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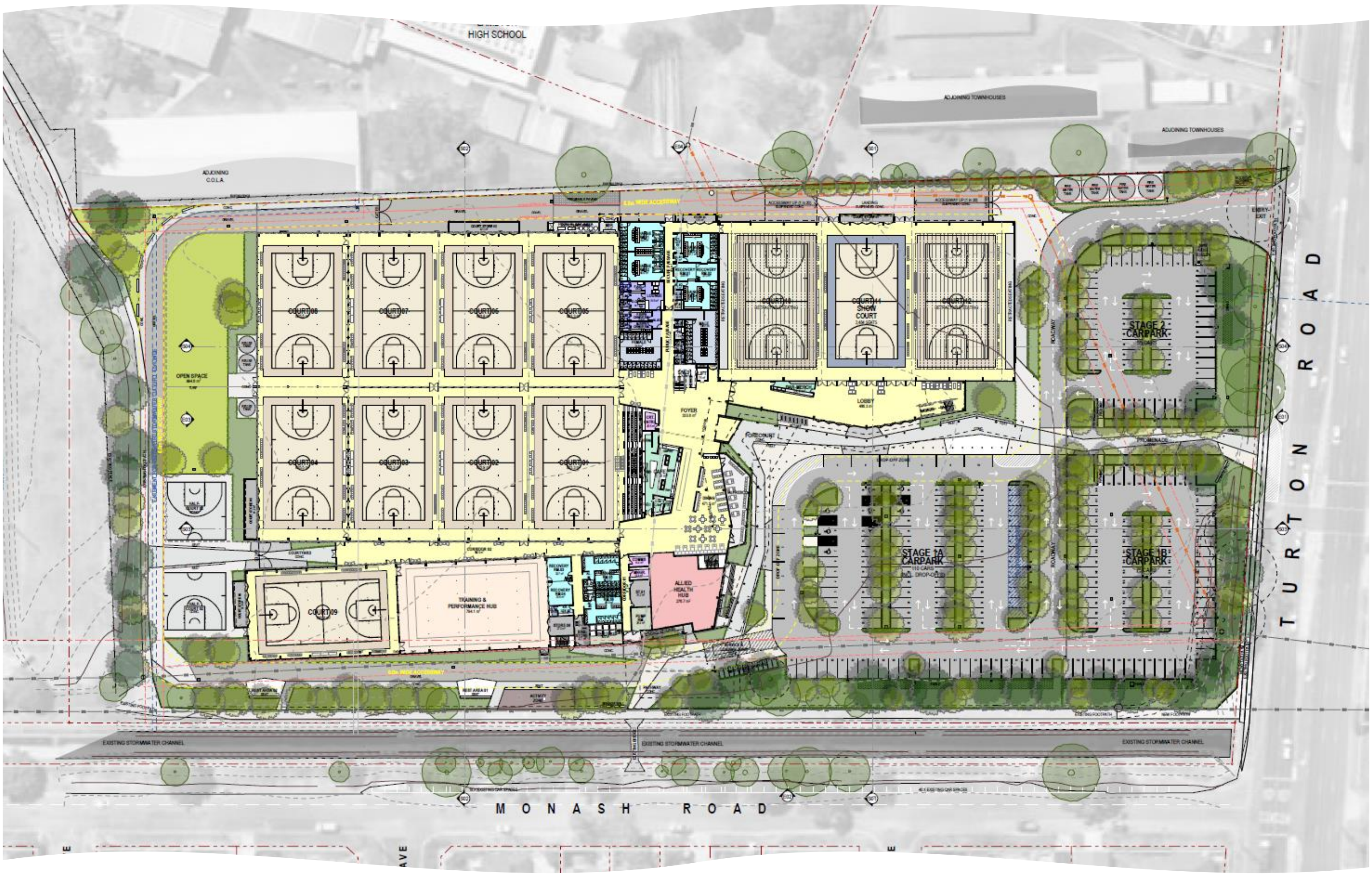
Hunter Indoor Sports Centre

Flood Impact and Risk Assessment

R.T2468.001.03



May 2024

Final Report

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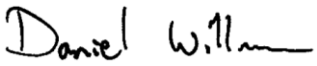

Synopsis

Flood Impact and Risk Assessment for proposed development on the Hunter Indoor Sports Centre at 2 Monash Road and 24 Wallarah Road, New Lambton, NSW.

Revision History

Revision	Description	Date
01	Draft	16/04/2024
02	Draft	15/05/2024
03	Final	20/05/2024

Disclaimer

Executive Summary

This Flood Impact and Risk Assessment is prepared to support the proposed development of the Hunter Indoor Sports Centre at 2 Monash Road and 24 Wallarah Road, New Lambton NSW. The assessment is underpinned by detailed modelling of design flood conditions of the Lambton Ker-rai Creek floodplain for a range of design flood magnitudes.

A TUFLOW software hydrodynamic model was developed to represent existing design flood conditions local to the proposed development. The modelling undertaken has aimed to provide consistency with the recent Throsby, Styx, and Cottage Creeks Flood Study.

The proposed development was designed with consideration of the existing flood risk as defined by the modelling, current flood planning controls and floodplain risk management objectives. The flood assessment investigated the existing and post-development flood conditions for a range of design flood event magnitudes including the 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF events. The future 2050 planning horizon conditions were also assessed for the 1% AEP event.

The developed flood model was utilised to assess the potential impact of any proposed works on existing flood conditions. The impact assessment indicated the proposed development has no material impact on existing flood conditions across the range of flood events considered (10% AEP up to the PMF event).

The proposed development has been assessed against the flood risk management requirements of the Newcastle LEP, Newcastle DCP, and requirements specific to the SEARs. This found the proposed development to satisfy all the requirements except condition C-7 of the Management of Risk to Property section of the Newcastle DCP, which relates to the flood hazard of areas used for car parking.

The DCP Management of Risk to Property condition C-7 requirement cannot be satisfied by the proposed development without impacting the retention of floodways and flood storage or having implications for off-site flood impacts, as this would require significant raising of the external surface levels throughout the proposed car park. Given this conflict between satisfying different aspects of the flood planning controls non-conformance with condition C-7 is considered the better option for overall flood risk management.

Alternative mitigation options can be implemented to manage the risk to vehicles parked at the Site during a flood event from being mobilised by flood waters and potentially impacting flooding elsewhere through resultant blockages. This could include the provision of a suitable bollard arrangement along the northern and southern boundaries of the car park area to prevent vehicles from being washed into the Lambton Ker-rai Creek or other key drainage infrastructure.

The key requirements for development of an effective FERP have been established. The development and adoption of an FERP requires full integration with the site management, health and safety and incident management structures and is typically required prior to occupation. However, the overall flood emergency response strategy, flood intelligence and key components of the FERP were assessed.

The staff members responsible for the FERP should monitor BoM severe weather warnings and be subscribed to the Newcastle Flood Alert Service. The recommended flood emergency response (if

people are present on the Site during a flood) is to seek refuge from flooding within the Site, only vacating the Site when it is safe to do so following the recession of flood inundation. There is however an opportunity to evacuate people from the Site (if required and safe to do so) and for flood emergency egress/ingress during a flood event, from the rear building access to Womboin Road.

The Flood Refuge area is the first-floor level of the building. With an available floor area of around 2000 m^2, the Flood Refuge can accommodate up to 2000 people potentially present on the Site. Being a fully functioning part of the building, the Flood Refuge is inherently well-equipped to service the needs of potential occupancy for an expected period of a few hours.

On-site flood refuge requires structural certification that the proposed building can withstand the expected hydraulic loads of the PMF event. Given the heavy construction type of the building this is expected to be readily achieved. The modelled flood depths adjacent to the building at the PMF event are locally as high as 1.4 m, with peak velocities typically no higher than up to 1.6 m/s. However, the modelled peak velocity is locally as high as 2.1 m/s at the south-eastern corner of the proposed Allied Health Club.

The site management should consider the need to cancel or postpone events if a relevant severe weather warning is issued by the BoM. Travel is typically discouraged in such circumstances due to the risk of heavy rainfall and strong winds increasing the risk of driving. Such advice was in place across Newcastle prior to the April 2015 flood event.

With the recommended flood risk management measures in place, the proposed development is supportable from a flood risk management assessment perspective.

For ease of reference, Table 1 lists the floodplain risk management SEARs and provides the relevant report section in which they are addressed.

Table 1 SEARs Table Response

Project SSD - 65595459	**Section**
SEARs	
13. Flooding Identify and describe any on-site flood impacts and risks associated with the proposed development, having regard to the relevant provisions of the NSW Floodplain Development Manual and other local or State studies and guidance.	6
Describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10 year, 1 in 100 year flood levels and the probable maximum flood, or an equivalent extreme event.	3
• Assess the impacts of the development, including any changes to flood risk both on-site or off-site, and identify any mitigation and management measures to minimise the impacts of flooding on the proposed development.	5.3
Provide a Flood Emergency Response Plan prepared by a suitably qualified person that	7

addresses: • **Likely flood behaviour;** • **Flood warning systems;** • **Education awareness program;** • **Evacuation and evasion procedures;** • **Evacuation routes and flood refuges; and** • Flood preparedness and awareness procedures for visitors.	
BCD Response	
9. The EIS must map the following features relevant to flooding as describe in the Floodplain Development Manual 2005 (NSW Government 2005) including: • Flood prone land • Flood planning area, the area below the flood planning level • Hydraulic categorisation (floodways and flood storage areas)	4 2.3
10. The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10 year, 1 in 100 year flood levels and the probable maximum flood, or an equivalent extreme event.	3
11. The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios: • Current flood behaviour for a range of design events as identified in 11 above. This includes the 1 in 200 and 1 in 500 year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	5.3
12. Modelling in the EIS must consider and document: • The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood. • Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories. • Relevant provisions of the NSW Floodplain Development Manual 2005.	5.3
13. The EIS must assess the impacts on the proposed development on flood behaviour, including: • Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure. • Consistency with Council floodplain risk management plans. • Compatibility with the flood hazard of the land. • Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land. • Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site.	5.3 6.2 6.1

• Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses. • Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council. • Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the SES and Council. • Emergency management, evacuation and access, and contingency measures for the development considering the full range of flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES. • Any impacts the development may have on the social and economic costs to the community as consequence of flooding.	6.2 7 5.3
City of Newcastle Response	
Site specific flood information: The development and the SEARs need to address the below flood conditions of the site: • The Throsby, Styx, and Cottage Creek Flood Study (Rhelm 2023) (TSCC), identifies the subject allotment is affected by Local Catchment Flooding during both the 1% Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF) events. The pertinent characteristics of this flooding are set out in Table 1 of Schedule 1 (attached) for the Applicant's information. • It is noted that the TSCC uses the 1% AEP 2050 as the Defined Flood Event and presents flood hazard using the H1-H6 scale provide in 'Flood Hazard – Flood risk management guideline FB03' by the Department of Planning and Environment (NSW). • A review of flood function diagrams in TSCC 2023 indicates the subject site is bisected diagonally by a large floodway which carries high velocity overland flow overtopping the Lambton Ker-rai Creek during the Probable Maximum Flood event due to flow restrictions at an existing pedestrian bridge over the creek channel. Similarly, a second overland floodway develops immediately downstream at the Turton Road culvert and crosses north through the subject site. Refer to Figures 1 to Figure 4 of Schedule 1 (attached).	3 4 2.3
Flood risk management requirements: The applicant must engage a suitably qualified engineer to address flood risks and flood impacts at the development in accordance with the relevant sections of the Newcastle Development Control Plan 2012 (NDCP 2012). The SEARs should have specific requirements for: • Flood modelling to assess the impacts of the development on existing floodways over the site, with results and recommendations provided in a Flood Impact Assessment Report prepared by a suitably qualified engineer. • Not more than 20% of any flood storage area is filled, or not more than 20% of flood volume is displaced by development over areas identified as flood storage during both the 1% AEP and the PMF events.	5.3 6.2
Flood emergency response plan: A draft flood emergency response plan should be prepared by a	7

professional engineer who is experienced in flood management, and included in documentation for a development proposal. The flood emergency response plan is to include, but not be limited to, the following components: • Likely flood behaviour • Flood warning systems • Education awareness program • Evacuation and evasion procedures • Evacuation routes and flood refuges, and • Flood preparedness and awareness procedures for visitors. Considerations are to include the full range of flood risks, the proposed use of the site, site access constraints and local area evacuation routes to high ground. The plan is to be aimed at self-directed evacuation or evasion to minimise the draw on limited State Emergency Services resources.	

Contents

List of Figures

List of Tables

1 Introduction

1.1 Project Overview

Torrent Consulting has been commissioned by Basketball Association of Newcastle Limited (BANL) to prepare this report in accordance with the technical requirements of the Secretary's Environmental Assessment Requirements (SEARs), and in support of the State Significant Development Application (SSD- 65595459) for the proposed Hunter Indoor Sport Centre with courts, indoor stadium, amenities and associated civil and landscaping works, at 2 Monash Road and 24 Wallarah Road, New Lambton (the Site).

The site is located at 2 Monash Road and 24 Wallarah Road, New Lambton (refer to Figure 1-1), within the Newcastle local government area (LGA). The site comprises multiple parcels of land and is legally described as:

- Lot 2380 DP755247
- Lot 2379 DP755247
- Lot 2378 DP755247
- Lot 2377 DP755247

The project area also includes the land on which the existing amenities block is located.

The Site is located beside Lambton Ker-rai Creek, which is a tributary of Styx Creek, located some 450 m downstream. The Site is known to be flood-prone, as identified in the Newcastle City-wide Floodplain Risk Management Study (BMT WBM, 2012) and the recent update to the Throsby, Styx, and Cottage Creeks Flood Study (Rhelm, 2023).

This Flood Impact and Risk Assessment supports a State Significant Development Application for the proposed construction of the HISC within the Site.

1.2 Scope of Assessment

This flood impact and risk assessment aims to review the existing design flooding constraints at the Site, investigate Site development potential and associated flood impacts, and identify potential flood mitigation options, if required. The Site location in the context of the local floodplain topography is shown in Figure 1-2.

The key components of the assessment summarised in the following document include :

- Review of existing flood risk information including previous studies and available flood mapping.
- Review of relevant flood related planning controls and development guidelines.
- Establishment of numerical hydraulic model to define existing flood risk for the Site and development constraints.
- Flood impact assessment of proposed development using hydraulic model and identify requirement for flood mitigation.
- Review flood warning and emergency response opportunity.
- Assessment of compatibility of proposed development with established flood risk.

Title:

Study Locality

0 100 200 m

approx. scale

Figure: 1-1

Revision: A

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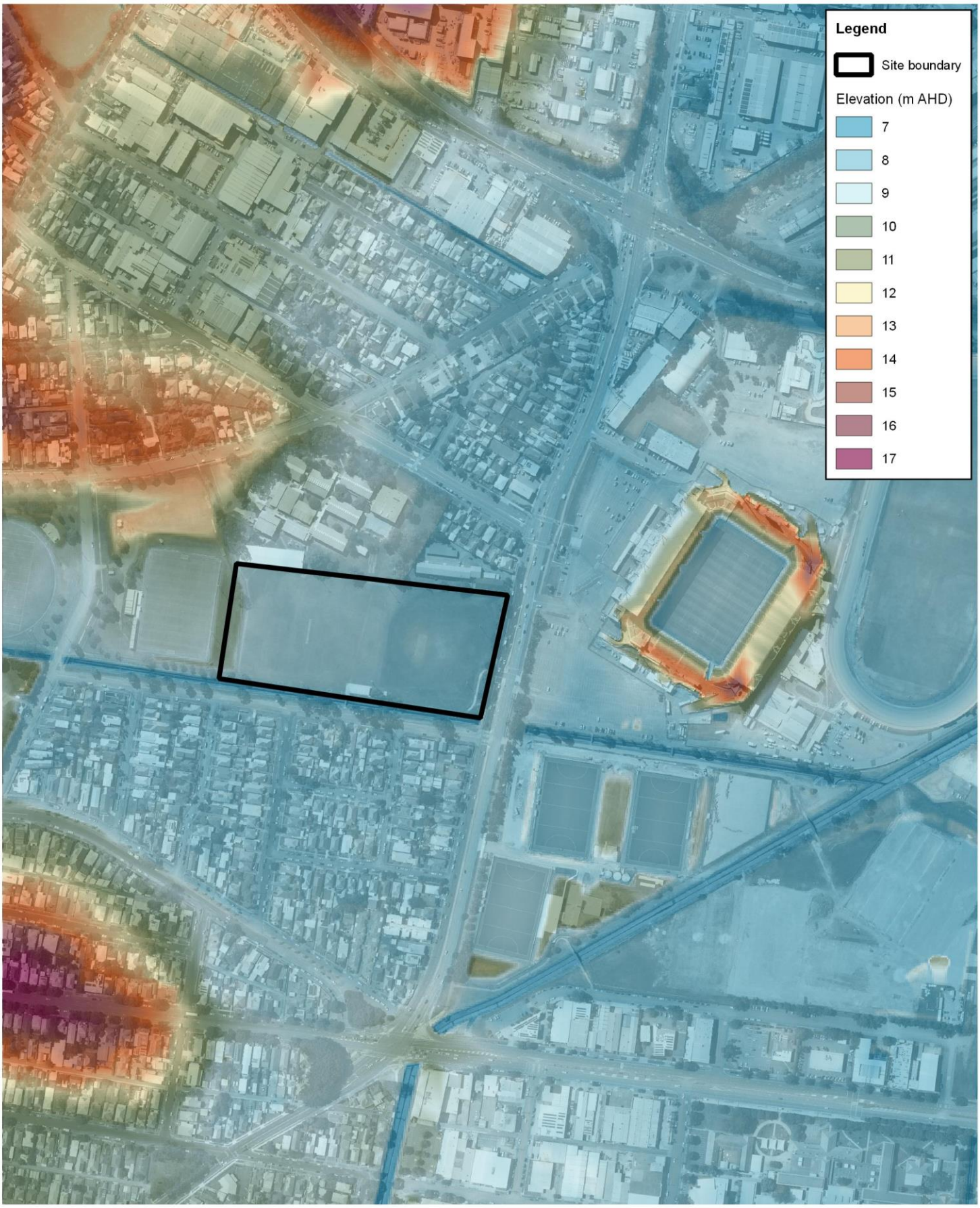

Title:

Local Floodplain Topography

0 100 200 m

approx. scale

Figure: **1-2**

Revision: **A**

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2 Flood Planning Requirements

A summary of relevant planning provisions with respect to flood risk management is provided hereunder.

2.1 Planning Secretary's Environmental Assessment Requirements

The Planning Secretary's Environmental Assessment Requirements (SEARs) relating to the proposed State Significant Development (SSD) were issued by the NSW Department of Planning and Environment on 22 January 2024 (SSD-65595459). The requirements relating to flooding are reproduced below.

The EIS must:

- identify and describe any on-site flood impacts and risks associated with the proposed development, having regard to the relevant provisions of the NSW Floodplain Development Manual and other local or State studies and guidance.
- describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10 year, 1 in 100 year flood levels and the probable maximum flood, or an equivalent extreme event.
- assess the impacts of the development, including any changes to flood risk both on-site or off-site, and identify any mitigation and management measures to minimise the impacts of flooding on the proposed development.
- Provide a Flood Emergency Response Plan prepared by a suitably qualified person that addresses:
    - Likely flood behaviour;
    - Flood warning systems;
    - Education awareness program;
    - Evacuation and evasion procedures;
    - Evacuation routes and flood refuges; and
    - Flood preparedness and awareness procedures for visitors.
- address matters raised by Biodiversity Conservation Division (BCD) at Attachment B.
- address matters raised by Council at Attachment B.

The BCD requirements in Attachment B referenced above are consistent with those typically issued in SEARs and can be summarised as:

- Map flood prone land, the flood planning area and flood function.
- Describe the flood assessment and modelling undertaken.
- Include the 10% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF events.
- Assess the impact of the proposed development on the existing flood behaviour.

The Council requirements in Attachment B request:

- Address the flood risks and flood impacts in accordance with the Newcastle DCP.
- Flood modelling to assess the impacts of the development on the existing floodways within the site.
- To not fill more than 20% of the flood storage area at either the 1% AEP or PMF event.
- Preparation of a Flood Emergency Response Plan.

2.2 Newcastle Local Environmental Plan (2012)

The Newcastle Local Environment Plan (LEP) 2012 provides a framework for development of land and land use in the City of Newcastle LGA. Clause 5.21 relates to flood planning which states the following objectives:

a) to minimise the flood risk to life and property associated with the use of land;

b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change;

c) to avoid significant adverse impacts on flood behaviour and the environment.

d) to enable the safe occupation and efficient evacuation of people in the event of a flood.

In supporting these objectives, the LEP includes provision that development consent must not be granted unless the consent authority is satisfied that the development:

(a) is compatible with the flood function and behaviour on the land, and

(b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and

(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and

(d) incorporates appropriate measures to manage risk to life in the event of a flood, and

(e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.

2.3 Newcastle Development Control Plan (2023)

The Newcastle Development Control Plan (DCP 2023) supplements the LEP 2012 by outlining controls that apply to various types of development across the LGA. Specifically, the DCP outlines development principles, objectives and standards that are intended to assist in the preparation of development applications by development proponents, and in the assessment of development applications by Council. Section B1(b) of the DCP 2023 specifically relates to development on flood prone land within areas for which a flood study has been undertaken after the release of the Australian Rainfall and Runoff (ARR) 2019 Guidelines.

The DCP 2023 specifies controls which are to be met for the development of flood-prone land, which fall under four objectives:

- The retention of floodways
- The protection of flood storage areas
- The management of risk to property
- The management of risk to life.

The controls supporting these objectives are detailed in Section 2.3.1 to Section 2.3.4.

2.3.1 Floodways

The planning controls relating to the retention of floodways are:

- C-1: no building or structure can be built, and no land can be filled with any materials in areas identified as floodways, except for small changes to ground levels that do not significantly change the flow patterns for roads, parking, below ground structures or landscaping.
- C-2: where dividing fences across floodways are unavoidable, they are constructed only of open type fencing that does not restrict the flow of flood waters and are resistant to blockage. New development is designed to avoid fences in floodways.

Mapping of floodways is provided by Council in Flood Function mapping at the 1% AEP 2050 planning horizon and the PMF events, as shown in Figure 2-1 and Figure 2-2, respectively. The 1% AEP mapping shows a floodway propagating northwards from the Lambton Ker-rai Creek channel into the south-east corner of the Site. At the PMF event the floodway extends across the eastern side of the Site and continuing northwards along Turton Road. A secondary floodway is also shown at the PMF event that traverses the Site in a north-easterly direction, joining the primary floodway in the north-east corner of the Site.

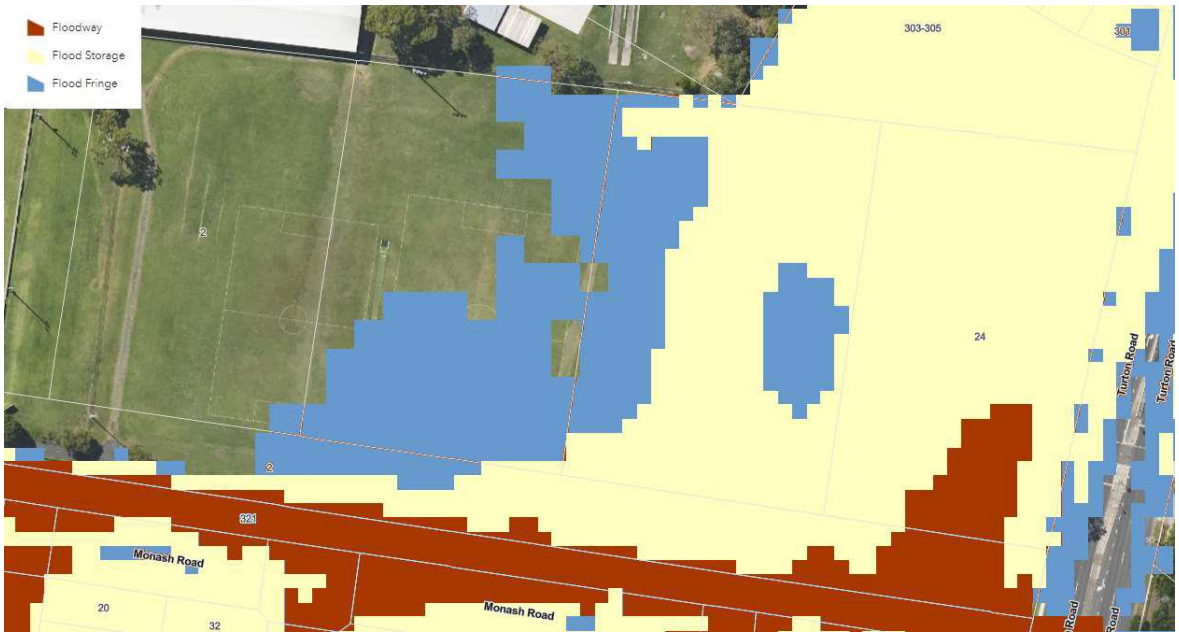


Figure 2-1 1% AEP (2050) Flood Function from Rhelm, 2023

While the consideration of floodways for events rarer than a 1% AEP is warranted, it is considered unreasonable to enforce planning controls based on a mapped floodway extent at the PMF event. This is due to the relatively arbitrary methods of floodway definition employed in flood studies and the extreme rarity of such event, which in small catchments such as the Throsby Creek system is around a 1-in-10-million annual probability.

Ultimately a floodway is best defined as land within which any obstructions will significantly impact flood behaviour, with relative flood impact assessment being used as a tool to determine this.

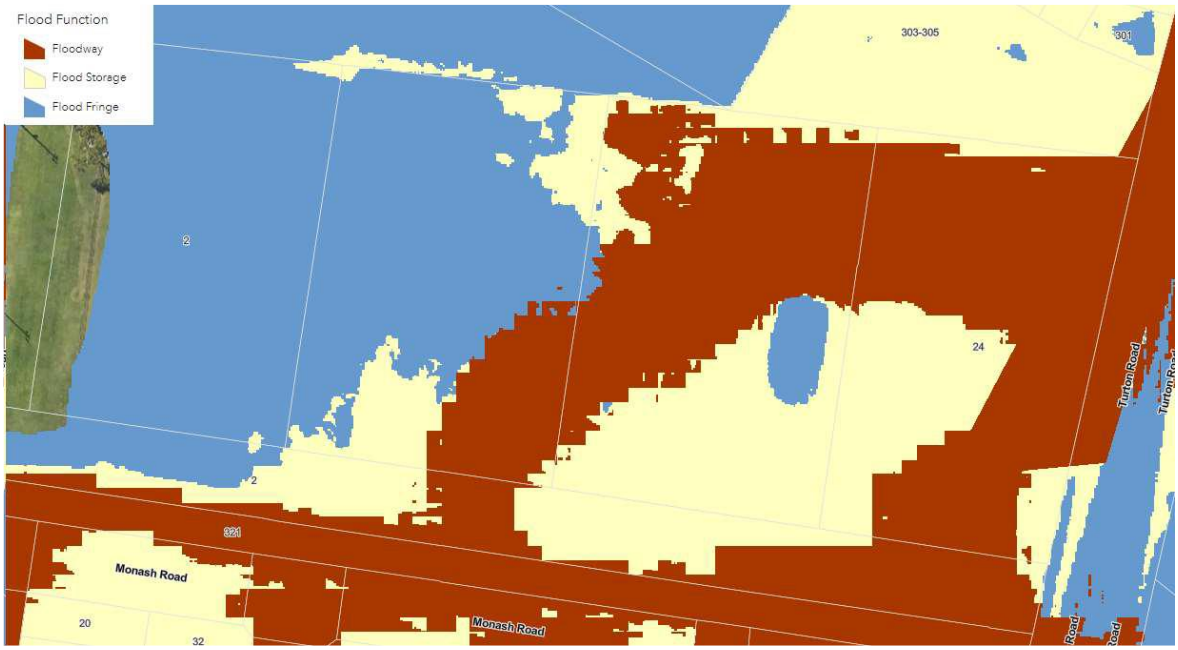


Figure 2-2 PMF Flood Function from Rhelm, 2023

2.3.2 Flood Storage Areas

The planning controls relating to the protection of flood storage areas are:

- C-1: not more than 20% of the area of any development site in a flood storage area is filled. The remaining 80% is generally developed allowing for underfloor storage of floodwater by the use of suspended floor techniques such as pier and beam construction.
- C-2: where it is proposed to fill development sites, the fill does not impede the flow of ordinary drainage from neighbouring properties, including overland flow.

Mapping of flood storage areas is provided by Council in Flood Function mapping at the 1% AEP 2050 planning horizon and the PMF events, as shown in Figure 2-1 and Figure 2-2, respectively. The flood storage area covers around the eastern 40% of the Site at the 1% AEP event, increasing to around the eastern 50% at the PMF event.

2.3.3 Management of Risk to Property

The planning controls relating to the management of risk to property from flooding are:

- C-1: floor levels of all occupiable rooms of all buildings are not set lower than the FPL.
- C-2: garage floor levels are no lower than the 1% 2050 AEP event. However, it is recognised that in some circumstances this may be impractical due to vehicular access constraints. In these cases, garage floor levels are as high as practicable.
- C-3: Basement garages may be acceptable where all potential water entry points are at or above the PMF, excepting that vehicular entry points can be at the FPL. In these cases, explicit points of refuge are accessible from the carpark in accordance with the controls for risk to life set out below.
- C-4: electrical fixtures such as power points, light fittings and switches are sited above the FPL unless they are on a separate circuit (with earth leakage protection) to the rest of the building.

- C-5: swimming pools are to be located to ensure they are not inundated from minor flooding events. Electrical connections and fixtures around swimming pools are to be sited at the FPL.
- C-6: Where parts of the building are proposed below the FPL, they are constructed of water-resistant materials.
- C-7: areas where cars, vans and trailers are parked, displayed or stored are only located in areas subject to property hazard of P1. Containers, bins, hoppers and other large floatable objects are not to be stored in these areas. Heavy vehicle parking areas can only be located in locations subject to P1 or P2 categories.
- C-8: timber framed, light steel construction, cavity brickwork and other conventional domestic building materials are generally suitable forms of construction where the property hazard is P1 to P4.
- C-9: property hazard of P5 is generally unsuitable for building construction and building is discouraged from these areas. Where building is necessary, the structure is certified by a practising structural engineer to withstand the hydraulic loads (including debris) induced by the flood waters.
- C-10: property hazard of P6 is unsuitable for any type of building construction.

The risk to property hazard categories P1 to P6 are defined as the 1% AEP (2050) H1 to H6 hazards of the classification system defined in Guideline 7-3 of the Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR, 2017). The hazard classification system is based on a combination of flood depth, flood velocity and the velocity-depth product, as shown in Figure 2-3.

2.3.4 Management of Risk to Life

The planning controls relating to the management of risk to life from flooding are:

- C-1: risk to life category L5 is generally unsuitable for building construction and building is discouraged from these areas. Reliable safe escape to high ground is likely not possible and normal building construction would likely suffer structural failure from the force of floodwaters, so that any people seeking refuge in the building would likely perish. Where building is necessary, the structure is certified by a practising structural engineer to withstand the hydraulic loads (including debris) induced by the flood waters.
- C-2: risk to life category of L6 is unsuitable for any type of building construction.
- C-3: the formation of islands in the floodplain during a flood is a potentially dangerous situation, especially when floods larger than the FPL totally inundate the island for an extended period. Development of such land is considered with great care.
- C-4: on-site refuge is to be provided for all development where the risk to life category is L3 or higher unless: the proposed development is less than 40 m from the perimeter of the PMF extent and the higher ground is accessible, or the proposed use is defined as commercial premises or industry in which case onsite refuge is only required where the hazard category is L4 or higher.
- C-5: where on-site refuge is required for a development, it should comply with the following minimum standards: the minimum on-site refuge level is the level of the PMF. On-site refuges are designed to cater for the number of people reasonably expected on the development site and are provided with emergency lighting, and on-site refuges are of a

construction type able to withstand the effects of flooding. Design certification by a practising structural engineer that the building is able to withstand the hydraulic loading due to flooding (at the PMF).

- C-6: emergency egress procedure for basements. A plan is developed detailing emergency egress procedures during a flood, as well as any refuge areas in reasonable proximity of the development. The plan is to be positioned in the basement car park in an easily recognisable location/s.

