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Flood Impact Assessment Report

Warrawong Plaza Redevelopment

Elanor Investors Group

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1 INTRODUCTION

The site of Warrawong Plaza in east Warrawong is located at 43-65 Cowper Street, fronting Cowper Street, King Street and Northcliffe Drive. The site currently consists of a major shopping mall with retail stores, supermarkets, a cinema, hospitality venues and other services.

In early 2023 the opportunity for the site to participate in the State Assessed Planning Proposal Pilot Program was identified, with the potential for the submission of a Planning Proposal which had the capacity to unlock housing supply on the site as well as provide affordable housing as part of the redevelopment of the site. This report has been prepared to support a Planning Proposal which will seek consent for:

- Amendment to the land use zoning of the Site (clause 2.1) from E2 Commercial Centre to MU1 Mixed Use.
- Increase in the Height of Building Development Standard from 24 m up to 75 m (variable between 24 m to 75 m).
- Amendment to the Key Sites Map to identify 43-65 Cowper Street, Warrawong as “Area 11”.
- Introduction of specific additional ‘Local Provisions’ in Part 7 of the WLEP 2009, through a Site-specific LEP clause 7.24 to allow for the mixed-use redevelopment of the existing retail centre at 43-65 Cowper Street, Warrawong, and references “Area 11” on the Key Sites Map.

The proposal will retain a minimum of 50,000m^2 of Gross Floor Area for non-residential land uses, and provide a public open space area with a minimum area of 3,000m^2. The development will deliver approximately 1,300 dwellings.

Development of this site is intended to take place over three stages:

- Stage 1 – Demolition and redevelopment of the northern section of the Warrawong Plaza
- Stage 2 – Demolition and redevelopment of the southern section of the Warrawong Plaza
- Stage 3 – Demolition and redevelopment of the centre of Warrawong Plaza and basement parking

The following assessment has been prepared to support planning requirements to ensure that the proposed development works at 43-65 Cowper Street, Warrawong are appropriately protected from the risk of overland flooding and to ensure the proposed development does not increase or alter the existing flooding risk to adjoining properties, key pedestrian pathways or the local road network.

As part of the flood assessment modelling of the existing and developed flood depth, water surface elevation, velocity, and flood hazard for the 1% AEP and PMF flood events in line with Australian Rainfall and Runoff 2019 guidelines has been completed.

1.1 Site

The site development shares three street frontages including Cowper Street, King Street and Northcliffe Drive. Figure 1-1 shows the location of the development site.

The catchment within this locality generally slopes in a south-westerly direction and outlets at Kully Bay. The site elevations vary significantly across the property, from approximately 9 metres AHD in the north-eastern corner of the property (Cowper Street) to around 3.2 metres AHD in the south-western corner of the property (King Street and Northcliffe Drive). Figure 1-2 shows the existing site topography.

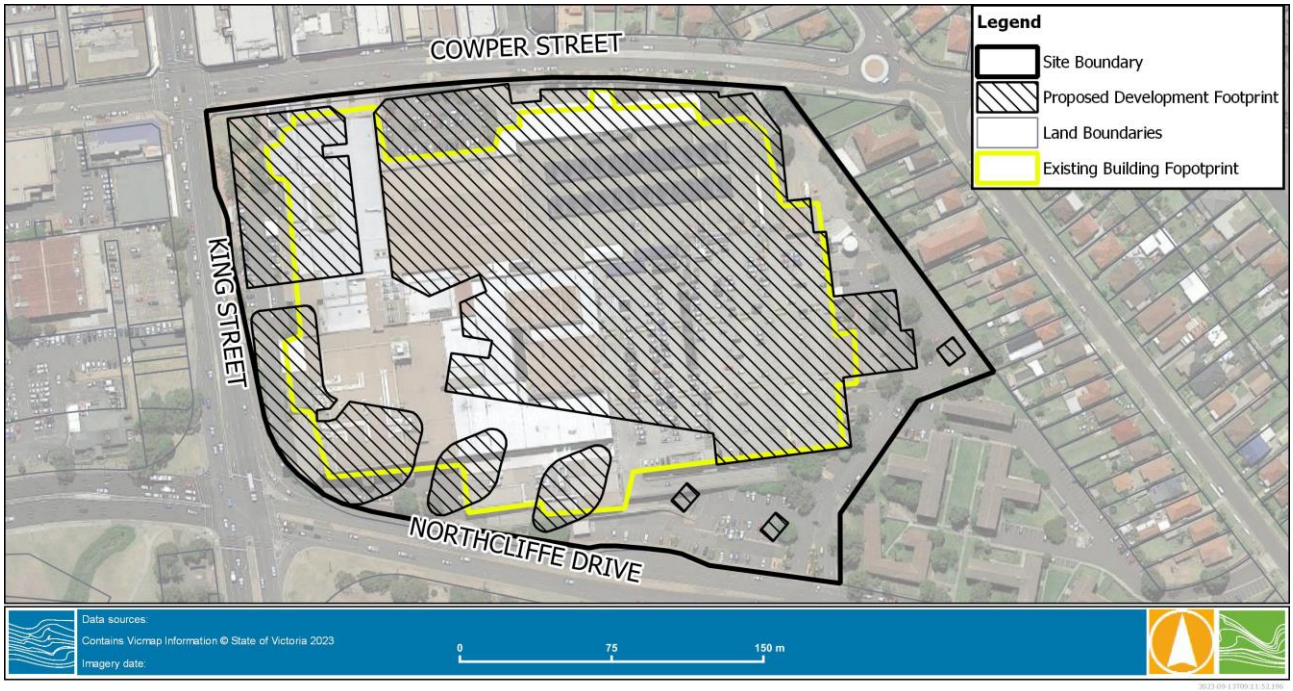

FIGURE 1-1 SITE LOCATION

FIGURE 1-2 SITE (MODEL) ELEVATION

2 EXISTING CONDITIONS

2.1 Existing Conditions Model Overview

The model utilised for this assessment was adapted from the Kully Bay Overland Flow Study (Rhelm, 2019) to include updates to the proposed development. A TUFLOW Rain-on-Grid hydraulic model at 2 metre grid resolution was used to reestablish the existing inundation conditions for the 1% AEP and PMF flood events at the site.

The schematisation of the model is consistent with the original model developed by Rhelm which used a direct rainfall approach. The model boundary and outflow boundary locations are shown in the Figure 2-1 below.

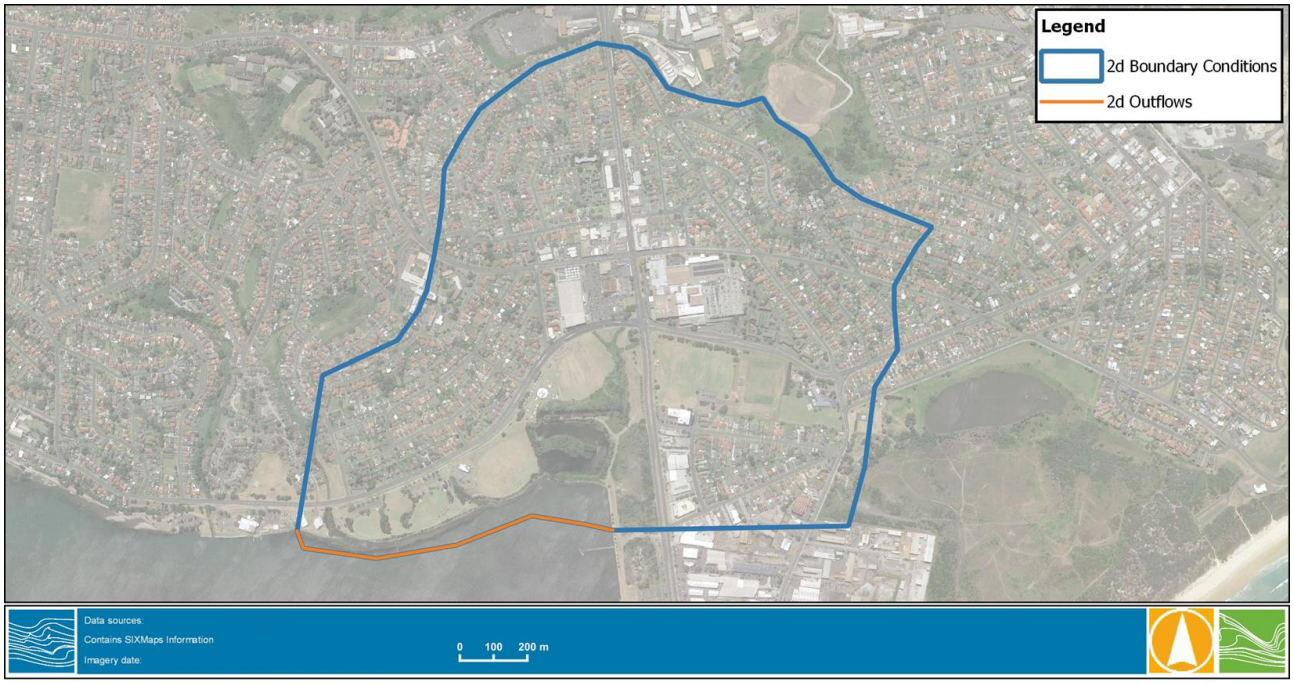

FIGURE 2-1 MODEL BOUNDARY

Table 2-1 below summarises the rainfall losses and hydraulic roughness (Manning's n) used for the hydraulic modelling as per the land use types within the area. A map of the material codes corresponding to the adopted model roughness is provided in Figure 2-2.

