Flood Impact and Risk Assessment

Randwick High School

Prepared for NSW Department of Education / 31 July 2025

241625

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Contents

1.0 Introduction 7
1.1 Reference Documents 7
1.2 Site Description 8
1.3 Proposed Activity Description 8
2.0 Site Description 10
2.1 Site Topography 10
2.2 Catchment Information 11
3.0 Flood Planning Requirements 12
3.1 Flood Effects 12
3.2 Building Floor Levels 12
3.3 Building Components 14
3.4 Driveway Access and Car Parking 14
3.5 Safety and Evacuation 15
4.0 Council Flood Model Review 16
4.1 Birds Gully and Bunnerong Road Flood Study (2021) 16
4.2 Newmarket Randwick 16
5.0 Hydraulic Model Setup 20
5.1 Consistent Model Parameters 20
5.1.1 2D Model Domain 20
5.1.2 Boundary Conditions – Inflows 21
5.1.3 Hydraulic Roughness 21
5.2 TTW Model Updates 21
5.2.1 Elevation Data 21
5.2.2 Building Footprints 24
5.2.3 Walls and Fences 26
5.2.4 Stormwater Data 29
5.2.5 Flood Hazard Assessment 31
5.2.6 Overview of Updated Existing Model 32
6.0 Flood Model Results 33
6.1 Critical Duration 33
6.2 Existing Conditions 33
6.3 Post-Development Conditions 40

6.3.1 Baseline Post-Development Model (Without Mitigation Measures) 40
6.3.2 Post-Development Model with Mitigation Measures 44
7.0 Climate Change 53
8.0 Flood Impact Assessment 57
9.0 Review of Flood Planning Requirements 59
9.1 Randwick DCP 59
9.2 DCP Departures – Floor Level Requirements 61
9.2.1 Other NSW Council DCP Requirements 61
9.2.2 Protection to the PMF 63
9.3 DCP Departures – Car Parking 66
10.0 Overview of Flood Risk 67
10.1 Population at Risk 67
10.2 Flood Resilience 67
10.2.1 New Development – Application of Freeboard 67
10.2.2 Block B Refurbishment 69
10.2.3 Rebuilding and Repair Works 69
10.3 Increased Connectivity 69
10.4 Mitigation Measures 69
10.5 Evaluation of Environmental Impacts 70
11.0 Conclusions and Recommendations 71
Appendix A 72
Appendix B 73
Appendix C 82

Rev	Date	Prepared By	Approved By	Remarks
1	10/07/2025	LC	EC	Draft
2	31/07/2025	LC	TM	REF Submission

Glossary and Abbreviations

Annual Exceedance Probability	AEP	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage
Australian Height Datum	AHD	A common national surface level datum often used as a referenced level for ground, flood and flood levels, approximately corresponding to mean sea level.
Average Recurrence Interval	ARI	The long-term average number of years between the occurrence of a flood equal to or larger in size than the selected event. ARI is the historical way of describing a flood event. AEP is generally the preferred terminology.
Bureau of Meteorology	BoM	An executive agency of the Australian Government responsible for providing weather services to Australia and surrounding areas.
Development Control Plan	DCP	A Development Control Plan is a document prepared by the Council which provides detailed guidelines which assist a person proposing to undertake a development. A DCP must be consistent with the provisions and objectives of a Local Environmental Plan (LEP).
Finished Floor Level	FFL	The level, or height, at which the floor of a building or structure (including alterations and additions) is proposed to be built.
Flood hazard		A source of potential harm or a situation with a potential to cause loss of life, injury and economic loss due to flooding. Flood hazard is defined as a function of the relationship between flood depth and velocity.
Flood Planning Level	FPL	The combination of the flood level from the defined flood event and freeboard selected for flood risk management purposes.
Freeboard		A factor of safety typically used in relation to the setting of floor levels or levee crest levels. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour etc.
Local Environmental Plan	LEP	LEPs provide a framework that guides planning decisions for local government areas through zoning and development controls. Zoning determines how land can be used (for example, for housing, industry, or recreation).
New South Wales State Emergency Service	NSW SES	The NSW SES is an agency of the Government of New South Wales, is an emergency and rescue service dedicated to assisting the community in times of natural and man-made disasters.
Probable Maximum Flood	PMF	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain.
Representative Concentration Pathways	RCP	RCPs make predictions of how concentrations of greenhouse gases in the atmosphere will change in future as a result of human activities. The four RCPs range from very high (RCP8.5) through to very low (RCP2.6) future concentrations.

Severe Weather Warning	The Bureau of Meteorology issues Severe Weather Warnings whenever severe weather is occurring in an area or is expected to develop or move into an area. Severe Weather Warnings are issued for: • Sustained winds of gale force (63 km/h) or more • Wind gusts of 90 km/h or more (100 km/h or more in Tasmania) • Very heavy rain that may lead to flash flooding • Widespread blizzards in Alpine areas • Very large waves and high tides expected to cause unusually damaging or dangerous conditions on the coast

Executive Summary

This Flood Impact and Risk Assessment has been prepared to support the Review of Environmental Factors (REF) being prepared on behalf of the NSW Department of Education (DoE) for the proposed Administration Building and Lecture Theatre at Randwick High School.

Randwick City Council's TUFLOW model for the Birds Gully and Bunnerong Road Flood Study was obtained and modified to determine overland flow and flood impacts at the site under pre- and post-development conditions. The model assessed flood behaviour for several flood events, including the 10%, 5%, 1%, 0.5% Annual Exceedance Probability (AEP), and the Probable Maximum Flood (PMF). Sensitivity testing for climate change was conducted under SSP2-4.5, with projected rainfall increases for 2090.

Key findings include:

- A critical duration assessment was conducted and identified the 30-minute storm duration as critical for the 1% AEP and PMF events at the site based on the available hydrological input data from Council.
- The site is significantly impacted by overland flooding, which is primarily sourced from excess runoff overtopping onto the site from Avoca Street, the site's eastern frontage. In the PMF event, flows also overtop onto the site from Barker Street in the northwest. Flows are primarily directed in a south/south-westerly direction across the site toward Rainbow Street.
- Given the flood affectation at the site, several mitigation measures were tested and incorporated into the current design, including raised bunding, flood walls, and level adjustments.
- Post-mitigation results demonstrate that the proposed buildings are flood-free in the 1% AEP event, with improved overland flow management and a reduction in flood hazard classification. Although the proposed buildings are impacted in the critical duration PMF event, flood depths at key building thresholds have been significantly reduced following the implementation of the above mitigation measures.
- Climate change sensitivity testing under the SSP2-4.5 scenario confirms that the mitigation strategy remains effective under future conditions, including in the 0.5% AEP CC2090 scenario, which includes a 40% uplift in rainfall.
- The development achieves a net improvement in overall flood resilience at the site, with negligible offsite impacts (generally within ±10 mm in the 1% AEP event). The proposal also improves flood refuge connectivity and enables effective emergency response strategies, including shelter-in-place.
- While strict compliance with Randwick DCP floor level controls is not feasible without significant adverse offsite impacts, the adopted design demonstrates good-practice flood risk management consistent with the REF pathway. Overall, potential flood risks and impacts can be appropriately mitigated or managed to ensure that there is minimal effect on the locality, community and/or the environment.
- A Flood Emergency Response Plan (FERP) has been developed for the new buildings and submitted alongside this report, providing actions for preparation, response, and recovery.

1.0 Introduction

This Flood Impact and Risk Assessment has been prepared to support the Review of Environmental Factors (REF) being prepared on behalf of the NSW Department of Education (DoE) for the proposed Administration Building at Randwick High School (the activity).

The purpose of the REF is to assess the potential environmental impacts of the activity prescribed by State Environmental Planning Policy (Transport and Infrastructure) 2021 (T&I SEPP) as "development permitted without consent" on land carried out by or on behalf of a public authority (NSW DoE) under Part 5 of the Environmental Planning and Assessment Act 1979 (EP&A Act). The activity is to be undertaken pursuant to Chapter 3, Part 3.4, Clause 3.37 of the T&I SEPP.

The purpose of this report is to outline the existing constraints of flooding and overland flow paths at the school site and provide an assessment into the likely impacts of the proposed activity in post-development conditions. The details of this report are based on currently available information at the time of writing.

1.1 Reference Documents

The following documents have been reviewed and referenced in preparing this report:

- Arcadia, Newmarket Randwick Masterplan, Available at: https://arcadiala.com.au/projects/master-planning-urban-design/newmarket-green-masterplan/
- Australian Institute of Disaster Resilience (AIDR) Guideline 7-3: Flood Hazard (2017)
- Barker Ryan Stewart (July 2024) Due Diligence Planning Pathways Assessment for Randwick Boys High School & Randwick Girls High School
- Department of Planning, Housing and Infrastructure – Planning Circular PS 24-001, Update on addressing flood risk in planning decisions, 1st March 2024
- Engineers Australia. (2019). *Australian Rainfall and Runoff: A Guide to Flood Estimation* (4th ed.). Commonwealth of Australia. https://arr.ga.gov.au
- FloodSafe guidelines and the relative FloodSafe Tool Kits
- NSW Department of Planning and Environment – Flood Risk Management Guideline LU01, June 2023
- NSW Department of Planning and Environment (2021) Considering Flooding in Land Use Planning Guideline
- NSW Department of Planning and Environment (2023) Flood Risk Management Manual https://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-manual
- NSW Planning Portal Spatial Viewer – https://www.planningportal.nsw.gov.au/spatialviewer/#/find-a-property/address
- Randwick City Council (2018) WMA Water – Birds Gully and Bunnerong Road Flood Study – Volume 1 and Volume 2.
- Randwick City Council DA Database – Development Application DA/887/2018/C, Newmarket Randwick
- Randwick City Council Development Control Plan (DCP, 2013)
- Randwick Local Environmental Plan (LEP, 2012);
- WJ Syme (2008) 'Flooding in Urban Areas - 2D Modelling Approaches for Buildings and Fences', Engineers Australia, 9th National Conference on Hydraulics in Water Engineering, Darwin Convention Centre, 23-26 September 2008

1.2 Site Description

Randwick High School is located at Avoca Street, Randwick. The school comprises two addresses; 298 Avoca Street, Randwick and Part 90-98E Rainbow Street, Randwick. The real property descriptions are Lot 1 DP 121453 and Part Lot 1738 DP48455.

The site is largely rectangular in shape with vehicular access provided from Rainbow Street in the south and Barker Street in the north. Pedestrian access is provided from the abovementioned roads, Avoca Street to the east and Fennelly Street to the west.

The site is zoned SP2 Educational Establishment in accordance with Randwick Local Environmental Plan 2012. An aerial image of the site is provided in Figure 2.

Figure 1: Aerial image of the site

1.3 Proposed Activity Description

The proposed activity includes the following:

- Tree removal;
- Demolition of ground slab associated with Block A (South)
- Reconfiguration of existing staff carparks;

- Construction of a combined administration (ground floor) and permanent classroom building (first floor);
- Construction of a lecture theatre;
- New pedestrian pathway connections providing access to Block C and H;
- Service connections; and
- Site landscaping works.

An extract of the proposed Site Plan is provided at Figure 2.

Figure 2: Extract of proposed Site Plan (Bennett and Trimble, 2025)

2.0 Site Description

2.1 Site Topography

Ground surface within the site boundary varies from a low of 37.3m AHD at the southwest corner of the lot, to a high of 50.0m AHD at the northeast corner of the site, adjacent to Barker Street. There is a predominant slope to the southwest toward the Rainbow Street frontage.

This is presented in the Digital Elevation Model (DEM) of the site presented in Figure 3, obtained from Elevation Information System (ELVIS), dated May 2020.

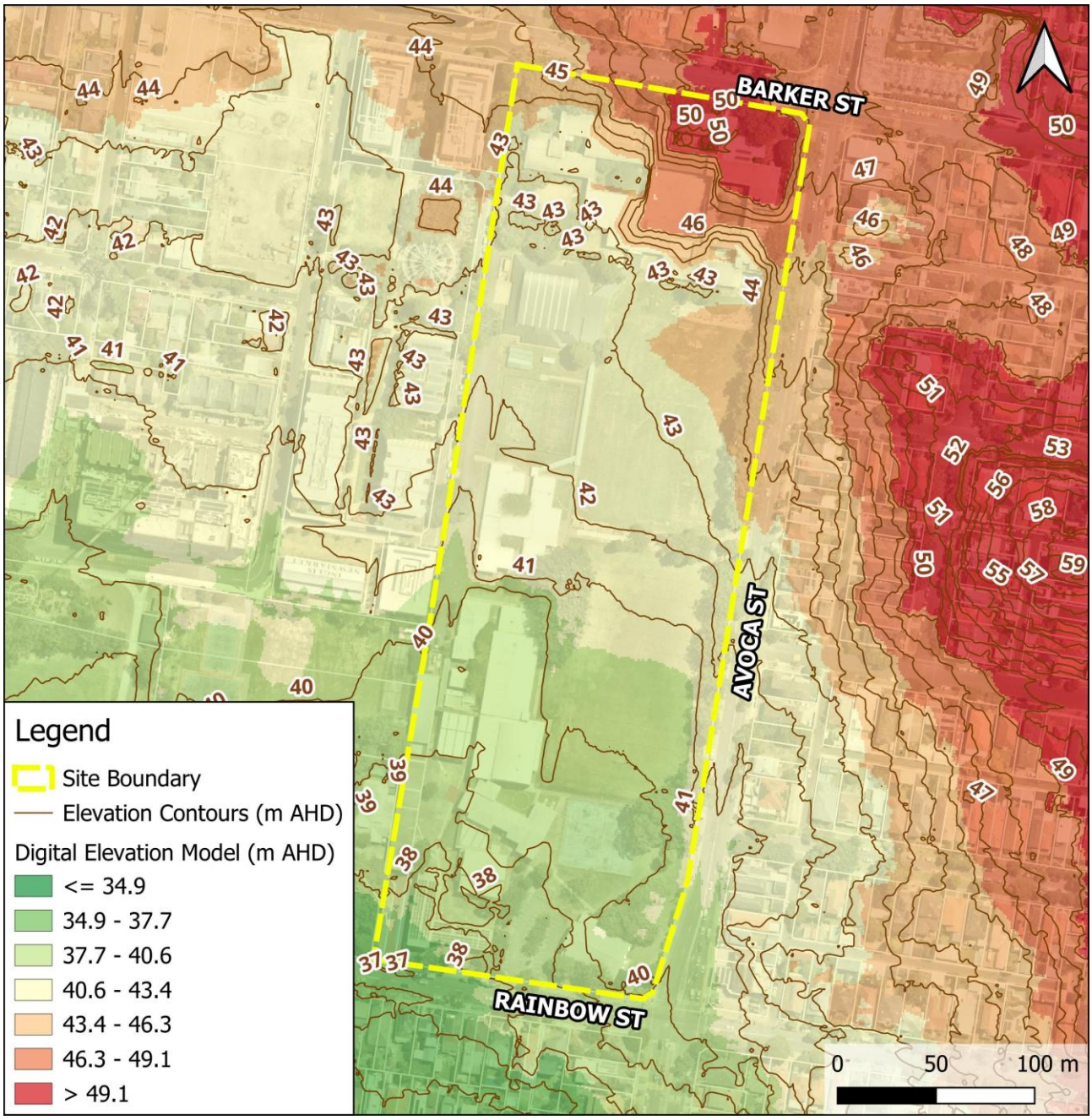


Figure 3: Topography of the site and surrounding area (Source: DEM obtained from ELVIS, 2020)

2.2 Catchment Information

The site is situated within the Birds Gully catchment, which covers a total area of 1.7 km^2. The catchment is highly urbanised, consisting of a combination of residential, commercial and industrial developments. Most waterways have been replaced by urban drainage networks, including concrete lined channels and pipes, including the Birds Gully trunk drainage network, presented in Figure 4.

This line drains the Birds Gully catchment and discharges to the Botany Bay wetlands at Eastlakes Golf Course, Daceyville. As presented in Figure 4, this trunk drainage line runs through the Randwick High School site.

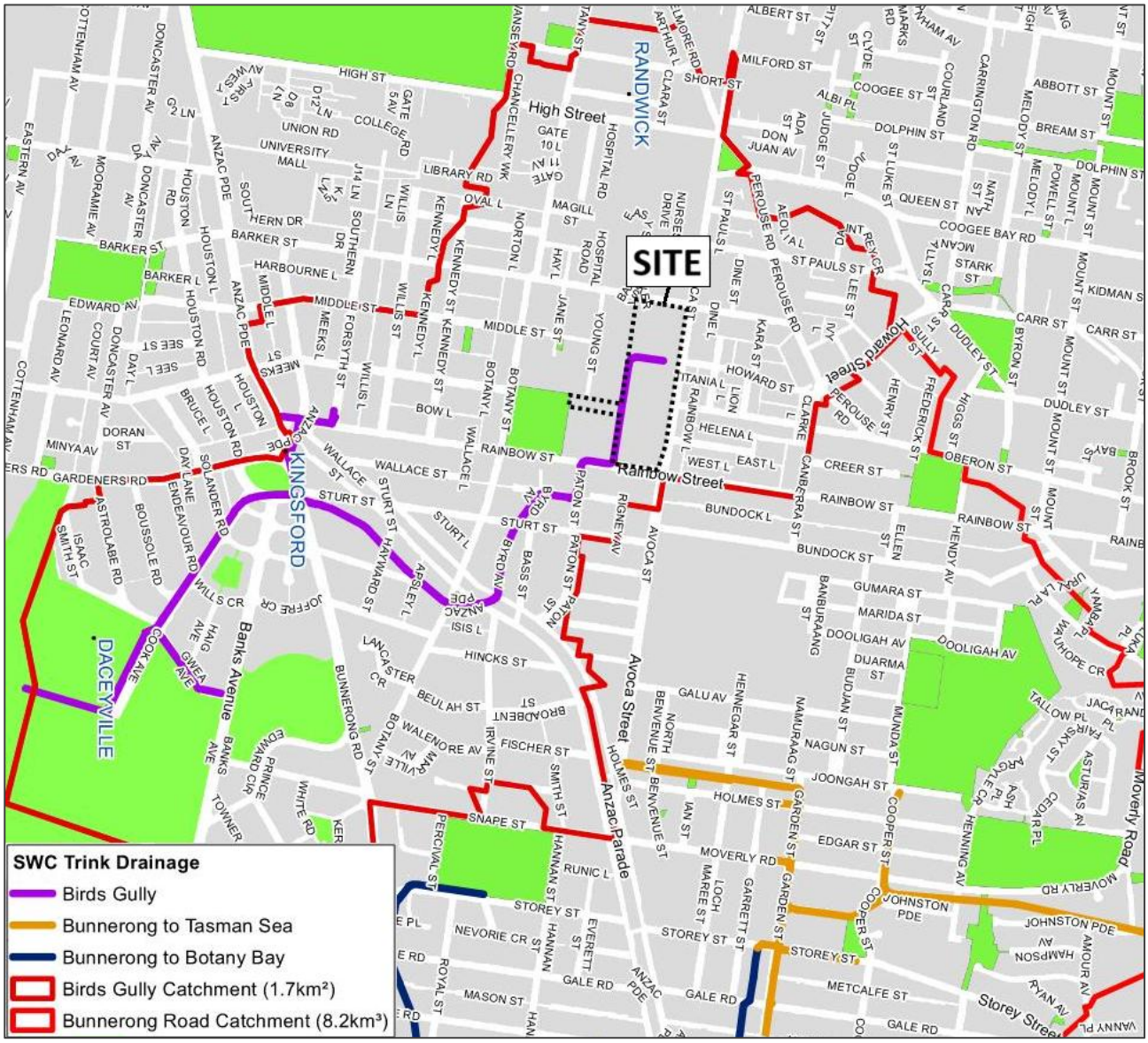


Figure 4: Trunk drainage lines surrounding the site (Source: adapted from Birds Gully and Bunnerong Road Flood Study Report, 2018)

3.0 Flood Planning Requirements

While compliance with the Development Control Plan (DCP) is not required under the REF pathway, relevant DCP provisions have been reviewed and are acknowledged in this study to demonstrate consideration of Council's planning objectives.

The current DCP in place covering the site is the Randwick City Council DCP (2013). Part B8, Section 5 of the DCP provides controls for development on flood prone land and applies to all land susceptible to flooding by the PMF plus the required freeboard.

3.1 Flood Effects

The controls related to flood effects are as follows (taken from Part B8 Section 5.2 Pg 10 of the DCP):

1) The development shall not increase flood effects elsewhere, having regard to loss of flood storage, changes in flood levels and velocities and the cumulative impact of multiple potential developments, for floods up to and including the 1% AEP flood.

2) Floodways and overland flow paths must not be obstructed or diverted onto adjoining properties.

3) Areas identified as flood storage areas must not be filled unless compensatory excavation is provided to ensure that there will be no net loss of floodplain storage volume below the 1% AEP flood.

These measures are considered in further detail in Section 8.0, which provides an overview of the impact of the proposed development on flood levels within and surrounding the site.

3.2 Building Floor Levels

The controls for buildings are as follows (taken from Part B8 Section 5.3 Pg 11 of the DCP):

1) Building floor levels shall comply with Table 1, with exceptions noted below:

    a) A single (once only) addition at the existing lowest habitable floor level may be permitted after a flood study has been prepared. Such an addition will be limited to:

    b) A maximum 10 square metres for existing single and dual occupancy dwellings,

    c) Up to 10 percent of the existing gross floor area for all other development (note for large buildings, this increase may be limited to a lower amount)

2) A certificate by a registered surveyor shall certify that the floor levels are not less than the required level.

3) Where the lowest habitable floor area is elevated more than 1.5m above ground level, a restriction is to be placed on the title of the land confirming that the sub-floor area is not to be enclosed.

The stringency of floor level controls is dependent on the land use type of the development. As a school, the site is regarded as a critical facility according to Randwick DCP. Table 1 is taken from Section 5.3 of the DCP, showing building floor levels requirements for habitable floors in critical facilities

As shown in Table 1, the minimum required floor level for buildings depends on whether the site is impacted

by “flooding” or an “overland flow path”. Part B8, Section 5.3 (Page 12) of the DCP provides the following definition of overland flow paths, which occur when:

a) The maximum cross-sectional depth flowing through and upstream of the site is less than 0.25m for the PMF for critical facilities; and

b) Existing surface levels within the site are above the floor level requirements, at the nearest downstream trapped low points, and

c) The flood study demonstrates that blockage to any upstream trapped low point does not increase the depth of flow to greater 0.25m.

The controls for buildings are ultimately dependent on the flood behaviour at the subject site. Section 6.0 of this report outlines the flood behaviour at Randwick High School, and Section 9.1 provides a review of these controls in relation to the proposed activity.

Table 1: Floor level requirements for buildings (Source: Table A of Section B8, Randwick DCP, 2013)

Scenario	Floor level
Habitable Floors - all development (excluding critical facilities)	
Inundated by flooding	1% AEP + 0.5m freeboard
Inundated by overland flow path	Two times the depth of flow in the 1% AEP flood with a minimum of 0.3m above the surrounding surface
Habitable floors - Critical facilities	
Inundated by flooding	PMF + 0.5m freeboard
Inundated by overland flow path	Two times the depth of flow in the PMF with a minimum of 0.3m above the surrounding surface
Non-habitable floors – residential outbuildings (excluding garages) *	
Gross floor area less than or equal to 10 square metres.	1% AEP but not less than 0.15m above surrounding ground level
Gross floor area greater than 10 square meters.	The applicable habitable floor level
Non-habitable floors – Industrial and commercial	
Located on flooding or overland flow path	1% AEP but not less than 0.15m above surrounding ground level
Material storage locations – all development	
Materials sensitive to flood damage, or which may cause pollution or be potentially hazardous during flooding	1% AEP + 0.5m freeboard

Non habitable floors include areas such as laundries or sheds, but exclude garages. All other floor spaces are habitable areas.

Industrial and commercial facilities include areas such as office space, show rooms, child care facilities, residential floor levels for hotels and tourist establishments.

Critical facilities include: hospitals, police, fire, ambulance, SES stations, major transport facilities, major sewage or water supply or electricity or telecommunication plants, schools nursing homes and retirement villages

3.3 Building Components

The controls for building components are as follows (taken from Part B8 Section 5.4 Pg 12 of the DCP):

1) All development shall have flood compatible building components below the floor levels identified in Table 1.

2) All structures shall be constructed to withstand the forces of floodwater, debris and buoyancy up to and including the floor levels identified in Table 1.

Section 9.1 provides an assessment of the proposed activity in relation to the above DCP controls.

3.4 Driveway Access and Car Parking

The controls for car parking are as follows (taken from Part B Section 5.5, Page 12-13 of the DCP):

1) Car parking floor levels shall comply with Table 2
2) Locate vehicular access where the road level is greater than or equal to the required floor level for the car park. Where road access above the required floor level is not available, locate vehicular access at the highest feasible location.
3) The level of the driveway between the road and car park shall be no lower than 0.3m below the 1% AEP flood or such that the depth of inundation during the 1% AEP flood is not greater than the depth of flooding at either the car park or the road where the site is accessed.
4) Barriers shall be provided to prevent floating vehicles leaving the site during the 1% AEP flood if the depth of flooding at the car space exceeds 0.3m.

Table 2 outlines the floor level requirements for car parking, with the 5% AEP flood event governing the minimum required level.

Table 2: Floor level requirements for car parking (Source: Table B of Section B8, Randwick DCP, 2013)

Scenario	Floor Level
Above ground level open car parking, car ports and garages	
Open car parking spaces and car ports	5% AEP flood
Residential garages with up to two spaces	1% AEP but not less than 0.15m above surrounding ground level
Residential garages with more than two spaces	Applicable residential habitable floor level requirement (Table A)
Enclosed industrial/ Commercial parking spaces	Applicable industrial/commercial floor level requirement (Table A)

3.5 Safety and Evacuation

The controls related to safety and evacuation are as follows (taken from Part B Section 5.6, Page 14 of the DCP):

1) Include a description of the safety and evacuation methodology with all DAs, including:

– The provision of reliable and safe egress for inhabitants from the lowest habitable floor level to a publicly accessible location above the PMF level.

– The method of access for emergency personnel.

Section 9.1 provides an overview of flood emergency response considerations at the site (refer to Item 5.1 in Table 9). This is outlined in more detail in TTW's Flood Emergency Response Plan for the new development, submitted alongside this report.

4.0 Council Flood Model Review

4.1 Birds Gully and Bunnerong Road Flood Study (2021)

The Birds Gully and Bunnerong Road Flood Study (2018) was undertaken by WMA Water on behalf of Randwick City Council to define and map the flood behaviour in the catchment, including an assessment of flooding from rainfall over the local catchment (overland flooding) alongside elevated water levels in open channels (mainstream flooding).

The study used hydrologic and hydraulic modelling techniques in order to define flood behaviour in the study area. A DRAINS hydrologic model was utilised to convert rainfall to runoff to derive discharge hydrographs, which provided the input data for the TUFLOW 2D hydraulic model. The ARR 2016 methodology was adopted for design flood estimation which utilises an ensemble of 10 temporal patterns that are applicable across four AEP ranges.

The general Council TUFLOW model configurations are as follows:

1. 2m cell size
2. TUFLOW release 2016-03-AE _iDP_w64
3. Council's DRAINS hydrographs were used as input data into the model
4. Topography based on 2011 LIDAR

As this flood study represents the most comprehensive data available for the Randwick area at the time of writing, TTW obtained the TUFLOW and DRAINS model files from Council to complete a flood assessment for Randwick High School.

4.2 Newmarket Randwick

Since the development of the Birds Gully and Bunnerong Road Flood Study, the region has undergone significant redevelopment, most notably through Cbus Property's 'Newmarket Randwick', a newly established mixed-use precinct which comprises 17 residential apartment buildings ranging from 3 to 8-storeys. The development has been staged as follows:

- Stage 1 was completed in 2021 and consists of Newmarket Residences and Dining on Barker Street, alongside Inglis Park and Figtree Pocket apartments, located on Young Street.
- Stage 2 is currently under construction and due for completion in 2025, consisting of Young and Fennelly Residences and Jane St Terraces.
- Stage 3 is currently in planning with a mix of residential dwellings and retail spaces and is due for release in 2025.

The Newmarket Randwick masterplan (prepared by Arcadia) is presented in Figure 5, demonstrating the proximity of the redevelopment works in relation to the Randwick High School site. The main changes surrounding the site are as follows:

- Construction of Yarraman Avenue, a new road linking the Newmarket Residences and Dining to Young Street. This road is directly adjacent to the site's western boundary;
- Upgrade works to Young Street;
- Construction of Fennelly Street, which connects the southern extent of Young Street to Botany Street;
- Separate to the Newmarket Randwick Development, the Rainbow St Public School site has been redeveloped. This school borders Randwick High School, located directly southwest of the site.

Figure 6 and Figure 7 present Council's model inputs set against aerial imagery from October 2017 (approximate date of the model build) and January 2025, respectively. From a review of updated aerial imagery, the building footprints are located atop of the newly constructed roads, and the gully lines no longer

align with the reconfigured kerb and gutter system on Young Street, which has been upgraded.

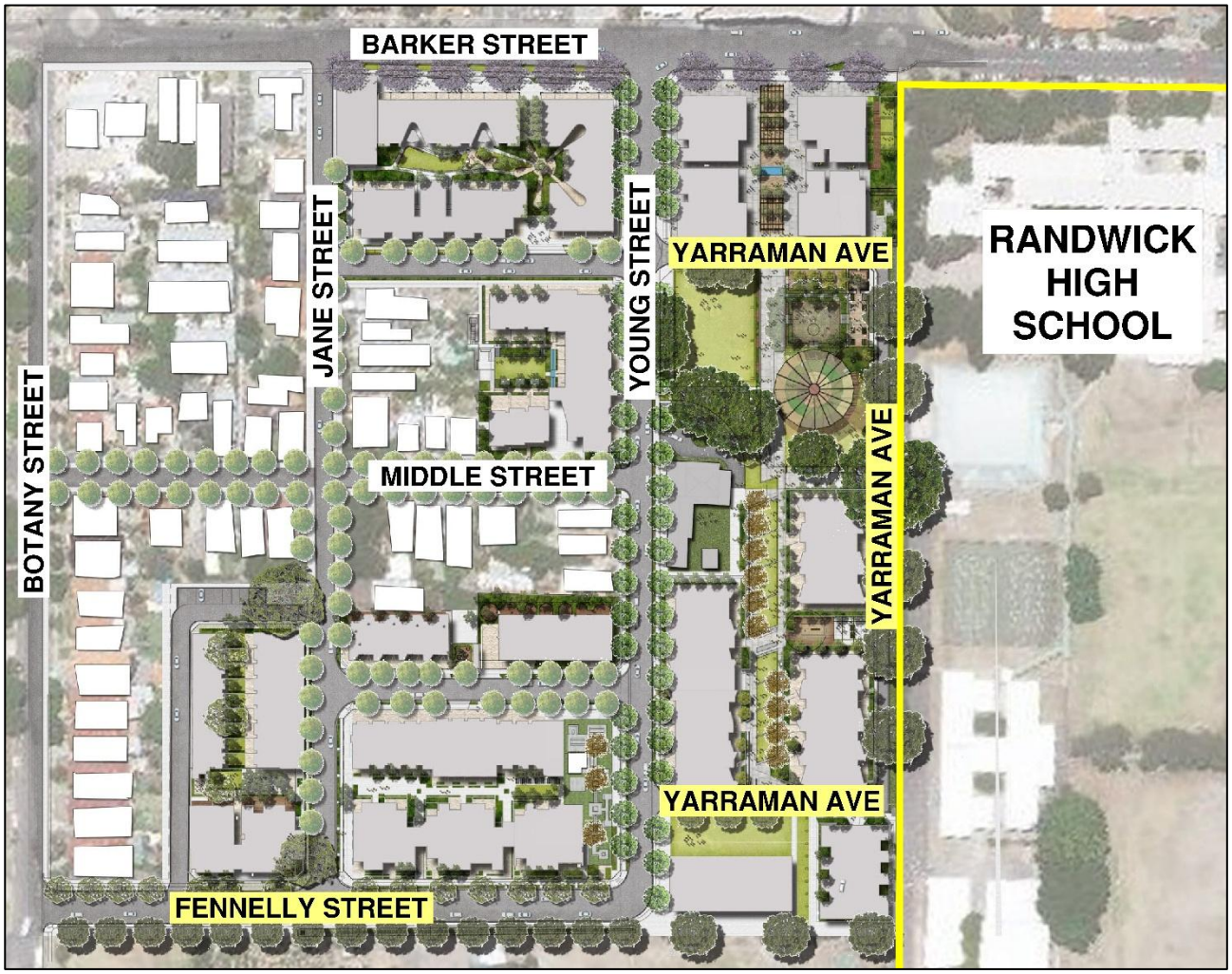


Figure 5: Newmarket Randwick Masterplan in relation to the Randwick High School site (Source: adapted from Arcadia)

Figure 6: Council's Birds Gully and Bunnerong Road model inputs set against October 2017 aerial imagery (Source: Nearmap, 19 October 2017)

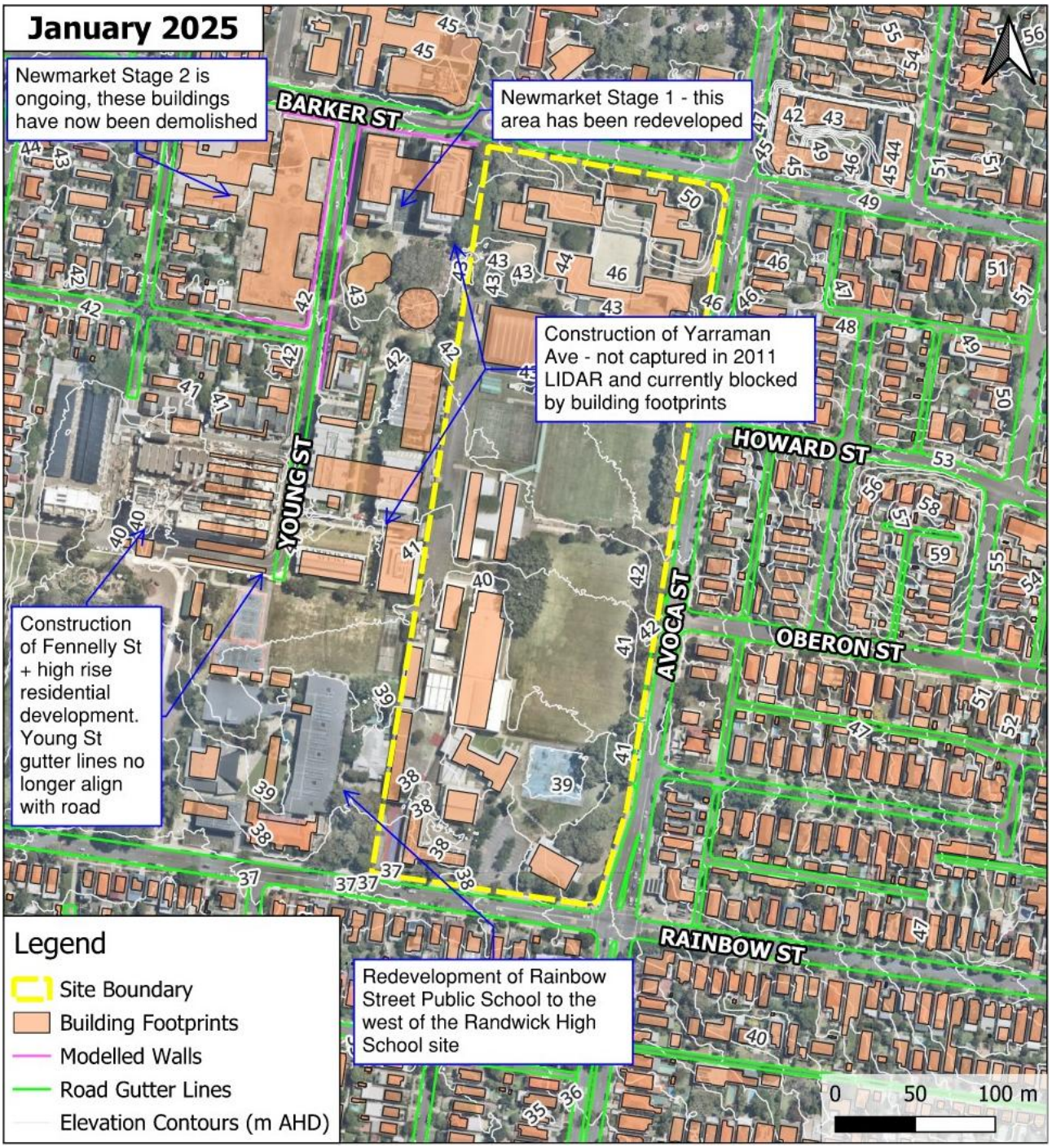


Figure 7: Council's Birds Gully and Bunnerong Road model inputs set against January 2025 aerial imagery (Source: Nearmap, 27 January 2025)

5.0 Hydraulic Model Setup

Following the above review, several updates were made to the model to ensure that it provides a robust representation of existing flood behaviour. Section 5.1 summarises key parameters that remain unchanged, while Section 5.2 outlines the amendments made in TTW's updated existing model. For more detail on model parameters not listed in this study, refer to Council's Bird's Gully and Bunnerong Road flood study report.