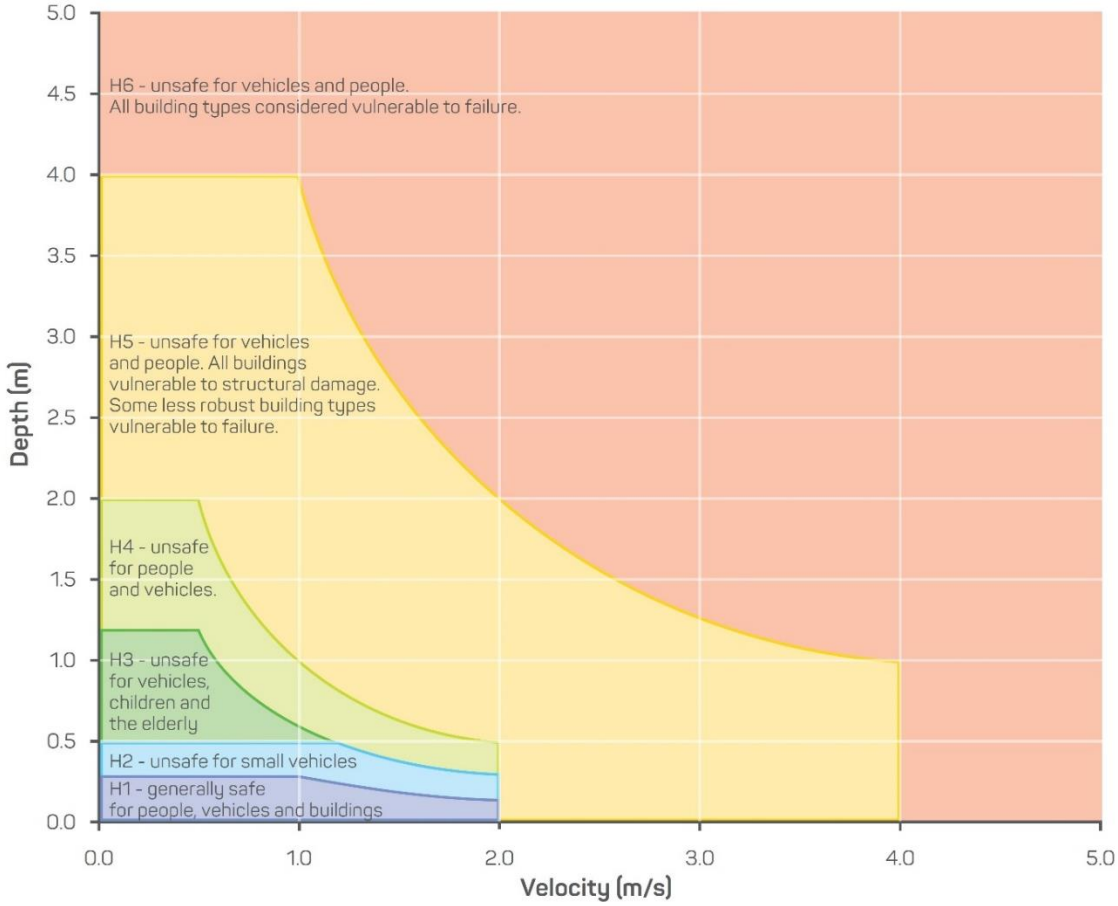


Figure 2-3 General Flood Hazard Vulnerability Curves (AIDR, 2017)

The risk to life hazard categories L1 to L6 are determined from the PMF H1 to H6 hazards of the AIDR classification system, with H1-H2 becoming L2 and H3-H6 mapping to L3-L6, respectively. The L1 classification is for Hunter River and ocean flooding, where significant warning times limit the risk to life.

3 Model Development

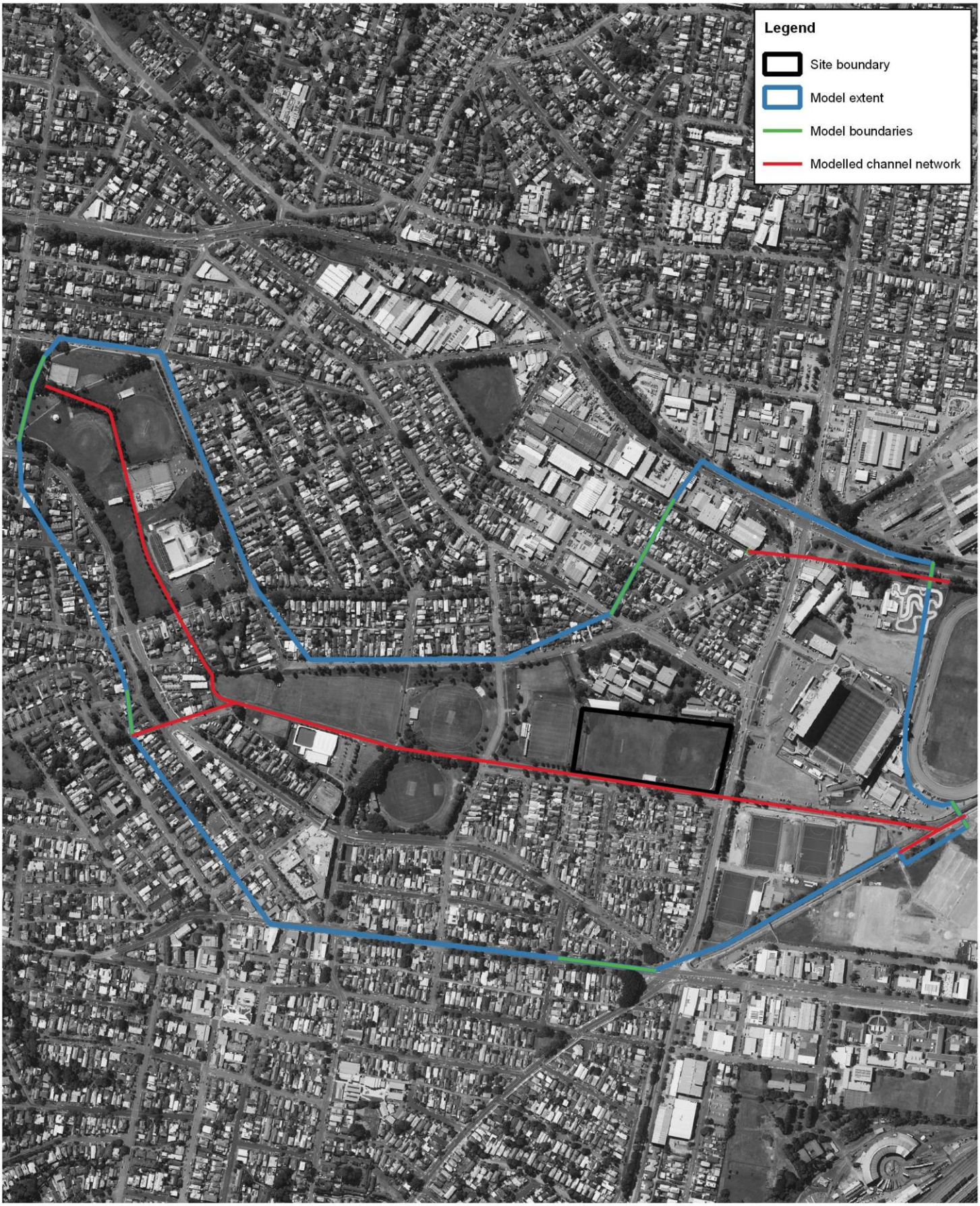
Detailed flood modelling of the Site is included within the recent update to the Throsby, Styx, and Cottage Creeks Flood Study (Rhelm, 2023). However, this study is still in the process of being finalised with regards to model handover and the protocols of future model use. Therefore, a TUFLOW model covering the area local to the Site has been developed to enable the undertaking of a relative flood impact assessment.

The TUFLOW model was developed from an existing model prepared by Torrent Consulting for City of Newcastle in the assessment of local pedestrian bridge rail replacement works. It utilises the 2014 NSW Spatial Services LiDAR data product, downloaded via the ELVIS Foundation Spatial Data portal to define the floodplain topography. A 2 m model grid cell resolution was adopted, with sub-grid sampling from a 1 m resolution DEM.

Channel and structure geometry was sourced from the original Throsby, Styx, and Cottage Creeks TUFLOW model (BMT WBM, 2012) and modelled as a 1-D network, dynamically linked to the 2-D floodplain representation. Appropriate model inflows and downstream boundary conditions were also extracted from the original TUFLOW model. The extent and configuration of the model is presented in Figure 3-1.

To better represent the local conditions modelled in the 2023 flood study, consistent structure blockage and hydraulic roughness parameters were adopted, and the model inflows were then scaled to provide a reasonable match with the flood extents and levels presented in the flood study mapping.

The simulated flood conditions include the 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP (2050) and PMF events. The 1% AEP event under expected future climate change conditions at the 2050 planning horizon has also been simulated.



Title:

Local TUFLOW Model Configuration

0 200 400 m

approx. scale

Figure: 3-1

Revision: A

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4 Design Flood Conditions

A comparison of the design flood extents for the 10% AEP, 1% AEP (2050) and PMF events is shown in Figure 4-1, providing an indication of the increase in flood extent with increasing flood magnitude. Around 30% of the Site is inundated at the 10% AEP event, around 70% at the 1% AEP event and almost the entire Site at the PMF event. The Flood Planning Area (FPA) is defined as the land that is elevated below the FPL, the extent of which is included in Figure 4-1. The building footprint of the proposed development is also shown for context.

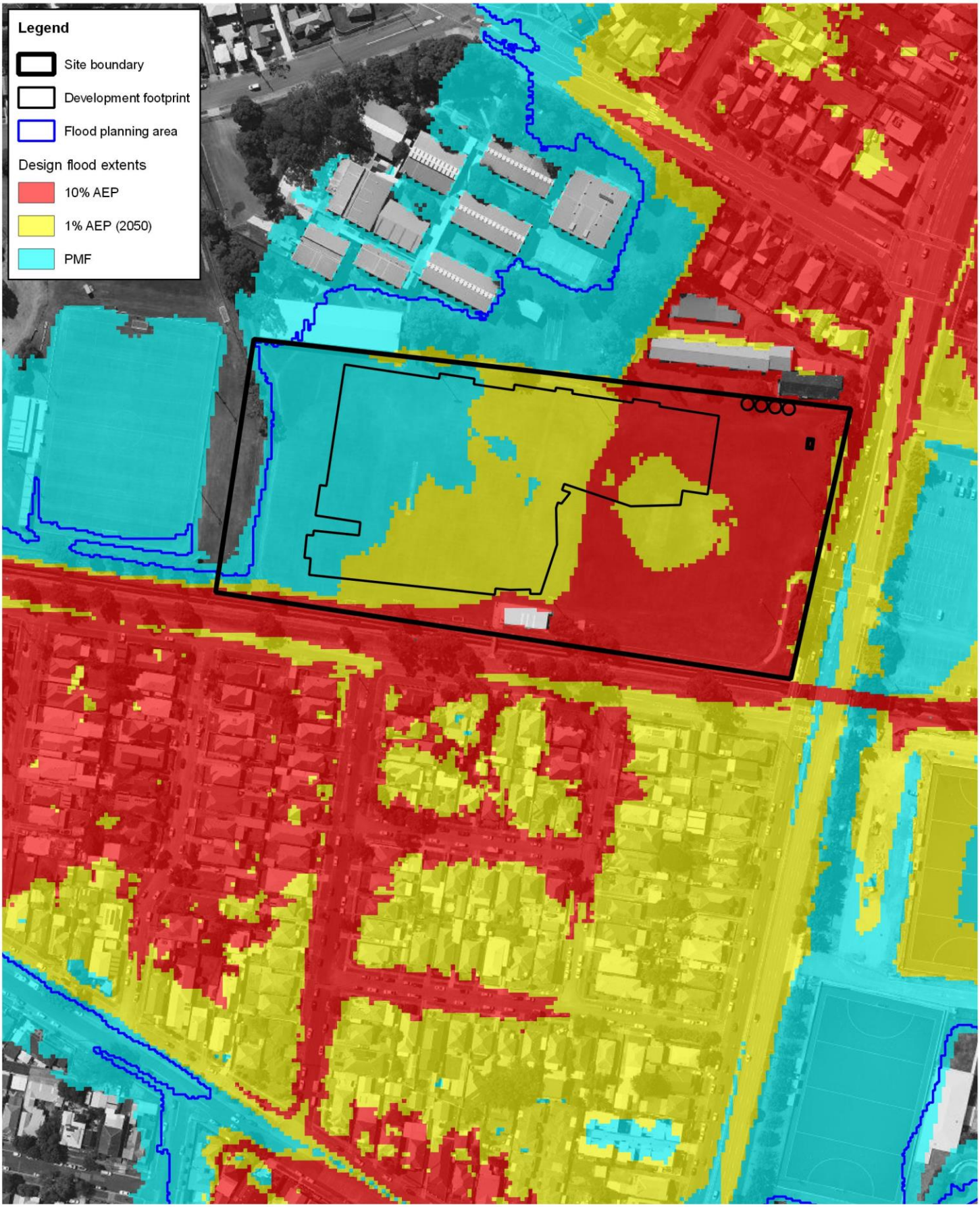
Careful consideration was given to the location of the proposed building to minimise potential impacts on flooding, whilst maintaining a visible frontage from Turton Road. Figure 4-2 presents the modelled flood flow distribution (velocity-depth product) at the 1% AEP (2050) event. It shows that flood flows are concentrated along and immediately adjacent to the Lambton Ker-rai Creek channel. When the capacity of the channel is exceeded, the physical obstruction of Turton Road and the Newcastle International Hockey Centre directs excess floodwaters overland thorough the Site, before flowing north (and downhill) along Turton Road to the drainage alignment running east along the southern side of Griffiths Road.

The function of the south-eastern corner and eastern edge of the Site as an important floodway for the conveyance of overland flow is evident in the yellow colouration mapped in Figure 4-2. The location of the building footprint has been designed to sit outside of the highly convective areas of the floodplain. It should be noted that the existing building structure located between the channel and the proposed building footprint is to be demolished as part of the development and so the flow path around the northern side if the building will realign itself parallel to the channel.

Figure 4-3 to Figure 4-5 show the modelled peak flood depth for the 10% AEP, 1% AEP (2050) and PMF events. At the 10% AEP event the Site is inundated by relatively shallow flood waters, to a depth of up to 0.5 m. The deepest depths within the Site increase to around 0.8 m at the 1% AEP (2050) event and to around 1.8 m at the PMF event.

Figure 4-6 to Figure 4-8 show the flood hazard mapping using the AIDR General Flood Hazard Vulnerability Curves (as shown in Figure 2-3) for the 10% AEP, 1% AEP (2050) and PMF events. At the 10% AEP event the Site is essentially a low hazard (H1-H2) flood environment. The lowest-lying part of the Site becomes a medium hazard (H3) flood environment at the 1% AEP (2050) event. At the PMF event most of the Site is a medium hazard (H3-H4) flood environment, with the southern 40 m of the Site becoming a high hazard (H5) flood environment.

Flood depth and flood hazard mapping for existing conditions is provided for additional design flood events in Appendix A.



Title:

Modelled Design Flood Extents

0 60 120 m

approx. scale

Figure: **4-1**

Revision: **A**

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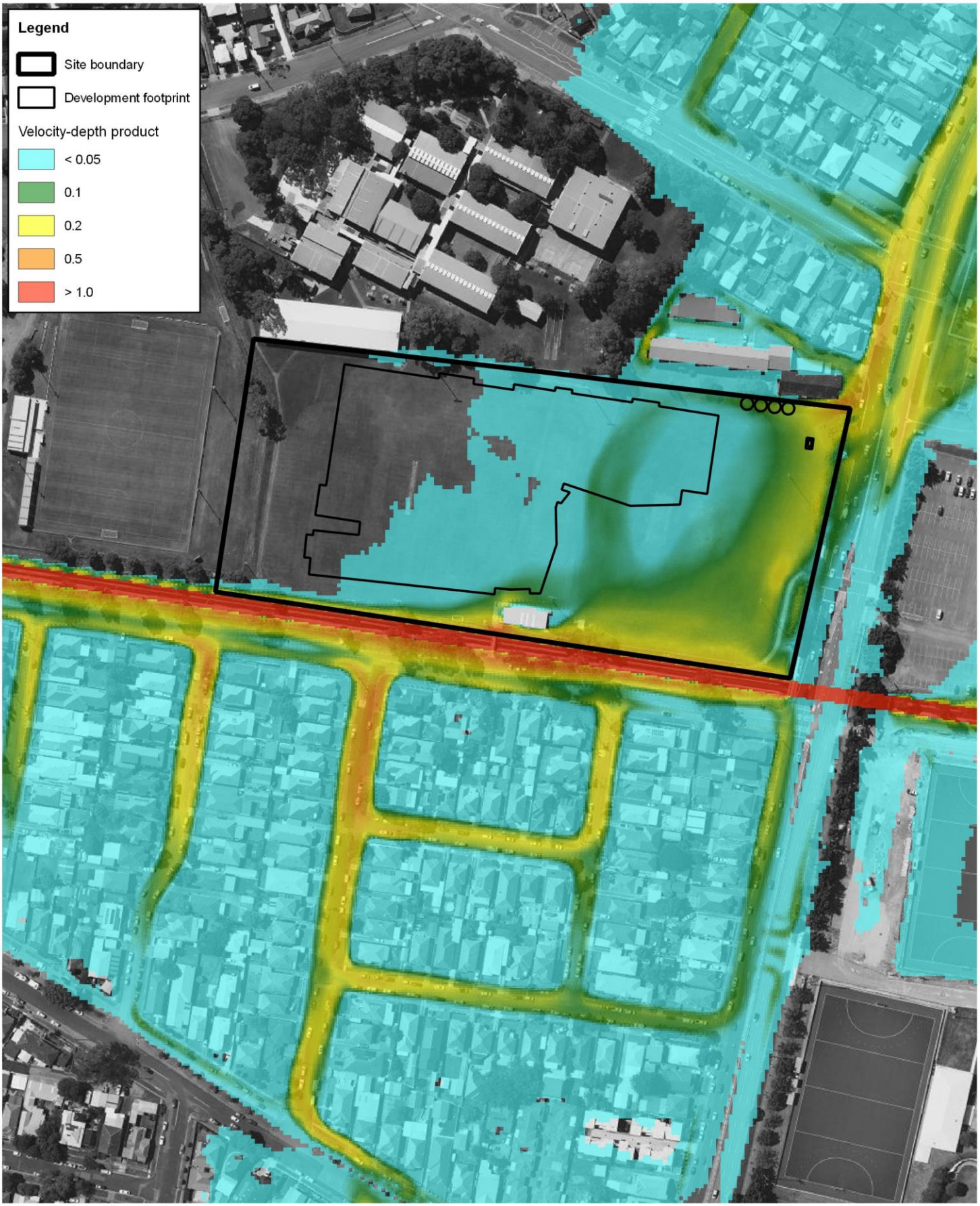

Title:

Modelled 1% AEP (2050) Flood Flow Distribution

0 60 120 m

approx. scale

Figure: **4-2**

Revision: **A**

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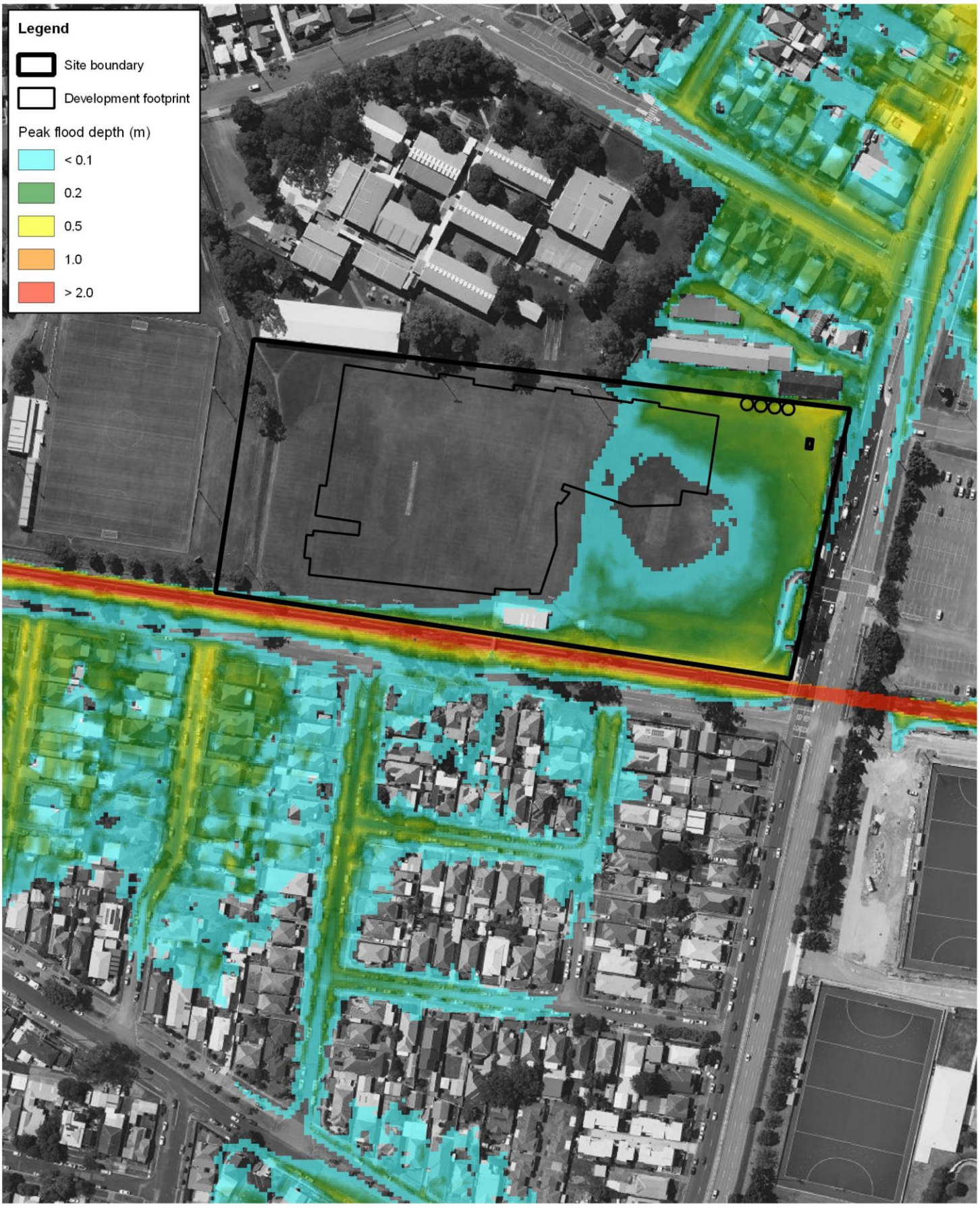

Title:

Modelled 10% AEP Peak Flood Depth

0 60 120 m

approx. scale

Figure: **4-3**

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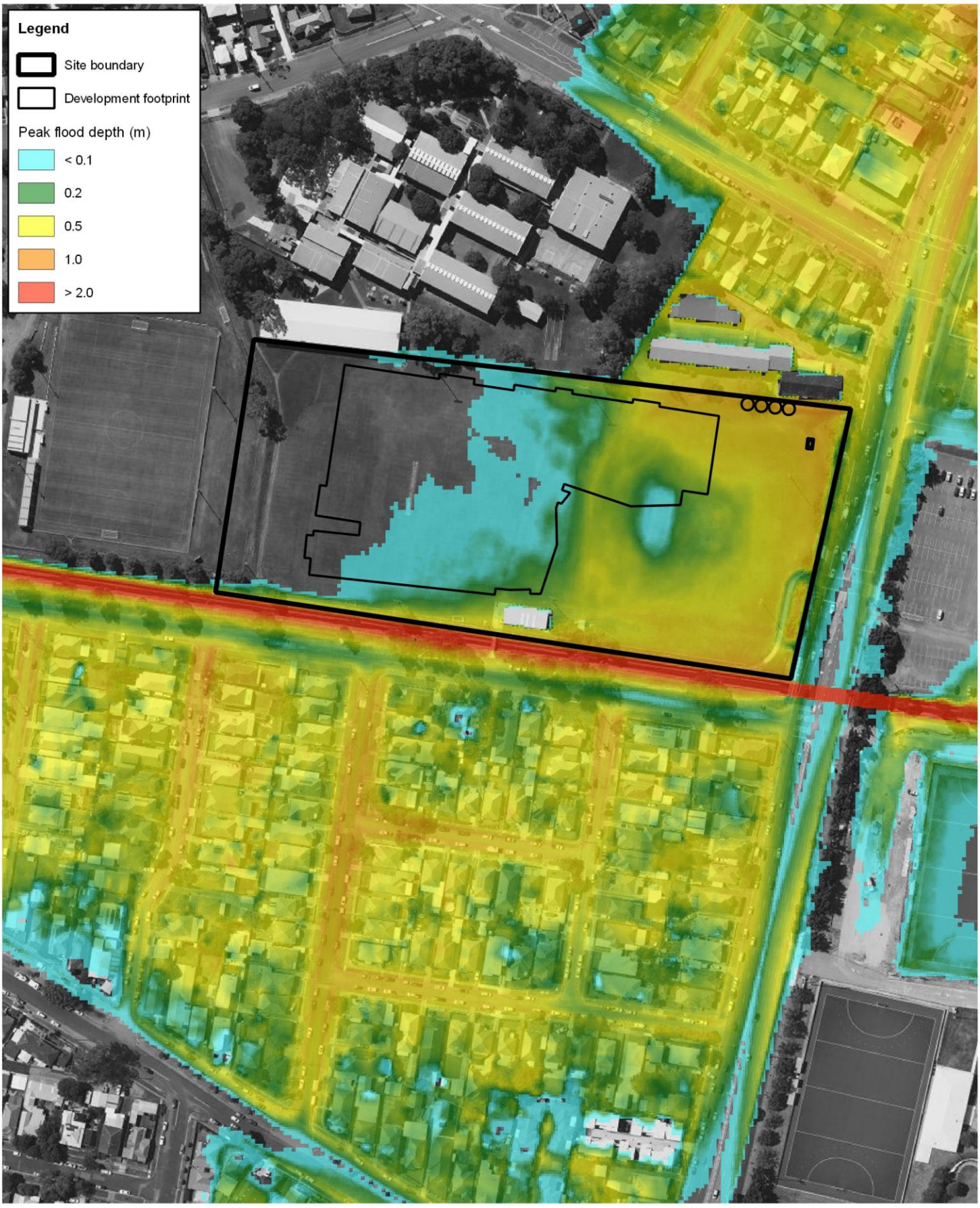

Title:

Modelled 1% AEP (2050) Peak Flood Depth

0 60 120 m

approx. scale

Figure: **4-4**

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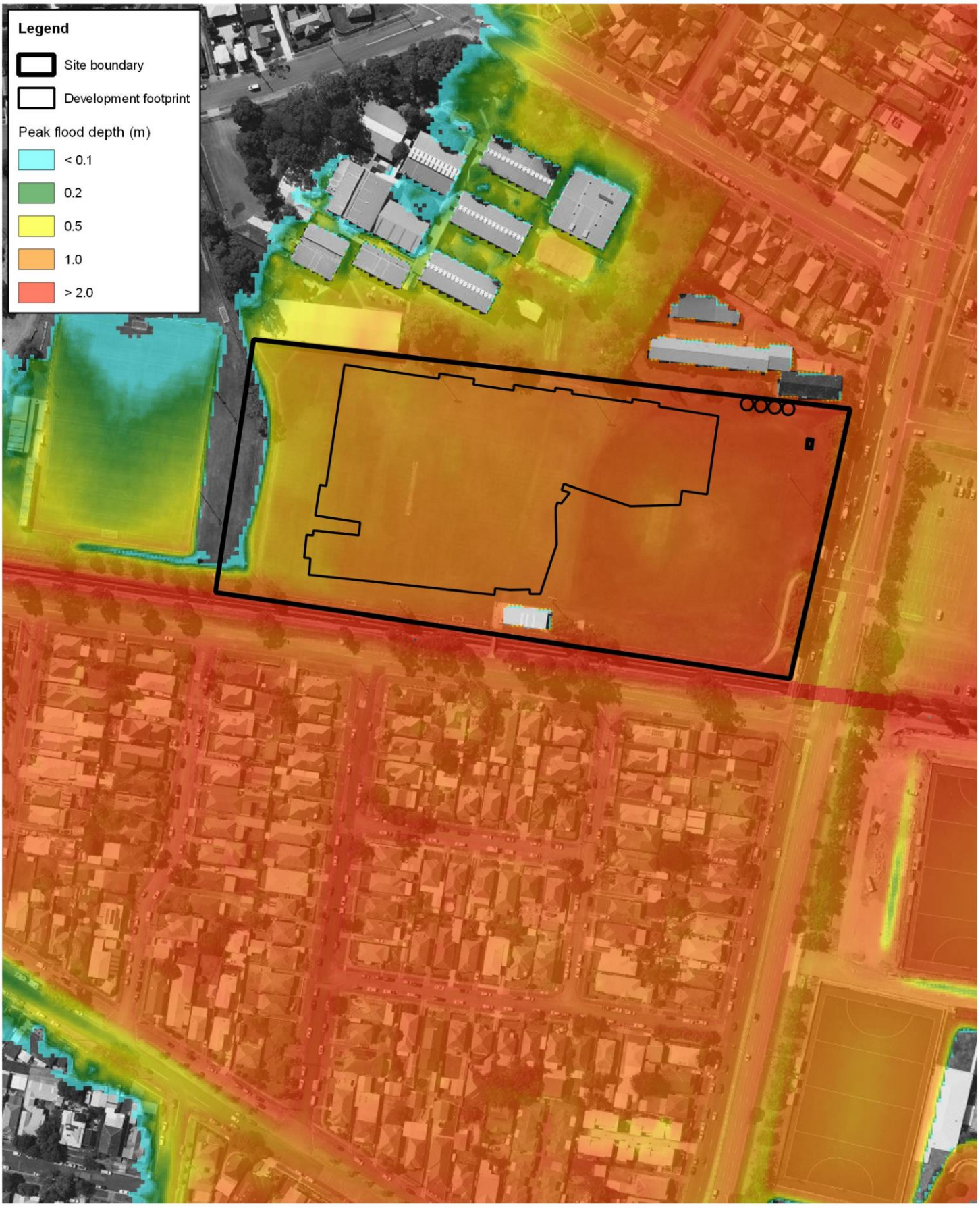

Title:

Modelled PMF Peak Flood Depth

0 60 120 m

approx. scale

Figure: **4-5**

Revision: **A**

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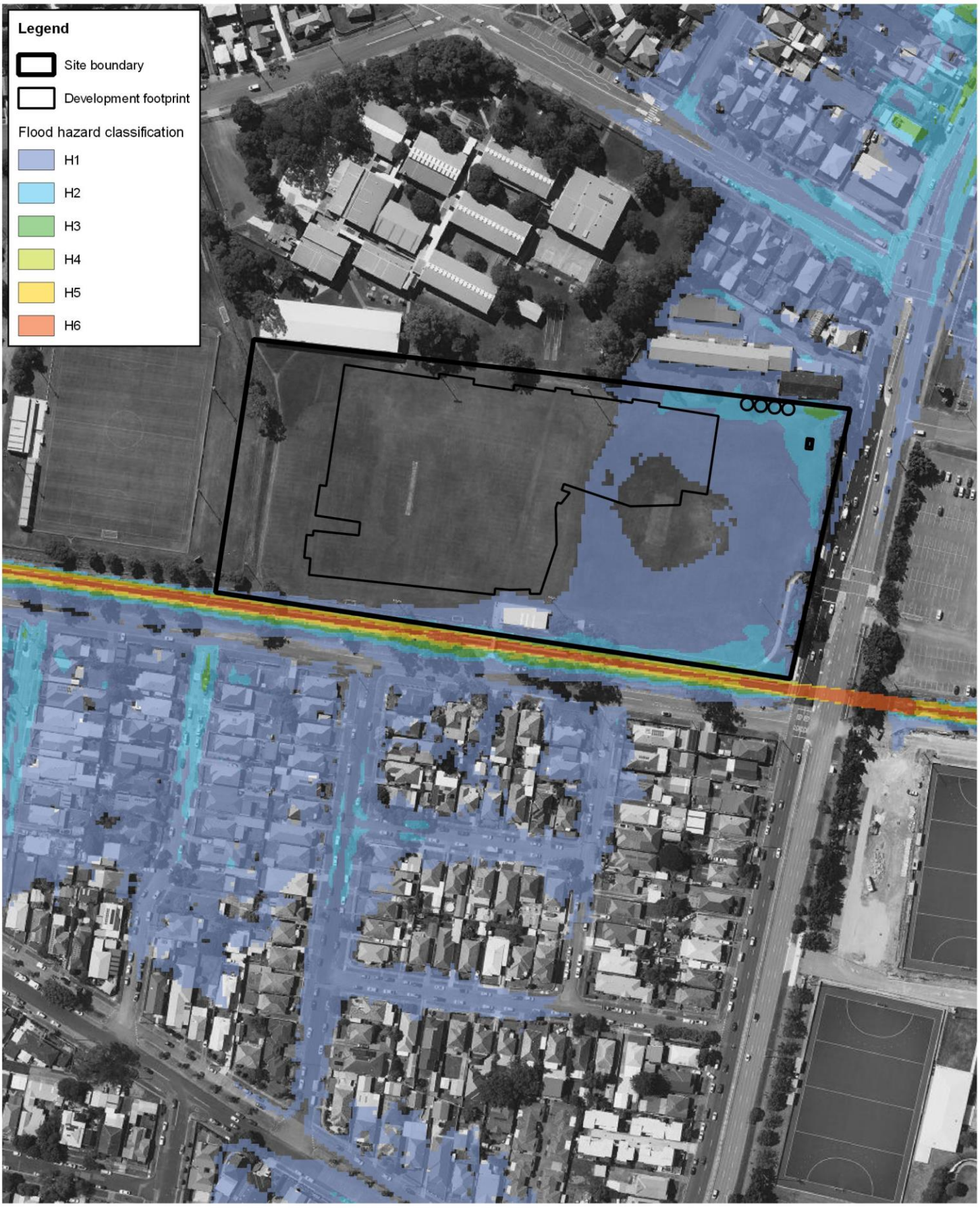

