Flood Impact and Risk Assessment

Bungendore High School

Prepared for NSW Department of Education / 14 March 2025

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Rev	Date	Prepared By	Approved By	Remarks
1	22/01/2025	LC	JM	Draft
2	11/02/2025	LC	MK	Final
3	12/02/2025	LC	MK	Final – client comments update
4	21/02/2025	LC	MK	Final – client preamble update
5	26/02/2025	LC	MK	Final – client preamble update
6	14/03/2025	LC	MK	Final – client preamble update

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 a Review of Environmental Factors (REF) for the NSW Department of Education (DoE) for the construction and operation of the new Bungendore High School (the activity), described as part Lot 125 in Deposited Plan 1297613 (current address is part of 18 Harp Avenue, Bungendore, NSW, 2621). The purpose of this report is to identify the existing constraints of flooding at the site and determine the likely flood impacts of the proposal in post-development conditions.

The assessment confirmed that the site and its immediate surrounding area are not affected by mainstream flooding (i.e. located outside the PMF flood extent of mainstream flooding) but will be subject to overland flow (refer to Section 4.2 for details). Therefore, a site specific TUFLOW model has been developed by TTW as part of the assessment (refer to Section 5 for details), to investigate the likely flood impacts that the proposed activity will have on its surrounding area and to determine if the proposed activity complies with the relevant flood-planning requirements.

The modelling results demonstrated that overland flows from the external upstream catchment are mainly contained within the adjacent road reserves in all events assessed (i.e. up to the PMF event), with no overland flows spilling onto the site. The results however, showed that there is some excess stormwater runoff generated within the site itself that will need further civil and stormwater design consideration, at the subsequent detailed design stage, to direct such flows away from the building openings and safely convey offsite into the drainage reserve at the site's western frontage. This has been included as a mitigation measure for the proposed activity, as discussed in Section 10. Nonetheless, the modelling results showed that the proposed activity will not cause any adverse flood impacts to adjacent properties in the 1% AEP event assessed, as discussed in Section 7.

Stormwater blockages and the potential increase in rainfall intensity due to climate change have also been considered and assessed as part of this study (refer to Section 8 for details), and the results showed no significant onsite impacts.

The assessment showed that the proposed activity generally complies with the relevant flood-planning requirements and standards, as discussed in Section 9. However, such compliance will need to be further reviewed and confirmed following the detailed design.

Given that the surrounding roads will be cutoff in severe storm events, a FERP (Flood Emergency Response Plan) has been recommended as part of this assessment. A separate Preliminary FERP has been prepared by TTW (TTW – 14 March 2025) to support the REF for the proposed activity.

1.0 Introduction

This Flood Impact and Risk Assessment has been prepared to support a Review of Environmental Factors (REF) for the NSW Department of Education (DoE) for the construction and operation of the new Bungendore 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 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, Section 3.37A of the T&I SEPP.

This document has been prepared in accordance with the *Guidelines for Division 5.1 assessments* (the Guidelines) by the Department of Planning, Housing and Infrastructure (DPHI). The purpose of this report is to identify the existing constraints of flooding at the site and determine the likely impacts of the proposal in post-development conditions. The details of this report are based on currently available information and correspondence undertaken at the time of writing.

1.1 Reference Documents

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

- Australian Institute of Disaster Resilience (AIDR) Guideline 7-3: Flood Hazard (2017)
- Bureau of Meteorology (2003) The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method
- FloodSafe guidelines and the relative FloodSafe Tool Kits
- NSW Department of Environment and Heritage – 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 Function – Flood Risk Management Guideline FB02
- NSW Department of Planning and Environment (2023) Flood Impact and Risk Assessment – Flood Risk Management Guide LU01
- NSW Department of Planning and Environment (2023) Flood Risk Management Manual (https://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-manual\)
- NSW Department of Planning, Housing and Infrastructure – Planning Circular PS 24-001, Update on addressing flood risk in planning decisions, 1st March 2024
- NSW Maps Viewer (Spatial Collaboration Portal - Map Viewers (nsw.gov.au))
- NSW Planning Portal Spatial Viewer (https://www.planningportal.nsw.gov.au/spatialviewer/)
- NSW State Emergency Service (SES) Guidelines
- Palerang Council (2014) Bungendore Floodplain Risk Management Study
- Palerang Council (2014) Bungendore Floodplain Risk Management Plan
- Palerang Council (2022) Palerang Development Control Plan 2015 (Updated November 2022)
- School Infrastructure (2020) School Site Selection and Development Guideline for Determining Appropriate School Sites
- TTW (2025) Preliminary Flood Emergency Response Plan, dated 14 March 2025.

2.0 Site Description

The current street address is part of 18 Harp Avenue, Bungendore, NSW, 2621 (the site), and is legally described as part Lot 125 in Deposited Plan 1297613. As shown at Figure 1, the proposed school site forms part of a larger lot which is the subject of a proposed residential subdivision.

The site is located within the North Bungendore Precinct (Elm Grove Estate) in Bungendore. As a result of precinct wide rezonings, the surrounding locality is currently transitioning from a semi-rural residential area to an urbanised area with new low density residential development.

The site is zoned R2 Low Density Residential, with all adjoining land also zoned R2 Low Density Residential.

The site has three frontages:

- Approx 500m southern frontage to Birchfield Drive.
- Approx 500m northern frontage to Bridget Avenue.
- Approx 100m eastern frontage to Winyu Rise.

The site is currently cleared of all vegetation and consists of grassland, having been prepared for the purposes of future low density residential development.

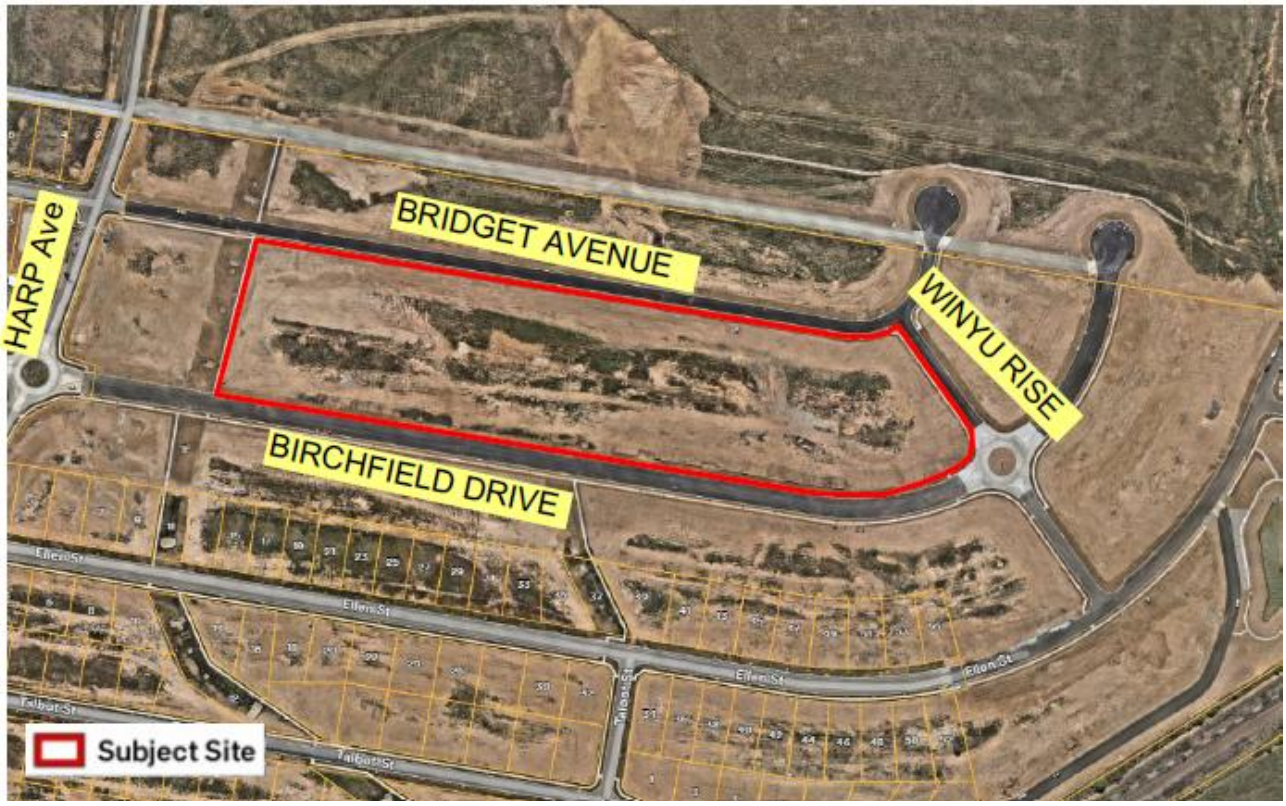


Figure 1: Aerial Photograph of the Site (Source: Urbis, 2024)

3.0 Proposed Activity Description

The proposed activity is for the construction and operation of a new high school in Bungendore at part 18 Harp Avenue, Bungendore (the **site**). The new high school will accommodate 600 students and 68 staff. The school will provide 26 general learning spaces, and three support learning spaces across two buildings. The buildings will be predominantly three-storeys in height and will include permanent and support teaching spaces, specialist learning hubs, a library, administrative areas and a staff hub.

Additional core facilities are also proposed including a standalone school hall with covered outdoor learning area (**COLA**), a car park, a kiss and drop zone along Birchfield Drive, sports courts and a sports field. The new school also features a single storey building with associated paddocks in the far western portion of the site designed for livestock management and hands-on agricultural learning.

Specifically, the proposal involves the following:

- Building A, a three-storey learning hub accommodating general learning spaces, a special education learning unit (**SELU**), a physical education centre, a performing arts space, and other core facilities including administrative areas, staff hub, library and end of trip facilities.
- Building B, a part three/part four storey learning hub accommodating general learning spaces, specialist workshops for food, textile, wood and metal workshops, as well as visual arts studios, science labs and staff areas.
- Building C, a standalone school hall with COLA.
- Building D, a single-storey agricultural block comprising an animal storage space, a COLA and internal workshop.
- On-site staff car park with 50 spaces with access via Bridget Avenue.
- Kiss and drop zones and bus bays along Birchfield Drive.
- Open play space including a sports courts and sports field.
- Associated utilities and services including a 1000kv padmount substation.
- Main pedestrian entrance to be located off Birchfield Drive.
- Secondary pedestrian access from Bridget Avenue.
- Public domain/off-site works including the removal of street trees.

The design has been masterplanned to allow for an additional future stage. The second stage does not form part of this proposal.

Figure 2 provides an extract of the proposed site plan.

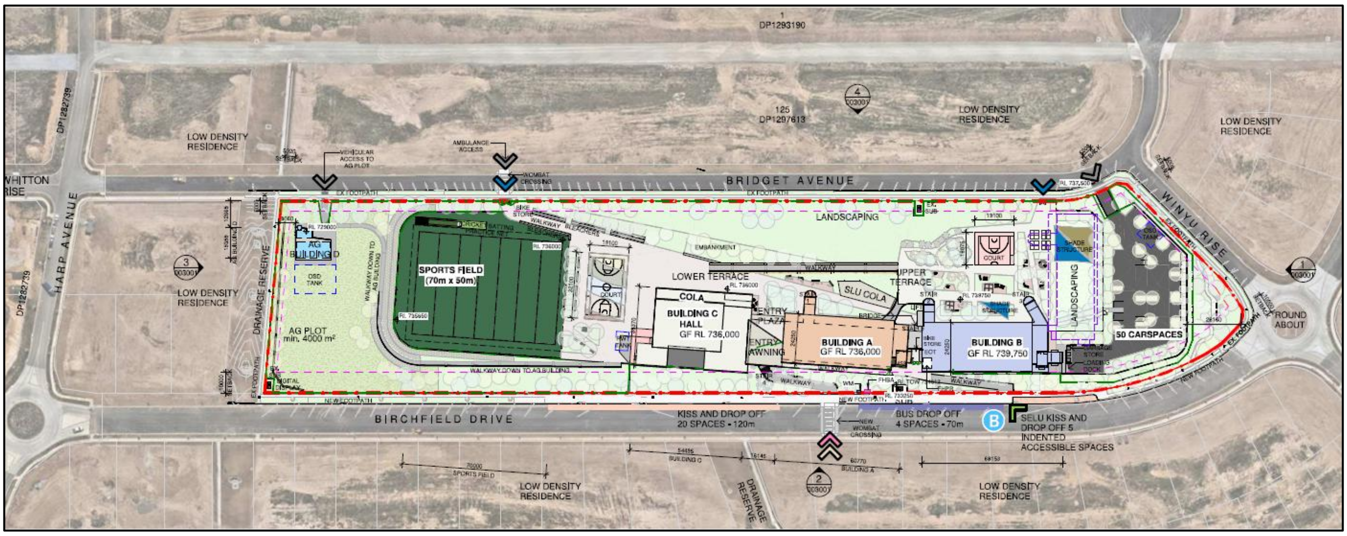


Figure 2: Site Plan (Source: NBRS, Feb 2025)

4.0 Site Characteristics

4.1 Hydrological Context

The proposed school site is situated within undulating topography on the southern flank of a local hill, with a predominant slope from the northern perimeter of the site towards the Birchfield Drive frontage in the south. Figure 3 presents the site location, bounded by Bridget Avenue to the north, Winyu Rise to the east, Birchfield Drive to the south and a riparian corridor to the west and south.

Aside from the construction of new roads in the area, the site and surrounding area are currently undeveloped, with plans for low density residential development to the north, south, and east of the site, and west of Harp Avenue. Based on the current Council flood mappings, the site and its immediate surrounding area are not mapped as flood prone lands as they are located outside the PMF flood extent of mainstream flooding (i.e. not affected by any creek/river floodings). This is discussed further in Section 4.2. Nonetheless, the site and its immediate surrounding area will still subject to overland flow flooding.

Figure 4 presents a comparison of the site in October 2016 and September 2023 based on historical aerial imagery from Google Earth and Nearmap, demonstrating how the natural watercourse that marks the site's western border has been reconfigured into a drainage reserve. The riparian corridor conveys flow in a southeasterly direction, where it eventually discharges into the newly constructed dam, located 300m south of the site. Several culverts have been constructed to convey flow beneath the new roads.

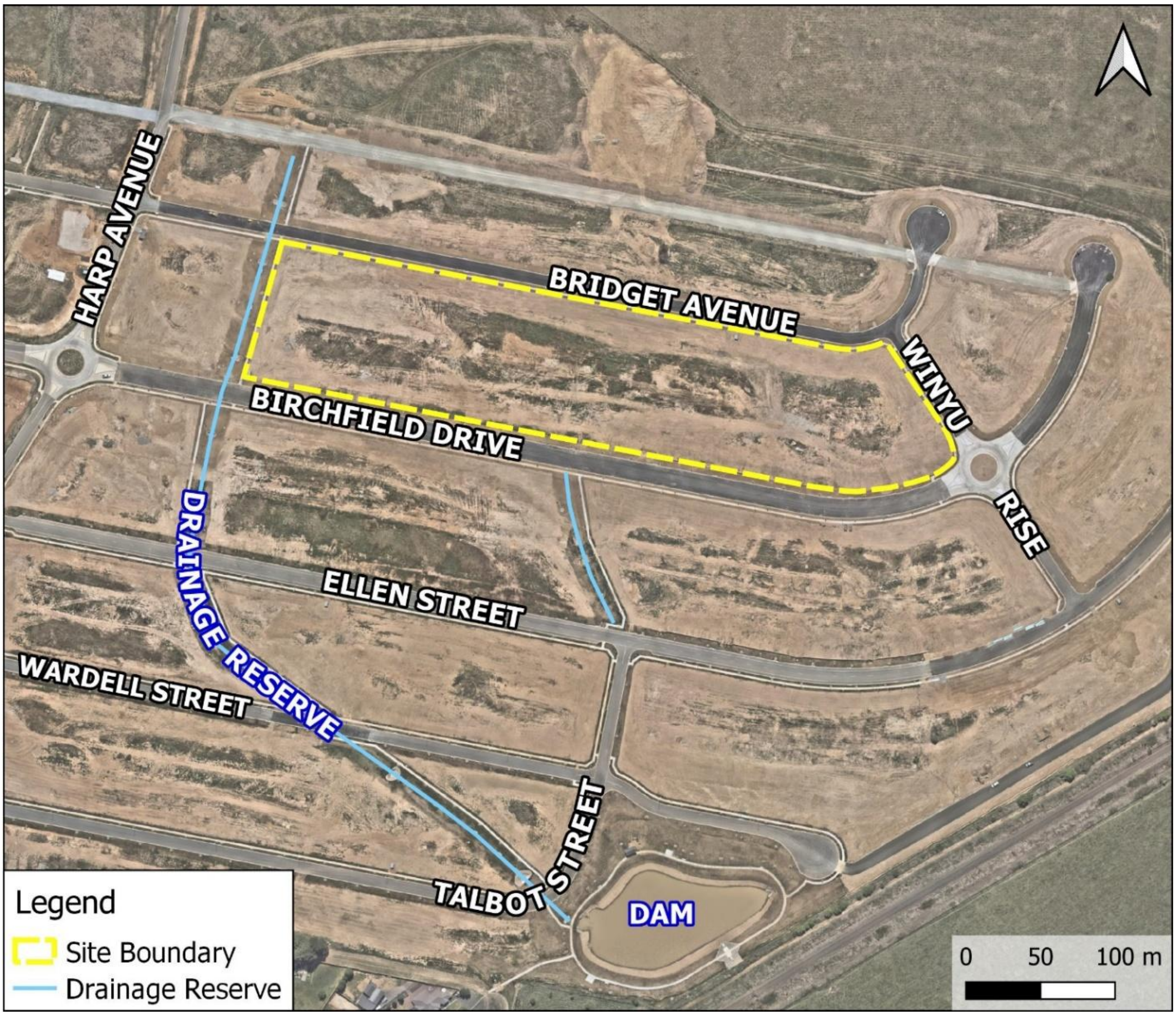


Figure 3: Bungendore High School site location (Source: Nearmap imagery taken 29 September 2023)

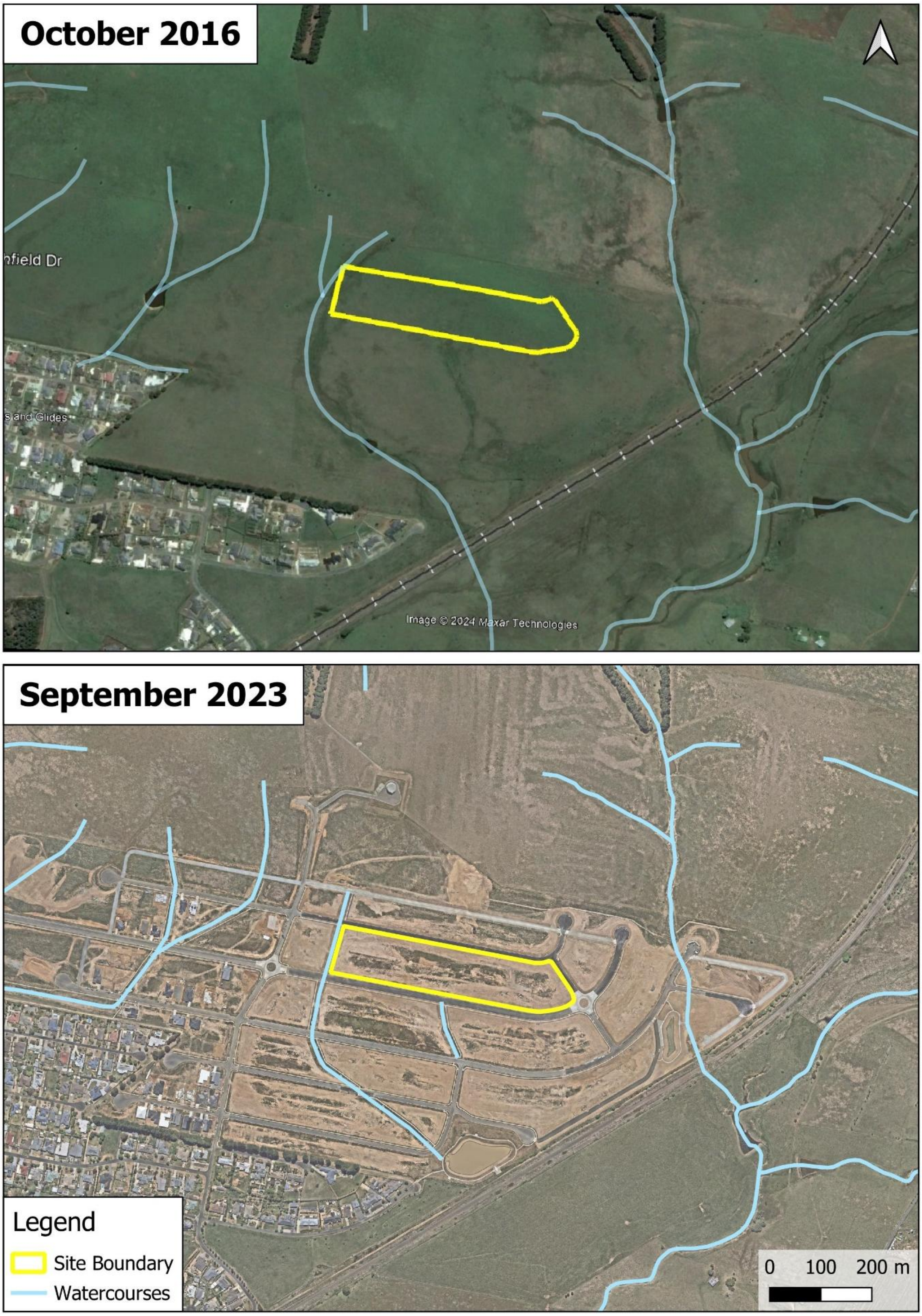


Figure 4: Site development and reconfiguration of watercourses between October 2016 and September 2023

4.2 Catchment Information

Bungendore is situated at the confluence of two creeks (Turallo Creek and Halfway Creek). The site itself is situated approximately 1.3km northeast of Turallo Creek, and 2.25km northeast of the confluence between the Turallo and Halfway Creeks. Worley Parsons were commissioned by Palerang Council to prepare the Bungendore Floodplain Risk Management Study (FRMS), published in 2014. As part of the FRMS, the RMA-2 flood model, originally produced for the Bungendore Flood Study (Patterson Britton & Partners, 2002), was updated and used to simulate flood behaviour. The extent of the Probable Maximum Flood (PMF) and the PMF levels are depicted in Figure 8. The results indicate that the site is not affected by mainstream flooding, with the site (indicated in yellow) outside of the PMF extent.

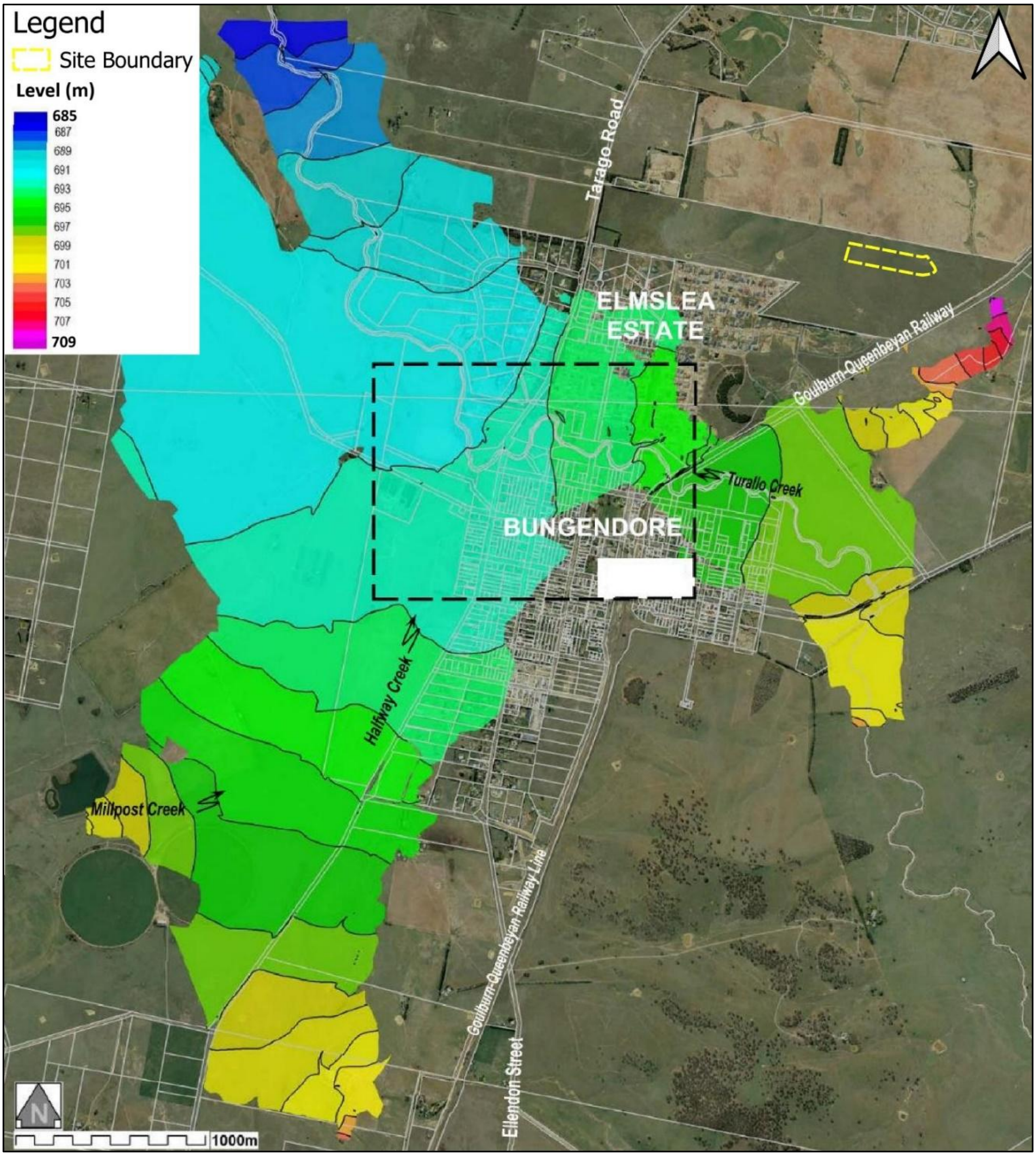


Figure 5: PMF extent and levels (m AHD) across Bungendore (Source: adapted from Bungendore FRMP 2014)

Further assessment of the study’s hydrological inputs demonstrates that the boundary condition at the unnamed creek to the east of the site was applied downstream of the site, where the creek intersects with the Goulburn-Queanbeyan Railway line. Despite this, however, assessment of LiDAR levels suggest that the creek bed level is approx. 710–715m AHD adjacent to the site, at least 15m below the minimum ground level across the east of the site. In addition, the creek is in a narrow valley with steep sides, as depicted in Figure 6, limiting the horizontal spread of the floodplain, with more concentrated flow during flood events. As such, there is no concern that the site could be impacted by mainstream flooding from this creek.

However, there are two drainage reserves to the west and south of the site. As the main drainage points relative to the site (located within just 10m of the property boundary), there is potential for overland flows to cross through the site as they drain into these riparian corridors. The impact of these flows has been reviewed via hydraulic modelling of the site, as outlined in Section 5.0 and 6.0.

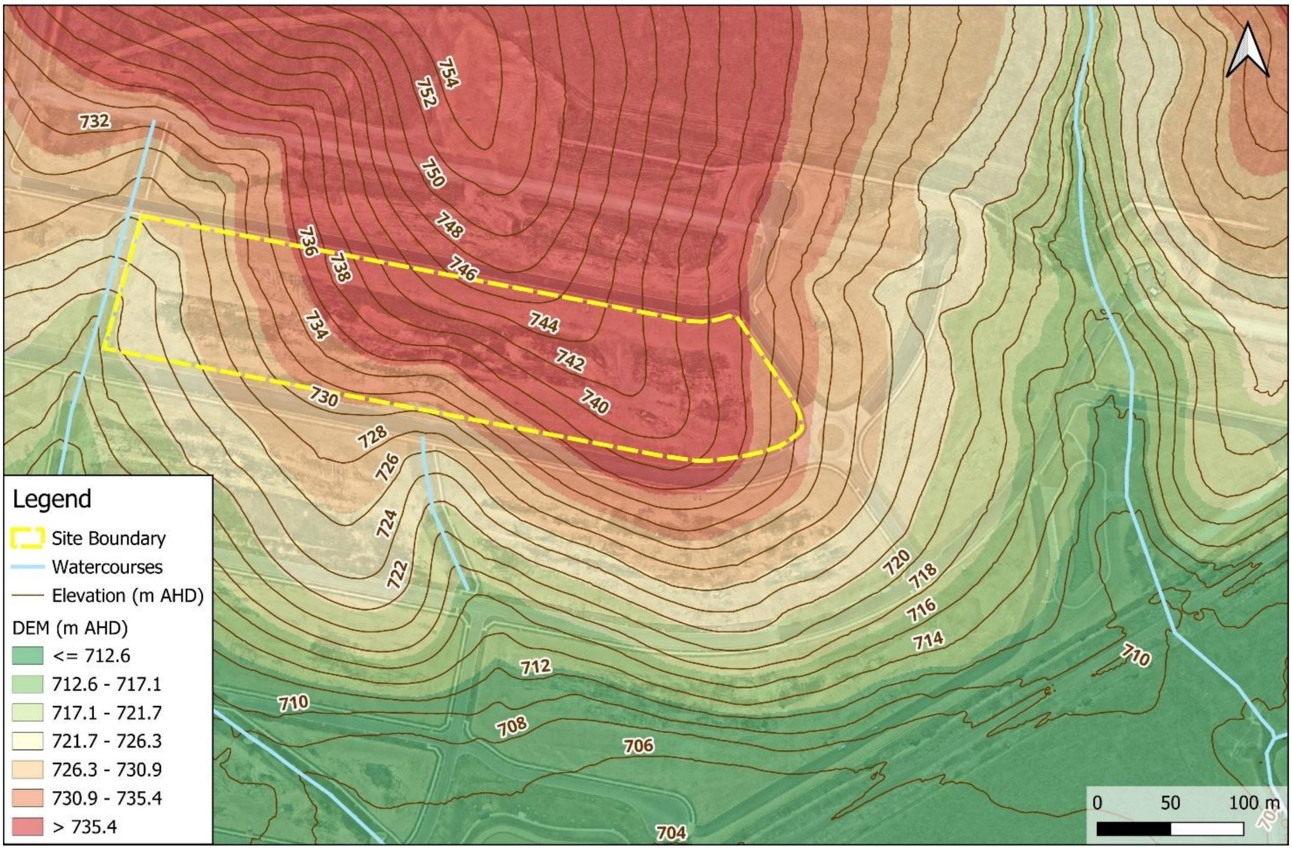


Figure 6: Elevation of the proposed Bungendore High School site in relation to the unnamed creek to the east of the site

5.0 TTW Hydraulic Model Setup

Given that the site is not included in the Bungendore Floodplain Risk Management Study model (and the existing flood study does not account for local overland flooding), a new 1D-2D hydraulic model was developed to assess flood behaviour at the site.

The model was developed using TUFLOW software and the following section outlines the hydraulic model setup, summarised in Table 1. The methodology applied in TTW's modelling is consistent with latest NSW flood modelling guidelines and Australian Rainfall and Runoff 2019 (ARR2019).