5.1 Consistent Model Parameters

5.1.1 2D Model Domain

The TUFLOW model boundary used in the Birds Gully and Bunnerong Road Flood Study was retained in TTW's model and is shown in Figure 8. A square 2m x 2m grid was utilised for the study. As TUFLOW samples elevation points at the cell centres, mid-sides and corners, surface elevations are therefore sampled every 1m, suitably representing topographical variations within the study area.

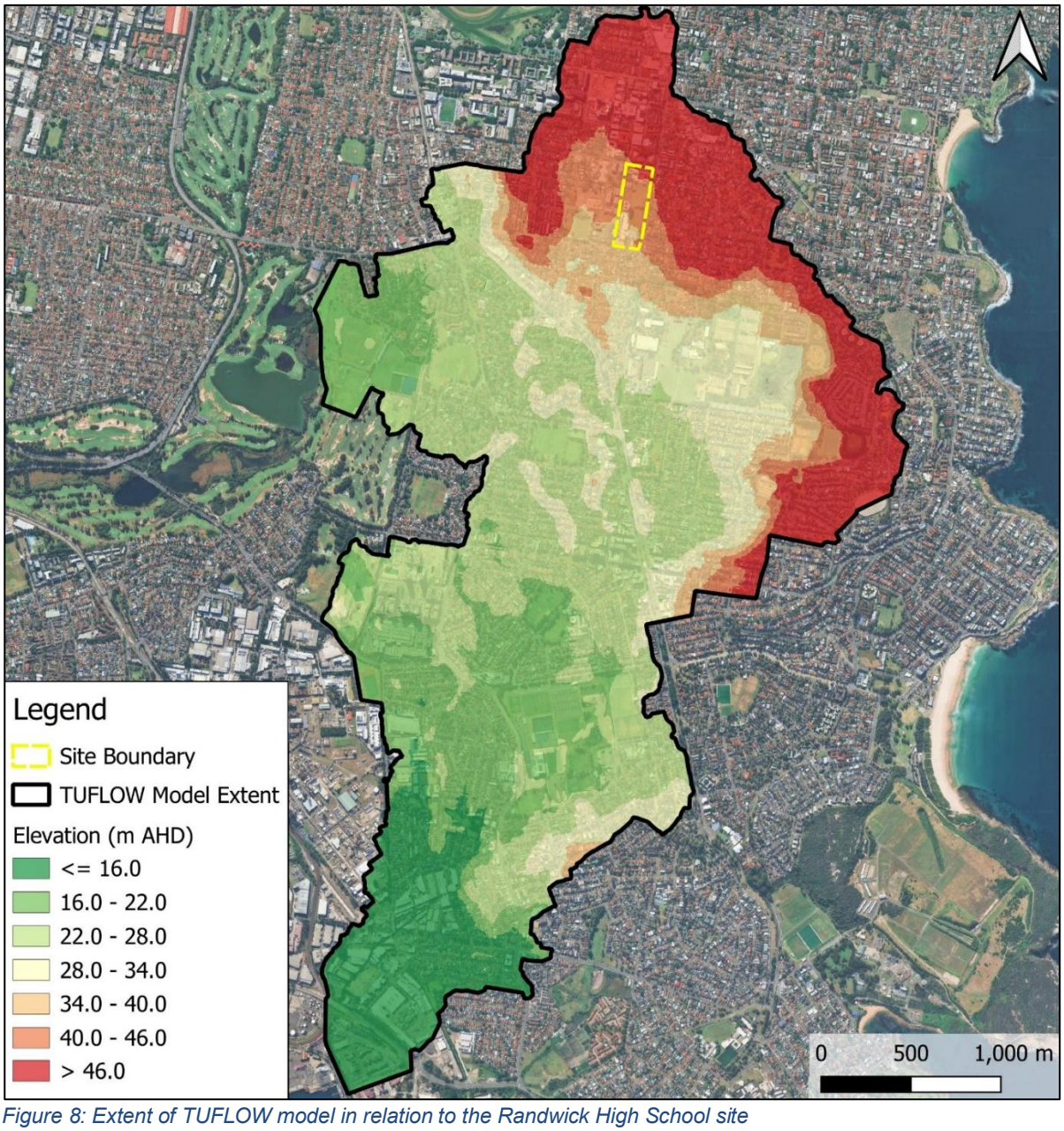


Figure 8: Extent of TUFLOW model in relation to the Randwick High School site

5.1.2 Boundary Conditions – Inflows

The upstream boundary conditions within the TUFLOW model are derived from Council's DRAINS hydrological model outputs. These were applied to the receiving area of the sub-catchments within the 2D domain of the hydraulic model. These inflow locations typically correspond with gutter lines and inlet pits on the roadway, or specific drainage reserves.

TTW obtained the DRAINS hydrographs and model utilised in the Birds Gully and Bunnerong Creek Flood Study from Randwick City Council. The study did not include an assessment of the 0.2% AEP (1-in-500-year ARI) event.

5.1.3 Hydraulic Roughness

The hydraulic roughness of a material is an estimate of the resistance to flow and energy loss due to friction between a surface and the flowing water. A higher hydraulic roughness indicates more resistance to the flow. Roughness in TUFLOW is modelled using the Manning's n roughness co-efficient. The Manning's n values adopted within Council's TUFLOW model were retained and are outlined in Table 3. These are consistent with typical values given in Chow, 1959 and Henderson, 1966.

Table 3: Manning's n values adopted in TUFLOW (Source: taken from Birds Gully and Bunnerong Road Flood Study)

Surface	Manning's n
Urban residential	0.05
Open space	0.03
Roads	0.02
Industrial	0.07
Infrastructure	0.06
Barracks	0.06
Concrete channel	0.015

5.2 TTW Model Updates

5.2.1 Elevation Data

As part of the model refinement to assess the proposed school upgrade, updates were made to the base topography using the latest publicly available LIDAR data (dated May 2020) in the vicinity of the subject site to capture recent changes in ground level.

The LIDAR (obtained from Elevation Information System (ELVIS)) has a spatial resolution of 1-metre and is a notable improvement on the elevation data used in Council's model, which is dated 2011. The May 2020 LIDAR captures the following new development:

- Redevelopment of Rainbow St Public School (completed in April 2019)
- New residential development on the eastern side of Young Street (completed in April 2020), including the Newmarket Residences, Figtree Park Apartments, and Newmarket Dining.
- Construction of Fennelly Street and Yarraman Avene (which was largely completed by April 2020, though the roads did not open for public access until May-June 2020)

To maintain model stability while ensuring a representative outcome for the subject site, the LiDAR update was limited to the local subcatchment. Figure 9 presents the portion of the model that was updated with 2020 LIDAR, extending to the upstream extent of the TUFLOW model towards Centennial Park, and marked by Sturt Street at the downstream extent. A sense check was undertaken along the boundary between the two datasets to confirm that there were no artificial steps or discontinuities in the model terrain.

To ensure the road gutter network along the new roads were represented accurately, breaklines were digitised along the gutter lines on Yarraman Avenue and Fennelly Street, and the ground levels reduced along these model cells by 150mm, creating a continuous flow path in the model. This is consistent with the approach adopted in Council's flood study.

In addition to the updated LIDAR data, the model was updated with new survey data for the site (obtained by CMS Surveyors on 29-31 July 2020) at a finer spatial resolution to increase the accuracy of surface levels within and surrounding the site. The extent of the survey is shown in Figure 10. Given the fine spatial resolution of the detailed survey data, the breakline method detailed above was not utilised in areas with survey – i.e. the portion of Barker Street, Avoca Street and Rainbow Street immediately adjacent to the site. In these areas, the survey information sufficiently captures the kerb and gutter system. Refer to Section 5.2.6 for an overview of TTW's model updates, including the revised gutter lines.

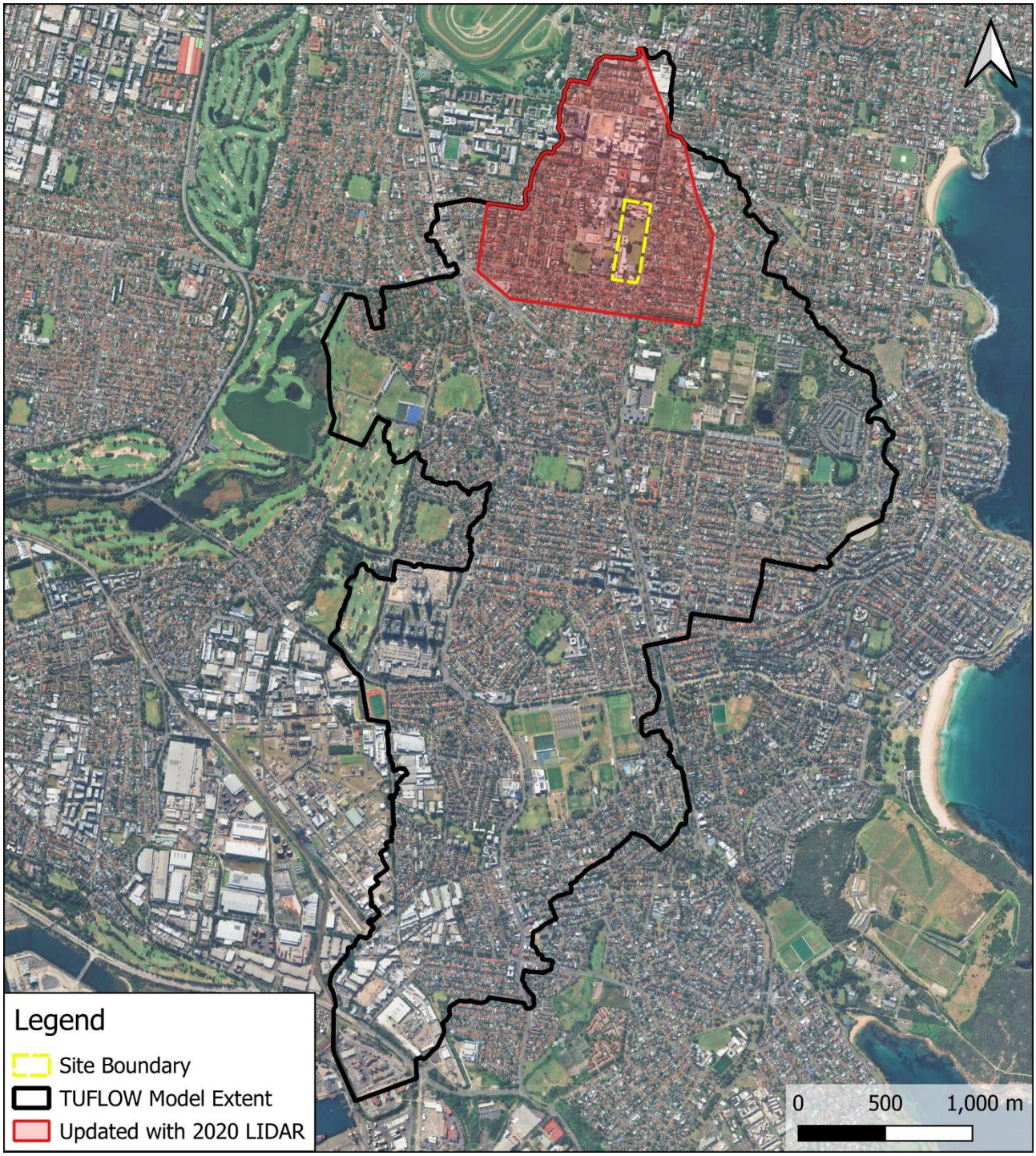


Figure 9: Extent of the TUFLOW model updated with 2020 LIDAR information

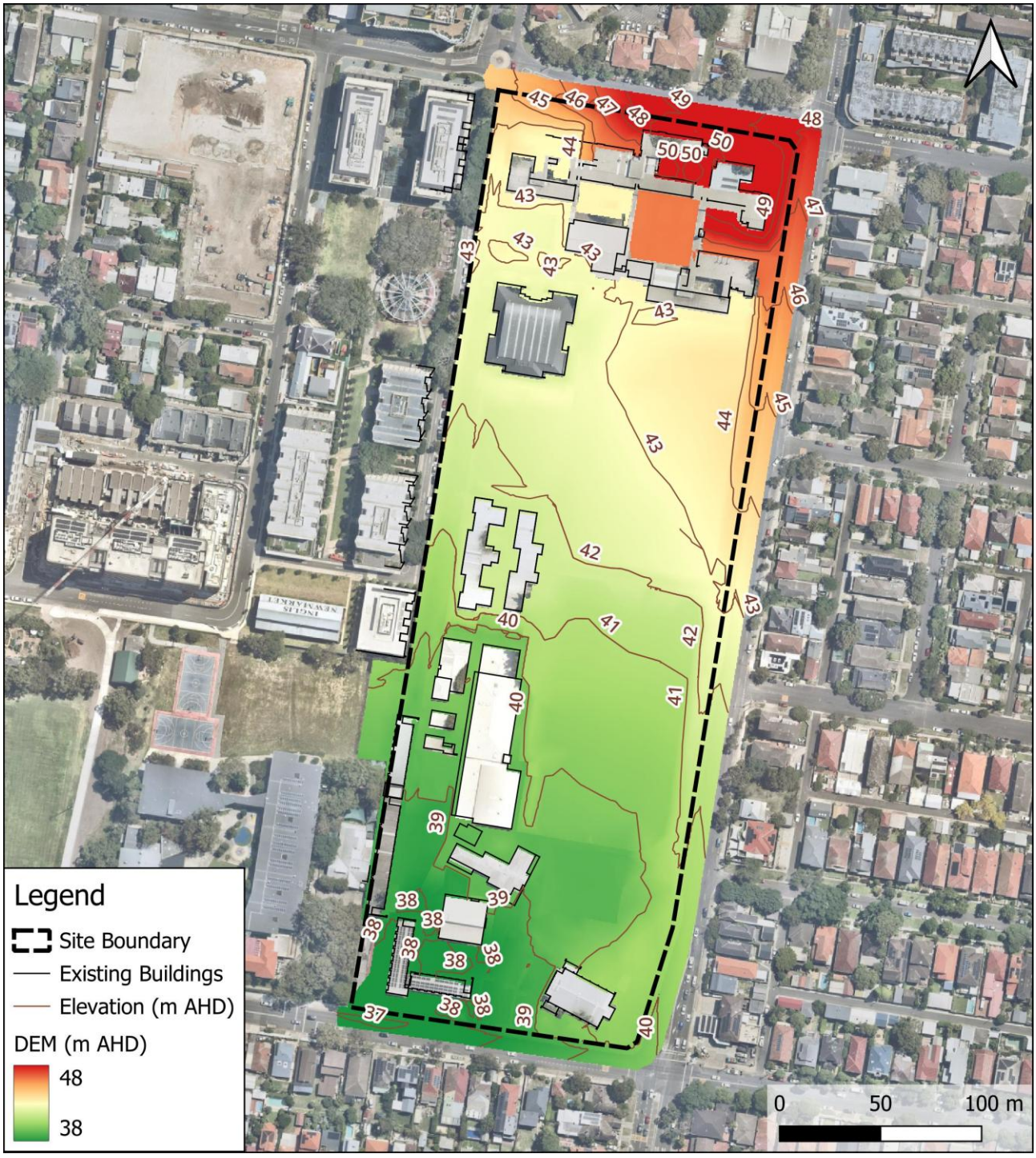


Figure 10: Extent of topographical survey information obtained for the site (Source: CMS Surveyors, June 2025)

5.2.2 Building Footprints

The building footprints in the surrounding area were modified based on aerial imagery dated January 2025 to represent changes following the recent construction works. For areas still under construction (i.e. between Jane Street, Young Street and Barker Street), ground floor plans were obtained from the planning portal website (reference DA/887/2018/C), depicted in Figure 11 and Figure 12. Building footprints were estimated based on georeferenced versions of these plans.

Buildings were blocked out from the 2D domain, preventing floodwaters from flowing through the buildings. To nullify these buildings, the BC code for each building was set to 0 in TUFLOW, deactivating the cells that correspond with the building footprint. This is consistent with Council's modelling approach in the Birds Gully and Bunnerong Road Flood Study.

Refer to Section 5.2.6 for an overview of TTW's model updates, including the revised building footprints.

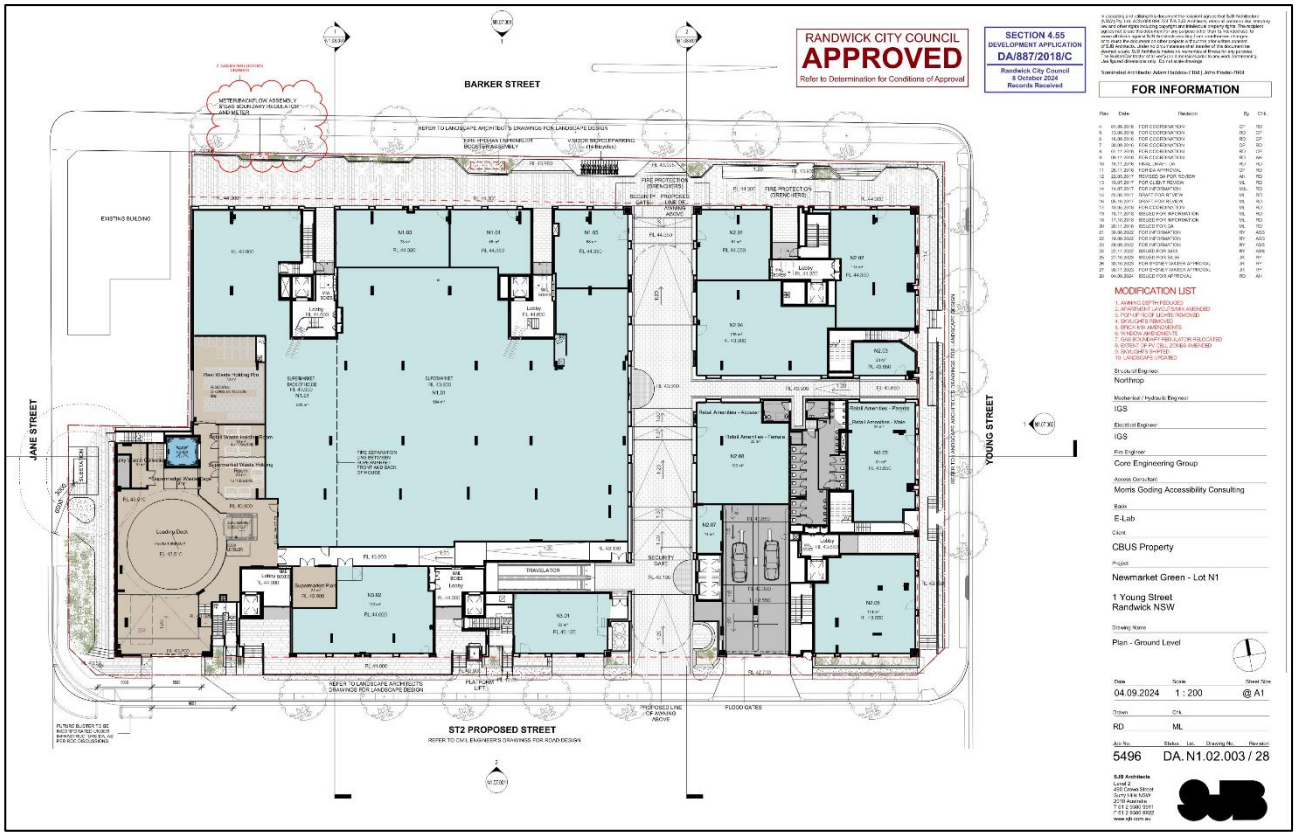


Figure 11: Ground floor plan for the Newmarket Green development at 1 Young Street (Source: SJB Architects, dated 4 September 2024, DA/887/2018/C)

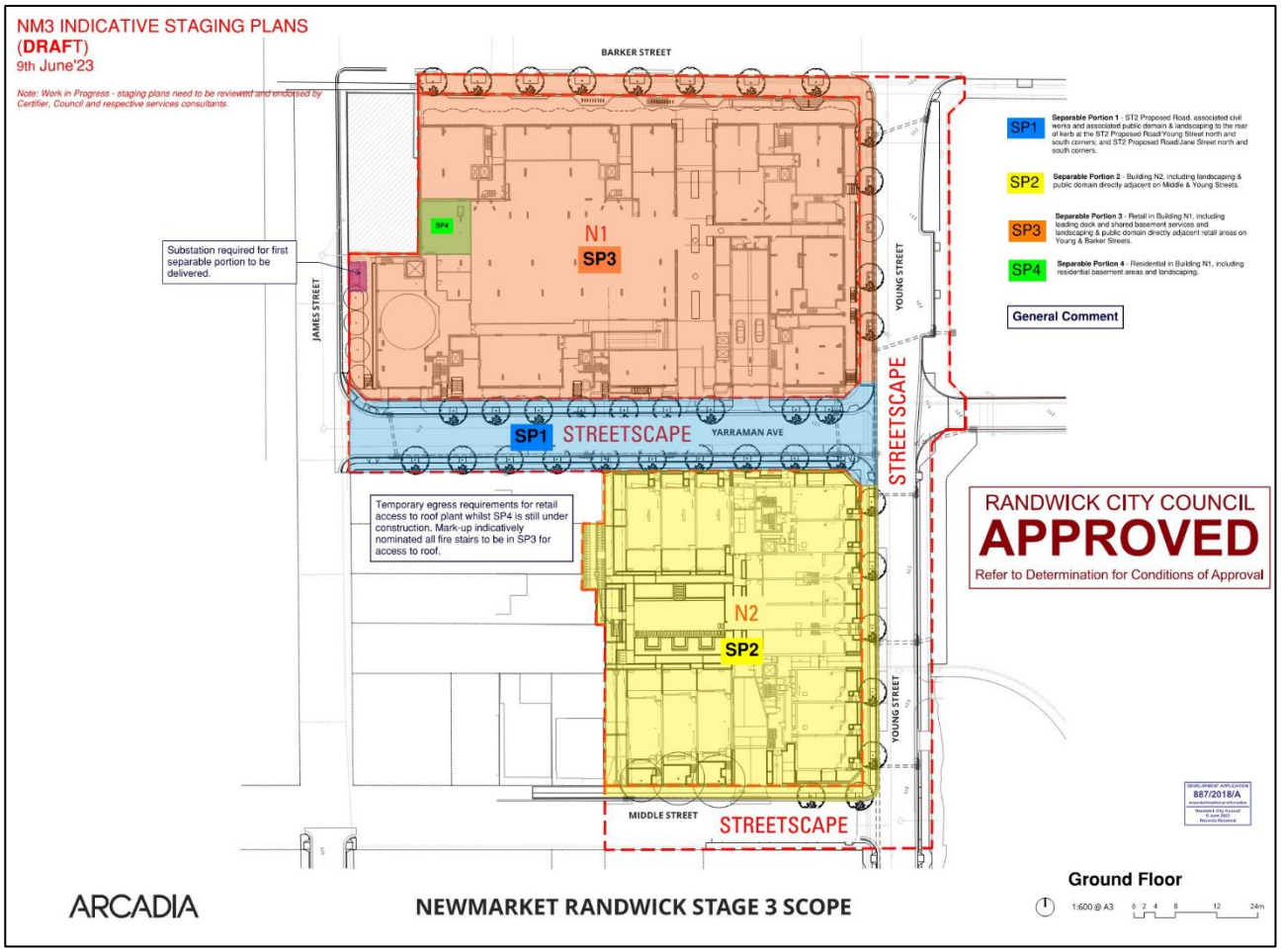


Figure 12: Indicative staging plan for Stage 2 of the Newmarket Development (Source: Arcadia, DA/887/2018/C)

5.2.3 Walls and Fences

In the Birds Gully and Bunnerong Road flood model, fences are represented via a loss of energy by adopting a slightly increased Manning's "n" roughness value for residential and commercial land use areas. As per Table 3, urban residential land use areas have been assigned a roughness value of 0.05, compared with of 0.03 for open spaces.

However, following a site visit to Randwick High School on 25 March 2025, several fences were identified around the perimeter of the site which would present a substantial impediment to flow that is not sufficiently represented in Council's model. Across the site's western boundary, a solid wooden fence separates the site from the Newmarket Randwick Precinct, presented in Figure 13. Within the site, portions of this fence are situated atop of a concrete or brick wall, with minimal gaps to allow any flows to pass through.

Across the eastern and northern site boundaries, a metal fence separates the site from the adjacent roadways (see Figure 14). Given this fence is partially open, it does not represent a full flow obstruction, but it may become blocked with debris and will redirect overland flows to some extent.

These fences have been modelled using Layered Flow Constrictions in TUFLOW to specify the depth-varying form loss of the structures. This allowed a partial blockage of the element flow below the top of the fence, and free flow above this. This approach is in accordance with the TUFLOW Manual (2023) and endorsed by WJ Syme (2008). Figure 15 summarises the blockage factor applied to each fence.

Walls within the site were modelled as full flow obstructions, consistent with Council's approach. The wall height data was taken from survey data from CMS Surveyors.

Figure 13: Wooden fence across the western site boundary (Source: TTW site walkover, 25 March 2025)

Figure 14: Metal fence across the eastern site boundary (Source: TTW site walkover, 25 March 2025)

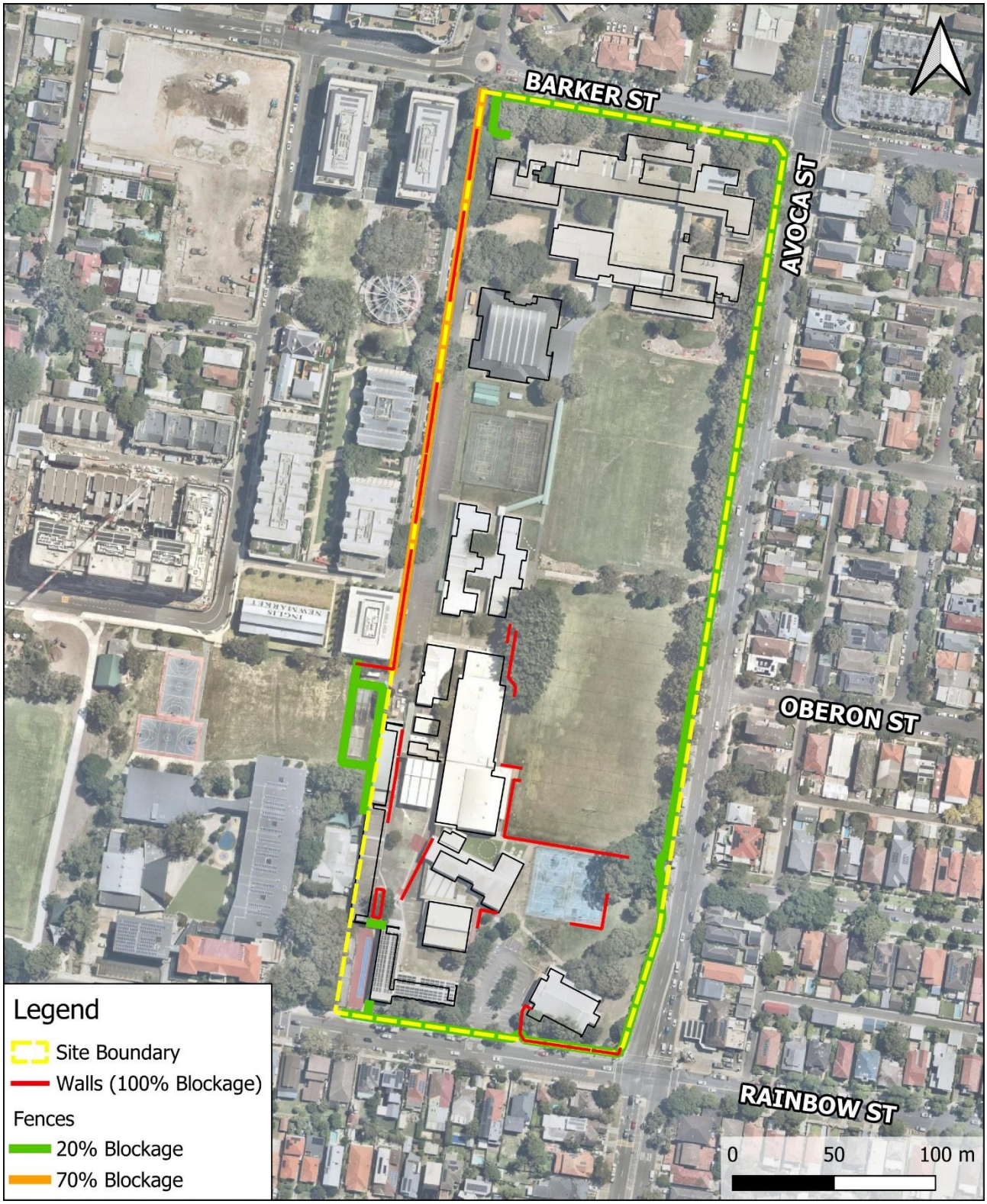


Figure 15: Overview of fences and walls incorporated into the model

5.2.4 Stormwater Data

The stormwater information within Council's model was reviewed and retained. The pipe network is of a significant size, including a 1300mm x 1000mm trunk drainage pipe that is diverted through the site.

A site walkover was undertaken by TTW on 25 March 2025, and several stormwater pits were observed across the newly constructed roads. TTW requested additional stormwater data for the surrounding area from Randwick City Council on 26 February 2025, specifically covering Yarraman Avenue, Fennelly Street, and Young Street.

Figure 16 provides a summary of the stormwater data already included in Council's model, and the new information obtained from Council on 18 March 2025. The new data did not provide any information on the stormwater network across the newly constructed and upgraded roads. The new pit and pipe information covering Helena Street and Avoca Street (at the junction with Howard Street) were incorporated into the model given their proximity to the site. This included seven 300mm diameter pipes.

Further stormwater drainage infrastructure data within the site itself was obtained from site survey data from July 2020 and May 2025. However, the survey data does not include pipe diameters. To adopt a conservative approach, no additional stormwater infrastructure within the site boundary was incorporated into the model. Note that out of the ten stormwater "pits" shown within the site in Figure 16, nine are modelled as junction pits and do not represent an inlet. They therefore do not capture or mitigate excess runoff within the site.