Title:

10% AEP Flood Hazard Classification

0 60 120 m

approx. scale

Figure: **4-6**

Revision: **A**

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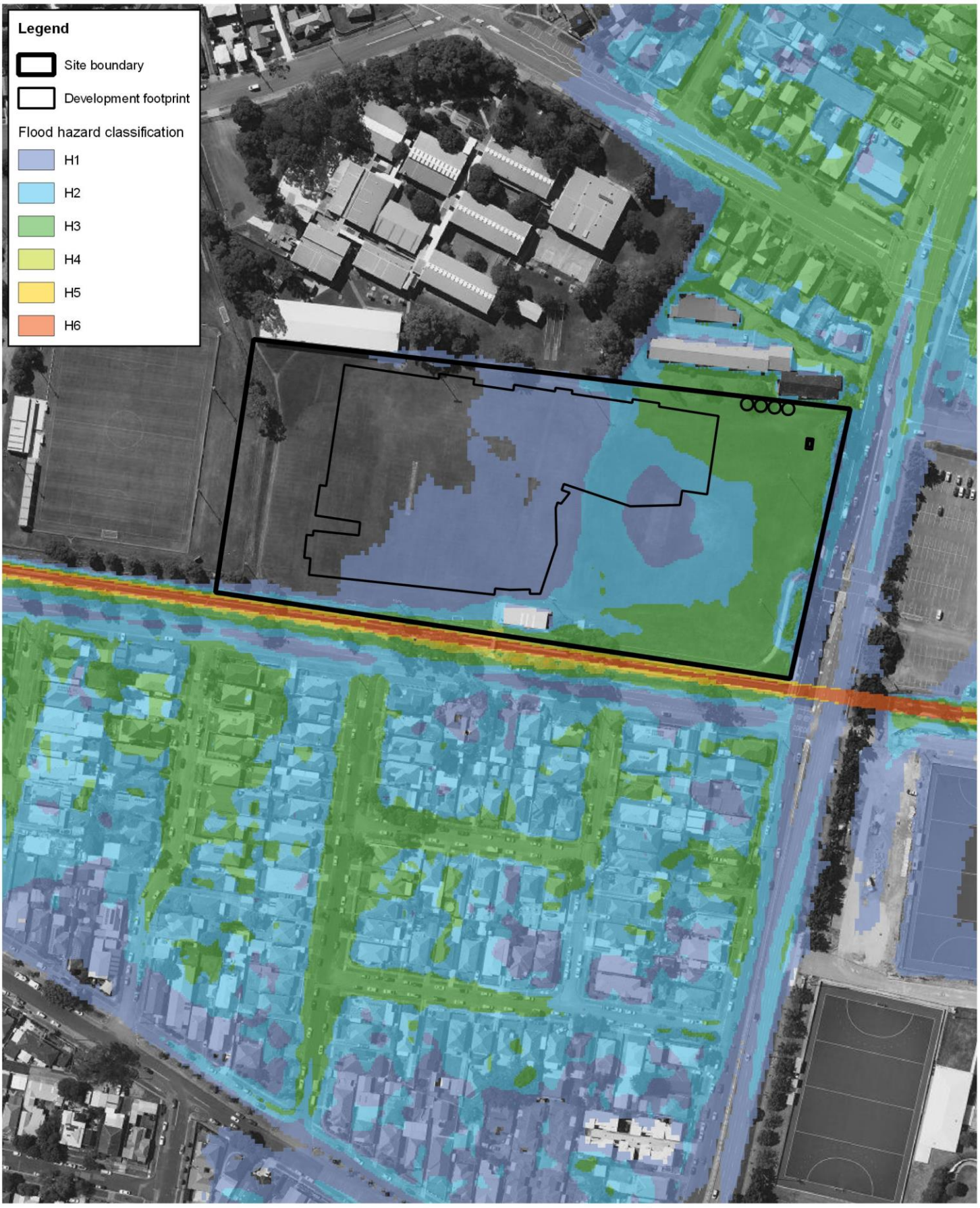

Title:

1% AEP (2050) Flood Hazard Classification

0 60 120 m

approx. scale

Figure: **4-7**

Revision: **A**

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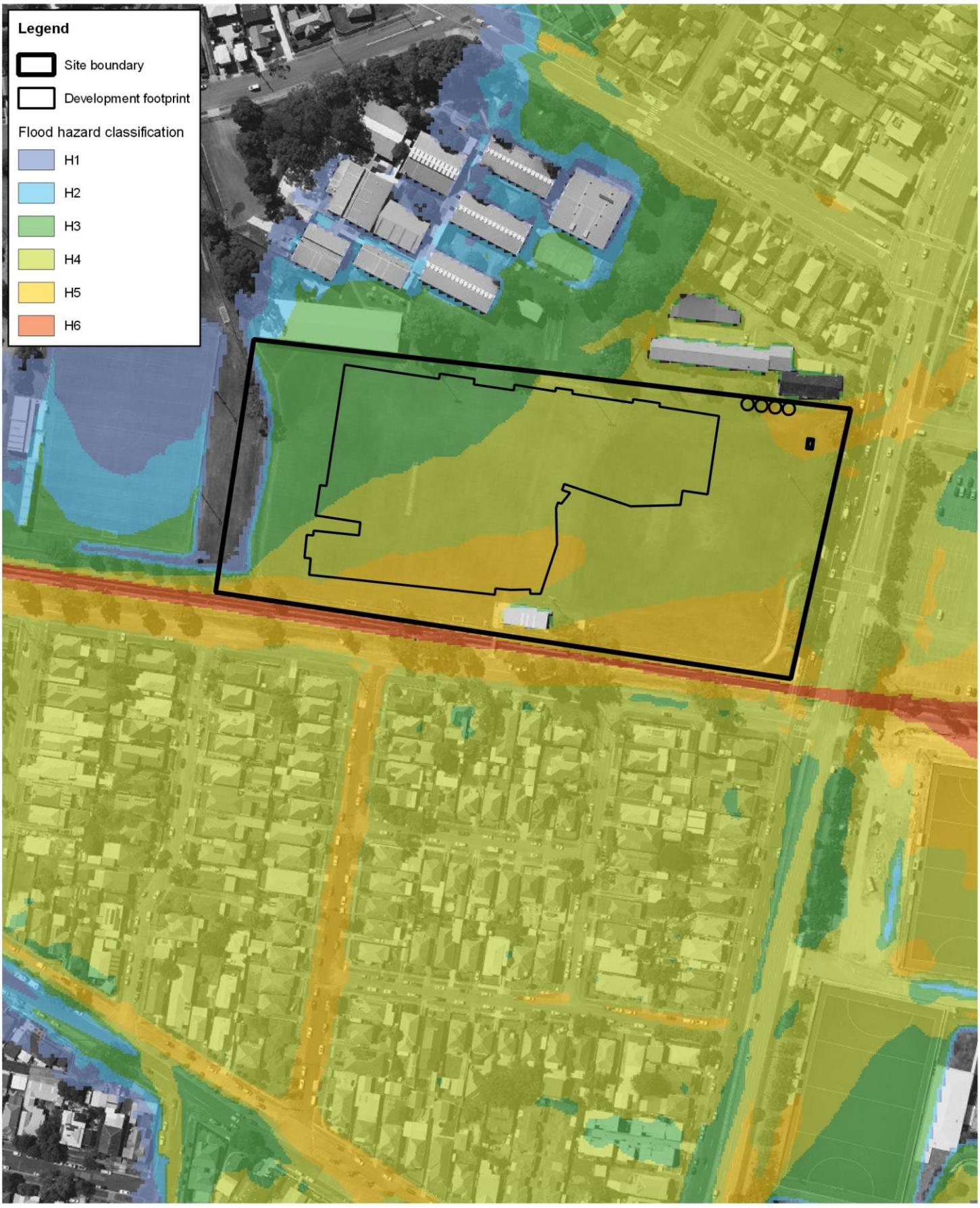

Title:

PMF Flood Hazard Classification

0 60 120 m

approx. scale

Figure: **4-8**

Revision: **A**

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5 Proposed Development

5.1 Design Layout and Model Representation

The proposed development details relating to the building footprint were provided by EJE in architectural drawings (14683-HISC-Draft Updated Floor Plans (01-05-2024).pdf). The proposed finished surface levels for external areas were provided by Northrop as design triangulation in dwg format (240508 - DESIGN TIN.dwg).

The design external surface levels were processed into a 0.5 m resolution digital elevation model and integrated into the TUFLOW model to modify the existing LiDAR survey elevations. The proposed building footprint was incorporated within the model as a full blockage to flow. Other development details implemented in the TUFLOW model are the fire water tanks and electricity substation kiosk along the northern Site boundary.

Initial flood impact assessment identified that a key constraint for the proposed development was the transition of external surfaces from the car parking up to the finished floor level of the building. The raising of existing surface levels within areas of flood flow concentration resulted in potential off-site impacts to the existing flood conditions. The design of the external finished surface model therefore underwent a few iterations to develop a design that did not impact flooding.

The model results were also found to be sensitive to the adopted parameters for the representation of the proposed vegetation planting scheme throughout the car park area. In response to this the proposed groundcover planting has omitted stiff grasses, being limited to softer grasses that will flatten when submerged by convective flood waters.

The hydraulic roughness of the existing Site condition was a Manning's 'n' of 0.04, which is appropriate for maintained turf. For the proposed developed Site conditions the car park and other paved surfaces have been changed to an 'n' value of 0.02, which is consistent with other existing impervious surfaces throughout the model.

The adopted representation of the planted groundcover is an 'n' value of 0.04 to convective flow conditions with flattened grass stalks. The dense central mass of the plants has then been modelled as a physical obstruction using the TUFLOW Layered Flow Constriction functionality, with blockage factors and losses representative of central masses 250 mm in diameter and 300 mm high, at a planting density of fiver per square metre. This provides a much greater impedance to flow at shallow depths below 300 mm. An alternative approach would have been to apply a depth-varying 'n' but there is significant uncertainty associated with the adoption of appropriate 'n' values for various depths of flow, hence the selection of the adopted method.

There are a couple to key locations at which the model results are too sensitive to the preferred groundcover planting scheme (where flows along the floodway through the Site are shallower) and so these were modified to be finished with paved surface and maintained turf, as identified in Figure 5-1. Scattered tree planting is acceptable throughout the planting areas (including the modified ones) as the hydraulic roughness is dominated by the groundcover.

Title:

Developed Model Roughness Representation

0 20 40 m

approx. scale

Figure: **5-1**

Revision: **A**

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5.2 Post-Development Flooding Conditions

The models developed to establish existing flood conditions have been modified to represent post-development conditions as described above.

Figure 5-2 to Figure 5-4 show the modelled peak flood depth mapping under post-development conditions for the 10% AEP, 1% AEP (2050) and PMF events. The corresponding flood hazard mapping is provided in Figure 5-5 to Figure 5-7. Flood depth and hazard mapping for additional design events under post-development conditions is provided in Appendix B.

The lowering of finished surface levels within the proposed car parking areas results is slightly deeper flooding than the existing conditions, as evident in the flood hazard classification at the 10% AEP and 1% AEP events, where the extent of medium hazard (H3) is increased within the Site. The obstruction of the proposed building re-distributes flood flows through the Site at the PMF event, concentrating them through the car parking areas, as evident within the mapping of the high hazard (H5) distribution.

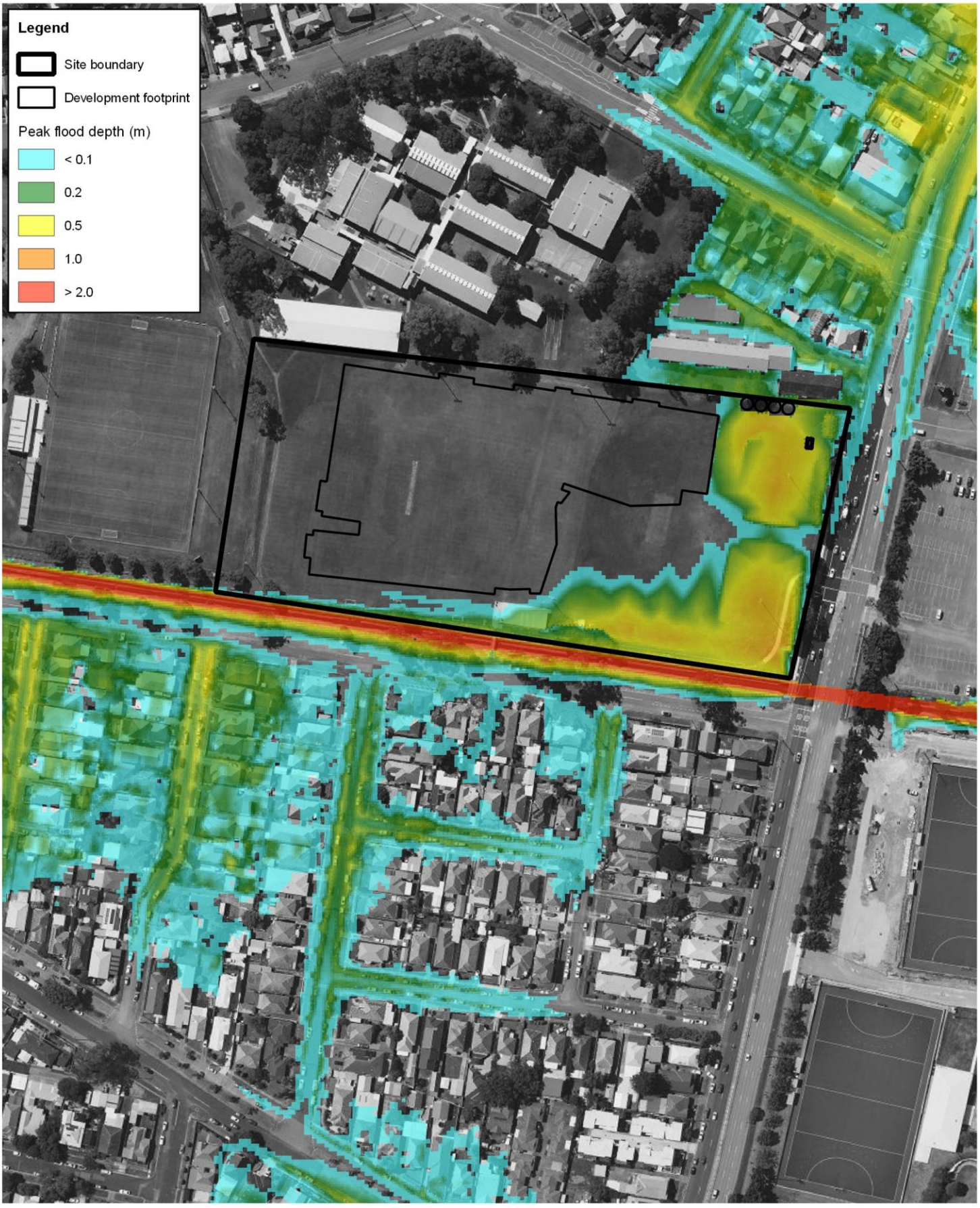
5.3 Impact Assessment

The relative impact of the proposed development has been considered in terms of potential changes to existing flood behaviour. The modelled change in peak flood level and flood velocity distribution is mapped for the 10% AEP, 1% AEP (2050) and PMF events, with flood level impact maps provided in Figure 5-8 to Figure 5-10 and the flood velocity impact maps provided in Figure 5-11 to Figure 5-13. Flood impact mapping for additional events is provided in Appendix C.

At the 10% AEP event the removal of the existing building structure and lowering of the ground surface levels in the proposed car park results in a minor reduction in the modelled peak flood levels. This includes off-site reductions in peak flood level of around 15-25 mm between Gloucester Avenue and Marina Avenue.

As for the flood levels, the modelled changes in peak flood velocity are largely within the Site and are associated with the removal of the existing amenities block and the regraded surface levels for the formation of the car park. There are other localised minor changes to the modelled peak flood velocity within some of the surrounding roadways, reflective of the model sensitivity in areas of low hydraulic roughness at the initial point of wetting. These are common artefacts of mapping modelled changes in peak flood velocity and do not represent tangible impacts.

The scale of the modelled flood impacts reduces for rarer flood events, becoming negligible by the 2% AEP. At the 1% AEP (2050) event, changes in the modelled peak flood level are effectively contained within the Site, principally associated with the removal of the existing amenities block. Changes in the modelled peak flood velocity are largely consistent with the 10% AEP event. There is a localised increase of over 0.5 m/s within the rear of the neighbouring lot at 303 Turton Road. However, the resultant peak flood velocities are no higher than 1.0 m/s and so are of no consequence, being too low for scour erosion risk.



Title:

Modelled 10% AEP Peak Flood Depth for Post-development Conditions

0 60 120 m

approx. scale

Figure: **5-2**

Revision: **A**

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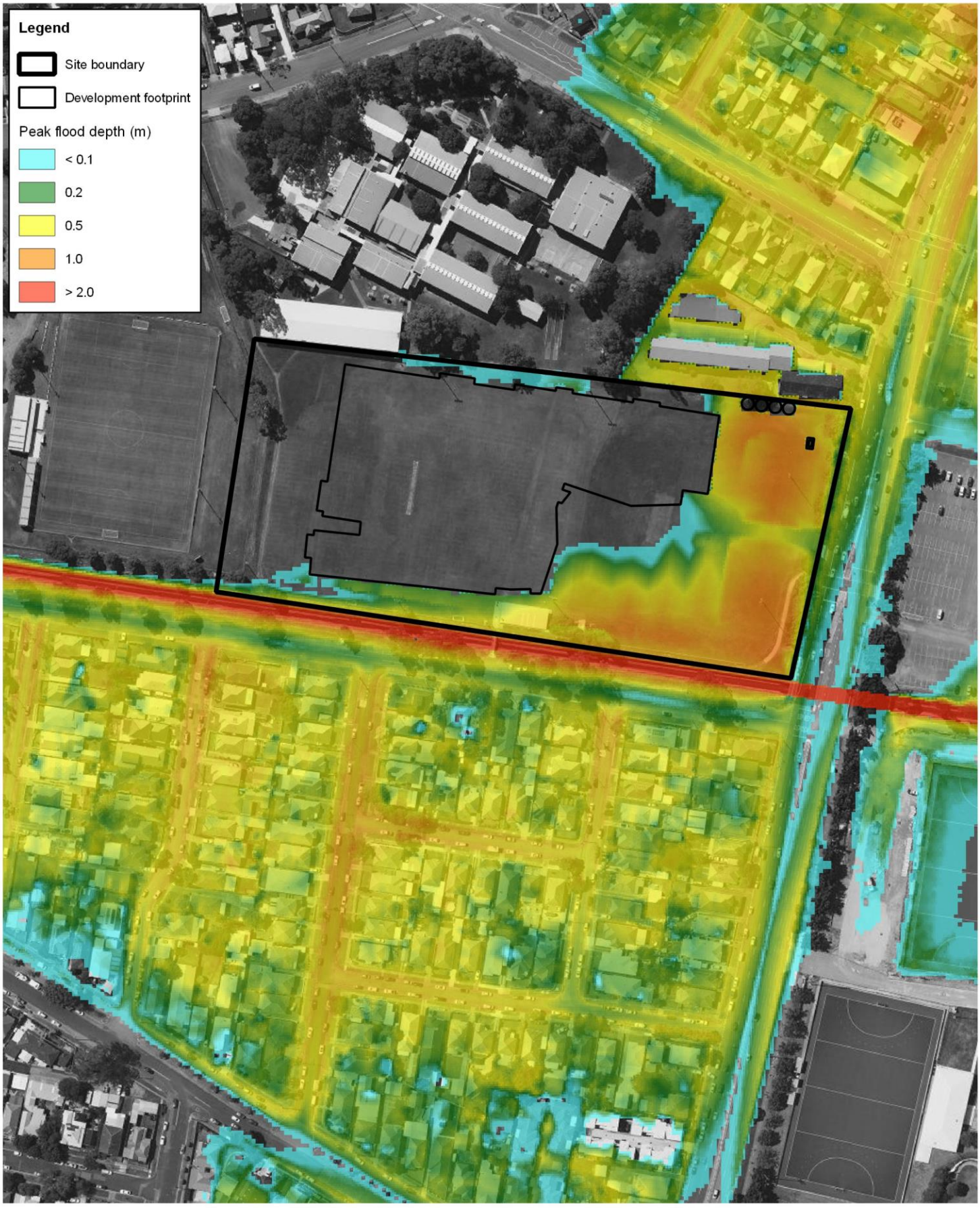

Title:

Modelled 1% AEP (2050) Peak Flood Depth for Post-development Conditions

0 60 120 m

approx. scale

Figure: **5-3**

Revision: **A**

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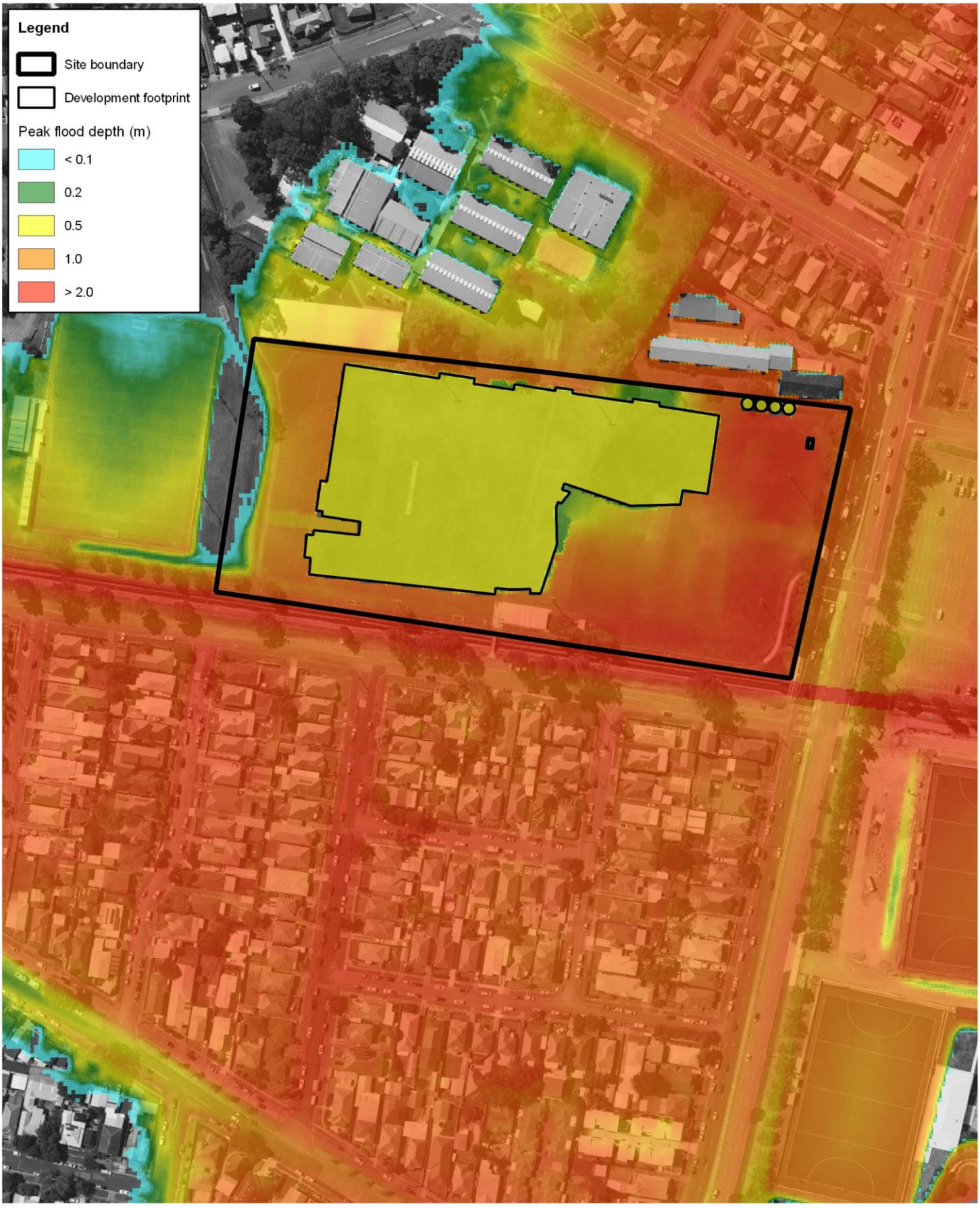

Title:

Modelled PMF Peak Flood Depth for Post-development Conditions

0 60 120 m

approx. scale

Figure: **5-4**

Revision: **A**

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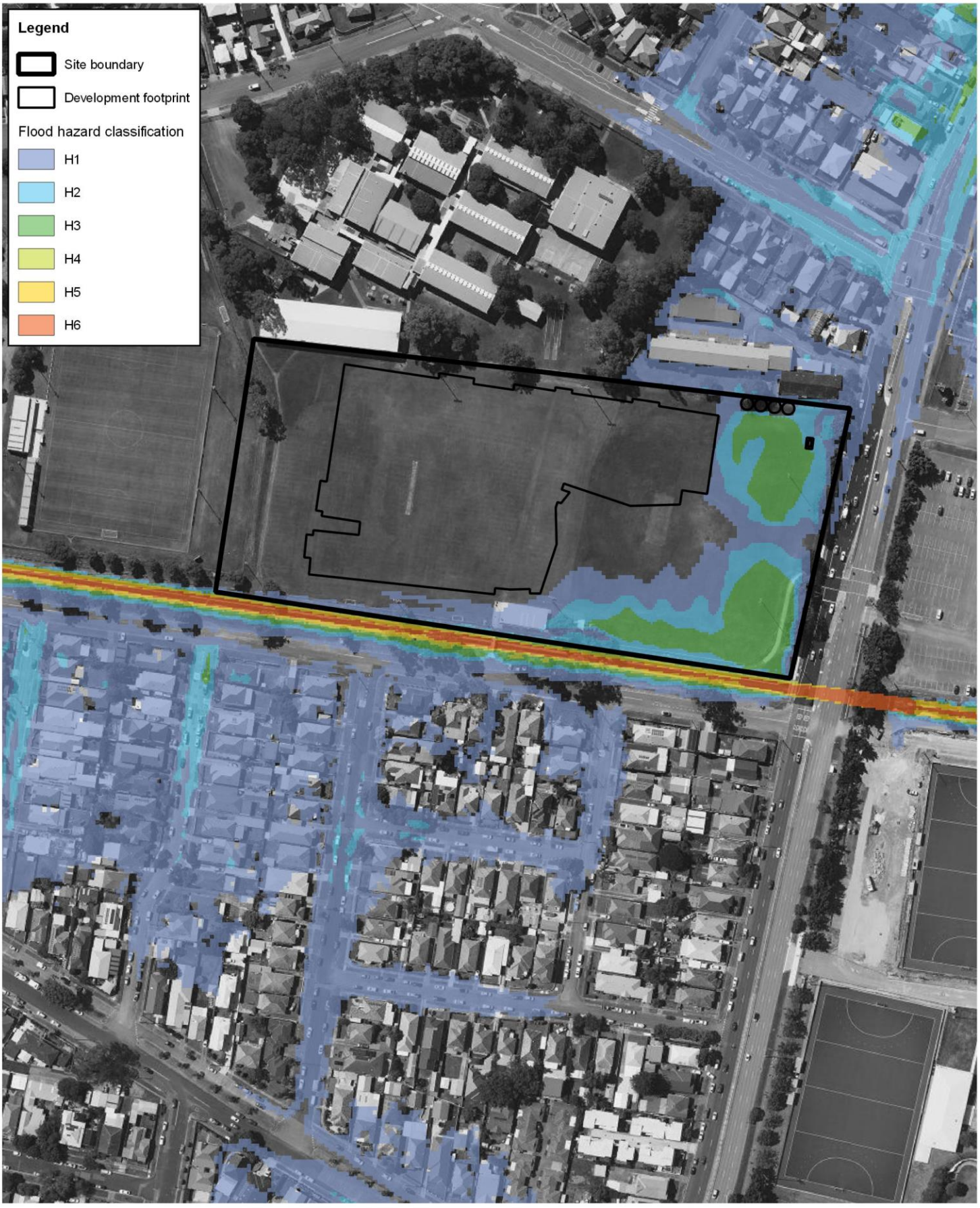

Title:

10% AEP Flood Hazard Classification for Post-development Conditions

0 60 120 m

approx. scale

Figure: **5-5**

Revision: **A**

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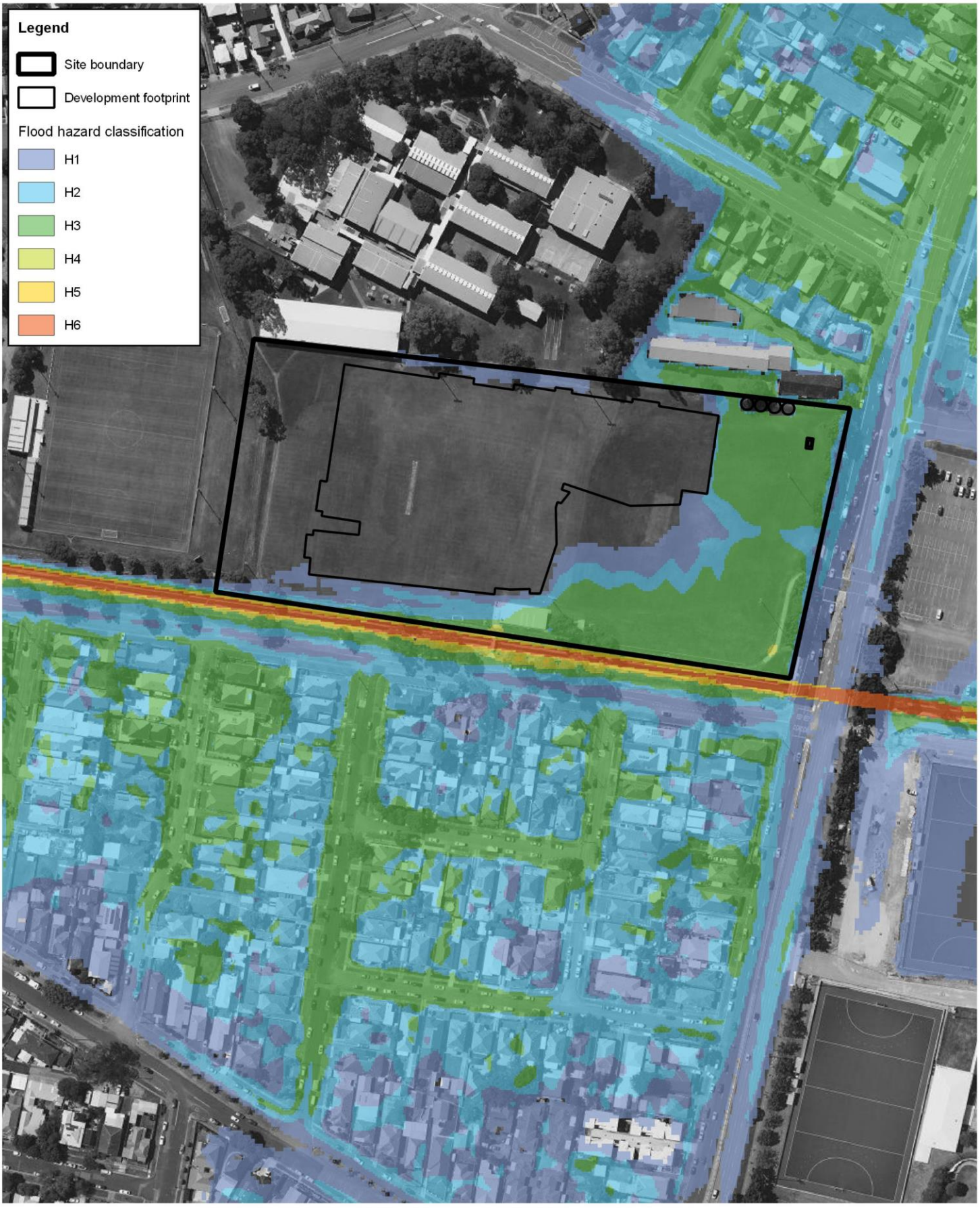

