth and elevation at each corner of the subject site during both the 1% AEP and PMF design storm events. Flood depths and elevations are presented to provide an understanding of the expected flood behaviour across the subject site (refer to Table 1).
- A comparison of the proposed floor levels with respect to the anticipated maximum flood levels which are provided to highlight opportunities for on-site flood refuge (refer to Table 2).
- A summary of the potentially hazardous rainfall depths that are expected to trigger evacuation/ on-site refuge and are expected to result in flooding across the subject site (refer to Table 3).
- The recommended flood emergency response measures, prior to, during and after a flood event including those responsible to managing each response measure (refer to Table 4).
- Example signage is provided to highlight the on-site refuge points and the procedure for facility users to follow in the event of a flood emergency (refer to the "Example Flood Signage Section below").

Table 1 - Summary of Flood Behaviour

Event	North-Eastern Corner	North-Western Corner	South-Eastern Corner	South-Western Corner
1% AEP Flood Level (mAHD)	29.92	30.25	30.22	30.38
1% AEP Flood Depth (m)	0.42	0.25	0.32	0.28
PMF Flood Level (mAHD)	30.40	30.66	30.73	30.94
PMF Flood Depth (m)	0.90	0.66	0.83	0.84

Table 2 - Internal Floor Levels

Floor	Level (m AHD)	Relationship to Flood Levels
Basement Level 3	19.50	Below 1% AEP, below PMF
Basement Level 2	22.50	Below 1% AEP, below PMF
Basement Level 1	25.50	Below 1% AEP, below PMF
Ground Level	31.20	**Above 1% AEP and PMF**
Upper Level 1	35.22	**Above 1% AEP and PMF**
Upper Level 2	38.82	**Above 1% AEP and PMF**

Table 3 - Potentially Hazardous Rainfall Depths

Depth	Timescale	Depth	Timescale	Depth	Timescale	Depth	Timescale
62.5mm	30-mins	86.7mm	1-hour	113.8mm	2-hours	166.2mm	6-hours

Table 4 - Flood Response Actions Summary

WHEN	WHAT	BY WHO
Prior to Flooding	**Nominate Flood Wardens and First Aid Officer** (at least one of each per Tenancy).	Chief Flood Warden (e.g. Building Manager)
	Assemble **Emergency Kit.**	First Aid Officer
	Check **Floodsafe Kit** every three months (one kit per Tenancy).	First Aid Officer
	Perform induction training for new staff.	Chief Flood Warden / Flood Wardens
	Coordinate drills twice per year (minimum).	Chief Flood Warden
	Sign up to the Early Warning Network and monitor weather situation at 4pm daily.	Chief Flood Warden
	Install and Maintain Flood Signage.	Chief Flood Warden / Flood Wardens
On-site Refuge	**Text / Email from the Early Warning Network** with rainfall predicted to be greater than; **62.5mm** in 30 minutes **86.7mm** in 1-hour **113.8mm** in 2-hours **166.2mm** in 6-hours	Chief Flood Warden
	If rainfall is predicted for the following day, **close the facility, and cancel all procedures / appointments.** **Notify the SES / Police** of the decision to close the facility.	Chief Flood Warden
	If rainfall is predicted for the same day, **make decision to seek refuge on-site and wait it out.** **Notify SES / Police** of the decision to seek refuge on-site and wait it out.	Chief Flood Warden
	Communicate decision to remain on-site with facility users and organise seating and lighting as required.	Chief Flood Warden and Flood Wardens
	Wait it out on Ground Floor and Upper Levels	All
	Maintain regular communication with staff and facility users.	Chief Flood Warden & Flood Wardens
	Do not attempt to access the basement levels or the flood chamber during a flood event.	All
	Do not attempt to drive or walk through floodwaters. If in a life-threatening situation, call 000 immediately.	All
Once Risk has Passed / After a Flood	Check all services and structural stability of building.	Qualified persons
	Return to occupation.	Chief Flood Warden

Example Signage and Refuge

Route to On-site Flood Refuge (Basement Level 3)

This property is flood prone with predicted depths surrounding the property of up to approximately 0.9 meters. **Refuge above predicted flood levels is available** on the Ground Floor level and above. In the event of a predicted flood event **proceed to the upper levels of the facility and remain in place to receive advice from the nominated Flood Wardens**.