Figure 16: Council stormwater infrastructure data (Source: Randwick City Council)

5.2.5 Flood Hazard Assessment

The relative vulnerability of the community to flood hazard has been assessed by using the flood hazard vulnerability curves set out in '*Handbook 7 – Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*' of the Australian Disaster Resilience Handbook Collection (2017).

These curves assess the vulnerability of people, vehicles and buildings to flooding based on the velocity and depth of flood flows. The flood hazard categories are outlined in Figure 17, ranging from a level of H1 (generally safe for people, vehicles and buildings) to H6 (unsafe for vehicles and people, with all buildings considered vulnerable to failure). Table 4 outlines the threshold limits for each hazard category.

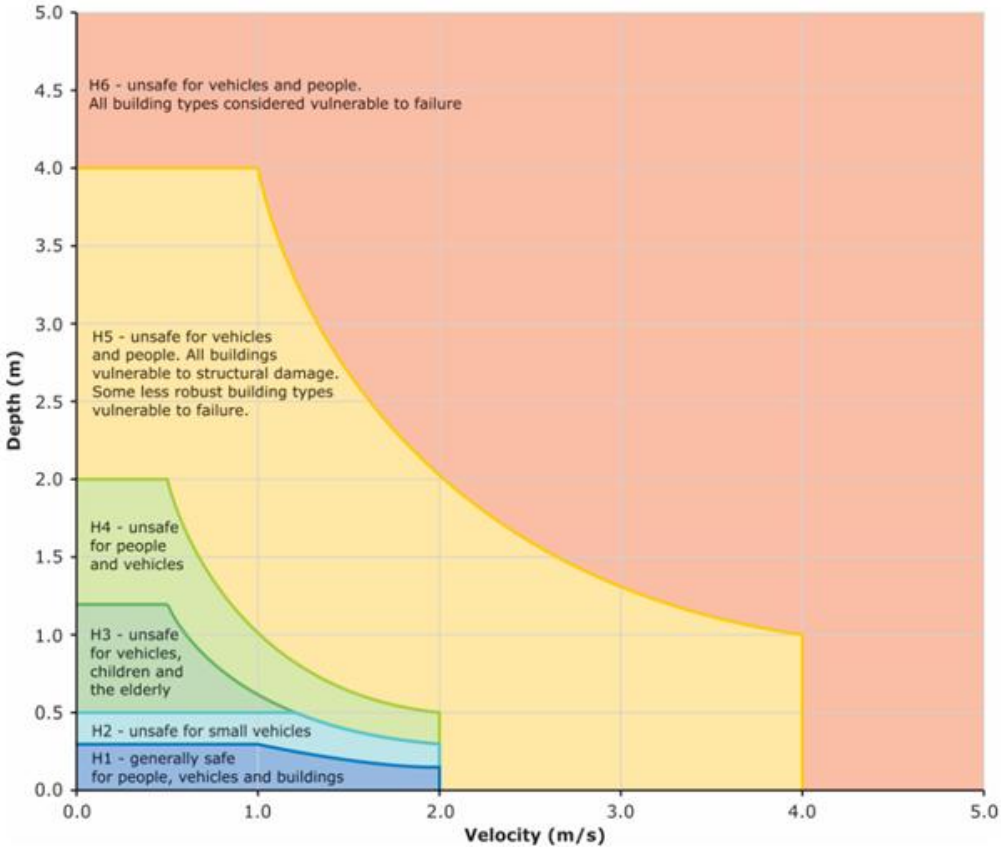


Figure 17: Flood hazard vulnerability curve (Source: Flood Risk Management Guide FB03, NSW DPE, 2022)

Table 4: Hazard vulnerability threshold limits

Hazard	Description	Classification Limit (m2/s)	Limiting still water depth (D) (m)	Limiting velocity (V) (m/s)
H1	Generally safe for people, vehicles and buildings	D x V ≤ 0.3	0.3	2.0
H2	Unsafe for small vehicles	D x V ≤ 0.6	0.5	2.0
H3	Unsafe for vehicles, children and the elderly	D x V ≤ 0.6	1.2	2.0
H4	Unsafe for people and vehicles	D x V ≤ 1.0	2.0	2.0
H5	Unsafe for people and vehicles. All buildings vulnerable to structural damage.	D x V ≤ 4.0	4.0	4.0
H6	Unsafe for people and vehicles. All building types considered vulnerable to failure.	D x V > 4.0	No Limit	No Limit

As this hazard analysis is not available using the 2016-03-AE_iDP_w64 TUFLOW release (used in Council's model), the TUFLOW engine used in this study was updated to the 2018-03-AC_iDP_w64 release.

5.2.6 Overview of Updated Existing Model

Figure 18 presents a summary of TTW's model updates, set against January 2025 aerial imagery. The model provides a robust representation of existing conditions at the site, including ground levels, building blockages and flow obstructions.

Figure 18: TTW model input data set against January 2025 aerial imagery (Source: Nearmap, 27 January 2025)

6.0 Flood Model Results

6.1 Critical Duration

The Birds Gully and Bunnerong Road Flood Study found that the 60-minute storm was critical for upper areas of the catchment affected by overland flow in the 10%, 5%, 1%, 0.5% AEP and PMF events. For smaller magnitude events (including the 1 EY (exceedance per year), 0.5 EY and 20% AEP), the shorter duration 30-minute event was found to be critical for overland flows.

Note that Council's Flood Study did not model flood behaviour in the 0.2% AEP (1-in-500-year ARI) event. Table 5 outlines the model runs completed for each event, alongside the critical duration identified for the Randwick High School site.

Table 5: Critical duration assessment for the site

Event	Storms Assessed	Median TP	Critical Duration
10% AEP	60 minutes	TP06	60-minute TP06
5% AEP	15 minutes	TP09	60-minute TP03
	30 minutes	TP06	
	60 minutes	TP03	
1% AEP	15 minutes	TP02	30-minute TP04
	30 minutes	TP04	
	60 minutes	TP05	
0.5% AEP**	60 minutes	TP06	60-minute TP06
PMF***	30 minutes	N/A	30-minute
	60 minutes		

*Full hydrological input files were not provided for 10% AEP event, only the 60-minute TP06 and the 180-minute TP02 hydrographs. A detailed critical duration assessment was therefore not possible for this event

**Full hydrological input files were not provided for the 0.5% AEP event, only the 60-minute TP06 and the 90-minute TP10 hydrographs. A detailed critical duration assessment was therefore not possible for this event.

***Storm durations lower than 30 minutes were not provided for the PMF event.

6.2 Existing Conditions

Figure 19, Figure 20 and Figure 21 demonstrate the flood depths and levels, velocity and hazard classification across the site in the 1% AEP event. Flood depths, levels, velocity and hazard level in the PMF event are presented in Figure 22, Figure 23 and Figure 24. Additional model outputs for the 10% AEP, 5% AEP and 0.5% AEP events are attached in Appendix B. The following observations have been made:

- The site is significantly impacted by overland flooding, which is primarily sourced from excess runoff overtopping onto the site from Avoca Street, the site's eastern frontage. In the PMF event, flows also overtop onto the site from Barker Street in the northwest. Flows are primarily directed in a south/south-westerly direction across the site toward Rainbow Street, which acts as a major drainage outlet.
- In the 1% AEP event, depths across the southwest of the site are typically around 300-400mm. In the PMF event, depths exceed 1.0m around the existing building cluster to the southwest of the site.
- In the PMF event, the majority of the site is flood affected. The only exception to this is the most northern portion of the site (at the former Girls' school), where ground levels are highest.
- In terms of hazard classification, the majority of flows in the 1% AEP event are classified as H1-H2 hazard, which is regarded as safe for people and children. Where flood depths are highest (at the southwest of the site), hazard level peaks at H3, which is unsafe for vehicles, children and the elderly. In the PMF event

hazard level onsite peaks at H5 over the southern car park, and the internal road adjacent to the site's western boundary. These high hazard flows are unsafe for people and vehicles, with all buildings vulnerable to structural damage.

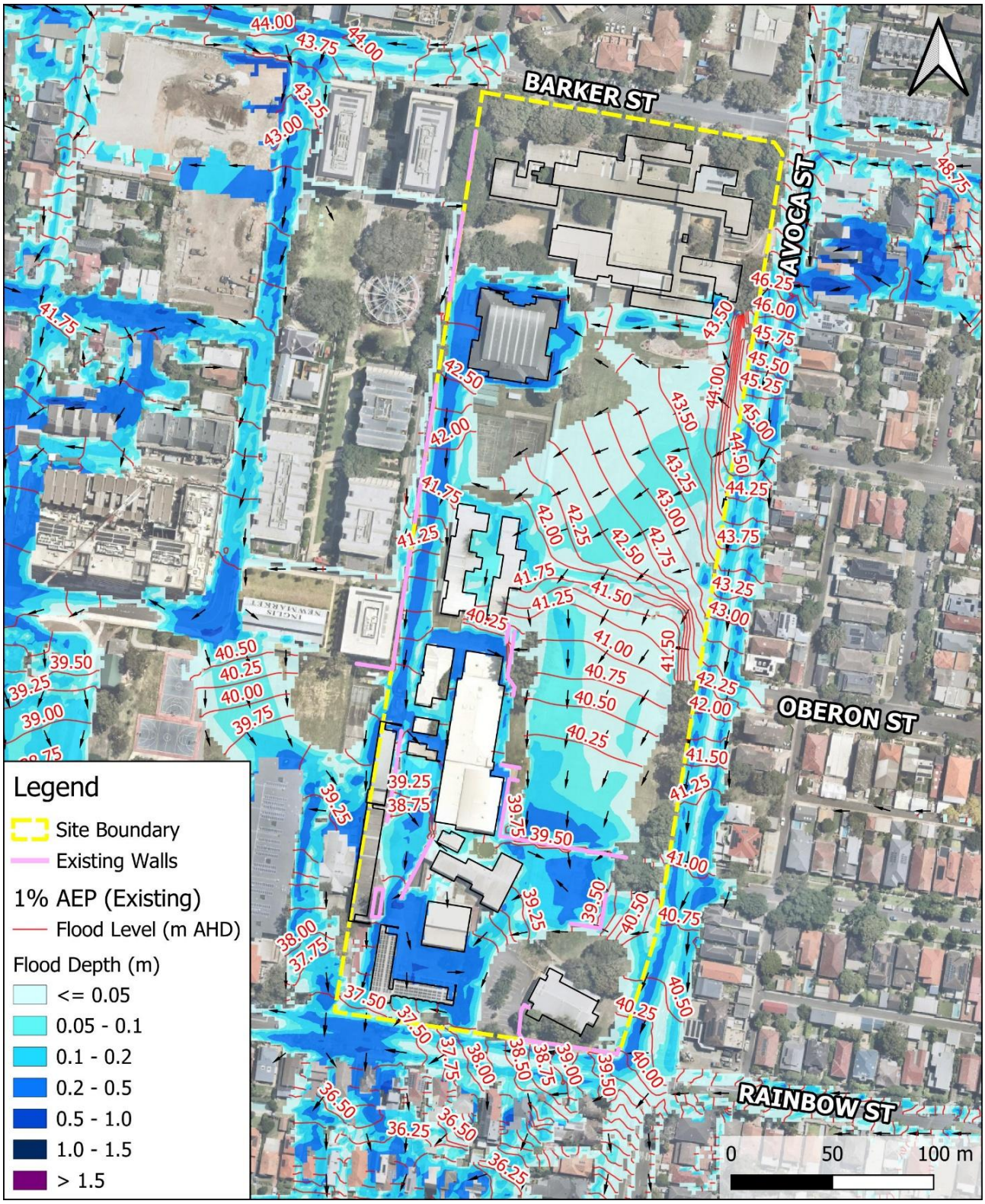


Figure 19: 1% AEP flood depths and levels at Randwick High School under existing conditions

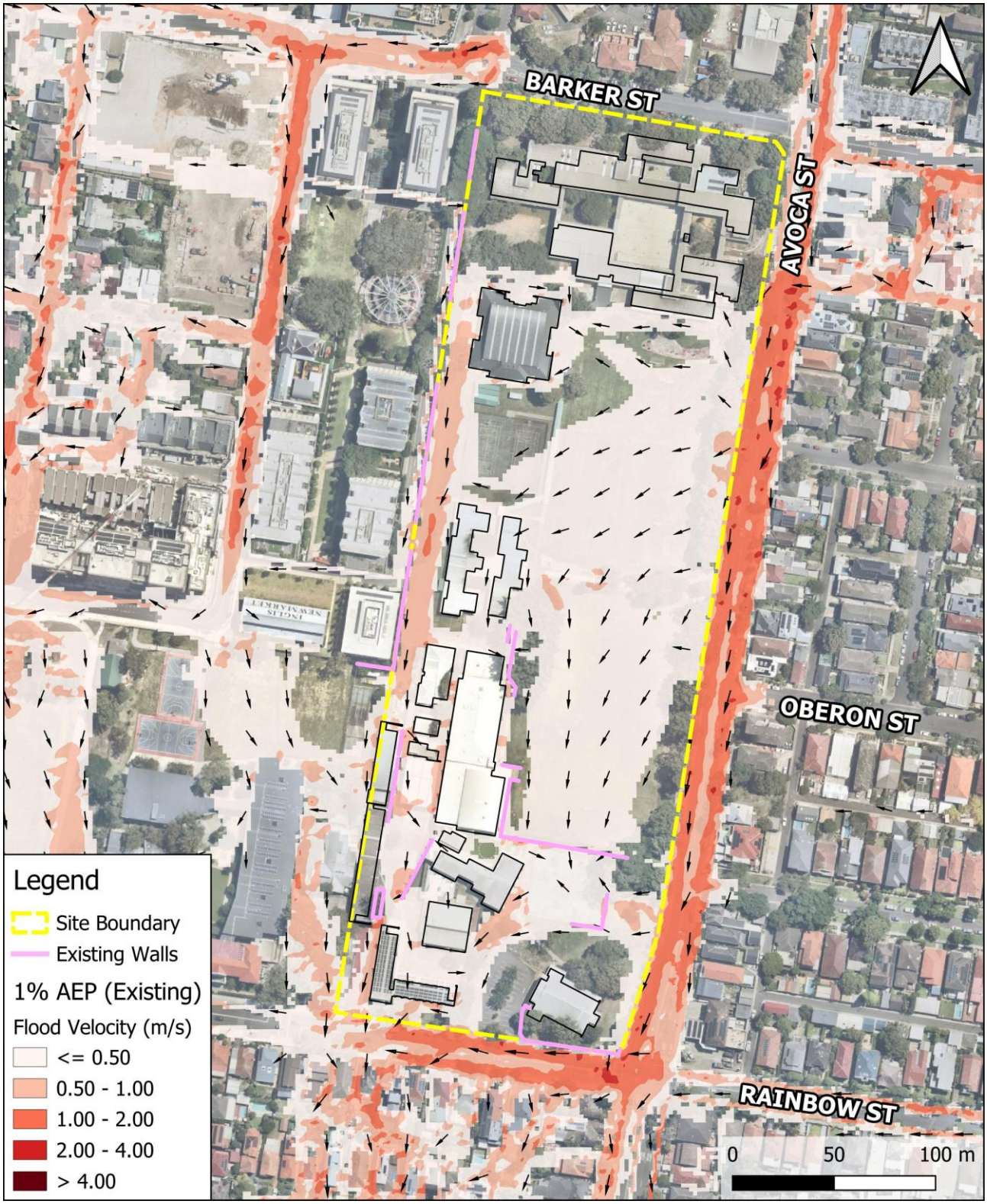


Figure 20: 1% AEP flood velocity at Randwick High School under existing conditions

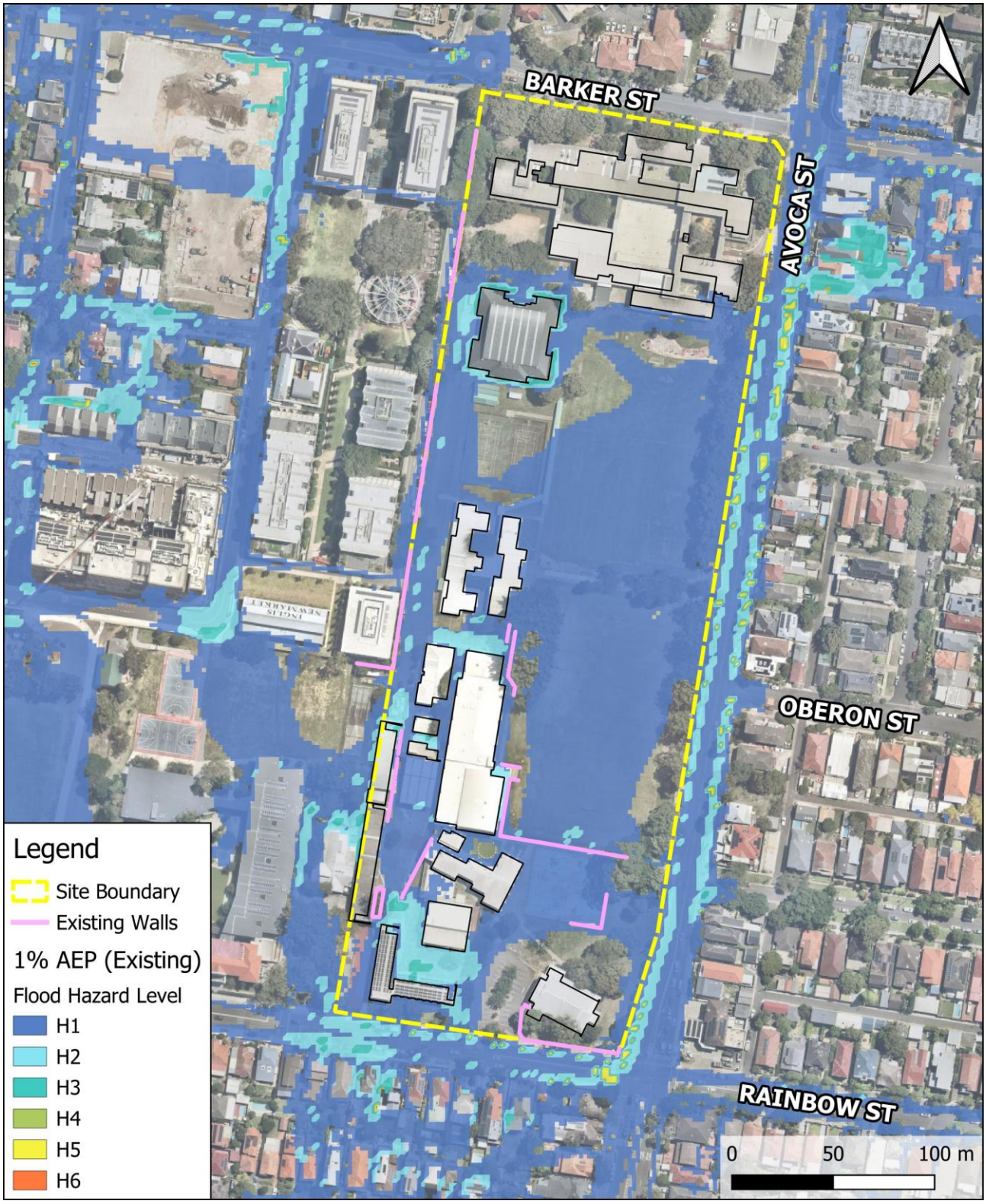


Figure 21: 1% AEP flood hazard levels at Randwick High School under existing conditions

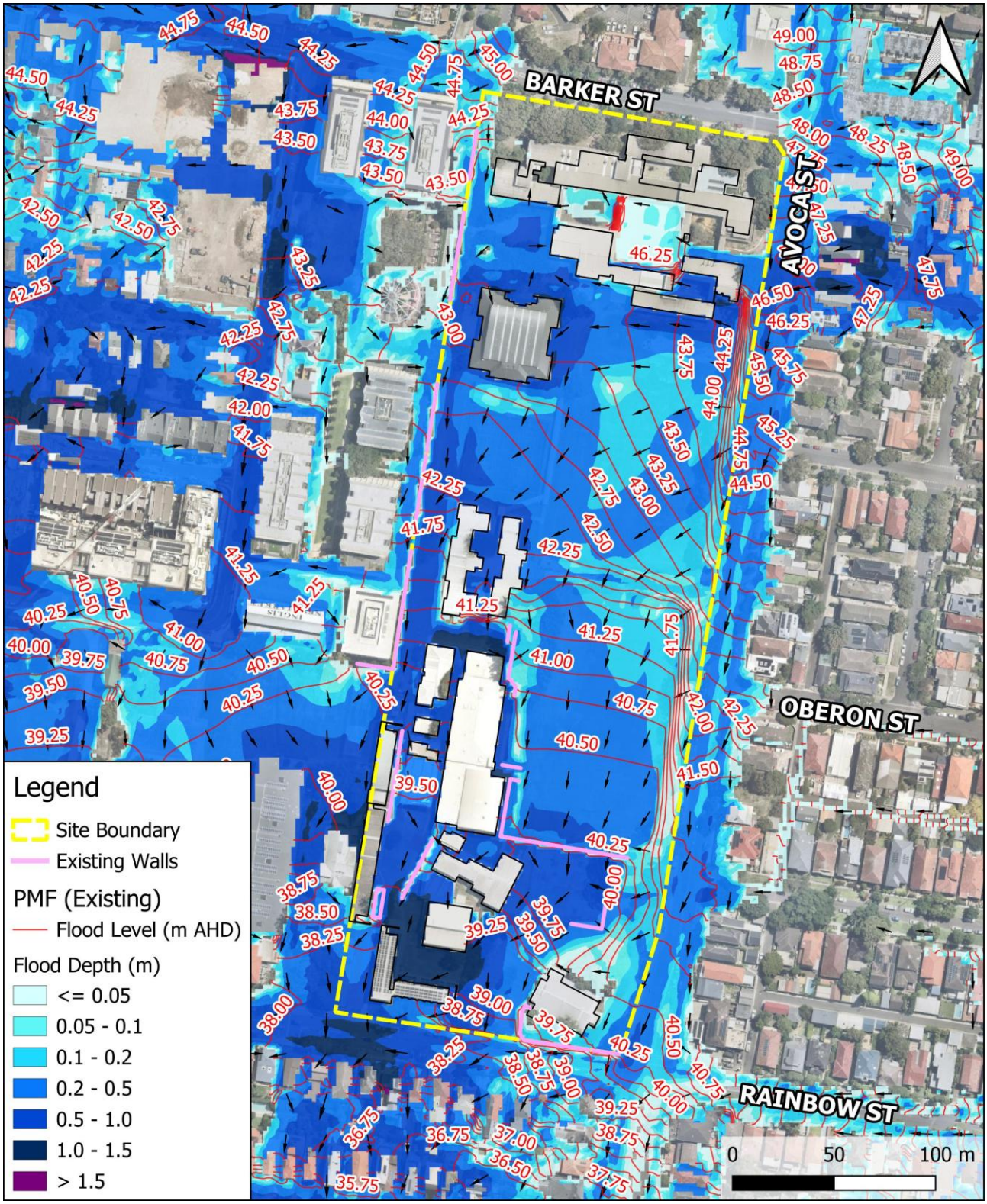


Figure 22: PMF depths and levels at Randwick High School under existing conditions

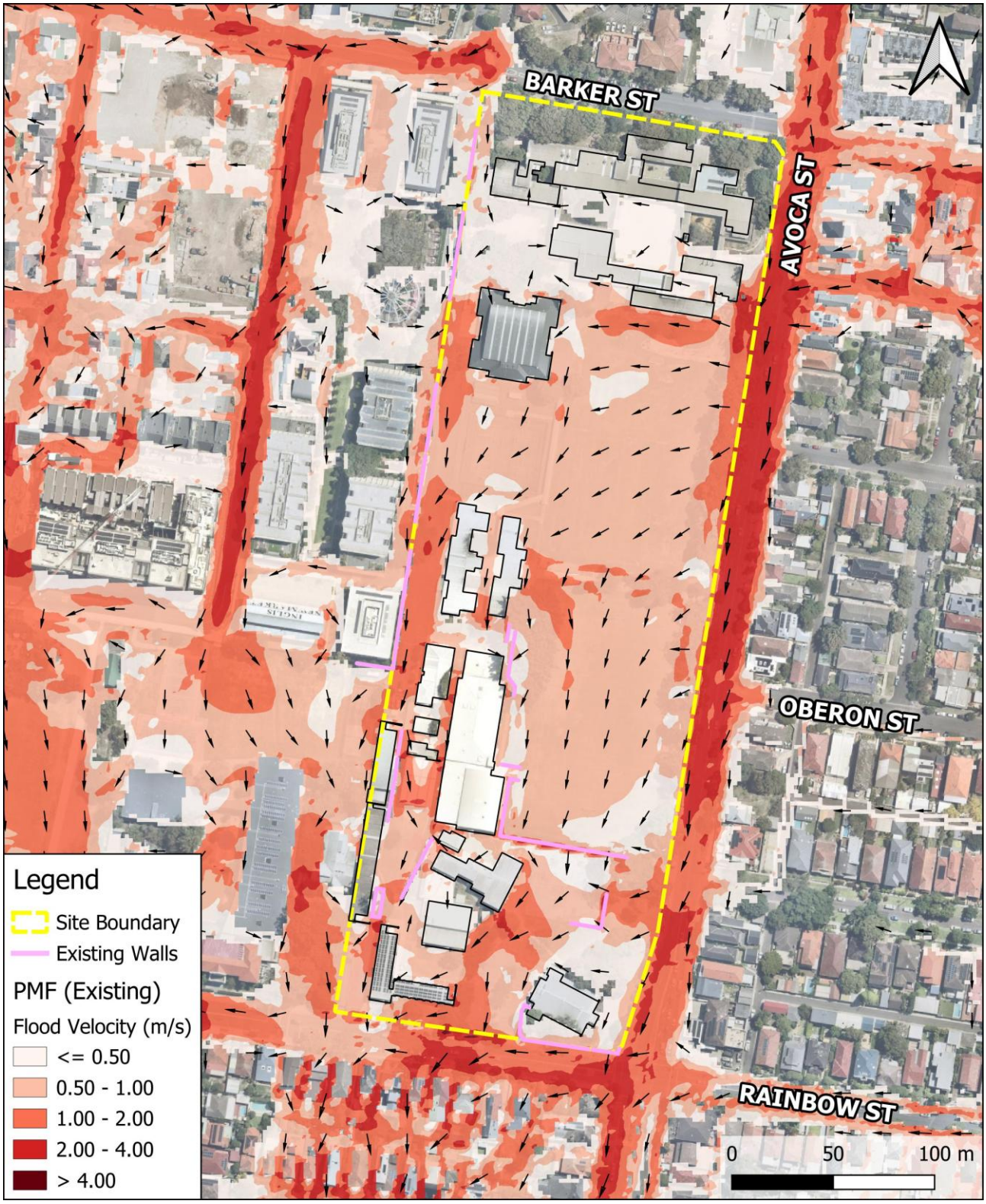


Figure 23: PMF velocity at Randwick High School under existing conditions

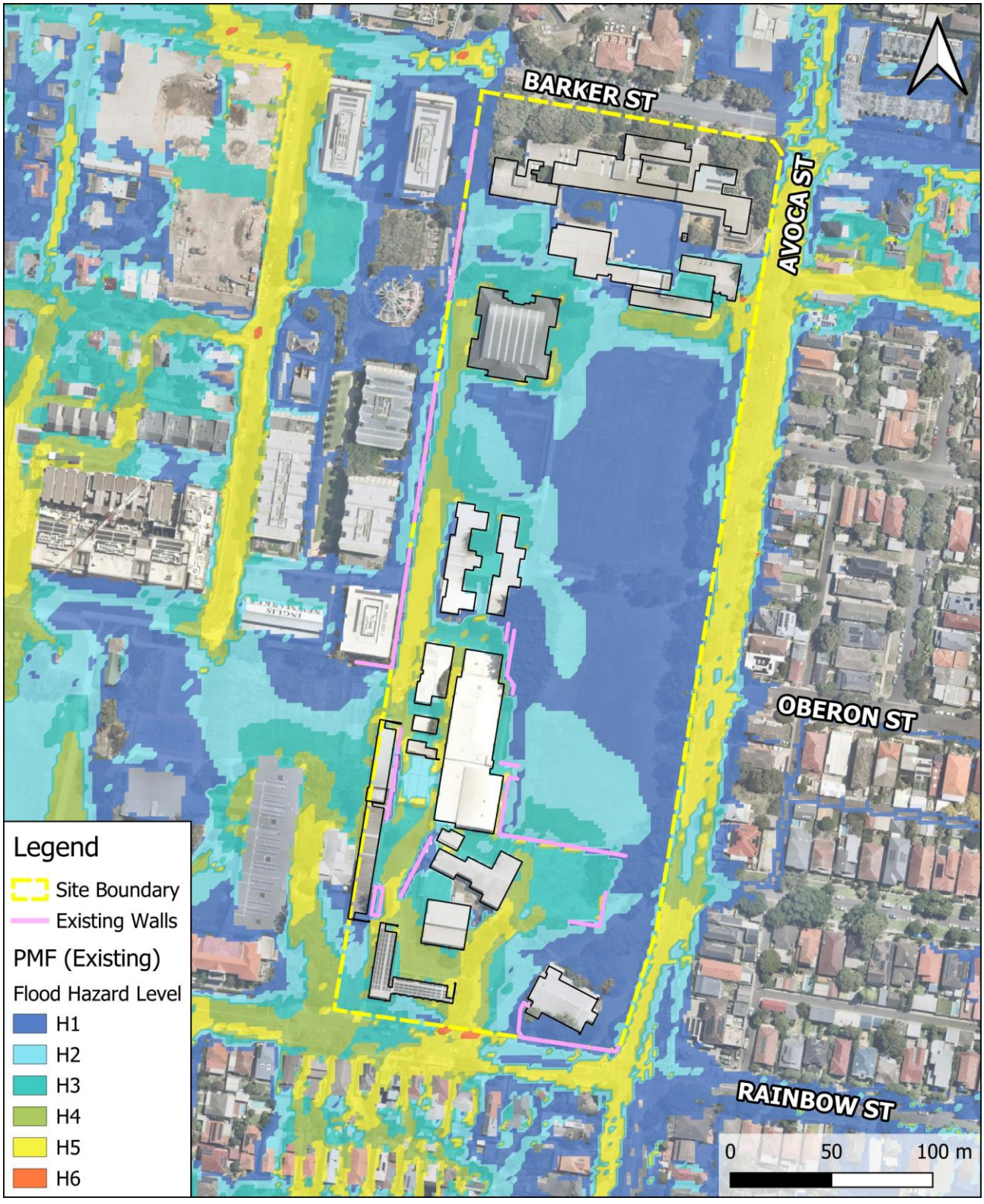


Figure 24: PMF hazard levels at Randwick High School under existing conditions

6.3 Post-Development Conditions

The existing conditions flood model was updated to create a post-development flood model, including the following amendments:

- Building blockages onsite were updated to reflect the proposed ground floor building footprint from the latest site plans.
- The site grading and levels were updated based on 3D design TINs from BG&E, the project's civil team.

Given the complexities of the site and positioning of the proposed buildings, it was necessary to test various mitigation measures to alleviate flood risk. The current design now includes several mitigation measures to improve flood resilience to both the new and existing buildings.

Section 6.3.1 presents the "baseline" post-development model outputs (prior to mitigation testing), while Section 6.3.2 presents the post-development flood conditions under the current design (with the addition of mitigation measures).

6.3.1 Baseline Post-Development Model (Without Mitigation Measures)

Figure 25 presents an overview of the baseline post-development model inputs, based on the preliminary design tin from BG&E, dated 3 April 2025. Figure 26 and Figure 27 present the flood depths and levels in post-development conditions, prior to the implementation of any mitigation measures. These outputs are based on the baseline design tin from BG&E, dated 3 April 2025. The new buildings displace floodwaters, which are redirected into nearby open areas, including the car park.

Table 6 provides an overview of the peak flood levels adjacent to the building openings in the 1% AEP and PMF events. Without mitigation measures, the admin building would be impacted by flood depths of up to 250mm in the 1% AEP event, and 700mm in the PMF event.

In addition, a flood impact assessment was conducted to determine any potential adverse impacts to neighbouring properties or changes to flood behaviour as a result of the development. Afflux mapping demonstrating the impact of the proposed development on 1% AEP flood levels (in comparison to existing conditions) is presented in Appendix A. The following observations have been made:

- Given the positioning of the proposed buildings within the main overland flow path across the south of the site, there is a significant increase in flood levels as the flows are diverted around the buildings.
- Flood levels increase most significantly to the west of the admin building, adjacent to the existing Block B, with an increase of 780mm in the 1% AEP event.