Title:

1% AEP (2050) Flood Hazard Classification for Post-development Conditions

0 60 120 m

approx. scale

Figure: **5-6**

Revision: **A**

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Title:

PMF Flood Hazard Classification for Post-development Conditions

0 60 120 m

approx. scale

Figure: 5-7

Revision: A

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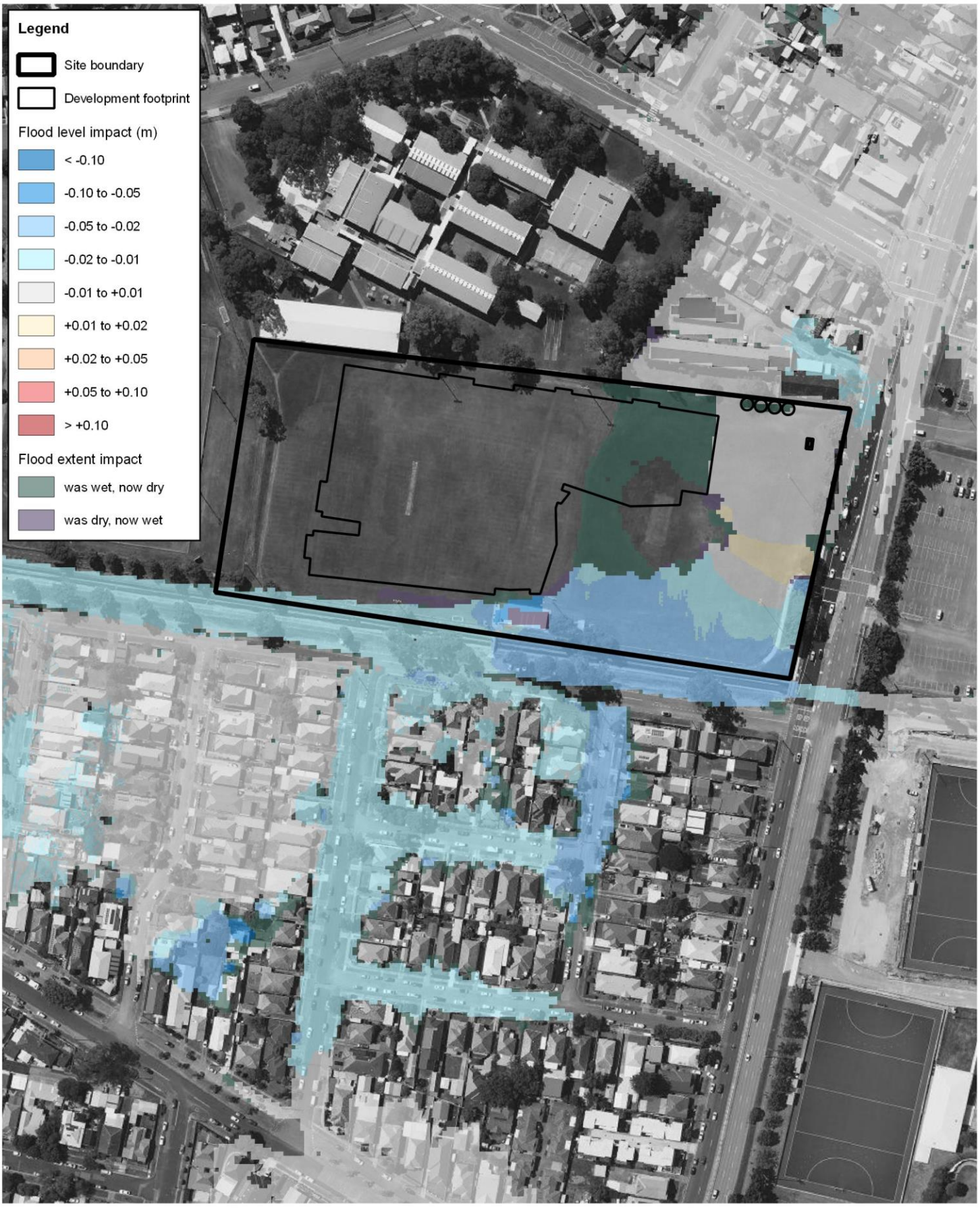

Title:

Modelled 10% AEP Peak Flood Level Impact

0 60 120 m

approx. scale

Figure: **5-8**

Revision: **A**

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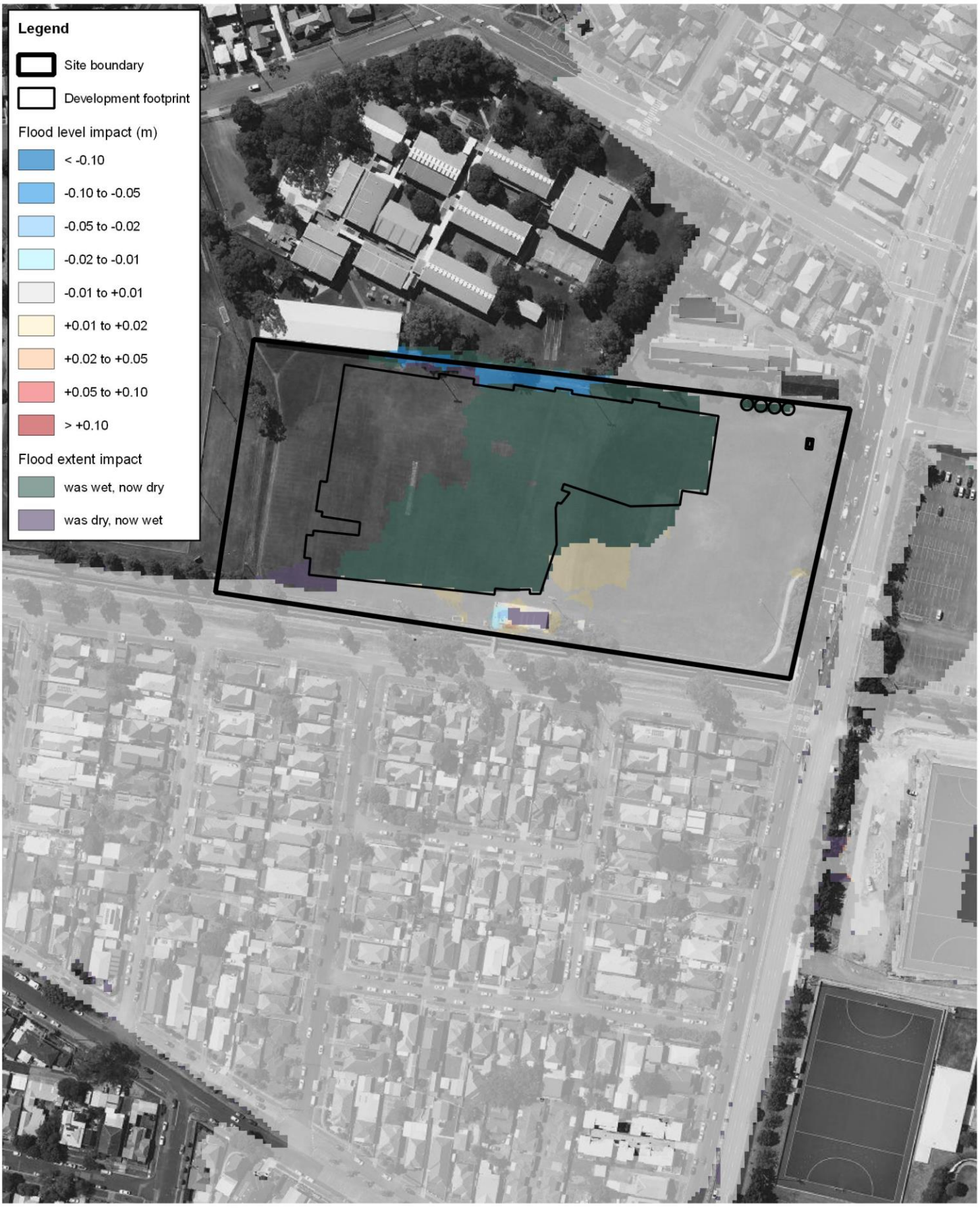

Title:

Modelled 1% AEP (2050) Peak Flood Level Impact

0 60 120 m

approx. scale

Figure: **5-9**

Revision: **A**

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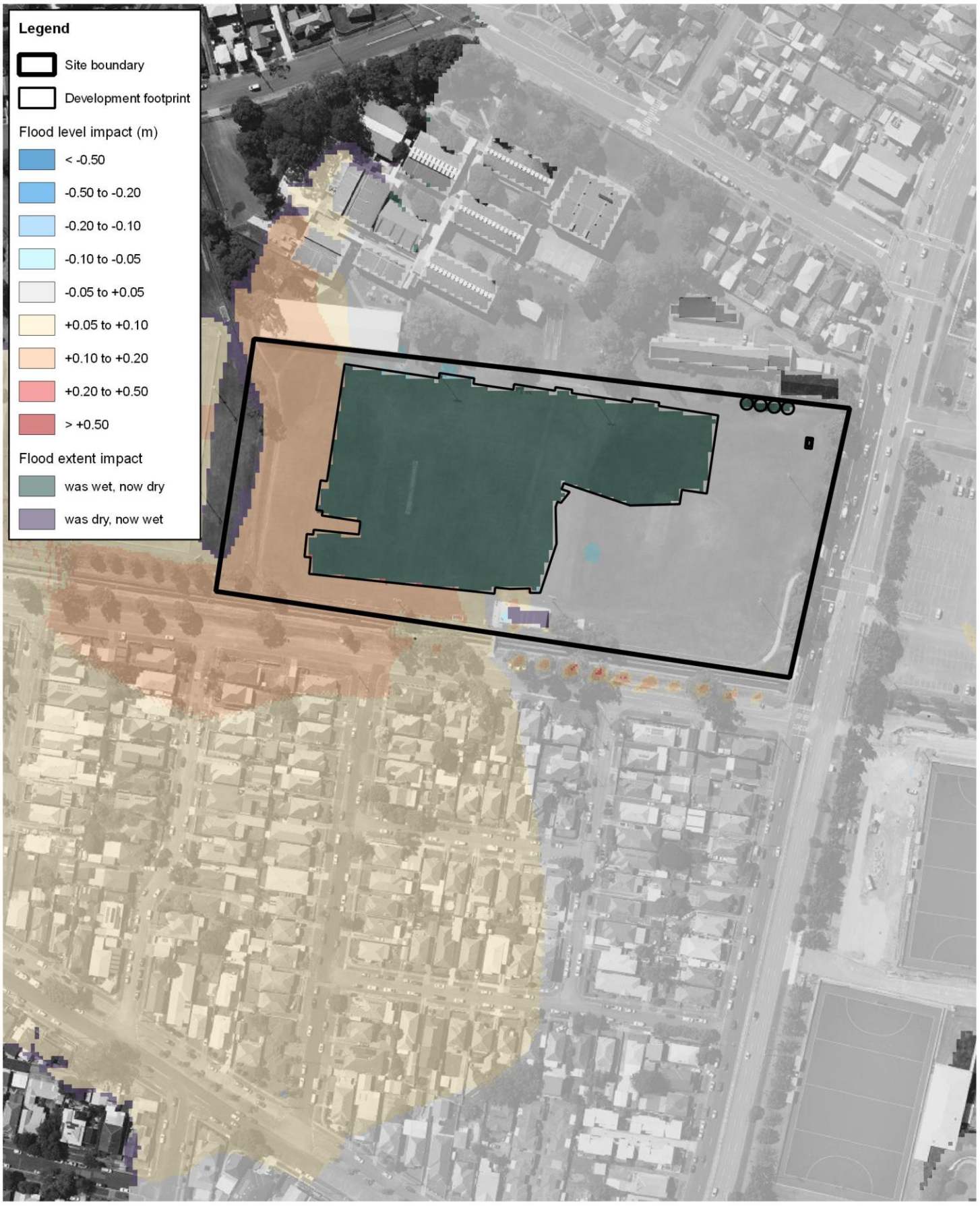

Title:

Modelled PMF Peak Flood Level Impact

0 60 120 m

approx. scale

Figure: **5-10**

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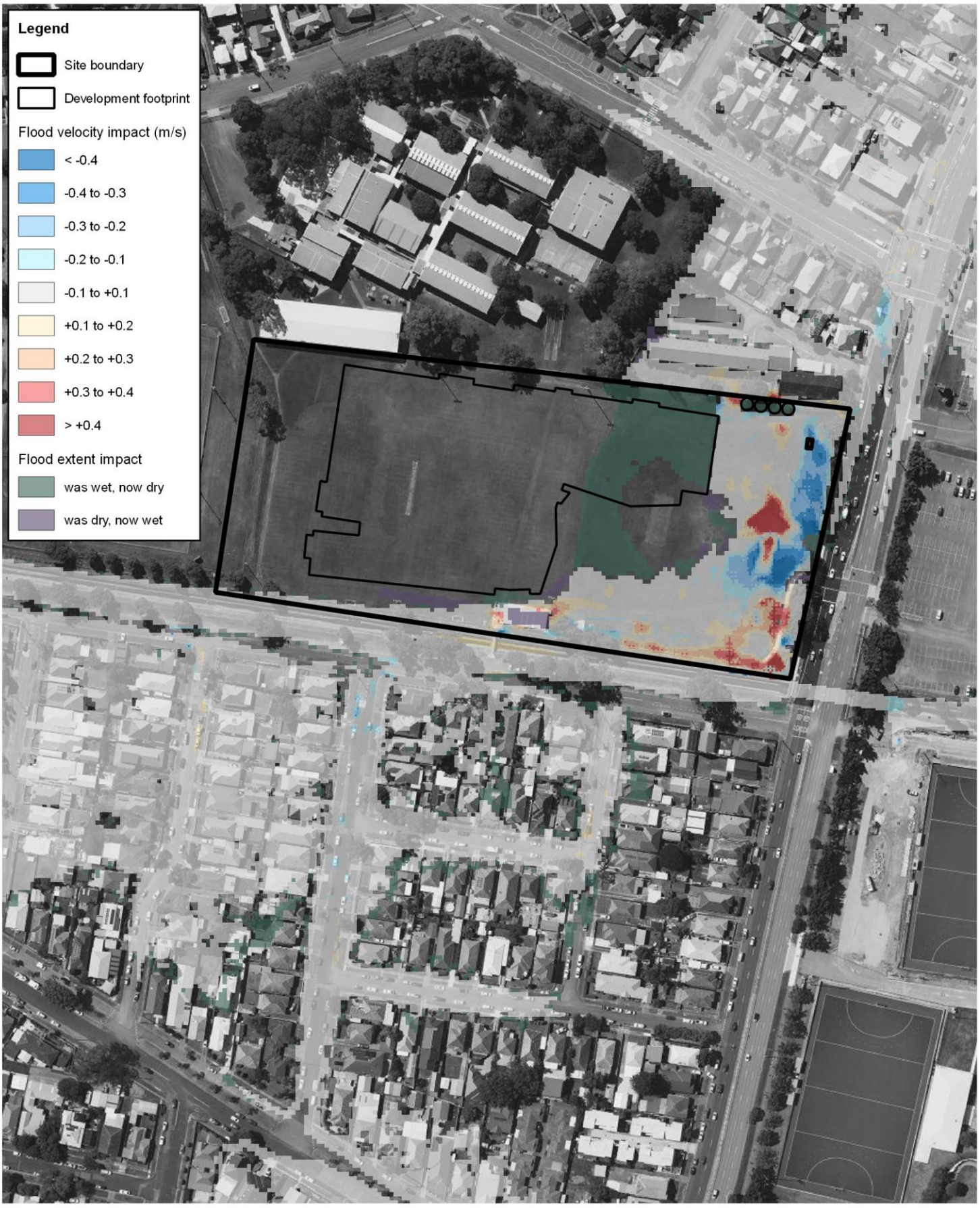

Title:

Modelled 10% AEP Peak Flood Velocity Impact

0 60 120 m

approx. scale

Figure: **5-11**

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Title:

Modelled 1% AEP (2050) Peak Flood Velocity Impact

0 60 120 m

approx. scale

Figure: **5-12**

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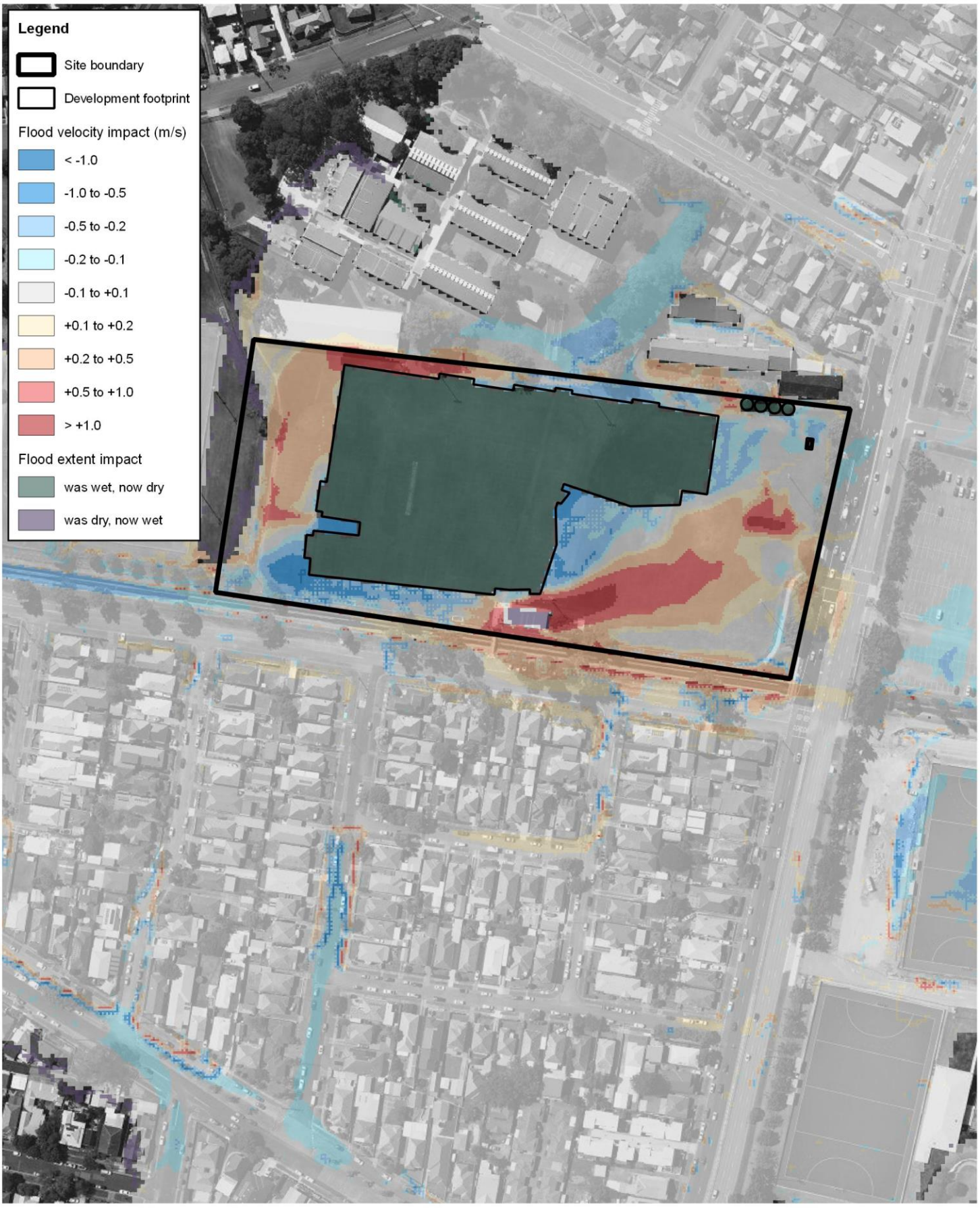

Title:

Modelled PMF Peak Flood Velocity Impact

0 60 120 m

approx. scale

Figure: **5-13**

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At the PMF event the proposed development results in a greater degree of flood flow redistribution than for the 10% AEP and 1% AEP (2050) events. However, other local hydraulic controls and the retention of the principal floodway through the Site serve to maintain only a minor degree of modelled flood impact. Immediately on the western side of the proposed building the peak flood levels at the PMF event are increased by up to around 150 mm. However, off-site the impacts are typically much less, with an increase of around 60-100 mm throughout the area between Marina Avenue and the Harker Oval.

The modelled impact to peak flood velocities at the PMF event better demonstrates the local flood flow redistribution through the Site. The removal of the existing amenities block, and obstruction of the proposed building, increase the peak velocity by up to 1.5 m/s within the Site, around the southern side of the development. Between the northern side of the proposed building and the adjacent higher ground of Lambton High School the peak velocity is increased by up to 1.3 m/s. Off-site increases are typically less than 0.3 m/s.

There is significant uncertainty in modelling the extreme hydraulic conditions of the PMF event, as there would be widespread destruction of property and scour erosion, which cannot be represented within the model. Therefore, absolute changes in modelled peak flood level or velocity are not typically scrutinised in flood impact assessments. The principal consideration at the PMF event is any potential wholesale change in flood risk profile, such as the creation of new flood flow paths or the changing of low hazard flood environments to high hazard ones. Comparison of the pre- and post-development PMF hazard mapping in Figure 4-8 and Figure 5-7 confirms that the high hazard distribution remains relatively consistent. The most significant off-site change is locally within some of the surrounding roads, where the existing flood hazard of H4 becomes H5. However, because this does not change the overall trafficability of the roads, this does not represent a tangible adverse impact.

Overall, the modelled flood impacts are minor and represent a negligible change in flood risk to existing property and infrastructure. This confirms the compatibility of the proposed development design with the existing flood function and that retention of the secondary floodway that is mapped across the Site at the PMF is not essential.

5.3.1 Impact of On-site Detention

In the pre-DA meeting City of Newcastle expressed a concern regarding the proposed development not including on-site detention (OSD) of stormwater. OSD was omitted from the design because the Site in constrained by flood water inundation at intermediate events such as the 10% AEP and 5% AEP. Further, the Site's location within the receiving environment of the catchment (below around 10 m AHD) rather than within the upper catchment, makes the potential benefit of OSD provision questionable.

Located within upper catchment areas, OSD limits the impact of development from increasing resultant peak runoff further downstream. However, further down the catchment, it can be more beneficial to let local stormwater discharge from a site earlier during a rainfall event to drain prior to the arrival of the peak flood flow from upstream.

With the Site being located at the inland end of the lower catchment, City of Newcastle requested a modelling-based assessment to support the position that not providing OSD at the Site would not worsen downstream flood conditions.

To assess this impact Northrop provided modelled Site runoff hydrographs for the post-development condition both with and without the provision of OSD, for the 10% AEP and 5% AEP 2-hour duration rainfall events. The 2-hour duration event was used as this is consistent with the catchment flood simulations.

The hydrographs were input to the TUFLOW model, and the 10% AEP and 5% AEP flood conditions were simulated for the with OSD and without OSD scenarios. The modelled flow hydrographs downstream of the Site were compared at Turton Road for both the Lambton Ker-rai Creek channel and the overflow along Turton Road to the north. This confirmed that the modelled flood conditions displayed only minor sensitivity to the OSD scenario, as shown in Table 5-1.

Table 5-1 Modelled OSD Scenario Peak Flows (m^3/s)

Design Scenario	Channel	North
10% AEP with OSD	25.7	1.21
10% AEP without OSD	25.7	1.19
5% AEP with OSD	26.5	2.53
5% AEP without OSD	26.5	2.50

6 Flood Risk Management

6.1 Newcastle LEP

As established in Section 2.2, development consent must not be granted unless the consent authority is satisfied that the development:

> *(a) is compatible with the flood function and behaviour on the land, and*
>
> *(b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and*
>
> *(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and*
>
> *(d) incorporates appropriate measures to manage risk to life in the event of a flood, and*
>
> *(e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.*

Items (a), (b) and (d) are closely related, as to demonstrate compatibility of development with the flood function and behaviour of the land requires both the off-site flood impacts and the management of flood risk to be adequately addressed. The flood impact assessment presented in Section 5.3 has concluded that the proposed development will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties. The incorporation of appropriate measures to manage risk to life in the event of a flood is a requirement of the Newcastle DCP and is demonstrated in Section 6.2.

Item (c) is dependent on a suitable flood emergency response, which is addressed in Section 7. Item (e) relates to natural watercourses and so is not applicable to the Site given the nature of the constructed drainage infrastructure. Nevertheless, the flood impact assessment in Section 5.3 did not identify significant changes in the flood velocity distribution that would provide concern even if the Lambton Ker-rai Creek was a natural watercourse.

6.2 Newcastle DCP

As established in Section 2.2, the Newcastle DCP specifies controls which are to be met for the development of flood-prone land, which fall under four objectives:

- The retention of floodways
- The protection of flood storage areas
- The management of risk to property
- The management of risk to life.

The assessment of the proposed development against the requirements of these four objectives is addressed in Section 6.2.1 to Section 6.2.4.

6.2.1 Floodways

The planning controls relating to the retention of floodways are:

- C-1: no building or structure can be built, and no land can be filled with any materials in areas identified as floodways, except for small changes to ground levels that do not significantly change the flow patterns for roads, parking, below ground structures or landscaping.
- C-2: where dividing fences across floodways are unavoidable, they are constructed only of open type fencing that does not restrict the flow of flood waters and are resistant to blockage. New development is designed to avoid fences in floodways.

As discussed in Section 4 and shown in Figure 2-1 and Figure 2-2, the existing flood behaviour within the Site is consistent with a floodway within land located at the eastern end of the Site, within which flood waters are conveyed northward from Lambton Ker-rai Creek to towards the Turton Road – Griffiths Road intersection. The proposed building and external surface design has deliberately avoided obstruction of this floodway. The minor structures of the fire water tanks and the electricity substation kiosk are located here but the flood impact assessment in Section 5.3 has confirmed that they do not adversely impact the existing flood function of the land.

Council's mapping in Figure 2-2 identifies a secondary floodway at the PMF event that flows across the location of the proposed building. However, with the other existing local hydraulic controls and the retention of the principal floodway through the east of the Site, the flood flows obstructed by the proposed building are readily re-distributed around the building without adversely impacting the existing flood function of the land at the PMF event, as confirmed through the flood impact assessment. The proposed development does not include any new fence structures and so both conditions C-1 and C-2 are adequately satisfied.

6.2.2 Flood Storage Areas

The planning controls relating to the protection of flood storage areas are:

- C-1: not more than 20% of the area of any development site in a flood storage area is filled. The remaining 80% is generally developed allowing for underfloor storage of floodwater by the use of suspended floor techniques such as pier and beam construction.
- C-2: where it is proposed to fill development sites, the fill does not impede the flow of ordinary drainage from neighbouring properties, including overland flow.

The capacity of the floodplain to store flood waters was assessed within the flood storage (and floodway) areas identified in Council's mapping for the 1% AEP (2050) and PMF events (refer Figure 2-1 and Figure 2-2, respectively). This found the existing flood storage volume within the areas mapped as floodway or flood storage to be around 8850 m^3 at the 1% AEP (2050) event and around 33 900 m^3 at the PMF event.

The calculation of the available flood storage volume within the areas mapped as floodway or flood storage post-development to be around 8370 m^3 at the 1% AEP (2050) event and around 32 700 m^3 at the PMF event. This represents around a 95% retention of existing flood storage volume and so the proposed development readily satisfies condition C-1.

The Site is at a lower elevation than the surrounding properties and so the potential to impede ordinary drainage from neighbouring properties is limited. A comparison of the existing and post-development surface levels around the perimeter of the Site has identified that the only location that the proposed development has the potential to impact local drainage is along the boundary with 303 Turton Road. The existing land at the rear of properties on the southern side of 303 Turton

Road drains to a shallow swale that runs along the northern boundary of the Site and is located within the Site. As the stormwater drainage design for the proposed development is further progressed, measures should be incorporated to ensure that this location can still freely drain.

6.2.3 Management of Risk to Property

The planning controls relating to the management of risk to property from flooding are:

- C-1: floor levels of all occupiable rooms of all buildings are not set lower than the FPL.
- C-2: garage floor levels are no lower than the 1% 2050 AEP event. However, it is recognised that in some circumstances this may be impractical due to vehicular access constraints. In these cases, garage floor levels are as high as practicable.
- C-3: Basement garages may be acceptable where all potential water entry points are at or above the PMF, excepting that vehicular entry points can be at the FPL. In these cases, explicit points of refuge are accessible from the carpark in accordance with the controls for risk to life set out below.
- C-4: electrical fixtures such as power points, light fittings and switches are sited above the FPL unless they are on a separate circuit (with earth leakage protection) to the rest of the building.
- C-5: swimming pools are to be located to ensure they are not inundated from minor flooding events. Electrical connections and fixtures around swimming pools are to be sited at the FPL.
- C-6: Where parts of the building are proposed below the FPL, they are constructed of water-resistant materials.
- C-7: areas where cars, vans and trailers are parked, displayed or stored are only located in areas subject to property hazard of P1. Containers, bins, hoppers and other large floatable objects are not to be stored in these areas. Heavy vehicle parking areas can only be located in locations subject to P1 or P2 categories.
- C-8: timber framed, light steel construction, cavity brickwork and other conventional domestic building materials are generally suitable forms of construction where the property hazard is P1 to P4.
- C-9: property hazard of P5 is generally unsuitable for building construction and building is discouraged from these areas. Where building is necessary, the structure is certified by a practising structural engineer to withstand the hydraulic loads (including debris) induced by the flood waters.
- C-10: property hazard of P6 is unsuitable for any type of building construction.

The proposed development does not include garages, basement parking or swimming pools and so conditions C-2, C-3 and C-5 are not applicable.

The finished floor level of the proposed building is set at 9.2 m AHD, which is 0.3 m above the FPL nominated by Council. Therefore, condition C-1 is inherently satisfied. Because the internal areas are above the FPL, condition C-4 is also inherently satisfied.

As shown in Figure 5-6, the highest flood hazard exposure to the proposed building at the 1% AEP (2050) event is H3. This translates to a P3 risk to property hazard and so conditions C-8, C-9 and C-10 are satisfied. The heavy construction type of the proposed development should also inherently satisfy condition C-6. However, this should be confirmed.

Condition C-7 cannot be satisfied by the proposed development without impacting the retention of floodways and flood storage or having implications for off-site flood impacts, as this would require significant raising of the external surface levels throughout the proposed car park. Given this conflict between satisfying different aspects of the flood planning controls non-conformance with condition C-7 of the management of risk to property objective is considered the better option for overall flood risk management.

Alternative mitigation options can be implemented to manage the risk of any vehicles parked at the Site during a flood event from being mobilised by flood waters and potentially impacting flooding elsewhere through resultant blockages. This could include the provision of a suitable bollard arrangement along the northern and southern boundaries of the car park area to prevent vehicles from being washed into the Lambton Ker-rai Creek or other key drainage infrastructure.