No attempt should be made to evacuate elsewhere through floodwater by foot or vehicle. Access to the basement carpark should not be attempted during a flood event and lifts should not be used.

During a flood event, and following commencement of the flood emergency alarm, please proceed to the ground floor and upper levels and await instruction from the Flood Wardens.

If assistance is required, please call the following emergency numbers:

Table 5 – Emergency Numbers

Person Organisation	Name	Number
Chief Flood Warden		
Deputy Flood Warden		
First Aid Officer		
SES	-	132 500
Police / Fire / Ambulance	-	000

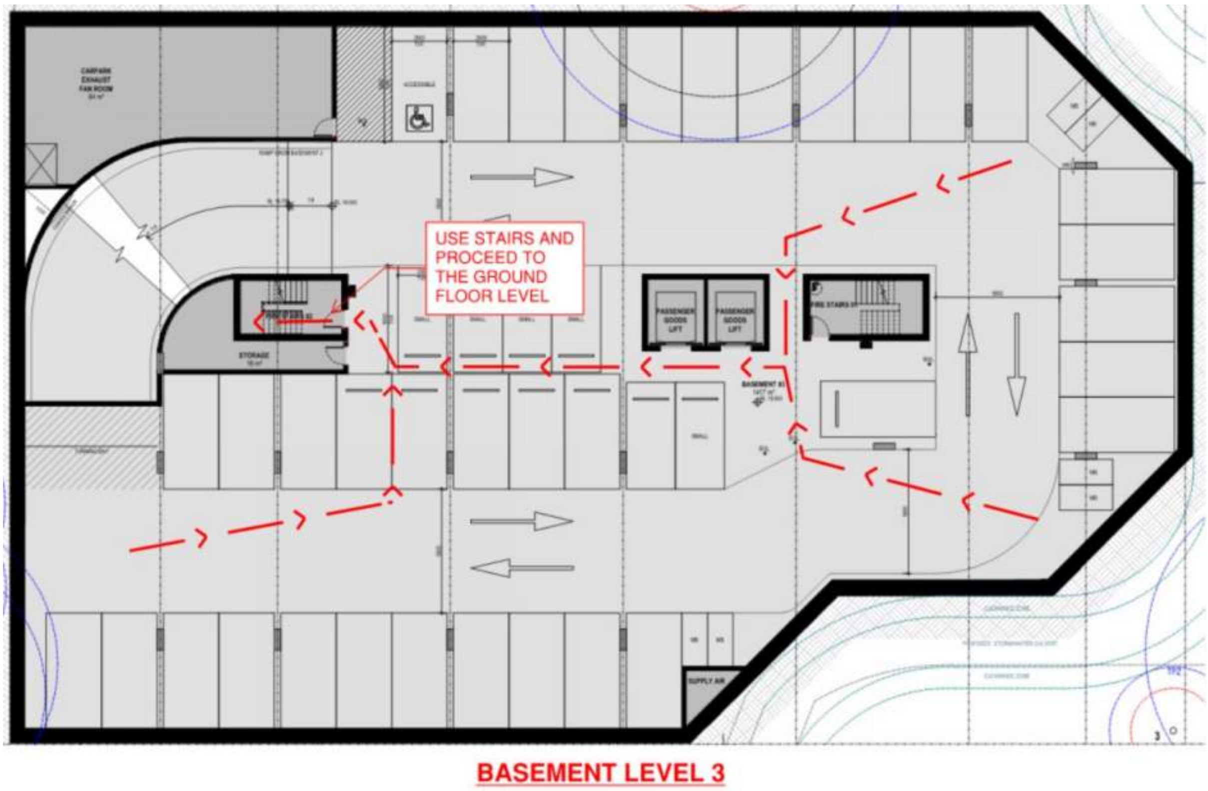


Figure 1 – Basement Level 3 Refuge

Route to On-site Flood Refuge (Basement Level 2)

This property is flood prone with predicted depths surrounding the property of up to approximately 0.9 meters. **Refuge above predicted flood levels is available** on the Ground Floor level and above. In the event of a predicted flood event **proceed to the upper levels of the facility and remain in place to receive advice from the nominated Flood Wardens**.

No attempt should be made to evacuate elsewhere through floodwater by foot or vehicle. Access to the basement carpark should not be attempted during a flood event and lifts should not be used.

During a flood event, and following commencement of the flood emergency alarm, please proceed to the ground floor and upper levels and await instruction from the Flood Wardens.