Table 6: Maximum 1% AEP and PMF levels adjacent to the proposed building openings in baseline post-development conditions

Building	FFL (m AHD)	Flood Level (m AHD)	
		1% AEP	PMF
Lecture Theatre	39.60	N/A – not flood affected	39.98 at northeast entry
Admin Building	39.00	39.25 at northwest entry	39.70 at northwest entry

Figure 25: Baseline post-development model setup (Source: preliminary design obtained from BG&E, dated 3 April 2025)

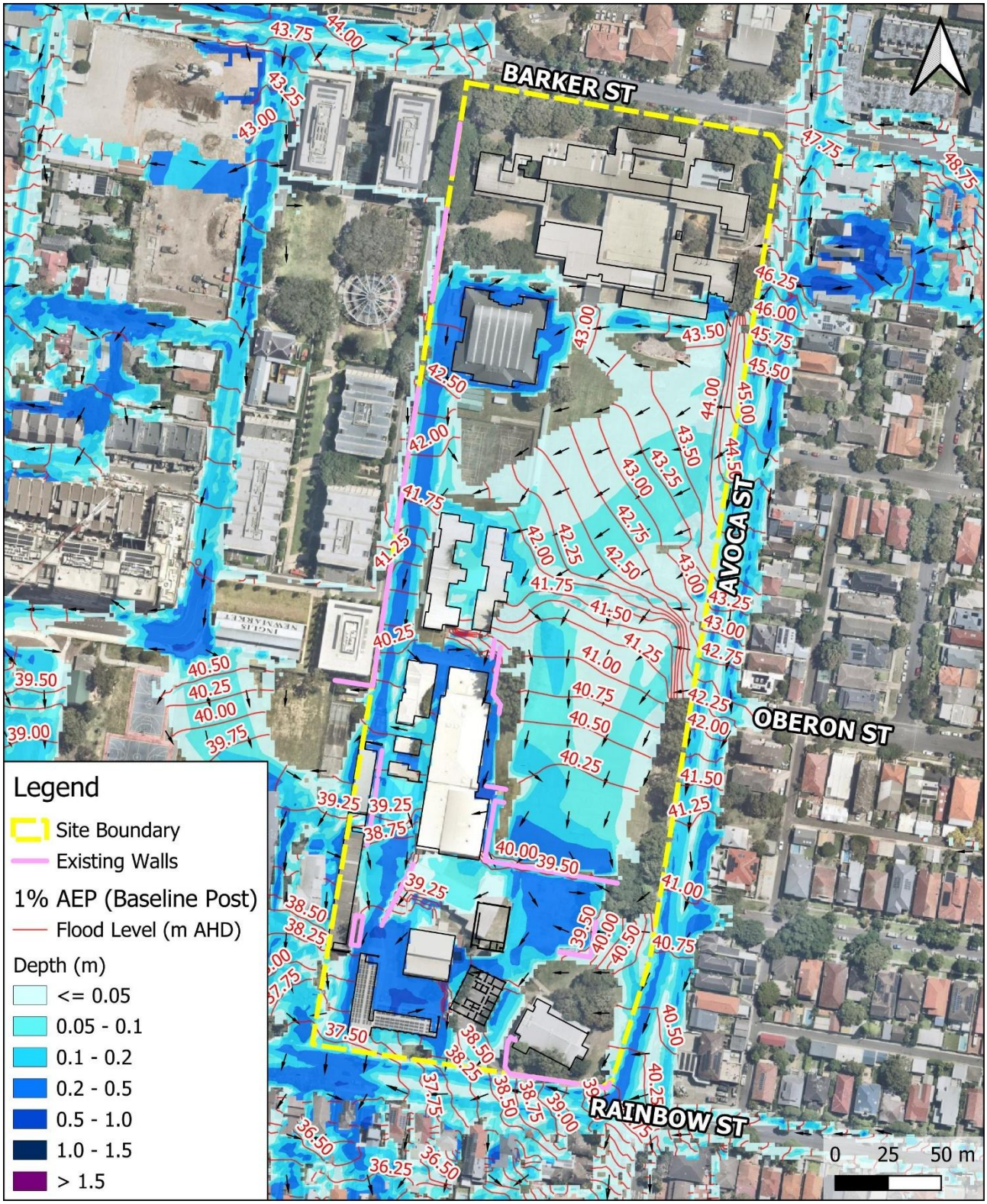


Figure 26: 1% AEP flood depths and levels at Randwick High School in baseline post-development conditions (without mitigation measures)

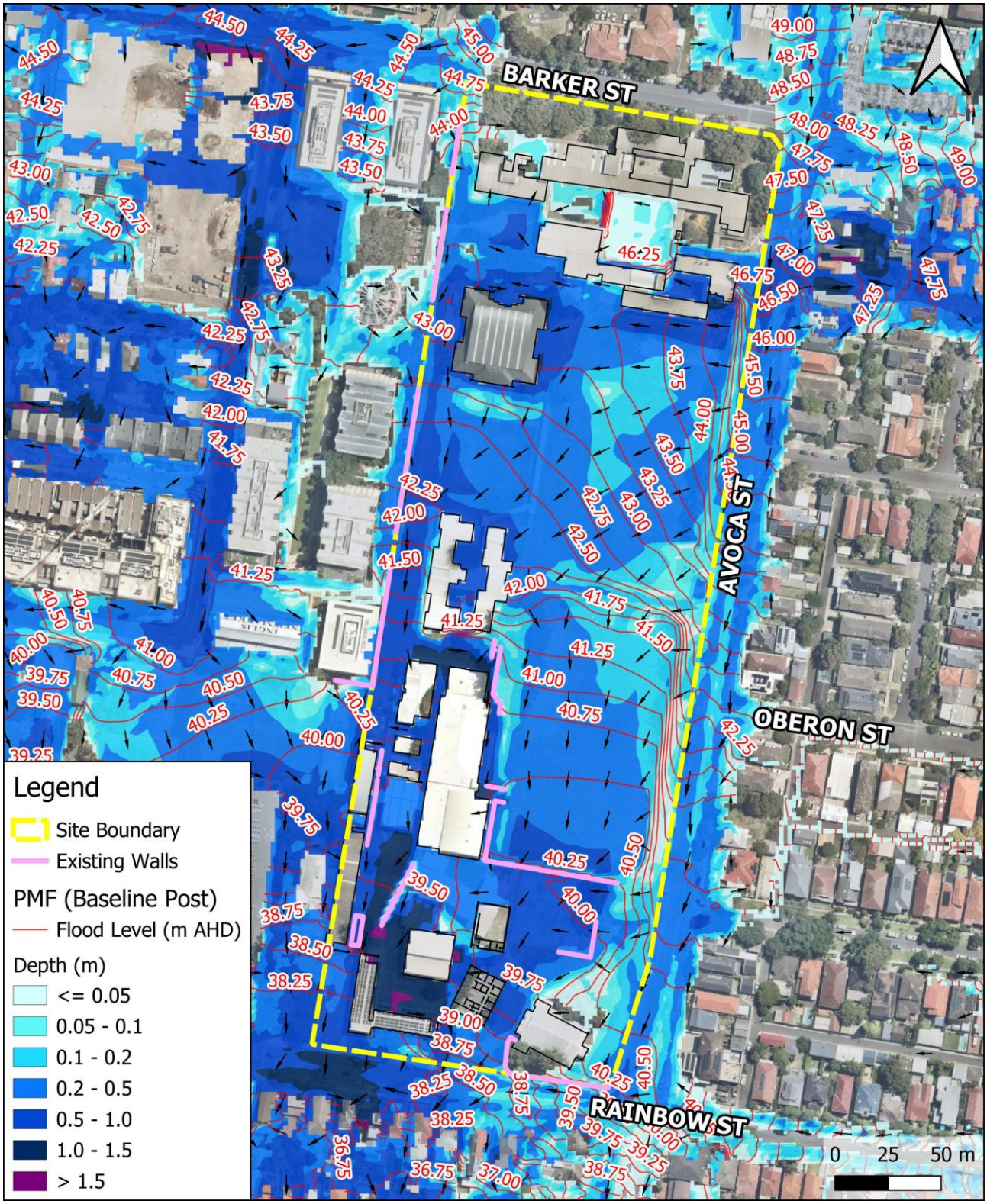


Figure 27: PMF depths and levels Randwick High School in baseline post-development conditions (without mitigation measures)

6.3.2 Post-Development Model with Mitigation Measures

Given the overall increase in flood risk to the site in baseline post-development conditions, it was necessary to incorporate several mitigation measures into the design. These are summarised in Figure 28, including a flood wall, ramps/steps, and an increased bund height over the open field.

The updated post-development model is based on the latest BG&E design tin, dated 30 June 2025.

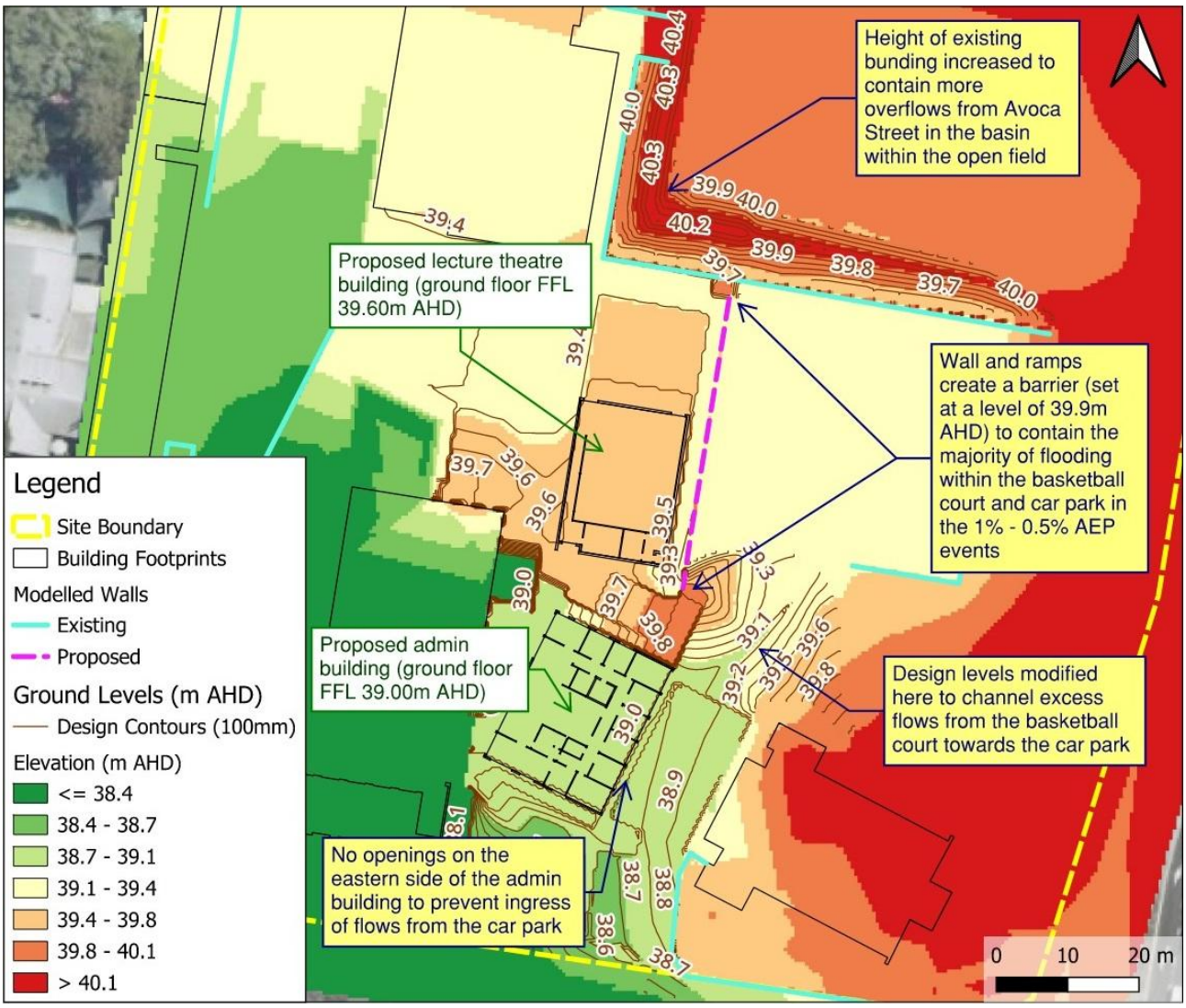


Figure 28: Updated post-development model setup (Source: latest design obtained from BG&E, dated 24 June 2025)

Model Outputs

Flood depths, levels, velocity and hazard level in the 1% AEP event under the revised post-development design are presented in Figure 29, Figure 30 and Figure 31, respectively. PMF depths, level, velocity and hazard levels are depicted in Figure 32, Figure 33 and Figure 34. Additional flood mapping is provided for the 10%, 5% and 0.5% AEP events in Appendix C.

- In the updated design, the proposed buildings are both flood-free in the 1% AEP event, with no above-floor inundation.
- Overflows from Avoca Street are largely contained within the open field and basketball court, away from the proposed and existing buildings. The 1% AEP flood level in the open field reaches 40.22m AHD in

post-development conditions, 300mm below the maximum bund height of 40.52m AHD. In the basketball court, the flood level peaks at 39.35m AHD, 560mm below the wall height of 39.9m AHD.

- Flows are directed from the basketball court into the car park. Although the car park is located directly east of the admin building, there are no doorways on this side of the building, preventing any ingress of flows.
- In the PMF event, both buildings are impacted by above-floor inundation, but impacts have reduced in comparison to baseline post-development conditions, most substantially at the admin building. With the implementation of mitigation measures, the PMF level adjacent to the student reception doorway (to the northwest of the admin building) decreases by 290mm. Table 7 provides an overview of peak flood levels in baseline post-development conditions versus updated post-development conditions.
- In addition, the new eastern entry to Block B (which includes a staircase and a lift to the lower ground floor) is impacted by flood depths exceeding 1 metre in the critical 30-minute PMF event, equating to a hazard level of H3 (unsafe for children). It should be noted that this area is not flood affected in the 0.5% AEP event (nor the longer duration 3-hour PMF storm). The overall risk is low, given that there is internal access to upper levels above the PMF. This is discussed further in Section 10.2.2. More information on managing these risks is provided in TTW's Flood Emergency Response Plan, submitted alongside this FIRA.

Table 7: Maximum 1% AEP and PMF levels adjacent to the proposed building openings in baseline post-development conditions

Building	FFL (m AHD)	Flood Level (m AHD)			
		Baseline Post-Development		Updated Post-Development	
		1% AEP	PMF	1% AEP	PMF
Lecture Theatre	39.60	N/A	39.98 at NE entry	N/A	39.95 at NEW entry
Admin Building	39.00	39.25 at NW entry	39.70 at NW entry	N/A	39.41 at NW entry

Impact of Mitigation Measures

The implementation of the mitigation measures ensures that flows are diverted away from the existing and proposed buildings. The impact of the mitigation measures on 1% AEP flood levels (in comparison to baseline post-development conditions) is presented in Figure 35, with a decrease of up to 80mm in flood levels north of Block D.

The small increase in flood levels immediately north of the proposed lecture theatre can be attributed to an increase in ground level here to accommodate the steps up to 39.9m AHD. Flows at this location are less than 50mm depth with the implementation of the mitigation measures. The impact of the updated design on existing flood behaviour is assessed in more detail in Section 8.0.

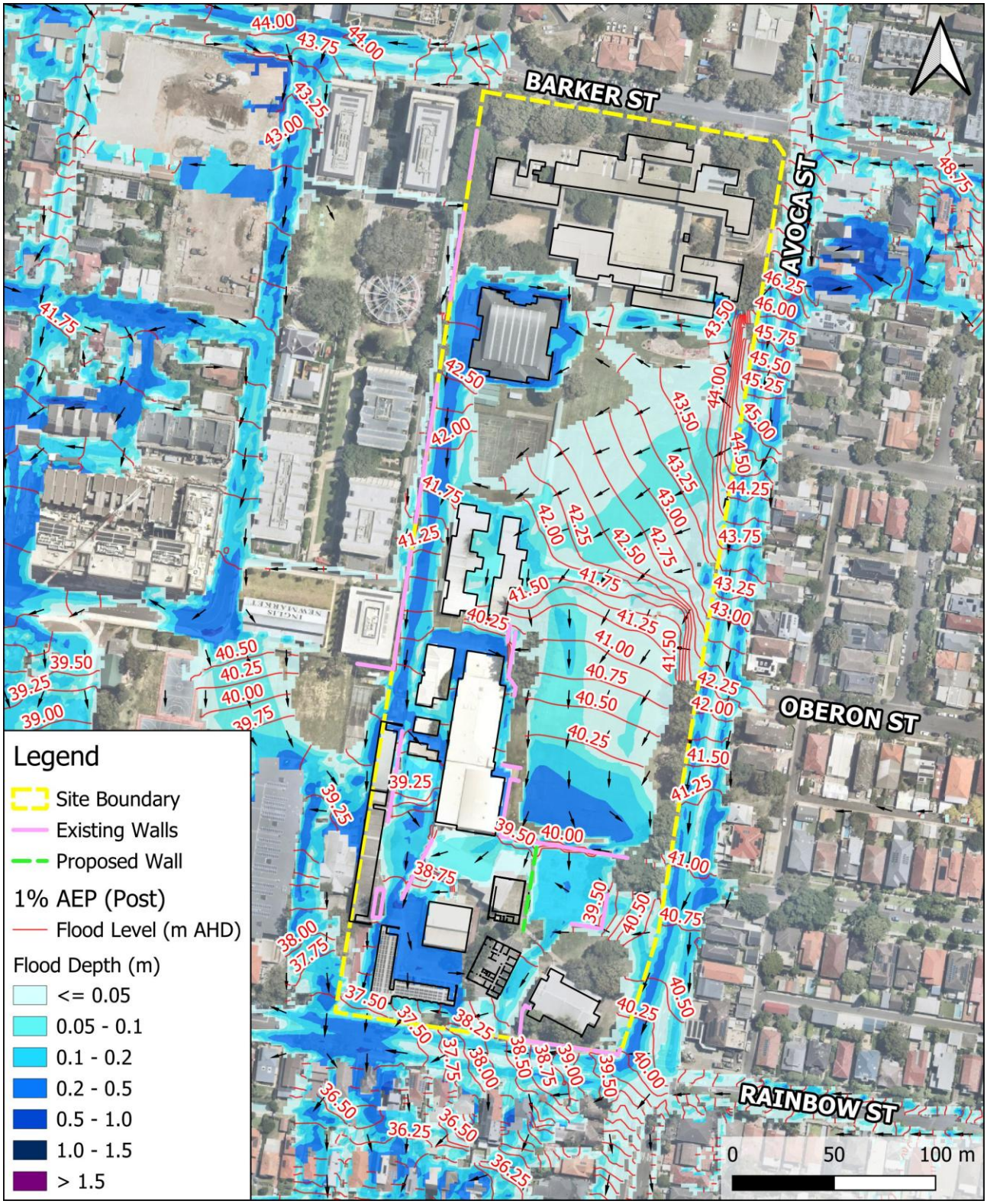


Figure 29: 1% AEP flood depths and levels at Randwick High School under post-development conditions (with mitigation)

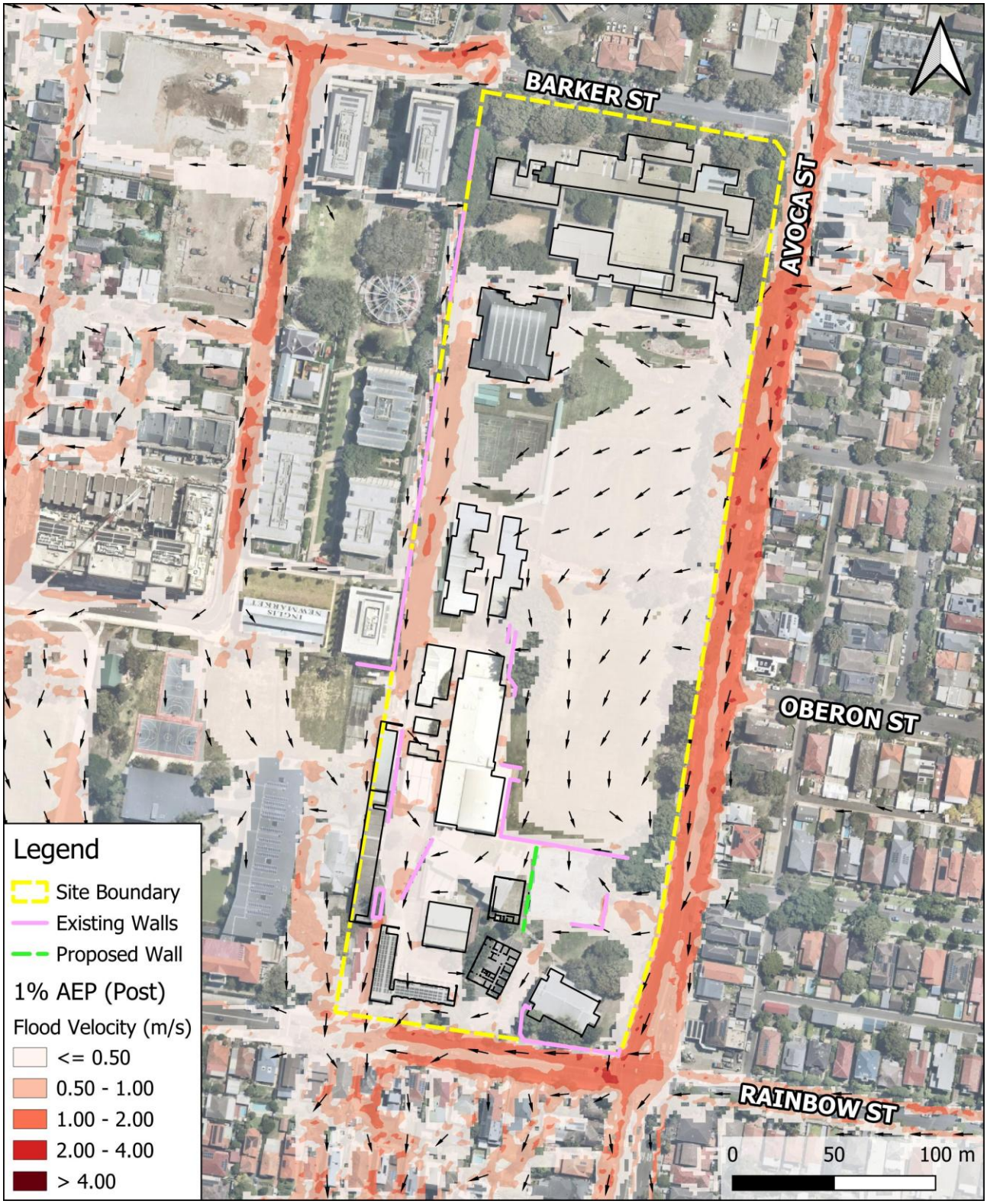


Figure 30: 1% AEP flood velocity at Randwick High School under post-development conditions (with mitigation)

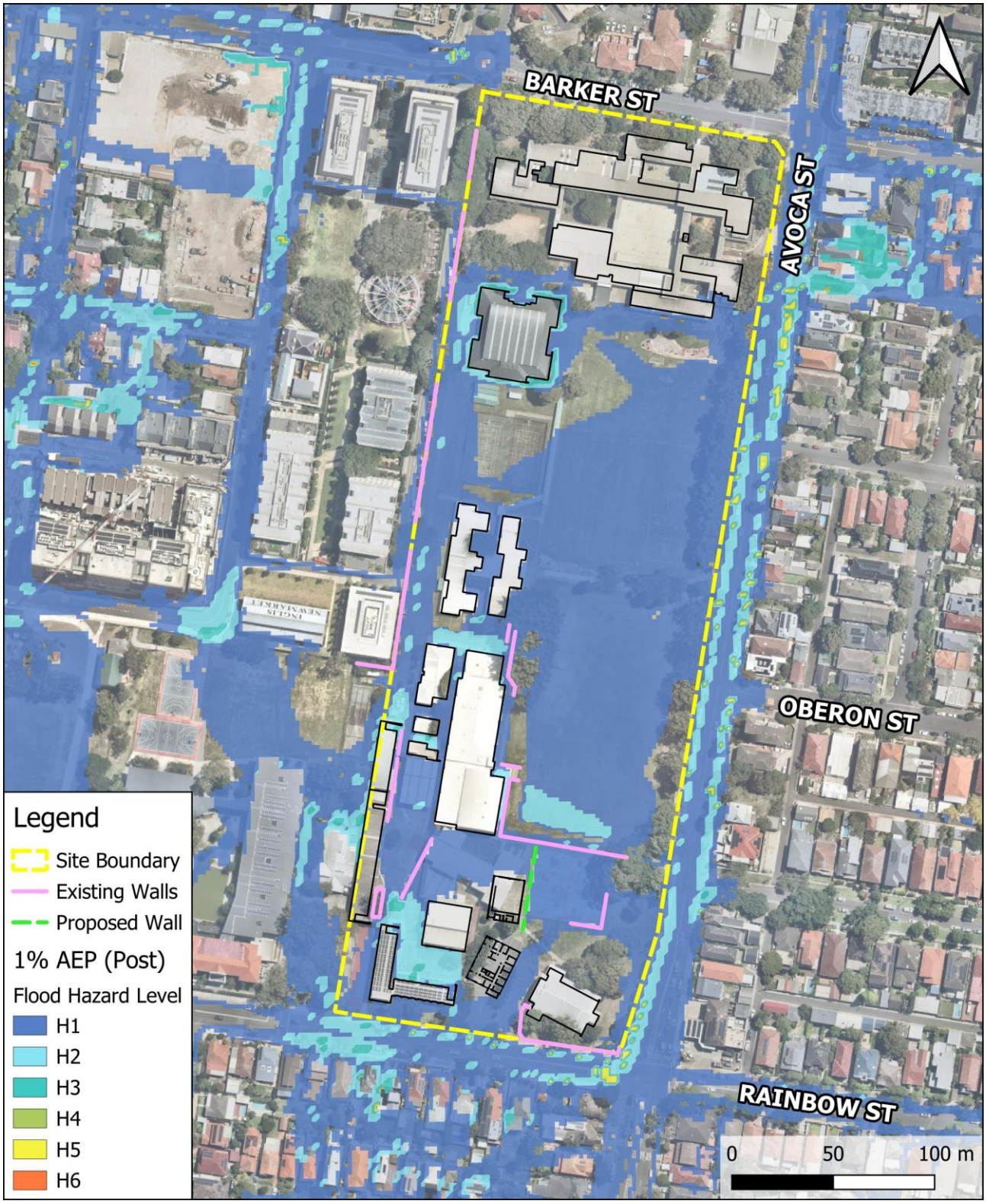


Figure 31: 1% AEP flood hazard at Randwick High School under post-development conditions (with mitigation)

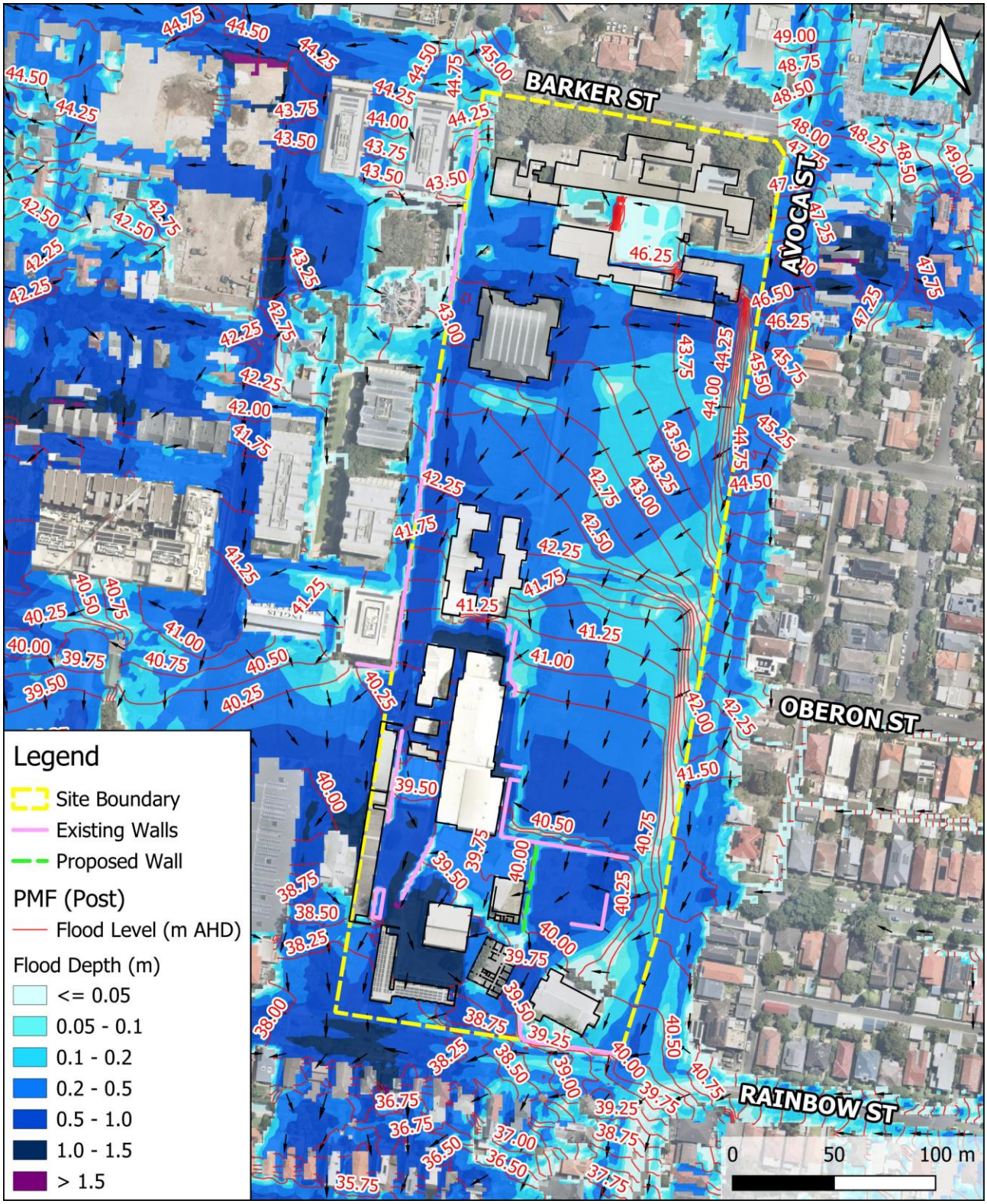


Figure 32: PMF depths and levels at Randwick High School under post-development conditions (with mitigation)

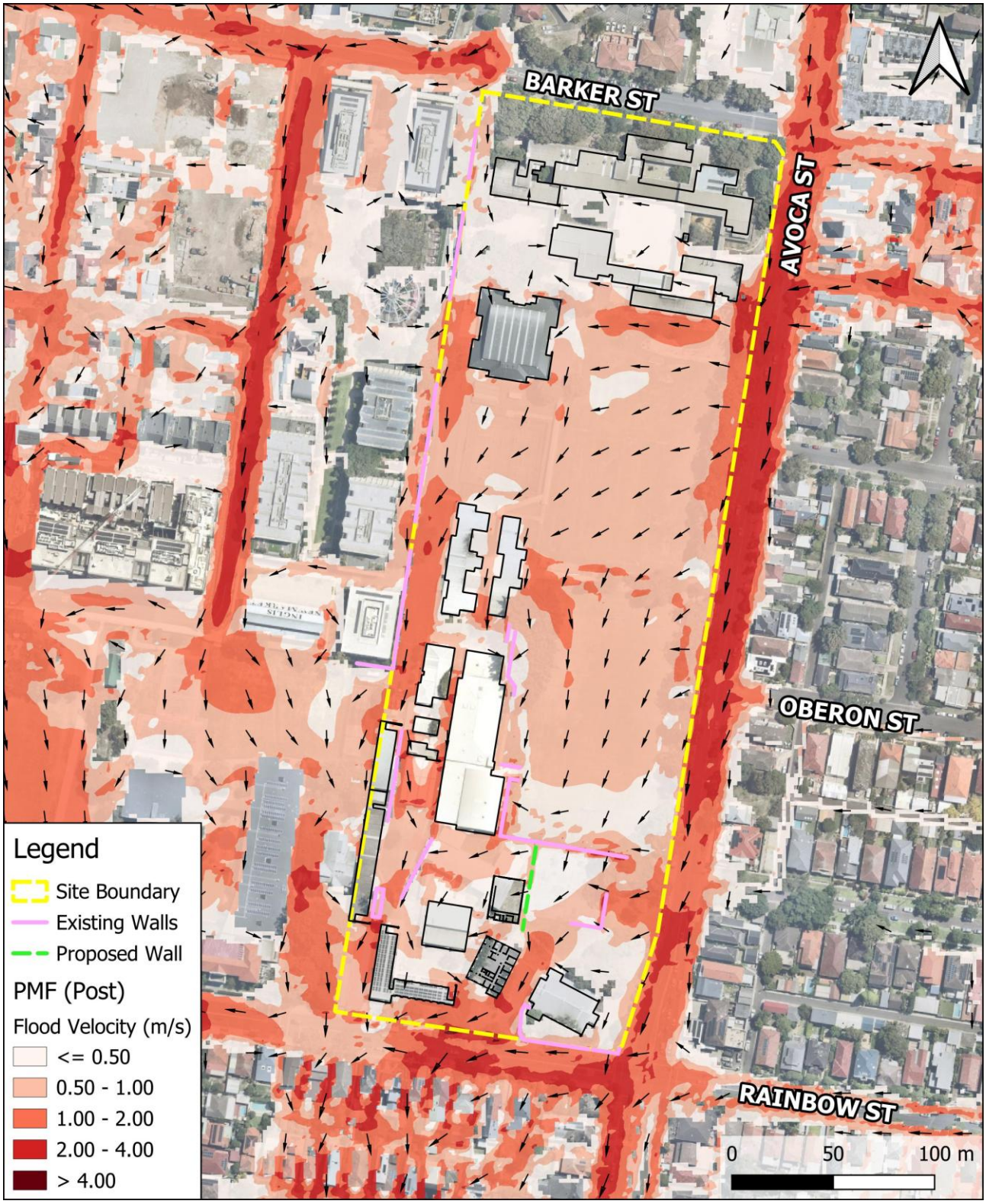


Figure 33: PMF velocity at Randwick High School under post-development conditions (with mitigation)