TABLE 2-1 MANNING'S N ROUGHNESS COEFFICIENTS AND LOSSES

Material Code	Land Use	Manning's n Roughness	Initial Loss	Continuing Loss
1	Default - residential	0.1	5	1
2	Carpark	0.02	2	0
3	Open space and parklands	0.03	9.2	2.4
4	Roads	0.015	2	0
5	Riparian and medium	0.06	10	2.5
6	Vegetation	0.05	10	2.5
7	Water	0.01	0	0
8	High roughness buildings	1	0	0

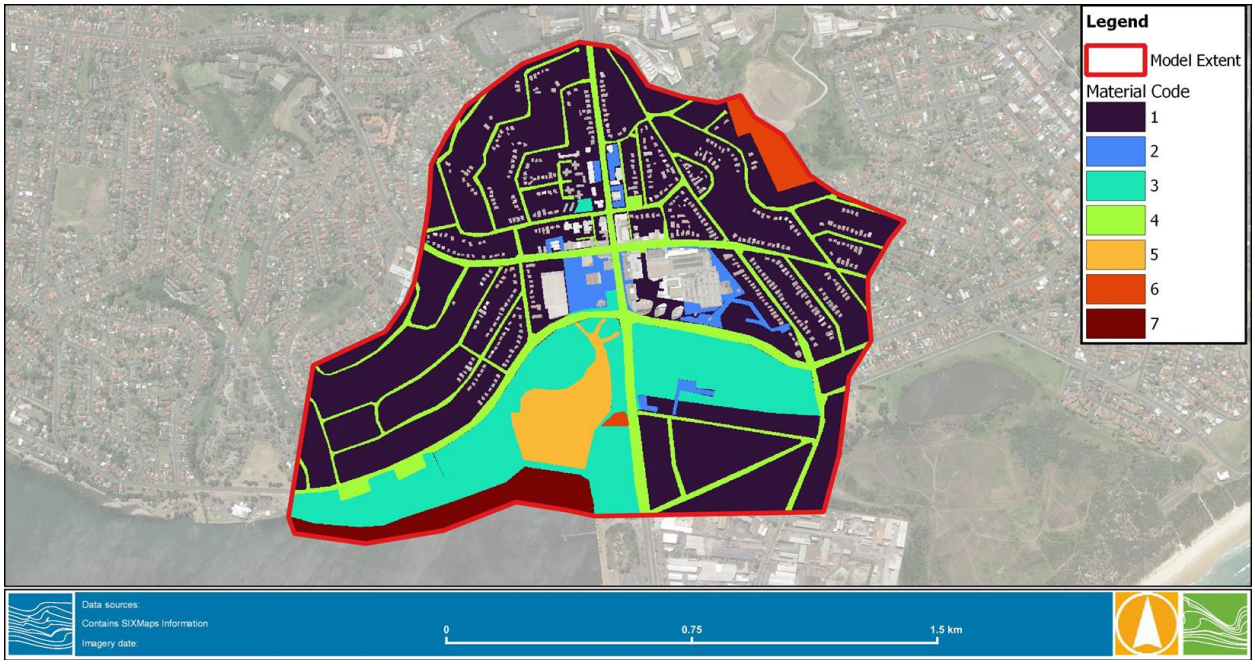

FIGURE 2-2 MODEL ROUGHNESS

The local drainage network including all pits and pipes was represented within the model to ensure that conveyance of surface flows and the sub-surface network is appropriately considered, shown in Figure 2-3. A 2.5 x 0.9m box culvert[1] stormwater pipe flows in a southerly direction from Cowper Street under the existing shopping centre to Northcliffe Drive and outlets at Kully Bay. These pipe connections are nodes and do not have any surface pits within the shopping centre footprint. There is one surface pit located within the carpark in the south-westerly corner of the site which also outlets to Northcliffe Drive.

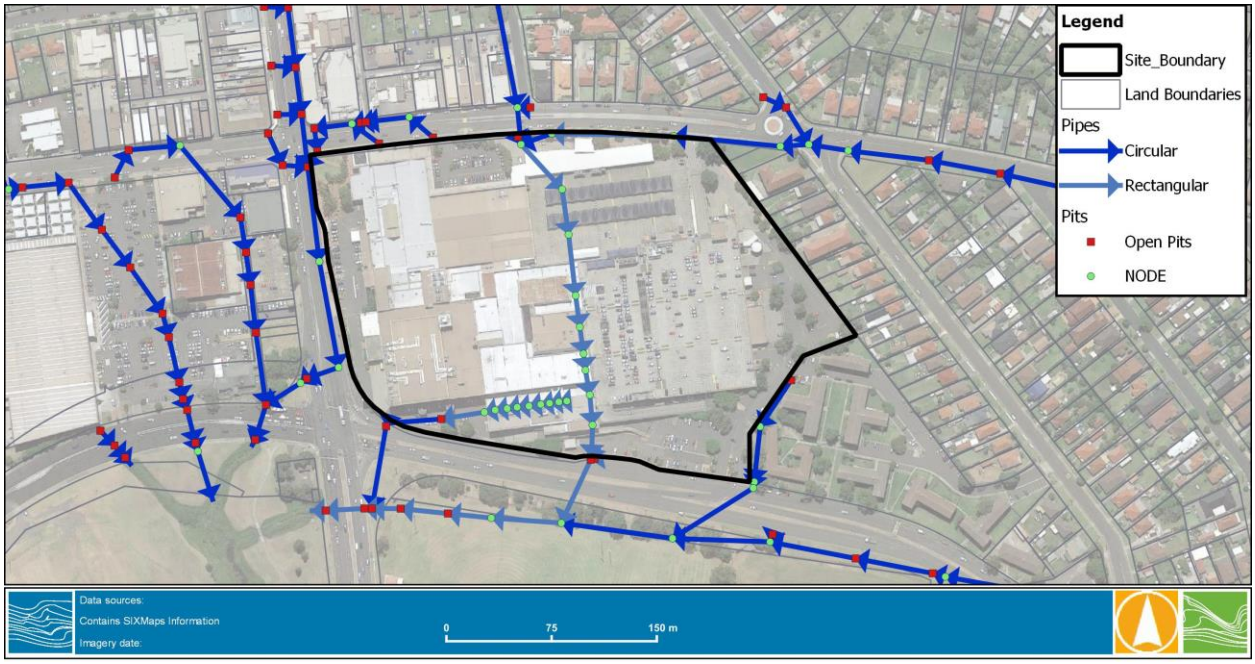

FIGURE 2-3 DRAINAGE NETWORK

[1] Dimension were taken from Rhelm model and will be surveyed in the next stage of the design.

2.2 Existing Conditions Results

Existing conditions modelling indicated flooding in this area is driven by medium duration storm events (90 and 120 minute), which is within a typical range for built up areas. Flooding mechanisms around the site include overland flood paths from the north along King Street and from the east along Northcliffe Drive. The model also utilises a high bay water level boundary condition (at Kully Bay) of 1.81 m AHD in the 1 % AEP event which is equivalent to a 5% AEP Lake water level and 2.24 m AHD in the PMF event which is equivalent to a 1% AEP Lake water level. This boundary condition interacts with flows to the south of the site.

An assessment of the modelled durations, which included the 15 min, 60 min, 90 min, 120 min and 180 min storm, indicates that maximum flood depths occur for the events ranging between the 90 – 120 minutes. Post processing of the TUFLOW extent and depth results used the combined maximum output of all modelling storm durations.

The models results were filtered by removing depths of less than 0.15 m or velocity depth products less than 0.1 m^2/s, consistent with processes applied by Rhelm during the previous study. Small puddles (<200m^2) were also filtered from the flood depth mapping.

Note that due to the filtering applied, cumulation of on-site stormwater run-off to localised depressions has been removed in some instances. While not shown in the below figures, it will be important to consider where local rainfall / run-off will accumulate and ensure that during landscaping and design that site-specific stormwater infrastructure is appropriately considered.