Table 1: TTW TUFLOW model setup

Model Domain	Dynamic 1D (pipe network) and 2D (floodplain)
Solver	TUFLOW HPC 2023-03-AE
Grid size	1m cell
DEM	2014 LiDAR + 2021 subdivision design contours + 2024 topographical survey for site area
Hydrology	IL/CL ARR 2019 temporal patterns
Model Inflows	Direct rainfall applied to full catchment
Map Cutoff	10mm for 10%, 1%, 0.5% and 0.2% AEP runs, 30mm cutoff for PMF
Events Analysed	10%, 1%, 0.5%, 0.2% AEP and PMF

5.1 2D Model Domain

The TUFLOW model boundary used in the overland flow assessment is depicted in Figure 7. A square 1m x 1m grid was utilised for the study. As TUFLOW samples elevation points at the cell centres, mid-sides and corners, surface elevations are sampled every 0.5m. This 1m grid size is therefore sufficient in representing topographical variations within the study area. Stage-discharge (water level versus flow rate) curves were adopted as the downstream boundary conditions. The stage-discharge relationship was generated by TUFLOW through specification of the downstream boundary slopes.

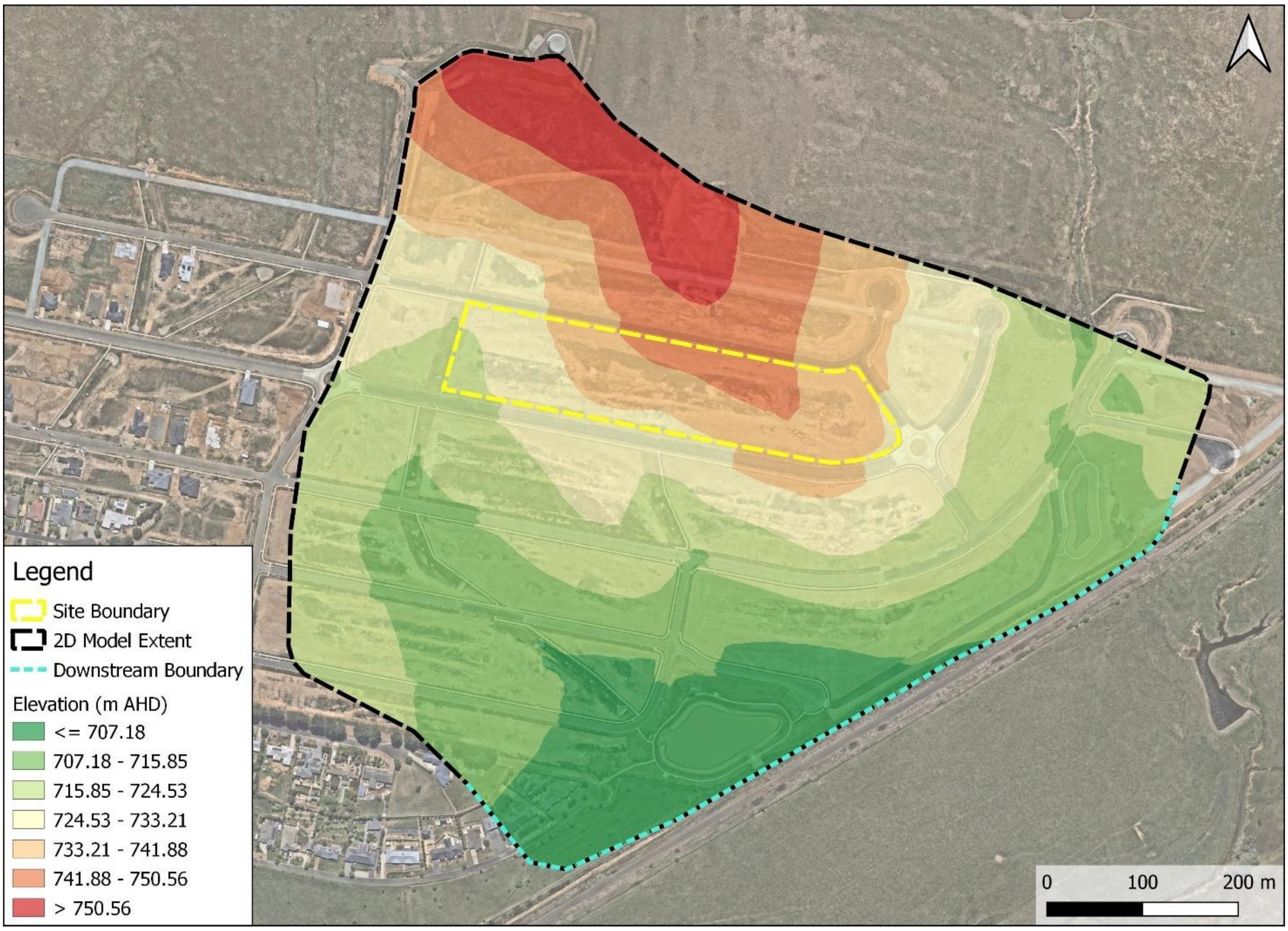


Figure 7: TTW TUFLOW model extent in relation to the site

5.2 1D Model Domain

Stormwater drainage infrastructure data relevant to the site was obtained from a combination of site survey data from Colliers and work as executed drawings for the Elm Grove Estate subdivision from Fraish Consulting, provided by Council.

The drainage pipe network surrounding the site is of a significant size, specifically the culvert system conveying flows across the drainage reserve to the west of the site. This includes twin 750mm diameter pipes conveying flow beneath Bridget Avenue, a 1200mm diameter pipe under both Birchfield Drive and Ellen Street, twin 1200mm diameter pipes under Wardell Street, and three 1200mm diameter pipes under Talbot Street, which discharge into the dam southeast of the site. In addition to these road culverts, a portion of the underground stormwater pit and pipe system within the drainage reserve has also been incorporated into the model, with pipe size varying from 525mm x 525mm to 1200mm x 750mm. Figure 8 presents the road culverts and stormwater drainage data incorporated into the model.

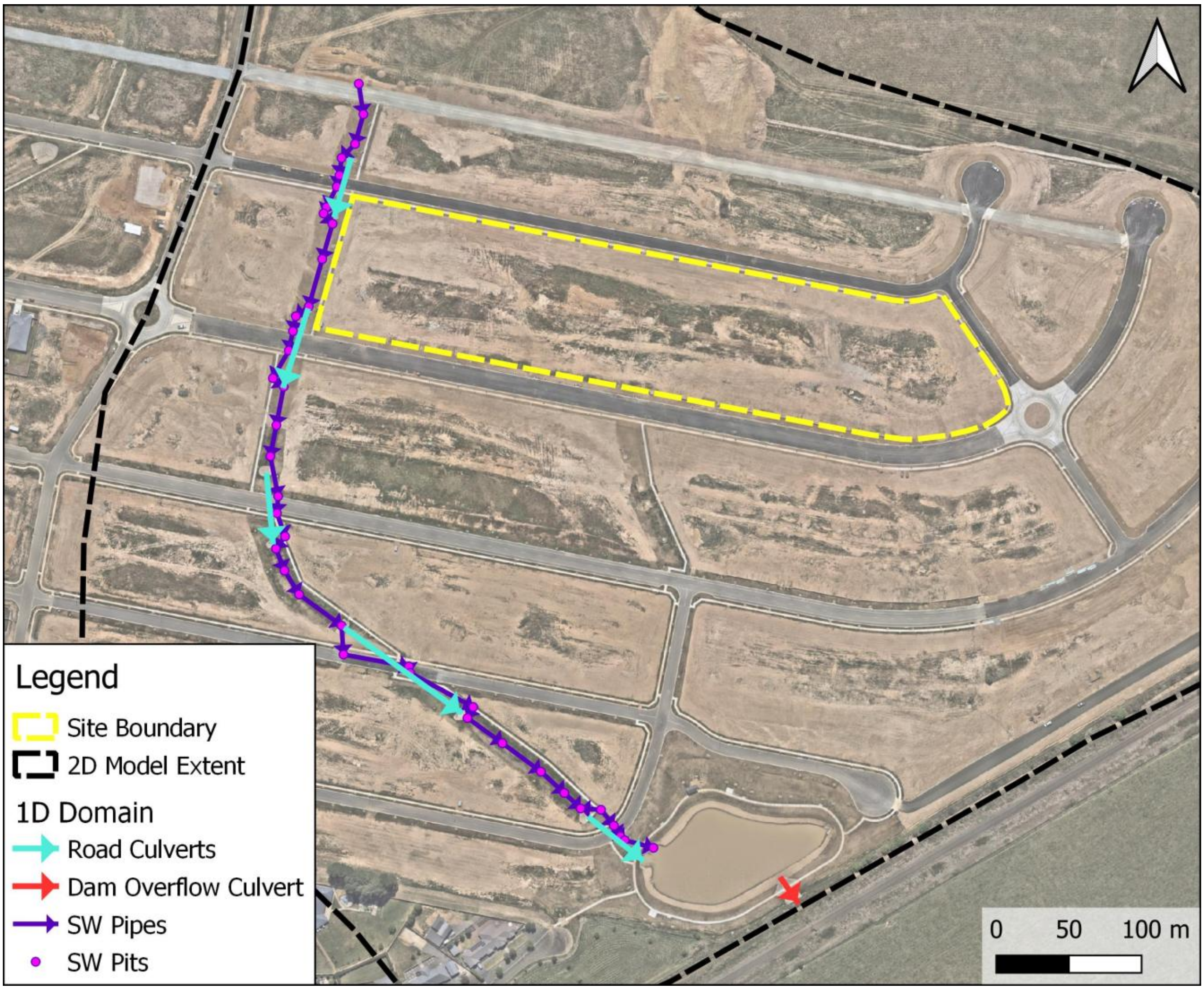


Figure 8: Stormwater pits and pipes incorporated into the hydraulic model

5.3 Hydrological Inputs

Boundary conditions define the location and volume of flows entering or exiting the model domain in every timestep. A Rainfall on Grid (ROG) hydrology approach has been adopted using a direct rainfall boundary condition, in which rainfall is applied to each active cell in the 2D mesh. Hydrologic losses and runoff are therefore calculated for each cell and routed through downstream cells to evaluate flood depths and velocities.

Hydrological inputs were derived from the Australian Rainfall and Runoff 2019 (ARR2019) data hub for the 10% AEP to 0.5% AEP events. Probable Maximum Precipitation (PMP) rainfall data was estimated by following the procedure detailed in the Generalised Short Duration Method (GSDM) report (Bureau of Meteorology, 2003).

As the ROG method is typically associated with substantial shallow sheet flow (as rainfall is applied to every active grid cell), depths of less than 0.01m have been filtered out of the hydraulic model outputs for all events, with the exception of the PMF, in which a 0.03m cutoff has been applied.

5.4 Topography

5.4.1 LiDAR Data

LiDAR data covering the site was obtained from ELVIS with a spatial resolution of 1 metre. The data was obtained as part of the Lake George LiDAR project in 2014. It should be noted that this dataset does not capture the recent development in the area, including the new roads and culverts, nor the reconfigured watercourses.

5.4.2 Elm Grove Estate Subdivision Design Contours

Design contours for the wider Elm Grove Estate subdivision (dated 2021, prepared by Fraish Consulting) were obtained from Queanbeyan-Palerang Regional Council. The contours cover the surrounding roads, drainage reserves and ponds. The extent of the data is presented in Figure 9. These contours were converted into a DEM format and combined with the 2014 LIDAR.

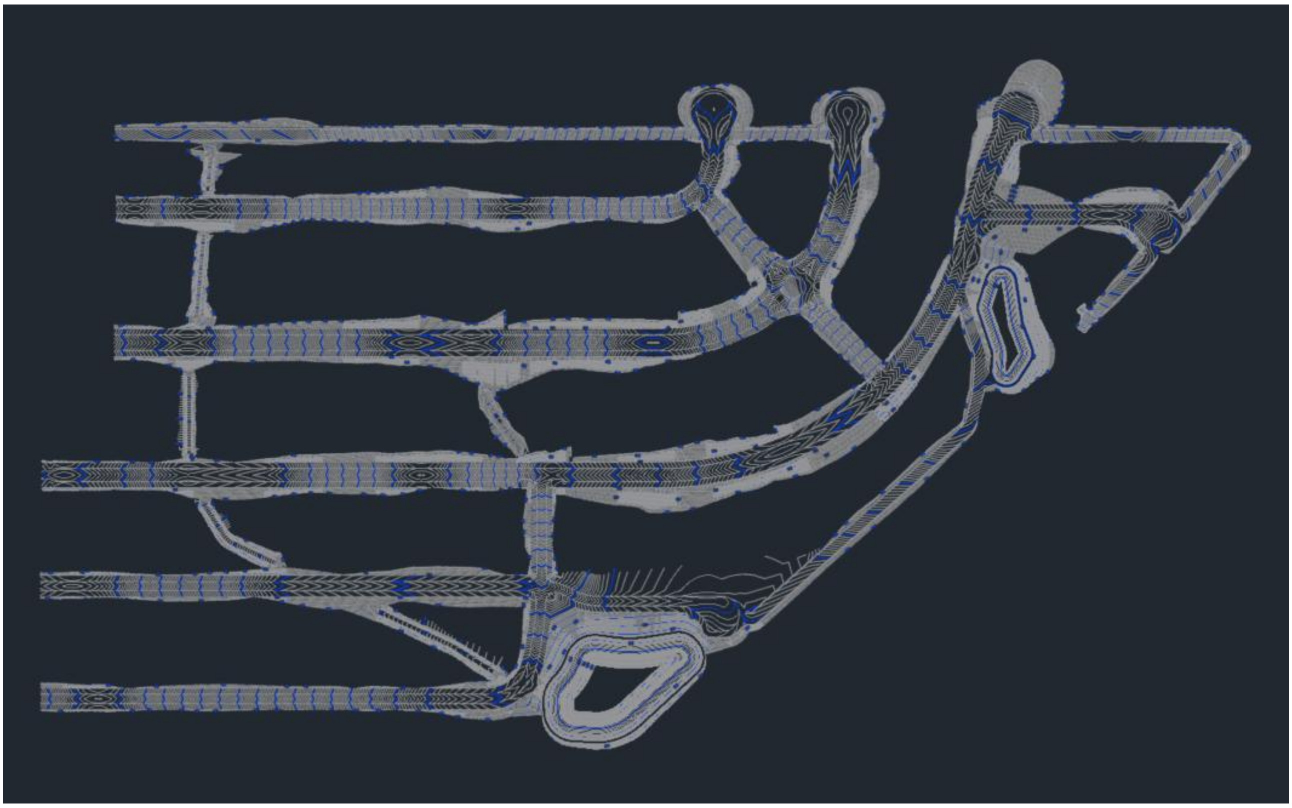


Figure 9: Extent of the design contours received for the Elm Grove Estate subdivision

5.4.3 Site Survey Data

Additional survey data was obtained on 18 September 2024 by Colliers and was incorporated into the model to increase the accuracy of surface levels within and surrounding the site. The extent of the survey is shown in Figure 10.

The final DEM utilised within the existing case model is presented in Figure 11, combining 2014 LIDAR, 2021 design contours, and 2024 detailed site survey data. Note that the elevations have been exaggerated (with a Z factor of 2) for visualisation purposes.

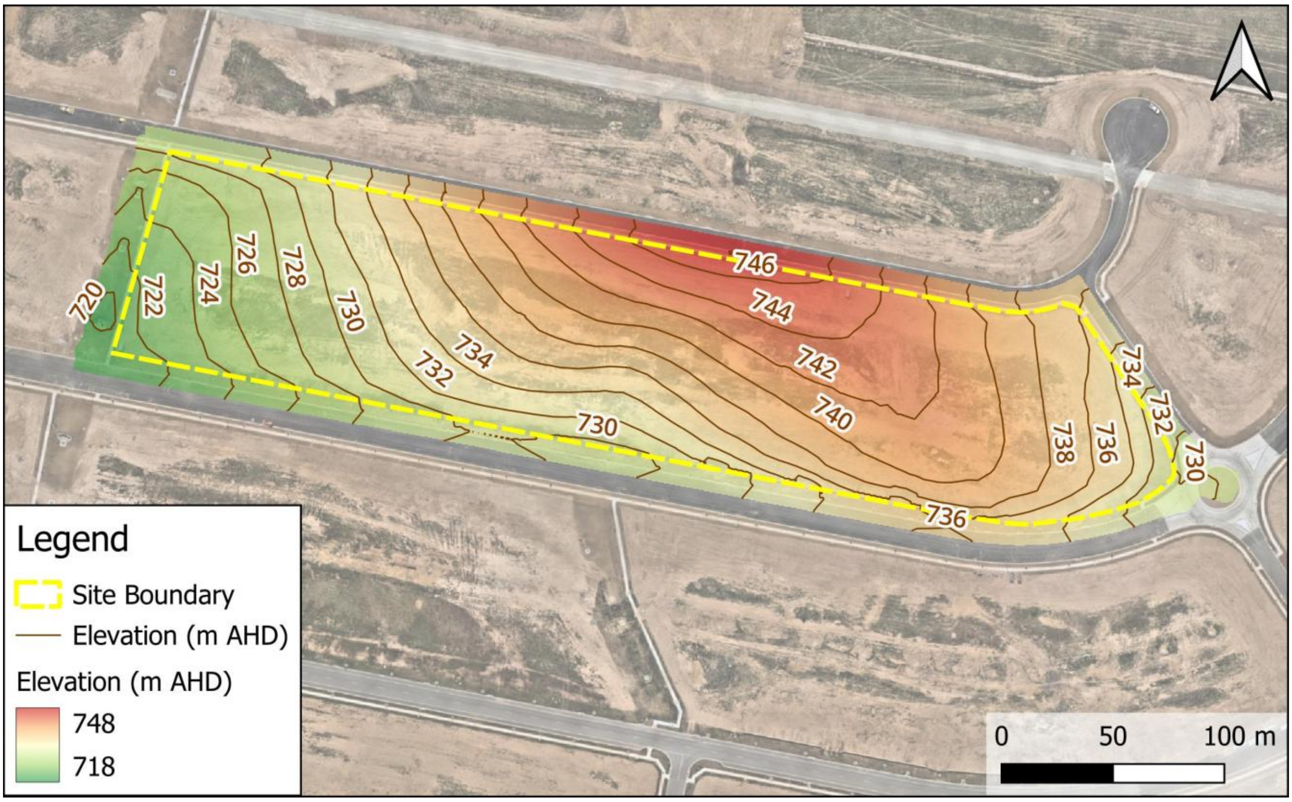


Figure 10: Detailed site survey information for the site

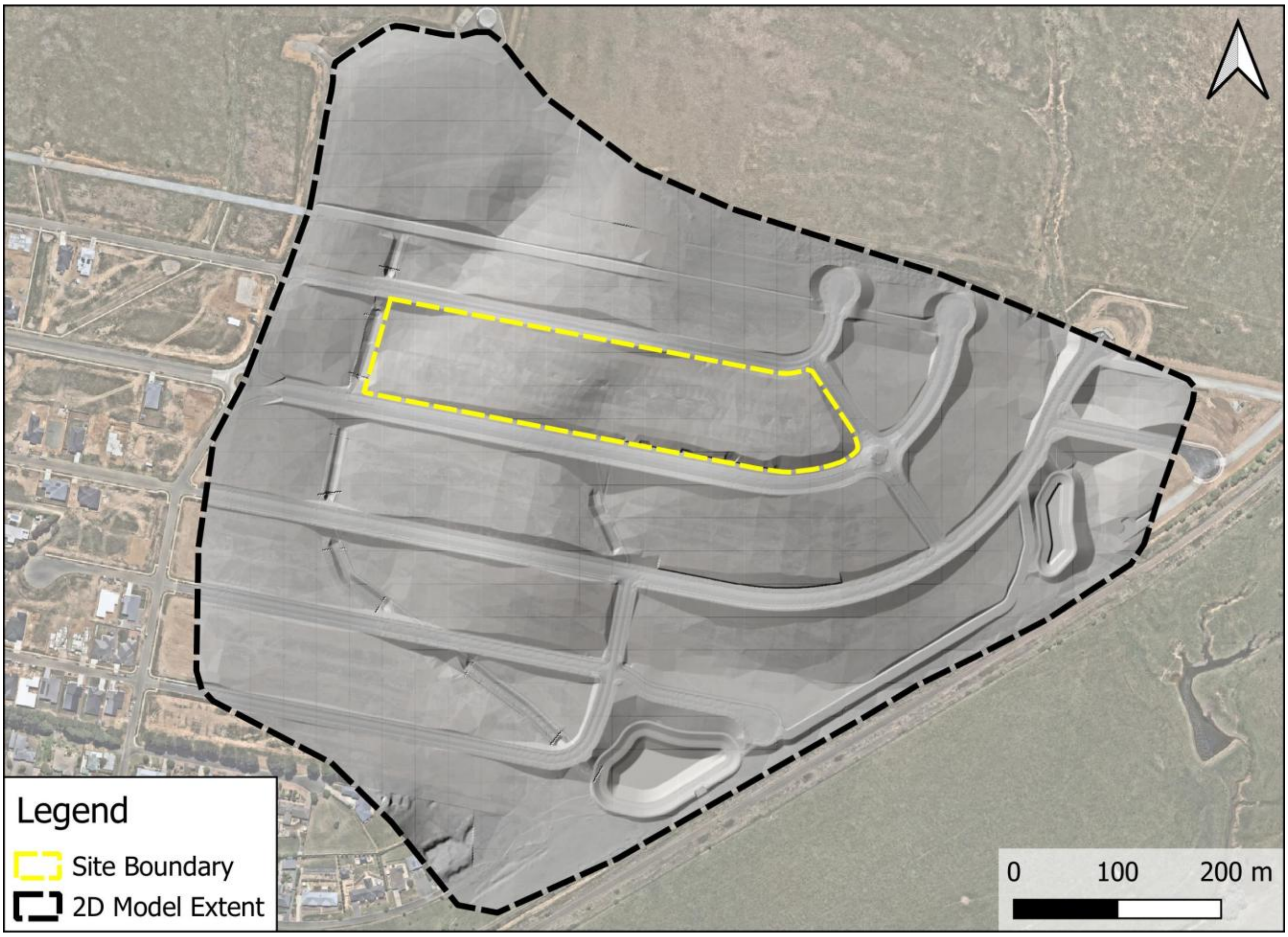


Figure 11: Digital elevation data utilised in the flood model

5.5 Hydraulic Roughness and Losses

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.

Manning's zones were set by analysing the latest Nearmap aerial photography of the site and surrounding area. The three material types adopted in the hydraulic model, and the subsequent Manning's n value applied to each, are outlined in Table 2. Rainfall excess and losses were adopted though initial and continuing losses (IL/CL) in accordance with ARR 2019 guidelines.

Table 2: Material ID and the corresponding land use category, initial loss, continuing loss and Manning's n values

Material ID	Land use category	Initial Loss (mm)	Continuing Loss (mm/hr)	Manning's 'n'
1	Short grass / bare earth	10.00	1.00	0.045
2	Road / Paved area	0.00	0.00	0.02
3	Low density vegetation	13.00	2.30	0.05

5.6 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 12, 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 3 outlines the threshold limits for each hazard category.

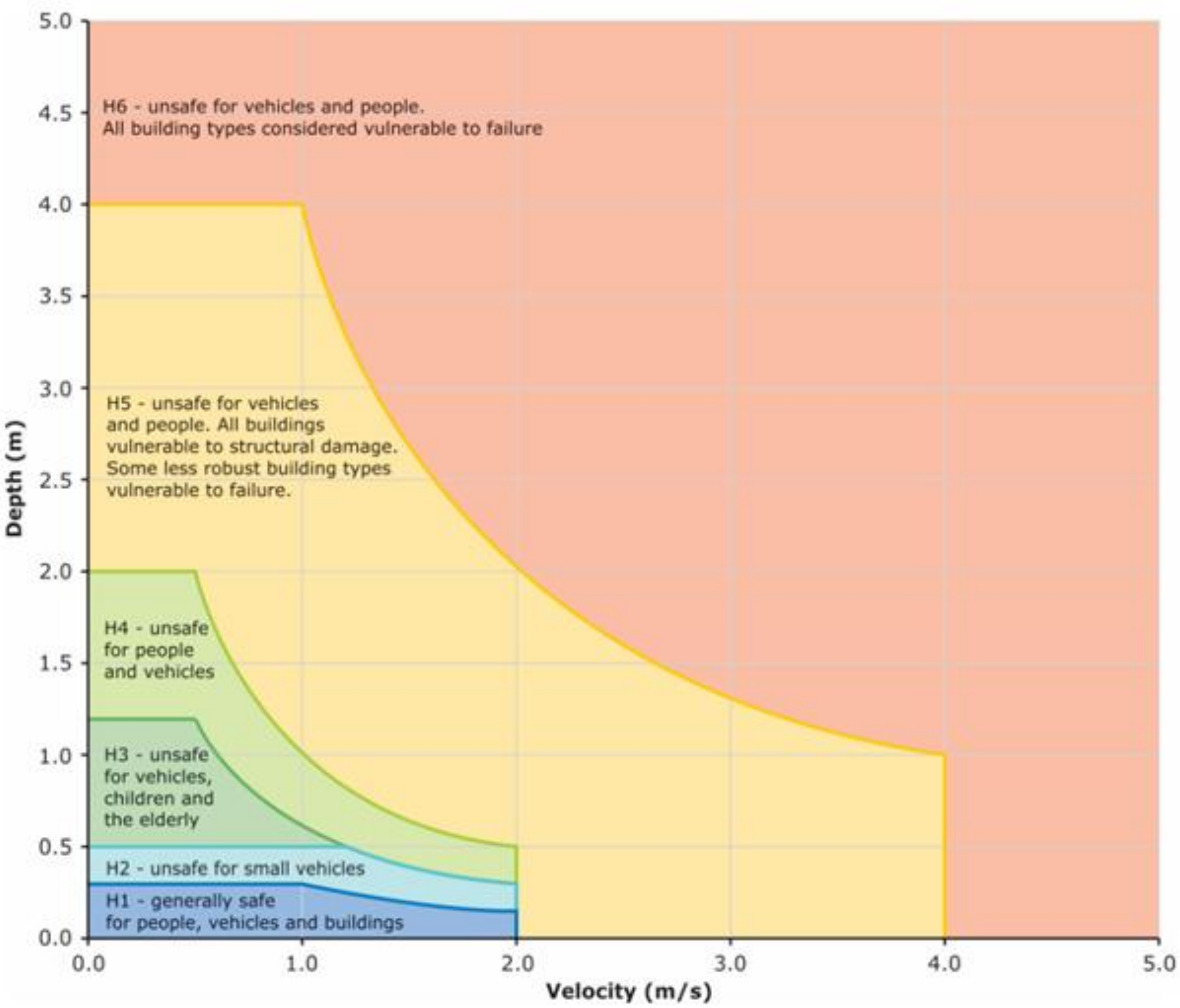


Figure 12: Flood hazard vulnerability curve (Source: Flood Risk Management Guide FB03 - Flood Hazard, NSW Department of Planning and Environment, 2022)

Table 3: 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

6.0 Flood Model Results

6.1 Critical Duration Assessment

Table 4 summarises the storm events run for each event, alongside the critical duration and median temporal pattern identified for the site.

Table 4: Critical duration assessment for the site

Event	Storm Durations Assessed (mins)	Critical Duration	Median Temporal Pattern
10% AEP	15, 20, 25, 30, 45, 60	25 minutes	TP06
1% AEP	10, 15, 20, 25, 30, 45, 60, and 90	15 minutes	TP04
0.5% AEP	10, 15, 20, 25, 30, 45, 60, and 90	15 minutes	TP04
0.2% AEP	10, 15, 20	15 minutes	TP04
PMF	10, 15, 30, 45	10 minutes	N/A

6.2 Existing Flood Behaviour

The flood depths and levels in the 1% AEP event are presented in Figure 13, with flow velocity and hazard classification depicted in Figure 14 and Figure 15, respectively. The maximum depths, levels, velocity and hazard classification in the PMF event are illustrated in Figure 16, Figure 17 and Figure 18, respectively. Results for the 10%, 0.5% and 0.2% AEP events are presented in Appendix A. The following observations have been made:

- The steep slope of the site (with a gradient of 18% in some areas) results in shallow depths and higher velocity flows, as overland flows are transported rapidly offsite. This is presented in Figure 13, which demonstrates that flood depths across the site in the 1% AEP event are negligible, and generally below 20mm. The only exception is a minor flow path to the west of the site that drains into the riparian corridor, which reaches a maximum of 75mm depth.
- In the PMF event, depths across the overall site typically do not exceed 50mm. Within the overland flow path to the west, however, depths exceed 100mm, with a small area reaching 200mm depth. Flow velocity in the PMF reaches up to 1.9m/s to the west of the site.
- In the 1% AEP event, flows within the site are classified as H1 hazard, regarded as low hazard and safe for people and vehicles. In the PMF event, the drainage reserve adjacent to the site's western border is classified as H5 hazard (unsafe for people and vehicles), with part of the overland flow path across the site reaching H2 hazard level.
- A 170m stretch of Bridget Avenue (adjacent to the site's northwest boundary) is similarly categorised as H5 hazard in the PMF, owing to flow velocities exceeding 2.0m/s across this road. On Birchfield Drive, the crossing over the drainage corridor is classified as H4 hazard, unsafe for people and vehicles.