6.2.4 Management of Risk to Life

The planning controls relating to the management of risk to life from flooding are:

- C-1: risk to life category L5 is generally unsuitable for building construction and building is discouraged from these areas. Reliable safe escape to high ground is likely not possible and normal building construction would likely suffer structural failure from the force of floodwaters, so that any people seeking refuge in the building would likely perish. Where building is necessary, the structure is certified by a practising structural engineer to withstand the hydraulic loads (including debris) induced by the flood waters.
- C-2: risk to life category of L6 is unsuitable for any type of building construction.
- C-3: the formation of islands in the floodplain during a flood is a potentially dangerous situation, especially when floods larger than the FPL totally inundate the island for an extended period. Development of such land is considered with great care.
- C-4: on-site refuge is to be provided for all development where the risk to life category is L3 or higher unless: the proposed development is less than 40 m from the perimeter of the PMF extent and the higher ground is accessible, or the proposed use is defined as commercial premises or industry in which case onsite refuge is only required where the hazard category is L4 or higher.
- C-5: where on-site refuge is required for a development, it should comply with the following minimum standards: the minimum on-site refuge level is the level of the PMF. On-site refuges are designed to cater for the number of people reasonably expected on the development site and are provided with emergency lighting, and on-site refuges are of a construction type able to withstand the effects of flooding. Design certification by a practising structural engineer that the building is able to withstand the hydraulic loading due to flooding (at the PMF).
- C-6: emergency egress procedure for basements. A plan is developed detailing emergency egress procedures during a flood, as well as any refuge areas in reasonable proximity of the development. The plan is to be positioned in the basement car park in an easily recognisable location/s.

The proposed development does not include a basement, is not located on a flood island and is not located within a risk to life category of L6 and so conditions C-2, C-3 and C-6 are not applicable.

As shown in Figure 5-7, the highest flood hazard exposure to the proposed building at the PMF event is H5. This translates to an L5 risk to life hazard and so condition C-1 needs to be satisfied

through structural certification that the proposed building can withstand the expected hydraulic loads of the PMF event. Given the heavy construction type of the building this is expected to be readily achieved. The modelled flood depths adjacent to the building at the PMF event are locally as high as 1.4 m, with peak velocities typically no higher than up to 1.6 m/s. However, the modelled peak velocity is locally as high as 2.1 m/s at the south-eastern corner of the proposed Allied Health Club.

The range of flood hazard conditions across the Site at the PMF event between H3 and L5 (corresponding to risk to life categories of L3 to L5) make the requirements to satisfy conditions C-4 and C-5 ambiguous. Nevertheless, both flood evacuation and on-site refuge are available options to the proposed development and are addressed in Section 7.

6.3 Planning Secretary's Environmental Assessment Requirements

The SEARs relating to flood assessment for the proposed specify that the EIS must:

- identify and describe any on-site flood impacts and risks associated with the proposed development, having regard to the relevant provisions of the NSW Floodplain Development Manual and other local or State studies and guidance.
- describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10 year, 1 in 100 year flood levels and the probable maximum flood, or an equivalent extreme event.
- assess the impacts of the development, including any changes to flood risk both on-site or off-site, and identify any mitigation and management measures to minimise the impacts of flooding on the proposed development.
- Provide a Flood Emergency Response Plan prepared by a suitably qualified person that addresses:
    - Likely flood behaviour;
    - Flood warning systems;
    - Education awareness program;
    - Evacuation and evasion procedures;
    - Evacuation routes and flood refuges; and
    - Flood preparedness and awareness procedures for visitors.
- address matters raised by Biodiversity Conservation Division (BCD) at Attachment B.
- address matters raised by Council at Attachment B.

The BCD requirements in Attachment B referenced above are consistent with those typically issued in SEARs and can be summarised as:

- Map flood prone land, the flood planning area and flood function.
- Describe the flood assessment and modelling undertaken.
- Include the 10% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF events.
- Assess the impact of the proposed development on the existing flood behaviour.

The Council requirements in Attachment B request:

- Address the flood risks and flood impacts in accordance with the Newcastle DCP.
- Flood modelling to assess the impacts of the development on the existing floodways within the site.

- To not fill more than 20% of the flood storage area at either the 1% AEP or PMF event.
- Preparation of a Flood Emergency Response Plan.

The NSW Flood Risk Management (FRM) Manual 2023 provides an overarching philosophy and framework for the management of flood risk. It is supported by several guidelines dealing with different aspects of the floodplain risk management process, including flood impact and risk assessment. This broadly requires consideration of the management of risk to life and risk to property from flooding, plus the potential of development to result in adverse impacts to the existing flood conditions, as provided in this assessment.

The flood modelling that has been undertaken for this assessment is described in Section 3 and Section 4 and includes modelling of the 10% AEP, 1% AEP and PMF events.

The assessment of impacts from the proposed development to the existing flood conditions is addressed in Section 5.3. The mitigation measures to minimise flood impacts include the retention of the floodway along the eastern side of the Site, the retention of on-site flood storage and the limitation of obstructions within the external car park area, as discussed.

The foundations for development of a Flood Emergency Response Plan (FERP) are provided in Section 7.

Flood prone land is defined as any land within the PMF extent. This has been mapped together with the FPA in Figure 4-1. The flood function mapping produced at the 1% AEP (2050) and PMF events was provided by Council, as shown in Figure 2-1 and Figure 2-2, respectively.

The flood assessment and modelling undertaken is described in Section 3 to Section 5. The 10% AEP, 1% AEP (2050) and PMF events have been included in these Sections. The 0.5% AEP and 0.2% AEP events have also been assessed (as have the 5% AEP and 2% AEP events) and flood depth, flood hazard and flood impacts mapping is provided for these in Appendix A to Appendix C.

The impact of the proposed development on the existing flood behaviour is assessed in Section 5.3.

The flood risks and flood impacts have been assessed in accordance with the Newcastle DCP, as presented in Section 6.2.

Flood modelling to assess the impacts of the development on the existing floodways within the Site has been undertaken, with the results discussed in Section 5.3.

The proposed development does not result in a net loss of greater than 20% of the existing flood storage volume at either the 1% AEP (2050) or PMF events, as assessed in Section 6.2.2.

The foundations for development of an FERP are provided in Section 7.

7 Flood Emergency Management

This section addresses the key requirements of an effective FERP. The development and adoption of an FERP requires full integration with the site management, health and safety and incident management structures and is typically required prior to occupation. However, the overall flood emergency response strategy, flood intelligence and key components of the FERP are provided below.

Ultimately the FERP will be developed within a standalone document, including triggers, actions, roles, and responsibilities. The FERP document is typically finalised for approval prior to issuing of an Occupation Certificate. At this stage of the approval process the key objective is to present the overall flood emergency management strategy for review and acceptance, as this will underpin the subsequent development of the adopted FERP.

7.1 Likely Flood Behaviour

7.1.1 Flood Probabilities

The Australian Rainfall and Runoff (ARR) 2019 guidelines describe two approaches that are typically used to express the probability of flood events:

- Annual Exceedance Probability (AEP) – the probability of an event being equalled or exceeded within a year. Typically, the AEP is estimated by extracting the annual maximum in each year to produce an Annual Maxima Series (AMS); and
- Average Recurrence Interval (ARI) – the average period between occurrences equalling or exceeding a given value. Usually, the ARI is derived from a Peak over Threshold series (PoTS) where every value over a chosen threshold is extracted from the period of record.

A summary of flood probability terminology from ARR 2019 is reproduced in Figure 7-1.

Very frequent flood events are expressed as exceedances per year (EY). At the other end of the probability spectrum, the Probable Maximum Flood (PMF) event is a function of the Probable Maximum Precipitation (PMP), which is the most rainfall that can be practically considered as being possible to occur over a given location or area. It is an extreme event with an approximate probability of between a 1-in-10,000 and a 1-in-10,000,000 AEP, dependant on catchment area. For small catchments such as Lambton Ker-rai Creek the approximate probability of the PMF event is a 1-in-10,000,000 AEP.

7.1.2 Flooding at the Site

The flood-producing weather events most-likely to affect the Site include East Coast Lows (ECL). The Bureau of Meteorology (BoM) defines ECLs as being very intense low-pressure systems characteristic of the eastern coastline of Australia, occurring on average several times each year. Although they can occur at any time of the year, they are more common during autumn and winter with a maximum frequency in June. East Coast Lows will often intensify rapidly over a period of 12-24 hours making them one of the more dangerous weather systems to affect the eastern coast.

Other weather systems that present a flood risk at the Site include ex-tropical cyclones that occasionally move south into NSW and severe thunderstorms that can develop quickly and affect relatively small areas.

Flood risk at the Site is principally from the capacity of the Lambton Ker-rai Creek stormwater channel being exceeded. Flood waters are typically relatively-well contained upstream of Wallarah Road but floodplain inundation becomes more extensive at the Site and further downstream. When the capacity of Lambton Ker-rai Creek is exceeded at Turton Road, flood waters inundate the floodplain at the Site and the residential area to the south of Monash Road. The obstruction presented by Turton Road forces excess flows northwards through the Site towards the Turton Road – Griffiths Road intersection.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
Intermediate	0.11	10	10	9.49
	0.05	5	20	19.5
Rare	0.02	2	50	49.5
	0.01	1	100	99.5
Very Rare	0.005	0.5	200	199.5
	0.002	0.2	500	499.5
	0.001	0.1	1000	999.5
Extreme	0.0005	0.05	2000	1999.5
	0.0002	0.02	5000	4999.5
			↓	
			PMP/ PMP Flood	

Figure 7-1 Flood Probability Terminology

The extent, depth and hazard of flood waters affecting the Site are shown in the flood mapping of Section 5.2 and Appendix B. The frequency of flooding can be impacted by the extent and magnitude of debris blockage to hydraulic structures within the stormwater drainage network and through the potential increase of rainfall intensity resulting from future climate change conditions. However, flood inundation is expected to occur at the Site from around the 10% AEP event.

Because of the urban and small catchment context of the local flood environment the rate of rise of flood waters can be rapid, particularly in an extreme event. However, this environment also produces floods of a relatively short duration, with flood waters quickly receding following the peak conditions.

For flood events such as the 10% AEP or 1% AEP, the rate of rise of flood waters within the Lambton Ker-rai Creek channel is in the order of 4 m per hour, increasing to over 10 m per hour for extreme flood event such as the PMF. Once the flood levels exceed the channel capacity the rate of rise reduces significantly, to around 1 m per hour across all events. The duration of floodplain inundation will vary on an event-specific basis but is expected to be in the order of between one to four hours.

7.2 Flood Warning Systems

7.2.1 Bureau of Meteorology

The BoM has a few generalised warning services that can provide an indication of an increased likelihood of flooding, including:

- Severe Weather Warnings
- Severe Thunderstorm Warnings
- Flood Watches
- Flood Warnings

The BoM issues Severe Weather Warnings whenever severe weather is occurring in an area or is expected to develop or move into an area. The warnings describe the area under threat and the expected hazards. Warnings are issued with varying lead-times, depending on the weather situation, and range from just an hour or two to 24 hours or sometimes more.

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
- Abnormally high tides (or storm tides) expected to exceed highest astronomical tide
- Unusually large surf waves expected to cause dangerous conditions on the coast
- Widespread blizzards in Alpine areas

The BoM issues Severe Thunderstorm Warnings to alert communities of the threat of these more dangerous thunderstorms. A severe thunderstorm is one that produces any of the following:

- Large hail (20 mm in diameter or larger)
- Giant hail (50 mm in diameter or larger)
- Damaging or destructive wind gusts (generally wind gusts exceeding 90 km/h)
- Heavy rainfall which may cause flash flooding
- Tornadoes

Most thunderstorms do not reach the level of intensity needed to produce these dangerous phenomena, so the BoM does not warn for all thunderstorms.

Standard public forecasts will include information when there is a reasonable risk of severe storms. This information will allow people to prepare for the potential severe weather. Severe thunderstorms can be quite localised and can develop quickly. The exact location of severe thunderstorms can be hard to predict. As it is difficult to forecast the precise location and movement of severe storms before they have started to develop, detailed warnings will generally be provided once they have been observed or detected. The detailed warnings are usually issued without much lead-time before the event.

Flood Watches and Flood Warnings are issued for catchments that have a formal flood warning system operated by the BoM, which typically have a critical duration for the generation of flood conditions exceeding six hours. This is for catchments much larger than Lambton Ker-rai Creek.

The current BoM Warnings active in NSW can be accessed at http://www.bom.gov.au/nsw/warnings/

The rainfall recently recorded by rainfall warning gauge locations across Newcastle can be accessed at http://www.bom.gov.au/nsw/flood/newcastle.shtml

Current rainfall radar monitoring for the Newcastle (Williamtown Airport) 64 km radius loop can be accessed at http://www.bom.gov.au/products/IDR044.loop.shtml#skip

7.2.2 Newcastle Flood Alert Service

City of Newcastle and partners 'NSW State Emergency Service', 'Bureau of Meteorology', 'Department of Planning, Industry and Environment' and 'Hunter Water Corporation' engage Early Warning Network (EWN) to administer a flash flood alert service for flood affected areas of Newcastle. This is an action of the Newcastle City Wide Floodplain Management Plan 2012.

Council trialled the flash flood alert service in Wallsend in 2016. A minor flood event occurred in January 2016, which was sufficient in testing the alert service to its full potential. The results of the trial were positive, and the registered users commended the service and expressed their approval to see it continue.

In 2017, Council expanded the alert service so that it can provide similar alerts in other flood affected areas of Newcastle. The service is permanent and free of charge to registered users and is managed by EWN.

The Newcastle Flood Alert Service comprises some ten continuous (pluviograph) rainfall gauges across the city. EWN constantly monitor the rainfall recorded by the gauges and issue flood warning alerts for eight different flood alert areas. The ‘Lambton, Hamilton, Islington, Broadmeadow and Mayfield’ flood alert area is the one in which the Site is located. There are three flood alert rainfall gauges within 2 km of the Site, located at Lambton Reservoir, Waratah Reservoir and Broadmeadow. EWN uses rainfall intensity thresholds recorded at the gauges to issue Minor, Moderate or Major Flood Warnings.

Whilst there would be limited time between a Flood Warning being issued through the Newcastle Flood Alert Service and inundation of the car park area at the Site, it would provide in the order of a 45-minute period prior to internal inundation of the building in an extreme flood event.

Once operational, the appropriate emergency management team for the Site should be subscribed to the Newcastle Flood Alert Service.

7.3 Education Awareness Program

All staff with FERP responsibilities are to undertake the required training. Ensuring that this training is provided is the responsibility of the emergency management team. Most training is consistent with the broader Emergency Management Planning and Critical Incident Management requirements and not specific to the FERP. This includes standard training for Wardens and First Aid Officers, etc.

Familiarisation with the FERP should form part of the induction and regular training for relevant staff. In addition, a full drill of a flood emergency response will be undertaken annually. The performance outcomes of the drill will be reviewed by the site management team.

Specific training is also to be provided to the Chief Warden and members of the emergency management team as to the accessibility and interpretation of the available flood warning information and how this can improve the decision-making process during the management of a flood emergency response.

7.4 Evacuation and Evasion Procedures

Frequent to intermediate flood events, whilst potentially resulting in localised inundation within the Site, only produce low to medium hazard flood conditions that do not present a significant risk to people located there. However, for an extreme flood event most of the Site will be inundated, including the potential for internal flooding of the building.

The flood hazard within the local and broader city-wide road network can be higher than within the Site and so leaving the Site during or immediately prior to a flood event can increase the level of risk, particularly given the context of the local “flash flood” environment. Coupled with a relatively short warning time, these conditions make evacuation from the Site prior to a flood challenging, from both a logistical and risk-based perspective.

The recommended flood emergency response (if people are present on the Site during a flood) is therefore to seek refuge from flooding within the Site, only vacating the Site when it is safe to do so following the recession of flood inundation. There is however an opportunity to evacuate people from the Site (if required and safe to do so) and for flood emergency egress/ingress during a flood event, from the rear building access to Womboin Road.

7.5 Evacuation Routes and Flood Refuges

The Flood Refuge area is the first-floor level of the building, which is above the PMF level of 9.45 m AHD. The 2400 m^2 first-floor mezzanine has around 2000 m^2 suitable for use as a Flood Refuge, which can accommodate up to 2000 people potentially present on the Site. A minimum of 1 m^2 per person is typically adopted for flood refuges within short duration (< 6-hour) flood environments, with 2 m^2 per person for long duration flood environments.

Being a fully functioning part of the building, the Flood Refuge is inherently well-equipped to service the needs of potential occupancy for an expected period of a few hours and includes the following:

- Emergency lighting (as implemented during construction of the building)
- Access to clean water (via the mains water supply)
- Access to bottled water and emergency snack foods
- Two-way radios for Wardens

- External battery source to power a mobile phone and laptop
- Torches and spare batteries
- First aid kits (to include basic first aid supplies, plus EpiPen and Defibrillator (AED)
- Fire-fighting equipment including fire extinguishers and fire blankets

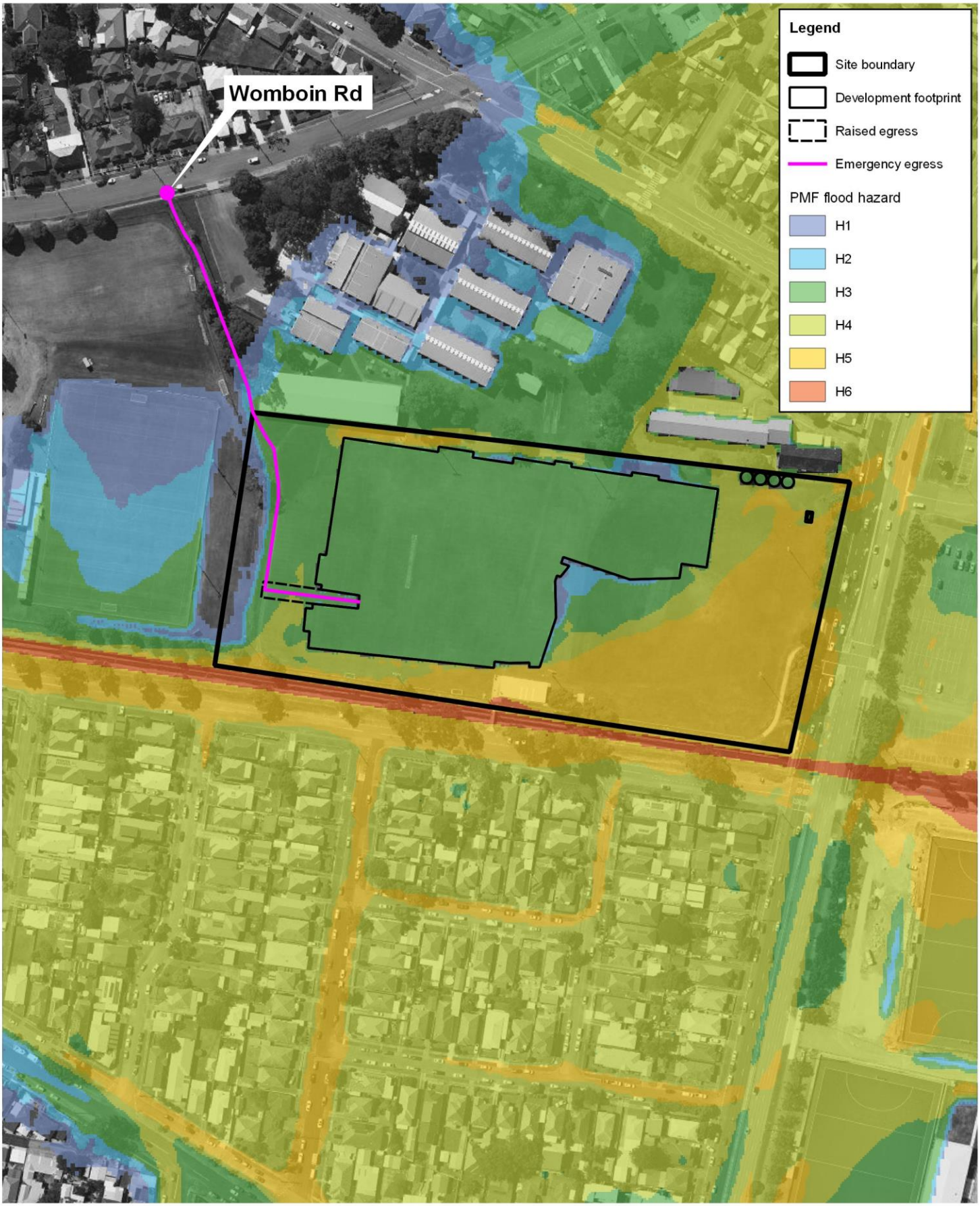
The flood emergency egress / ingress route from Womboin Road is shown in Figure 7-2. A length of around 45 m between the rear doors of the building and an existing footpath has been raised to the FPL to provide a rising pedestrian access to Womboin Road. Flood-free land above the PMF event is reached around 165 m from exiting the building. The flood hazard condition during the peak of the PMF event is H3, which is suitable for wading by adults. This will enable access to the building by emergency services personnel, if required and/or to evacuate people from the Site.

7.6 Flood Preparedness and Awareness Procedures for Visitors

Visitors to the Site are to be directed by staff as to what to do in the event of a flood. It is recommended that a simple two-sided 'Summary FERP' document be produced that can be wall-mounted alongside fire emergency information.

The principal risk to visitors from flooding is the potential of inundation within the car park, as it is far more likely than that of internal inundation within the building. Signage should be displayed within the car park advising of the risk of flash flooding during intense rainfall. Regular visitors to the Site should be advised to park off-site (such as on Womboin Road) or arrange alternative transport if they are concerned about the potential risk to their vehicle during periods of heavy rainfall.

The site management should consider the need to cancel or postpone events if a relevant severe weather warning is issued by the BoM. Travel is typically discouraged in such circumstances due to the risk of heavy rainfall and strong winds increasing the risk of driving. Such advice was in place across Newcastle prior to the April 2015 flood event.



Title:

Flood Egress / Ingress Route

0 60 120 m

approx. scale

Figure: 7-2

Revision: A

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8 Project Staging

The proposal has been designed so that the project can be delivered as an initial block of six courts with subsequent additions to be delivered over several construction stages, as described below:

Stage 1A

A single storey building with total gross floor area (GFA) of approximately 10 218 m^2 comprising:

- Ground floor: 6 x basketball courts, amenities to support the functioning of the complex including bathrooms, change rooms, lobby and foyer, retail tenancy and café.
- Car park with 110 spaces.

Stage 1B

- Ground floor extension to the west to provide 2 x courts with a GFA of approximately 1630 m^2.
- Additional 75 car parks, total 185 spaces at completion of Stage 1b.
- Mezzanine level: function rooms, administration space and training areas.

Stage 2

Extension to the northern and southern sides of the existing building with total additional GFA of approximately 7180 m^2 comprising:

- Ground floor 3 x courts including show court with retractable grandstand seating over the two adjacent courts.
- Extension to the southern side of the building to provide 1 x court plus high-performance training area.
- Mezzanine level: extension of mezzanine to provide additional corporate spaces.
- Expansion of existing car park to provide 240 spaces.

This Flood Impact and Risk Assessment has considered the ultimate Stage 2 configuration of the proposed development. Modelling of flood impacts has also been undertaken for the Stage 1A and Stage 1B development plans. This confirmed that the potential flood impacts are consistent with those assessed and presented for Stage 2, with no adverse off-site impacts identified.

The development of an FERP will need to be updated to be correct for the current development at the time of occupation. The key impacts of the proposed staging on flood emergency response management are:

- The raised pathway providing egress to Womboin Road should be extended to enable access from a rear door of the building.
- The first-floor level at the completion of the Stage 1A development is limited to an unutilised area to facilitate subsequent Stage 1B extension. As a Flood Refuge it can accommodate up to around 600 people but will need to be provisioned accordingly (refer Section 7.5).
- Most of the first-floor area nominated for Flood Refuge is constructed as part of the Stage 1B development, albeit with a reduced capacity to accommodate up to around 1600 people.

9 Conclusions

This Flood Impact and Risk Assessment is prepared to support the proposed development of the Hunter Indoor Sports Centre at 2 Monash Road and 24 Wallarah Road, New Lambton NSW. The assessment is underpinned by detailed modelling of design flood conditions of the Lambton Ker-rai Creek floodplain for a range of design flood magnitudes.

A TUFLOW software hydrodynamic model was developed to represent existing design flood conditions local to the proposed development. The modelling undertaken has aimed to provide consistency with the recent Throsby, Styx, and Cottage Creeks Flood Study.

The proposed development was designed with consideration of the existing flood risk as defined by the modelling, current flood planning controls and floodplain risk management objectives. The flood assessment investigated the existing and post-development flood conditions for a range of design flood event magnitudes including the 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF events. The future 2050 planning horizon conditions were also assessed for the 1% AEP event.

The developed flood model was utilised to assess the potential impact of any proposed works on existing flood conditions. The impact assessment indicated the proposed development has no material impact on existing flood conditions across the range of flood events considered (10% AEP up to the PMF event).

The proposed development has been assessed against the flood risk management requirements of the Newcastle LEP, Newcastle DCP, and requirements specific to the SEARs. This found the proposed development to satisfy all the requirements except condition C-7 of the Management of Risk to Property section of the Newcastle DCP, which relates to the flood hazard of areas used for car parking.

The DCP Management of Risk to Property condition C-7 requirement cannot be satisfied by the proposed development without impacting the retention of floodways and flood storage or having implications for off-site flood impacts, as this would require significant raising of the external surface levels throughout the proposed car park. Given this conflict between satisfying different aspects of the flood planning controls non-conformance with condition C-7 is the better option for overall flood risk management.

Alternative mitigation options can be implemented to manage the risk of any vehicles parked at the Site during a flood event from being mobilised by flood waters and potentially impacting flooding elsewhere through resultant blockages. This could include the provision of a suitable bollard arrangement along the northern and southern boundaries of the car park area to prevent vehicles from being washed into the Lambton Ker-rai Creek or other key drainage infrastructure.

The key requirements for development of an effective FERP have been established. The development and adoption of an FERP requires full integration with the site management, health and safety and incident management structures and is typically required prior to occupation. However, the overall flood emergency response strategy, flood intelligence and key components of the FERP were assessed.

The staff members responsible for the FERP should monitor BoM severe weather warnings and be subscribed to the Newcastle Flood Alert Service. The recommended flood emergency response (if

people are present on the Site during a flood) is to seek refuge from flooding within the Site, only vacating the Site when it is safe to do so following the recession of flood inundation. There is however an opportunity to evacuate people from the Site (if required and safe to do so) and for flood emergency egress/ingress during a flood event, from the rear building access to Womboin Road.

The Flood Refuge area is the first-floor level of the building. With an available floor area of around 2000 m^2, the Flood Refuge can accommodate up to 2000 people potentially present on the Site. Being a fully functioning part of the building, the Flood Refuge is inherently well-equipped to service the needs of potential occupancy for an expected period of a few hours.

On-site flood refuge requires structural certification that the proposed building can withstand the expected hydraulic loads of the PMF event. Given the heavy construction type of the building this is expected to be readily achieved. The modelled flood depths adjacent to the building at the PMF event are locally as high as 1.4 m, with peak velocities typically no higher than 0.8-1.2 m/s. However, the modelled peak velocity is locally as high as 1.5-1.8 m/s at the south-eastern corner of the proposed Allied Health Club and at the western end of the northern side of the building, between the building and the higher ground of the adjacent Lambton High School.

The site management should consider the need to cancel or postpone events if a relevant severe weather warning is issued by the BoM. Travel is typically discouraged in such circumstances due to the risk of heavy rainfall and strong winds increasing the risk of driving. Such advice was in place across Newcastle prior to the April 2015 flood event.

With the recommended flood risk management measures in place, the proposed development is supportable from a flood risk management assessment perspective.

