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13 August 2020

Sanjeev K Loura
Warriewood Developers Pty Ltd
3 Kerrie Rd, Oatlands NSW 2117

Attention: Sanjeev K Loura

Dear Sanjeev,

RE: 45 WARRIEWOOD ROAD, WARRIEWOOD FLOOD IMPACT ASSESSMENT

BMT was commissioned to provide a flood impact assessment for the proposed development at 45-49 Warriewood Road, Warriewood (the site). This report has been prepared to accompany the Environmental Impact Statement (EIS) for the site.

The proposed development is comprised of the subdivision and civil works of Lot 2 DP349085 and Lot 1 DO349085 45-49 Warriewood Road, Warriewood (see Figure 1). The site is located adjacent to Narrabeen Creek (flowing along the southern boundary of the site) and is classified as Flood Category 1 – High Hazard, with the southern portion of the site being inundated by floodwaters in the 1% AEP flood event.

Council Requirements

In accordance with the *Pittwater Local Environment Plan 2014* and *Pittwater 21 Development Control Plan* (Northern Beaches Council), the following flood planning restrictions are applicable to the site:

- Calculations to illustrate that any fill or structures do not result in a decrease in the floodplain volume of a floodway or flood storage area within the property for any flood event up to the 1% AEP event;
- Climate change assessment to determine the impact of sea level rise and increase in rainfall volume to flood behaviour at the site;
- Development structures are designed and constructed so as not to impede the floodway or flood conveyance on the site;
- No adverse flood impact on surrounding properties or on flooding processes for any event up to the Probable Maximum Flood (PMF) event and,
- The development cannot create any additional flood prone lots (i.e. all lots need to be above the flood planning event + 0.5m freeboard allowance). The flood planning event to be considered is the 1% AEP event.

A full list of planning requirements is shown in Table 1 and Table 2.

Table 1 Planning requirements from the *Pittwater Local Environment Plan 2014*

Pittwater LEP 2014 Clause	Response
7.3 Flood planning **(1)** *The objectives of this clause are as follows;*	
(a) to minimise the flood risk to life and property associated with the use of land,	As shown in the flood mapping figures, in the PMF event, the development area is located outside of the flood extent.
(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,	As shown in the flood hazard map for the 1% AEP event, the area of development is located outside both low and high hazard areas.
(c) to avoid significant adverse impacts on flood behaviour and the environment.	As shown in Appendix C, there is no significant adverse impacts on flood behaviour for a range of design flood events.
(2) *This clause applies to land at or below the flood planning level.*	Development area occurs in land above the FPL.
(3) *Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development—*	
(a) is compatible with the flood hazard of the land, and	The area of development is not located within the zones of high flood hazard as shown in the flood mapping figures in Appendix A and B.
(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and	As shown in Appendix C, there is no significant adverse impacts on flood behaviour for a range of design flood events.
(c) incorporates appropriate measures to manage risk to life from flood, and	Appropriate measures have been incorporated into the proposed design as shown in the impact maps in Appendix C. The area of development is located outside of the flood extent for a range of events including the PMF.
(d) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding	As shown in Appendix C, there is no significant adverse impacts on flood behaviour for a range of design flood events.
(4) *A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005, unless it is otherwise defined in this clause.*	Noted

Pittwater LEP 2014 Clause	Response
(5) *In this clause—* *(a) flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metres freeboard, or other freeboard determined by an adopted floodplain risk management plan.* *(b) floodplain risk management plan has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0), published in April 2005 by the NSW Government.*	Flood planning level has been adopted as the 1% AEP event plus 0.5 metres freeboard.