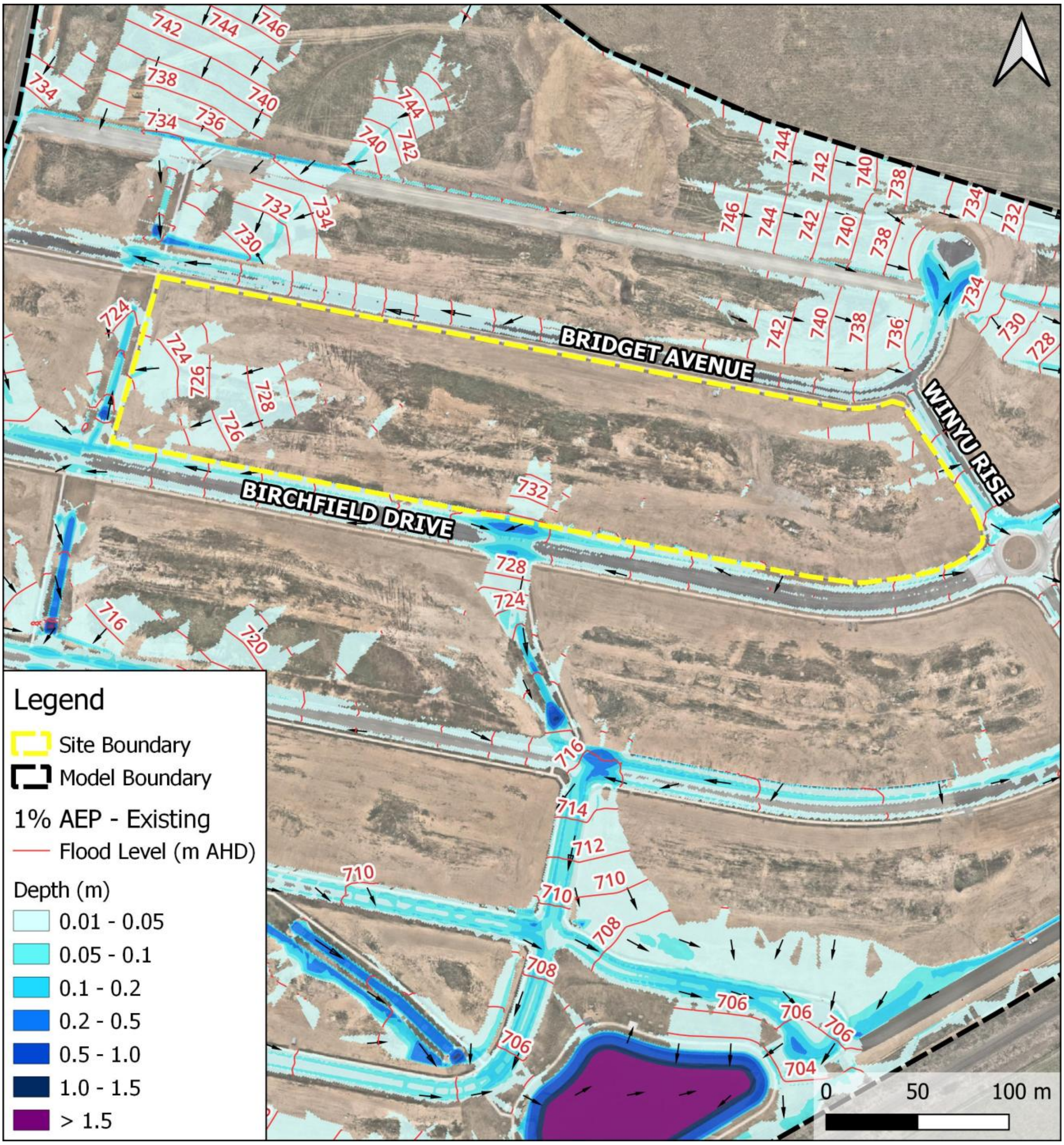


Figure 13: 1% AEP event – flood depths and levels surrounding the BHS site under existing conditions

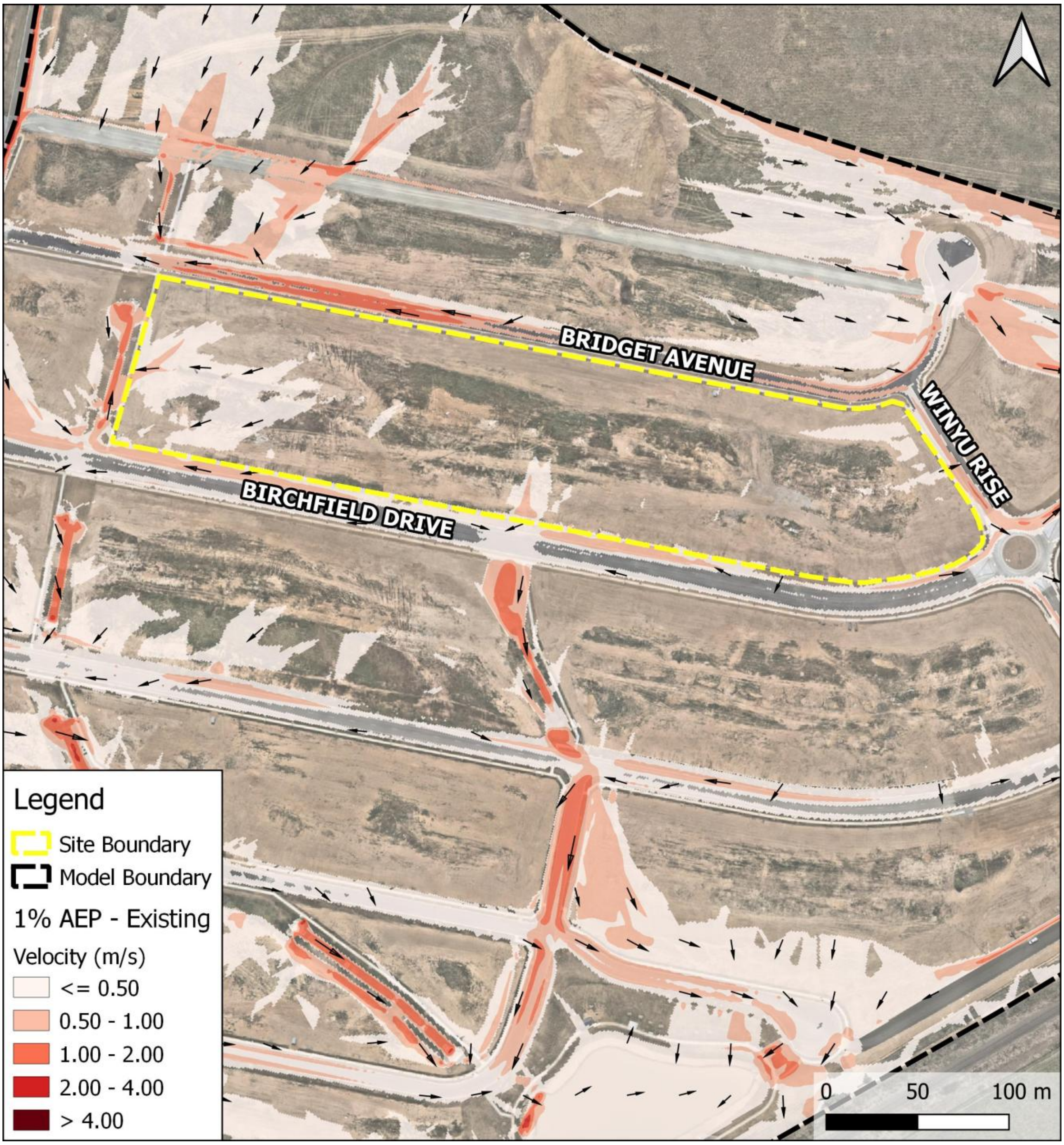


Figure 14: 1% AEP event – flood velocities surrounding the BHS site under existing conditions

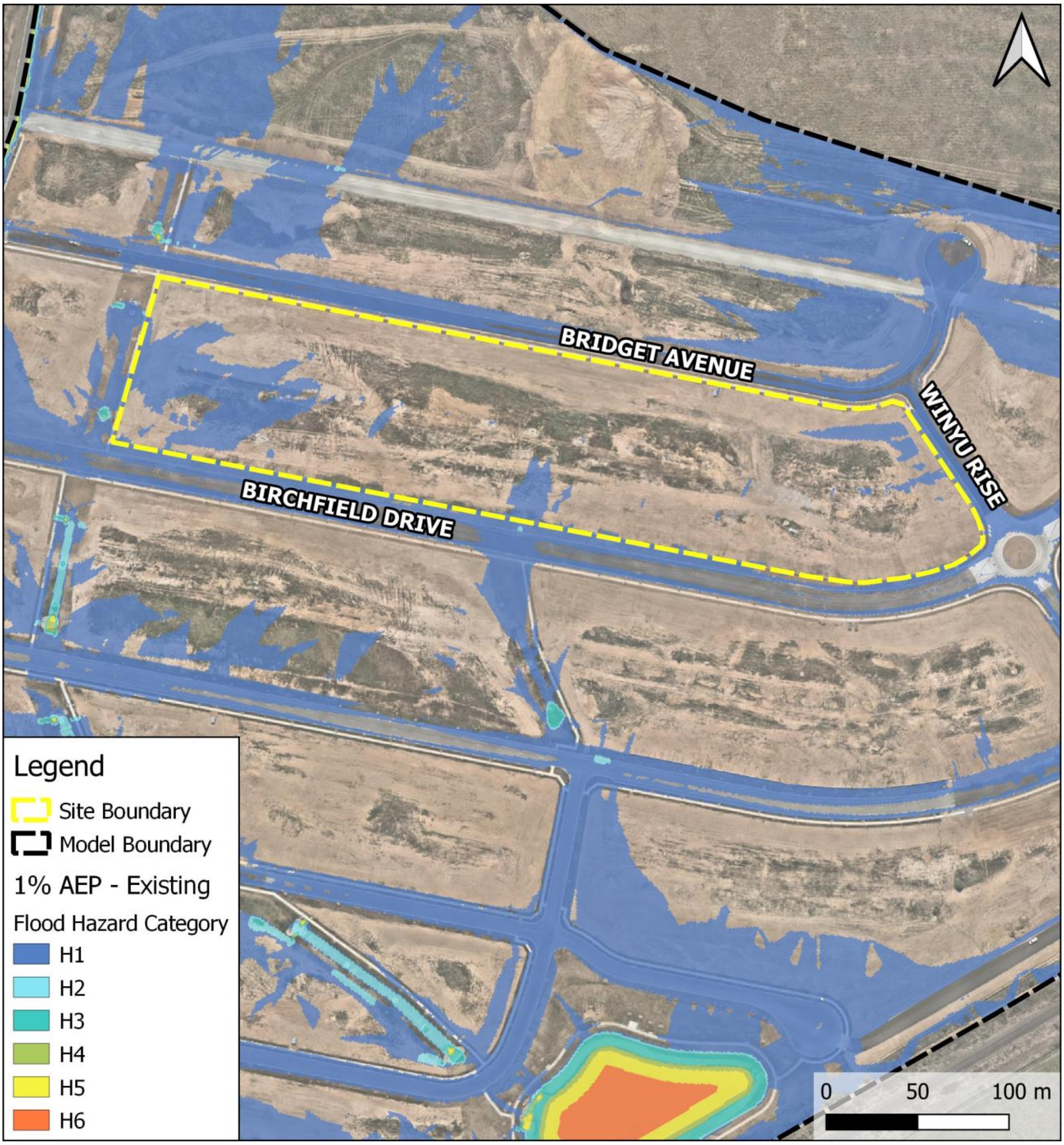


Figure 15: 1% AEP event – flood hazard classification surrounding the BHS site under existing conditions

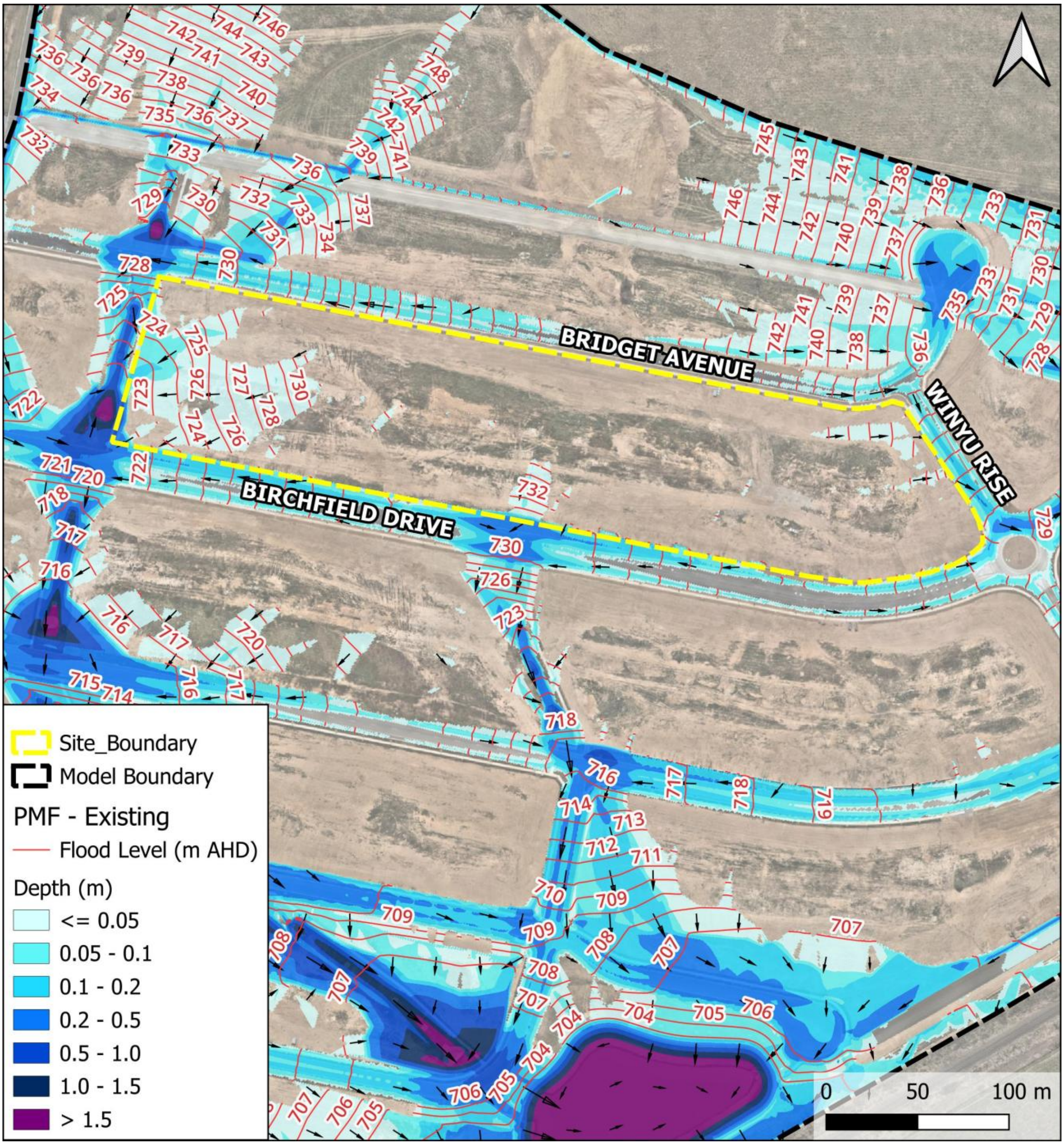


Figure 16: PMF event – flood depths and levels surrounding the BHS site under existing conditions

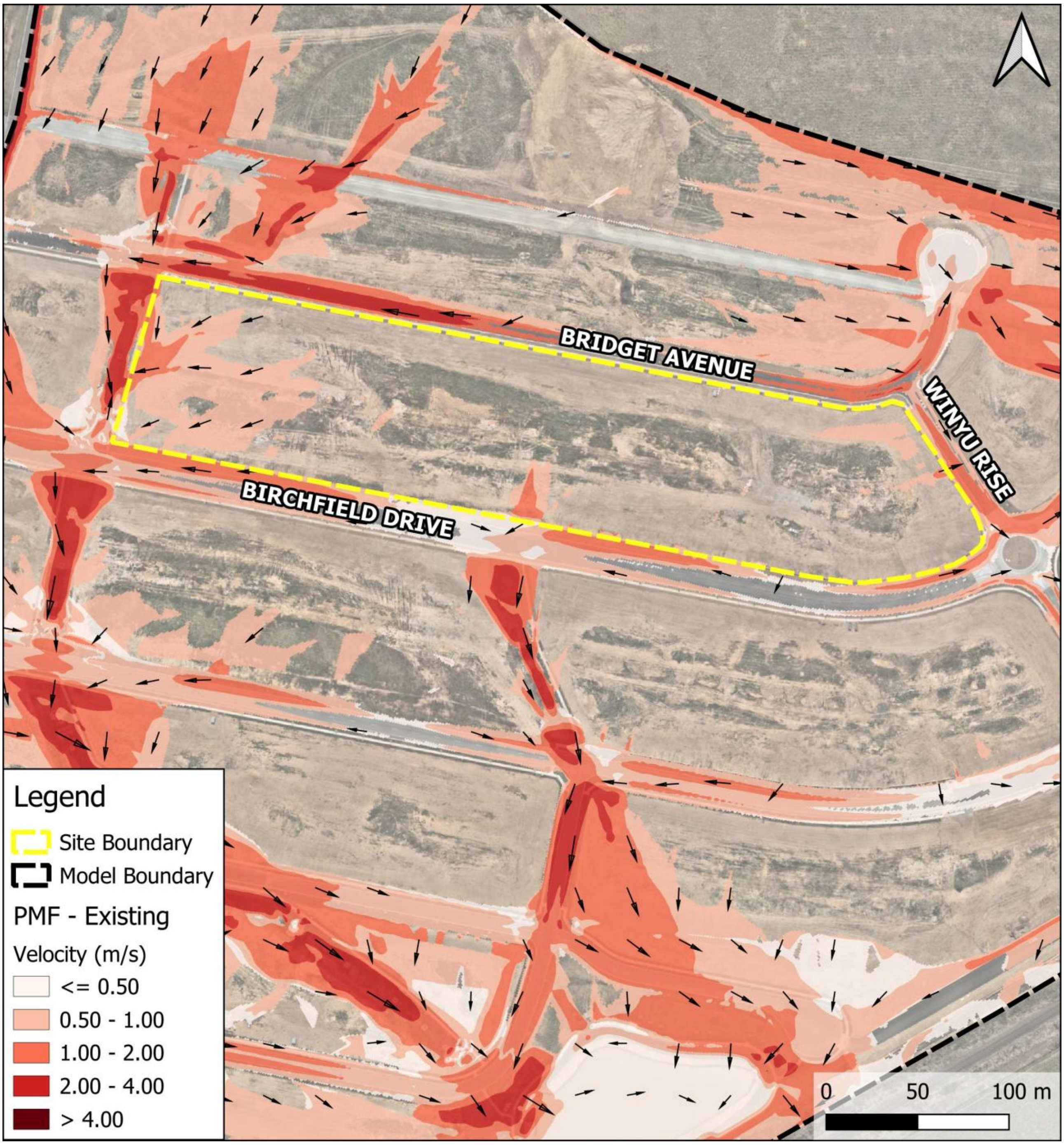


Figure 17: PMF event – flood velocities surrounding the BHS site under existing conditions

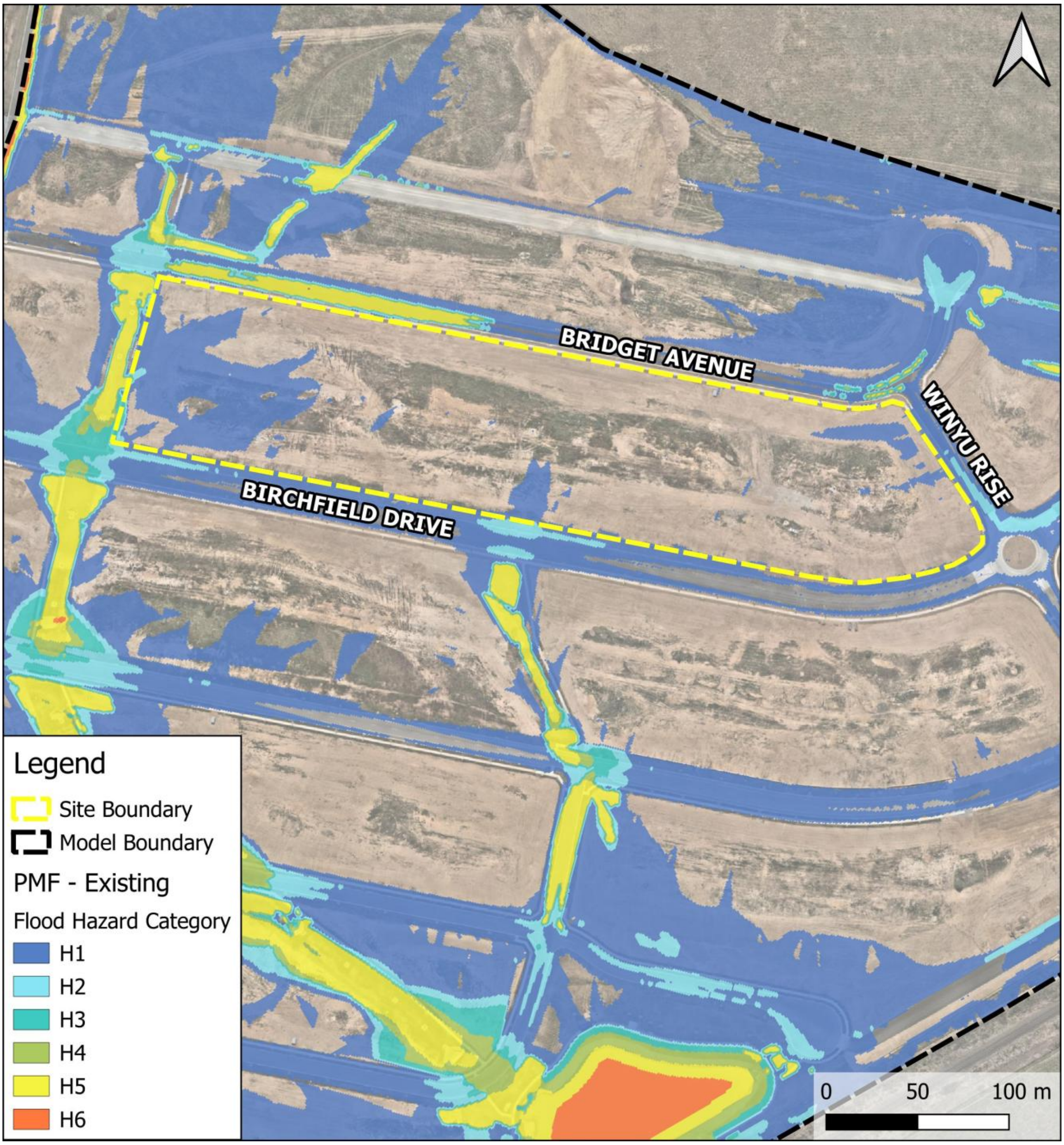


Figure 18: PMF event – flood hazard classification surrounding the BHS site under existing conditions

6.3 Post-Development Flood Behaviour

6.3.1 Model Updates

The existing conditions flood model was updated to create a post-development flood model by incorporating the proposed buildings (based on the building footprints shown in the latest site plan shown in Figure 2), updating the Manning's n, and incorporating the site grading and levels included in the design TIN from Enstruct, dated 7th January 2025.

Figure 19 presents the proposed post-development levels across the site. Given the site is located on a steep slope, the design has incorporated significant cut and fill, with distinct terraces. Along the north of the site, there is a proposed cut of approximately 5m depth, forming an exposed rock retaining wall. This is depicted in Figure 20, which presents a cross-section through Bridget Avenue (Point A), towards Building A in the south. The profile demonstrates a 4.8m drop in elevation over a distance of 4.6m from approximately RL 743.8m AHD to RL 739.00m AHD. Figure 21 illustrates a cross-sectional profile from Bridget Avenue (Point A) through the sports courts and into the drainage reserve west of the site, with the steep slope replaced by terraced plateaus.

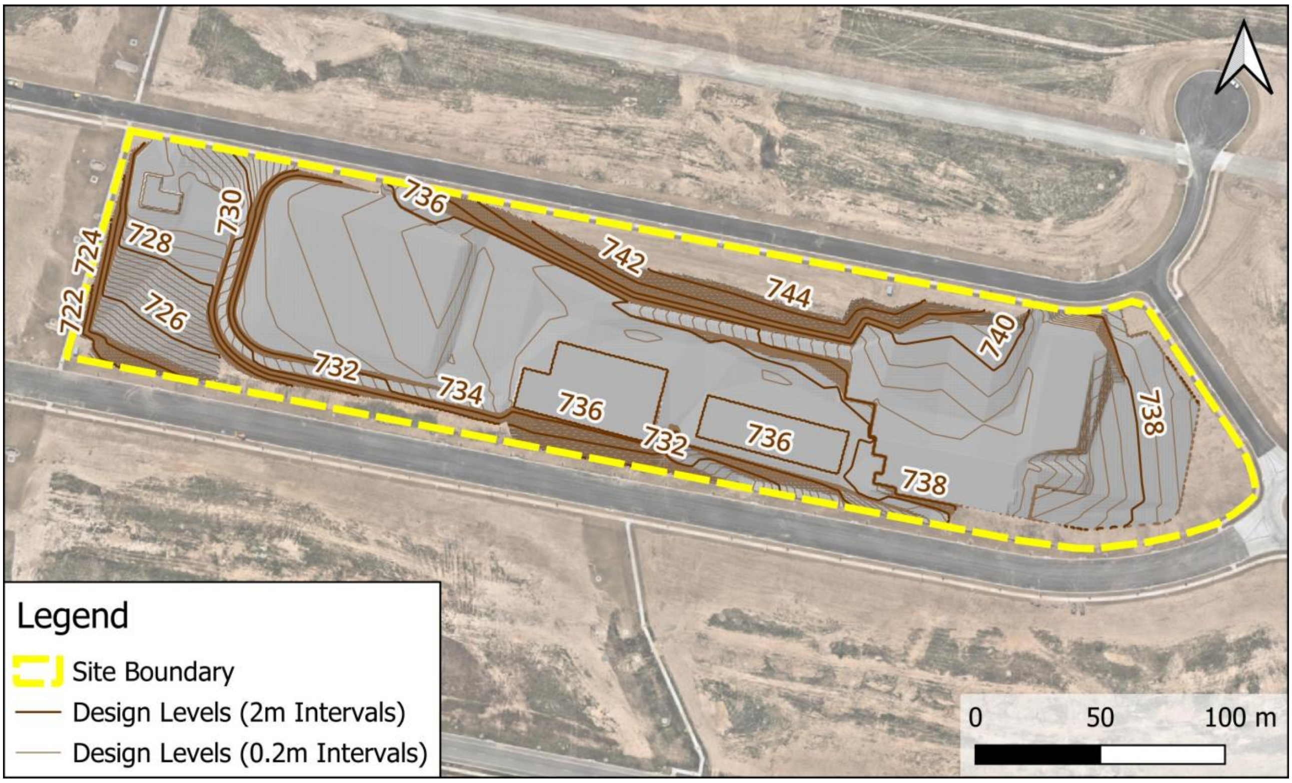


Figure 19: Post-development surface levels across the Bungendore High School Site (Source: design levels provided by Enstruct, dated 7 January 2025)

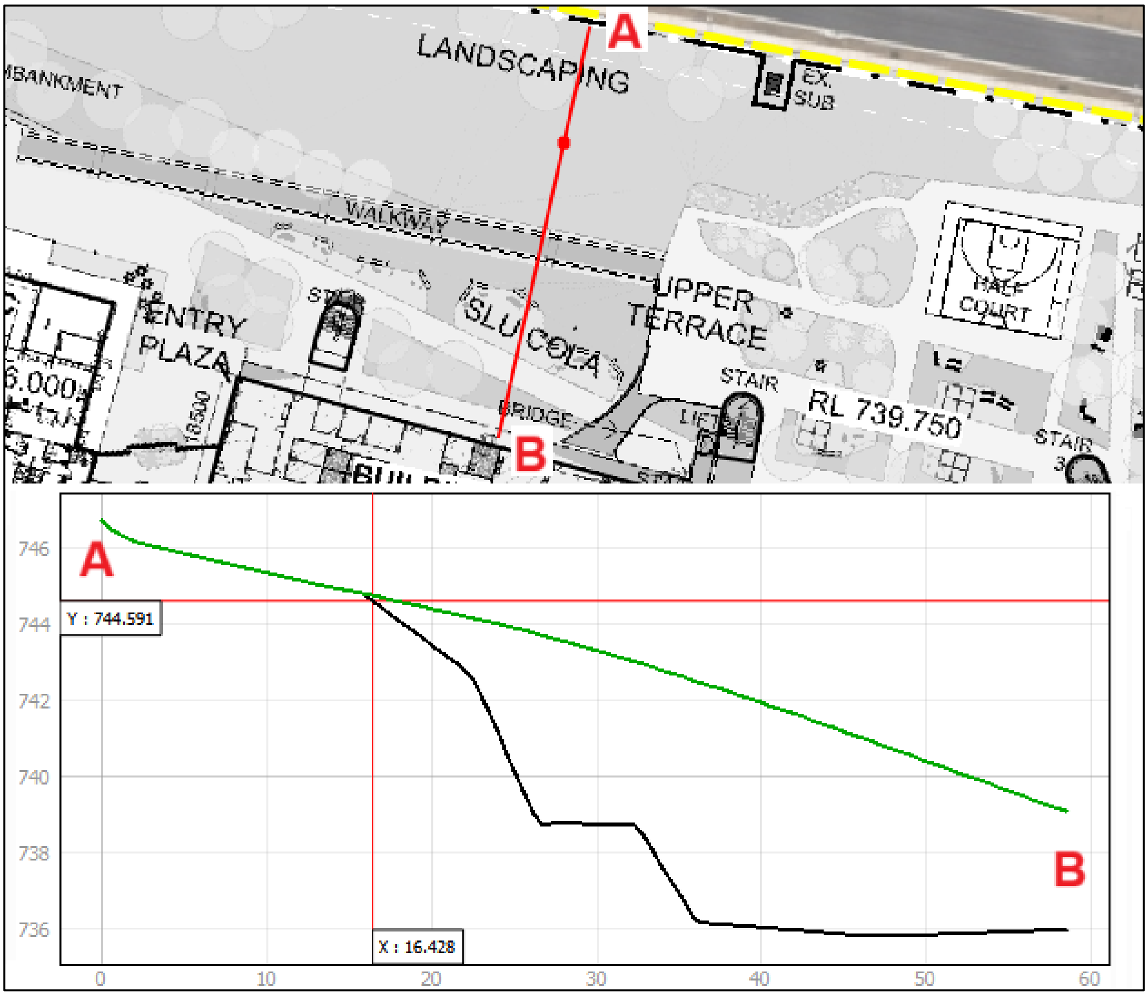


Figure 20: Cross-sectional profile from Bridget Ave (Point A) towards the proposed Building A (Point B)

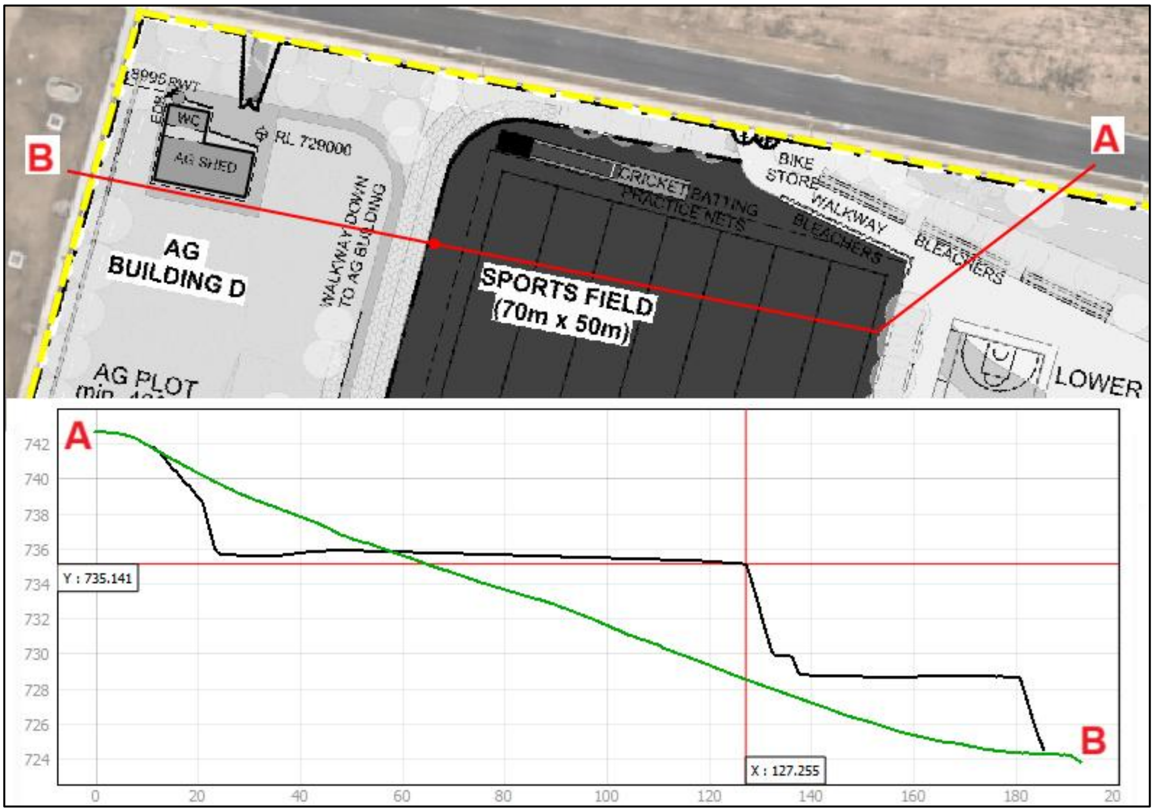


Figure 21: Cross-sectional profile from Bridget Ave (Point A) towards the drainage reserve (Point B)

6.3.2 Post-Development Scenario Results

Given the significant change in topography, the design has a clear impact on the routing of overland flows across the site. The flood depths and levels in the 1% AEP event are presented in Figure 22, with flow velocity and hazard classification depicted in Figure 23 and Figure 24, respectively. The maximum depths, levels, velocity and hazard classification in the PMF event are illustrated in Figure 25, Figure 26 and Figure 27, respectively. Results for the 10%, 0.5% and 0.2% AEP events are presented in Appendix B. The following observations have been made:

- In post-development conditions, the site is unaffected by overland flows generated offsite, which are contained within the adjacent roadways in all modelled events, up to and including the PMF. In the 1% AEP event, depths within the western drainage reserve (external to the site) reach a maximum of 870mm. In the PMF event, depths here peak at 2700mm.
- In terms of offsite hazard, as with the existing conditions, all surrounding access roads are trafficable in the 1% AEP event (H1 hazard level). In the PMF event, however, Bridget Avenue is cut off by high hazard (H5) flows, while the crossing over the drainage reserve on Birchfield Drive is cut off by flows with a hazard classification of H4 (unsafe for vehicles).
- Within the site boundary, there is some ponding from excess runoff generated onsite. On the upper terrace, adjacent to Building B, depths reach a maximum of 230mm in both the 1% AEP and PMF events. On the lower terrace, adjacent to Building A, depths reach a maximum of 190mm in the 1% AEP event, and 330mm in the PMF event.
- In terms of hazard onsite, the majority of flows onsite are classified as low hazard (H1) in all events, up to and including the PMF. In the critical duration PMF event, there is an isolated area with high hazard flows adjacent to the main stairway entry to the site. This is a result of the high velocity of flows given the steep gradient, with velocity exceeding 3.5m/s in some areas. This area is low hazard in all other modelled events, including the 0.2% AEP event (see Appendix B).
- Table 5 summarises flood levels adjacent to the proposed building openings in all modelled design storm events. The point locations are presented in Figure 28. It is noted that the current design shows that excess runoff is conveyed over the edge of the upper terrace into the lower terrace, increasing onsite runoff levels north of Building A, which rise above the proposed Finished Floor Level (FFL).
- However, these flows are generated onsite (i.e. are not an external overland flow or wider flooding issue) and can be managed through more detailed stormwater management of the site. These minor flows will be collected, contained and diverted around the proposed buildings as part of more detailed civil site grading and stormwater design at the detailed design stage, which will prevent any above-floor impacts.
- Detailed design of the onsite stormwater system will allow onsite stormwater to be managed through a combination of site grading, stormwater drainage, including swales, and potential increase to the capacity of the existing flow path (directly to the north of Buildings A and C). To further reduce flows at Building A, a wall can be implemented along the edge of the upper terrace. These mitigation measures will convey flows out to the main existing drainage channel to the west of the site and prevent any above-floor impacts to the buildings.