The existing conditions 1% AEP flood depth (Figure 2-4) and PMF Flood depth (Figure 2-5) results indicate flooding depths varying across the site from 0 – 1.3 metres, with the greatest depths identified within low points of the existing carpark to the east of the centre near Woolworths, and along the Cowper Street frontage.

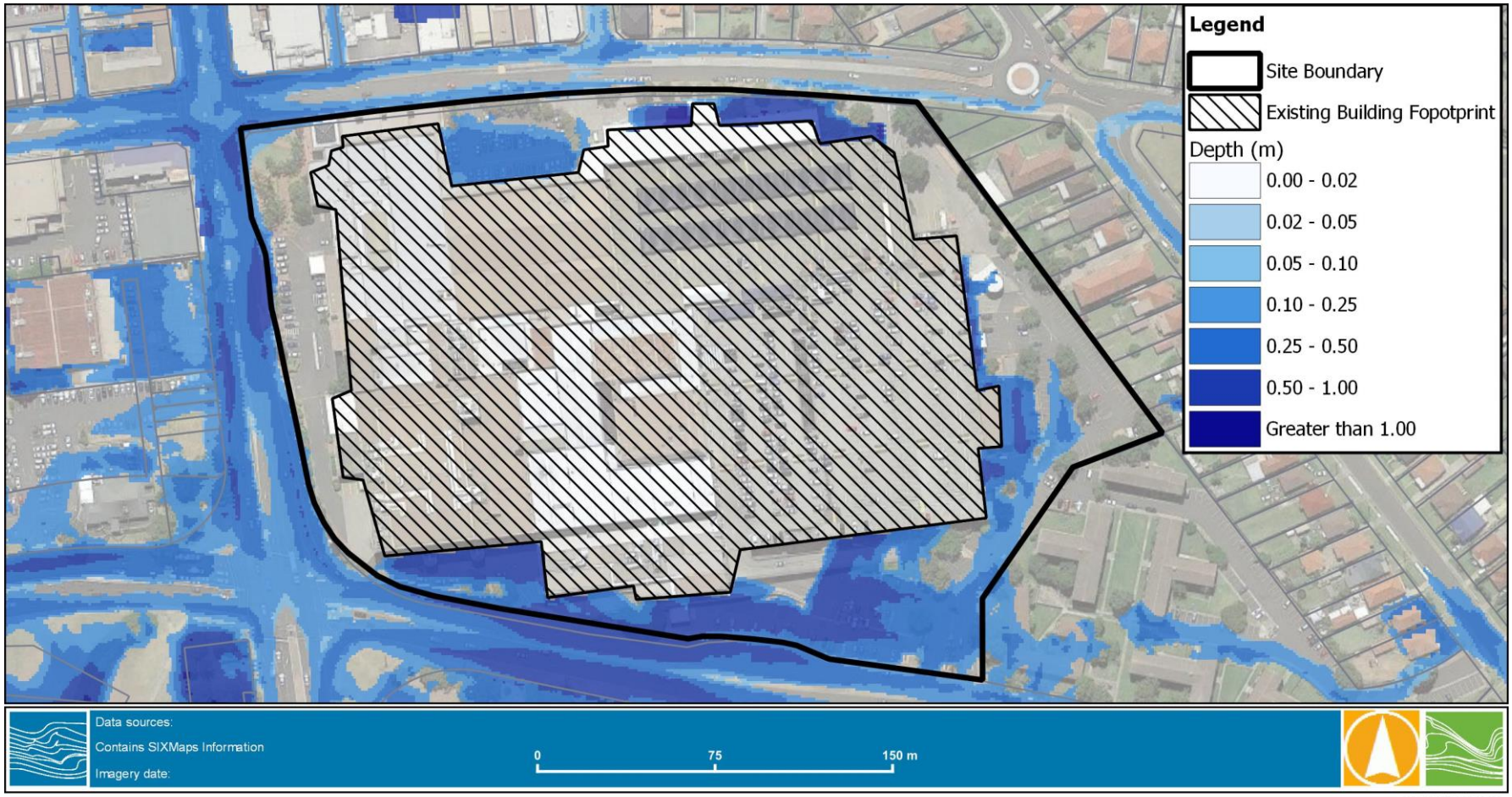

FIGURE 2-4 1% AEP FLOOD DEPTH – EXISTING CONDITION

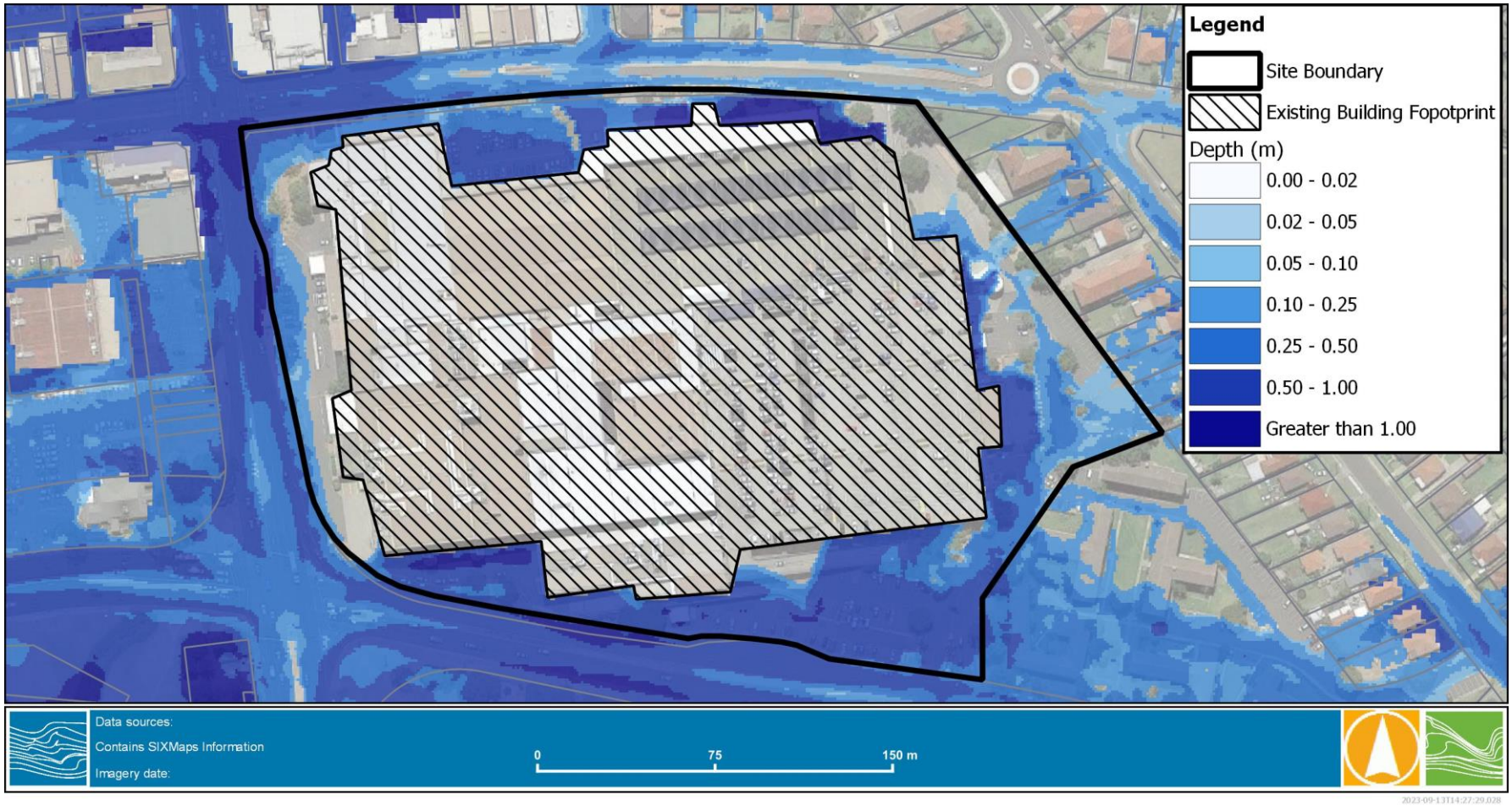

FIGURE 2-5 PMF FLOOD DEPTH – EXISTING CONDITIONS

3 DEVELOPED REFERNCE DESIGN CONDITIONS

3.1 Reference Design Conditions Overview

Reference design condition flood modelling of this site represented the construction of the proposed new buildings for the reference design. The reference design layout plans are shown in Figure 3-1 and Figure 3-2. The modelled changes to represent the proposed building footprint are shown in Figure 3-2.

The modelling assumed a proposed building footprint including finished floor levels in line with plans provided as shown in Figure 3-2. There is a raised internal access network between the proposed buildings at a level of 6 m AHD, shown in light grey in Figure 3.3. There are three locations which slope from the existing ground level at the road access entry locations to the proposed raised internal access network. These access ramps are located at Cowper Street, King Street and Northcliffe Drive, shown in dark grey in Figure 3-3.