If assistance is required, please call the following emergency numbers:

Table 6 – Emergency Numbers

Person Organisation	Name	Number
Chief Flood Warden		
Deputy Flood Warden		
First Aid Officer		
SES	-	132 500
Police / Fire / Ambulance	-	000

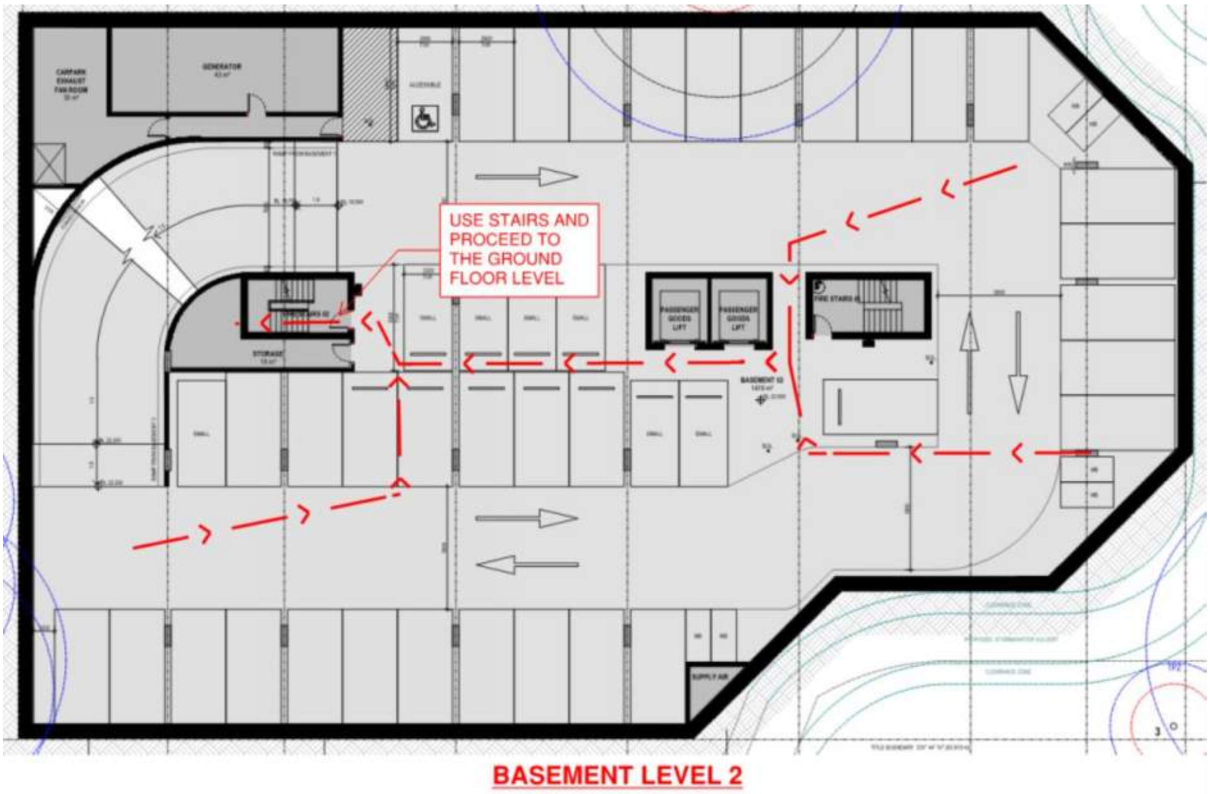


Figure 2 - Basement Level 2 Refuge

Route to On-site Flood Refuge (Basement Level 1)

This property is flood prone with predicted depths surrounding the property of up to approximately 0.9 meters. **Refuge above predicted flood levels is available** on the Ground Floor level and above. In the event of a predicted flood event **proceed to the upper levels of the facility and remain in place to receive advice from the nominated Flood Wardens**.

No attempt should be made to evacuate elsewhere through floodwater by foot or vehicle. Access to the basement carpark should not be attempted during a flood event and lifts should not be used.

During a flood event, and following commencement of the flood emergency alarm, please proceed to the ground floor and upper levels and await instruction from the Flood Wardens.