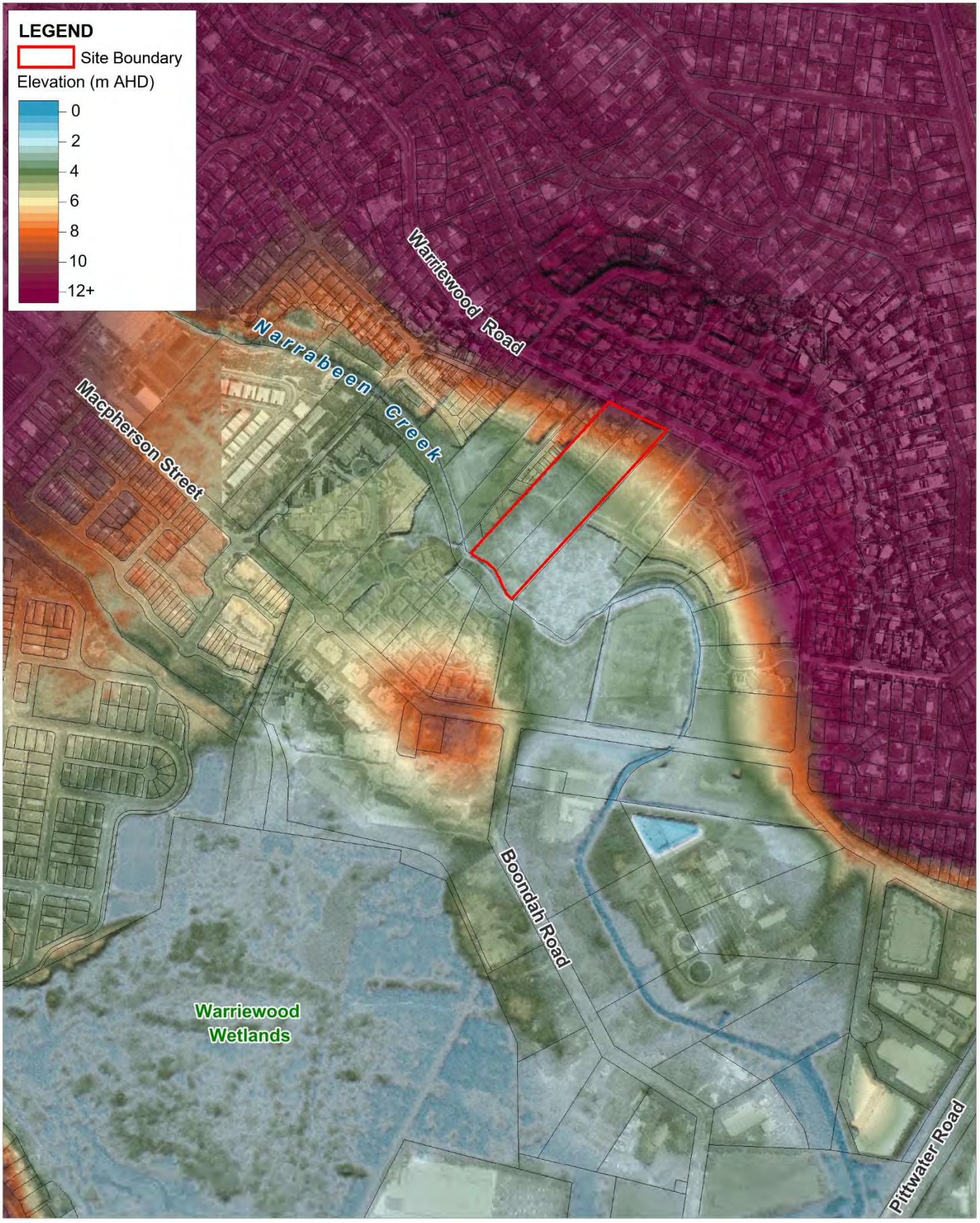
Table 2 Pittwater 21 DCP Flooding Requirements