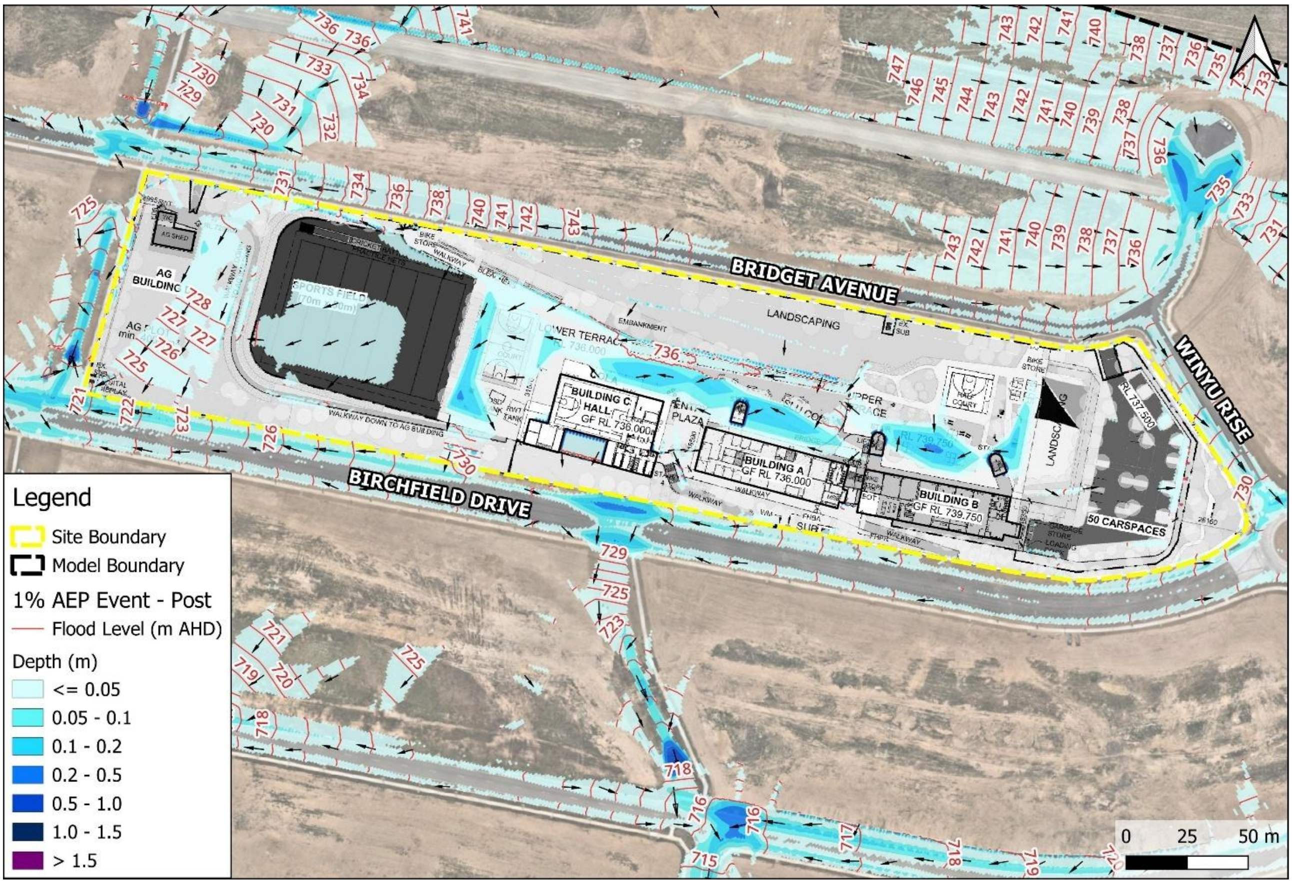


Figure 22: 1% AEP event – flood depths and levels surrounding the BHS site under post-development conditions

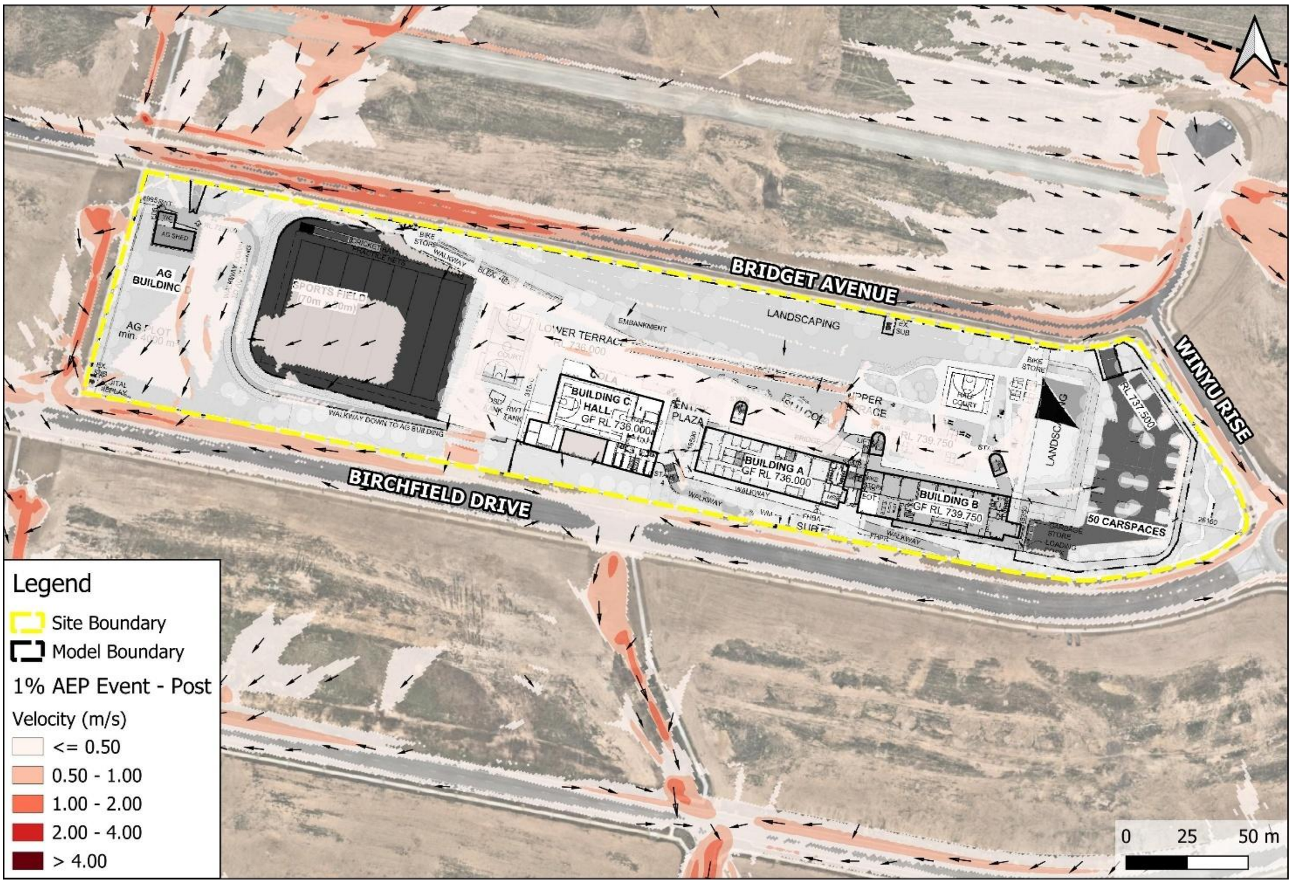


Figure 23: 1% AEP event – flood velocities surrounding the BHS site under post-development conditions

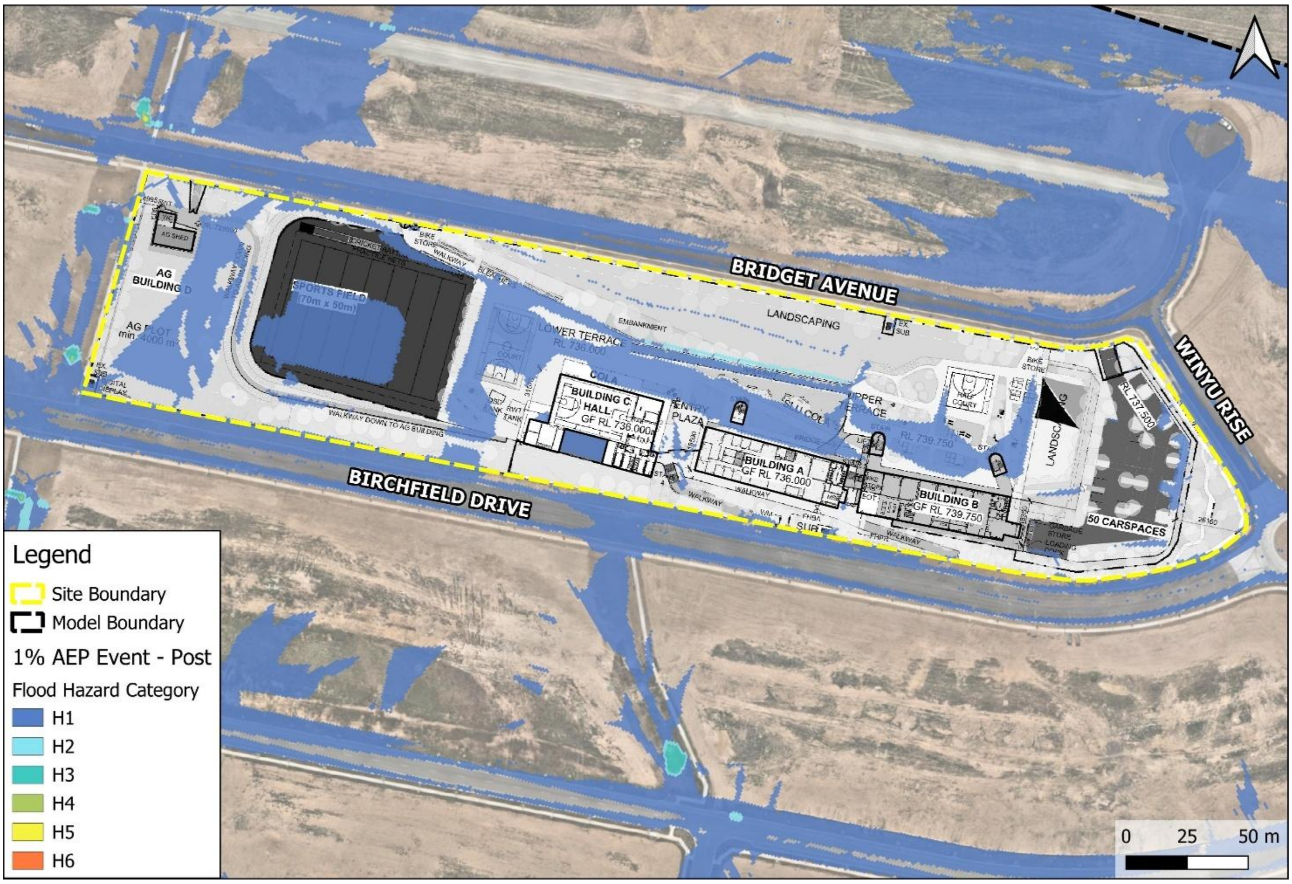


Figure 24: 1% AEP event – flood hazard classification surrounding the BHS site under post-development conditions

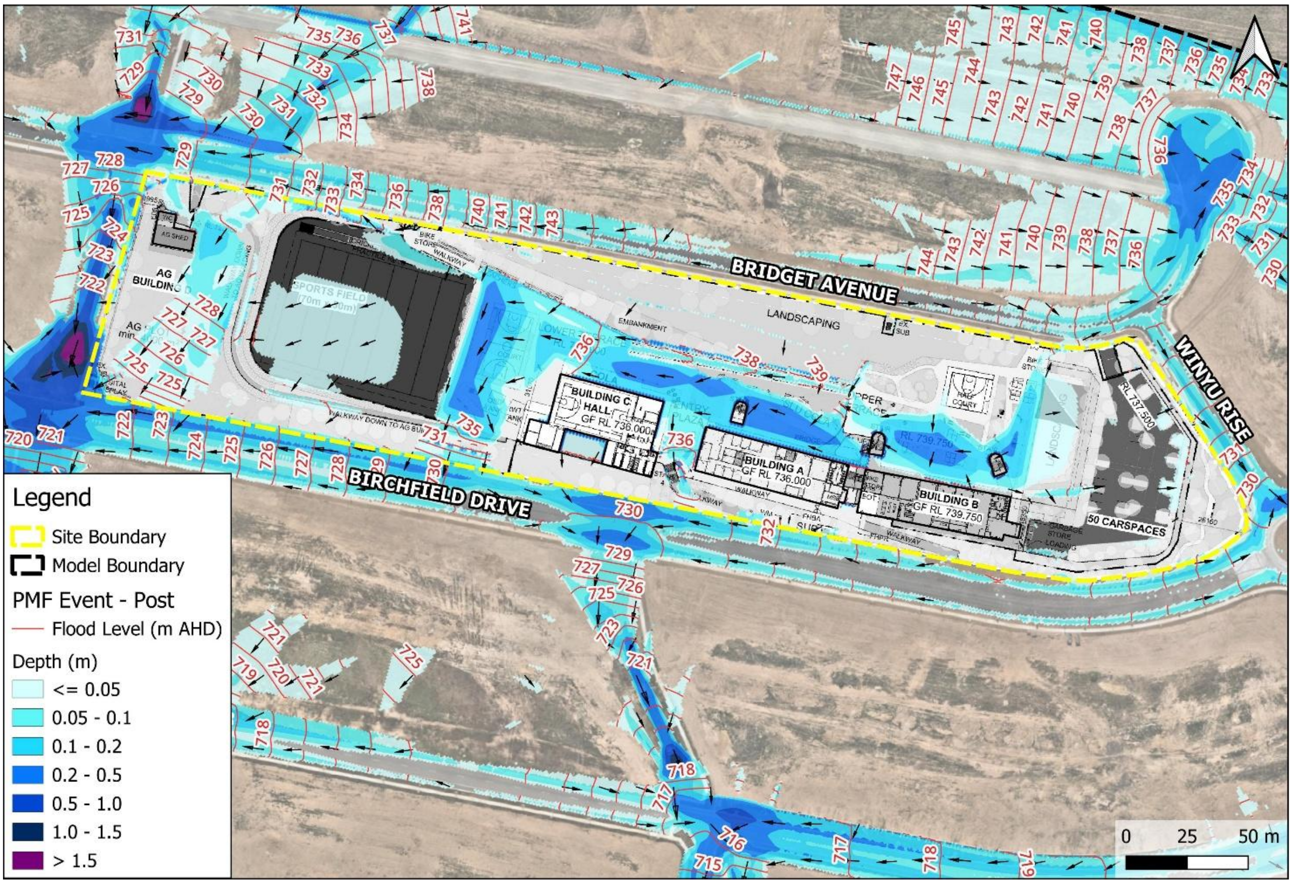


Figure 25: PMF event – flood depths and levels surrounding the BHS site under post-development conditions

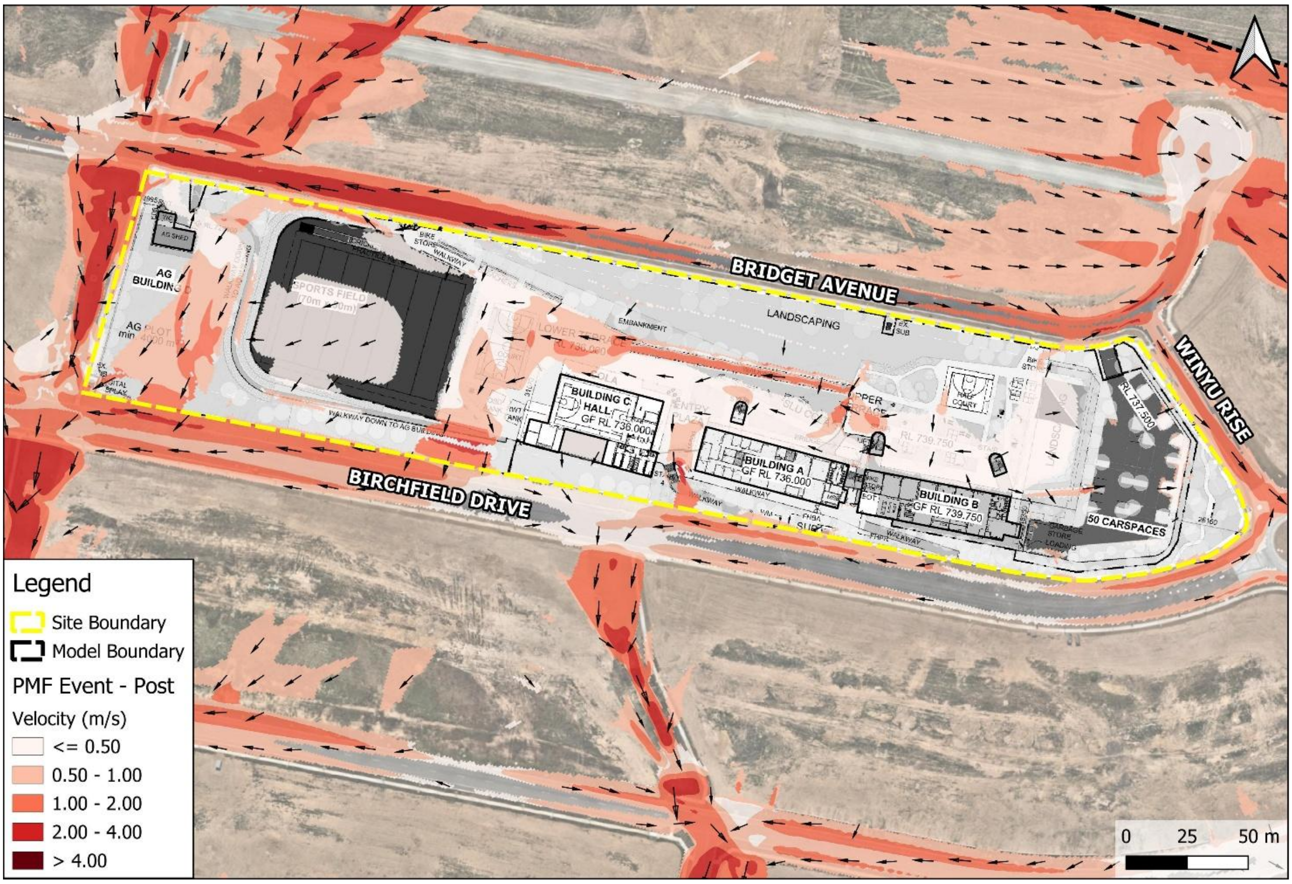


Figure 26: PMF event – flood velocities surrounding the BHS site under post-development conditions

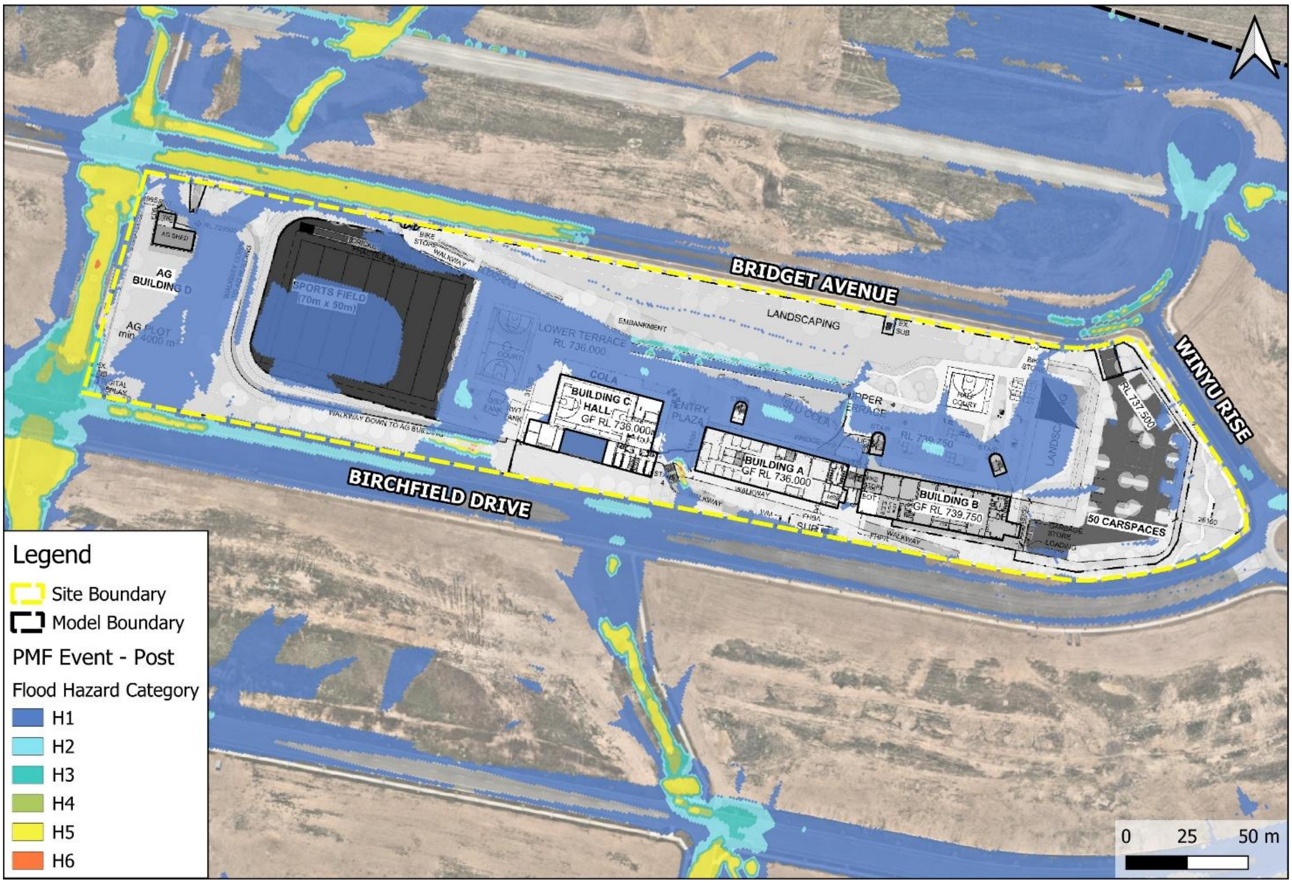


Figure 27: PMF event – flood hazard classification surrounding the BHS site under post-development conditions

Table 5: Flood levels at the proposed buildings under post-development conditions (see Figure 28 for point locations)

Point	Adjacent Building	Building FFL (m AHD)	Post-Development Flood Level (m AHD)				
			10% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
A	AG Building	729.00	NA	NA	NA	NA	728.86
B	C	736.00	NA	NA	NA	NA	735.95
C			NA	NA	NA	NA	736.05
D	A	736.00	NA	735.96	735.97	735.99	736.07
E			NA	735.97	735.98	735.99	736.11
F	B	739.75	NA	NA	739.65	739.66	739.74

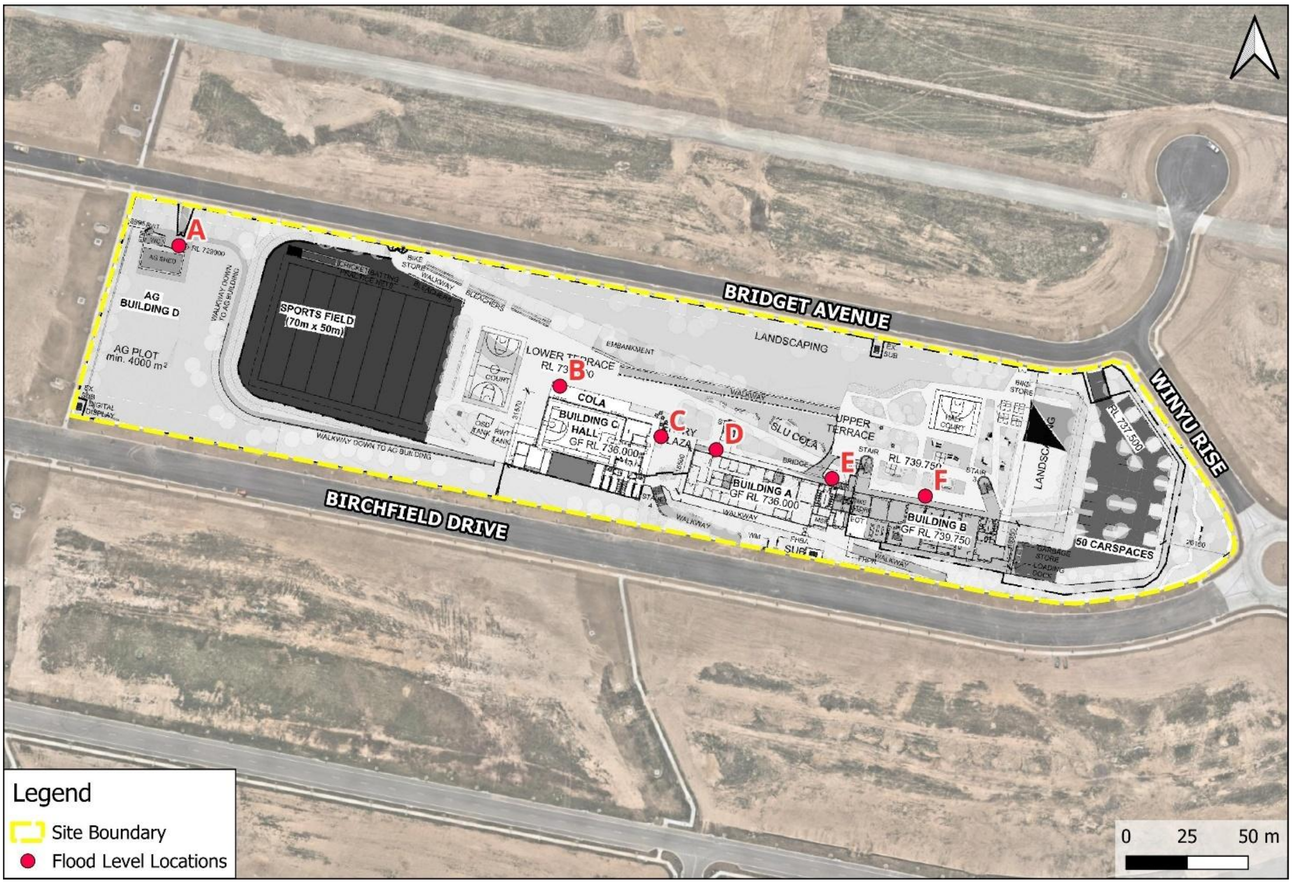


Figure 28: Flood Level Assessment Locations (see Table 5 for flood levels)

7.0 Evaluation of Environmental Impacts

A flood impact assessment has been undertaken to ensure the proposed activity would not result in either an unacceptable flood level increase or worsening of the flood conditions over neighbouring properties. The flood level impact map for the proposed activity in the 1% AEP event is shown in Figure 29.

The flood impact assessment shows that there are some local changes in flood level within the site due to modification of the ground level. While there are areas to the west of the site which are no longer flood affected in the post-development scenario (owing to the rerouting of the overland flow path), there are increases in flood level of approximately +3m to +7m as a result of fill. These impacts are only those contained within the site (i.e. not impacting on areas external to the site) and afflux is therefore not considered significant, with negligible depths of just 15mm on the sports field in the 1% AEP event, and a maximum depth of 54mm over the agricultural plot in this event.