If assistance is required, please call the following emergency numbers:

Table 7 – Emergency Numbers

Person Organisation	Name	Number
Chief Flood Warden		
Deputy Flood Warden		
First Aid Officer		
SES	-	132 500
Police / Fire / Ambulance	-	000

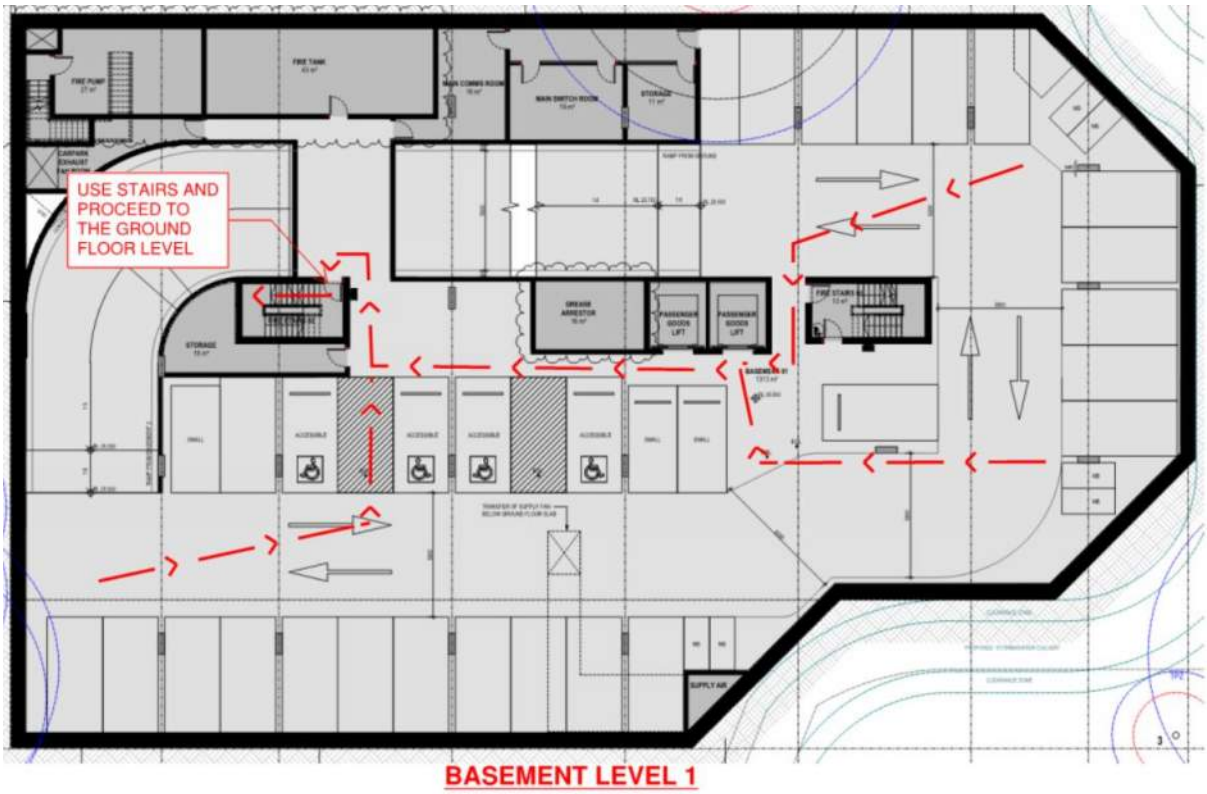


Figure 3 – Basement Level 1 Refuge

Route to On-site Flood Refuge (Ground Floor Level)

This property is flood prone with predicted depths surrounding the property of up to approximately 0.9 meters. **Refuge above predicted flood levels is available** on the Ground Floor level and above. In the event of a predicted flood event **proceed to the upper levels of the facility and remain in place to receive advice from the nominated Flood Wardens**.

No attempt should be made to evacuate elsewhere through floodwater by foot or vehicle. Access to the basement carpark should not be attempted during a flood event and lifts should not be used.

During a flood event, and following commencement of the flood emergency alarm, please proceed to the ground floor and upper levels and await instruction from the Flood Wardens.