10 References

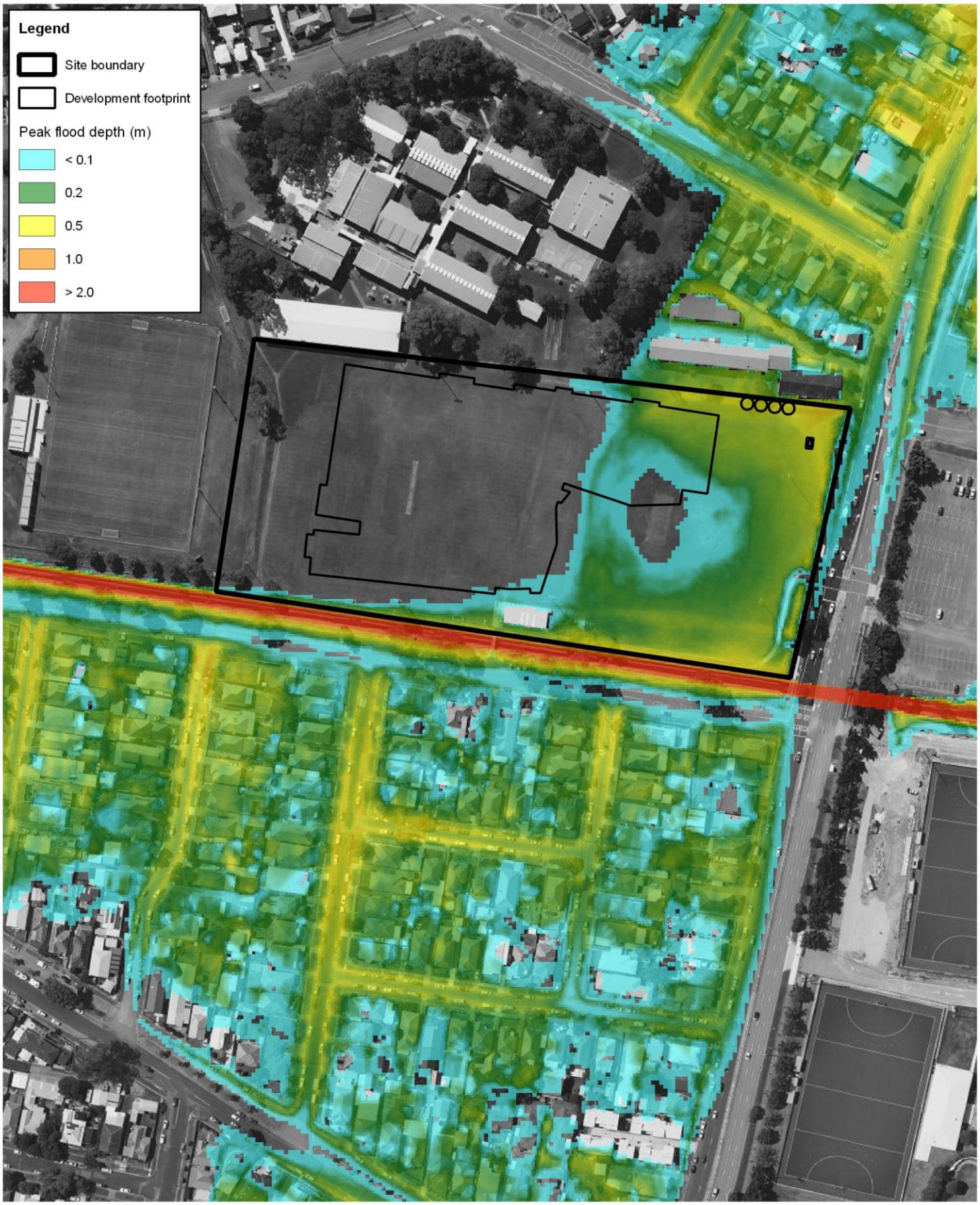
AIDR (2017) *Guideline 7-3, Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*

City of Newcastle Council (2023) *Development Control Plan*

Geoscience Australia (2019) *Australian Rainfall and Runoff: A Guide to Flood Estimation*

Rhelm (2023) *Throsby, Styx, and Cottage Creeks Flood Study*

Appendix A Existing Conditions Flood Mapping



Title:

Modelled 5% AEP Peak Flood Depth

0 60 120 m

approx. scale

Figure: **A-1**

Revision: **A**

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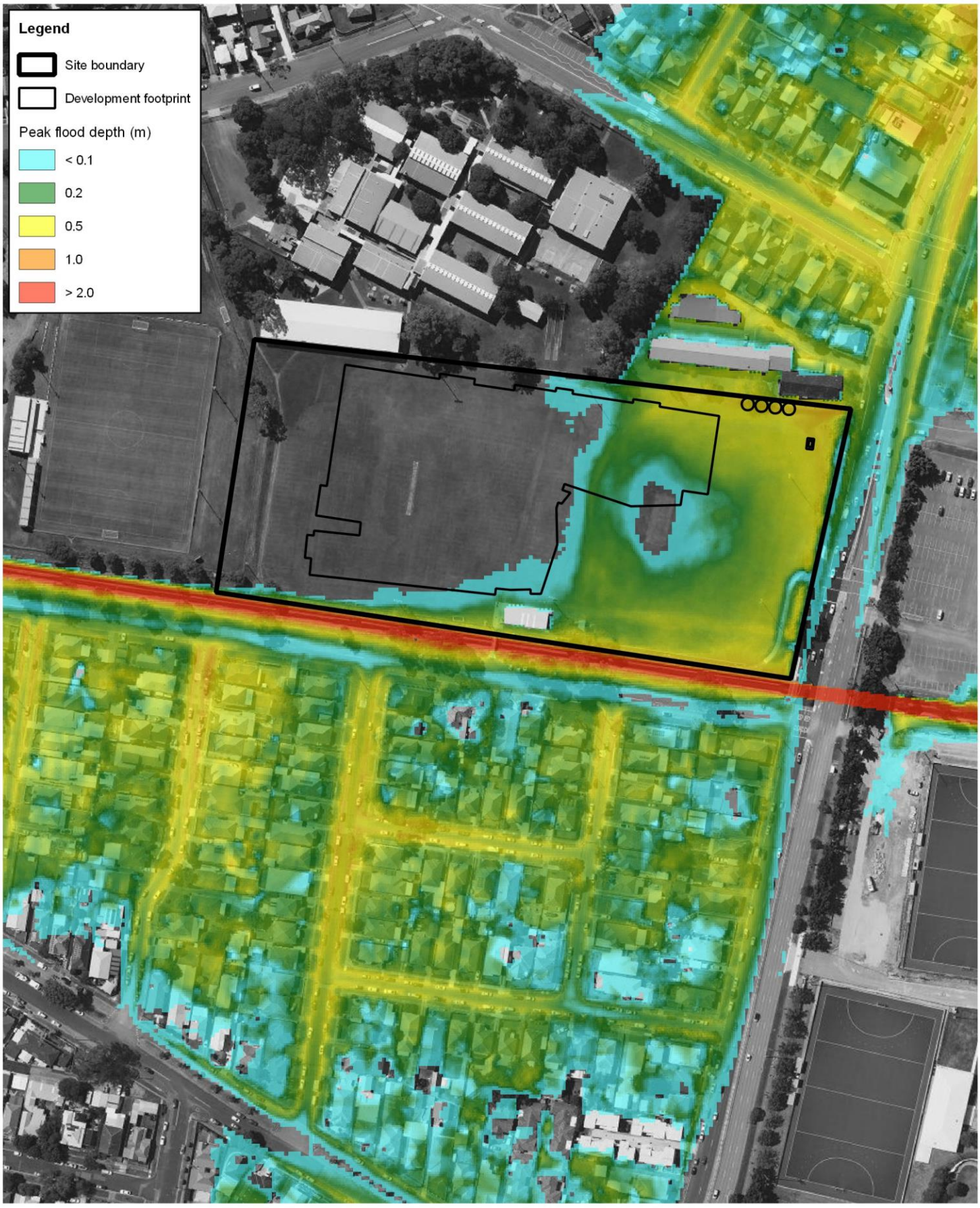

Title:

Modelled 2% AEP Peak Flood Depth

0 60 120 m

approx. scale

Figure: **A-2**

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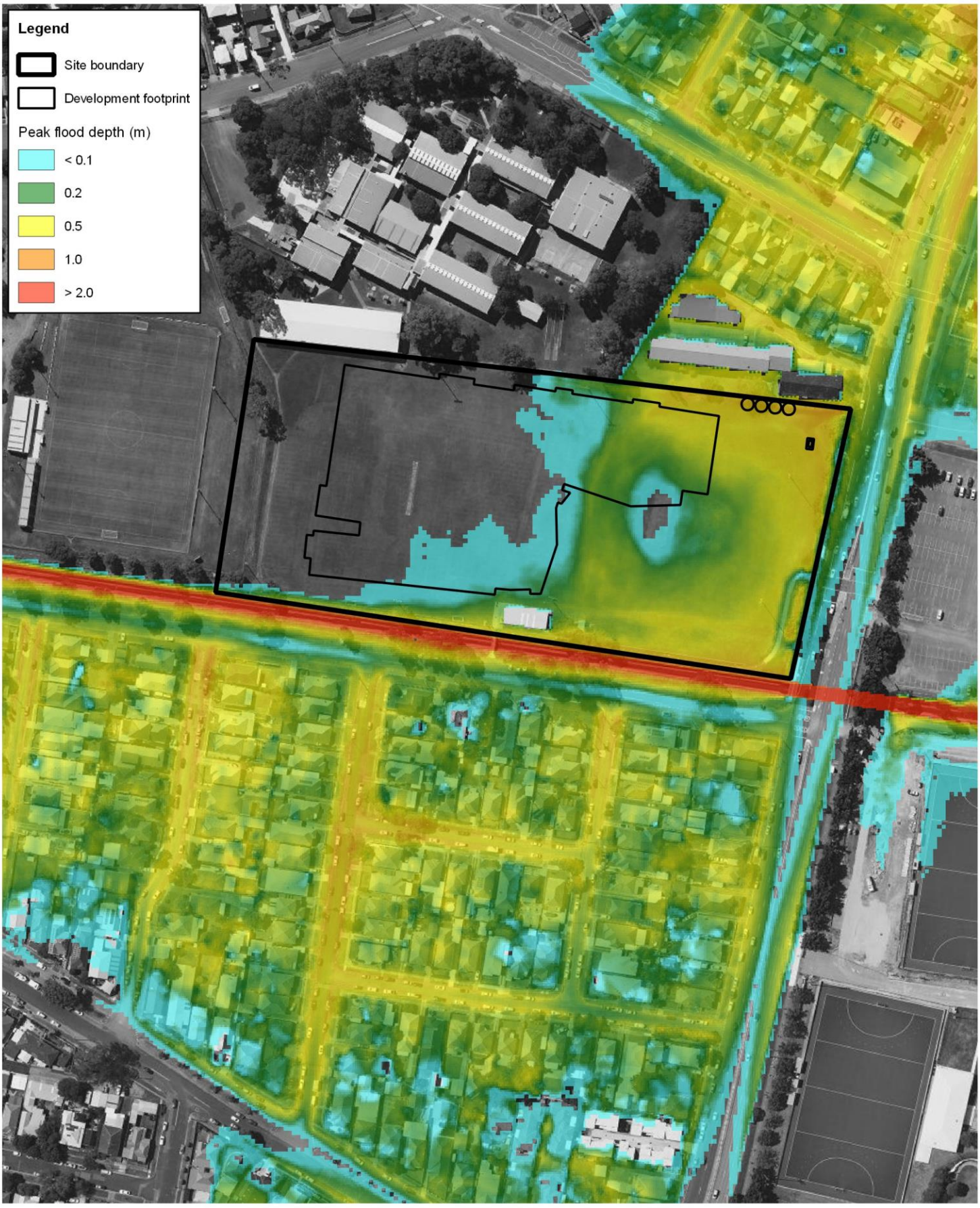

Title:

Modelled 1% AEP Peak Flood Depth

0 60 120 m

approx. scale

Figure: **A-3**

Revision: **A**

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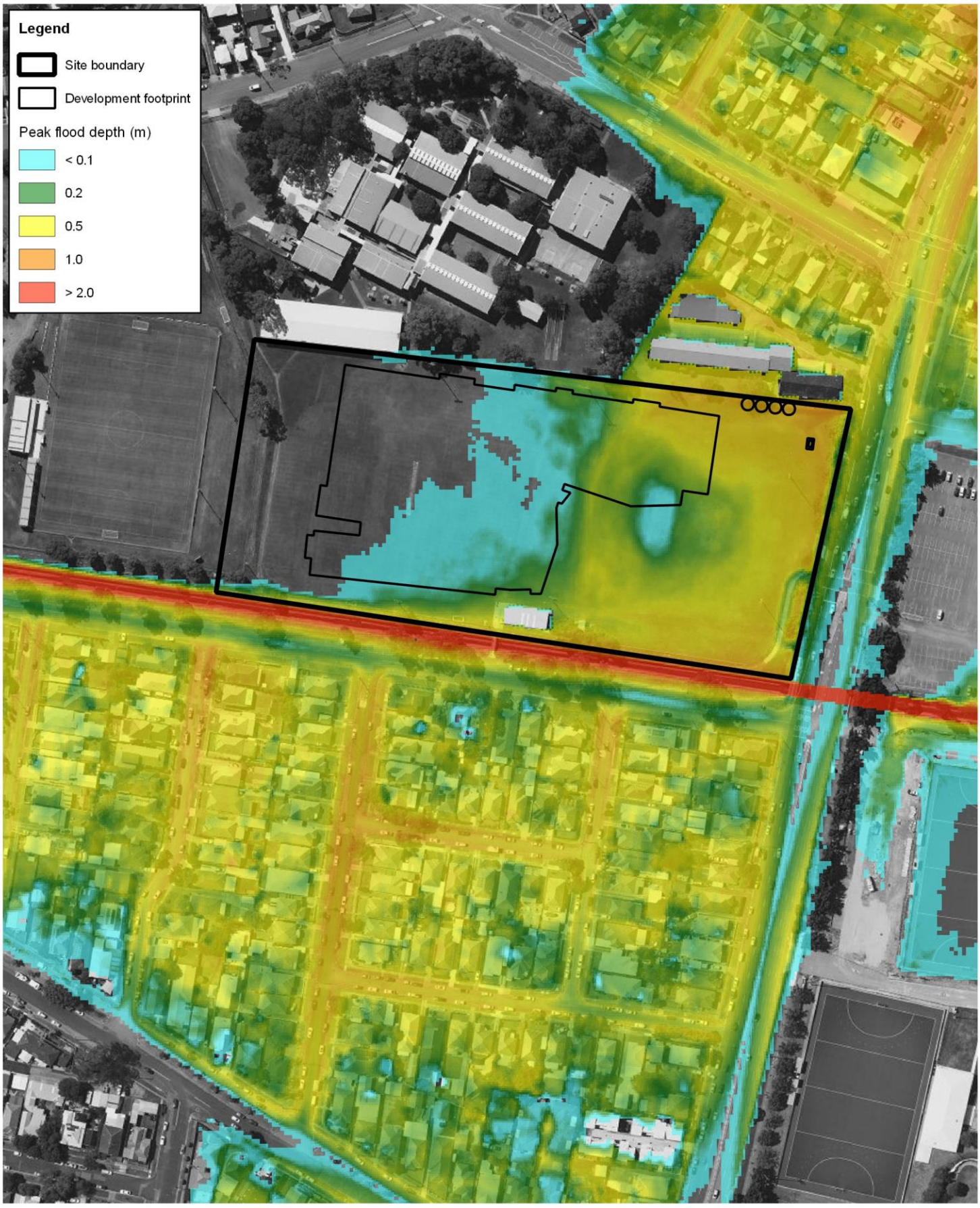

Title:

Modelled 0.5% AEP Peak Flood Depth

0 60 120 m

approx. scale

Figure: **A-4**

Revision: **A**

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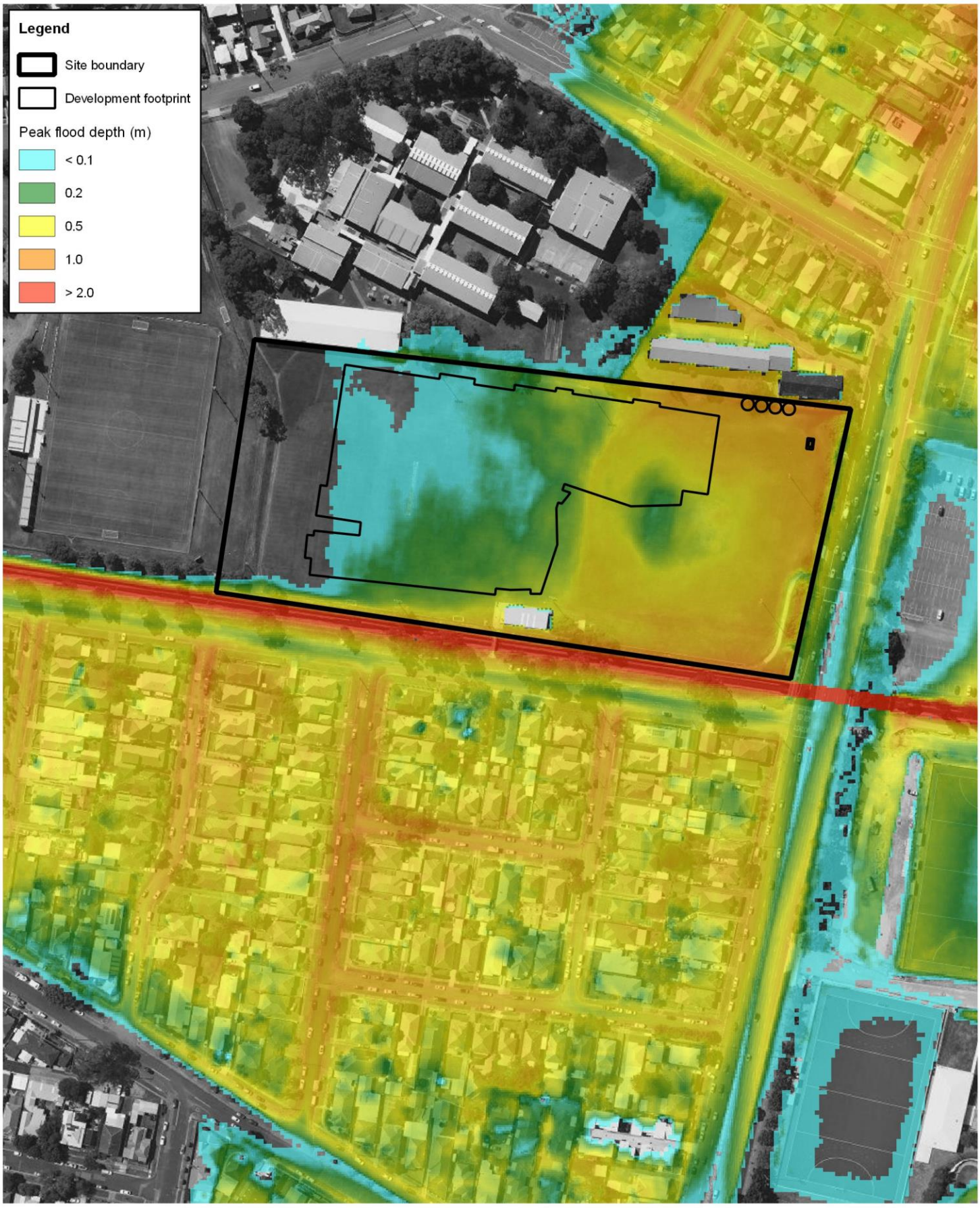

Title:

Modelled 0.2% AEP Peak Flood Depth

0 60 120 m

approx. scale

Figure: **A-5**

Revision: **A**

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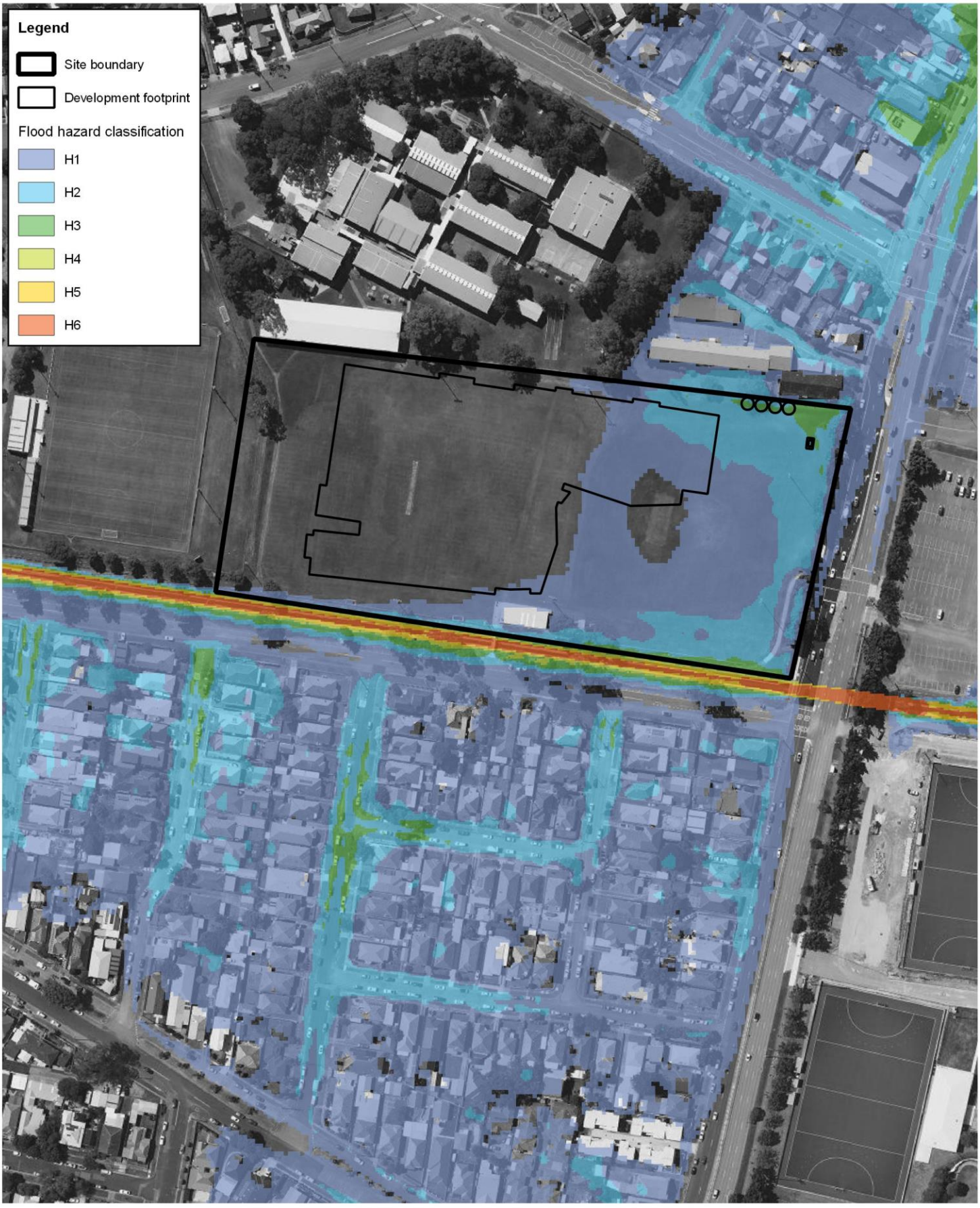

Title:

5% AEP Flood Hazard Classification

0 60 120 m

approx. scale

Figure: **A-6**

Revision: **A**

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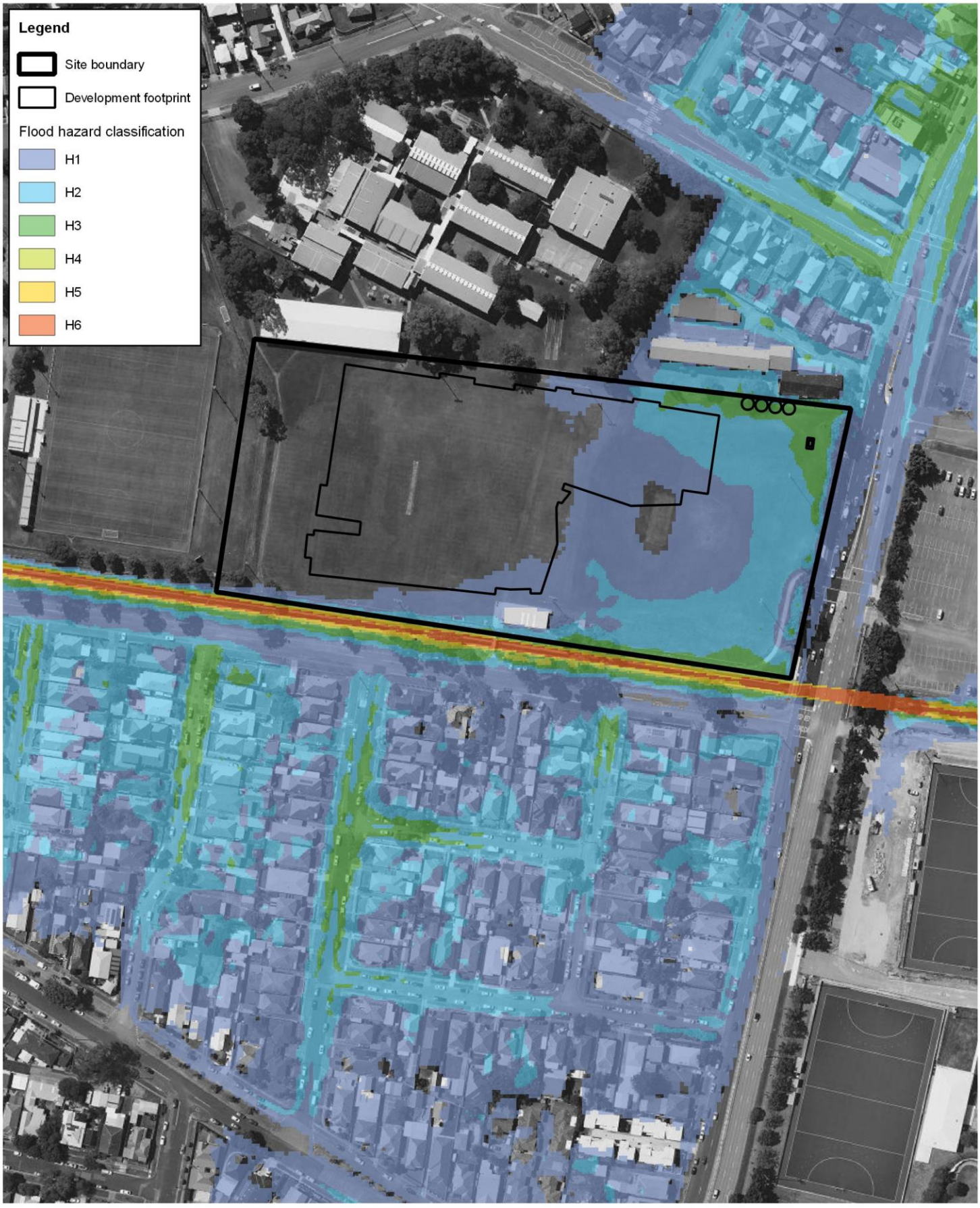

Title:

2% AEP Flood Hazard Classification

0 60 120 m

approx. scale

Figure: **A-7**

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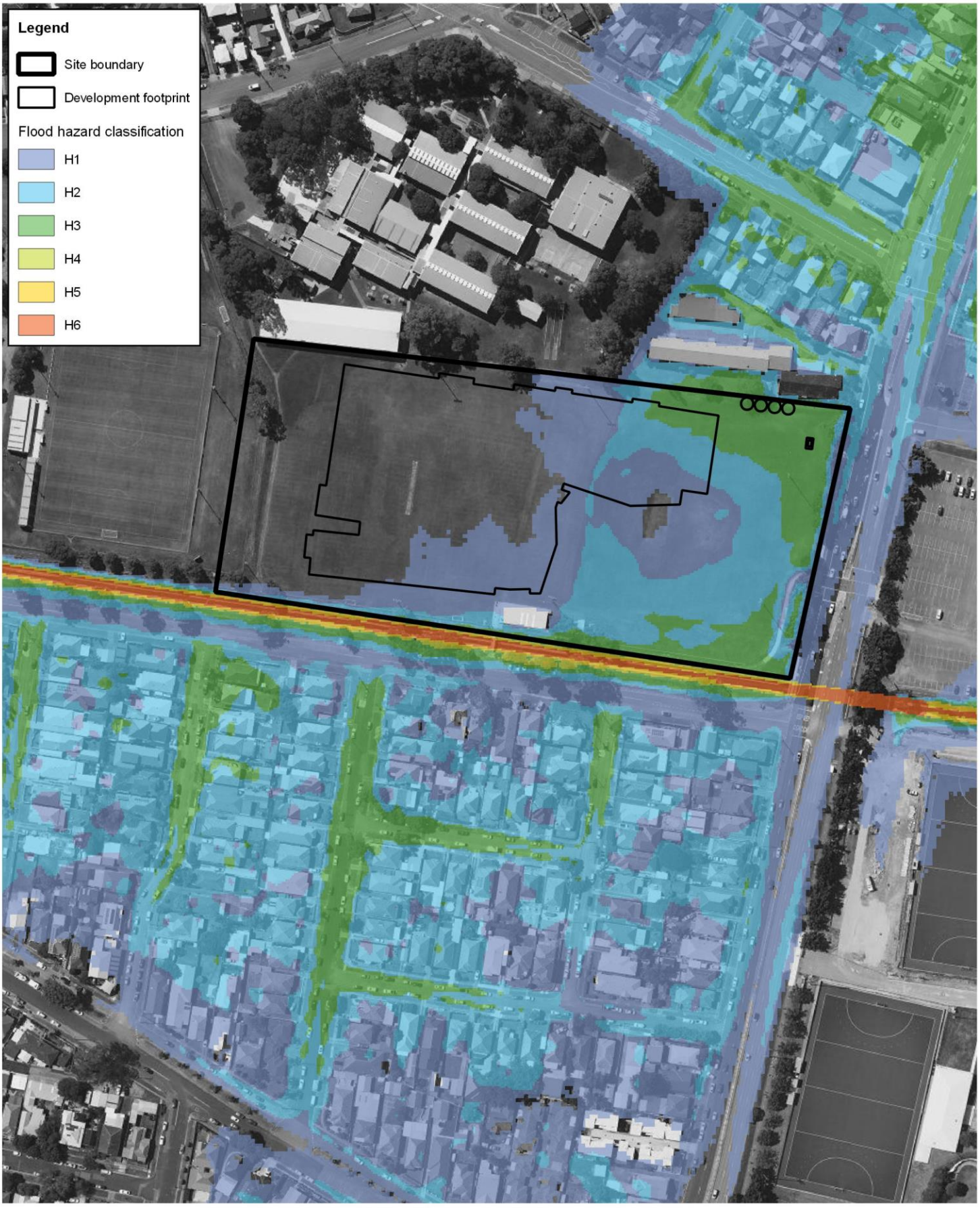

Title:

1% AEP Flood Hazard Classification

0 60 120 m

approx. scale

Figure: **A-8**

Revision: **A**

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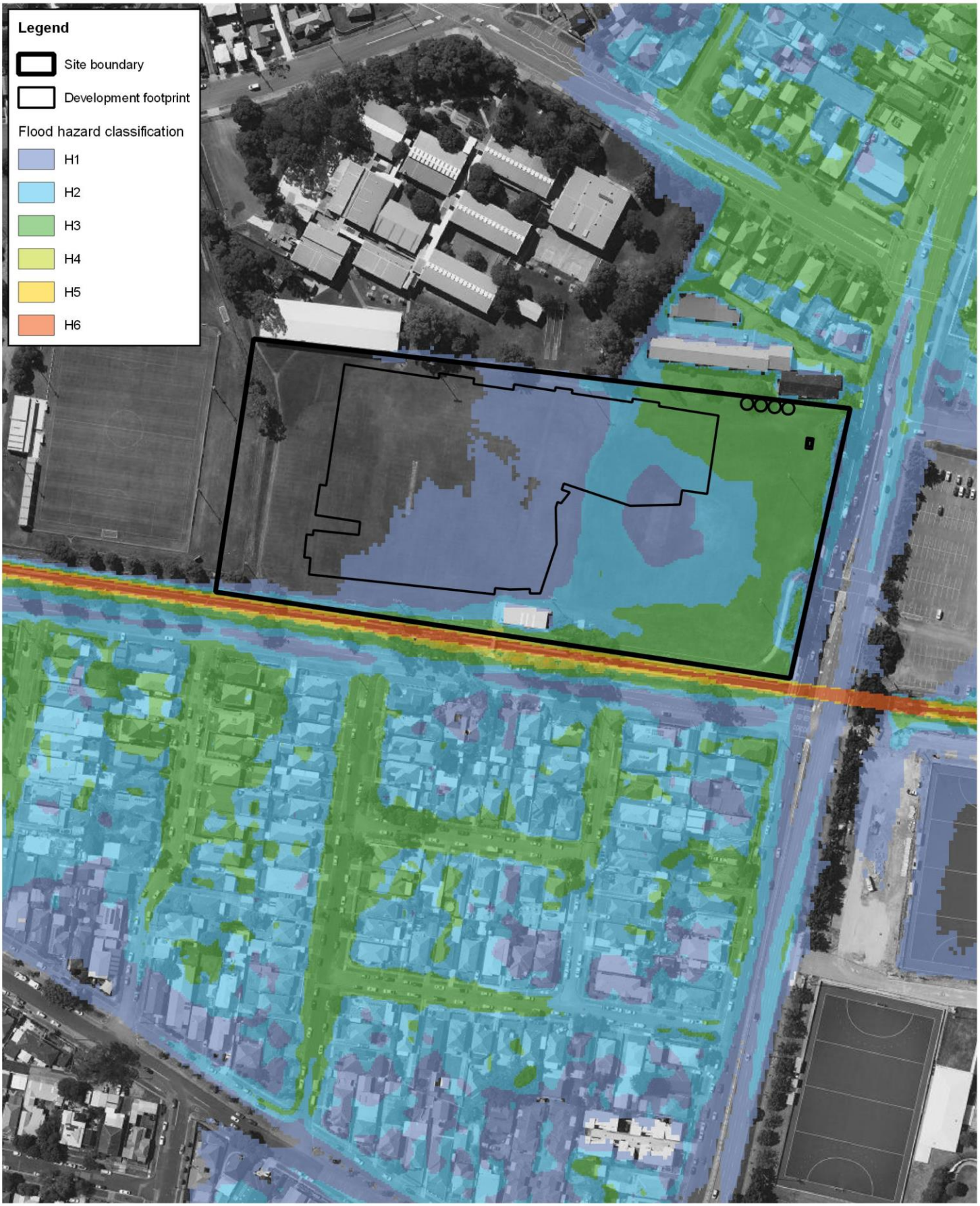

Title:

0.5% AEP Flood Hazard Classification

0 60 120 m

approx. scale

Figure: **A-9**

Revision: **A**

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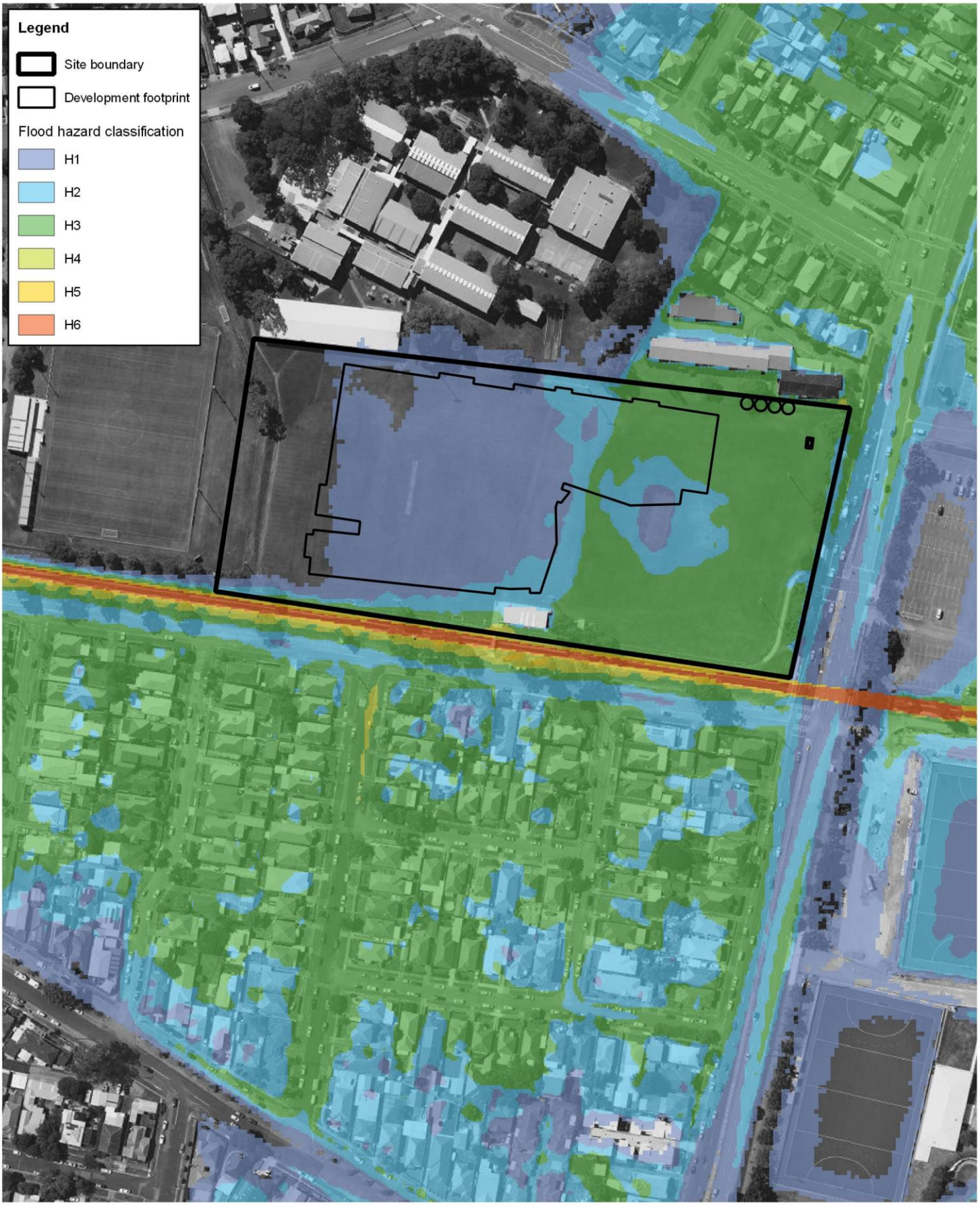