Offsite, there are some increases in 1% AEP flood level on the western end of Birchfield Drive, to the south and southwest of the site. Increases are generally around +15mm, peaking at +30mm just south of the AG Building walkway. This localised increase is not considered significant as it does not affect adjacent properties, and it is contained within the kerb and gutter system. Further, the results show that the estimated 1% AEP flood hazard at this area remained unchanged (H1) in post-development conditions (refer to Figure 15 and Figure 24 for the 1% AEP event hazard mapping of the existing and post-development scenarios, respectively). Flood levels along Talbot Street have also fallen in the post-development scenario, with reductions of 10mm to 50mm.

The extent and nature of potential impacts are low and will not have significant impact on the locality, community and/or the environment. Potential impacts can be appropriately mitigated or managed to ensure that there is minimal impact on the locality, community and/or the environment.

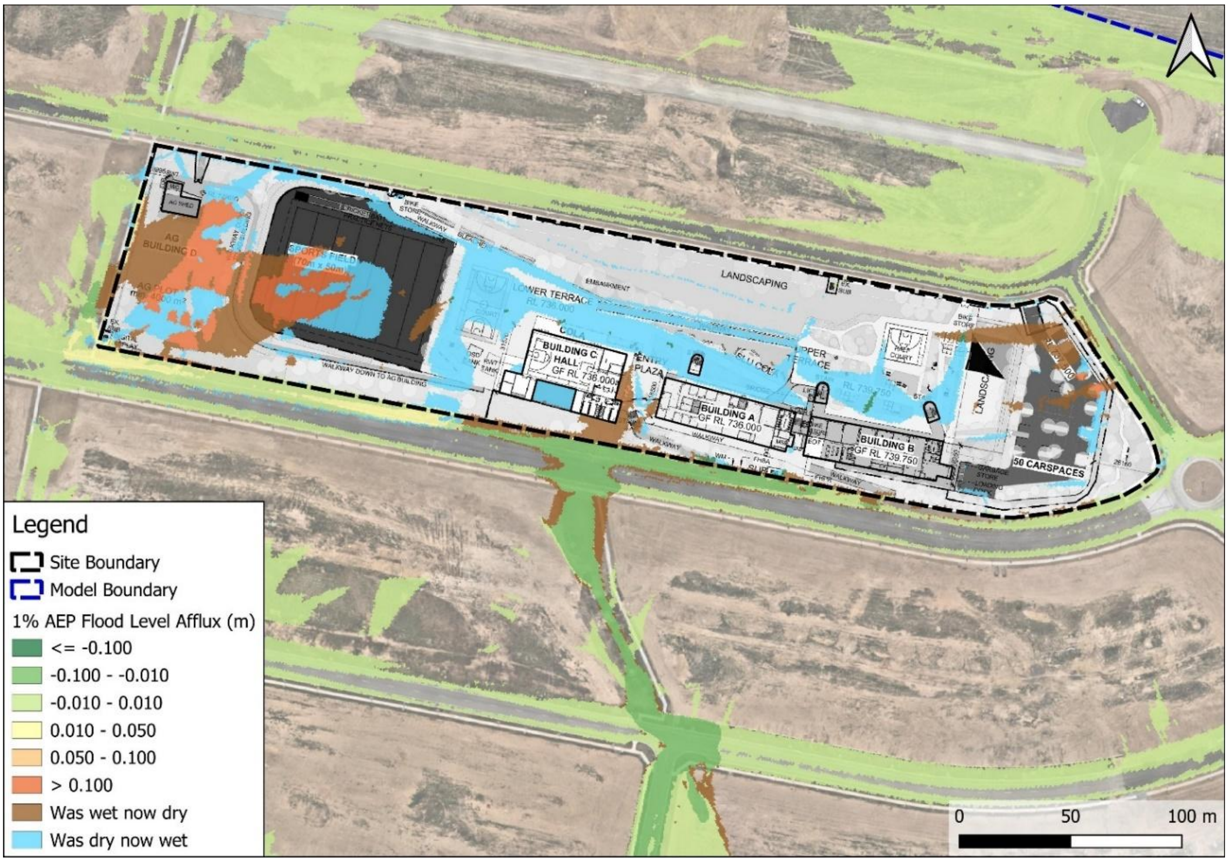


Figure 29: Flood level afflux – Impact of proposed activity on flood levels in the 1% AEP event

8.0 Sensitivity Assessment

The sensitivity of the model to varying model parameters has been assessed in the following section. The sensitivity of flood levels to climate change is analysed in Section 8.1, while the impact of pit and pipe blockage is outlined in Section 8.2.

The increase in flood levels is assessed for three offsite locations over Bridget Avenue and Birchfield Drive, and two locations within the school boundary. These are labelled in Figure 30.

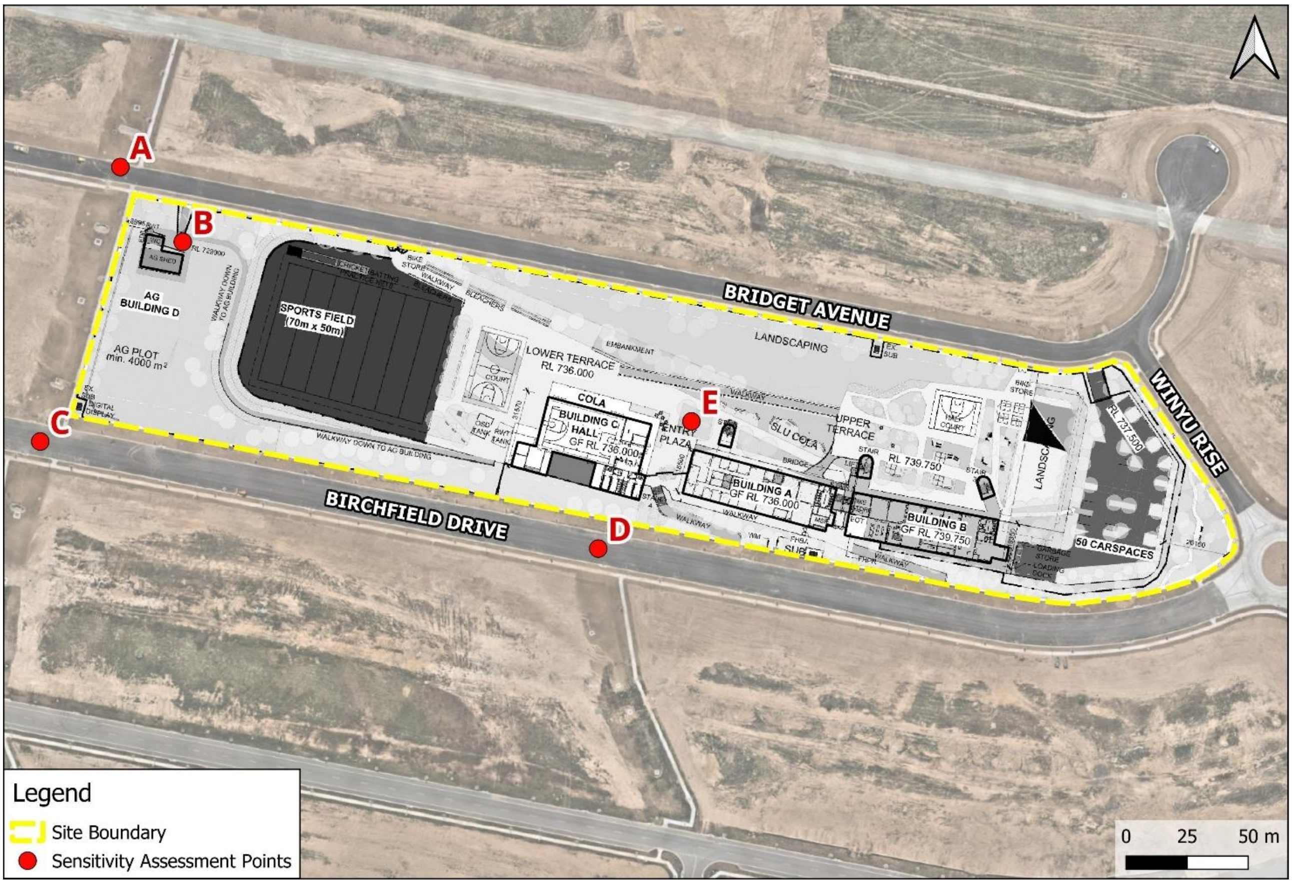


Figure 30: Point locations where flood level sensitivity has been assessed

8.1 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 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) 3-7.0. SSP3-7.0 is a medium to high reference scenario that assumes that CO_2 emissions will double by 2100. Specifically, this study uses the SSP3-7.0 climate change factors for the year 2070 and 2100 for storm durations of less than 1 hour:

- SSP3-7.0 2070: 42% increase in rainfall (CC2070)
- SSP3-7.0 2100: 66% increase in rainfall (CC2100)

These climate change factors were applied to the 1% AEP, 0.5% AEP and 0.2% AEP event rainfall patterns, as per the requirements of the Flood Risk Management Guideline LU01. Table 6 provides a summary of the flood level increase at five locations within and surrounding the site. The highest increase is observed at Point C (located at the crossing over the drainage reserve on Birchfield Drive), which demonstrates an increase of 131mm in the 0.2% AEP event under the CC2100 scenario.

Figure 31 and Figure 32 demonstrate the flood level afflux in the 1% AEP event in the CC2070 and CC2100 scenarios, respectively. Afflux maps for the 0.5% AEP and 0.2% AEP events are attached in Appendix C. The results indicate that, for the majority of the site, flood levels are only expected to increase by 10 to 30mm in the 1% AEP event under both the 2070 and 2100 scenarios. Within the site, the largest increase in flood levels is expected at the sports court. Flood levels here are up to 56mm higher in the CC2100 scenario.

The most significant increases in flood level are predicted offsite, within the drainage reserve west of the site, with an increase of up to 600mm in the CC2070 scenario, and 900mm in the CC2100.

Table 6: Climate change sensitivity at five locations within and surrounding the site. Refer to Figure 30 for locations.

	Flood Level (m AHD) Increase Due to Climate Change								
	1% AEP			**0.5% AEP**			**0.2% AEP**		
	Flood Level	CC2070	CC2100	Flood Level	CC2070	CC2100	Flood Level	CC2070	CC2100
A	728.32	+21mm	+28mm	728.33	+19mm	+26mm	728.34	+17mm	+24mm
B	728.79	+9mm	+14mm	728.80	+11mm	+16mm	728.80	+11mm	+16mm
C	720.71	+15mm	+33mm	720.71	+28mm	+48mm	720.72	+40mm	+131mm
D	729.85	+19mm	+27mm	729.86	+19mm	+27mm	729.87	+19mm	+28mm
E	735.96	+28mm	+38mm	735.97	+25mm	+34mm	735.98	+21mm	+28mm

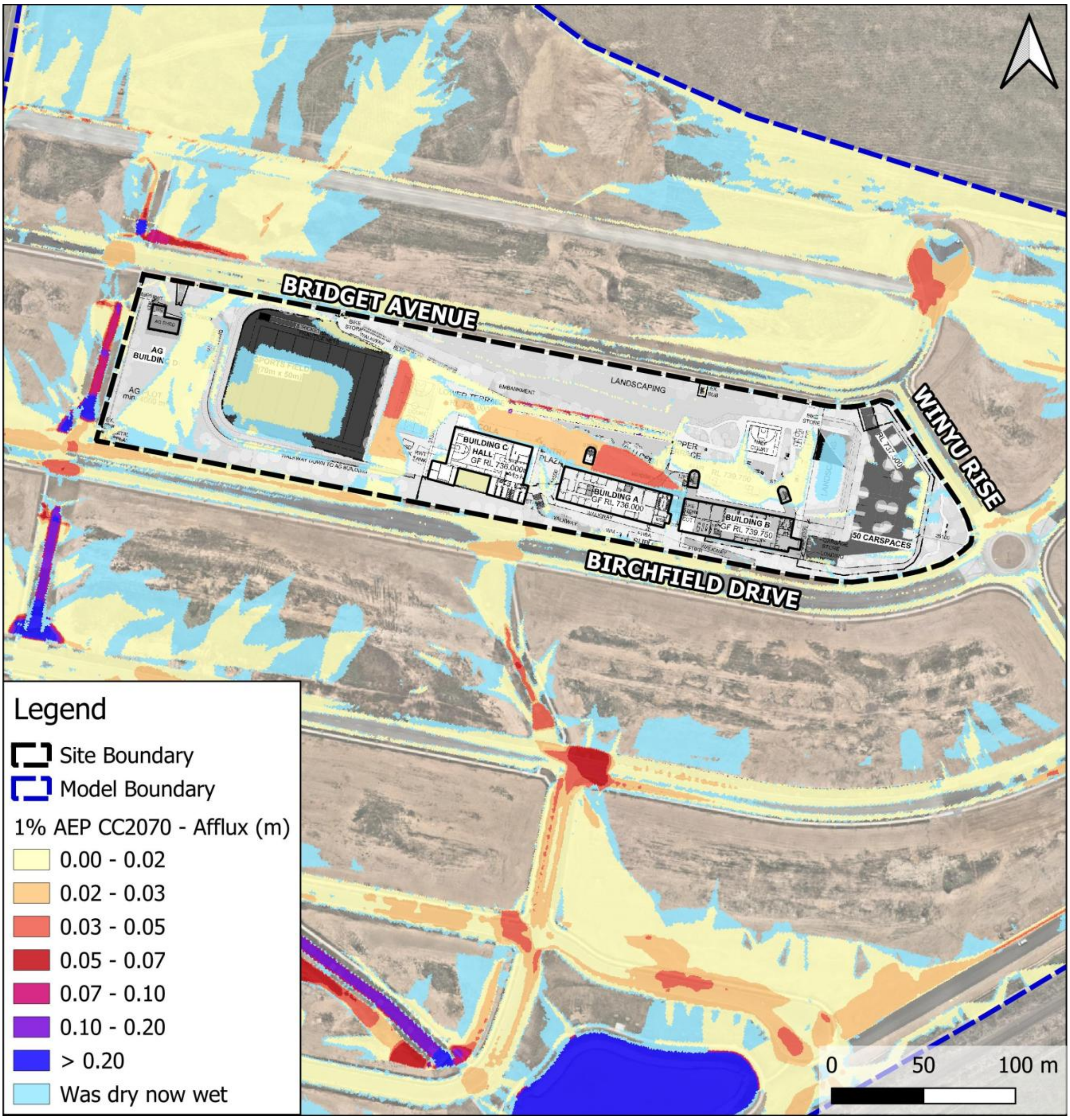


Figure 31: Flood level afflux (m) under the 1% AEP CC2070 scenario

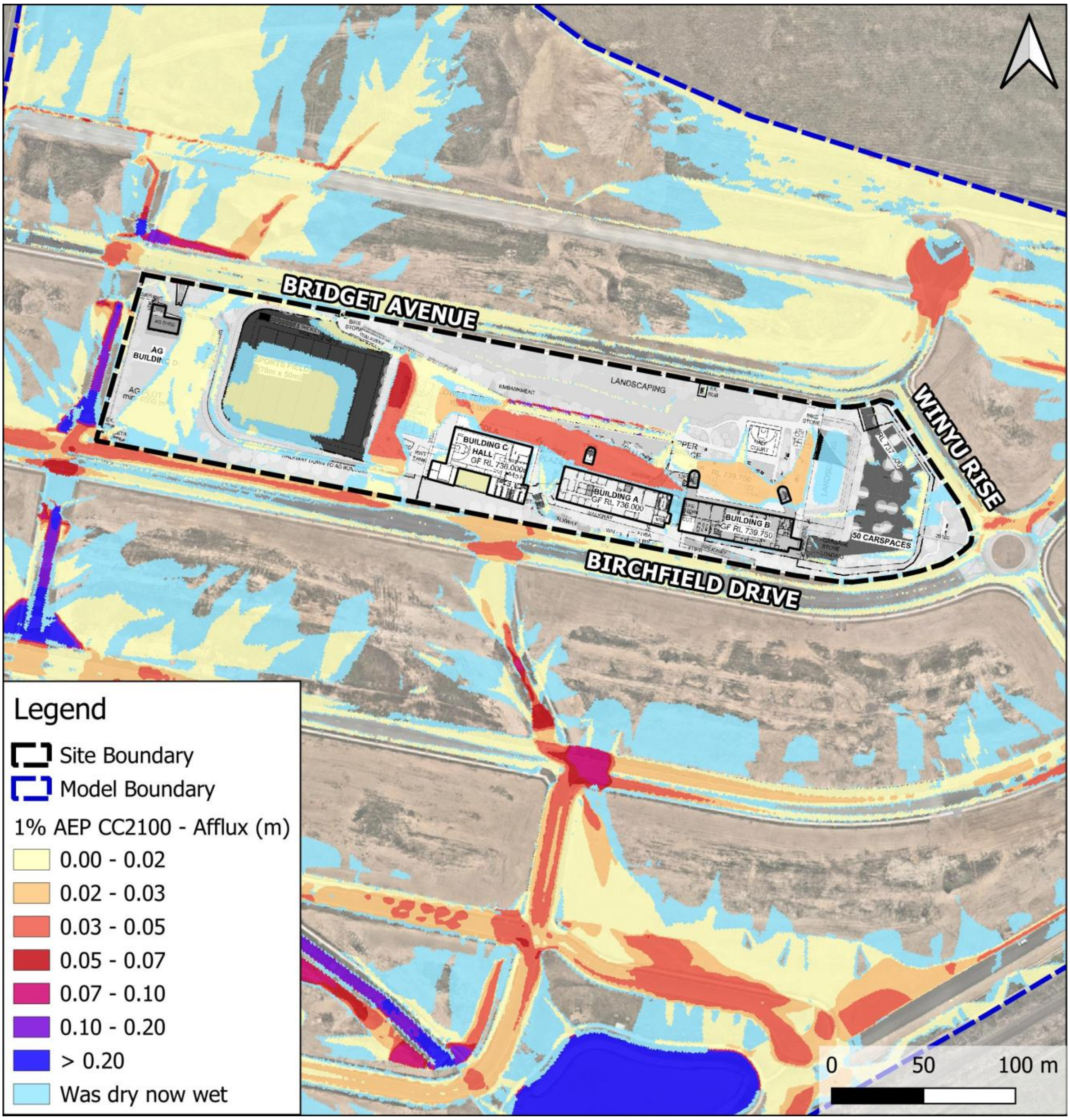


Figure 32: Flood level afflux (m) under the 1% AEP CC2100 scenario

8.2 Blockage Assessment

Table 7 outlines the flood level increase at Point A (on Bridget Avenue) and Point C (on Birchfield Drive) resulting from a 50% and 100% blockage in the post-development scenario. Figure 33 depicts the flood level afflux for the 1% AEP event under the 50% blockage scenario and Figure 34 presents the 100% blockage scenario results.

As shown in the afflux mapping, blockage of the road culverts and main pit and pipe network across the west of the site has negligible impacts upon the site. The main impact is contained within the drainage reserve itself, with a flood level increase of up to 300mm in the 50% blockage scenario, and 1850mm in the 100% blockage scenario. Flows overtop onto the road crossings, increasing the flood level by 190mm at the crossing over Birchfield Drive (Point C), and 160mm over Bridget Avenue (Point A).

Within the site boundary, in the 100% blockage scenario there is an increase of less than 10mm in flood levels over the western extent of the site, and a minor increase in flood extent at the southwest corner of the site.

Table 7: Pipe blockage sensitivity at two locations close to the site. Refer to Figure 30 for locations.

	Flood Level Increase		
	Design Flood Level (0% blockage)	**50% Blockage**	**100% Blockage**
Point A	728.32 m AHD	+17mm	+161mm
Point C	720.71 m AHD	+5mm	+185mm

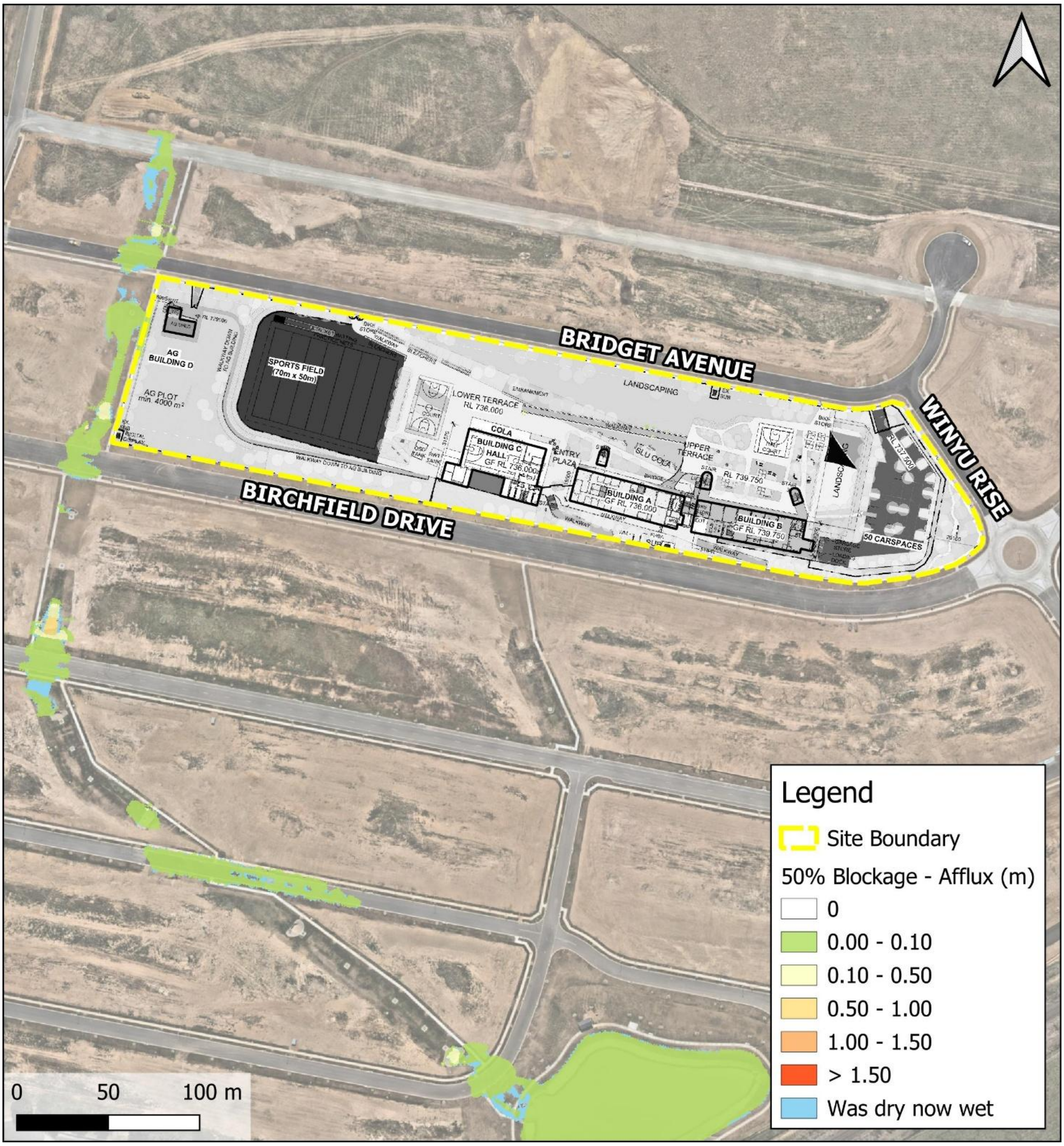


Figure 33: Impact of 50% blockage on 1% AEP flood levels

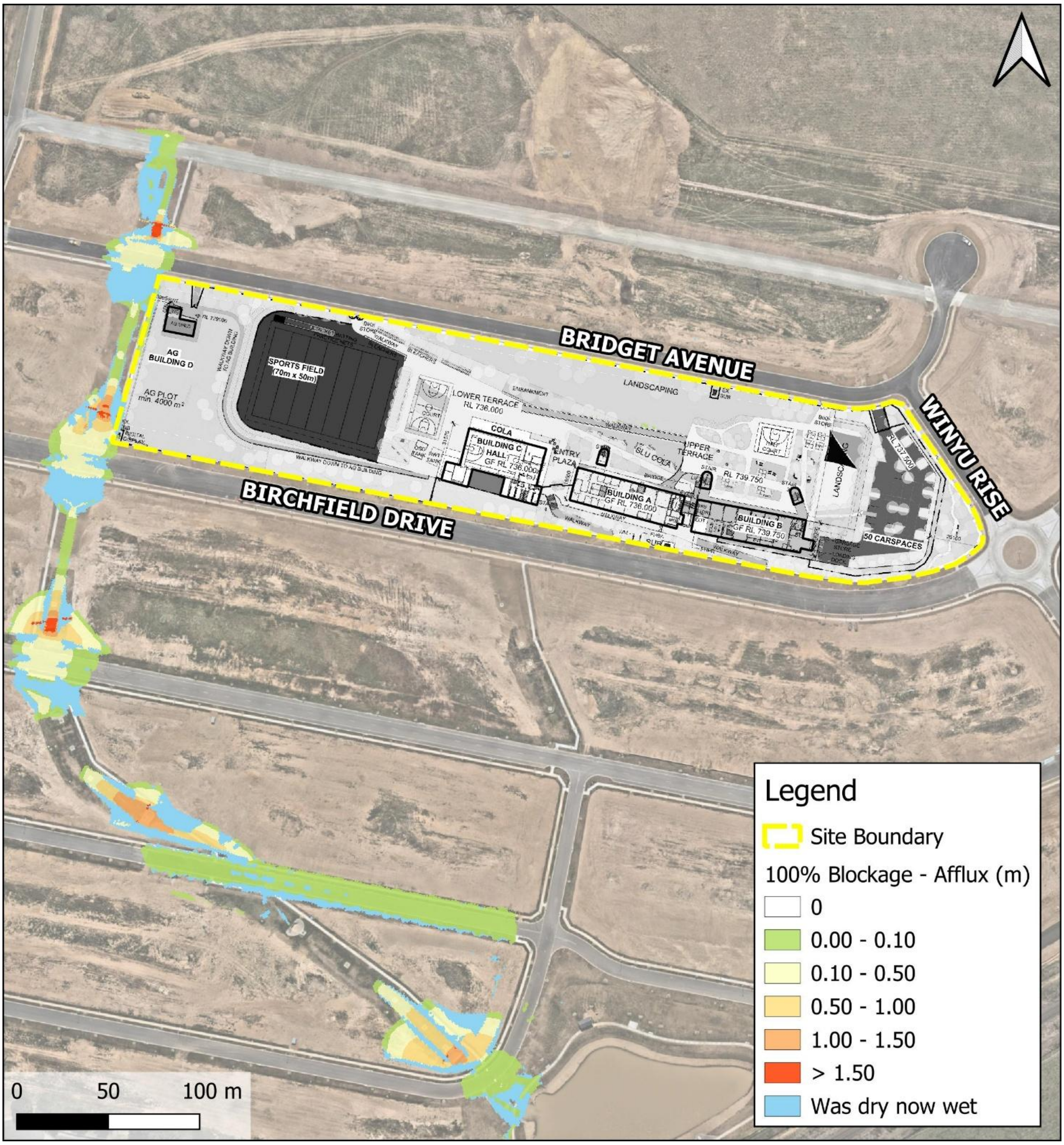


Figure 34: Impact of 100% blockage on 1% AEP flood levels

9.0 Flood Planning Requirements

9.1 Queanbeyan-Palerang Development Control Plan

The Palerang Development Control Plan (DCP) came into effect in May 2015, and was most recently amended in November 2022. The DCP expands on the aims, objectives and other provisions of the QPRLEP2022 and provides detailed development provisions for development in the former Palerang LGA.

Section B9 of the DCP addresses controls related to Flood Planning. Clause 5.21 of QPRLEP2022 requires that proposed development considers flood hazard.

9.1.1 Objectives

The objectives of Section B9 of the DCP are:

- To comply with the objectives of Clause 5.21 of the QPRLEP2022
- To ensure the impacts of the full range of floods, up to and including the probable maximum flood, are considered when assessing development of flood prone land
- To take account of social, economic and ecological factors in relation to flood issues
- To ensure development is in accordance with the principles contained in the Floodplain Development Manual, issued by the NSW Government
- To only permit development where the full potential risk to life from flooding can be managed for all floods up to and including the Probable Maximum Flood.
- To minimise the impact of flooding and flood liability on individual owners and occupiers
- To ensure development and construction materials are compatible with the flood hazard

9.1.2 Development Controls

Section B9.1 of the Palerang DCP outlines the following general controls for development on flood prone land:

- Consideration must be given to development on land below the flood planning level, but only if it is not located within a floodway or high hazard area as stated in the Floodplain Development Manual
- Any portion of any building that may be subject to the effects of flood waters is to be built from flood compatible materials
- All services associated with the development are to be adequately flood proofed
- No on-site sewage management system shall be located within a flood planning area.

There is no separate category within the development controls for educational facilities in the Palerang DCP. Controls have therefore been taken from Section B9.2 ‘Residential – new development’, as these are the most stringent controls:

- Developments designed to cater for vulnerable sections of the community (such as seniors housing) are not suitable for land identified as being a Flood Planning Area
- Floor levels of habitable rooms are to be at or above the Flood Planning Level
- Flood safe access and emergency egress for all flood events up to the 1% AEP event plus 500mm freeboard is to be provided
- Proposed earthworks are not to increase the flooding hazard or flood damage to other properties or adversely affect other properties during flood events

Although the DCP does not provide a definition of the adopted Flood Planning Level for the LGA, it refers to the NSW Floodplain Development Manual (2005), which defines the Flood Planning Level as the 1% AEP flood level plus an appropriate freeboard, typically 500mm for residential development. As outlined in Section 4.2, the bed level of the unnamed creek situated 230m east of the site is approximately 710–715.00m AHD. With a ground floor level of 736.00–739.75m AHD for Building A, B and C, the proposed school is elevated a minimum of 20 metres above this watercourse, with no risk of mainstream flooding at the site.

Further flood planning level guidance is outlined in Appendix K4 of the 2005 Floodplain Development Manual, which acknowledges that consideration of the PMF level may be required for developments with particular evacuation or emergency response issues, including critical or sensitive land uses.

For overland flows, the site is unaffected by any overland flows generated offsite, which are contained within the adjacent road reserves. The current design will be refined in the detailed design stage via further stormwater management considerations to reduce runoff levels adjacent to building openings. This will be reviewed in consultation with the project's civil design team.

9.2 SINSW Guidelines

School Infrastructure New South Wales (SINSW) have their own framework for school site selection and development guidelines which should also be considered. For flooding, the framework provides the following guidelines:

i. The site (or a significant portion of the site) will be located above the 1-in-200-year (0.5% AEP) flood level;
ii. The site will provide flood free access for pedestrians and vehicles (in particular, emergency vehicles during a flood event);
iii. Buildings must be located on land above the Flood Prone Land Contour (i.e., land susceptible to flooding in the PMF) where possible.

Point i): The 0.5% AEP flood depths and levels are presented in Figure 35. All ground floor openings to each building are set above the 0.5% AEP level, as shown in Table 5 (Section 6.3.2). The development is therefore compliant with this guideline.