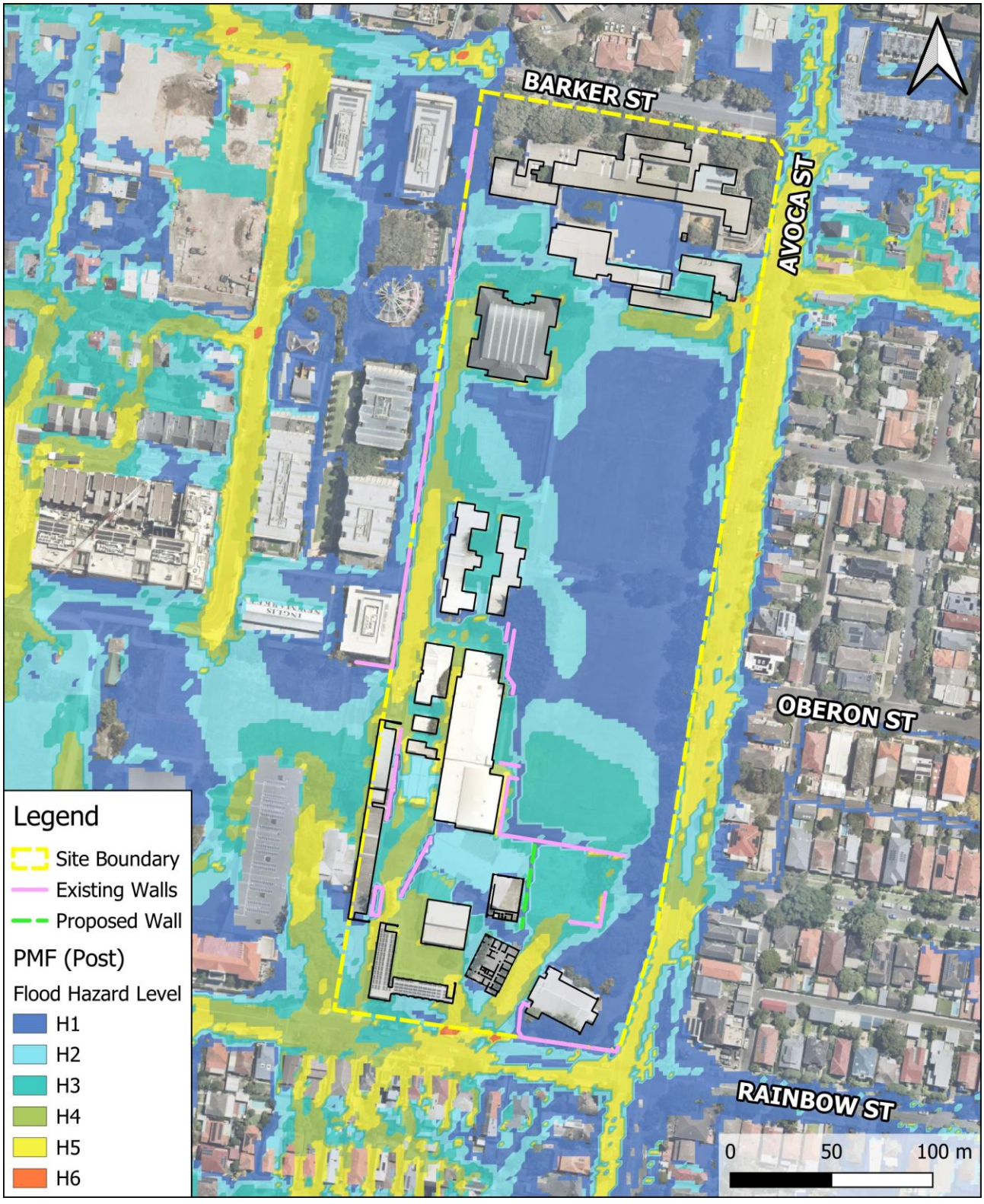


Figure 34: PMF hazard level at Randwick High School under post-development conditions (with mitigation)

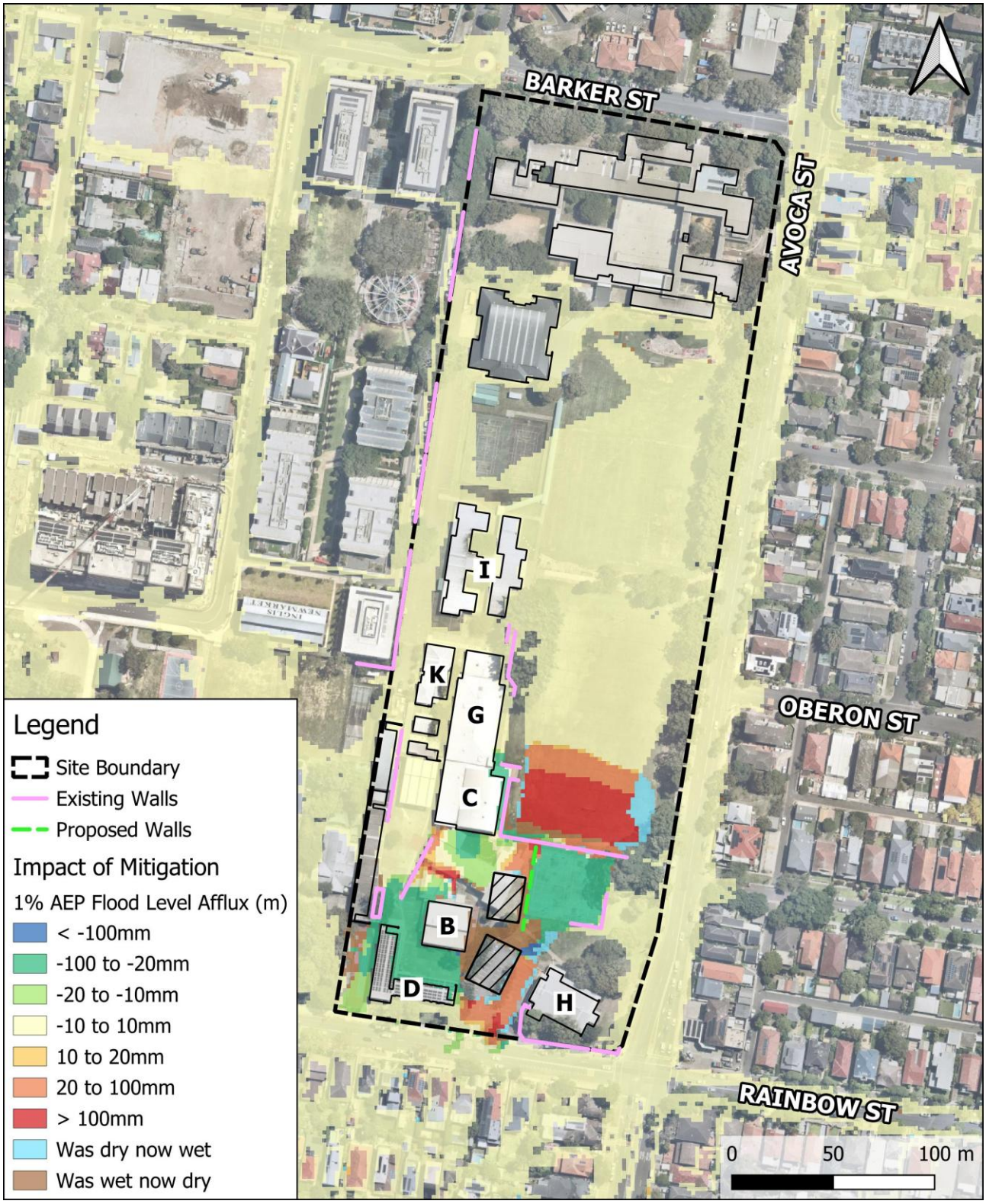


Figure 35: Impact of mitigation measures on baseline post-development 1% AEP flood levels

7.0 Climate Change

Climate change is expected to have an adverse impact on rainfall intensities, which has the potential to have a significant impact on flood behaviour. The Birds Gully and Bunnerong Road Flood Study included an assessment of climate change via an increase in rainfall intensity of 10%, 20% and 30% AEP. However, the ARR2019 guidelines were updated on 27th August 2024 with new guidance on how to consider climate change when planning for future floods, which includes variable rainfall adjustments based on storm duration.

For this study, a sensitivity analysis has been carried out to determine the impact of climate change on local flood conditions under the Shared Socioeconomic Pathway (SSP) 2-4.5. SSP2-4.5 is a medium reference scenario that corresponds to a 2.4°C increase in temperature by the end of the century. The 2090 (CC2090) projections indicate a rainfall increase of 40% under SSP2-4.5. This increase was applied to the 1% AEP and 0.5% AEP event rainfall. Table 8 provides a summary of the flood level increase at six locations within the site, labelled in Figure 36.

Figure 37 demonstrates the flood level afflux in the 1% AEP event in the CC2090 scenario. Figure 38 presents the flood level afflux for the 0.5% AEP event.

- The results indicate that for the majority of the site, 1% AEP flood levels are expected to increase by 25-50mm in the CC2090 scenario.
- However, more significant increases are expected within flood storage areas. Based on the flood assessment locations, the largest increase in flood level is anticipated at Point D, within the existing basketball court, with a 179mm increase under CC2090.
- Of the six assessment points, the highest 1% AEP flood level is recorded at Point A within the open field, at 40.22m AHD, increasing to 40.34m AHD in the CC2090 scenario. Given that the current design includes a top of bund height of 40.52m AHD, the bund will not be overtopped even under future climate change, and the proposed buildings are not impacted.
- This is demonstrated in the negligible flood level increases recorded at Point B and C, with a maximum increase in 1% AEP flood levels of 25mm at Point B, northwest of the lecture theatre. Depths here remain below 150mm even under the 1% AEP CC2090 scenario.
- As a further sensitivity test, the CC2090 projections were applied to the 0.5% AEP event, with a maximum increase of 184mm in the basketball court (reaching 39.73m AHD, 170mm below the top of wall height). Similarly, floodwaters within the informal basin pond to a level of 40.42m AHD, and do not overtop the bund. At Point C, flood levels reach a maximum of 39.52m AHD, with no flood impacts to either the admin building nor the lecture theatre.
- The proposed development is consequently protected against future climate change.

Table 8: Climate change sensitivity at six locations within the site. Refer to Figure 36 for locations

Point	Flood Level (m AHD) Increase Due to Climate Change			
	1% AEP Event		0.5% AEP Event	
	Present-day	CC2090	Present-day	CC2090
A	40.22	+117 mm	40.34	+76 mm
B	39.41	+25 mm	39.44	+24 mm
C	39.49	+17 mm	39.50	+20 mm
D	39.34	+179 mm	39.55	+184 mm
E	39.19	+118 mm	39.32	+131 mm
F	38.38	+111 mm	38.49	+138 mm

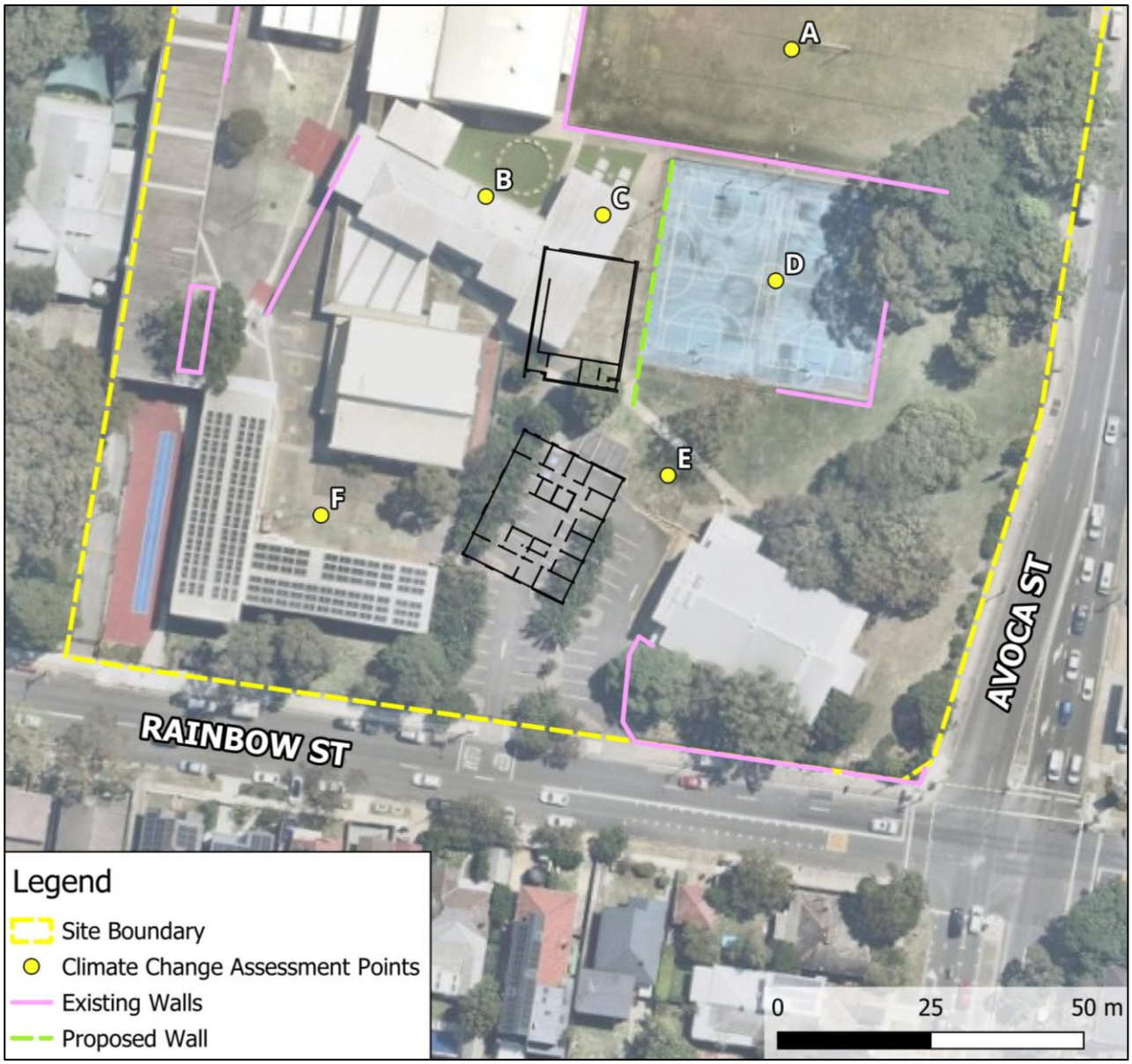


Figure 36: Location of climate change assessment points within the Randwick High School site

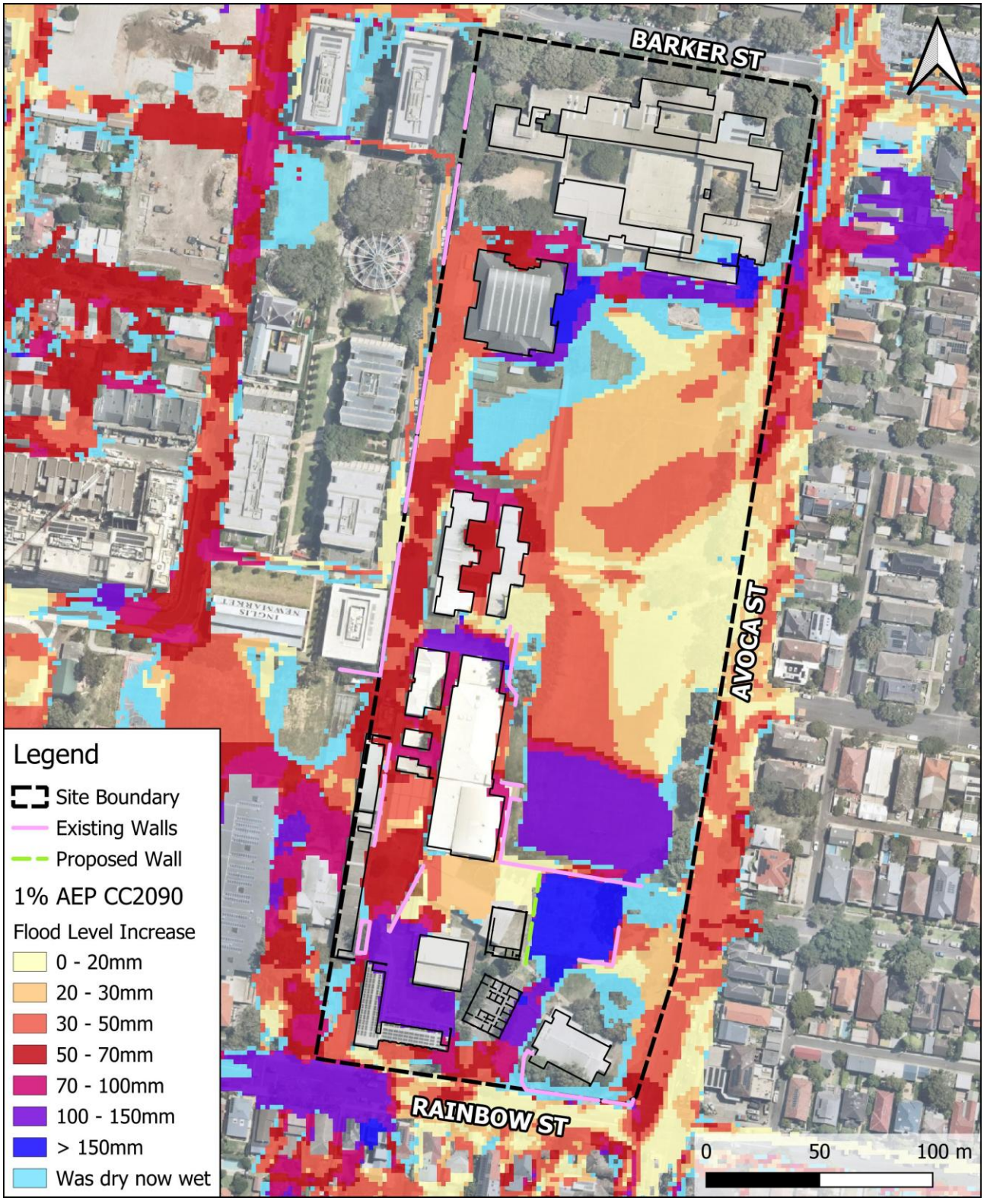


Figure 37: 1% AEP flood level increase at the site under the CC2090 scenario

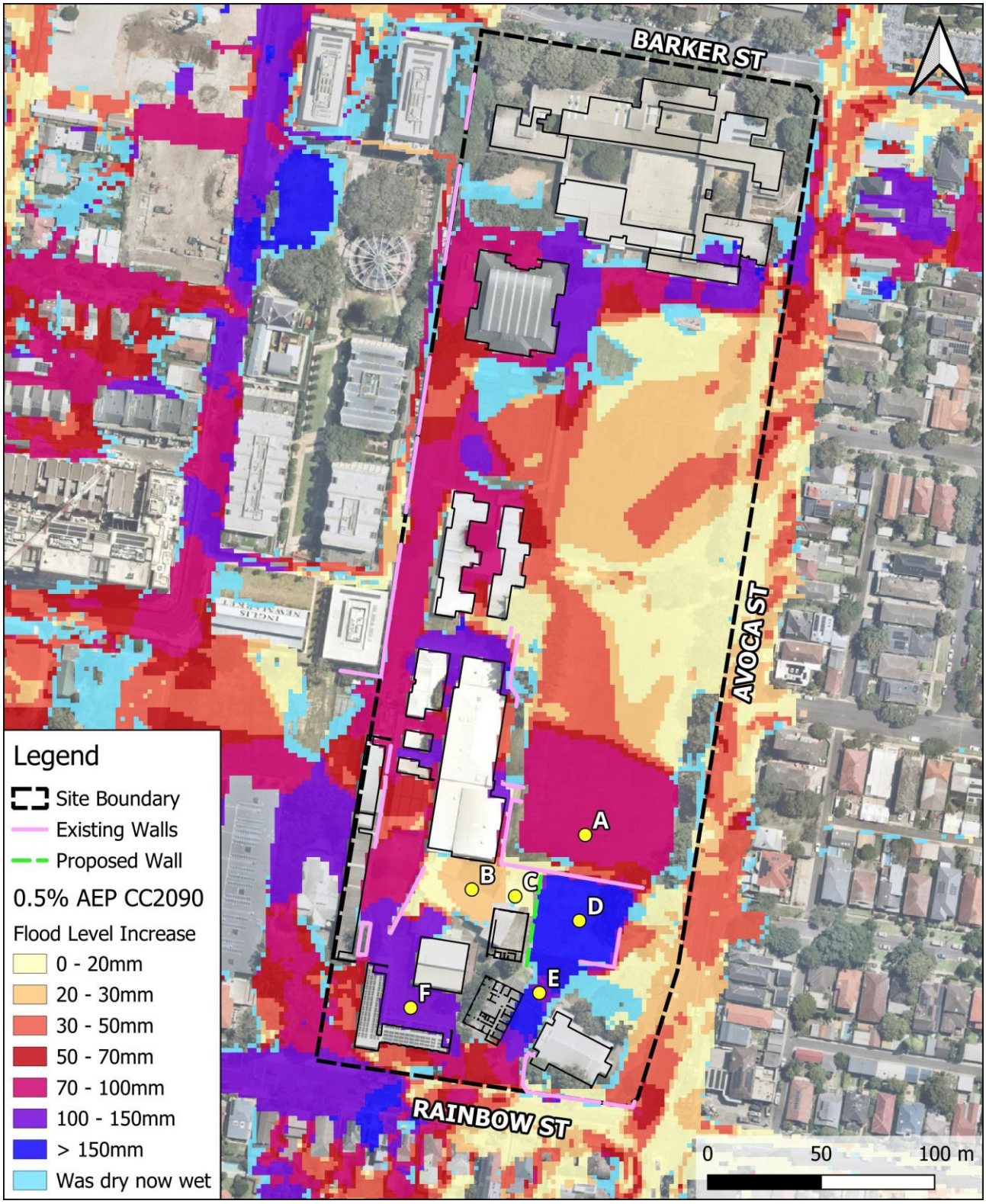


Figure 38: 0.5% AEP flood level increase at the site under the CC2090 scenario

8.0 Flood Impact Assessment

It is necessary to review any potential adverse impacts to neighbouring properties or changes to flood behaviour as a result of the development. The impact of the proposed development on 1% AEP flood levels (in comparison to existing conditions) is presented in Figure 39. The following observations have been made:

- The most notable change in flood levels occurs within the open field, where levels rise by up to 165 mm. This is primarily due to the raised bund height, which increases storage capacity in this area. This increase in flood level is contained within the field and does not adversely impact either the new or existing buildings.
- By increasing the capacity of the basin within the field, the overall flood risk to the site is reduced, with a decrease in 1% AEP flood level up to 87mm adjacent to Block C, and 25mm southeast of Block D.
- There is a minor increase in flood extent onsite, with shallow flows (less than 100mm deep) passing over the now-demolished Block A, which previously obstructed flow.
- The redirection of the existing overland flow path has also resulted in an increase in flood extent across the car park. However, relocating the flow path to this location is considered a safer outcome overall, as it shifts runoff away from the main building cluster. The resulting flood hazard in the car park is low (H1) in the 1% AEP event, which is generally considered safe for people, children, and vehicles.
- Offsite, there is a minor increase in flood levels over 10mm within the gutter of Rainbow Street. This can be attributed to the shift in the overland flow path and discharge point onto Rainbow Street. This increase in level is compensated by a parallel decrease in flood level of up to 36mm at the former discharge location, 15 metres to the west.

Overall, the proposed development incorporates a number of mitigation measures that result in a reduction of flood risk for both the new and existing buildings.

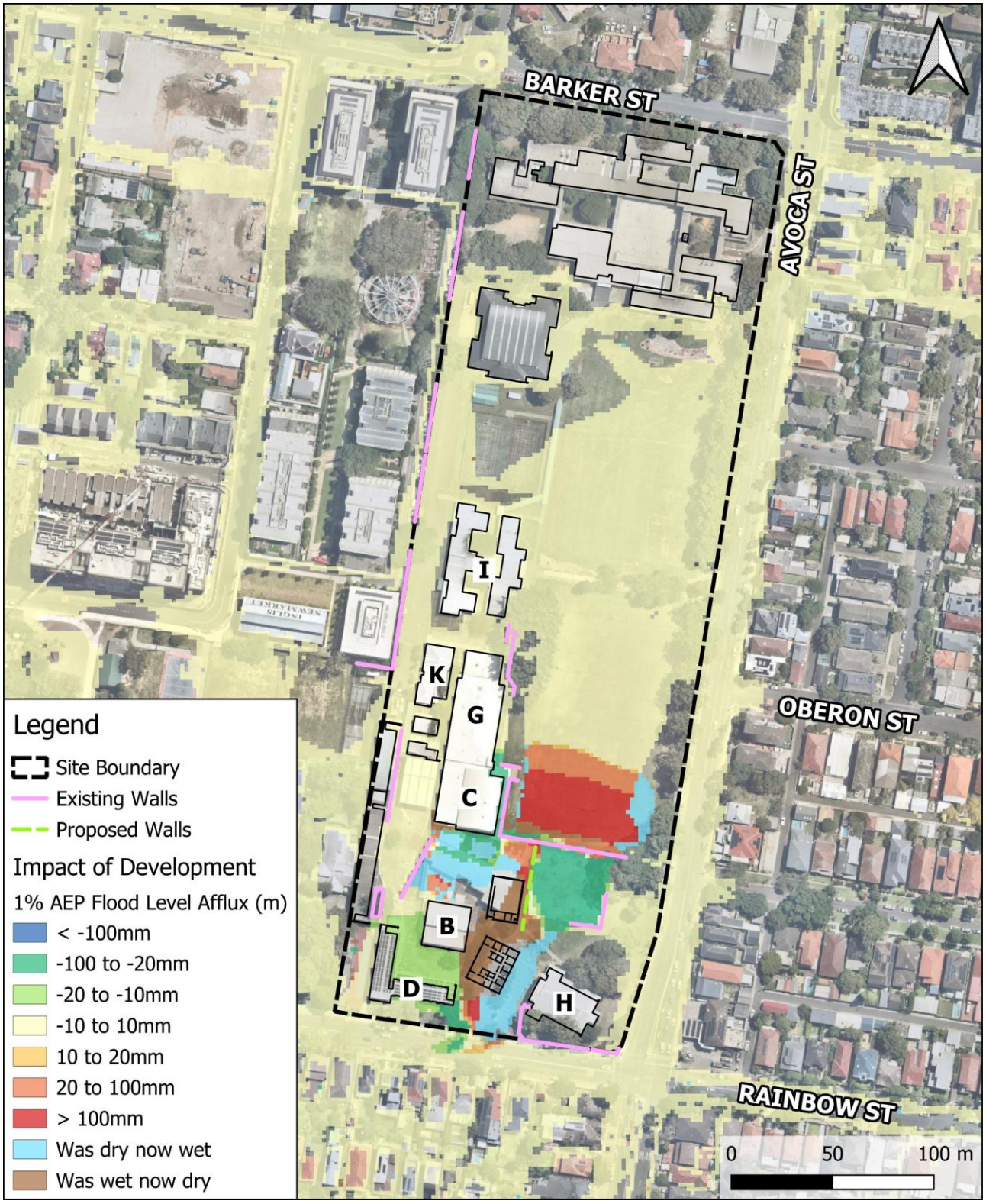


Figure 39: Impact of proposed development (with mitigation measures) on existing 1% AEP flood levels

9.0 Review of Flood Planning Requirements

Relevant DCP provisions are acknowledged in this study to demonstrate consideration of Council's planning objectives, though it is noted that compliance with these controls is not required.

9.1 Randwick DCP

Table 9 presents an overview of the proposed development in relation to the design considerations set out in Randwick DCP.

Table 9: Randwick DCP flood controls and TTW comment

Flood Control		TTW Review
Flood Effects Caused by Development		
1.1	The development shall not increase flood effects elsewhere, having regard to loss of flood storage, changes in flood levels and velocities and the cumulative impact of multiple potential developments, for floods up to and including the 1% AEP flood.	As presented in the flood impact assessment in Section 8.0, the proposed development includes a number of mitigation measures that improve the overall flood risk to both the new buildings and the existing buildings. There is a reduction in flood level of up to 87mm adjacent to the existing Block C. Across Rainbow Street, the isolated increase in flood levels over 10mm can be attributed to the shift in the discharge point. This is compensated by a decrease in flood level of up to 35mm at the former discharge location. No adjacent properties are impacted by the proposed development.
1.2	Floodways and overland flow paths must not be obstructed or diverted onto adjoining properties.	
1.3	Areas identified as flood storage areas must not be filled unless compensatory excavation is provided to ensure that there will be no net loss of floodplain storage volume below the 1% AEP flood.	N/A for Randwick HS development
Floor Levels		
2.1	Building floor levels shall comply with Table 1.	As presented in the flood model outputs in Section 6.2 and 6.3, the development area is "inundated by flooding" as opposed to overland flows, given that flood depths exceed 250mm in the PMF event. Based on this, the floor level requirement set out in Randwick DCP is the PMF level plus 500mm freeboard. Although educational facilities are typically regarded as sensitive due to the more vulnerable nature of site users, the application of a freeboard on top of the PMF level is not standard practice throughout NSW and is particularly onerous. This control is reviewed further in Section 0.
		The fire pump room is considered critical infrastructure for the operation and life safety performance of the school development. As such, the minimum floor level for the fire pump room should be consistent with flood resilience requirements for critical infrastructure. Based on current site plans, fire pump room is located on higher ground adjacent to the site's eastern boundary, with flood depths below 200mm. This is regarded as "overland flooding" in Council's DCP. As such, freeboard is not required at this location. The PMF level adjacent to the fire pump room is 40.60m AHD. The room itself is 10mm above this, while the fire pump equipment is set at 40.66m AHD, 60mm above the PMF level.

Building Components		
3.1	All development shall have flood compatible building components below the floor levels identified in Table 1 (i.e., PMF level + 500mm).	The proposed buildings are not vulnerable to failure during a flood event. Level 1 of both buildings will be unaffected by flooding in events up to and including the PMF as the suspended structure is founded on concrete columns sitting on a pile foundation. This is isolated from the ground floor structure, which is designed as slab on ground. The façade elements may be damaged in rare flood events (of a larger magnitude than the 0.5% AEP (200-year ARI) event) and require repair or reconstruction. Refer to BG&E's structural documentation for further information.
3.2	All structures shall be constructed to withstand the forces of floodwater, debris and buoyancy up to and including the floor levels identified in Table 1 (i.e., PMF level + 500mm).	
Driveway Access and Car Parking		
4.1	1) Car parking floor levels shall comply with Table 2 (i.e. 5% AEP flood level). 2) Locate vehicular access where the road level is greater than or equal to the required floor level for the car park. Where road access above the required floor level is not available, locate vehicular access at the highest feasible location. 3) The level of the driveway between the road and car park shall be no lower than 0.3m below the 1% AEP flood or such that the depth of inundation during the 1% AEP flood is not greater than the depth of flooding at either the car park or the road where the site is accessed. 4) Barriers shall be provided to prevent floating vehicles leaving the site during the 1% AEP flood if the depth of flooding at the car space exceeds 0.3m.	The upgrade works include redevelopment works at the existing car park onsite. It should be noted that the overall capacity of the car park is reduced, given that the proposed admin building is located atop of the existing car park. Although the car park is below the 5% AEP flood level, the overall hazard level of flows is reduced in post-development conditions. Refer to Section 9.3 for further review and assessment. As presented in the post-development hazard classification of 1% AEP flows in Figure 31, the maximum hazard level across the car park is H1. Flows with a hazard classification of H1 are less than 300mm depth, with no risk to vehicles. Barriers are consequently not required.
Safety and Evacuation		
5.1	Include a description of the safety and evacuation methodology with all DAs, including: – The provision of reliable and safe egress for inhabitants from the lowest habitable floor level to a publicly accessible location above the PMF level. – The method of access for emergency personnel.	Where there is advanced notice of a significant rainfall event that is likely to cause flooding in the area, pre-emptive closure of the school is recommended as the primary emergency response strategy. Given the school is impacted by flash flooding, there may not always be sufficient warning time to allow for this. If this is the case, the secondary emergency response strategy for the proposed buildings is to shelter-in-place. Both the admin building and lecture theatre provide internal access to Level 1, well above the PMF level. Refer to TTW's Flood Emergency Response Plan (FERP) for the proposed buildings for more detail, submitted alongside this FIRA.

9.2 DCP Departures – Floor Level Requirements

As aforementioned, the Randwick DCP advises that critical facilities impacted by flooding should have a floor level set to the PMF level plus 500mm freeboard. Although educational facilities are typically regarded as sensitive due to the more vulnerable nature of site users, the application of a freeboard on top of the PMF level is not standard practice throughout NSW and is particularly onerous.

9.2.1 Other NSW Council DCP Requirements

Whilst many Council DCPs require educational facilities to be set at or above the PMF level, there are several examples of Councils across NSW that apply lower floor level requirements, some of which are outlined below.

Campbelltown Council

The floor level requirements within Campbelltown (Sustainable City) DCP (2015) are shown below, taken from Part 2 Section 2.8 of the DCP. The maximum floor level requirement for this Council is the 1% AEP flood level plus 500mm freeboard.

Table 2.8.1 Floor Level Requirements

Development Criteria	Where the depth of flow is:	Minimum Freeboard above the predicted 100yr ARI Flood level
Floor Level for any dwelling room* including all commercial or industrial areas	< 300mm	300mm
	> 300mm	500mm
Floor Level in relation to any creek or major stormwater line including detention basins for any dwelling room# including all commercial or industrial areas	Any depth	500mm
Garage or shed Floor Level**	<300mm	100mm
	>300mm	300mm
Underside of solid fencing where overland flow is to be accommodated	Any depth	100mm (min)

** For the purpose of Clause 2.8.2 b) 'a dwelling room' is any room within or attached to a dwelling excluding a garage or shed.*

Canterbury-Bankstown DCP (2023)

Chapter 2 'Site Considerations' Part 2 'Flood Risk Management' of the Canterbury-Bankstown DCP outlines the development controls which apply to flood liable land in the LGA. Flood planning controls in the Canterbury-Bankstown LGA are based on land use category and flood risk precinct.