Ground levels around the outsides of the building between the surrounding roads and the reference design are based on current topographic information. It is assumed these design surfaces will be developed further and tied into existing road levels as the project progresses.

It is noted that the two eastern residential buildings in the reference design along Northcliffe Drive will be located on columns, as shown in Figure 3-2. This aims to prevent the buildings blocking the existing flow paths which pass through this area. The existing flow paths are displayed in Figure 3-3.

FIGURE 3-1 REFERENCE DESIGN LAYOUT

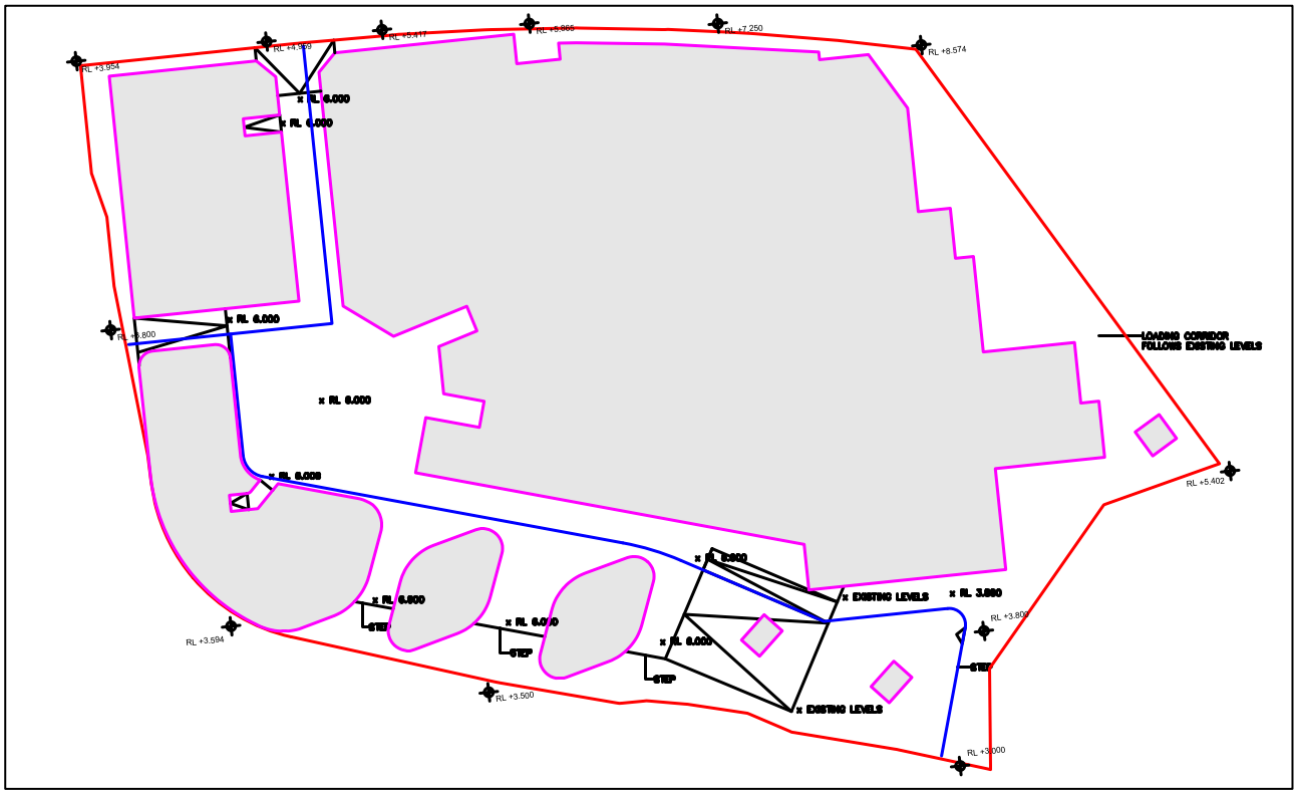

FIGURE 3-2 REFERENCE DESIGN LAYOUT – BUILDING FOOTPRINTS

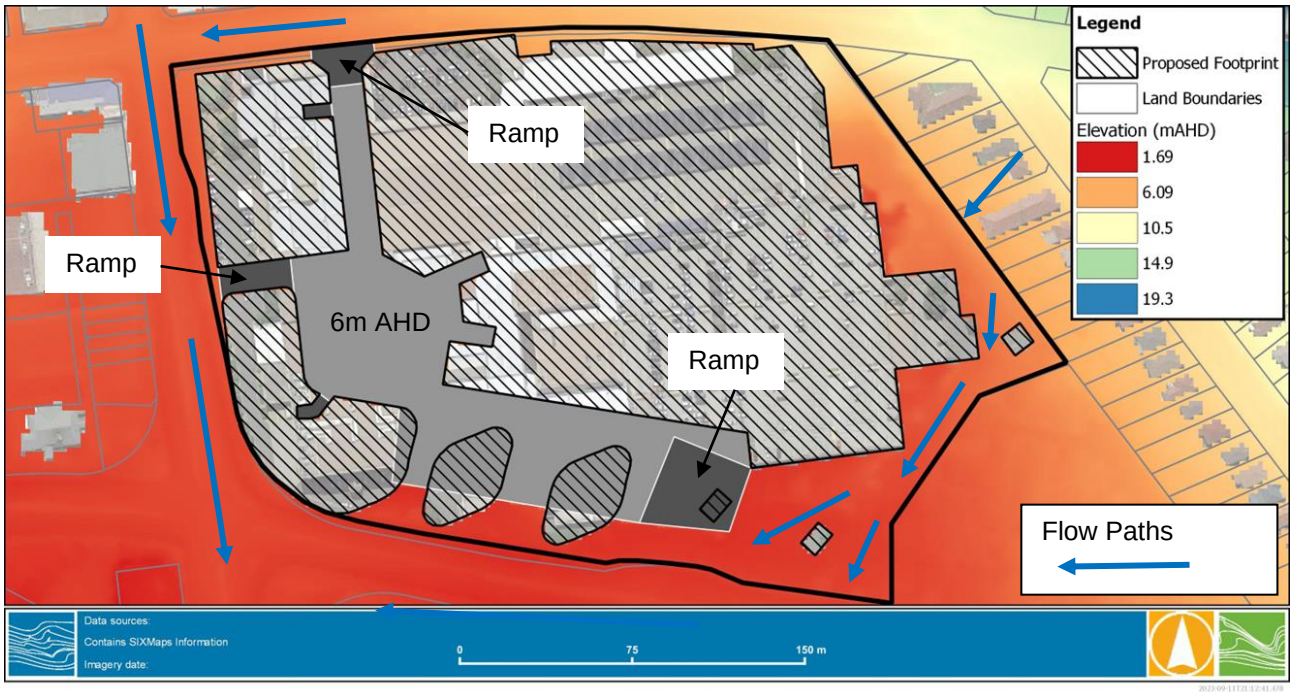

FIGURE 3-3 PROPOSED REFERENCE DESIGN BUILDING FOOTPRINT

3.2 Reference Design Conditions Results

Flood modelling results for developed conditions flood depths is shown in Figure 3-4 (1% AEP) and Figure 3-9 (PMF). The water surface elevations for the 1% AEP and PMF flood events have been produced and are shown in Figure 3-5 and Figure 3-10. Results indicate high water depths along the Northcliffe Drive frontage and along the eastern property boundary. In addition, flood velocity for both the PMF and 1% AEP events are presented in Figure 3-6 (1% AEP) and Figure 3-11 (PMF). High flow velocities of greater than 1m/s are shown to occur along the eastern property boundary where flows have been concentrated within the narrow accessway.

Similar to the existing conditions, the model results were filtered by removing depths of less than 0.15 m or velocity depth products less than 0.1 m^2/s, consistent with processed applied by Rhelm during the previous study. Small puddles (<200m^2) were also filtered from the flood depth mapping.

3.2.1 Flood Impact Assessment

A comparison of the difference between developed and existing conditions flood depths (afflux mapping) is shown in Figure 3-7 and Figure 3-8 for the 1% AEP and Figure 3-12 and Figure 3-13 for the PM.F

Flooding depths during the 1% AEP are impacted by the reference design development layout. This is due to the removal of the available floodplain storage in the existing eastern carpark and changes to the active flow path which passes through the eastern carpark and into Northcliffe Drive. The area of impact is localised to within the eastern carpark and along Cowper Street and King Street beside the new building frontages.

During the 1% AEP event, the impacts result in both an increase and decrease in flood depths external to the site, within Cowper Street and King Street. The increase in flood depths is generally below 20 cm and occurs over the King Street road reserve as a result of flow being redirected westerly into the road caused by the new building footprint. Similarly, this is observed in the Cowper Street road reserve where the new building footprint redirects the runoff northerly into the road reserve, noting that the increase in flood depths is generally below 15 cm. No flood depth impacts are observed to any external residential properties.