Point ii): The surrounding access roads are impacted by flows with a hazard category of H1 in the 1% AEP event, which is regarded as low hazard and safe for children and vehicles. In the critical duration PMF event, these roads are temporarily cut off by local catchment flows, which become hazardous where they cross over the drainage reserves. However, given the short critical duration, the site is not isolated for an extended period. More detailed analysis is provided in TTW's Preliminary Flood Emergency Response Plan (FERP) for the site, dated 14 March 2025.

Point iii): The buildings are located well above the land susceptible to mainstream flooding from creeks and rivers in the PMF event. In terms of overland flows, further refinement of the civil grading and stormwater considerations will be investigated in the detailed design stage in order to lower PMF levels from flows generated within the site. This will convey excess runoff away from building openings in the PMF event.

The proposed building is therefore broadly compliant with the SINSW guidelines for educational site selection.

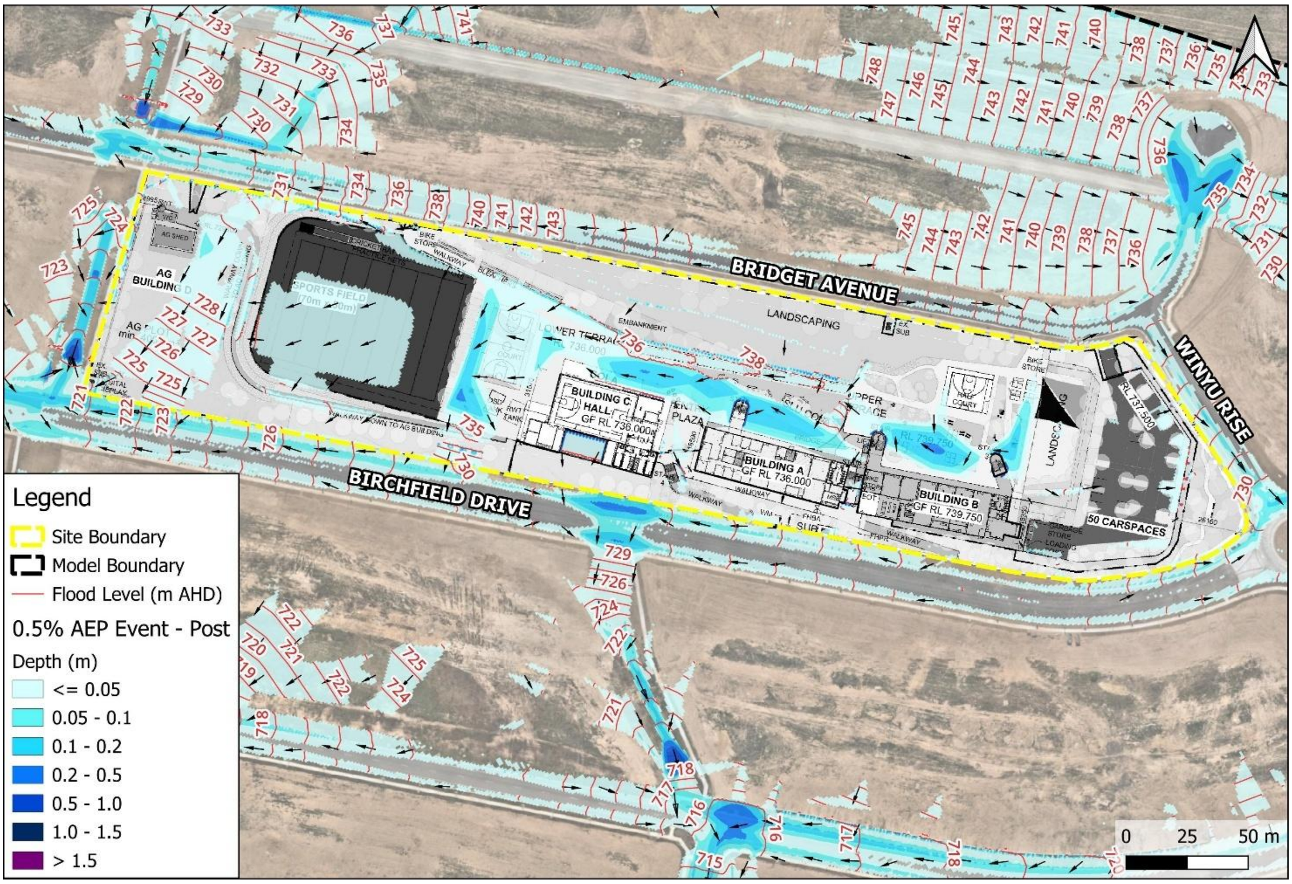


Figure 35: 0.5% AEP event depths and levels within and surrounding the site

9.3 Floor Level Guidance

Given the sensitivity of the site as an educational facility, and in line with standard practice for new schools throughout NSW, the floor levels of the new buildings should be set above the PMF level. This aligns with the SINSW guidelines, which recommend schools are outside of flood prone land where possible.

In addition, given the short critical duration of flooding at the site (10 minutes in the PMF event and 15 minutes in the 1% AEP event), shelter-in-place is a likely response strategy for the school during flash flood events where there is not sufficient warning time to pre-emptively close or evacuate the school. Vertical evacuation (via the internal movement of occupants to upper levels above the PMF level) is difficult at the site, as this relies on access to external staircases, which are surrounded by overland flows (albeit low hazard) in significant flood events. To ensure the safety of all site users during shelter-in-place procedures, buildings should be set at or above the PMF level. This will be achieved in the detailed design stage in consultation with the project's civil design team.

More detail on the flood response strategy for the site is outlined in TTW's Preliminary Flood Emergency Response Plan, dated 14 March 2025.

9.4 Essential Energy Distribution Underground Design and Construction Manual

The Essential Energy Distribution Underground Design and Construction Manual CEOM7098 outlines the following easement requirements, with item 6 relating to flooding:

1. Size of Easement: The easement required for a pad-mount substation should be 7,000mm x 4,200m.

2. Placement: The pad-mount must be centrally positioned within the easement to maintain access to the doors and meet operational requirements.
3. Access Requirements: Essential Energy personnel must have unimpeded 24/7 access to the substation from a public street, including for vehicles such as heavy trucks with mounted cranes.
4. Protection from Vehicles: Measures such as bollards, or a minimum 230mm high kerb must be installed to prevent vehicle damage
5. No Encroachments: The easement must remain free of any other utility services, structures, or vegetation that could hinder maintenance and operational access.
6. Flood: base of the substation must be above the PMF.

All features and structures proposed within the school should be set and design to meet the relevant Council's and approving authorities' flooding requirements. Currently, the PMF level at the substation reaches a maximum of 733.20m AHD. The base of the substation is currently set to 733.25m AHD and is therefore compliant with the CEOM7098 requirements.

10.0 Mitigation Measures

Mitigation measures identified as necessary are outlined in Table 8.

Table 8: Mitigation Measures

Mitigation Name	Aspect	Mitigation Measure	Reason
Internal stormwater management	Detailed design	Refinement of civil and stormwater considerations to increase capacity of the existing flow path north of Buildings A and C, and implementation of a wall around the edge of the upper terrace to restrict overflows into the lower terrace.	To ensure excess runoff during significant rainfall events are directed away from building openings
Operational Flood Emergency Response Plan (FERP)	During design phase and prior to the commencement of operation phase	A Preliminary FERP prepared by TTW (14 March 2025) and submitted together with this report, is based on the Concept Design information for the proposed activity, and must be reviewed following the detailed design stage, and updated to reflect the final design features of the proposed activity, prior to the site becoming operational.	To provide emergency response guidance in the event of a flood event and further reduce flood risks associated with the activity during operational phase.

11.0 Conclusions and Recommendations

TTW produced a 1D-2D hydraulic model for the site to investigate the impact of the proposed activity on flood behaviour and assess the suitability of the site for further development. Modelling concluded that:

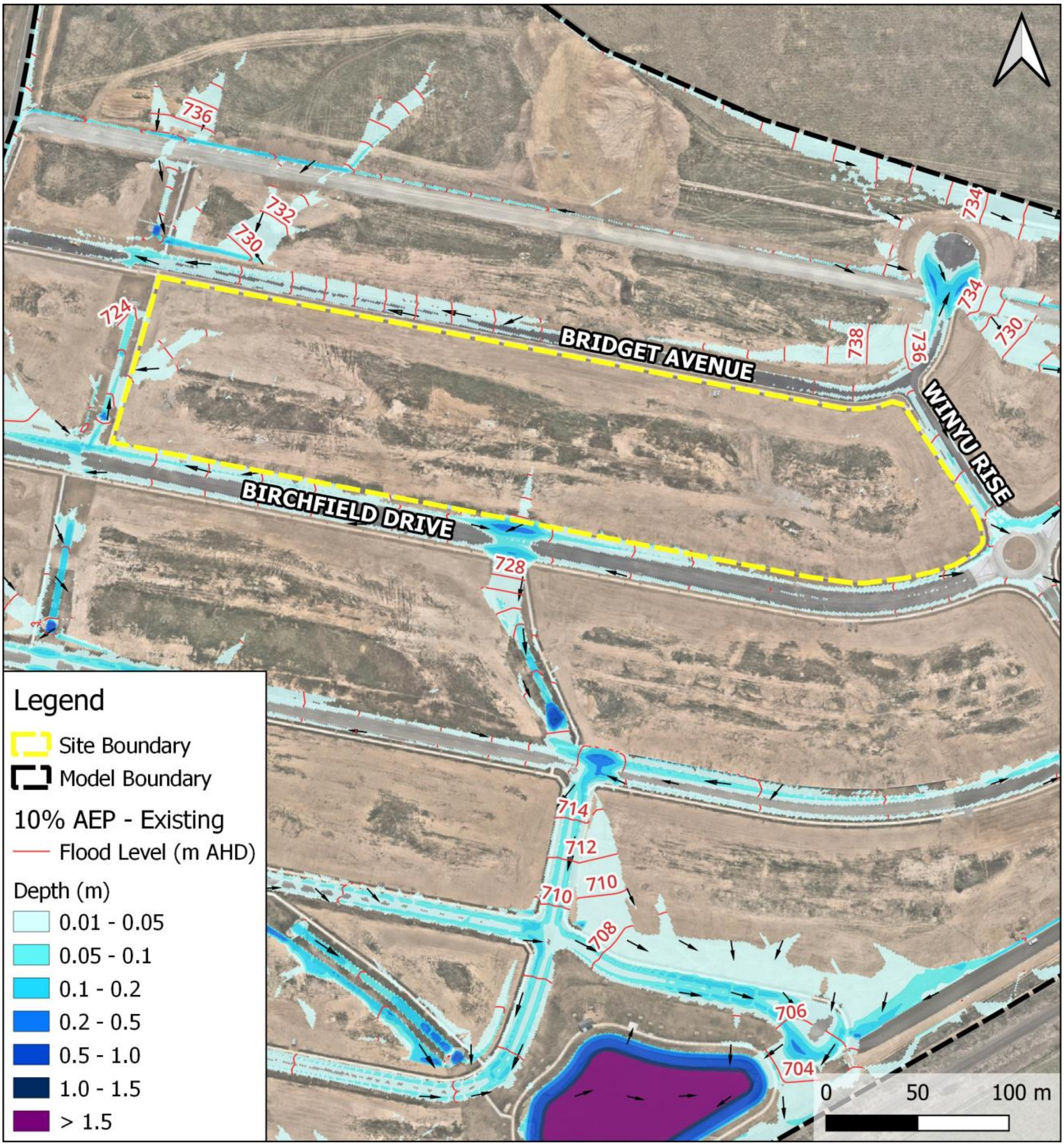
- The Bungendore High School site is unaffected by both mainstream flooding and overland flooding from sources external to the site. Overland flows from the local upstream catchment are contained within the adjacent road reserves in all modelled events, with no overflows spill onto the site.
- The PMF has been defined as the critical event for floor level requirements given the short warning time associated with flash flood behaviour in the area, and the need for site users to temporarily shelter-in-place within the buildings when there is not sufficient warning time.
- In post-development conditions, there is some excess runoff generated onsite that can be managed by civil and stormwater design considerations, at a detailed design stage, to direct these minor flows away from the building openings and safely discharged offsite into the drainage reserve at the site's western frontage.
- 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 activity has no offsite impacts on adjacent properties in the 1% AEP event. Within the site, localised flood level increases can be attributed to changes in site grading and fill.
- The potential impact of climate change has been considered, with the CC2100 scenario including a 66% increase in rainfall. In the 1% AEP event, flood levels to the north of the proposed buildings increase by 38mm under the CC2100 scenario (Point E), equating to a level of 735.997m AHD, below the current FFL of 736.00m AHD.
- Additional sensitivity testing of pit blockages and the joint probability of catchment flooding and storm surge have also been assessed, with negligible onsite impacts.
- The proposed activity broadly complies with the relevant flood-related standards and requirements of the Palerang DCP, SINSW site selection guidelines, and the NSW Floodplain Risk Management Manual. This should be further reviewed following detailed design.
- A preliminary FERP has been prepared in a separate document (Preliminary Flood Emergency Response Plan (TTW – 14 March 2025)). It is worth noting that this preliminary FERP will need to be updated prior to the operational phase of the proposed activity, to reflect the final school design features adopted.

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

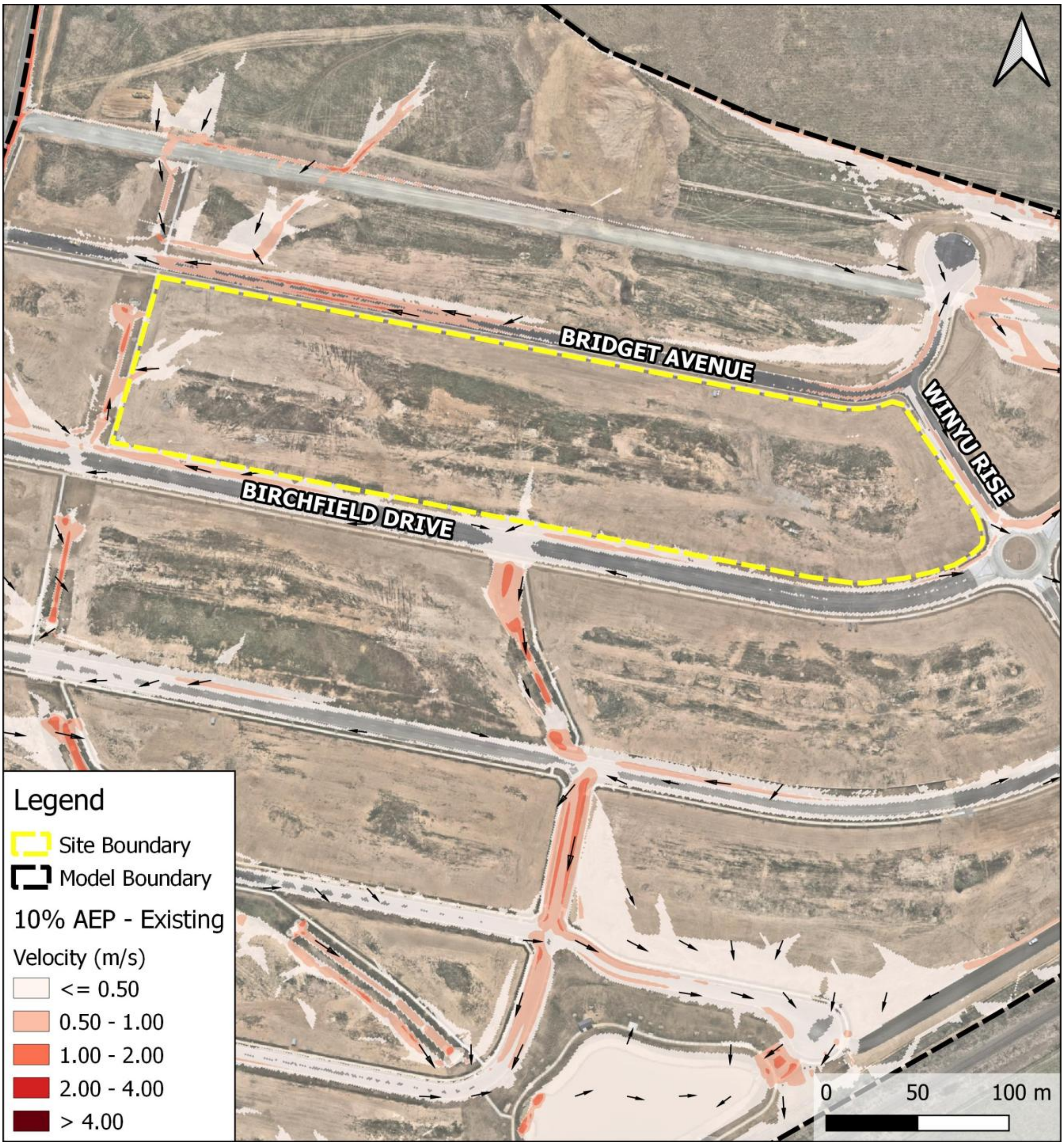
Prepared by **TTW (NSW) PTY LTD**	Updated and Authorised By **TTW (NSW) PTY LTD**
LAURA CALDWELL Civil Flood Modeller	**MICHAEL KOI** Associate (Flood)

Appendix A – Additional Existing Scenario Results

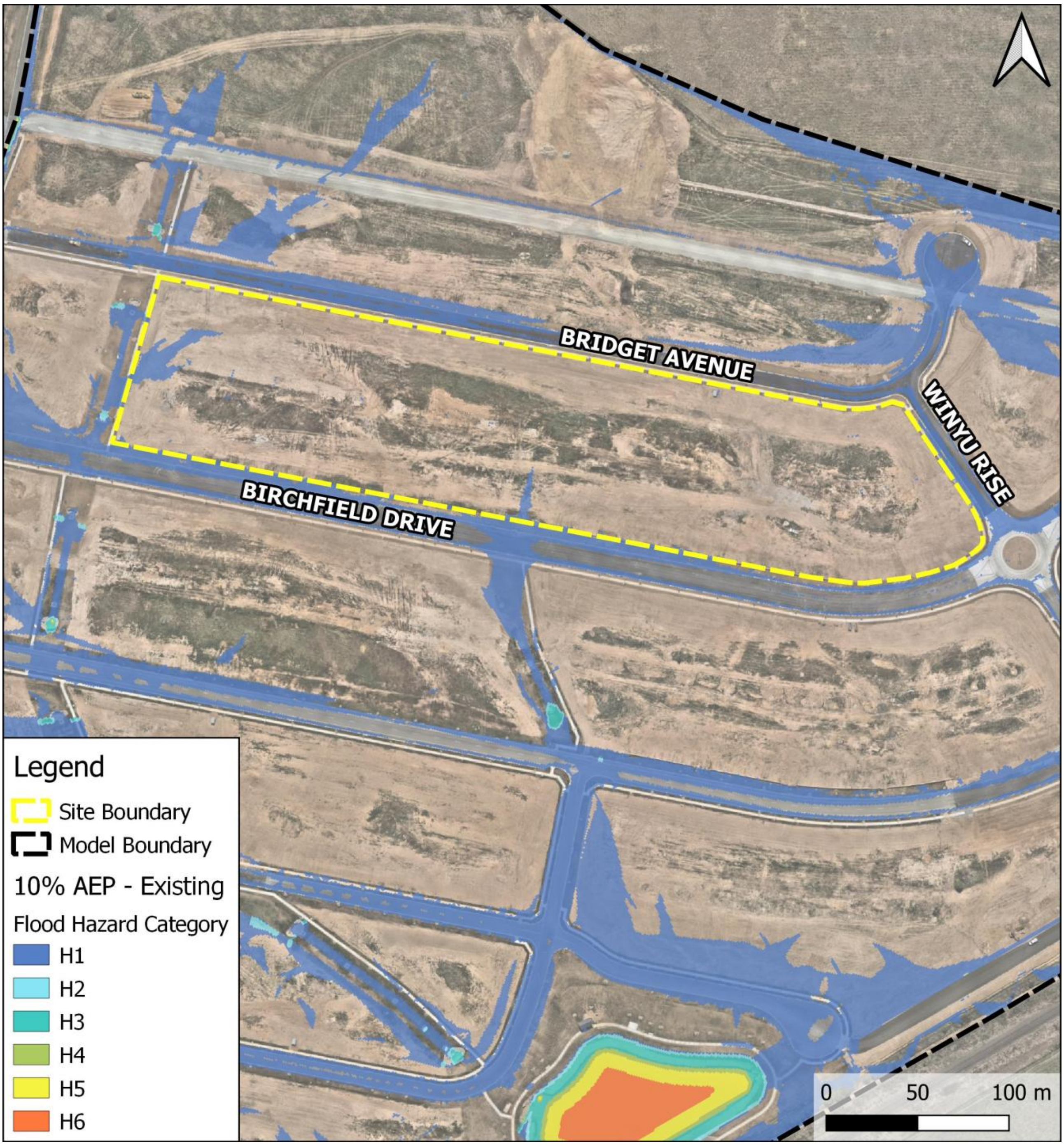
10% AEP Event



Appendix A 1: 10% AEP event – flood depths and levels surrounding the BHS site under existing conditions

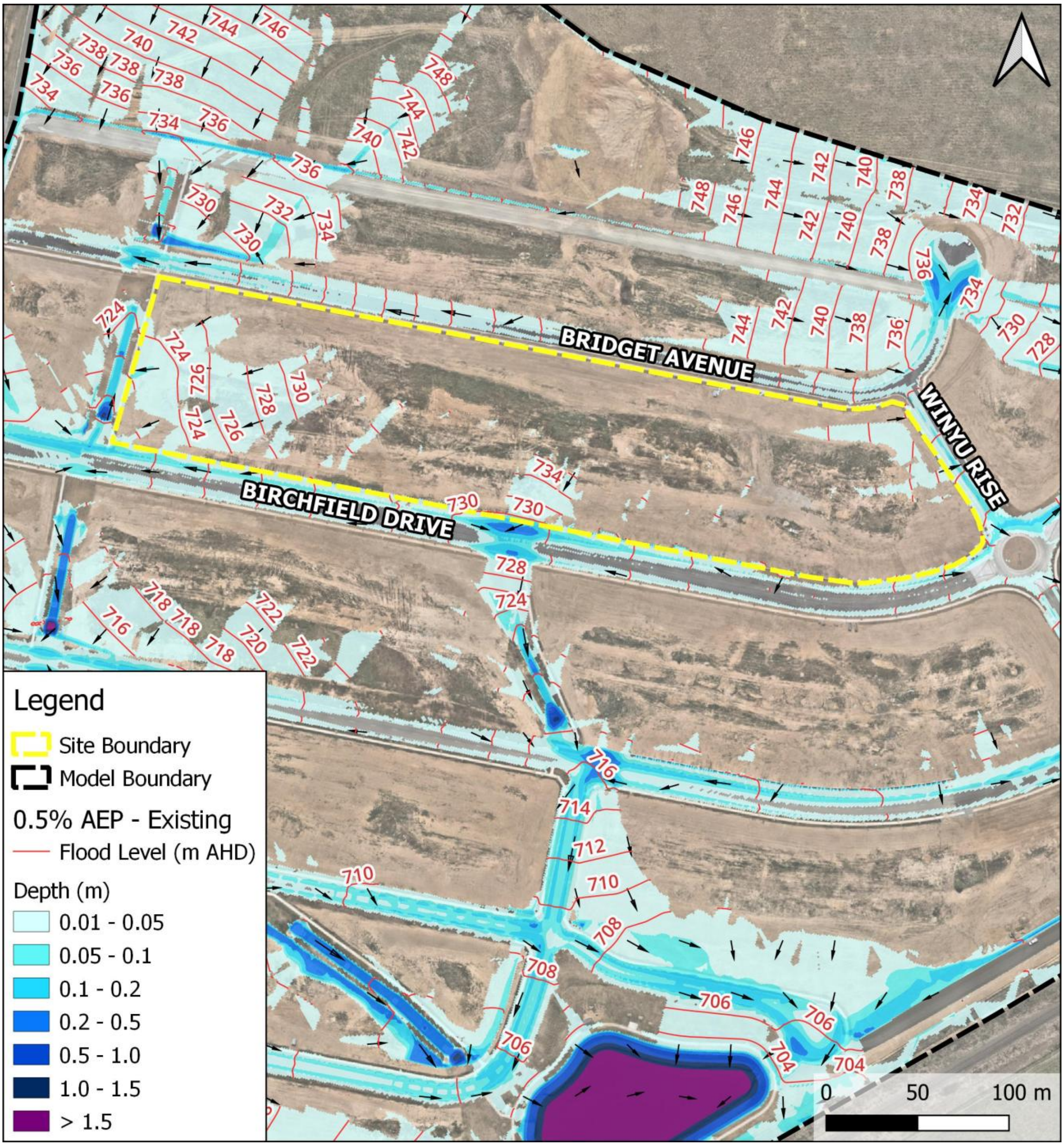


Appendix A 2: 10% AEP event – flood velocities surrounding the BHS site under existing conditions

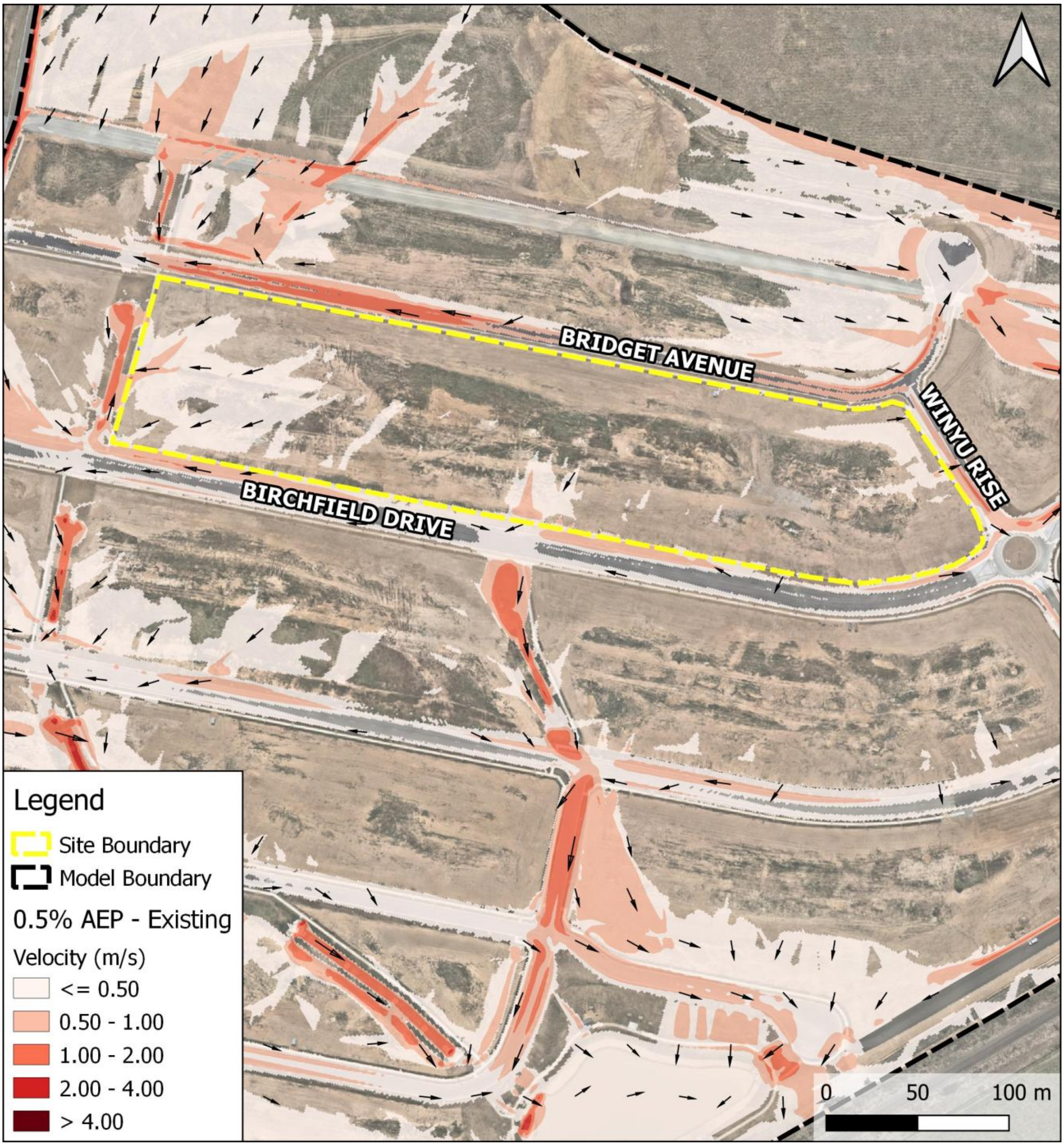


Appendix A 3: 10% AEP event – flood hazard classification surrounding the BHS site under existing conditions

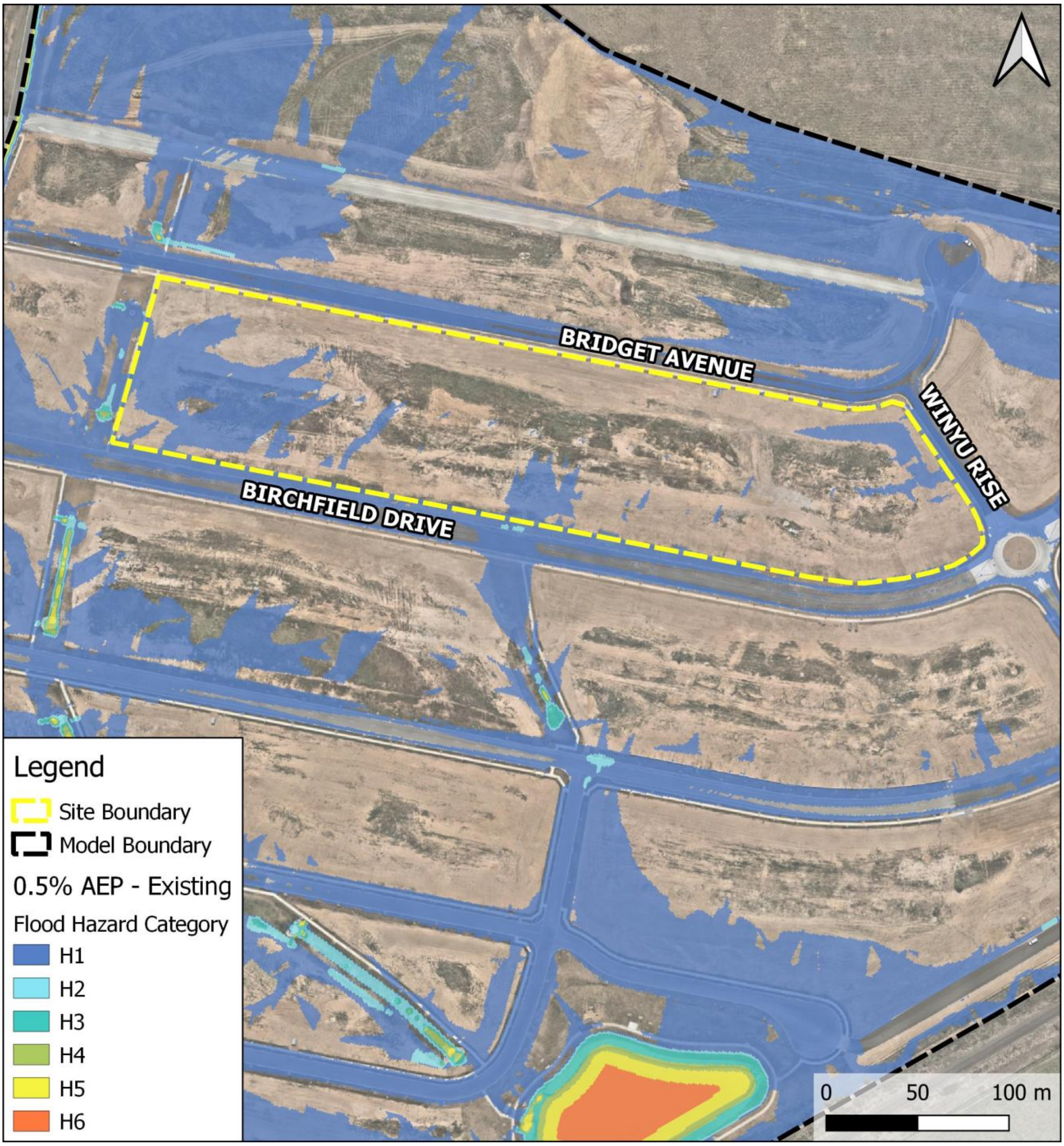
0.5% AEP Event



Appendix A 4: 0.5% AEP event – flood depths and levels surrounding the BHS site under existing conditions