The land use categories within the Canterbury-Bankstown LGA are outlined in Table 10. Based on Schedule 2 of Council's DCP, educational establishments are considered a 'residential' use. The flood matrix is shown in Table 11. Development of educational facilities is not permitted on High Flood Risk land, which is defined as areas with high flood hazard in the 1% AEP event. As presented in Section 6.3.2, the site is regarded as low hazard in this event.

The maximum floor level requirement for residential land uses within the Low and Medium Flood Risk areas is the 1% AEP flood level plus freeboard.

Table 10: Land use categories in the Canterbury-Bankstown DCP

Schedule 2–Land Use Categories

Critical uses and facilities	Community facilities which may provide an important contribution to the notification or evacuation of the community during flood events; hospitals; nursing homes
Sensitive uses and facilities	Correctional centres; liquid fuel depots; offensive storage establishments; seniors housing; telecommunications facilities; waste disposal facilities; public utility undertakings (including generating works) which are essential to evacuation during periods of flood or if affected would unreasonably affect the ability of the community to return to normal activities after flood events
Subdivision	Subdivision of land which involves the creation of new allotments, with potential for further development
Residential	Attached dwellings; bed and breakfast establishments; boarding houses; camp sites or caravan parks (long-term sites[2] only); centre-based child care facilities; community facilities (other than sensitive uses and facilities); dual occupancies; dwellings; dwelling houses educational establishments family day care centres; health consulting rooms; home based child care; home businesses; home occupations; group homes; manor houses; multi dwelling housing; multi dwelling housing (terraces); residential flat buildings; secondary dwellings; semi-detached dwellings; serviced apartments; utility installations (other than critical utilities)

Table 11: Canterbury-Bankstown DCP flood control matrix

Planning consideration	Flood Risk Precincts																							
	Low Flood Risk								Medium Flood Risk								High Flood Risk							
	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development
Floor level		3		2	2	2	1,6	4,7				2,6,7	5,6,7	2,6,7	1,6	4,7							1,6	4,7
Building components & method		2										1	1	1	1	1							1	1
Structural soundness		3										1	1	1	1	1							1	1
Flood effects		2	3	3	3	3	3	3			1	2	2	2	2	2							1	1
Car parking & driveway access		1,3,5,6,7		9	9	9	9	9				1,3,5,6,7	1,3,5,6,7	1,3,5,6,7	2,4,6,7	6,7,8							2,4,6,7	6,7,8
Evacuation		2,3,4		7	7	7	7	7			6	2,3	1,3	2,3	4,3	2,3							4,3	2,3
Management & design		4,5									1		2,3,5	2,3,5	2,3,5	2,3,5							2,3,5	2,3,5

COLOUR LEGEND: Not Relevant; Potentially Unsuitable Land Use

Floor level

1	All floor levels to be no lower than the 20-year flood unless justified by site-specific assessment.
2	Habitable floor levels to be no lower than the 100-year flood level plus freeboard.
3	Habitable floor levels to be no lower than the PMF level. Non-habitable floor levels to be no lower than the PMF level unless justified by a site-specific assessment.
4	Floor levels to be no lower than the design floor level. Where this is not practical due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be a+B46s high as practical and when undertaking alterations and additions, no lower than the existing floor level.
5	The level of habitable floor areas to be equal to or greater than the 100-year flood level plus freeboard. If this level is impractical for a development in an employment zone, the floor level should be as high as possible.
6	Non-habitable floor levels to be no lower than the 20-year flood unless justified by site-specific assessment.
7	A restriction is to be placed on the title of the land, pursuant to section 88B of the *Conveyancing Act 1919*, where the lowest habitable floor area is elevated more than 1.5m above finished ground level, confirming that the undercroft area is not to be enclosed. The use of roller shutters or similar measures (such as hit and miss brickwork) to enclose this area is however permissible.

9.2.2 Protection to the PMF

The feasibility of providing protection to the new buildings against the PMF and the PMF plus 500mm freeboard has been investigated in detail. Table 12 provides an overview of the PMF levels at each entrance to the building, which are labelled in Figure 40.

For the lecture theatre, the maximum PMF level adjacent to the building openings is 350mm above the current FFL. For the admin building, the PMF level is up to 410mm above the FFL. Given the high depth of flows, it is not possible to lift the FFL (or the individual building openings) above the PMF level without subsequently raising the external levels to meet accessibility requirements, which would in turn further raise the PMF level.

As an alternative, additional mitigation testing was conducted to assess the feasibility of reducing or eradicating PMF flows in the development area. This was achieved by implementing a 500mm concrete base to the fence along the Avoca Street frontage. The outcome of this test can be summarised as follows:

- Excess runoff from Avoca Street no longer overtops into the site, leaving the new buildings flood free in all events. No requirement for the increased bund height nor the proposed wall.
- Existing buildings across the west of the site remain flood affected in the PMF event due to overflows from Barker Street and Young Street.
- However, the addition of the concrete base across the Avoca Street frontage results in significant adverse offsite impacts, with increases between 20-100mm across the roadway. Adverse impacts on flood levels are shown over 1.1km downstream of the site. Flood extent also increases, with at least two additional properties impacted in the 1% AEP event when they were previously unaffected. This is shown in Figure 41.

All mitigation efforts have been exhausted and demonstrate that compliance with the Randwick DCP is not achievable without significant adverse offsite impacts.

Table 12: PMF level assessment adjacent to each of the building threshold levels

Point	PMF Level (m AHD) Assessment			
	Location	**FFL**	**PMF Level**	**PMF + 500mm Freeboard**
A	NW entry to lecture theatre	39.60	39.80	40.30
B	NE entry to lecture theatre		39.95	40.45
C	Main entrance to lecture theatre		39.73	40.23
D	Accessible WC		39.79	40.29
E	Student reception	39.00	39.41	39.91
F	Western entry to public reception		39.34	39.84
G	Southern entry to public reception		39.16	39.66
H	Staircase to Level 1		39.06	39.56

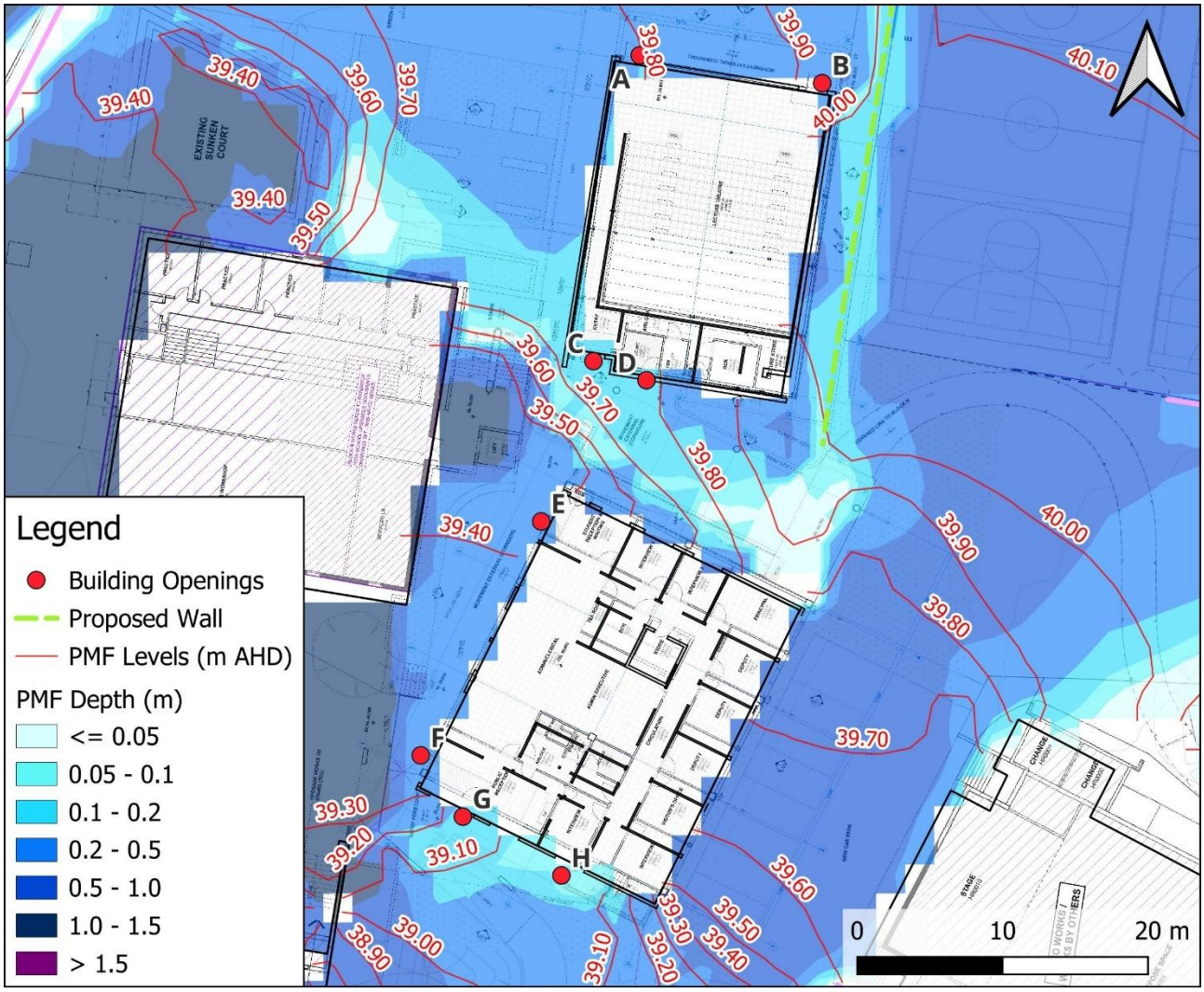


Figure 40: Building openings in relation to PMF depths and levels. See Table 12 for PMF level assessment

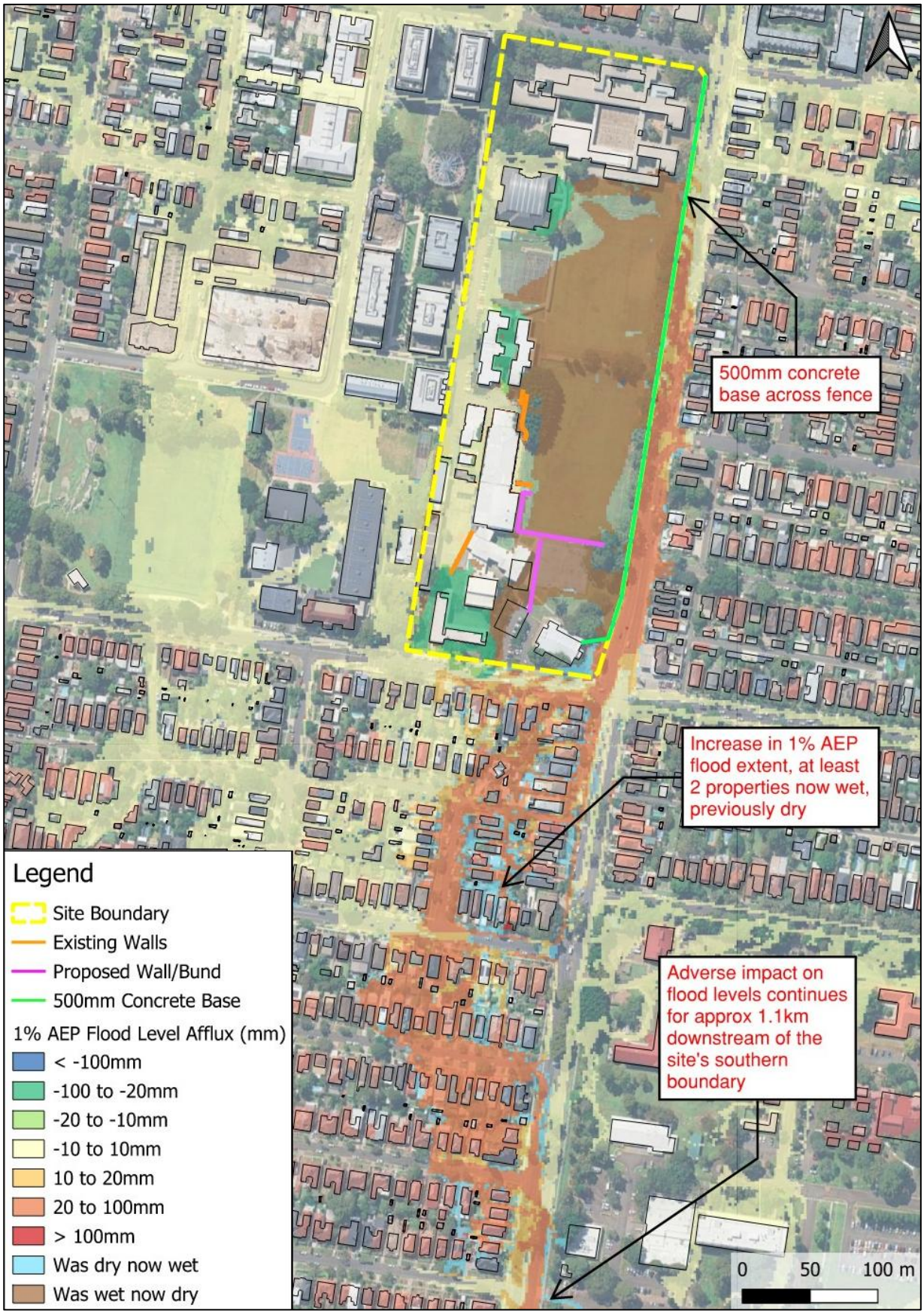


Figure 41: Impact of a 500mm concrete bund along the fence on Avoca Streeton 1% AEP flood levels

9.3 DCP Departures – Car Parking

According to Part B Section 5.5 of Randwick DCP, open car parks should be set above the 5% AEP flood level. Figure 42 presents a comparison of flood hazard levels across the car park area in existing and proposed conditions. The following observations have been made:

- In existing conditions, whilst the eastern extent of the car park is flood-free, the western side of the car park is impacted by depths exceeding 300mm, regarded as “H2” hazard, which is potentially unsafe for small vehicles.
- In post-development conditions, although the flood extent has increased (given that the overland flow path has been redirected into the car park, away from the proposed and existing building cluster), the maximum hazard level is H1 in the 10% AEP–1% AEP events. This is regarded as generally safe for people, children and vehicles. The H2 hazard classification is not reached within the car park until the 0.5% AEP event (200-year ARI).

Whilst the car park is below the 5% AEP flood level, the overall flood hazard of the car park is lower in post-development conditions. In addition, it should also be noted that the upgrade works (which are largely located atop of the existing car park) reduce the number of car parking spaces available, and consequently lower the overall exposure to any risk.

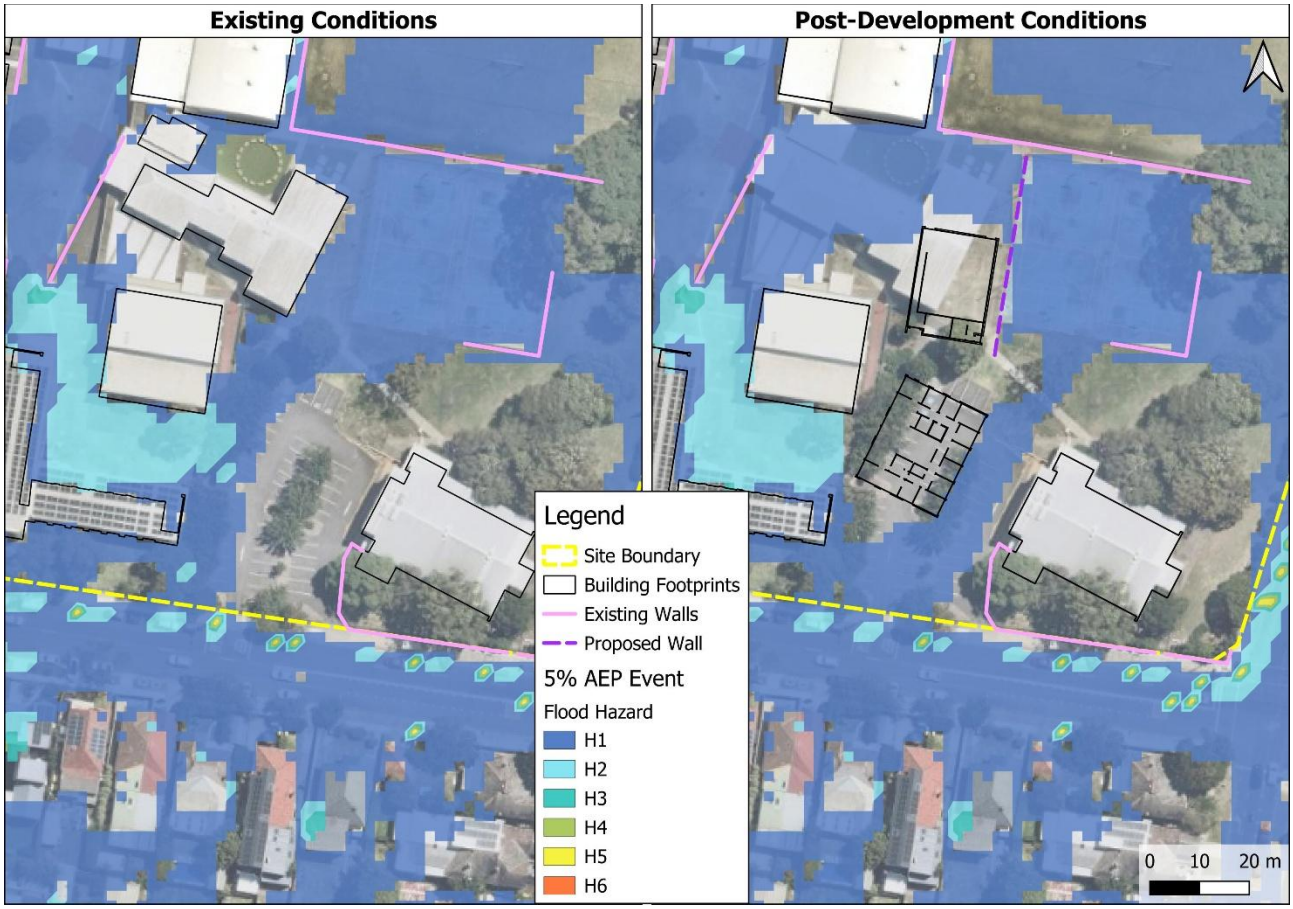


Figure 42: 5% AEP flood hazard levels at the car park area in existing and post-development conditions

10.0 Overview of Flood Risk

10.1 Population at Risk

The proposed upgrade works at the site do not include any increase in student enrolment capacity and consequently will not result in an increased "population at risk" during flood events. The development primarily involves reconfiguration and improvement of the existing school infrastructure and amenities, rather than expansion of its operational scale.

In terms of land use, the two proposed buildings include an administration building and a lecture theatre. Of these, the admin building is more significantly impacted by flooding (with a peak PMF flood level of RL 39.41 m AHD, 410 mm above the proposed FFL). However, the ground floor of this building is intended for non-critical functions such as administrative offices, interview rooms, reception areas, and storage. All classrooms and core educational spaces are located on the upper floor, well above the PMF level, thereby reducing the risk to more vulnerable occupants during extreme flood events. Staff on the ground floor of the admin building will be familiar with flood emergency response actions, as per the preparedness actions outlined in TTW's FERP, submitted alongside this FIRA.

Overall, the upgrade works enhance the school's flood resilience by providing improved access to safe refuge areas above the PMF. The development also improves connectivity between existing buildings, most of which are more significantly flood-affected, thereby improving the school's ability to respond safely during rare floods.

10.2 Flood Resilience

10.2.1 New Development – Application of Freeboard

As aforementioned, several mitigation measures have been incorporated into the design to improve flood risk and limit the frequency of flood impacts. This includes increasing the height of the existing bunding across the southern field, and the addition of a flood wall to the west of the basketball court. Table 13 provides a summary of the flood levels in these flood storage areas, compared with the adjacent design wall/bund height. The point locations are presented in Figure 43.

- 550mm freeboard has been applied to the 1% AEP level in the basketball court (with a top of wall level of 39.9m AHD, alongside steps and ramps up to this level) to limit overflows towards the building cluster.
- For the open field, 300mm freeboard has been applied to the bund height in the southwest corner. This represents the maximum feasible freeboard without compromising the clear sightlines (for surveillance purposes) and recreational functionality of the field.
- No freeboard has been applied to the eastern extent of the bund to encourage overflows in this area, into the basketball court and away from the building cluster.

The remaining residual flows around the proposed development in the 1% AEP event (to the northwest of the lecture theatre) are minor and not regarded as flooding. This flow is sourced from the internal road south of Block I and directed along the pathway to the west of the open fields. As presented in Figure 29, this sheet flow is less than 100mm deep in the 1% AEP event and will be largely mitigated via a channel drain across the pathway, which has not been modelled.

As discussed in Section 5.2.4, no additional stormwater infrastructure was incorporated into the model (in both existing and post-development conditions), given that pipe diameter has not been surveyed. The flood model outputs are consequently a worst-case representation of flooding at the site. Amendments to the site grading in this area directs any residual flows towards the existing sunken court, and away from the proposed buildings.

Overall, the mitigation strategy remains effective in the 0.5% AEP event, and under future conditions in the CC2090 event, which includes a 40% uplift in rainfall in short-duration events. Any impact to the proposed building is in events of an incredibly rare magnitude and very low likelihood. The frequency of any flood impacts to the development is low.

Table 13: Mitigation wall/bund heights compared with adjacent flood levels

Point	Top of Wall/Bund	Post-Development Flood Level (m AHD)				Adopted 1% AEP Freeboard
		1% AEP	1% AEP CC2090	0.5% AEP	PMF	
A	40.52	40.22	40.34	40.34	40.64	300 mm
B	40.52					
C	40.35					N/A
D	40.20					N/A
E	39.90	39.35	39.52	39.54	40.10	500 mm

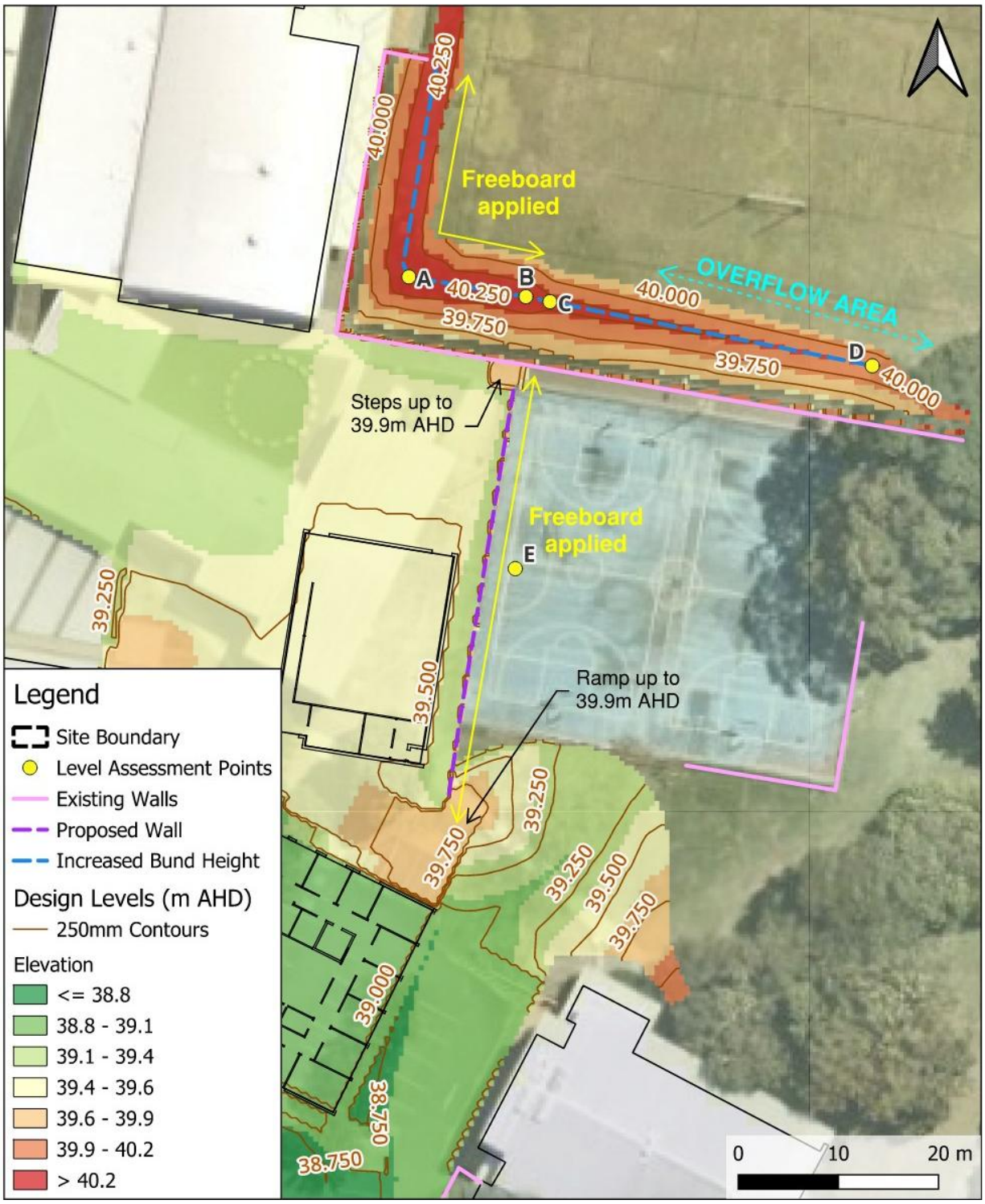


Figure 43: Mitigation wall and bund level assessment points

10.2.2 Block B Refurbishment

The upgrade works to the site include refurbishment and external upgrade works to some of the existing buildings, including Block B, which is situated to the west of the proposed new buildings. Included in these upgrades is the addition of a new eastern entry to Block B (refer to Figure 39), which includes a staircase and a lift to the lower ground floor to improve accessibility.

With the proposed drop in levels at this location, this localised area is impacted by hazard levels of H3 (unsafe for children and vehicles) in the PMF event, with depths exceeding 1.0m in the critical 30-minute storm duration. However, this area is not flood affected in either the 0.5% AEP event, or the longer 3-hour duration PMF storm. The overall risk is low, especially given that the door to the building is not flood proof and therefore water will enter the building, and the modelled ponding level would not be reached. There are also internal and external access stairs to upper levels above the PMF.

In addition, as part of the upgrade works, the existing eastern entry will be raised above the 1% AEP level. The current doorway is set at 38.2m AHD, with an adjacent flood level of 38.4m AHD in the 1% AEP event. To reduce the overall flood risk to the building, the proposed design includes external and internal steps and ramps to accommodate a new doorway set at 38.5m AHD, 100mm above the 1% AEP level. Whilst the new eastern entrance to the building is subject to inundation in the critical PMF event, the proposed works will ensure the building is flood-free in events up to and including the 0.5% AEP event. This presents a significant improvement to the existing flood risk and flood frequency for this block.

10.2.3 Rebuilding and Repair Works

In the unlikely event that inundation of the new buildings occurs, they may be unusable for a period of time due to repairs. The Asset Management Unit (AMU) of Department of Education is responsible for emergency management rebuilding in the event of storm or flood damage. As part of the REF process, the AMU were consulted to confirm their support for the DCP departure. The AMU confirmed via email correspondence on 14 July 2025 that they would manage repairs in the event of flood inundation.

10.3 Increased Connectivity

The proposed development includes connections to Blocks B, C and D via external corridors and covered walkways on Level 1. Review of the existing flood behaviour onsite suggests that these existing buildings are flood affected in the 1% AEP event, whilst the proposed buildings are not impacted in either the 1% AEP or 0.5% AEP events.

The lower ground directly north of Block D and west of Block B is a flood storage area, with more prolonged ponding in this area. Not only do the proposed buildings provide a higher level of protection than the existing buildings onsite, the installation of covered connections between Level 1 of the Blocks B, C and D and the new buildings provides flood-free access to a lower-risk building, and substantially reduces the potential period of isolation, particularly for any staff and students in Block D.

In terms of safety of occupants, the upgrade works improve the ability to implement emergency procedures across the school as a whole, improving the overall flood risk and safe refuge space at the site.

10.4 Mitigation Measures

Aside from the mitigation measures incorporated into the design (including the increased bund height and flood wall at the basketball court), additional measures identified as necessary are outlined in Table 14.

Table 14: Mitigation Measures

Project Stage	Mitigation Measures	Reason for Mitigation Measure
Operation	Preparation and implementation of an	To identify the most appropriate flood emergency response strategy for the site

	operational Flood Emergency Response Plan (FERP)	based on an assessment of the time to inundation and recession. A preliminary Flood Emergency Response Plan has been produced and submitted alongside this report. This must be reviewed prior to the commence of operation, with roles assigned to relevant staff members.

10.5 Evaluation of Environmental Impacts

Based on the identification of potential issues, and an assessment of the nature and extent of the impacts of the proposed activity, it is determined that:

- The flood impact assessment for the 1% AEP event confirms that changes to offsite flood levels are generally within +/- 10mm. The proposed activity is considered to result in negligible offsite impacts.
- The extent and nature of potential impacts are low and will not have significant adverse effects on the locality, community and the environment.
- Potential flood risks and impacts can be appropriately mitigated or managed to ensure that there is minimal effect on the locality, community and/or the environment.

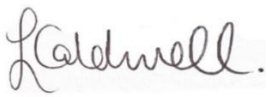
11.0 Conclusions and Recommendations

TTW updated Council's Bords Gully and Bunnerong Road Flood Study model to investigate the impact of the proposed activity on flood behaviour and assess the suitability of the site for further activity. Modelling concluded that:

- The Randwick High School site is impacted by overland flows in both existing and post-development conditions primarily due to excess runoff across Avoca Street, which overtops into the site across its eastern frontage.
- The implementation of targeted flood mitigation measures ensures the proposed buildings remain flood-free in the 1% and 0.5% AEP events.
- The proposed activity is resilient to climate change impacts. The impact of climate change has been considered in three scenarios, including a projected 40% increase in rainfall under the CC2090 scenario. In the 0.5% AEP event, flood levels to the west of the lecture theatre increase by 20mm under the CC2090 scenario, equating to a level of 39.52m AHD, below the ground floor level of 39.60m AHD.
- The proposed activity has no significant impact on flood behaviour or flood hazard in the 1% AEP event. Review of flood levels in existing versus post-development conditions shows that the proposed activity has no offsite impacts on adjacent properties or roads in the 1% AEP event. Where impacts exceed 10mm, this can be attributed to an eastward shift in the overland flow path at the site and is offset by a concurrent decrease in flood level.
- While strict compliance with Randwick DCP floor level controls is not feasible without adverse offsite impacts, the adopted design demonstrates good-practice flood risk management consistent with the REF pathway. The current design delivers measurable improvements in overall flood risk, including reduced inundation to existing buildings, safer egress options, and improved site connectivity.
- The proposed works are considered consistent with the intent of relevant flood planning controls and demonstrate that flood risks can be appropriately mitigated and managed. The development will not result in significant environmental impacts and is therefore considered suitable to proceed under Part 5 of the EP&A Act.
- A Flood Emergency Response Plan has been prepared by TTW and submitted alongside this report.

The findings in this report are based on currently available information, regulations and correspondence undertaken at the time of writing.