More significant increases are observed within the site boundary. The maximum existing conditions flooding depths within the site boundary during the 1% AEP event is 1.75 m along Cowper Street, while in the proposed reference design scenario flooding depths reach up to 2.75 m within the eastern carpark adjacent to the new Woolworths extension. The maximum existing conditions flooding depths within the site boundary during the PMF event are 1.95 m along Cowper Street and during reference design conditions 2.84 m around the eastern carpark adjacent to the new Woolworths extension.

In the 1% AEP event, the results indicate that the flooding within the site ranges from generally safe (H1) to Unsafe for People & Vehicles, Buildings Vulnerable to Damage (H5). The flood hazard along King Street and Northcliffe Drive is an existing issue with flood depth and velocity shown to be unsafe for people and vehicles. The impact of the reference design development has a minor effect on the flood hazard levels along King Street, slightly increasing the area in which H5 is experienced. Despite this increase, the overall hazard from flooding is relatively unchanged. No changes in hazard level are observed at other properties.

The maximum existing velocity within the site boundary during the 1% AEP event decreases from 3.48 m/s to 3.30 m/s. The maximum velocity on site is observed in the eastern carpark in the main flow path. It is assumed the velocity slightly reduces due to the blockage of the proposed new building.

3.2.2 Lake Flooding

The reference design development would have a minor impact on lake flooding in all events up to and including the PMF. The following calculations are provided as an estimate to give a sense of the magnitude of potential impacts which are being contemplated. The following analysis assumes that the land below the PMF on site has a sensitive "Flood Storage" category (rather than Flood Fringe) where the occupation of flood storage volume on site will result in the displacement of floodwaters and an increase in flood levels elsewhere. To estimate the displaced volume we have assumed that the volume of lake floodwaters displaced by the reference design development in a flood up to the PMF would be equal to the area of the site below the PMF level multiplied by the difference between the lake PMF level (3.24 m AHD) and the minimum level on site (2.3 m AHD). This is a highly conservative approach, overestimating the volume of water displaced by the reference design development because:

- the existing landscape slopes down towards 2.3 m AHD at the southern margin of the site, rather than being a flat surface at 2.3 m AHD; and
- in existing conditions a large part of this volume is occupied by the existing shopping centre.

The area of the site below the lake PMF would be 28,150 m^2. The PMF level is 3.24 m AHD and the minimum level on site is 2.3 m AHD. The volume of water that may potentially be displaced in a flood up to the FPL is therefore:

$$\begin{aligned} Volume_{displaced\ floodwater} &= Area_{below\ PMF} \times (PMF - Level_{lowest\ level\ on\ site}) \\ &= 28{,}150\ m^2 \times (3.24\ m - 2.3\ m) \\ &= 26{,}461\ m^3 \end{aligned}$$

The surface area of Lake Macquarie is 35.8 km^2, which is 35,800,000 m^2. Therefore, the volume of the lake between 2.3 m AHD and 3.24 m AHD in existing conditions is:

$$\begin{aligned} Lake\ Volume_{existing\ conditions} &= Lake\ Area \times (PMF - Level_{lowest\ level\ on\ site}) \\ &= 35{,}800{,}000\ m^2 \times (3.24\ m - 2.3\ m) \\ &= 33{,}652{,}000\ m^3 \end{aligned}$$

This is a conservative underestimation of the lake that assumes the surface area of the lake does not change as floodwaters rise. Due to the downward slope of the topography towards the water around the lake, in a flood event the surface area of the lake would increase as the lake level rises, resulting in a much larger lake volume than that estimated above.

In post-development conditions the reference design development would displace up to 26,461 m^3 of floodwaters, which would be dispersed across the surface of the lake. The increase in flood level would be:

$$\begin{aligned} Increase\ in\ flood\ level &= \frac{Volume_{displaced\ floodwater}}{Lake\ Area} \\ &= \frac{26{,}461\ m^3}{35{,}800{,}000\ m^2} \\ &= 0.00074\ m \\ &= 0.74\ mm \end{aligned}$$

The displacement of floodwaters would therefore result in a 0.74 mm increase in lake flood levels in a flood up to the PMF. However, this is an overestimation given that:

- the surface area of the lake would increase as floodwaters rise
- the topography of the site slopes down rather than being a flat surface at 0.87 m AHD
- much of the area below the lake PMF on site is already occupied by an existing building.

The 0.74 mm flood increase conservatively estimated above is well within the permissible 20 mm for individual developments.

FIGURE 3-4 1% AEP FLOOD DEPTH - REFERENCE DESIGN

FIGURE 3-5 1% AEP FLOOD LEVELS - REFERENCE DESIGN

FIGURE 3-6 1% AEP PEAK VELOCITY - REFERENCE DESIGN

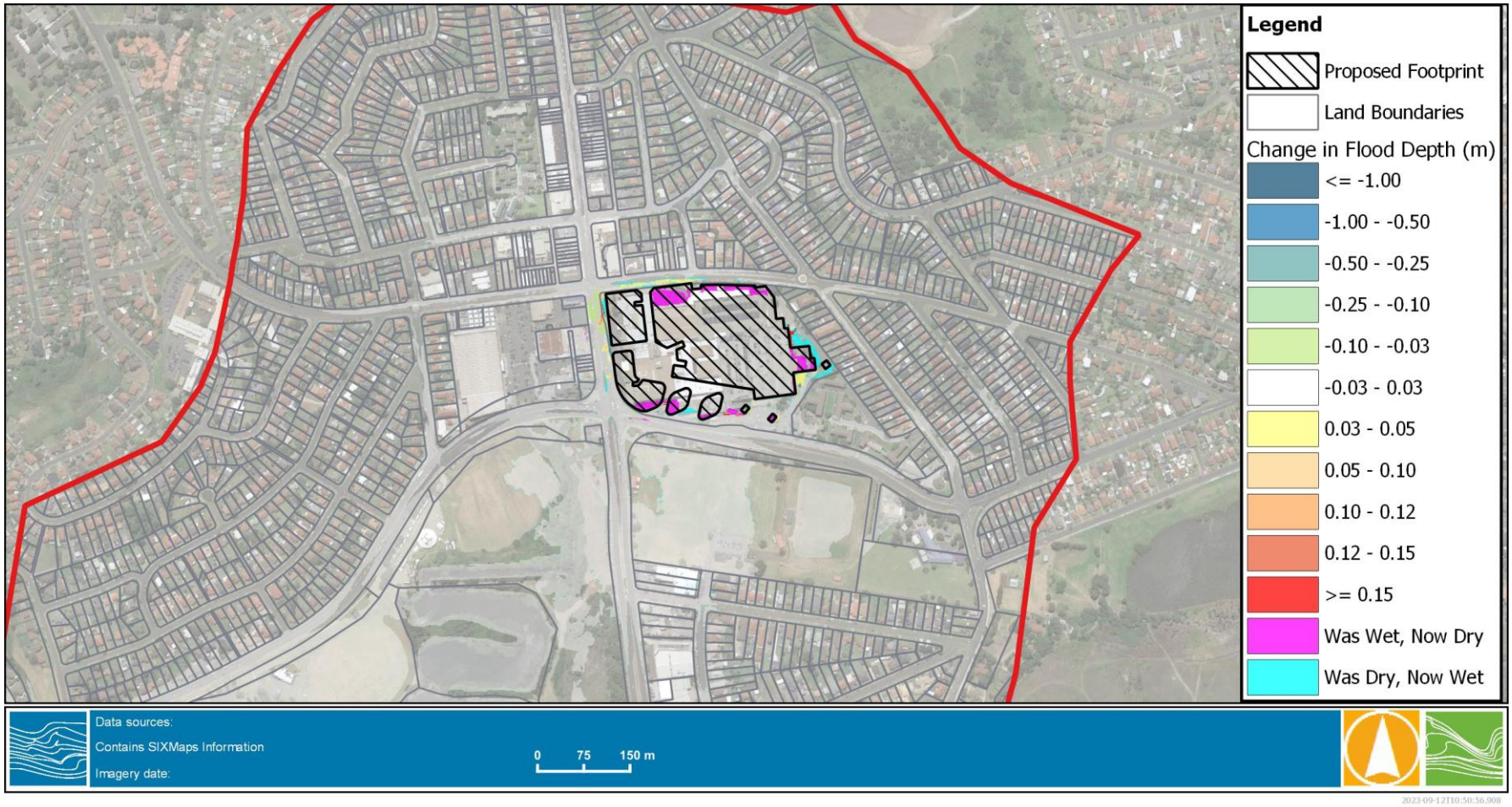

FIGURE 3-7 1% AEP FLOOD DEPTH DIFFERENCE REFERENCE DESIGN VS EXISTING

FIGURE 3-8 1% AEP FLOOD DEPTH DIFFERENCE REFERENCE DESIGN VS EXISTING (SITE SPECIFIC)