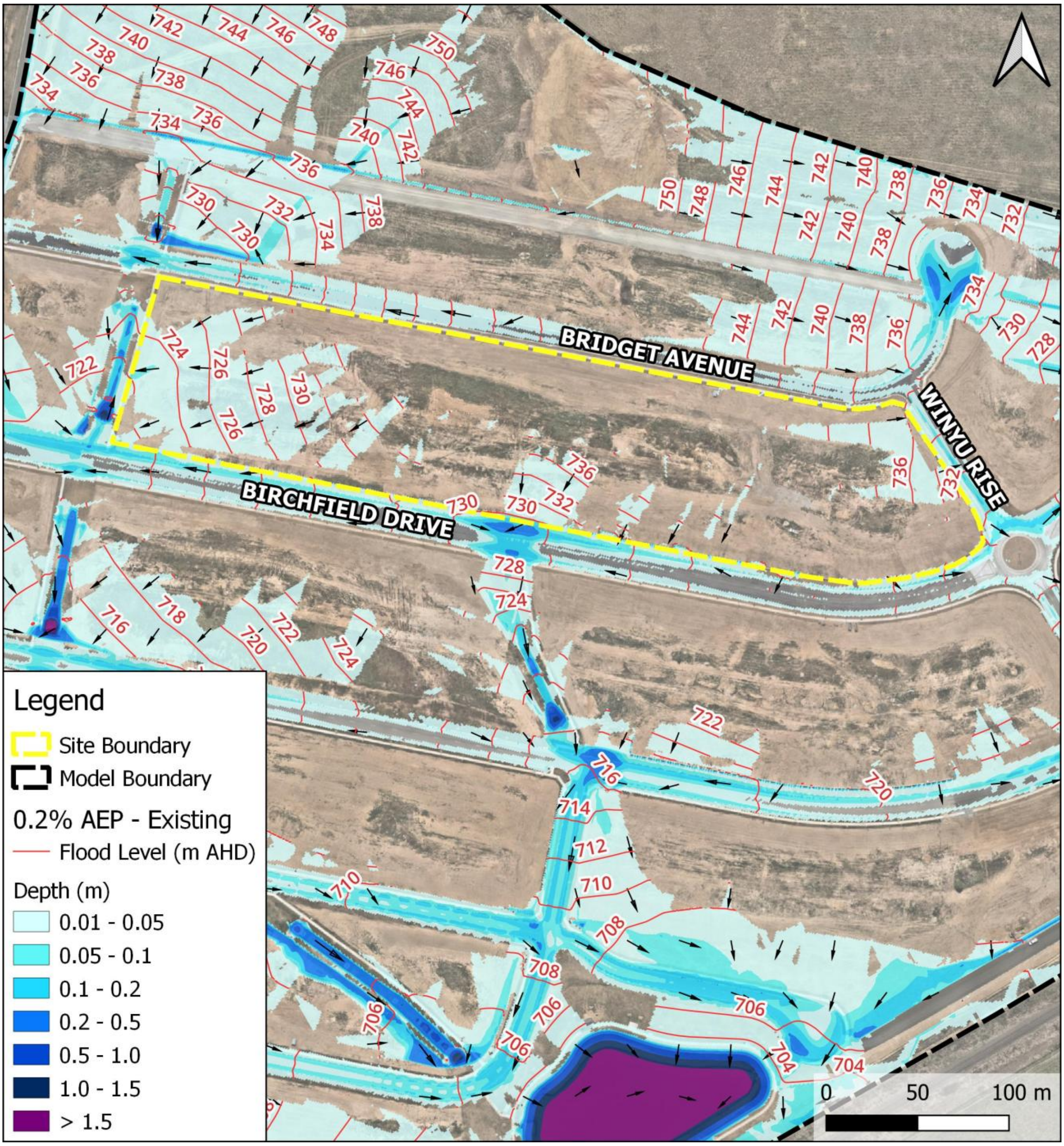


Appendix A 5: 0.5% AEP event – flood velocities surrounding the BHS site under existing conditions

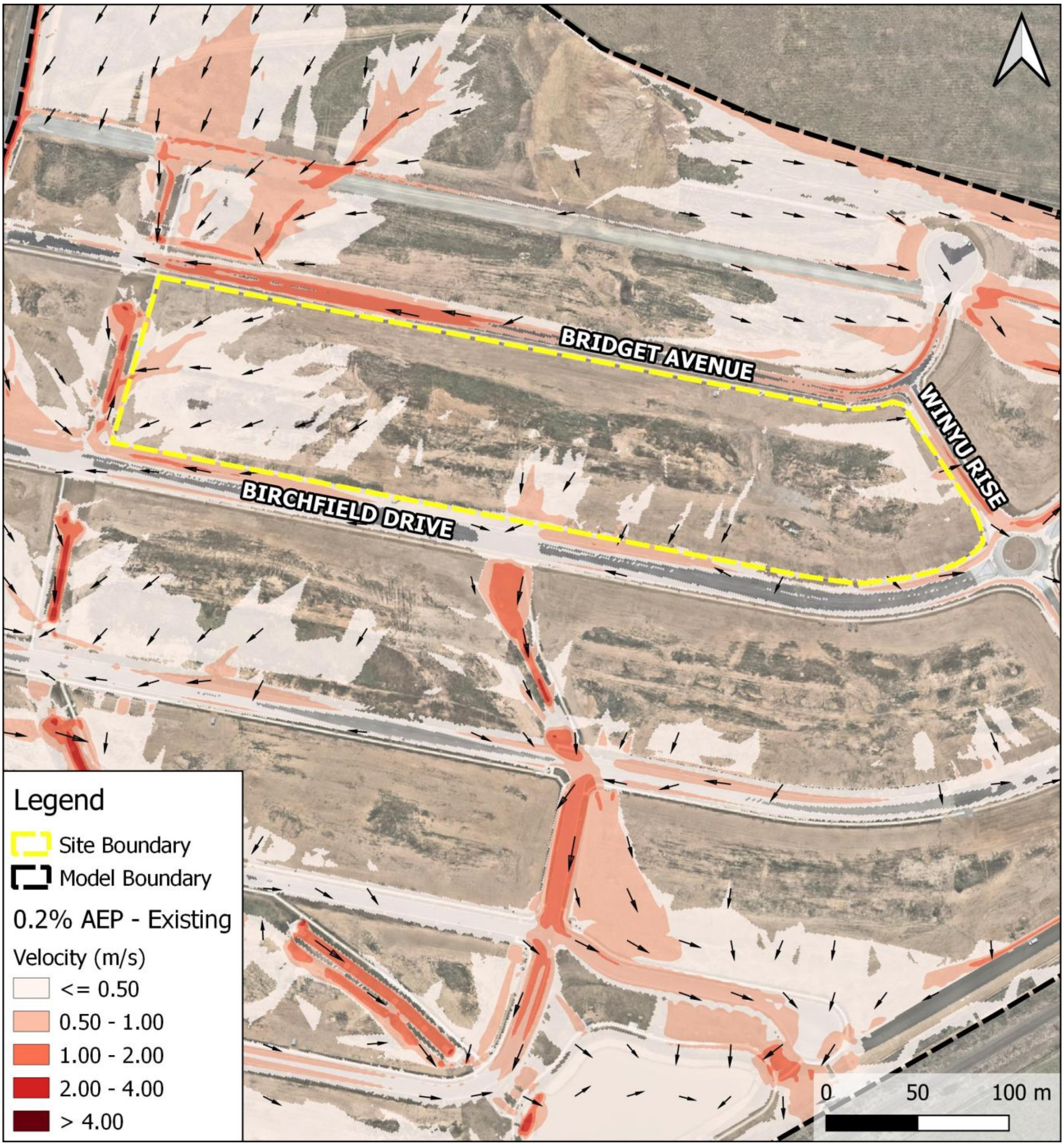


Appendix A 6: 0.5% AEP event – flood hazard classification surrounding the BHS site under existing conditions

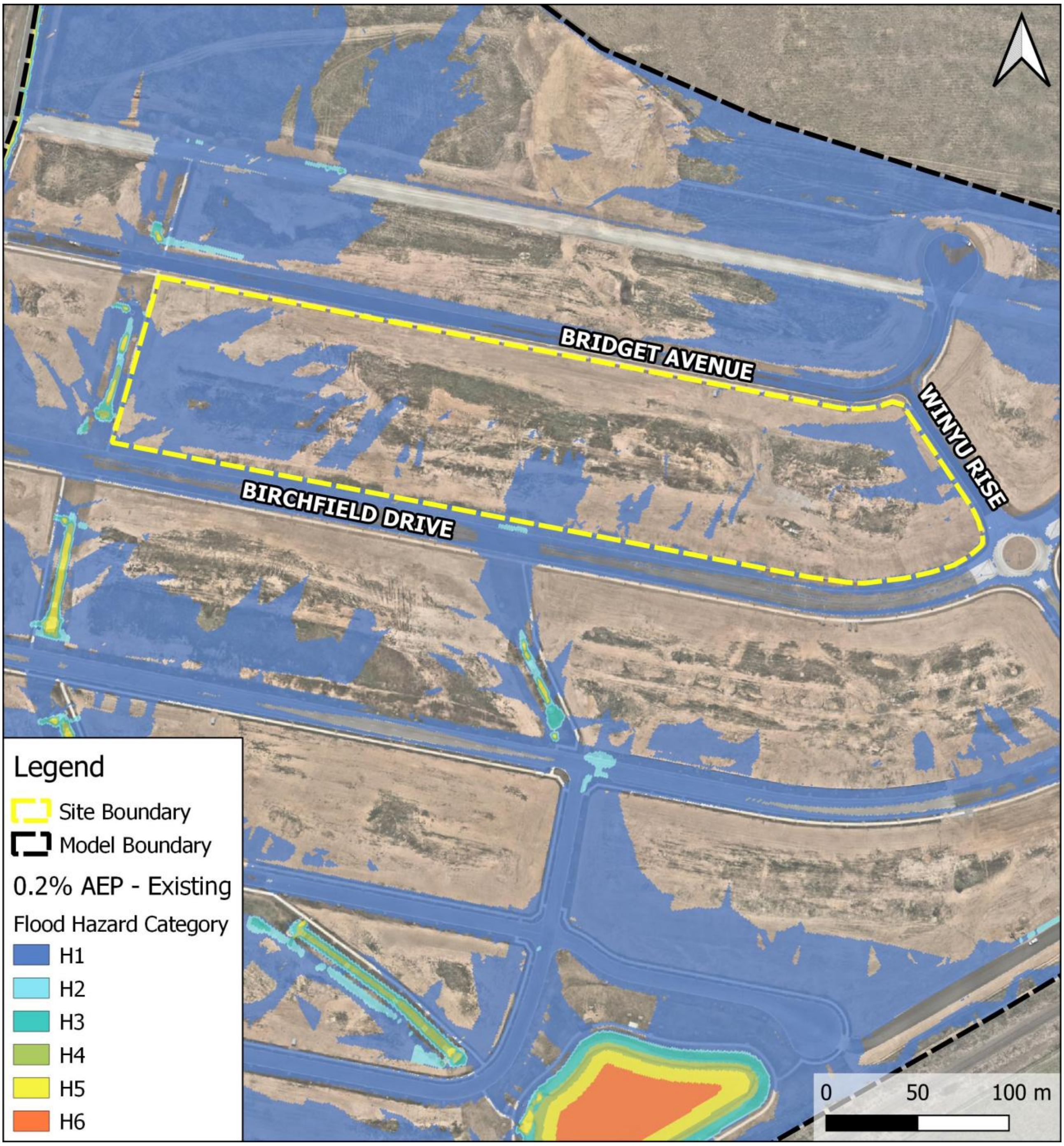
0.2% AEP Event



Appendix A 7: 0.2% AEP event – flood depths and levels surrounding the BHS site under existing conditions



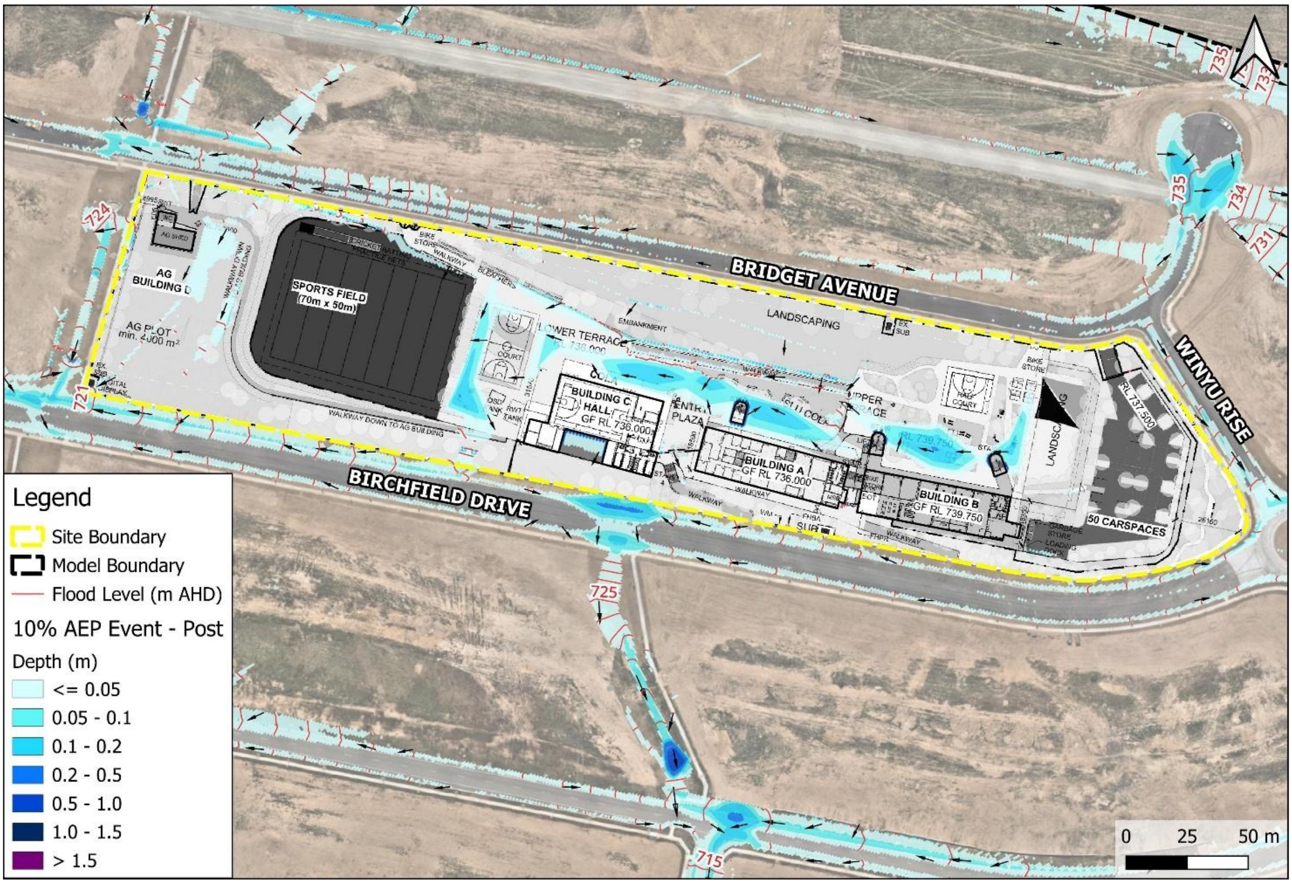
Appendix A 8: 0.2% AEP event – flood velocities surrounding the BHS site under existing conditions



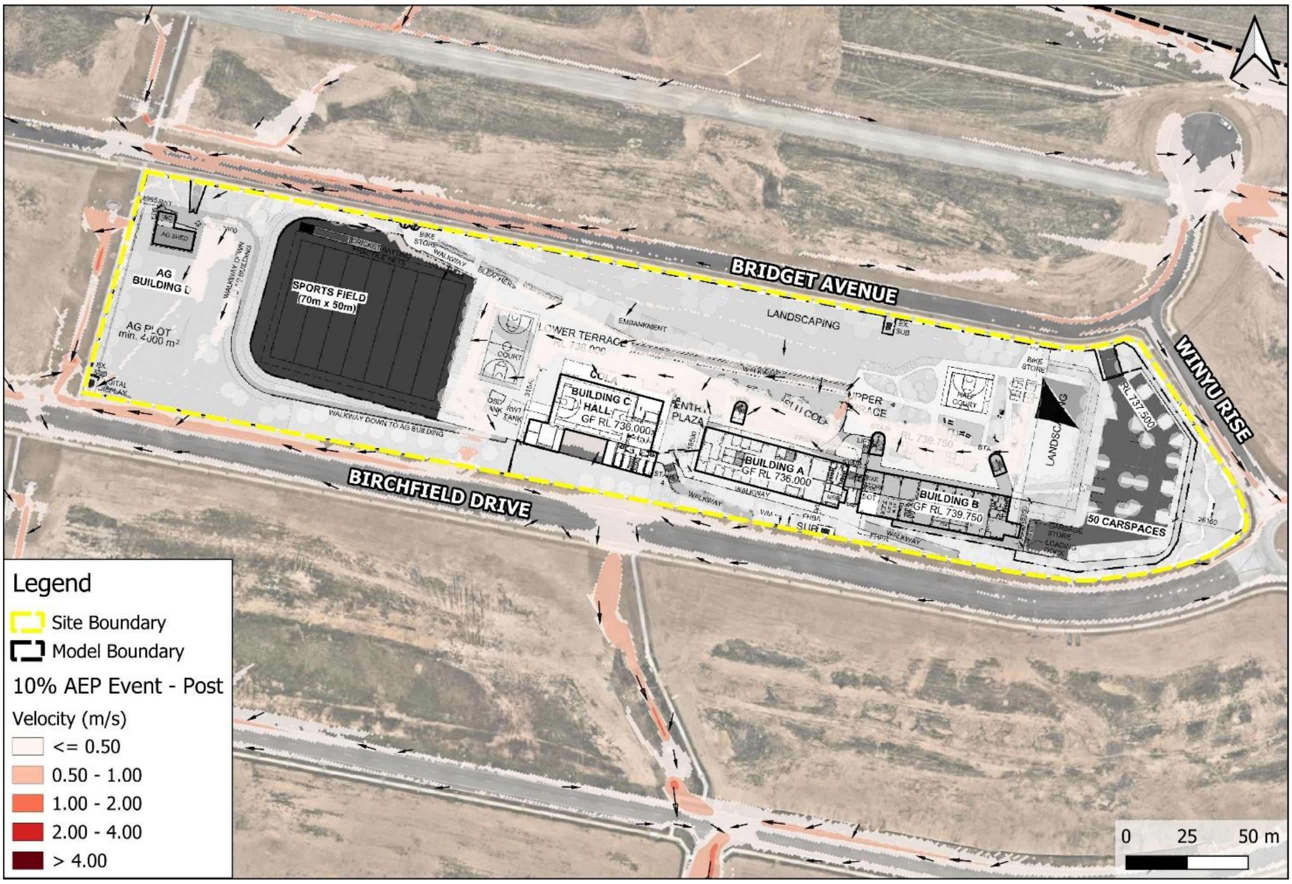
Appendix A 9: 0.2% AEP event – flood hazard classification surrounding the BHS site under existing conditions

Appendix B – Additional Post-Development Scenario Results

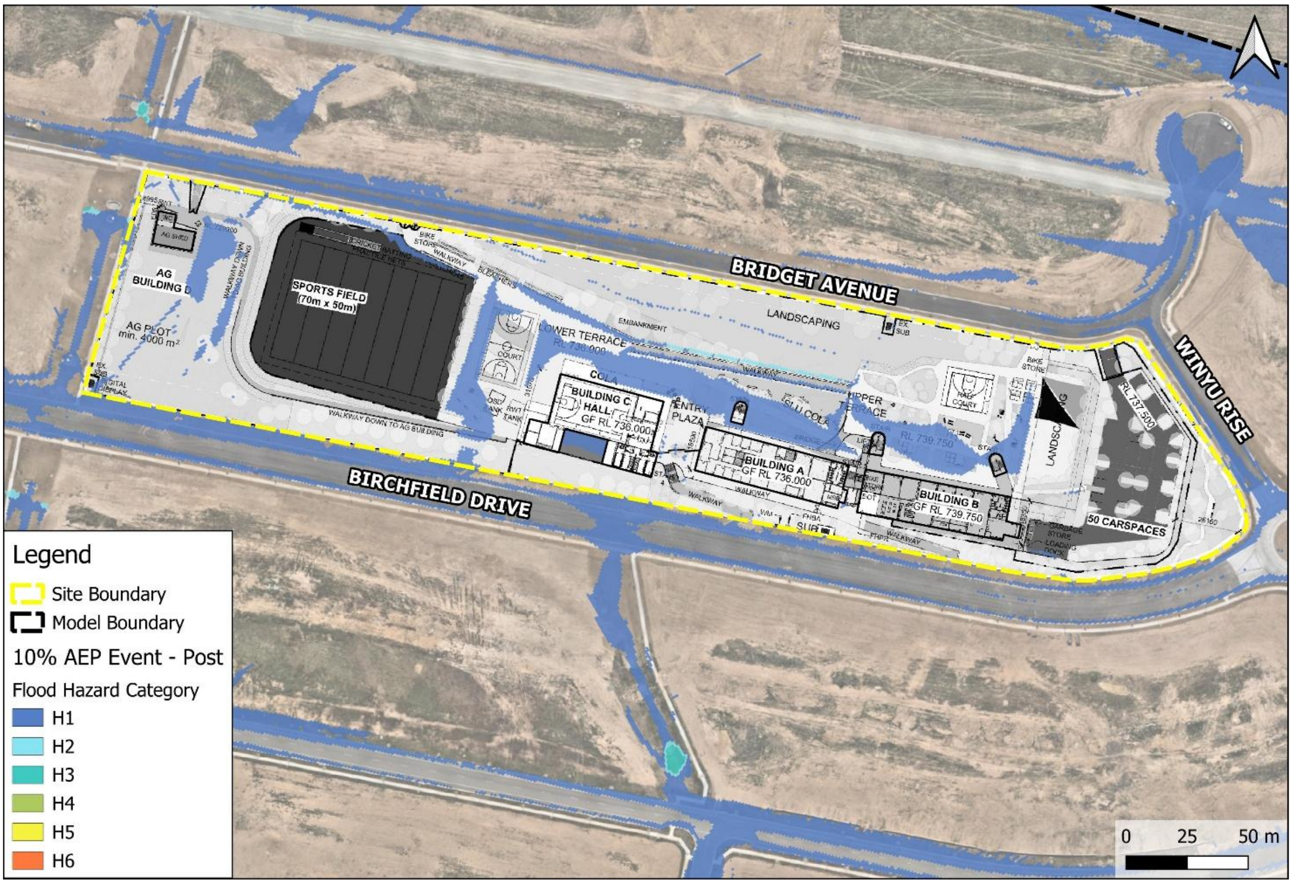
10% AEP Event



Appendix B 1: 10% AEP event – flood depths and levels surrounding the BHS site under post-development conditions

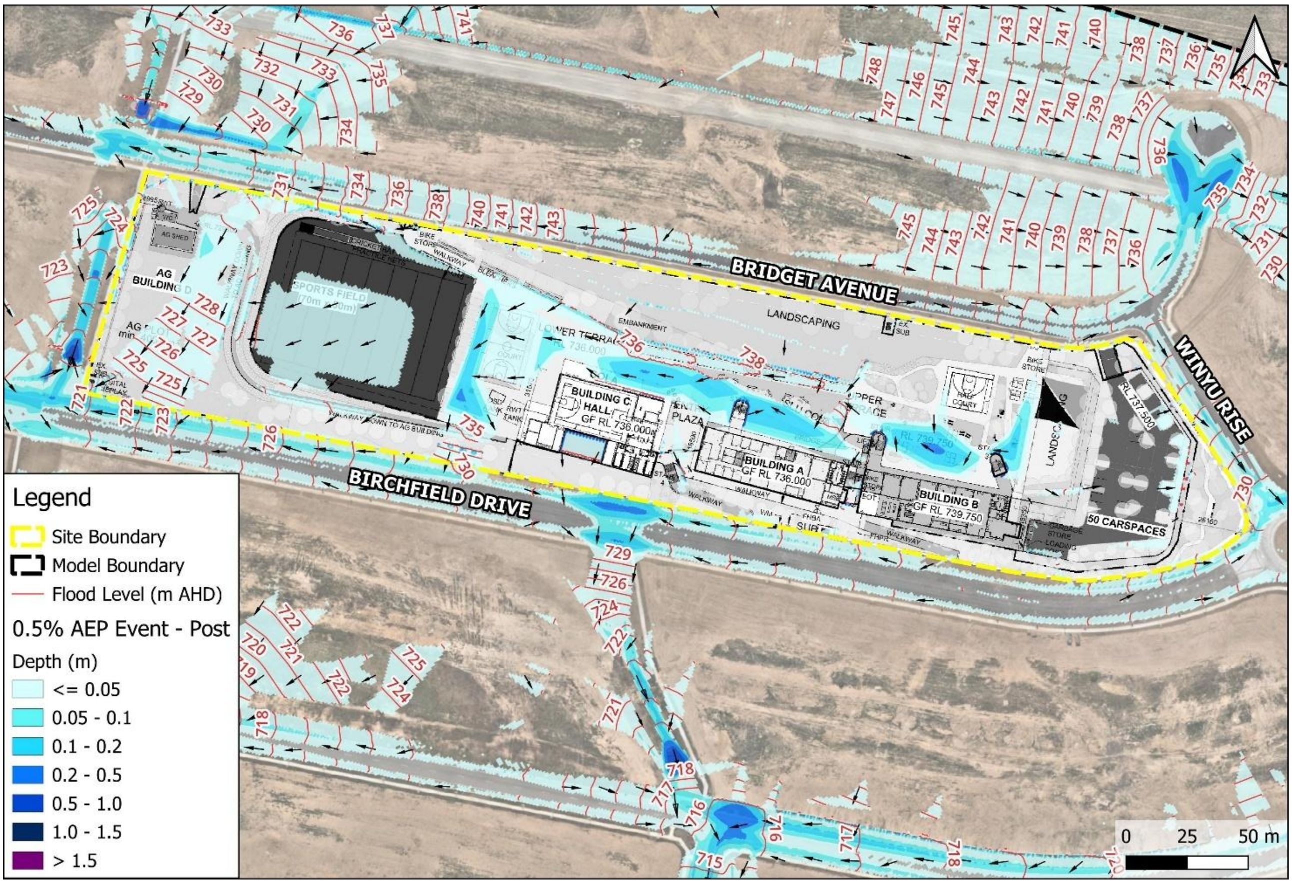


Appendix B 2: 10% AEP event – flood velocities surrounding the BHS site under post-development conditions

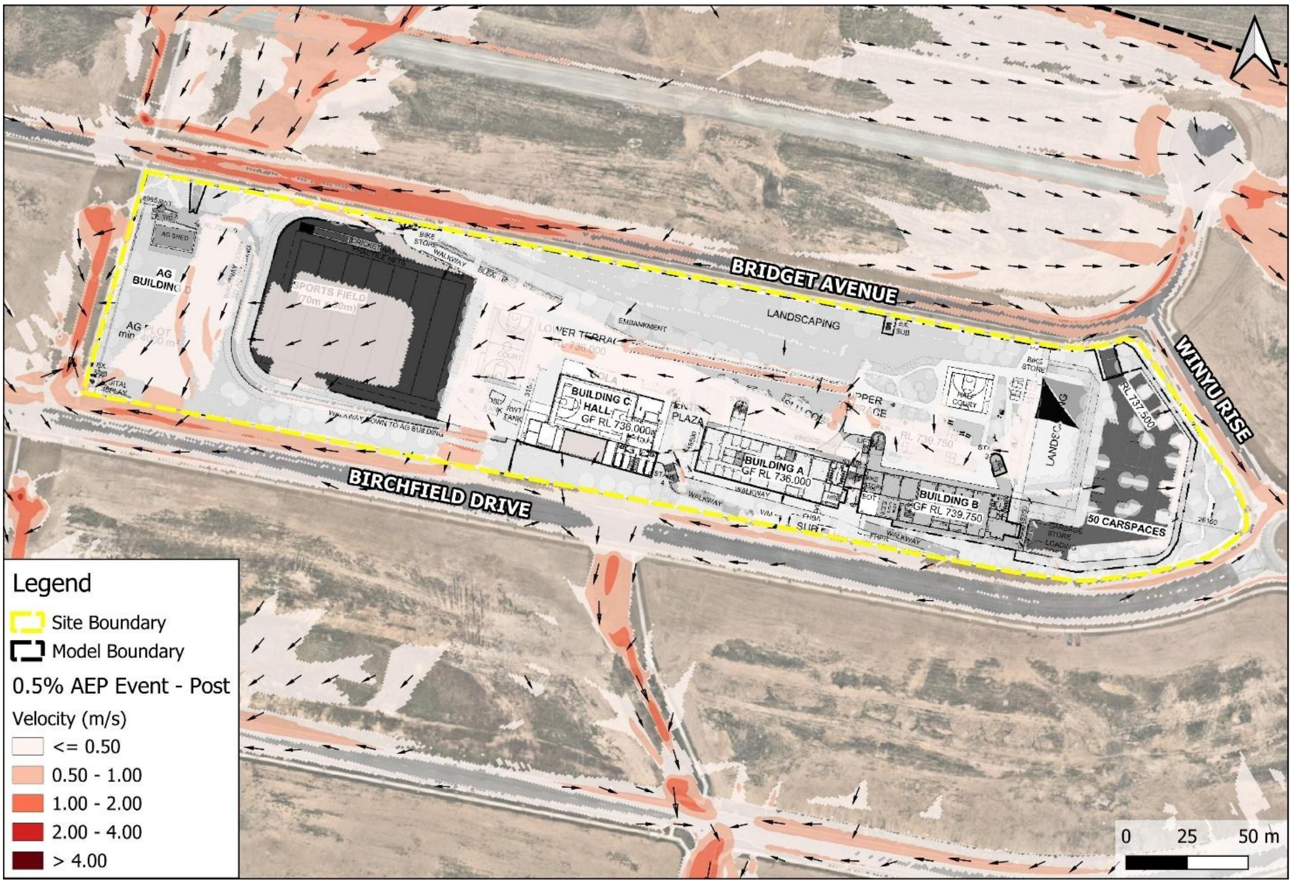


Appendix B 3: 10% AEP event – flood hazard classification surrounding the BHS site under post-development conditions