Title:

0.2% AEP Flood Hazard Classification

0 60 120 m

approx. scale

Figure: **A-10**

Revision: **A**

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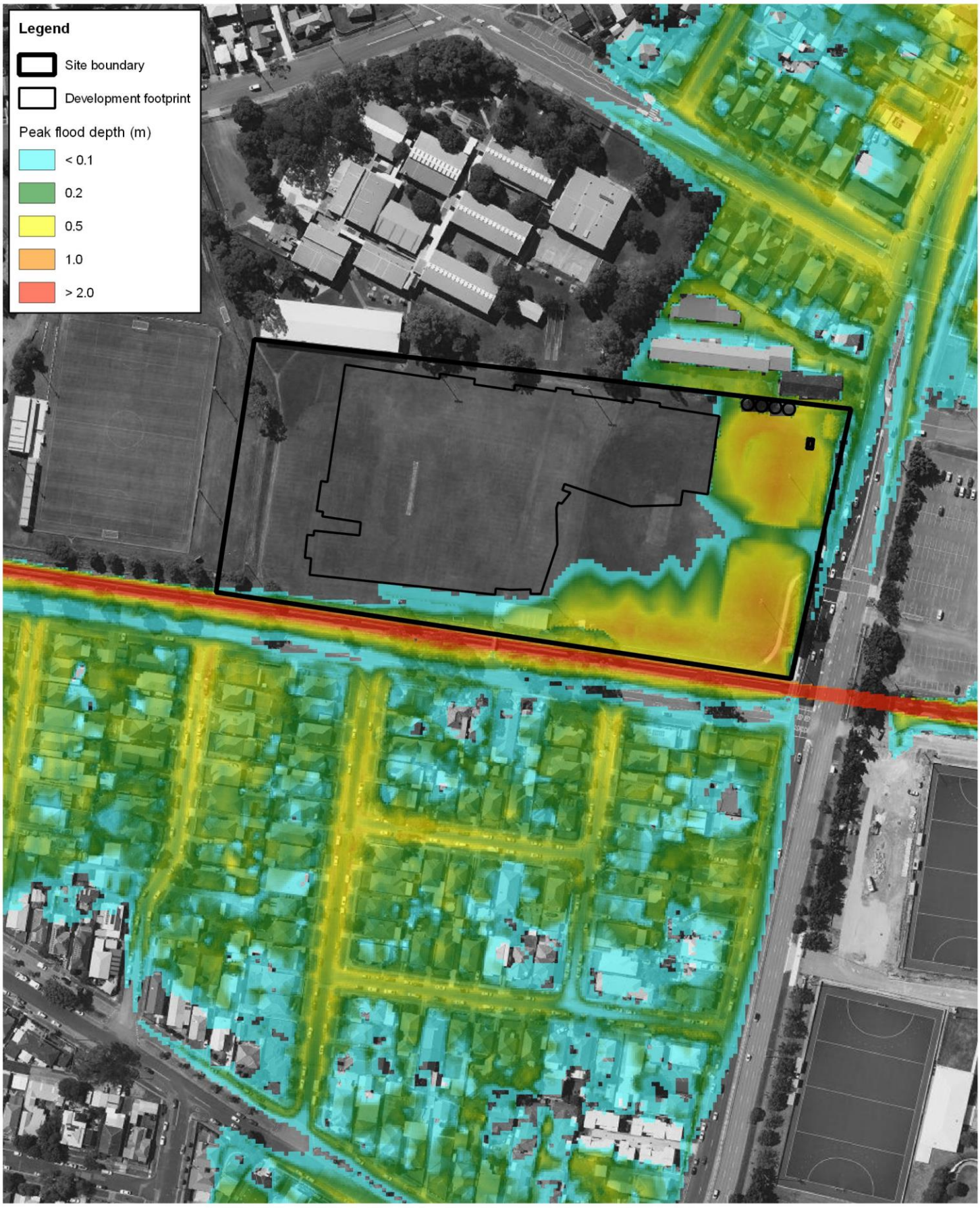
Appendix B Post-Development Flood Mapping



Title:

Modelled 5% AEP Peak Flood Depth for Post-development Conditions

0 60 120 m

approx. scale

Figure: **B-1**

Revision: **A**

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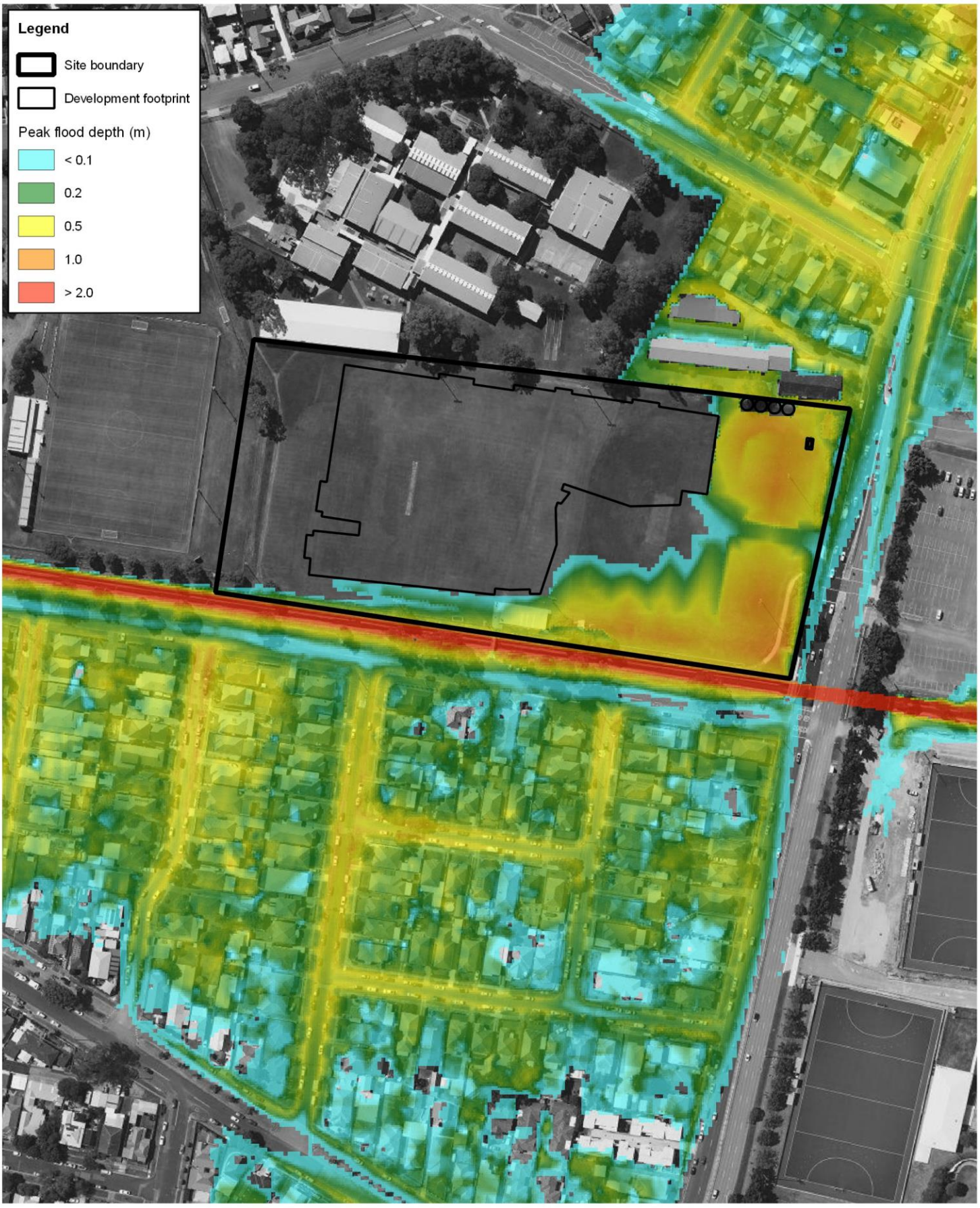

Title:

Modelled 2% AEP Peak Flood Depth for Post-development Conditions

0 60 120 m

approx. scale

Figure: **B-2**

Revision: **A**

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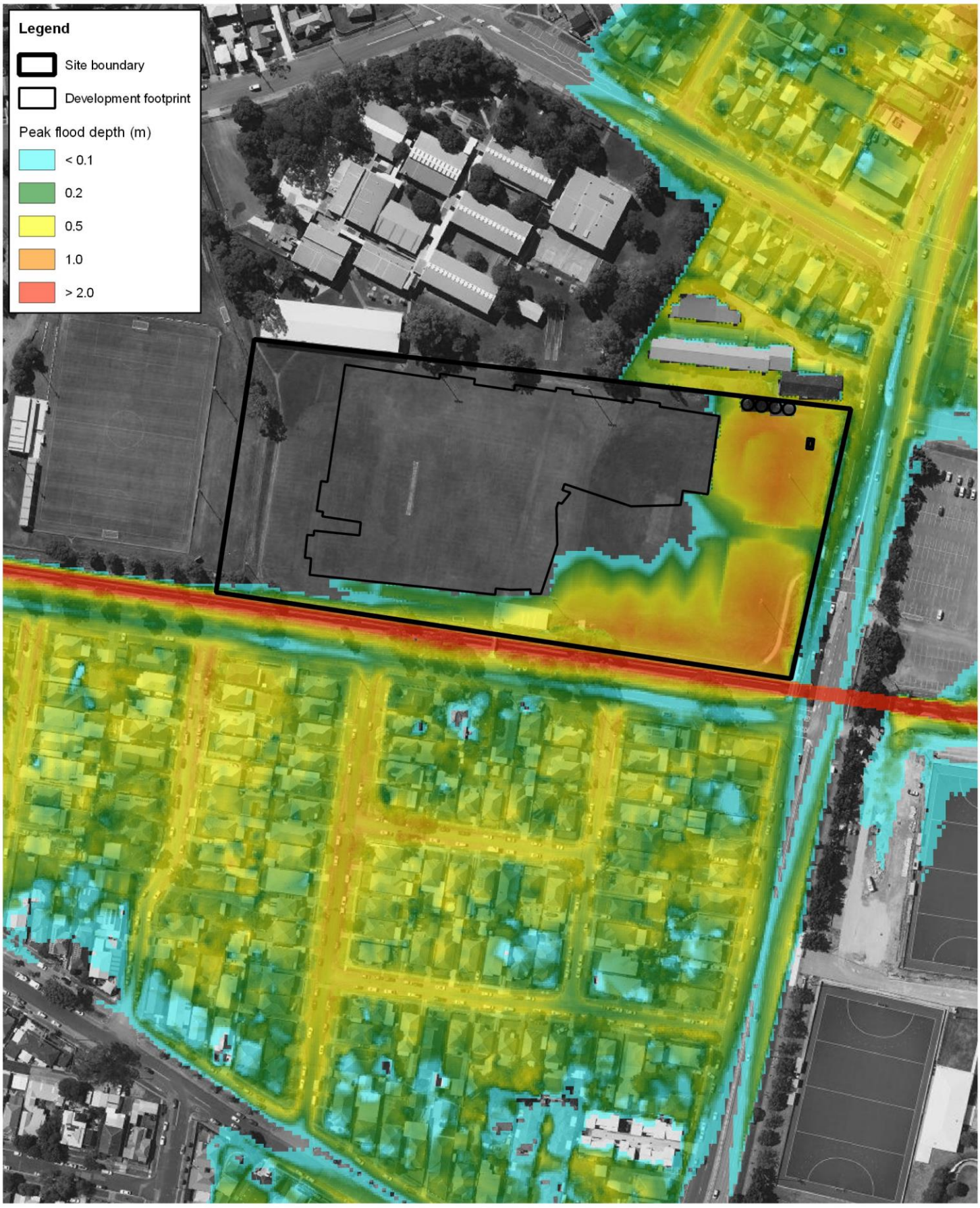

Title:

Modelled 1% AEP Peak Flood Depth for Post-development Conditions

0 60 120 m

approx. scale

Figure: **B-3**

Revision: **A**

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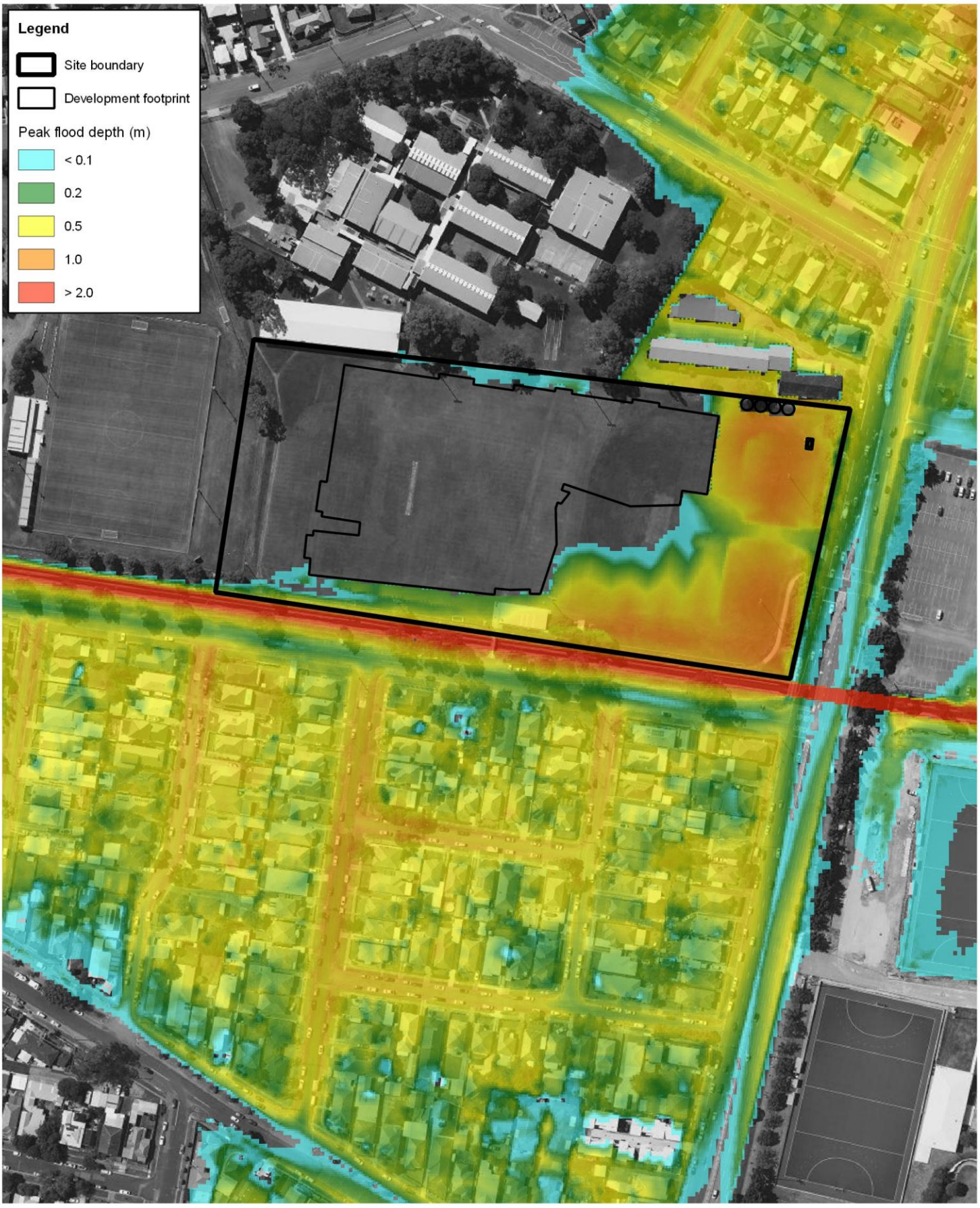

Title:

Modelled 0.5% AEP Peak Flood Depth for Post-development Conditions

0 60 120 m

approx. scale

Figure: **B-4**

Revision: **A**

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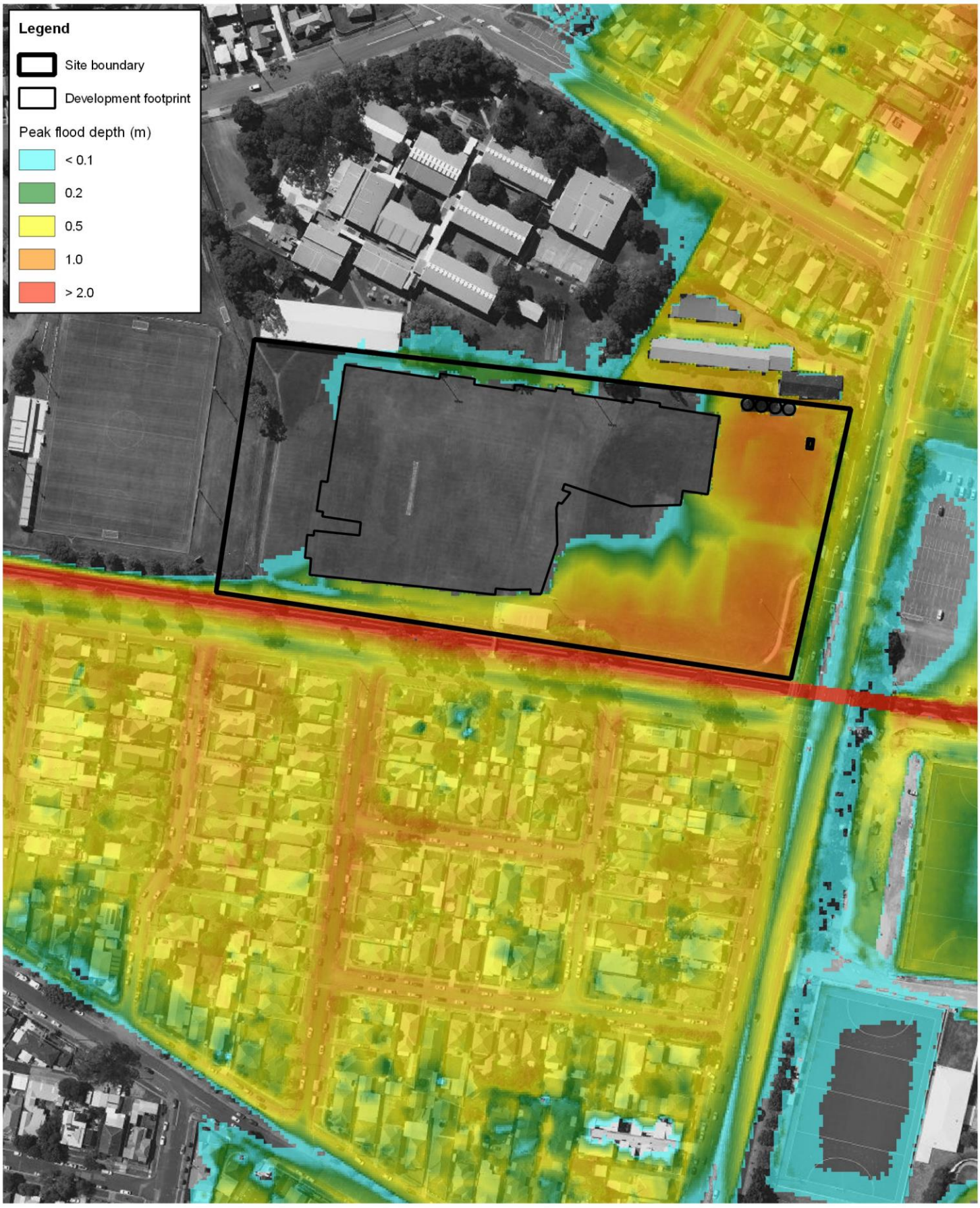

Title:

Modelled 0.2% AEP Peak Flood Depth for Post-development Conditions

0 60 120 m

approx. scale

Figure: **B-5**

Revision: **A**

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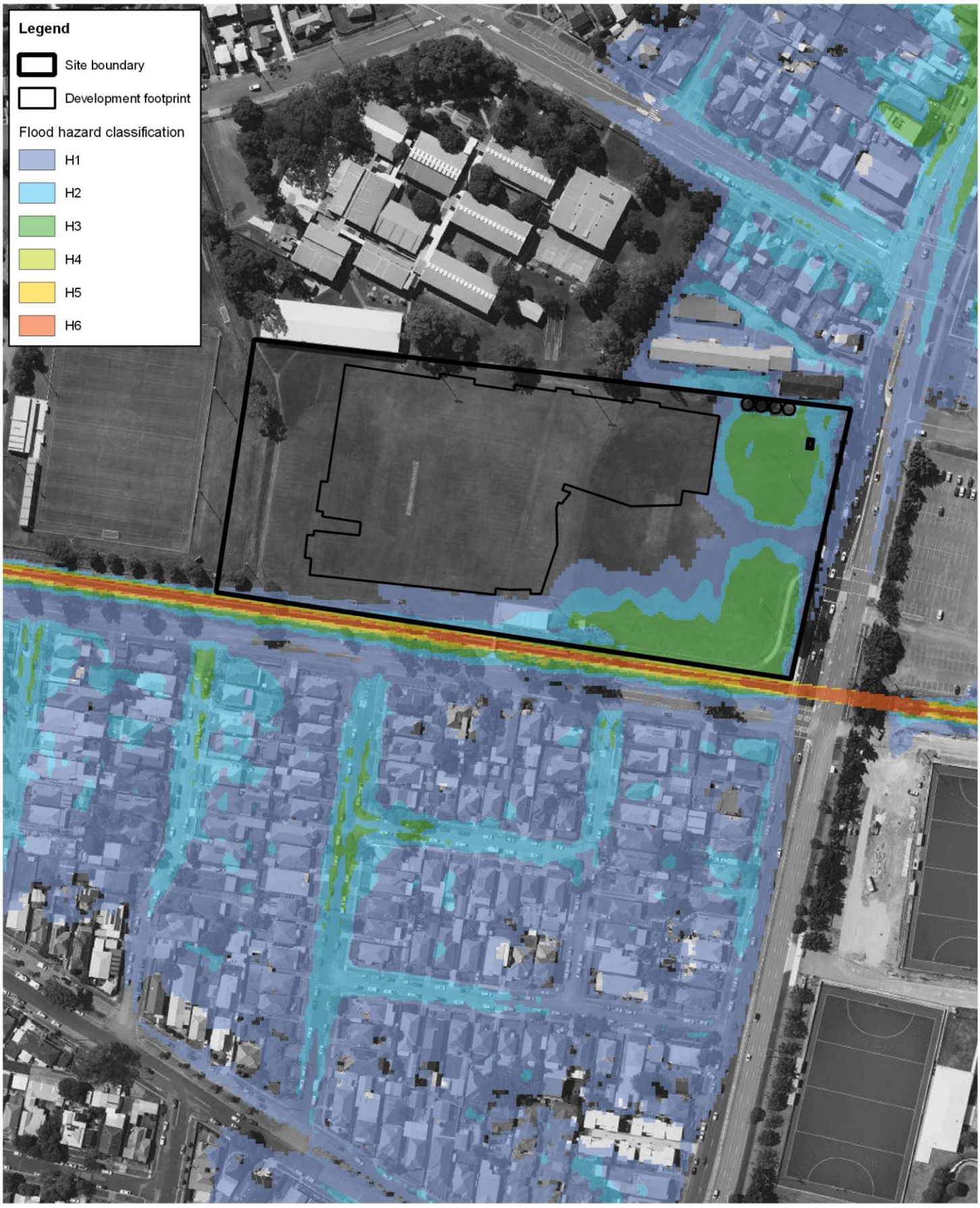

Title:

5% AEP Flood Hazard Classification for Post-development Conditions

0 60 120 m

approx. scale

Figure: **B-6**

Revision: **A**

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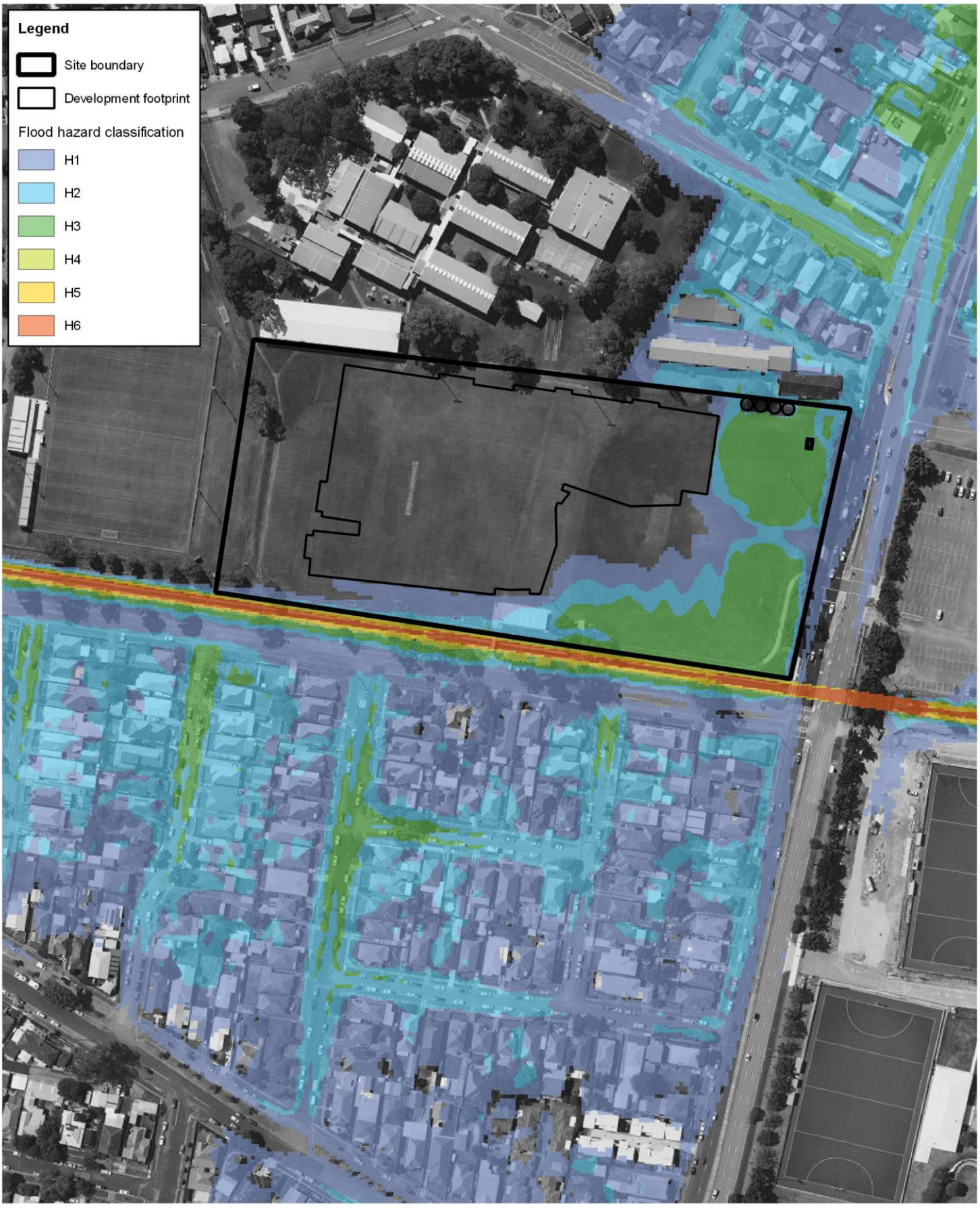

Title:

2% AEP Flood Hazard Classification for Post-development Conditions

0 60 120 m

approx. scale

Figure: **B-7**

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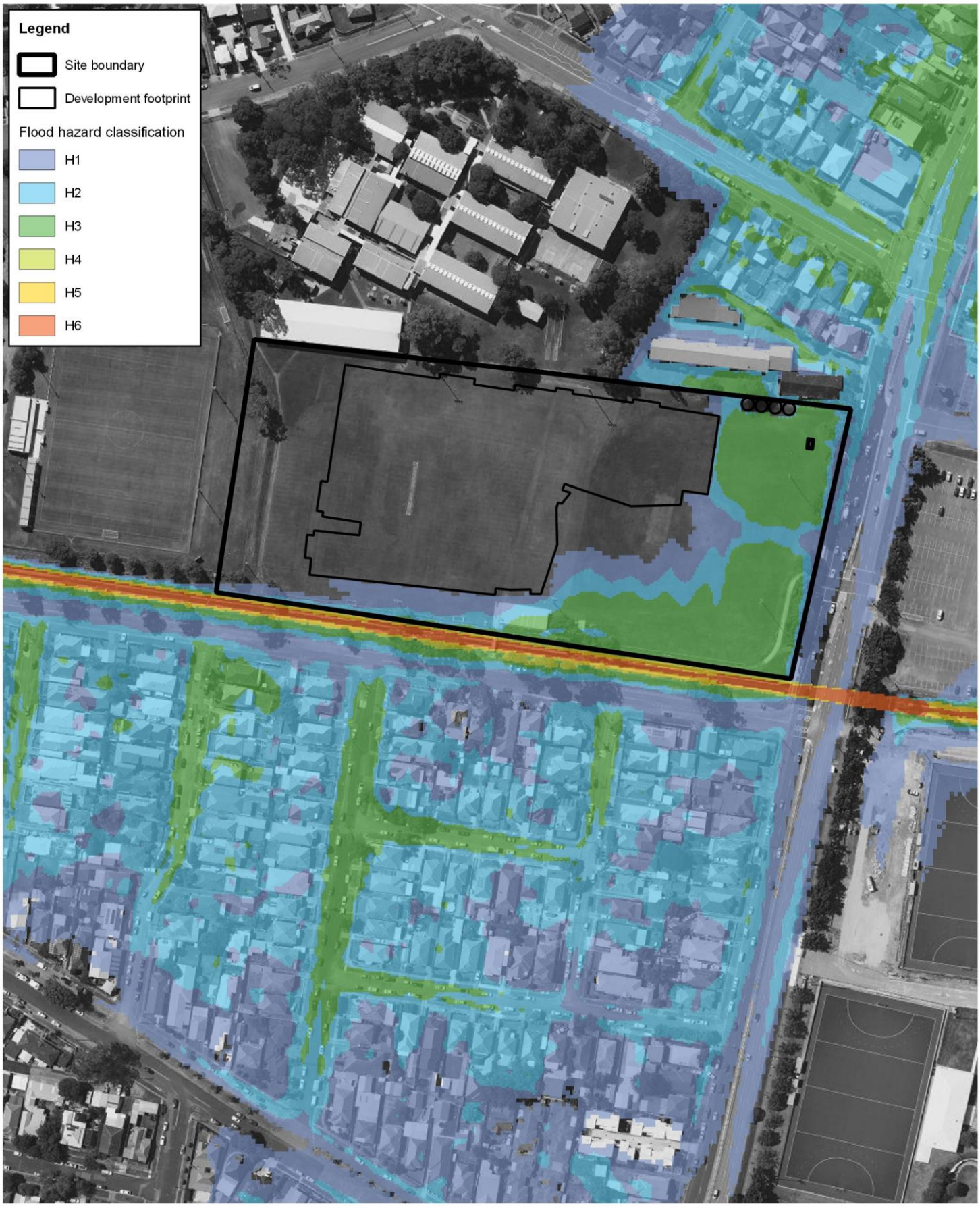