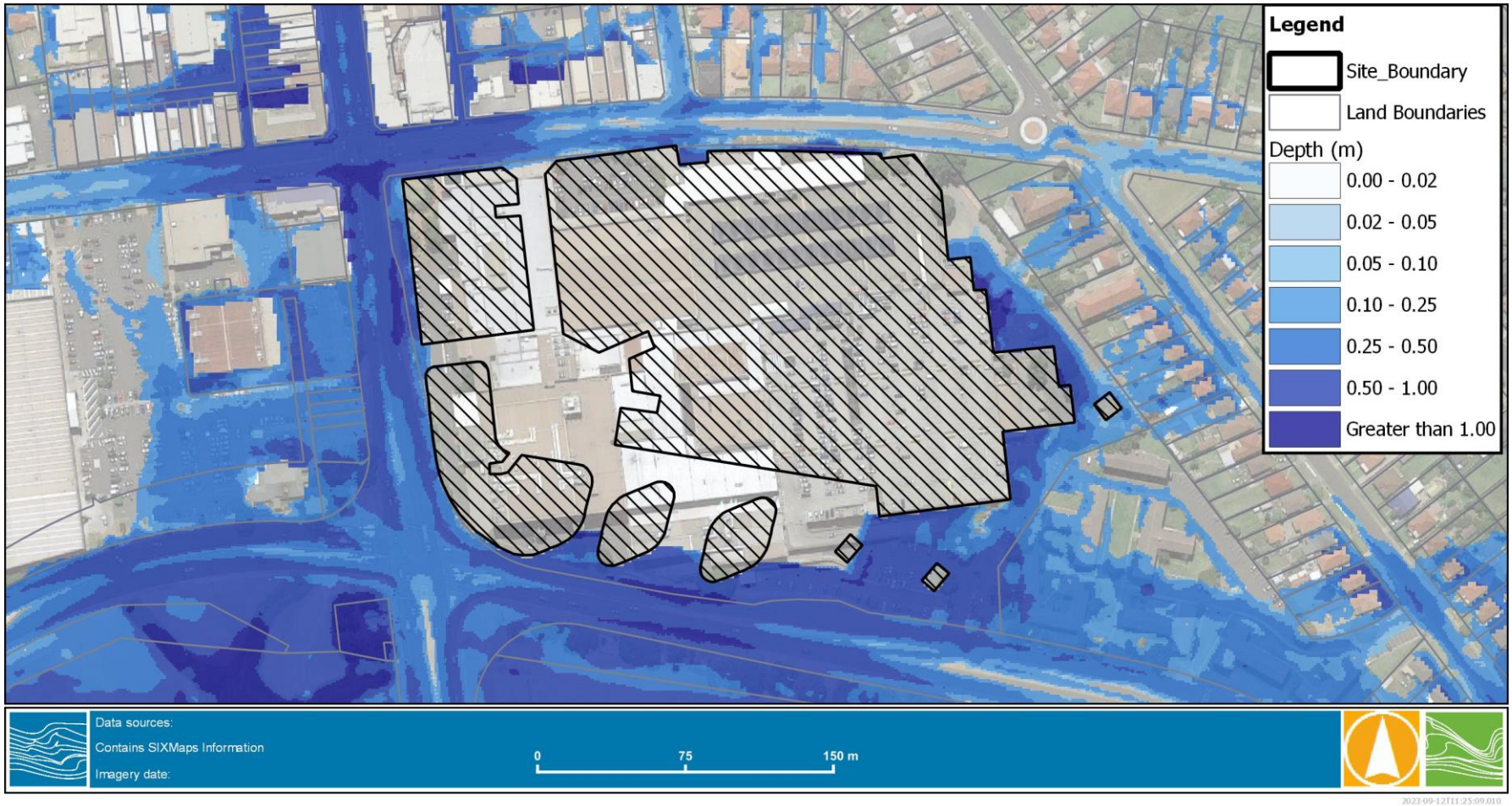

FIGURE 3-9 PMF FLOOD DEPTH - REFERENCE DESIGN

FIGURE 3-10 PMF FLOOD LEVELS - REFERENCE DESIGN

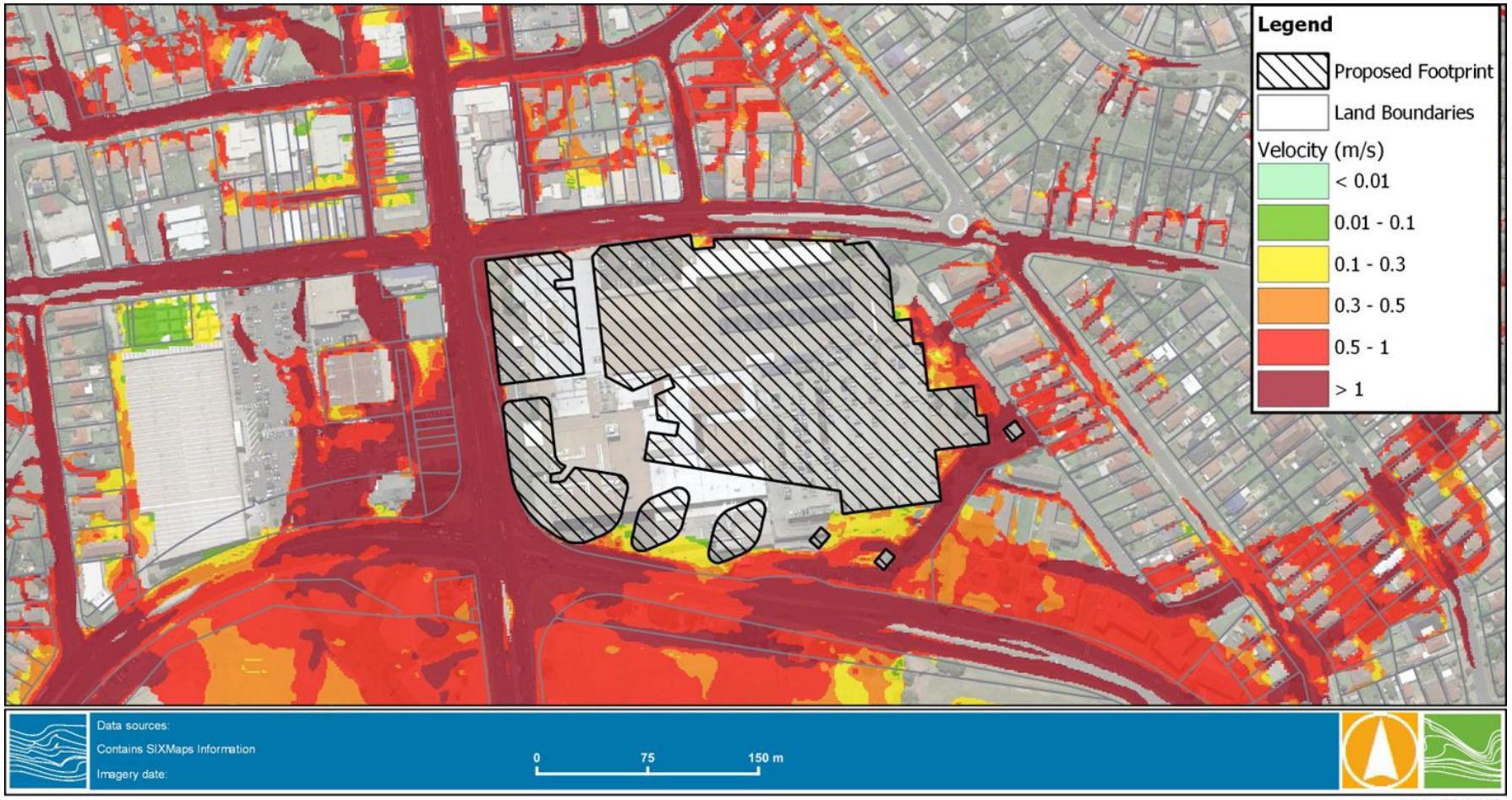

FIGURE 3-11 PMF PEAK VELOCITY - REFERENCE DESIGN

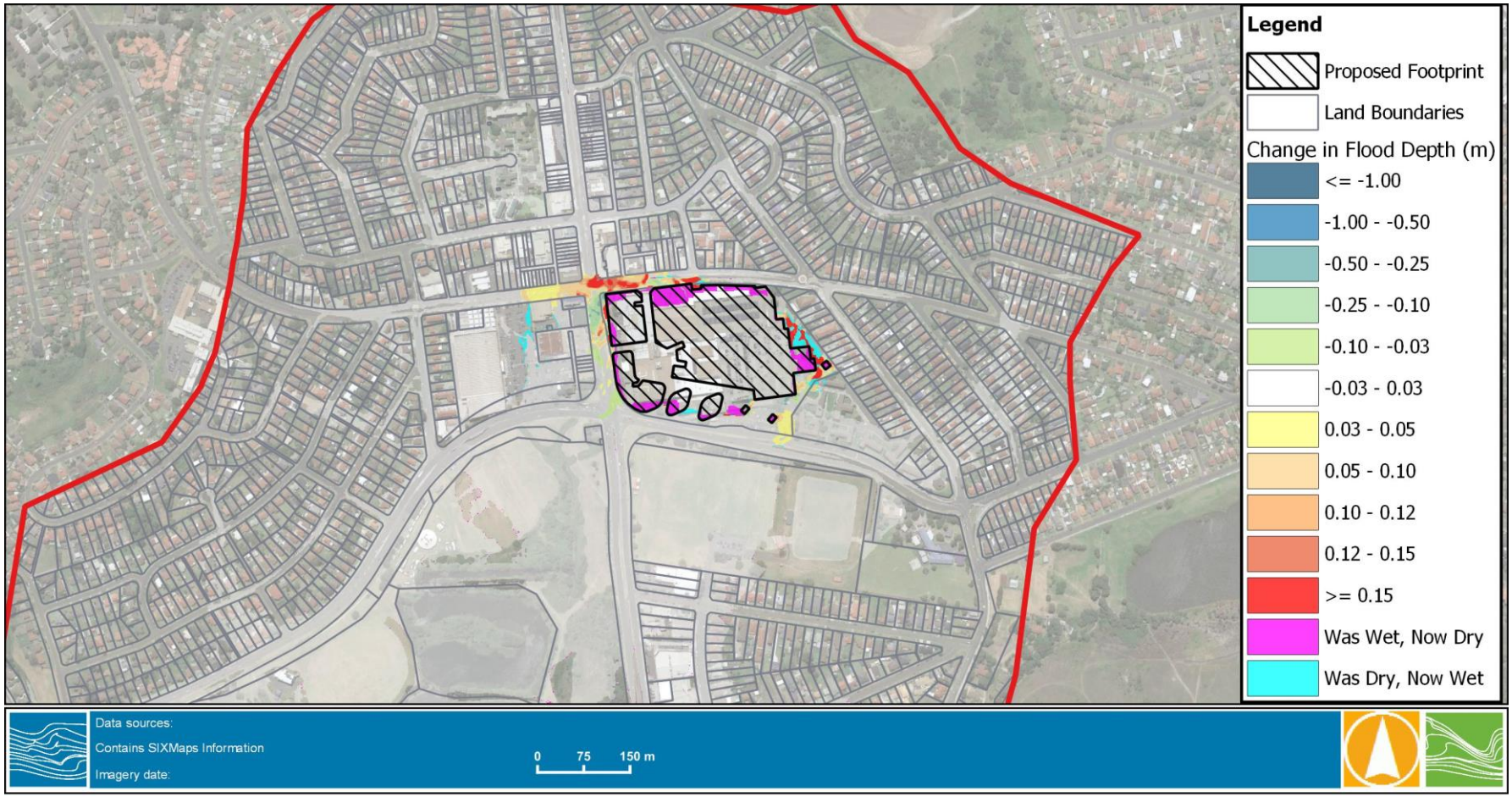

FIGURE 3-12 PMF FLOOD DEPTH DIFFERENCE REFERENCE DESIGN VS EXISTING

FIGURE 3-13 PMF FLOOD DEPTH DIFFERENCE REFERENCE DESIGN VS EXISTING (SITE SPECIFIC)

3.2.3 Flood Hazard Results

Flood Hazard results for the developed conditions modelling has been provided for this area (1% AEP in Figure 3-15 and PMG in Figure 3-16). Flood hazard mapping is used to advise of safe vehicle and pedestrian limits as well as for the safety requirements of the building location. The flood hazard mapping presented has followed ARR2019 recommendations, adopting flood hazard categories as outlined in the Australian Emergency Management Institute 20142 (Figure 3-14).

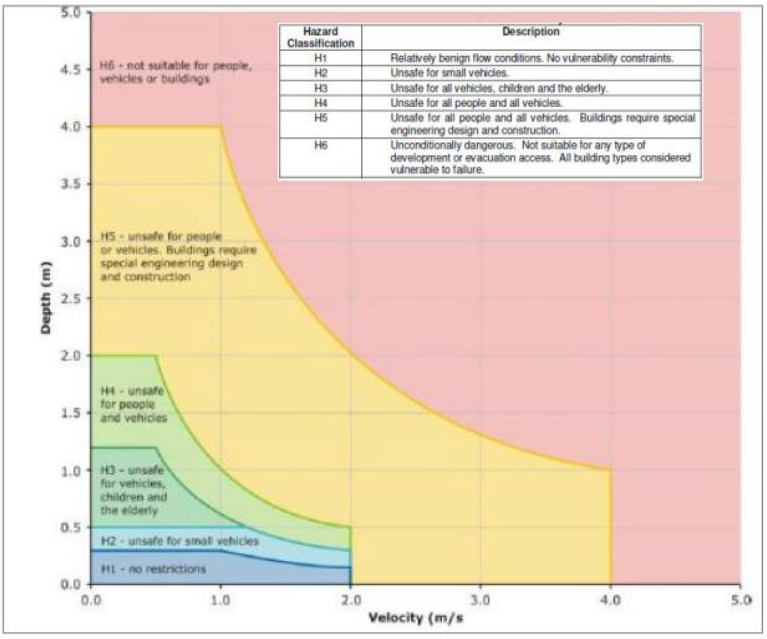

FIGURE 3-14 FLOOD HAZARD CLASSIFICATION

In the 1% AEP event, the results indicate that the flooding within the reference design site ranges from generally safe (H1) to Unsafe for People & Vehicles. Buildings Vulnerable to Damage (H5).

The most significant hazard is along King Street and a small area of Northcliffe Drive, with large hazard ratings of up to H5 experienced along the roadway.

The flood hazard along King Street and Northcliffe Drive is an existing issue. The impact of the proposed reference design has a minor impact on the flood hazard experienced along King Street, slightly increasing the area in which H5 is experienced. Despite this increase, the overall hazard from flooding is relatively unchanged. No changes are observed at other properties.

TABLE 3-1 FLOOD HAZARD CLASSIFICATIONS

Hazard Category	Description
H1	Generally safe
H2	Unsafe for Small Vehicles
H3	Unsafe for Vehicles, Children & Elderly
H4	Unsafe for People & Vehicles
H5	Unsafe for People & Vehicles. Buildings Vulnerable to Damage.
H6	Unsafe for People & Vehicles. Buildings Vulnerable to Failure