Pittwater 21 DCP Clause	Response
B3 Hazard Controls: B3.11 Flood Prone Land	
A3; *The applicant shall include in their submission, calculations to illustrate that any fill or other structures that reduce the total flood storage are replaced by Compensatory Works.*	Calculations in the change of total onsite flood storage for the 1% AEP event is presented in the 'Flood Impact Assessment' section of the report.
B1; *Flood mitigation works or stormwater devices that modify a major drainage system, stormwater system, natural water course, floodway or flood behaviour within or outside the development site may be permitted subject to demonstration through a Flood Management Report that they comply with the Flood Prone Land Design Standard found on Council's webpage.*	Flood modelling is undertaken to demonstrate the impacts on Narrabeen creek, further work is required by civil engineers to design site drainage to cater for local flows.
B2; *A Section 88B notation under the Conveyancing Act 1919 may be required to be placed on the title describing the location and type of flood mitigation works with a requirement for their retention and maintenance.*	No additional flood mitigation works are required to address impacts on Narrabeen Creek.
E1; *New development must provide an appropriately sized area to safely shelter in place above the Probable Maximum Flood level and appropriate access to this area should be available from all areas within the development.*	The majority of the development area is not within the flood extent for events up to and including the PMF, appropriate access to safe sheltering areas is also available from all areas of the development.
F1; *New floor levels within the development shall be at or above, the Flood Planning Level. A reduced Flood Planning Level may be considered only where it is permitted in this Development Control Plan.* *The structure must be flood proofed (wet or dry) to the Flood Planning Level. This control cannot be applied to critical or vulnerable uses.*	The area of development is located above the Flood Planning Level as determined by the modelling of the 1% AEP event + freeboard. The development area is flood proofed to the flood planning level by adding fill to raise the land out of the flood extent.
F2; *All development structures must be designed and constructed so as not to impede the floodway or flood conveyance on the site, as well as ensuring no loss of flood storage in a 1% AEP Event. Where the dwelling is located over a flow path it must be elevated on suspended pier/pile*	Flood modelling has been undertaken demonstrate that the development will not impede the floodway and will be located above the flood planning level.

Pittwater 21 DCP Clause	Response
footings such that the level of the underside of all floors including balconies and decks within the flood affected area are at or above, or raised to the Flood Planning Level to allow clear passage of the floodwaters under the building. The development must comply with the Flood Prone Land Design Standard.	The change of total onsite flood storage for the 1% AEP event is presented in the 'Flood Impact Assessment' section of the report. Note that no flood impacts were associated with the development for the 1% AEP flood level.
F3; *Where the lowest floor has been elevated to allow the passage of flood waters, a restriction shall be imposed on the title of the land, pursuant to S88B of the Conveyancing Act confirming that the under croft area is not to be enclosed.*	Development structures are located above the flood planning level for the site.
F6; *Any existing floor level may be retained below the Flood Planning Level when undertaking a first floor addition provided that:* *(a) it is not located within a floodway;* *(b) there is no increase to the building footprint below the Flood Planning Level;* *(c) it is flood proofed to the Flood Planning Level;*	This is a new development that will not retain existing structures. .
F8; *The minimum floor level of any first-floor additions shall be at or above the Probable Maximum Flood Level*.	Flood mapping figures in Appendix B show the proposed development structures to be outside of the flood extent for a range of events including the PMF.
H1; *Fencing, including pool fencing, shall be designed so as not to impede the flow of flood waters and not to increase flood affectation on surrounding land. Appropriate fencing must comply with the Flood Prone Land Design Standard in addition to other regulatory requirements of pool fencing.*	Fencing including pool fencing is designed to be located outside of the flood extent for a range of events including the PMF.
B3.12 Climate Change Assessment for Land Identified on Flood Hazard Maps *Clause C6.4 Flood - Warriewood Valley Residential Sectors, Buffer Areas or Development Sites, Clause C6.5 Flood - Warriewood Valley Employment Generating Sectors, Buffer Areas or Development Sites and in accordance with Council's Warriewood Valley Urban Land Release Water Management Specification (February 2001 or as amended). The climate change assessment shall include the impacts of climate change on the property over the life of the development and the adaptive measures to be incorporated in the design of the project. The following climate change scenarios shall be considered:* • ***Scenario 1:*** *Impacts of sea level rise only* • ***Scenario 2:*** *Impacts of sea level rise combined with increased rainfall volume*	Flood modelling undertaken for a range of events to carry out a sensitivity analysis of sea level rise and rainfall volume increase on flood behaviour.
C6.1 Flooding *The flood levels are to be determined as part of*	