If assistance is required, please call the following emergency numbers:

Table 8 – Emergency Numbers

Person Organisation	Name	Number
Chief Flood Warden		
Deputy Flood Warden		
First Aid Officer		
SES	-	132 500
Police / Fire / Ambulance	-	000

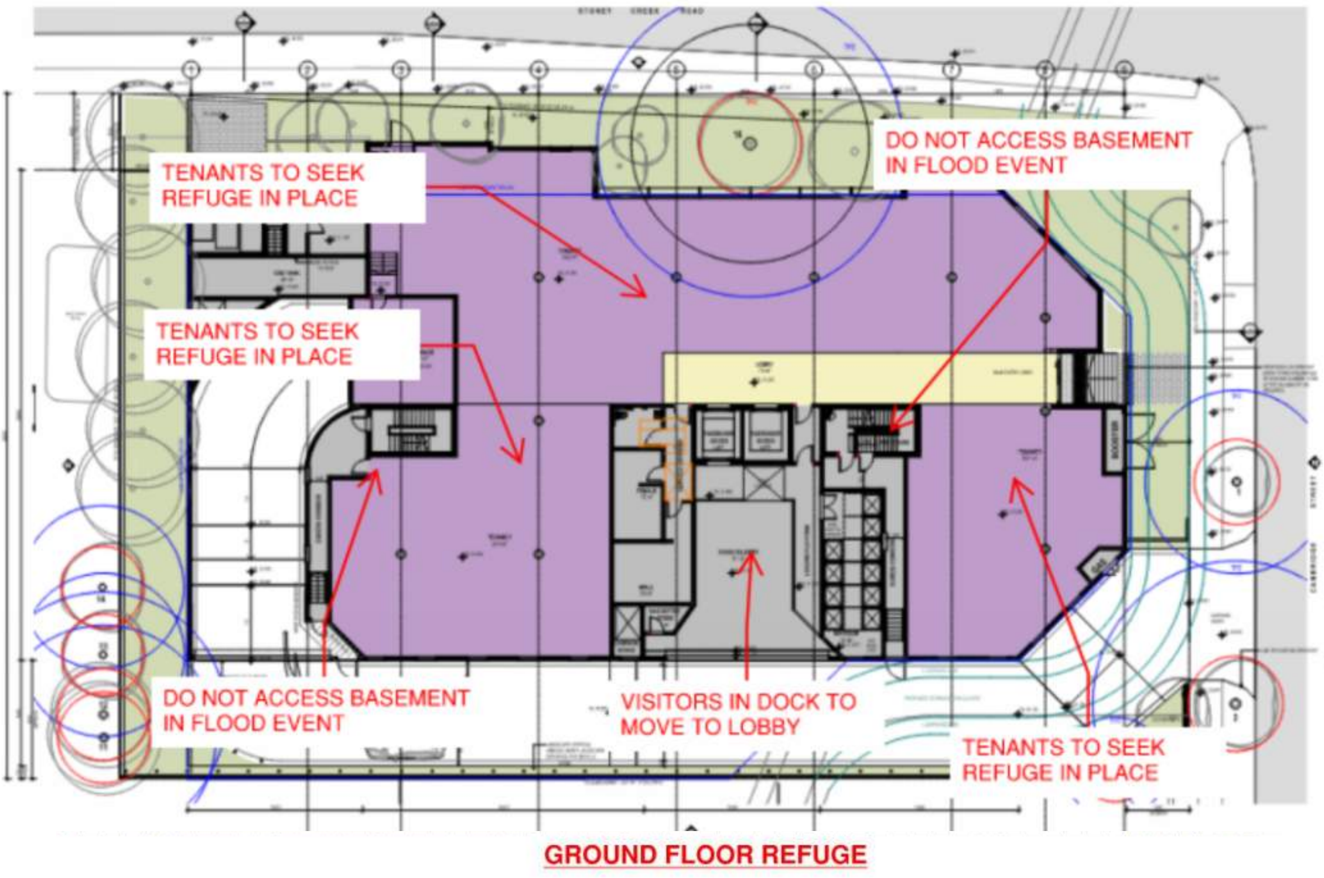


Figure 4 – Ground Floor Level Refuge

Route to On-site Flood Refuge (Upper Level 1)

This property is flood prone with predicted depths surrounding the property of up to approximately 0.9 meters. **Refuge above predicted flood levels is available** on the Ground Floor level and above. In the event of a predicted flood event **proceed to the upper levels of the facility and remain in place to receive advice from the nominated Flood Wardens**.

No attempt should be made to evacuate elsewhere through floodwater by foot or vehicle. Access to the basement carpark should not be attempted during a flood event and lifts should not be used.