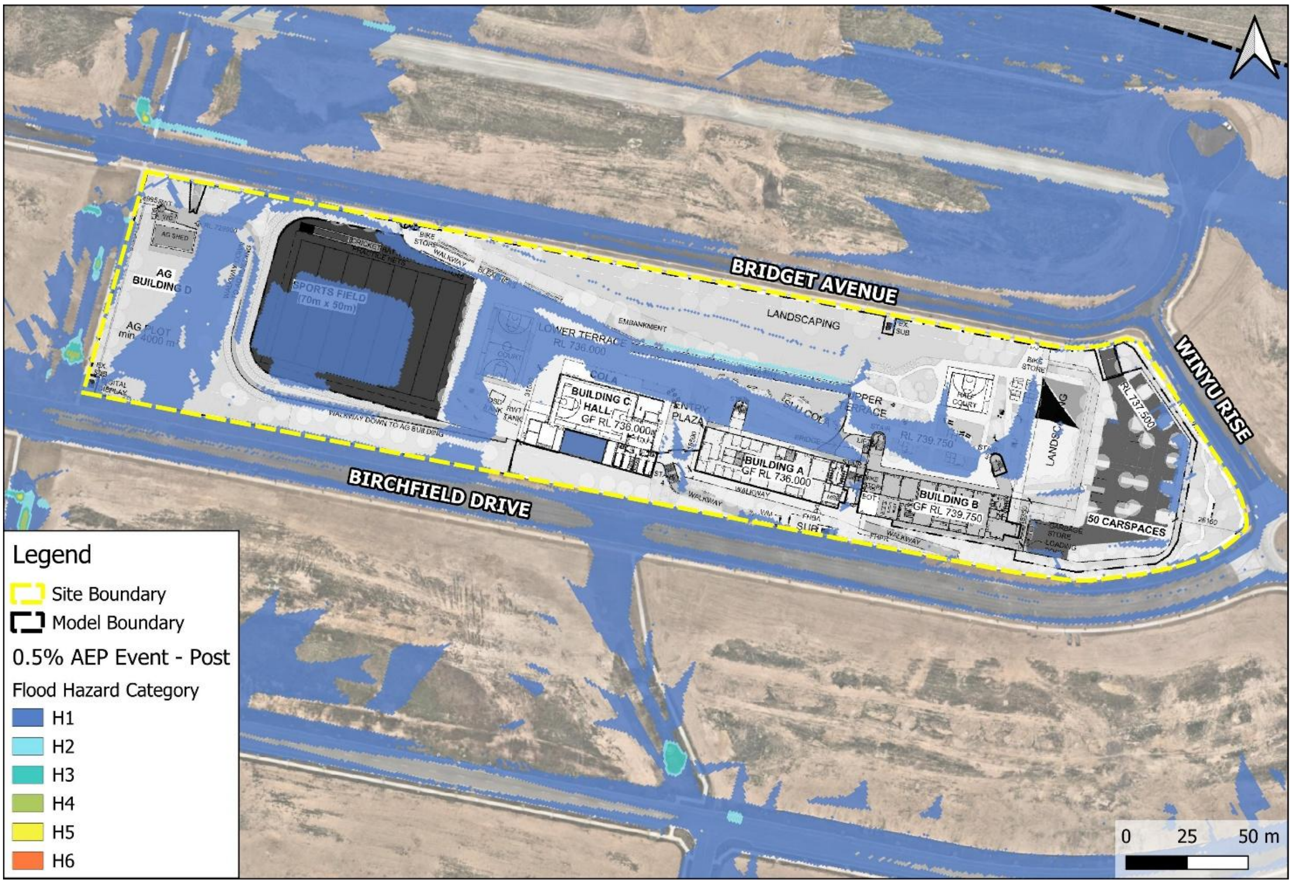
0.5% AEP Event



Appendix B 4: 0.5% AEP event – flood depths and levels surrounding the BHS site under post-development conditions

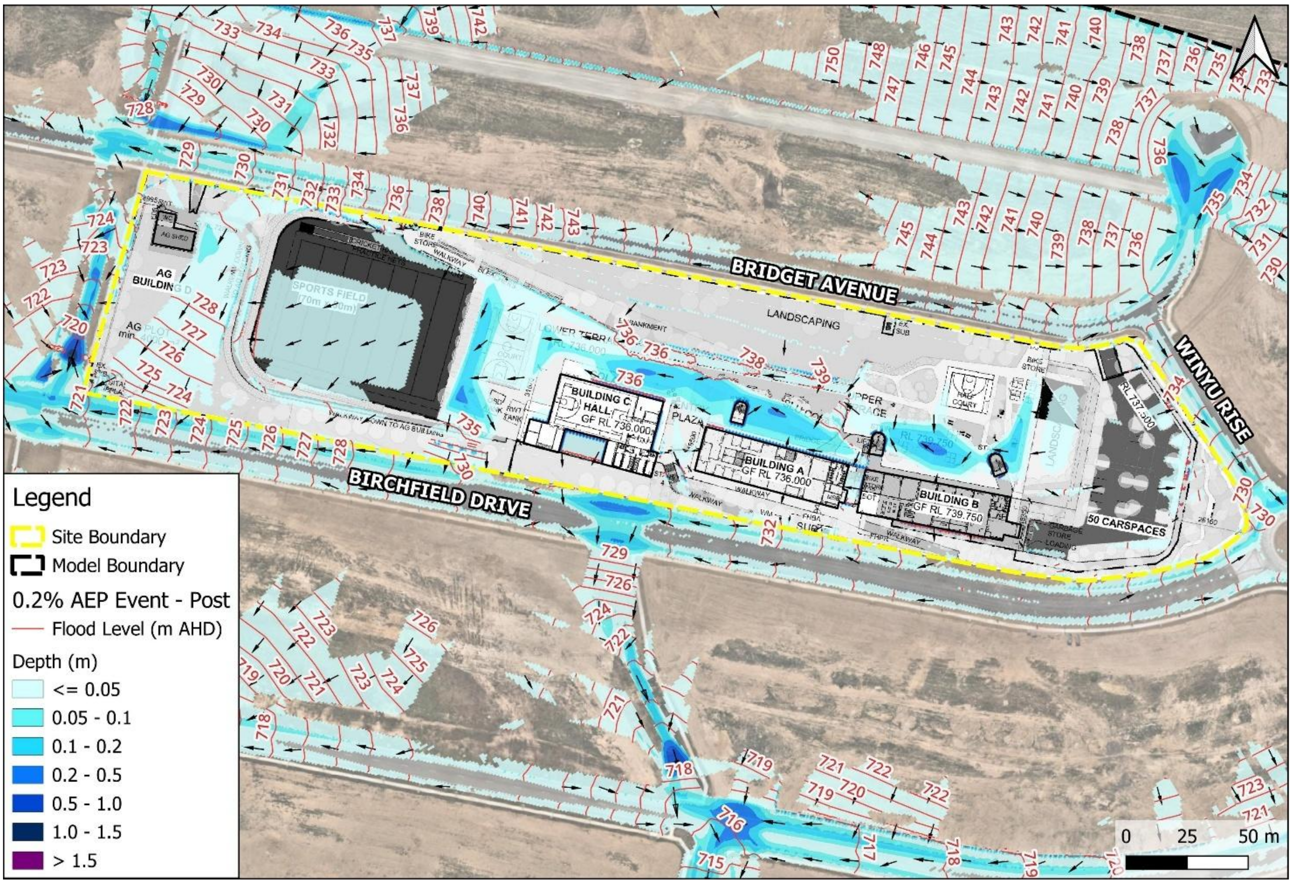


Appendix B 5: 0.5% AEP event – flood velocities surrounding the BHS site under post-development conditions

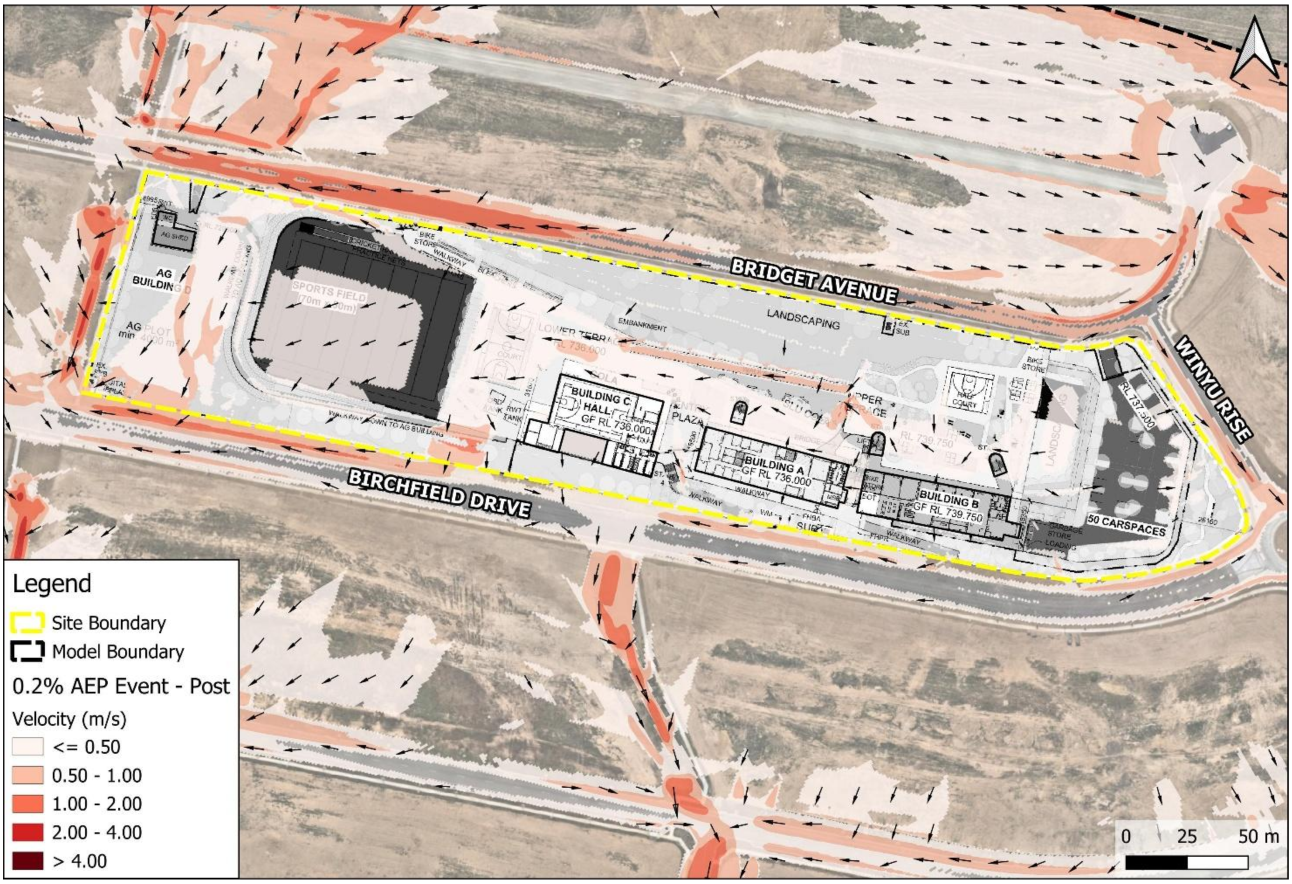


Appendix B 6: 0.5% AEP event – flood hazard classification surrounding the BHS site under post-development conditions

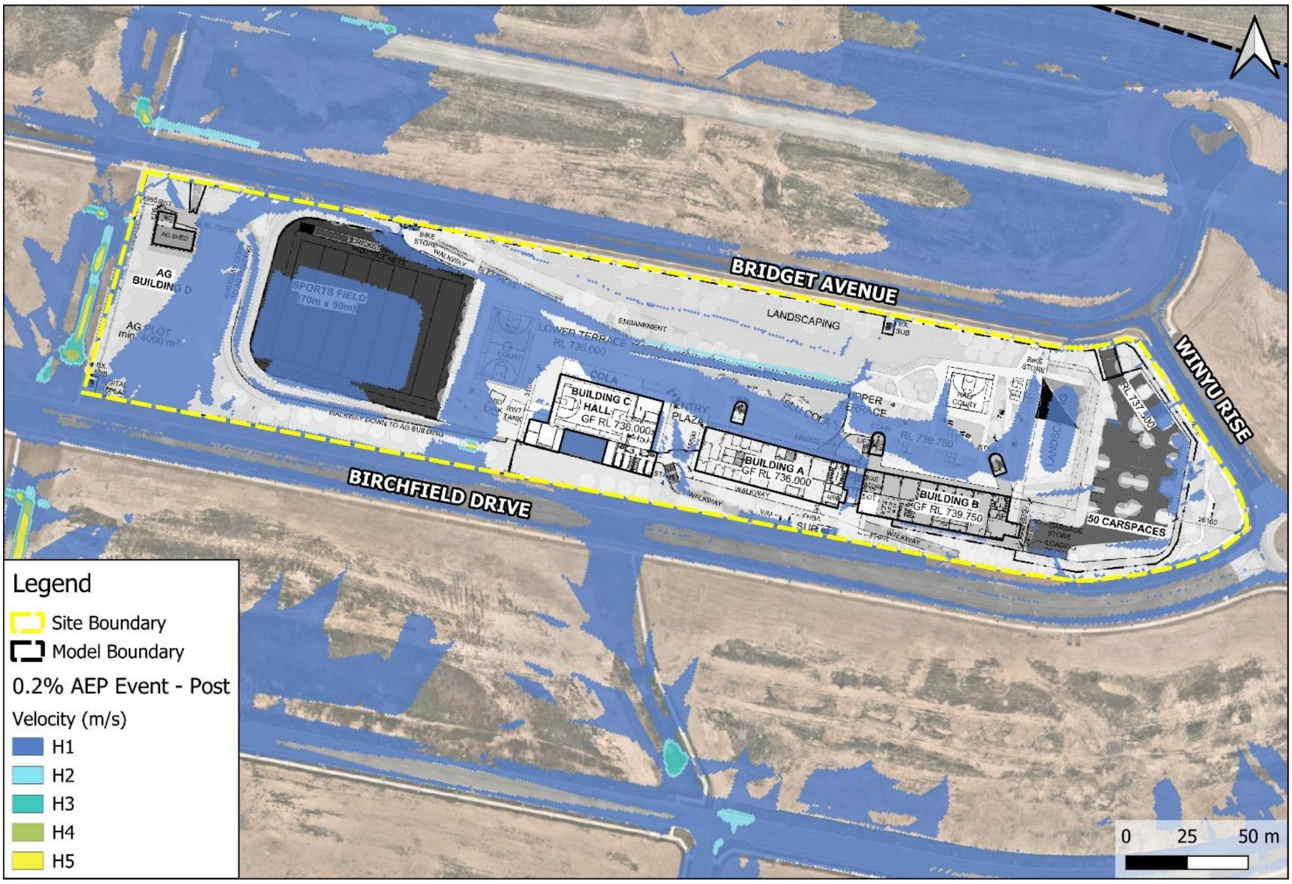
0.2% AEP Event



Appendix B 7: 0.2% AEP event – flood depths and levels surrounding the BHS site under post-development conditions



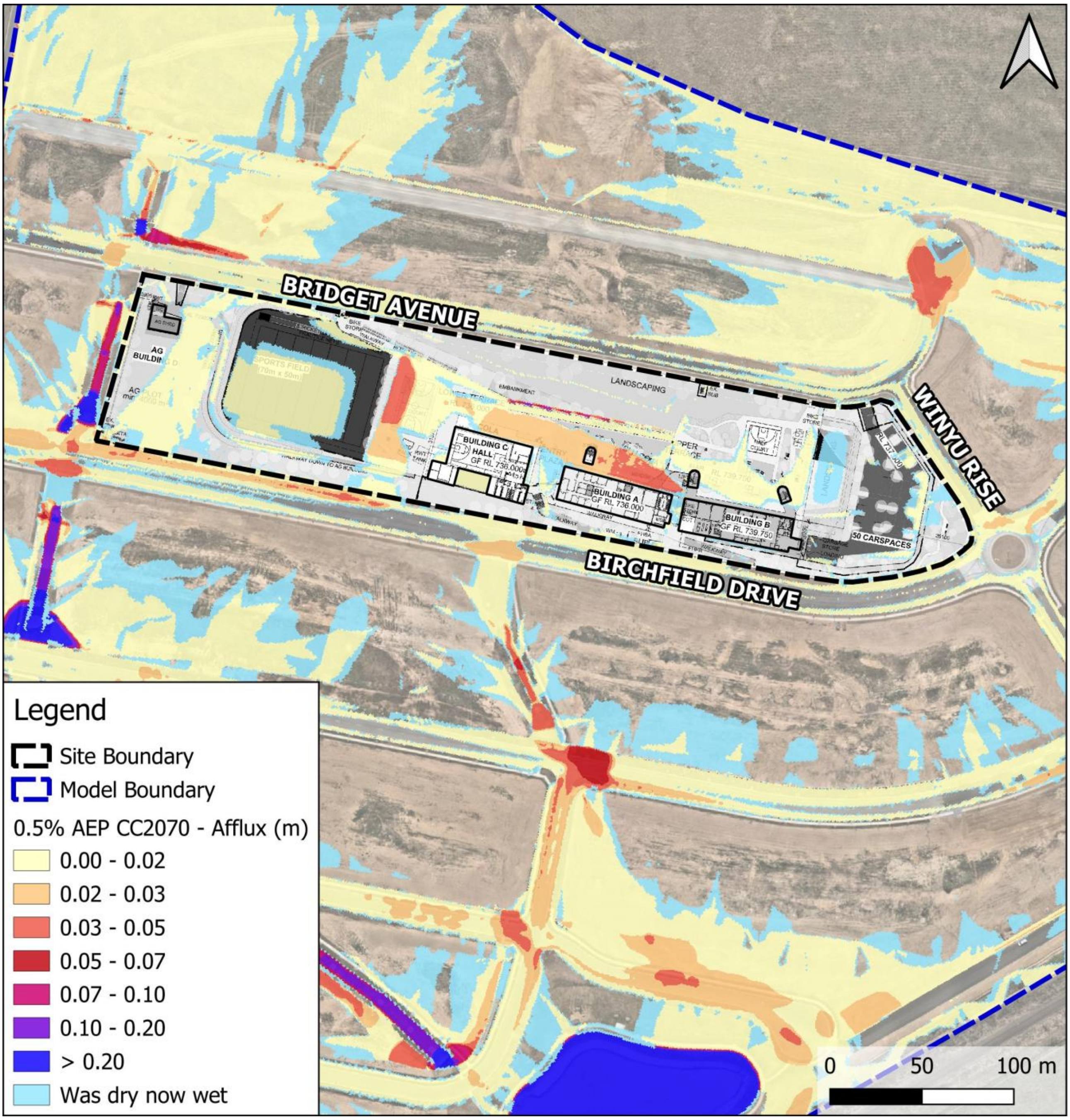
Appendix B 8: 0.2% AEP event – flood velocities surrounding the BHS site under post-development conditions



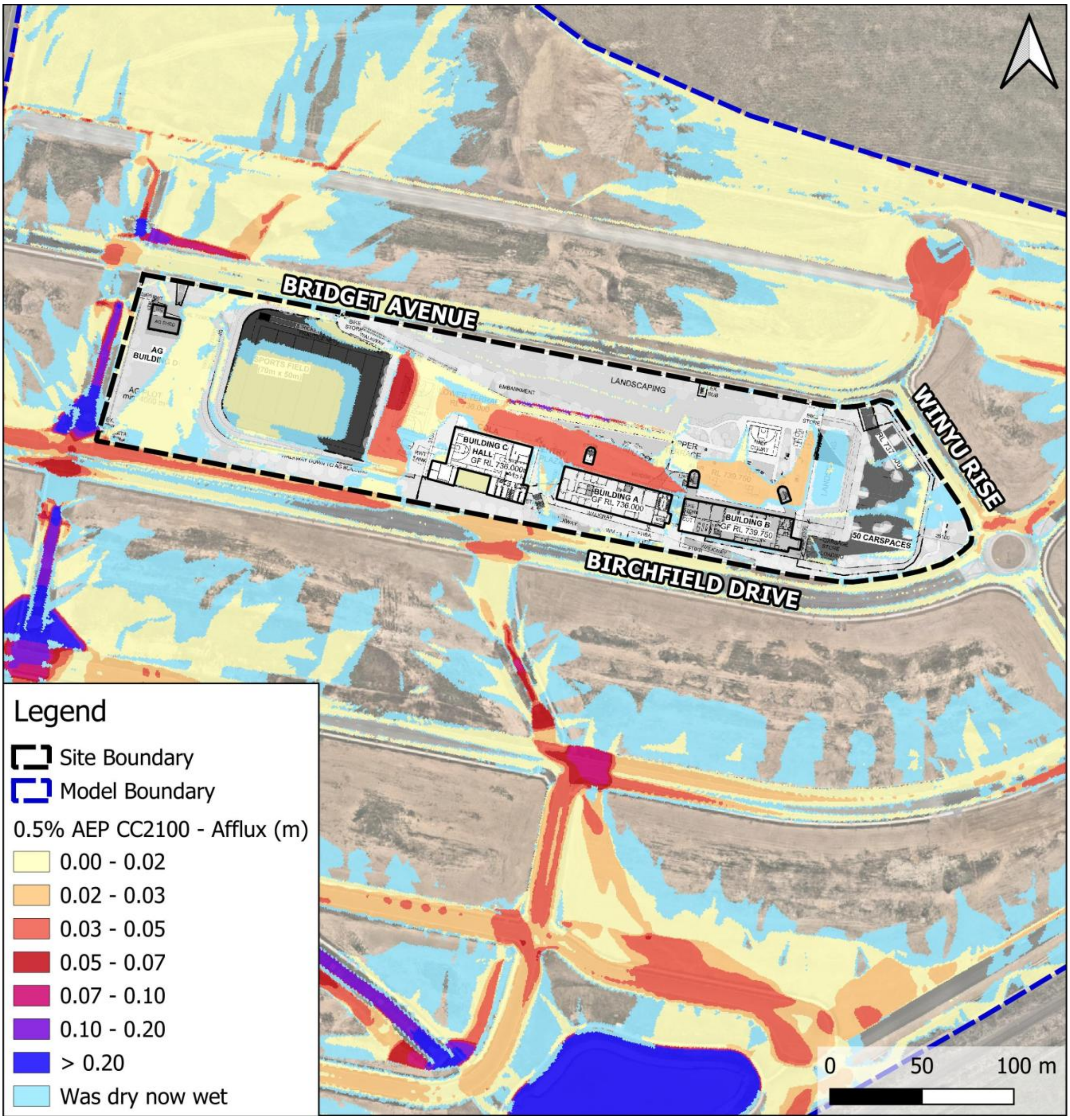
Appendix B 9: 0.2% AEP event – flood hazard classification surrounding the BHS site under post-development conditions

Appendix C – Additional Climate Change Results

0.5% AEP Event

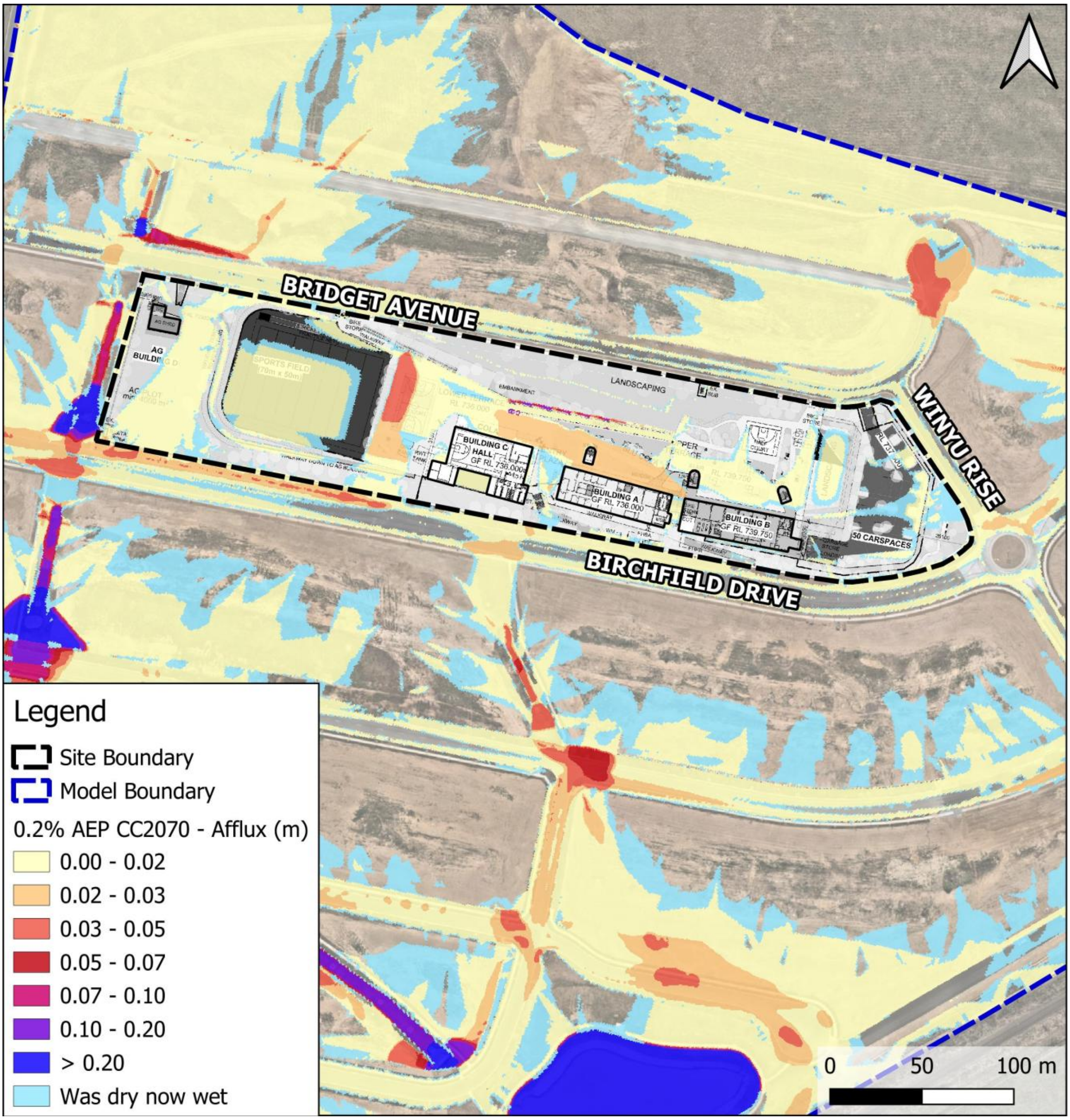


Appendix C 1: Flood level afflux (m) under the 0.5% AEP CC2070 scenario

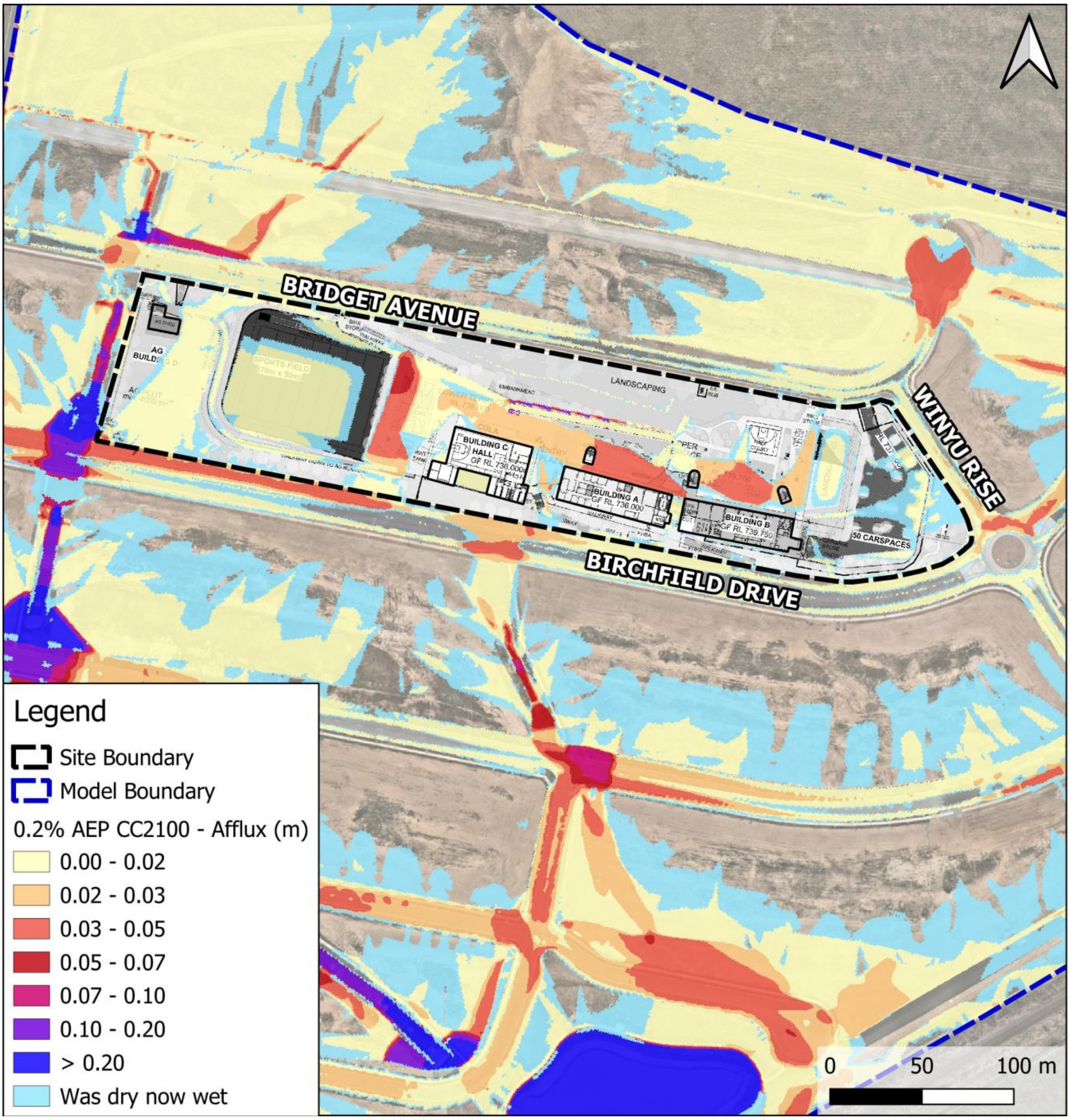


Appendix C 2: Flood level afflux (m) under the 0.5% AEP CC2100 scenario

0.2% AEP Event



Appendix C 3: Flood level afflux (m) under the 0.2% AEP CC2070 scenario



Appendix C 4: Flood level afflux (m) under the 0.2% AEP CC2100 scenario