Pittwater 21 DCP Clause	Response
the Water Management Report. The information to be obtained includes:	
• *the 50% Annual Exceedance Probability (AEP) flood levels with climate change impacts including sea level rise combined with increase rainfall volume;*	Modelled as the 2 Year ARI event from the Narrabeen Lagoon Flood Study Climate change sensitivity test modelled using the 1% AEP +CC downstream boundary and 30% increase in rainfall volume (Figure D-1)
• *the 20% AEP flood levels with climate change impacts including sea level rise combined with increase rainfall volume;*	Modelled as the 20% AEP event from the Narrabeen Lagoon Flood Study Climate change sensitivity test modelled using the 1% AEP +CC downstream boundary and 30% increase in rainfall volume (Figure D-2)
• *the 1% AEP flood levels with climate change impacts including sea level rise combined with increase rainfall volume;*	Modelled as the 1% AEP event from the Narrabeen Lagoon Flood Study Climate change sensitivity test modelled using the 1% AEP +CC downstream boundary and 30% increase in rainfall volume (Figure D-3)
• *the Flood Planning Level (FPL) - equal to the 1% AEP flood level plus freeboard (as defined within clause A1.9 of this DCP) with climate change impacts including sea level rise combined with increase rainfall volume;*	FPL set as the modelled 1% AEP event + 0.5m Freeboard Climate change sensitivity test modelled using the 1% AEP +CC downstream boundary and 30% increase in rainfall volume
• *the Probable Maximum Flood (PMF) level with climate change impacts including sea level rise combined with increase rainfall volume;*	Modelled as the PMF event from the Narrabeen Lagoon Flood Study Climate change sensitivity test modelled using the 1% AEP +CC downstream boundary and 30% increase in rainfall volume (Figure D-4)
• *the flow velocities for the 1% AEP flood and Probable Maximum Flood with climate change impacts including sea level rise combined with increase rainfall volume; and*	Flow velocities modelled for a range of events based on the Narrabeen Lagoon Flood Study and presented as velocity vectors in the flood mapping figures. Flow velocities presented in Appendix A and B Climate change impacts presented in Appendix D
• *the Flood Category and Flood Hazard Classification as defined in clause A1.9 of this DCP with climate change impacts including sea level rise combined with increase rainfall volume.* • *Flood Hazard is classified as either Low Hazard or High Hazard.*	Flood categorisation and flood hazard results produced using the 1% AEP results. Flood categorisation and flood hazard mapping presented in Appendix A and B
Likely flood impacts from the development must also be assessed and where required, mitigated. The filling of land will only be permitted where it	Flood modelling for a range of events shows no additional adverse flood level impacts on the subject and surrounding

Pittwater 21 DCP Clause	Response
can be demonstrated within the Water Management Report that: • *there is no net decrease in the floodplain volume of the floodway or flood storage area within the property, for any flood event up to the 1% AEP flood event and the PMF event including climate change considerations for both design events; and/or* • *there is no additional adverse flood impact on the subject and surrounding properties and flooding processes for any flood event up to the PMF event including climate change impacts.*	properties for any event up to the PMF event including climate change impacts.
The Water Management Report must identify the minimum floor level requirements for development in accordance with the Flood Hazard and Flood Category applicable to the proposed land use specified in Flood Risk Management Policy. *The subdivision of land requires the building platforms for each additional allotment to be created at or above the Flood Planning Level (plus climate change). The Plan of Subdivision is to include the Flood Planning Level (plus climate change) for each new allotment created.*	Minimum flood level requirements are obtained from the Flood Planning Level (FPL). The proposed development structure is located above the FPL and meet the requirements for development in accordance with the Flood Hazard and Flood Category.



Title:
Site Locality

Figure: **1**

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Existing Flood Risk

Background

BMT previously completed a flood study of the Narrabeen Lagoon catchment on behalf of Pittwater and Warringah Councils in 2013. This study included the hydraulic modelling of the Narrabeen Lagoon catchment including the reach of Narrabeen Creek adjacent to the study site.

The original model developed as part of the Narrabeen Lagoon Flood Study (BMT WBM, 2013) was a detailed two-dimensional TUFLOW hydraulic computer model of the catchment with a 6 m grid resolution, for the simulation of catchment-wide design flood behaviour. The model was calibrated to previous major flood events in the catchment including April 1988 and March 2011. Due to the relatively coarse grid resolution, the reach of Narrabeen Creek between Jubilee Avenue and Macpherson Street was modelled as a 1D channel embedded within the 2D representation of the wider floodplain.