During a flood event, and following commencement of the flood emergency alarm, please proceed to the ground floor and upper levels and await instruction from the Flood Wardens.

If assistance is required, please call the following emergency numbers:

Table 9 – Emergency Numbers

Person Organisation	Name	Number
Chief Flood Warden		
Deputy Flood Warden		
First Aid Officer		
SES	-	132 500
Police / Fire / Ambulance	-	000

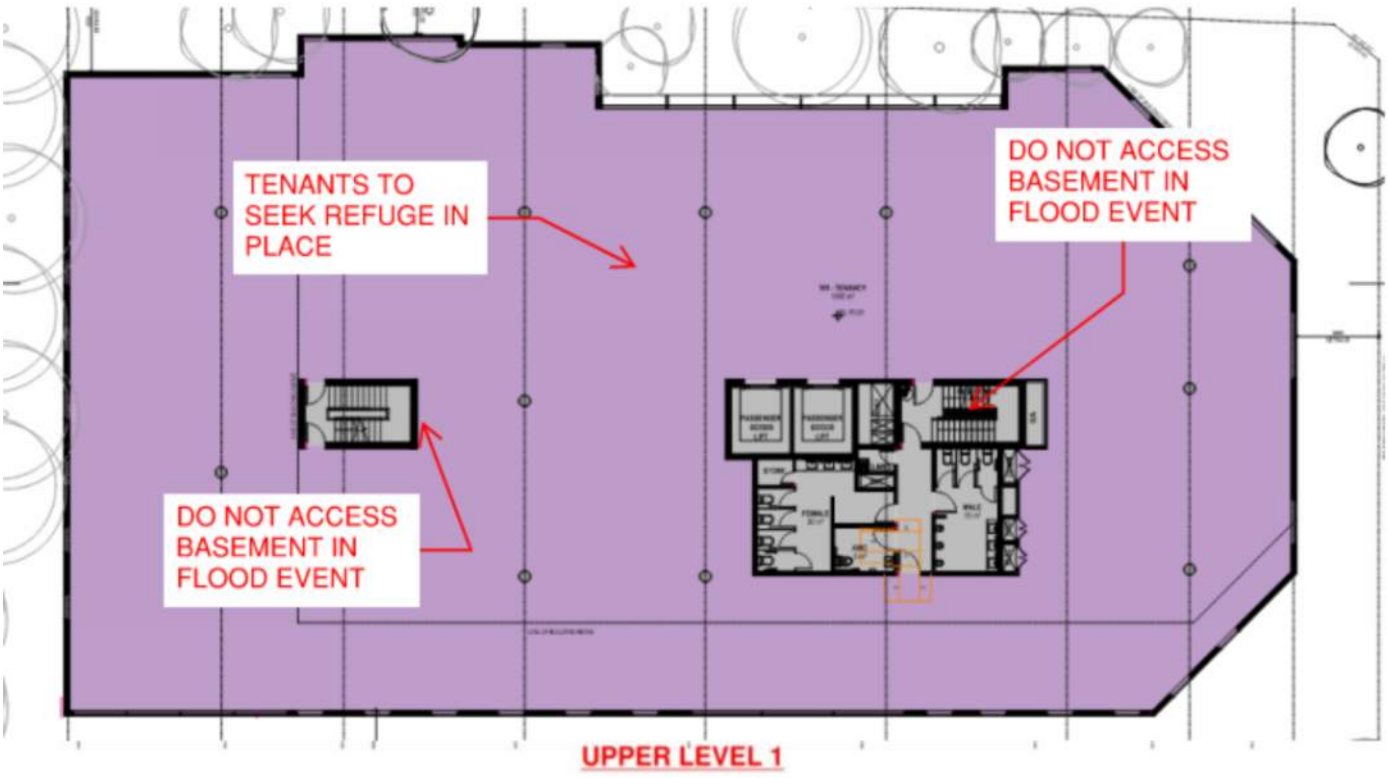


Figure 5 – Upper Level 1 Refuge

Route to On-site Flood Refuge (Upper Level 2)

This property is flood prone with predicted depths surrounding the property of up to approximately 0.9 meters. **Refuge above predicted flood levels is available** on the Ground Floor level and above. In the event of a predicted flood event **proceed to the upper levels of the facility and remain in place to receive advice from the nominated Flood Wardens**.

No attempt should be made to evacuate elsewhere through floodwater by foot or vehicle. Access to the basement carpark should not be attempted during a flood event and lifts should not be used.