[2] https://knowledHge.aidr.org.au/resources/handbook-7-managing-the-floodplain/

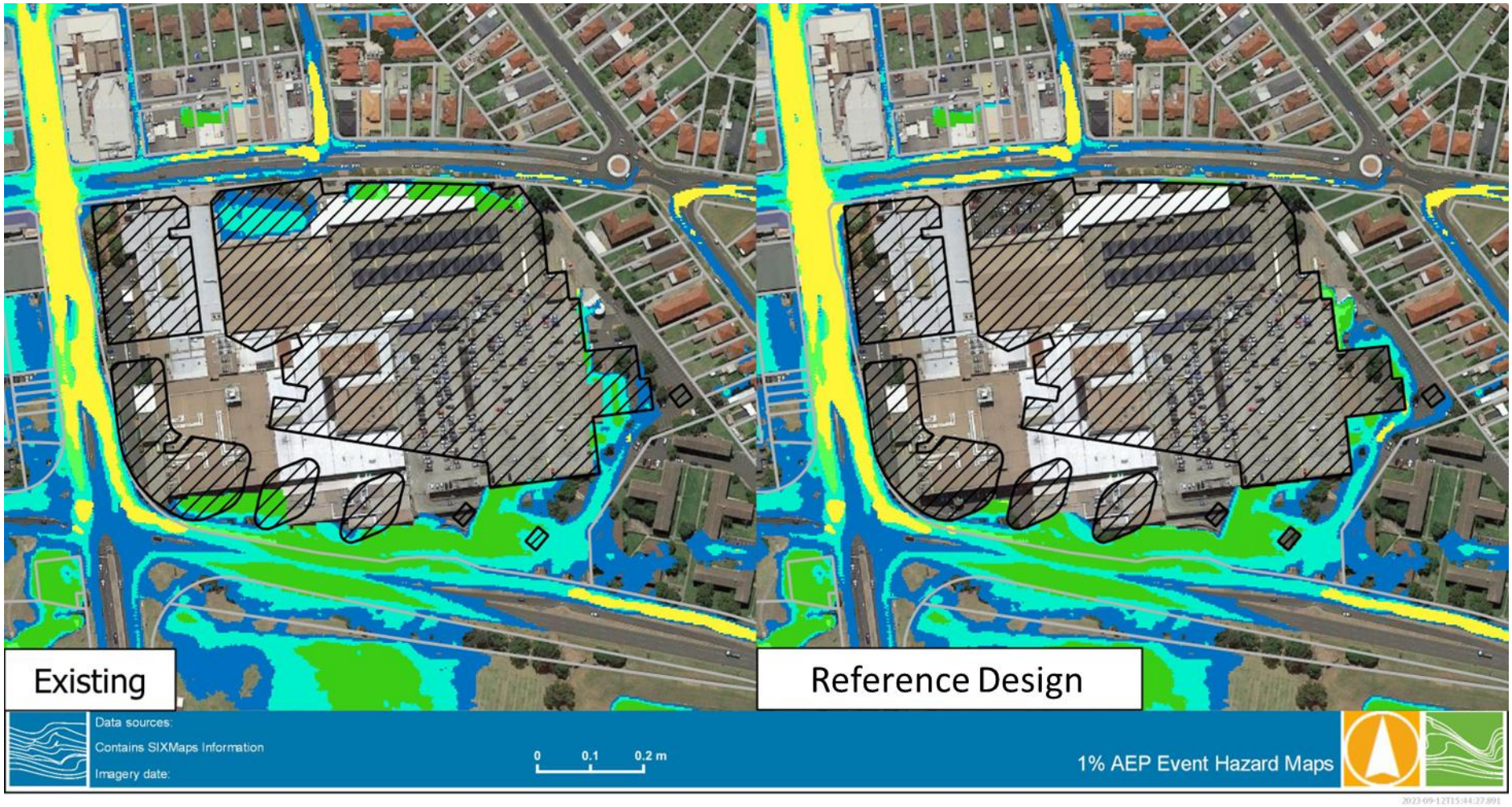

FIGURE 3-15 1% AEP FLOOD HAZARD – EXISTING AND REFERENCE DESIGN CONDITIONS (LEGEND ABOVE IN TABLE 3-1)

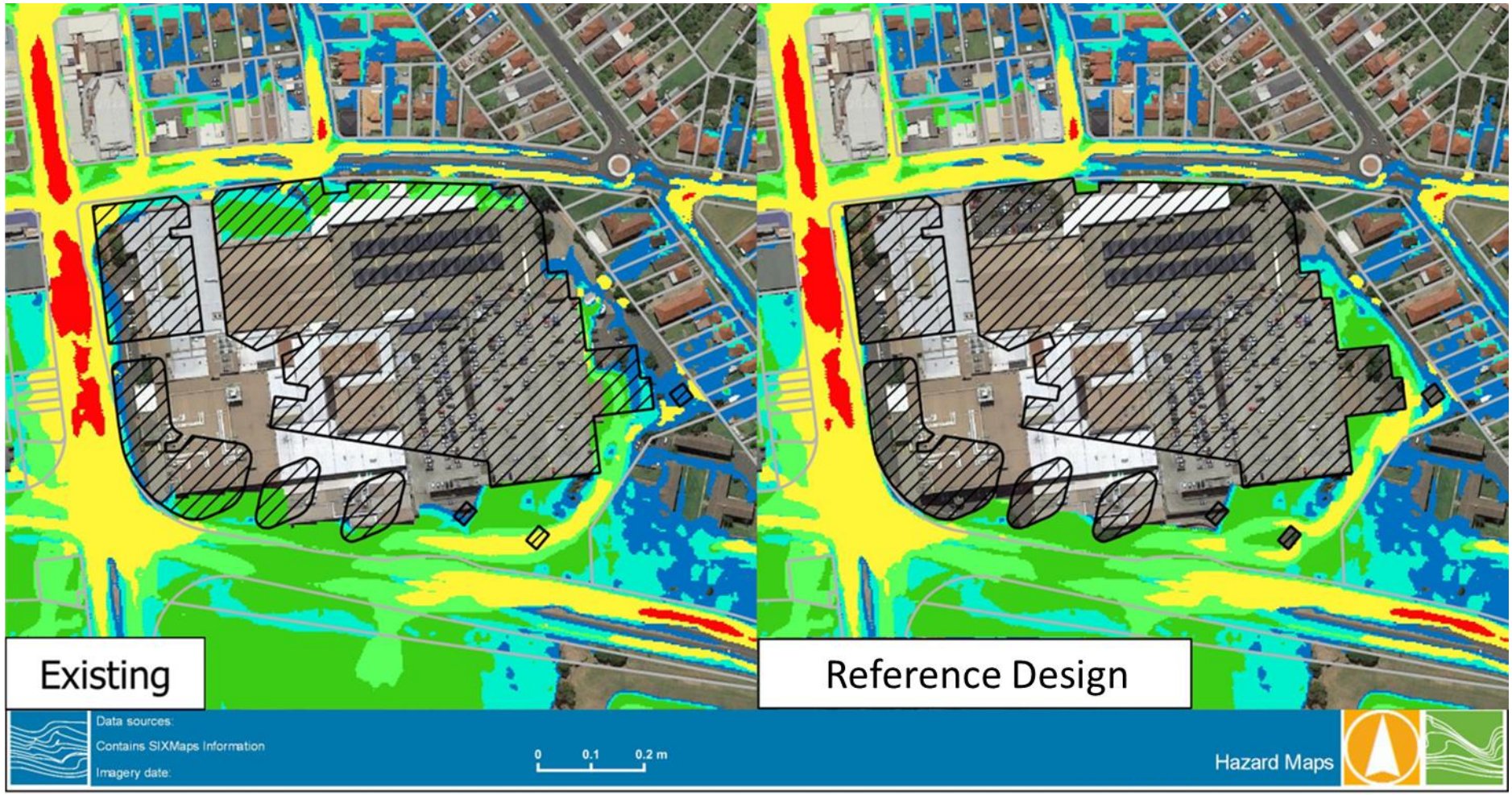

FIGURE 3-16 PMF FLOOD HAZARD – EXISTING AND REFERENCE DESIGN CONDITIONS (LEGEND ABOVE IN TABLE 3-1)

4 SUMMARY AND DISCUSSION

Flood modelling of the site under developed conditions representing the reference design has shown that the major overland flow path through the eastern carpark is impacted by the proposed works. This is due to the removal of the available floodplain storage in the existing eastern carpark and changes to the active flow path which passes through the eastern carpark and into Northcliffe Drive. The area of impact is localised to within the eastern carpark and external to the site along Cowper Street and King Street along the new building frontage.

During the 1% AEP flood event the increase in flood depths is generally below 20 cm in the King Street road reserve and 15 cm in the Cowper Street road reserve. No impacts are observed to any external residential dwellings during the 1% AEP flood event. During the PMF event the areas of impact are increased with changes to flood depth observed external to the property, within the residential land east of the site. Flood depth increases are generally below 10 cm. During the PMF flood event the increase in flood depths is generally below 22 cm in the King Street road reserve and 30 cm in the Cowper Street road reserve. It is likely that these areas of increased depths can be reduced with further drainage design, landscaping and flood mitigation, if required.

Flood depth information indicated a hazard classification range from generally safe (H1) to Unsafe for People & Vehicles. Buildings Vulnerable to Damage (H5) within the reference design development area and surrounding area during the 1% AEP flood event. The impact of the reference design development has a minor impact on the flood hazard levels in the surrounding areas, slightly increasing the area in which H5 is experienced. No changes in hazard classification are observed within adjoining properties.

A summary of minimum and maximum depths, heights and velocity in the 1% AEP and PMF events under existing and reference design conditions are presented in Table 4.1.

TABLE 4-1 SUMMARY OF VALUES

	1% AEP Existing	1% AEP Proposed	PMF Existing	PMF Proposed
Minimum Depth	0.00	0.00	0.00	0.00
Maximum Depth	1.75	2.75	1.95	2.84
Minimum Height	3.10	3.08	3.38	3.27
Maximum Height	8.77	7.40	8.81	7.69
Minimum Velocity	0.01	0.01	0.01	0.02
Maximum Velocity	3.48	3.30	4.06	4.45

Further design on site will need to consider the flow paths in the eastern carpark and the impacts to King Street and Cowper Street. The Preliminary Flood Advice Report (Water Technology) will discuss flood management considerations for redevelopment of the Warrawong Plaza based on the current planning instruments applicable to the site.

As assessment of the potential impact of displaced flood storage during PMF flooding events on the lake was also undertaken. The assessment which is highly conservative and likely significantly overestimates the changes in Lake flood level estimated that water levels during this event would at most increase by 0.74mm as a result of the reference design development, which is noted as being within permissible limits.

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