Prepared by
TTW (NSW) PTY LTD



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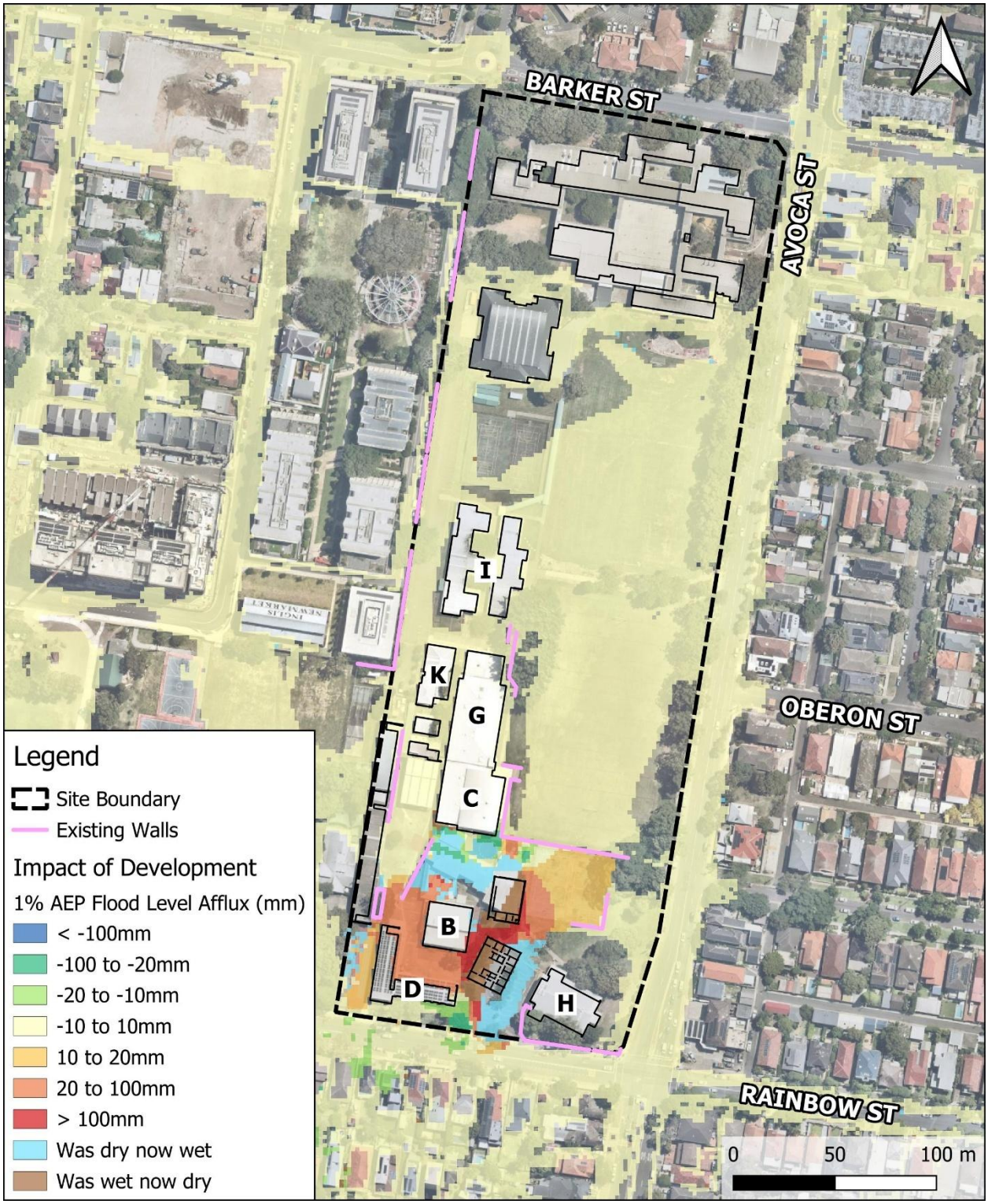
Appendix A

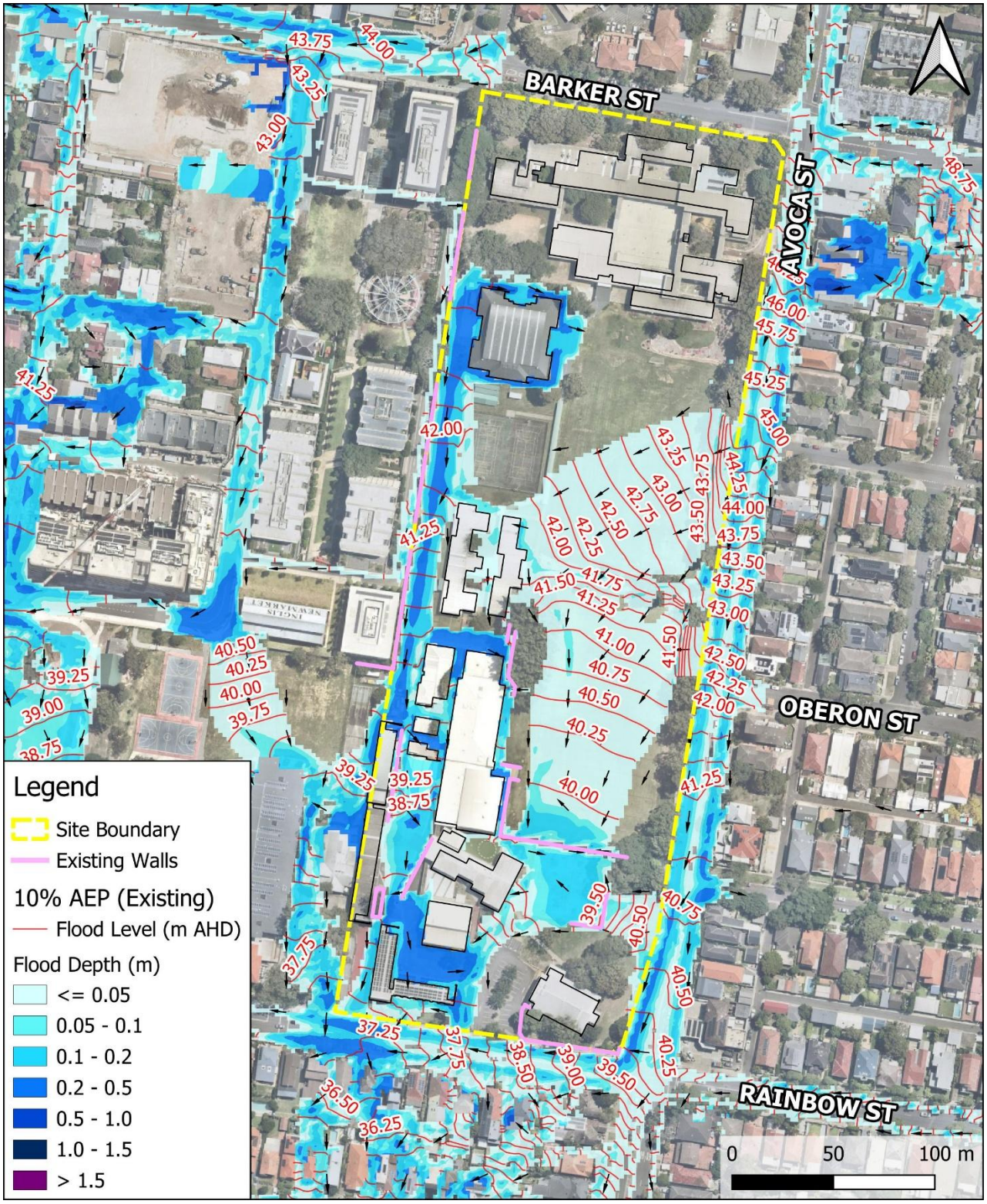
Impact Assessment Mapping



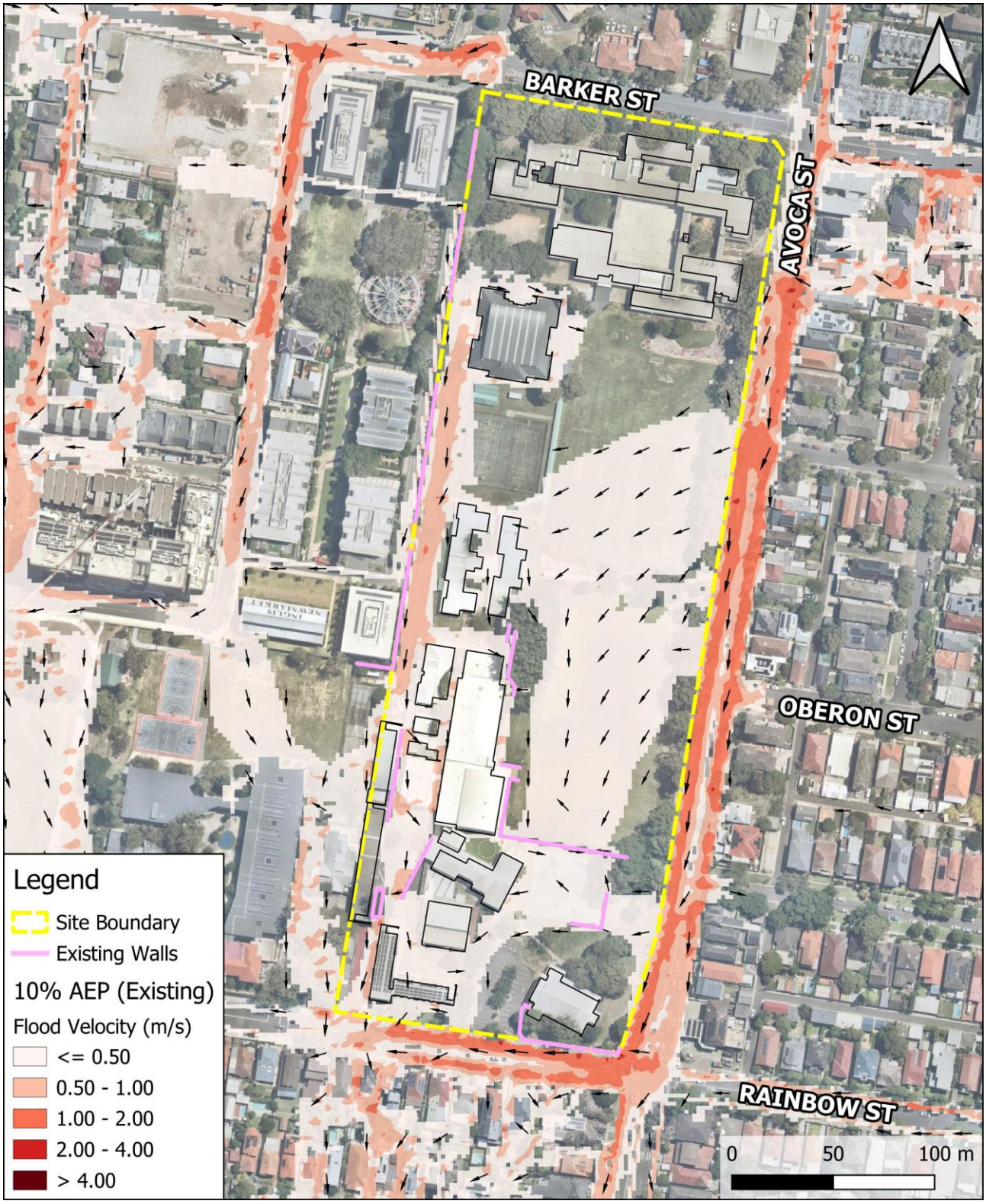
Appendix A 1: Impact of the proposed development on existing 1% AEP flood levels prior to any mitigation measures

Appendix B

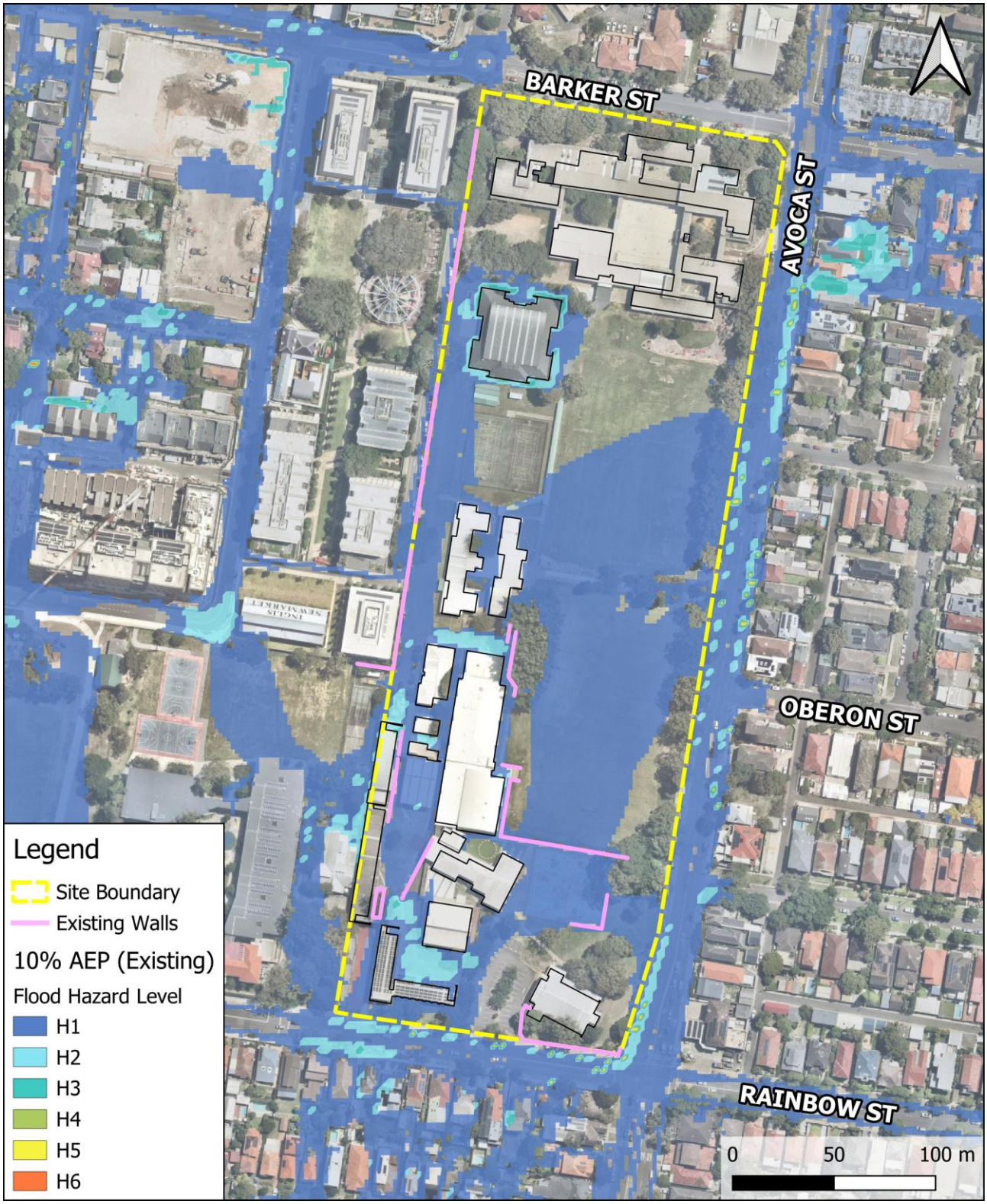
Additional Existing Scenario Results



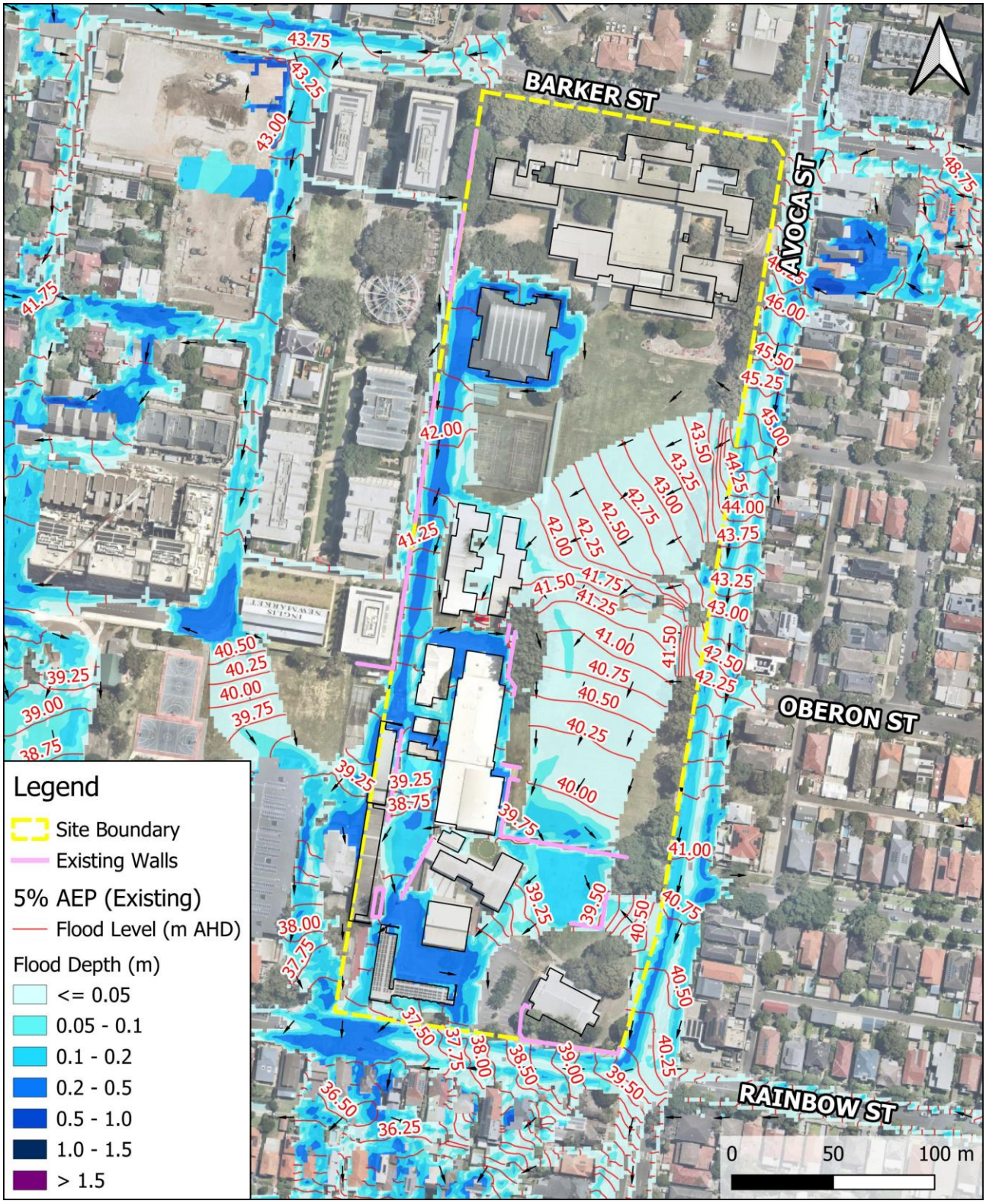
Appendix B 1: 10% AEP flood depths and levels at Randwick High School under existing conditions



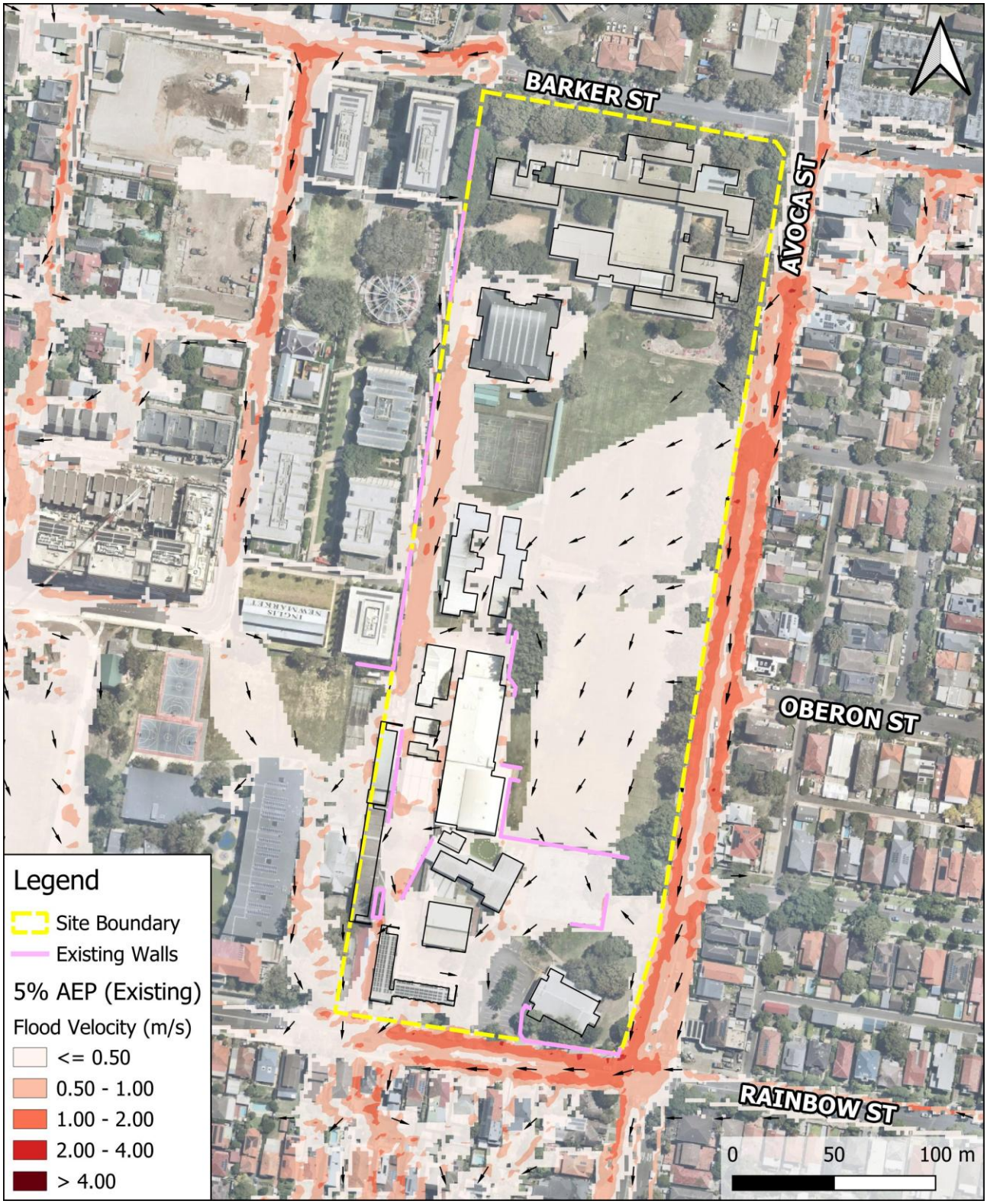
Appendix B 2: 10% AEP flood velocity at Randwick High School under existing conditions



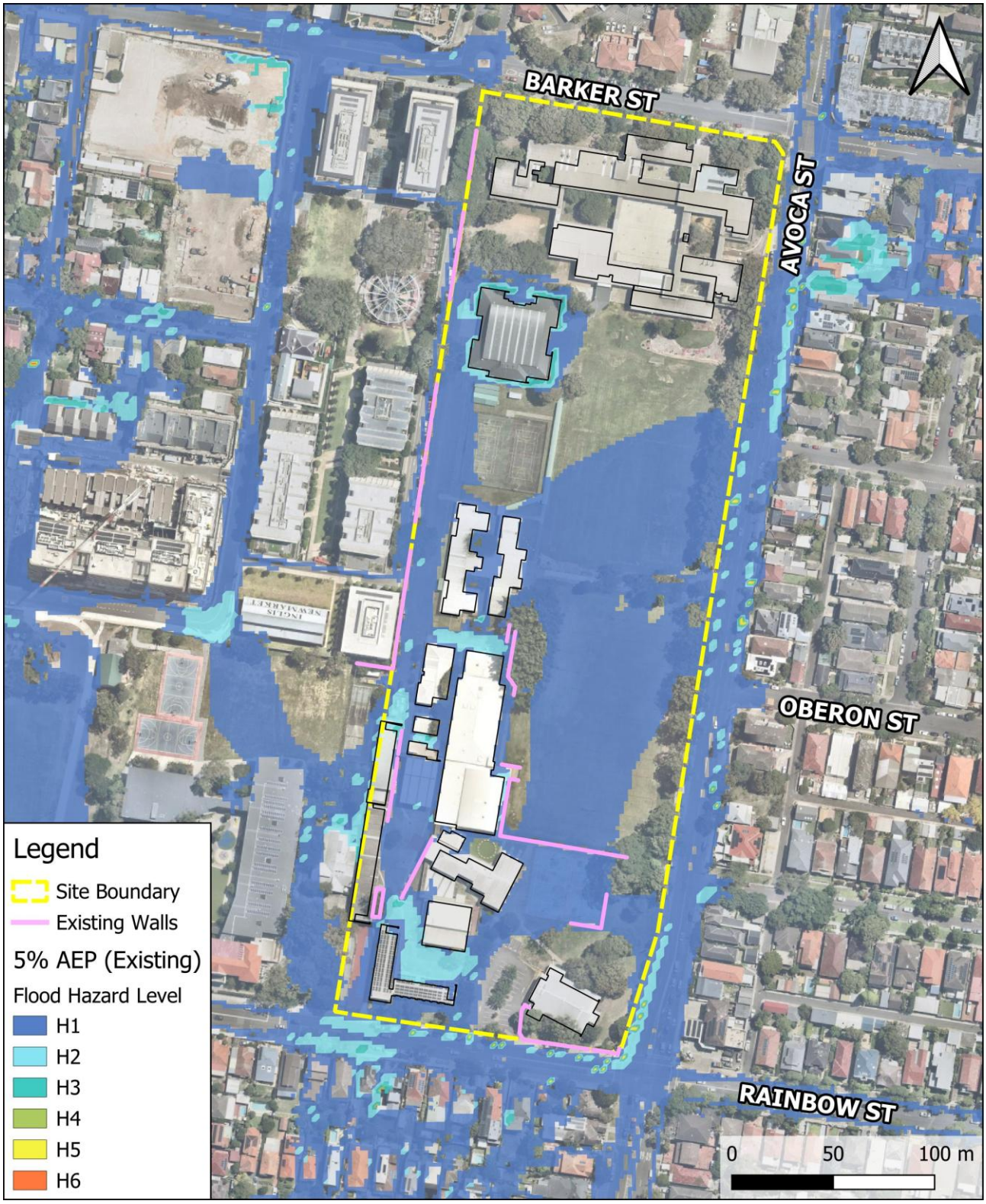
Appendix B 3: 10% AEP flood hazard level at Randwick High School under existing conditions



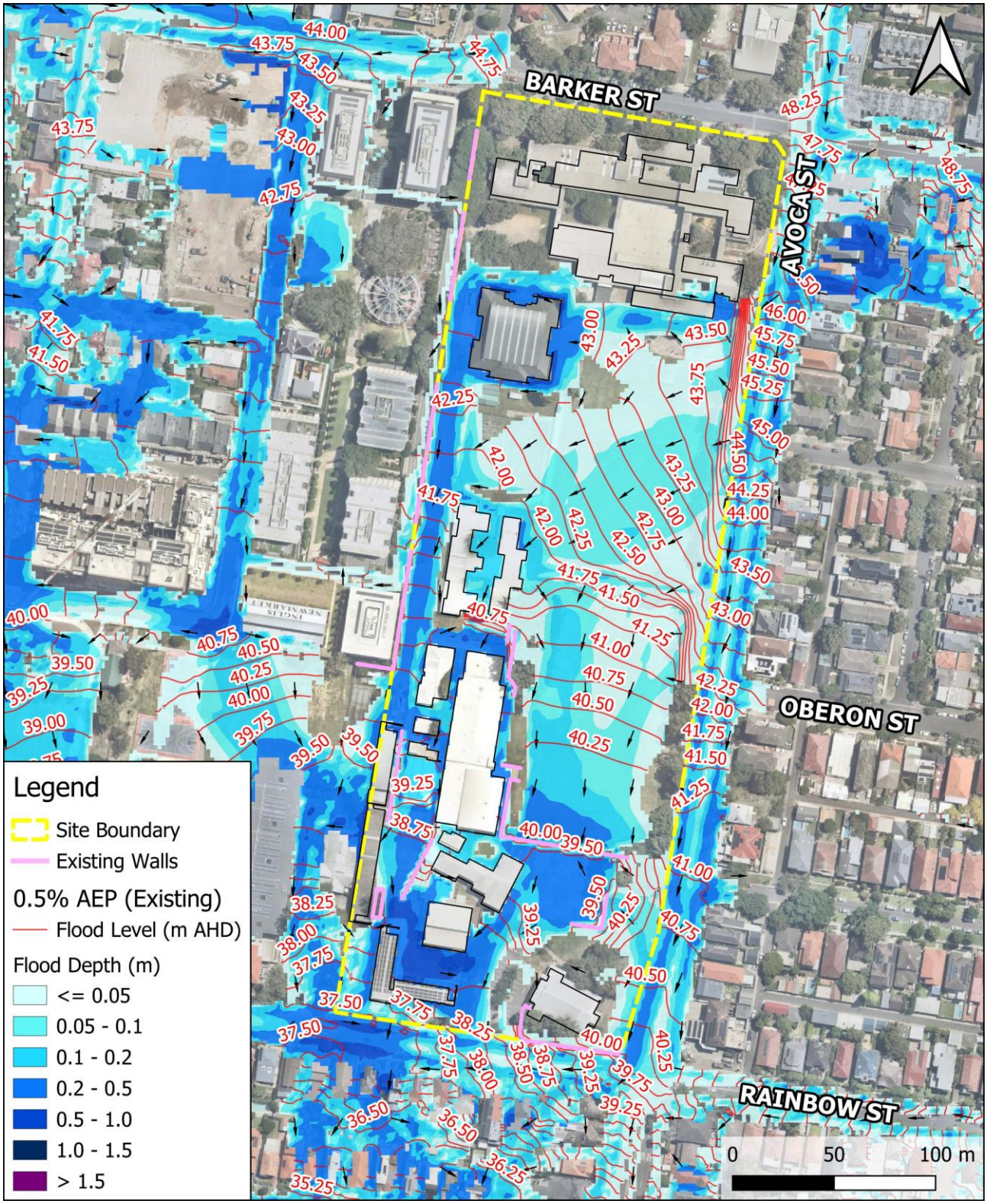
Appendix B 4: 5% AEP flood depths and levels at Randwick High School under existing conditions



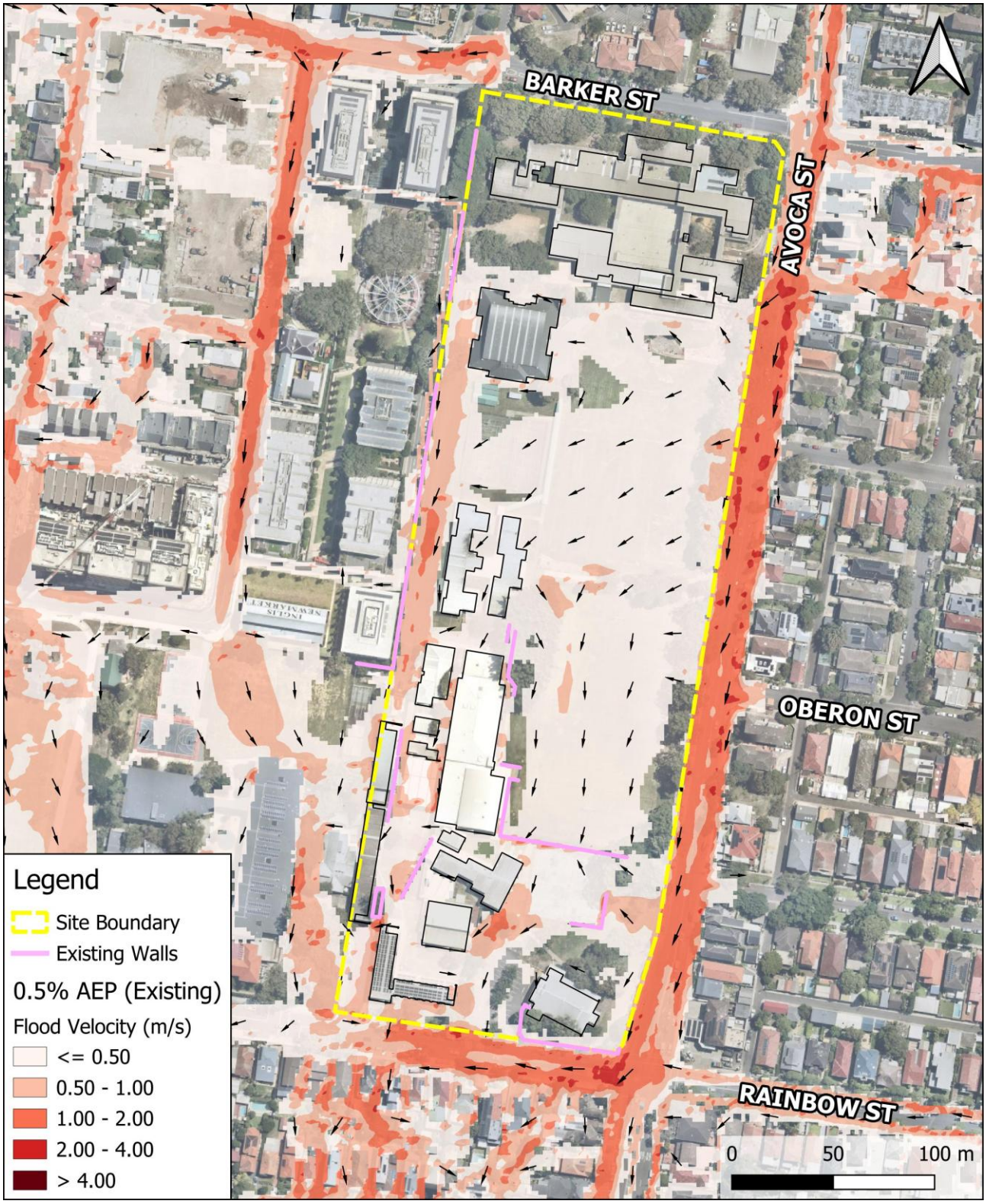
Appendix B 5: 5% AEP flood velocity at Randwick High School under existing conditions



Appendix B 6: 5% AEP flood hazard level at Randwick High School under existing conditions



Appendix B 7: 0.5% AEP flood depths and levels at Randwick High School under existing conditions