During a flood event, and following commencement of the flood emergency alarm, please proceed to the ground floor and upper levels and await instruction from the Flood Wardens.

If assistance is required, please call the following emergency numbers:

Table 10 – Emergency Numbers

Person Organisation	Name	Number
Chief Flood Warden		
Deputy Flood Warden		
First Aid Officer		
SES	-	132 500
Police / Fire / Ambulance	-	000

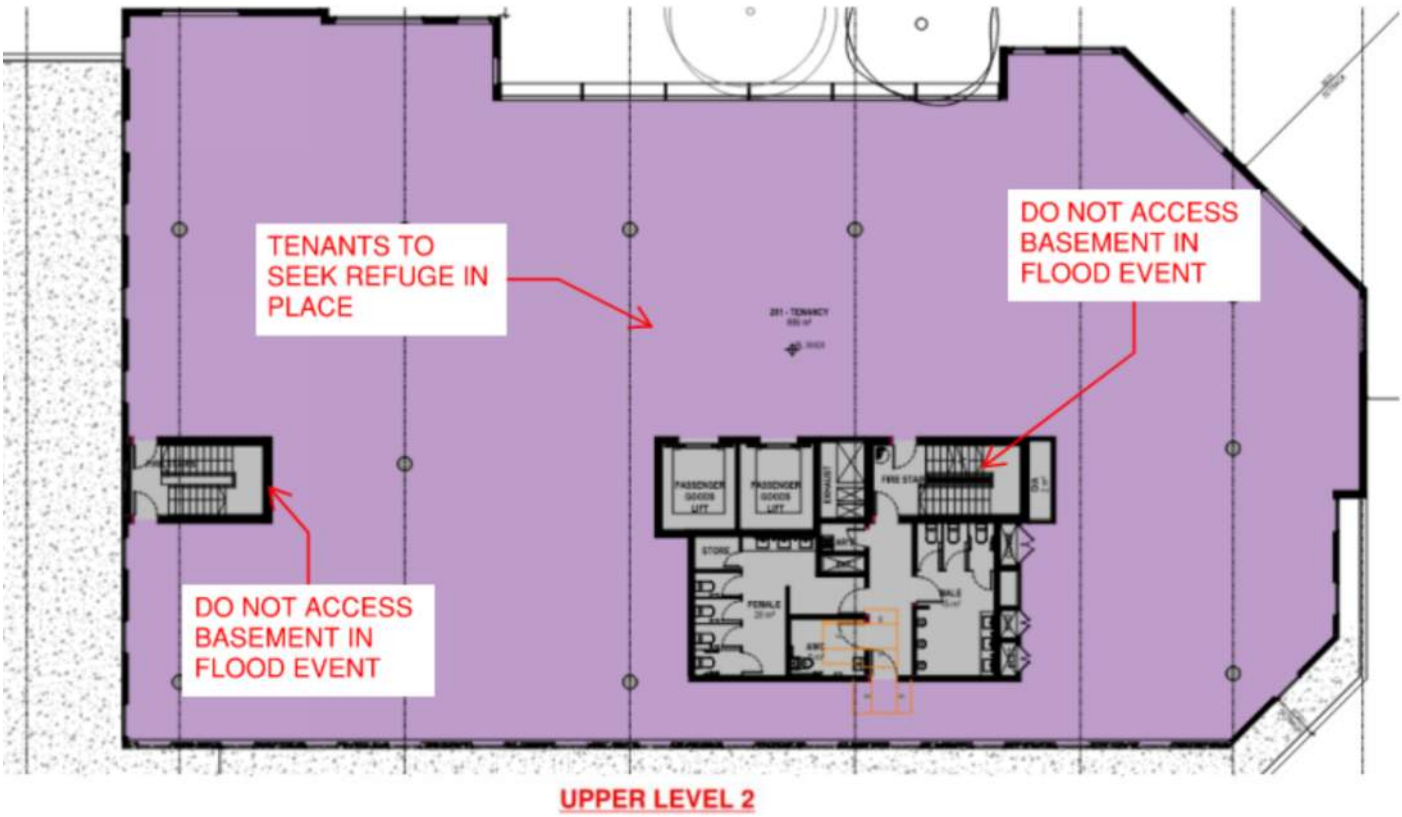


Figure 6 – Upper Level 2 Refuge