Title:

1% AEP Flood Hazard Classification for Post-development Conditions

0 60 120 m

approx. scale

Figure: **B-8**

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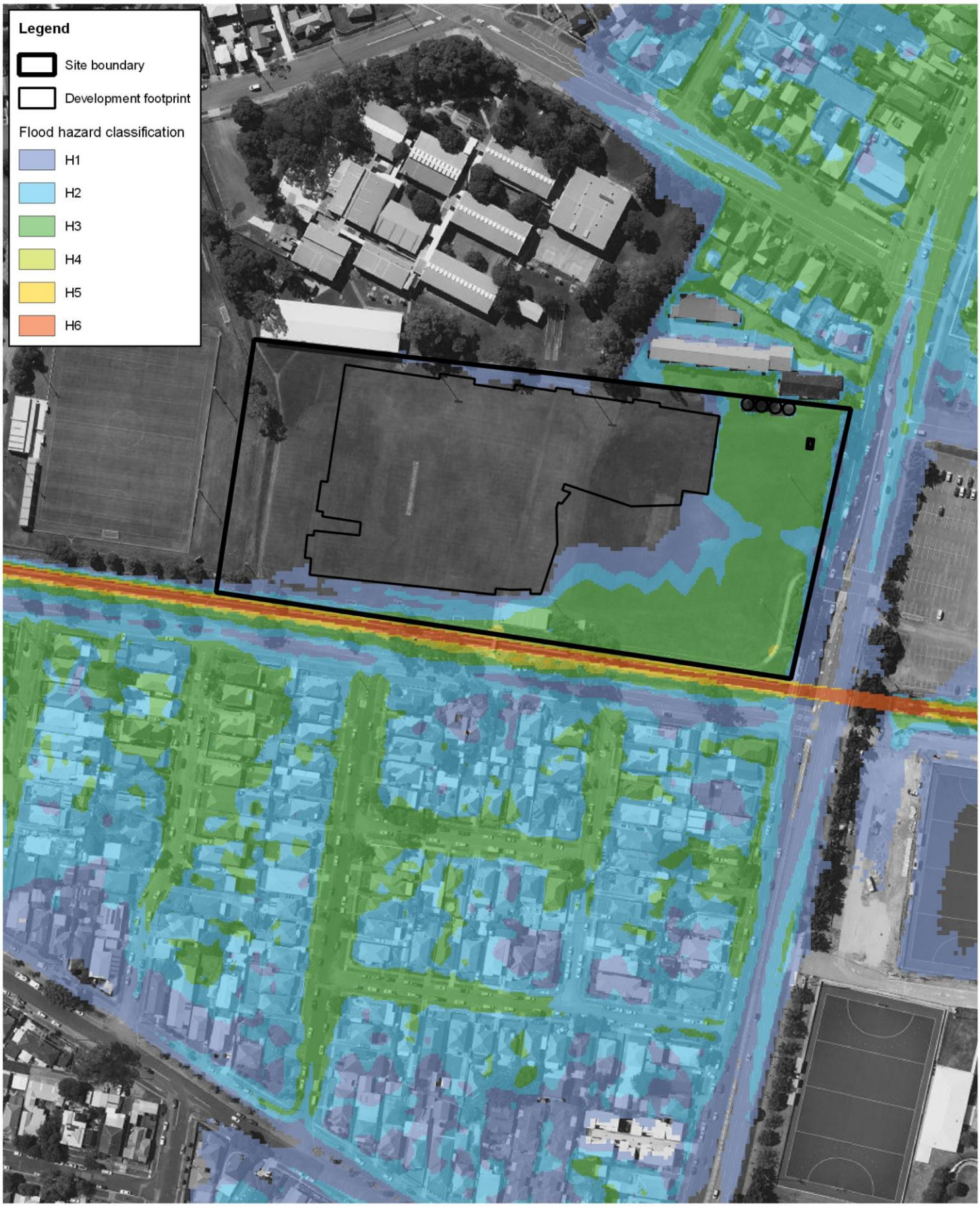

Title:

0.5% AEP Flood Hazard Classification for Post-development Conditions

0 60 120 m

approx. scale

Figure: **B-9**

Revision: **A**

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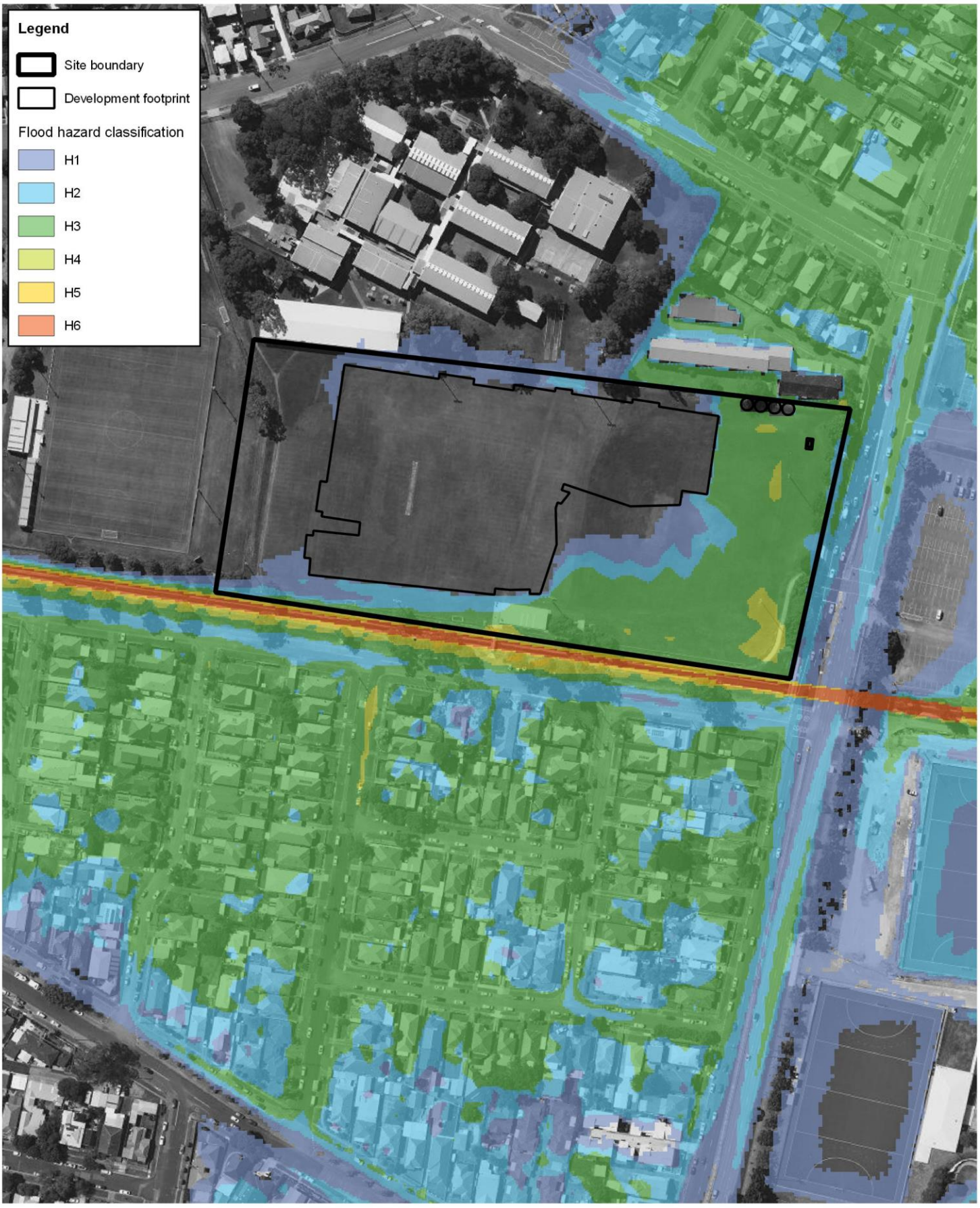

Title:

0.2% AEP Flood Hazard Classification for Post-development Conditions

0 60 120 m

approx. scale

Figure: **B-10**

Revision: **A**

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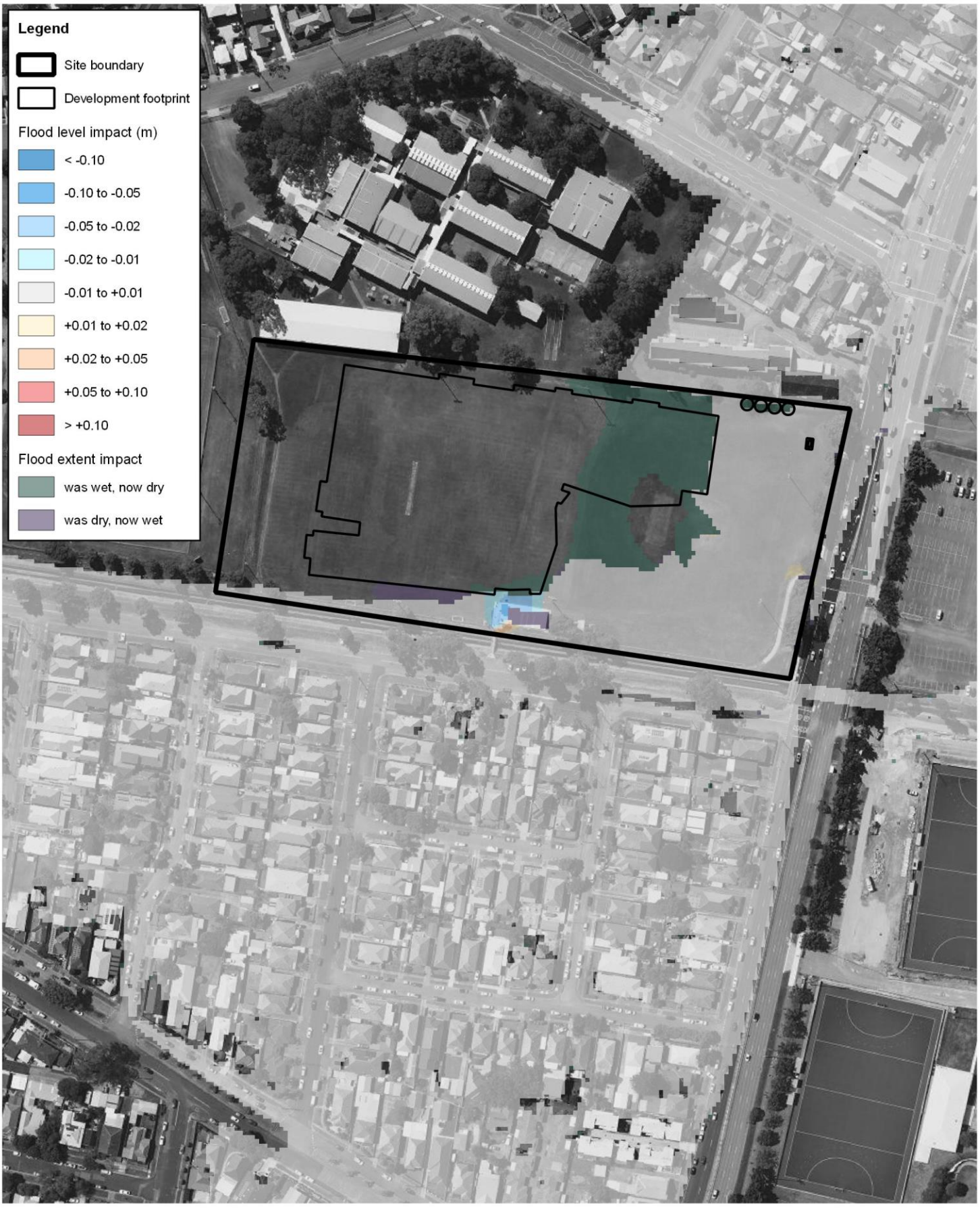
Appendix C Flood Impact Mapping



Title:

Modelled 5% AEP Peak Flood Level Impact

0 60 120 m

approx. scale

Figure: **C-1**

Revision: **A**

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Title:

Modelled 2% AEP Peak Flood Level Impact

0 60 120 m

approx. scale

Figure: **C-2**

Revision: **A**

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Title:

Modelled 1% AEP Peak Flood Level Impact

0 60 120 m

approx. scale

Figure: **C-3**

Revision: **A**

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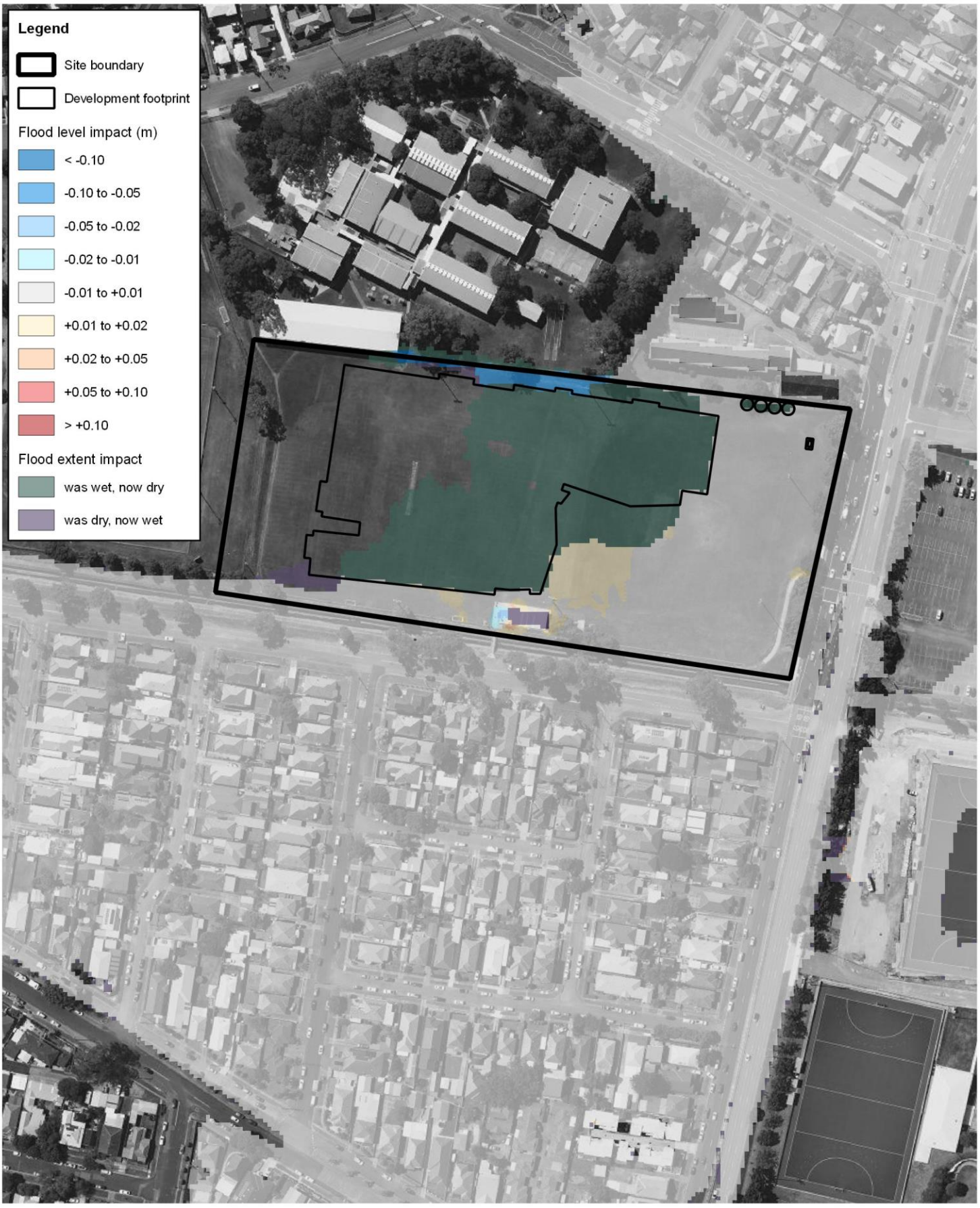

Title:

Modelled 0.5% AEP Peak Flood Level Impact

0 60 120 m

approx. scale

Figure: **C-4**

Revision: **A**

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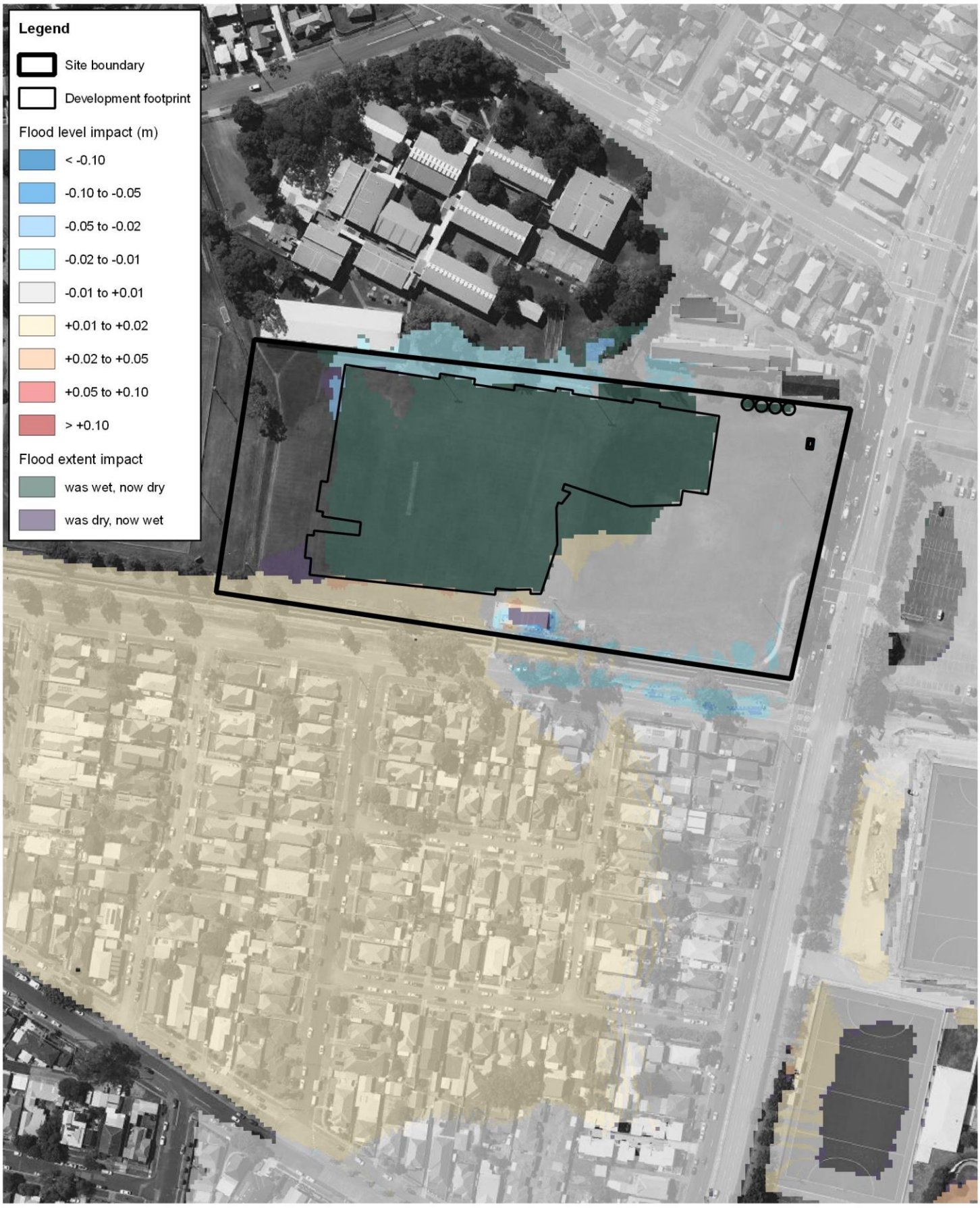

Title:

Modelled 0.2% AEP Peak Flood Level Impact

0 60 120 m

approx. scale

Figure: **C-5**

Revision: **A**

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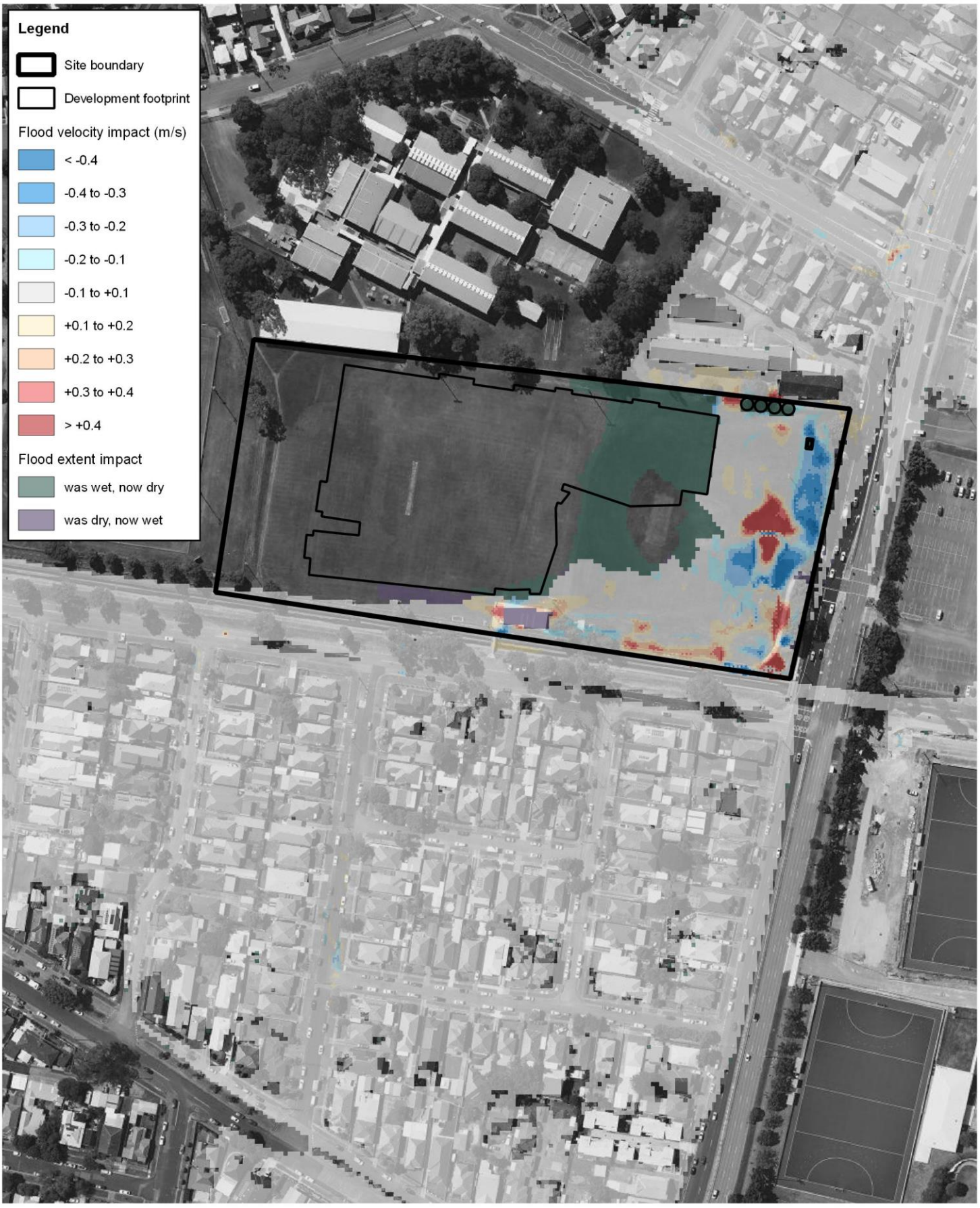

Title:

Modelled 5% AEP Peak Flood Velocity Impact

0 60 120 m

approx. scale

Figure: **C-6**

Revision: **A**

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Title:

Modelled 2% AEP Peak Flood Velocity Impact

0 60 120 m

approx. scale

Figure: **C-7**

Revision: **A**

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Title:

Modelled 1% AEP Peak Flood Velocity Impact

0 60 120 m

approx. scale

Figure: **C-8**

Revision: **A**

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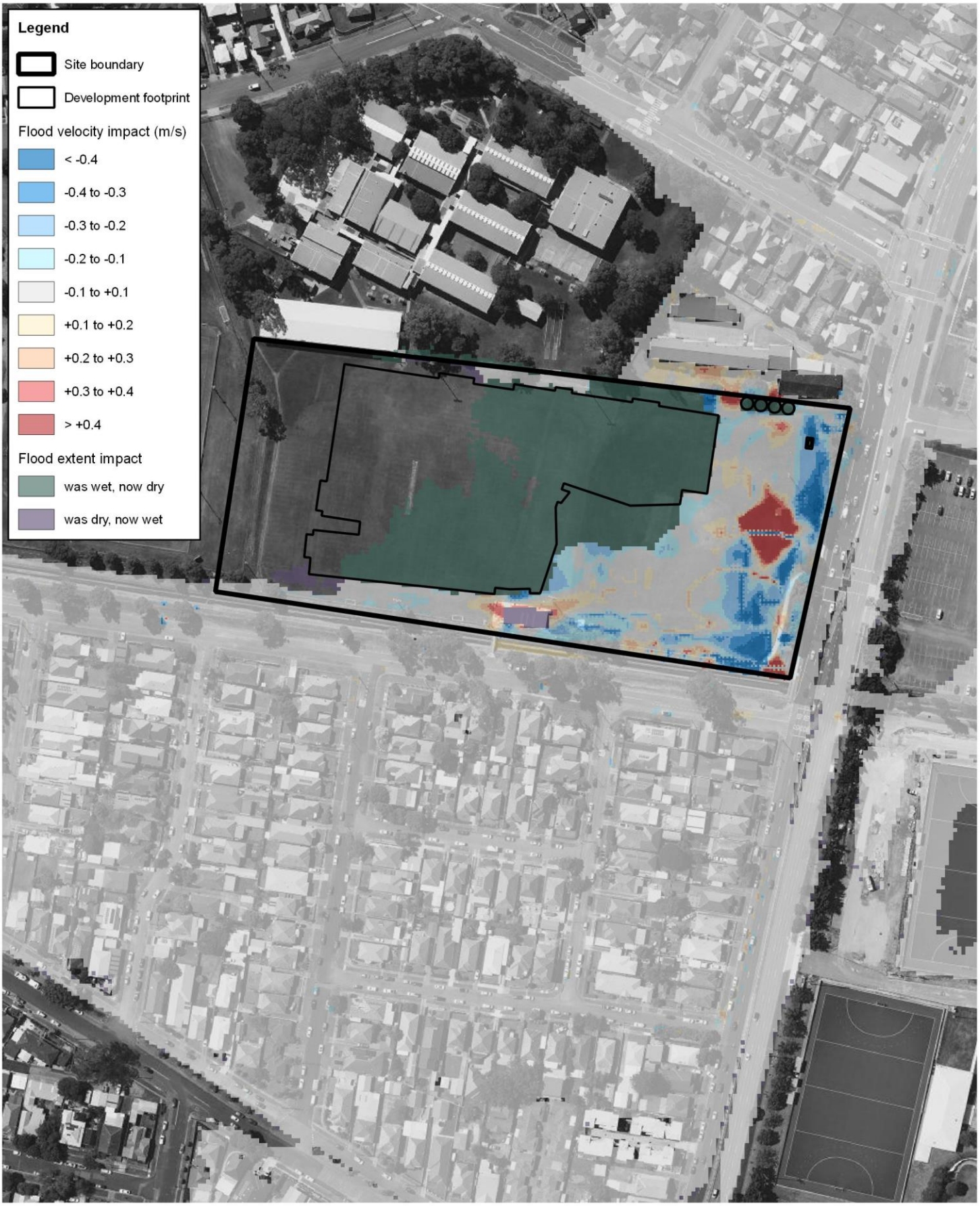

Title:

Modelled 0.5% AEP Peak Flood Velocity Impact

0 60 120 m

approx. scale

Figure: **C-9**

Revision: **A**

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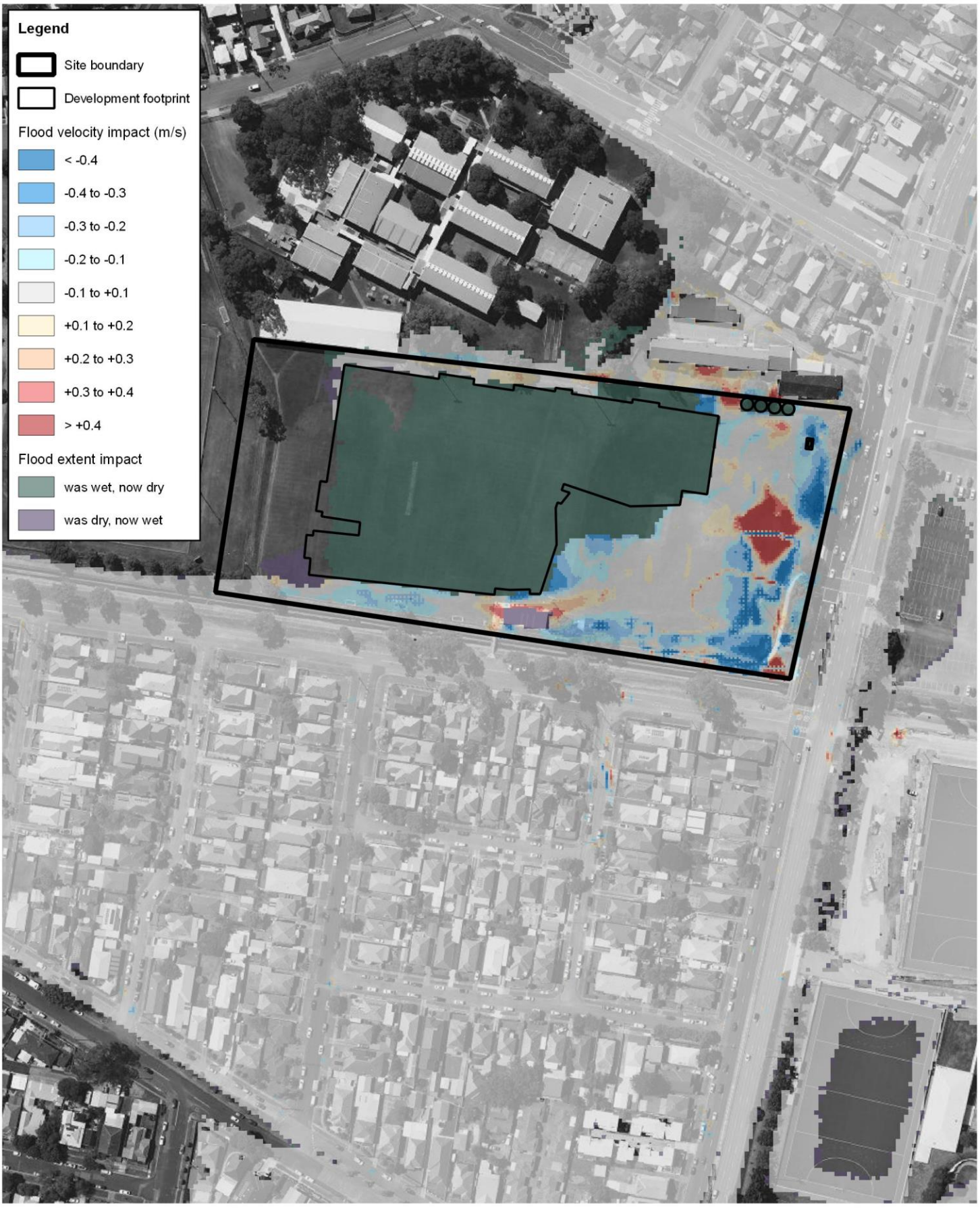

Title:

Modelled 0.2% AEP Peak Flood Velocity Impact

0 60 120 m

approx. scale

Figure: **C-10**

Revision: **A**

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