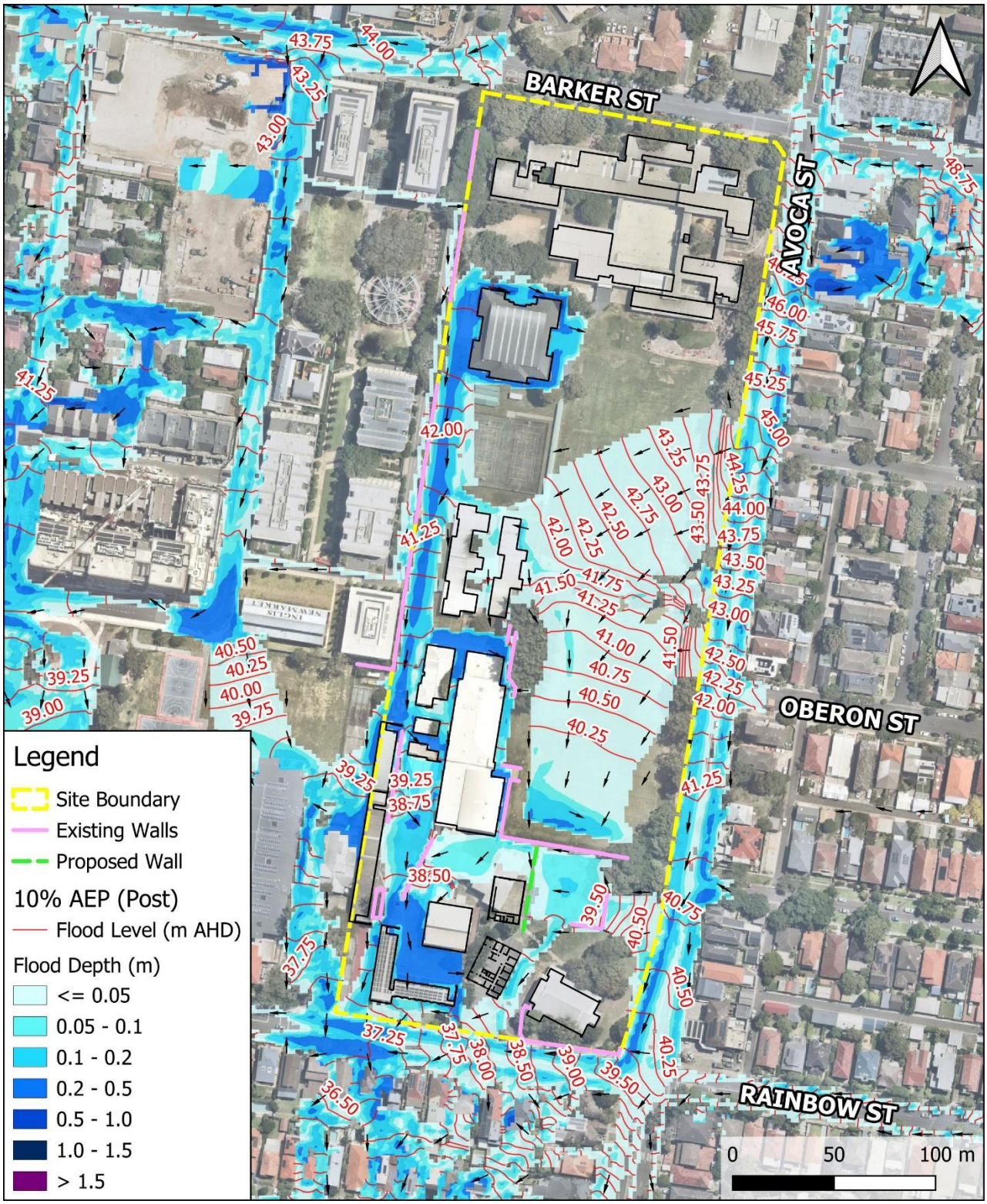


Appendix B 8: 0.5% AEP flood velocity at Randwick High School under existing conditions

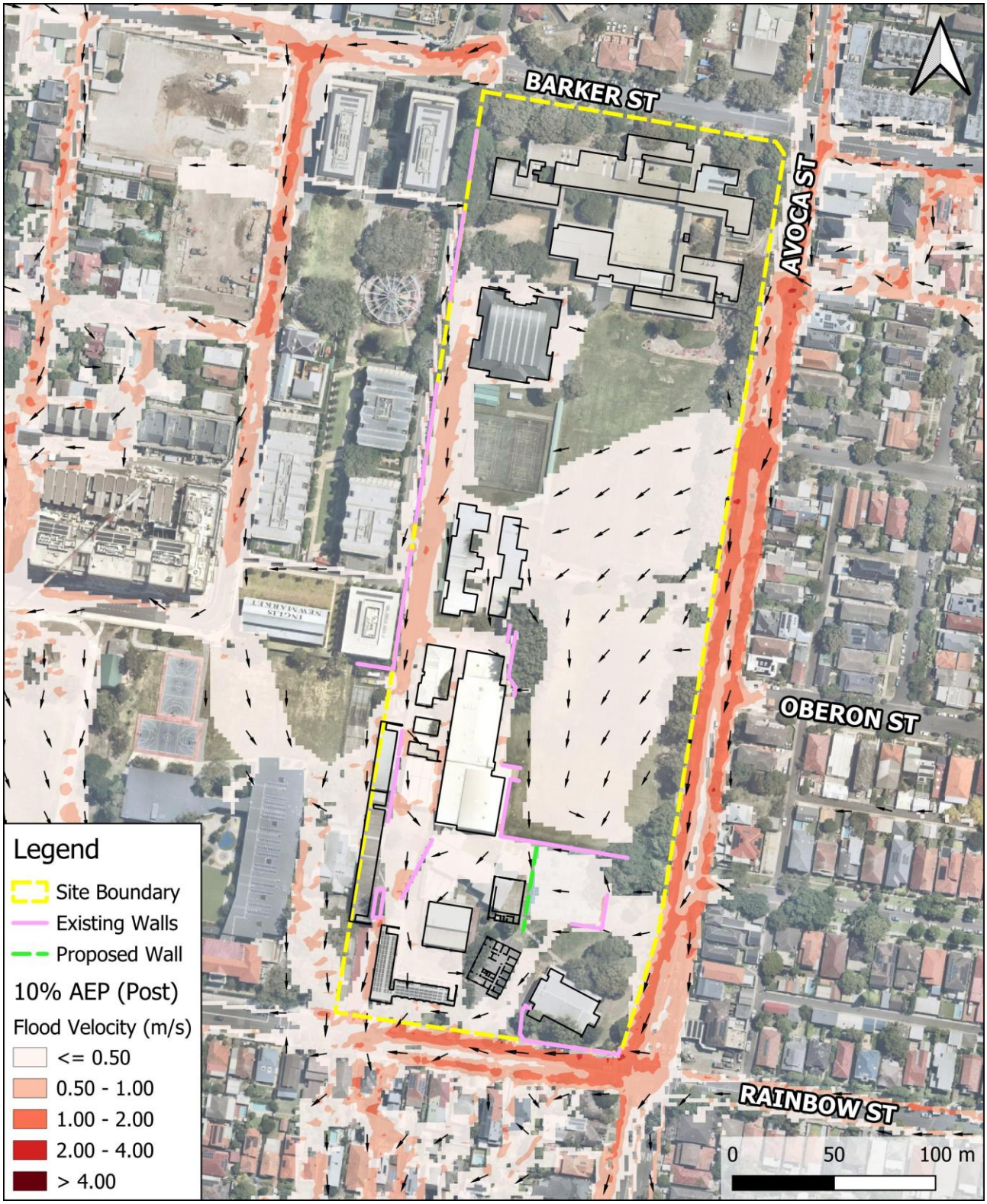
Appendix B 9: 0.5% AEP flood hazard level at Randwick High School under existing conditions

Appendix C

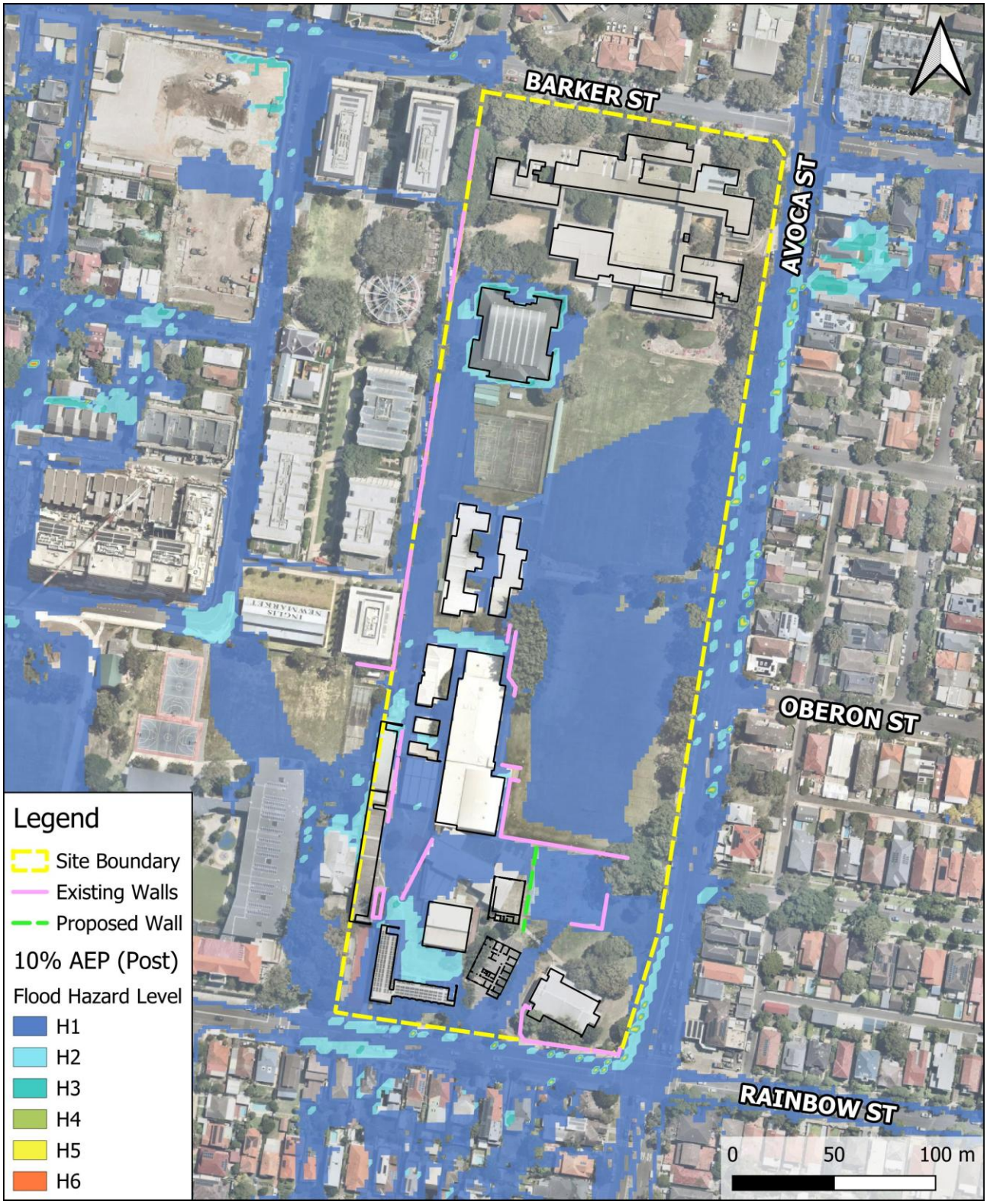
Additional Post-Development Scenario Results



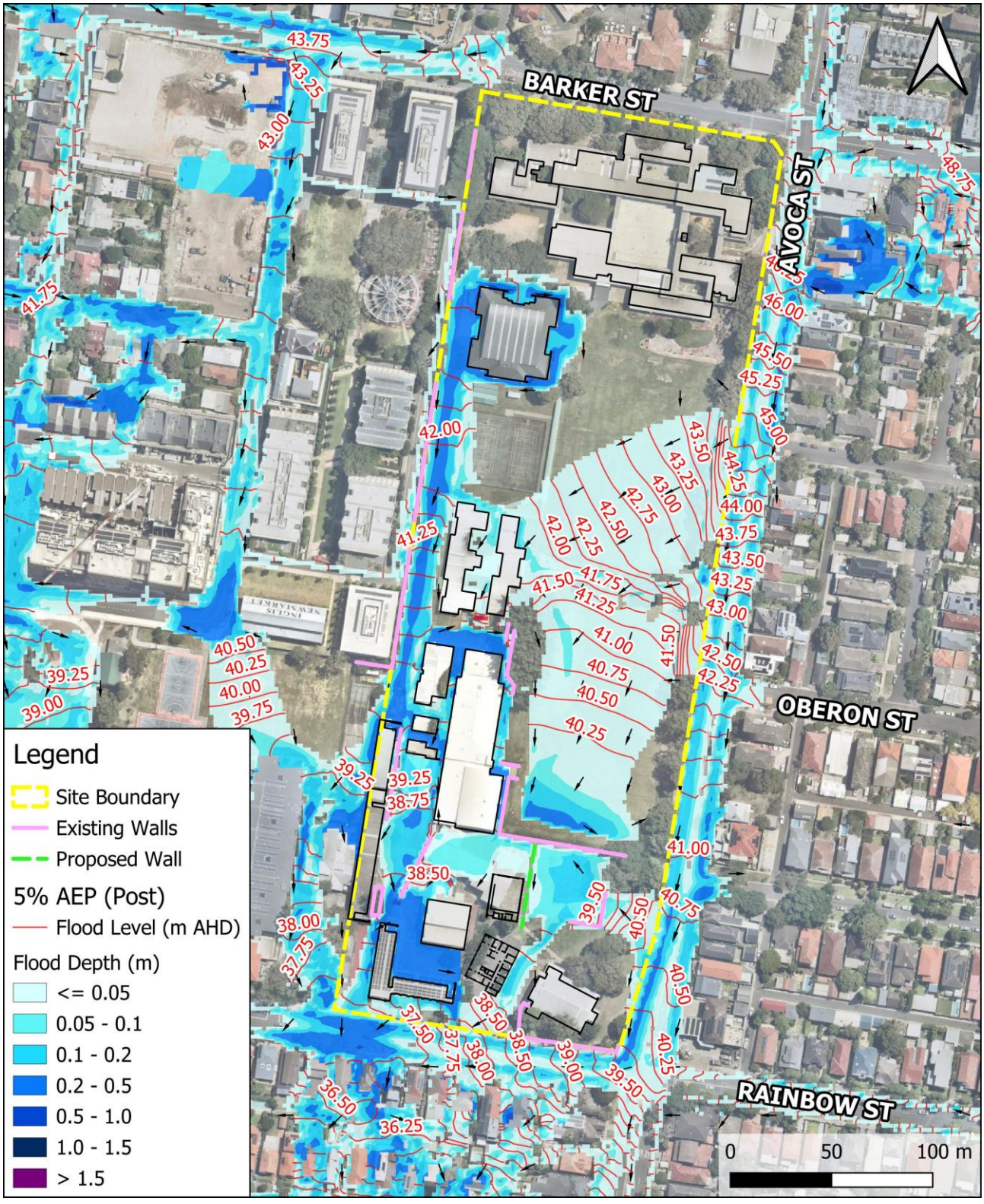
Appendix C 1: 10% AEP flood depths and levels at Randwick High School under post-development conditions



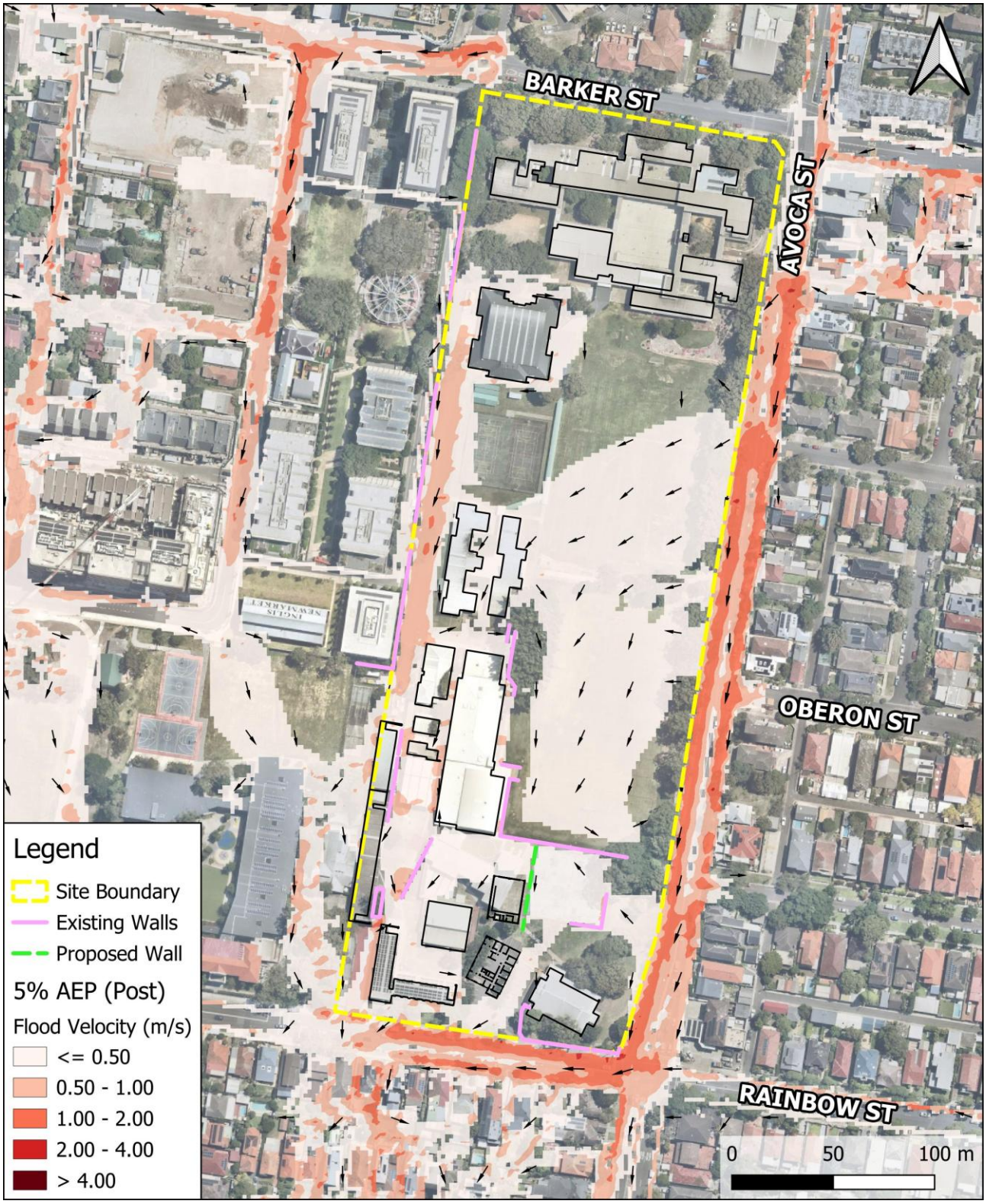
Appendix C 2: 10% AEP flood velocity at Randwick High School under post-development conditions



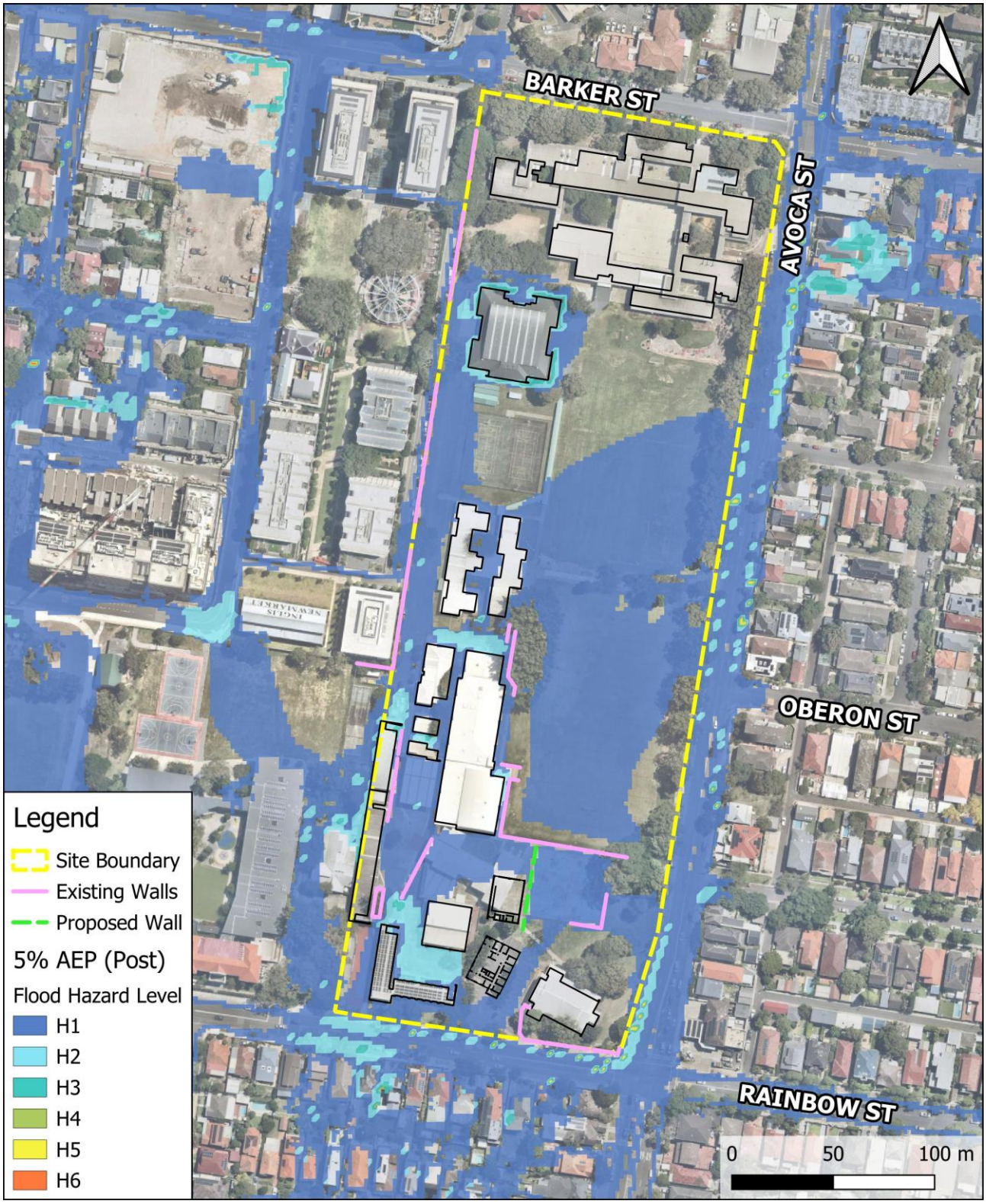
Appendix C 3: 10% AEP flood hazard level at Randwick High School under post-development conditions



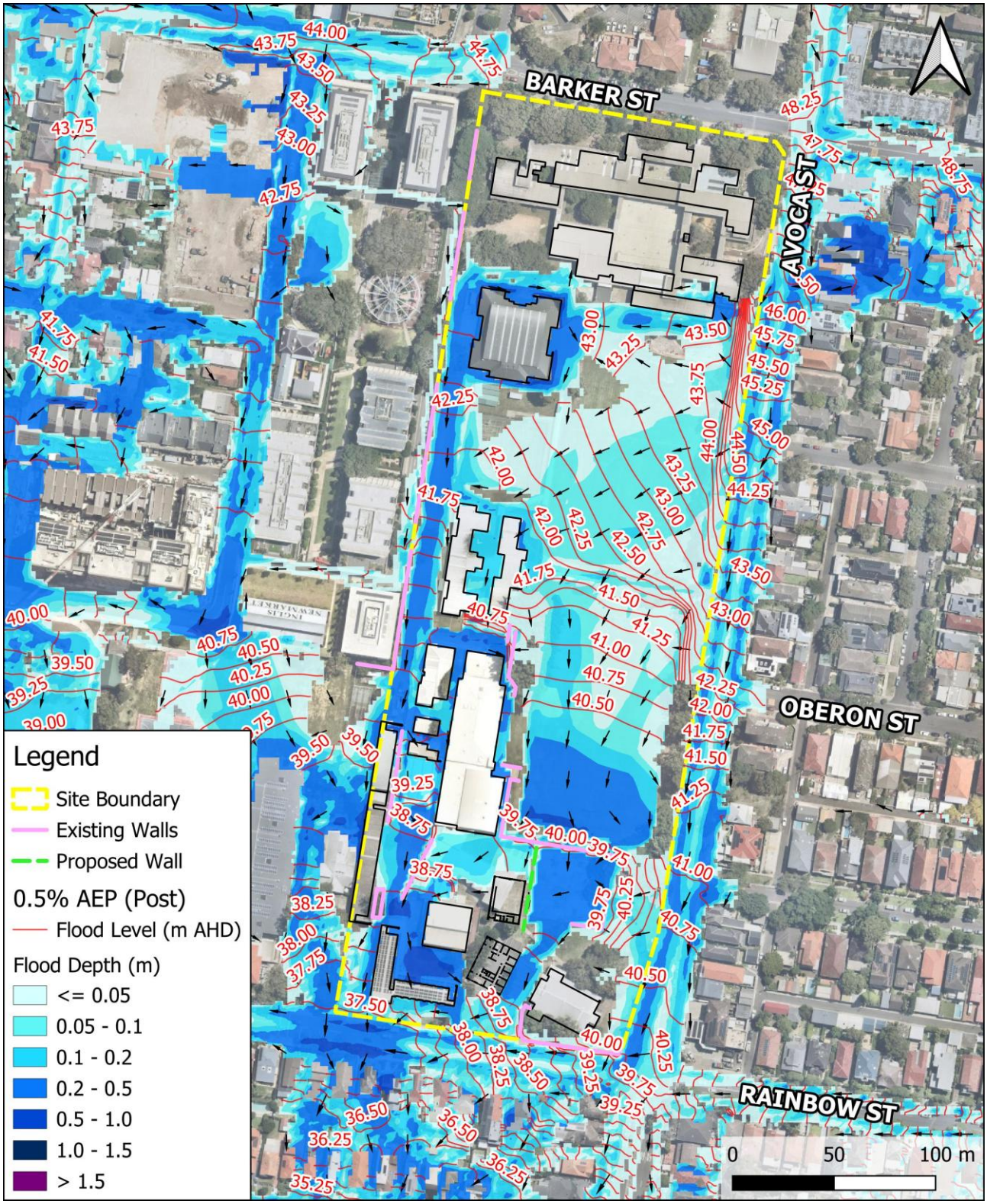
Appendix C 4: 5% AEP flood depths and levels at Randwick High School under post-development conditions



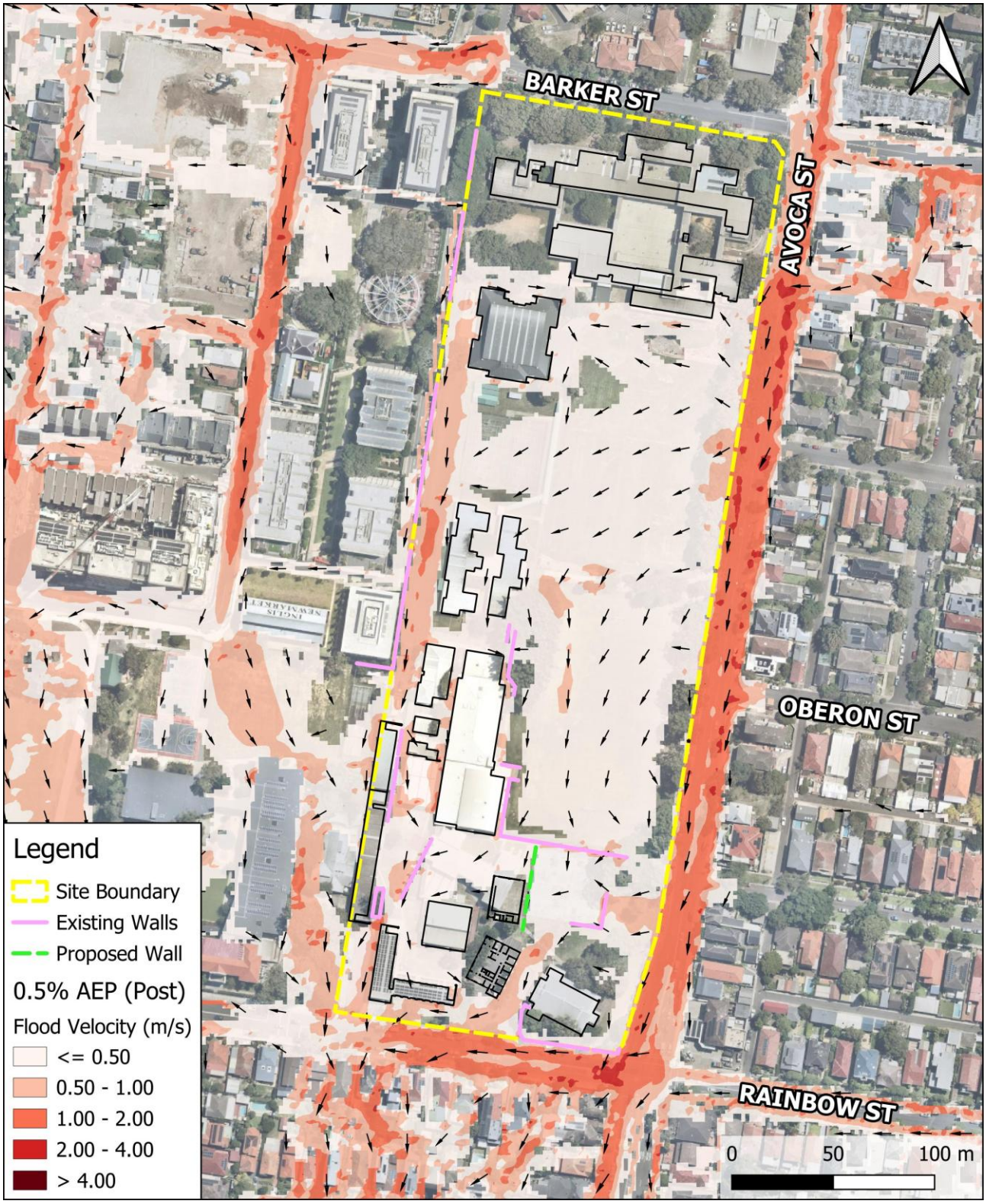
Appendix C 5: 5% AEP flood velocity at Randwick High School under post-development conditions



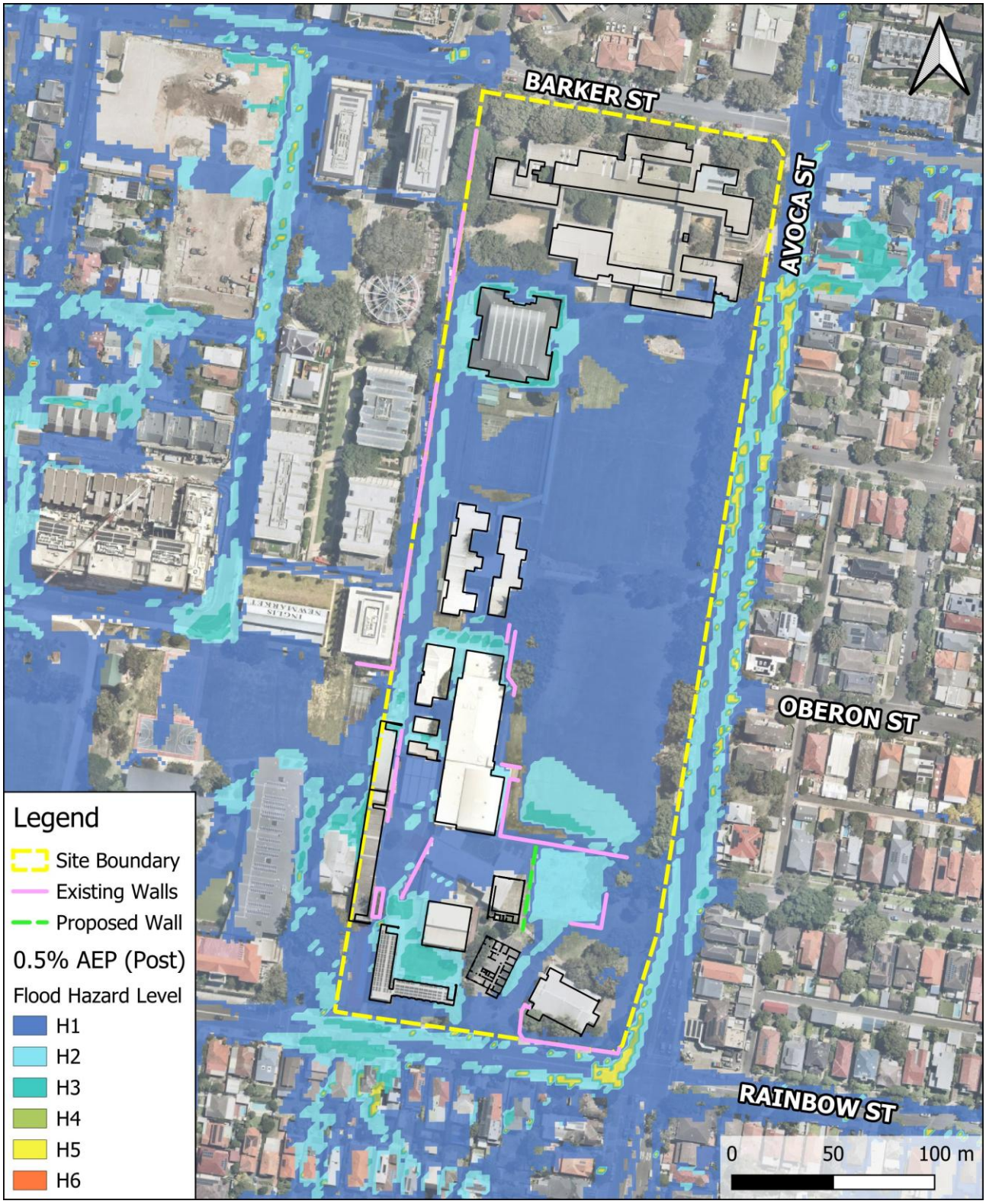
Appendix C 6: 5% AEP flood hazard level at Randwick High School under post-development conditions



Appendix C 7: 0.5% AEP flood depths and levels at Randwick High School under post-development conditions



Appendix C 8: 0.5% AEP flood velocity at Randwick High School under post-development conditions



Appendix C 9: 0.5% AEP flood hazard level at Randwick High School under post-development conditions