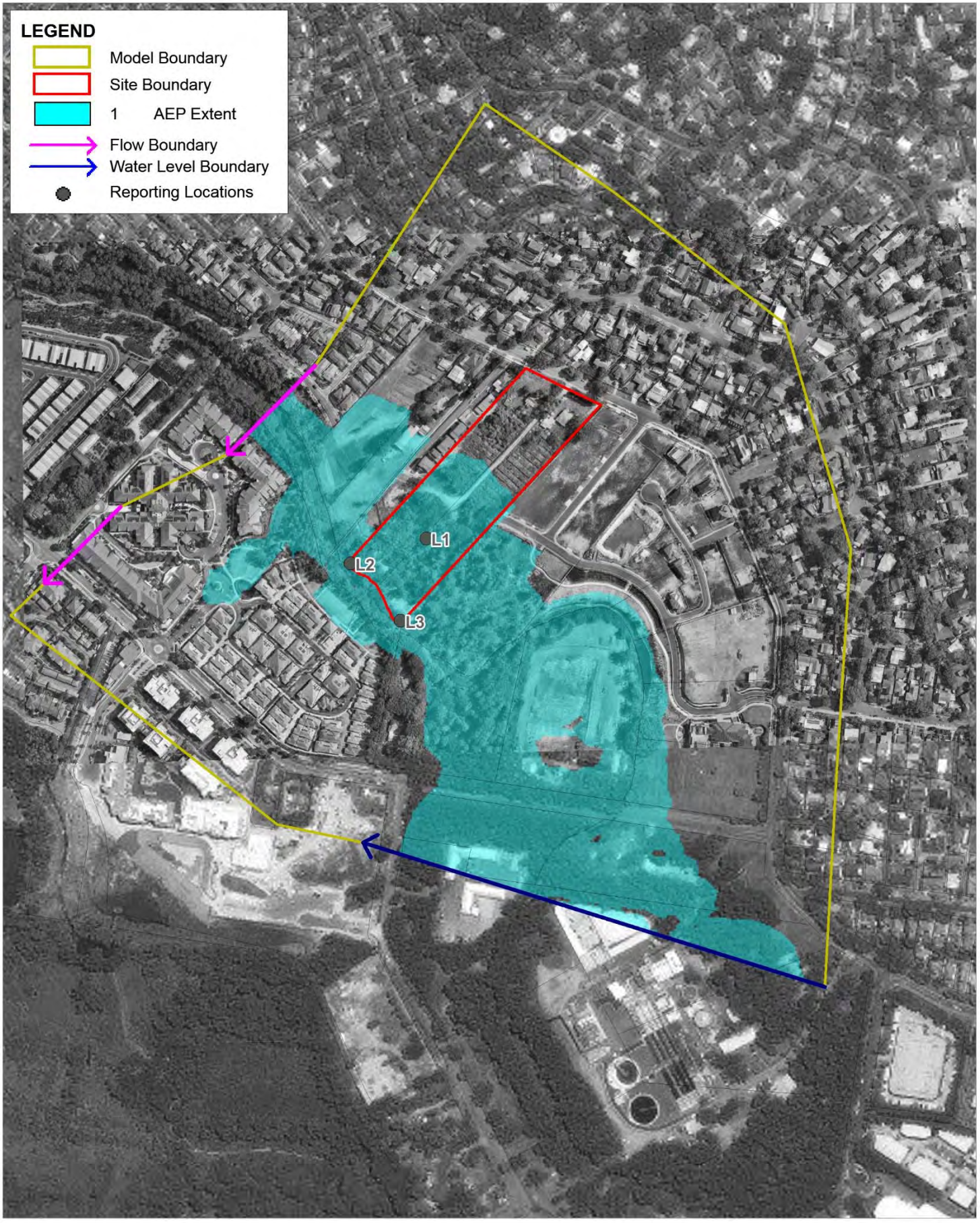
To better represent the existing design flood behaviour and enable the assessment of the channel modification proposed as part of the earthworks for the site, a refined local model of the Narrabeen Creek catchment was developed with a 2 m grid resolution, extending from 60 m downstream of Brands Lane to 130 m downstream of Macpherson Street, as shown in Figure 2. The refined model consisted of an upstream flow time series and downstream water level time series, both of which were extracted from the original Narrabeen Lagoon catchment-wide TUFLOW model. The model topography was defined by a combination of LiDAR data and site survey provided by Forge Venture Management and Craig and Rhodes (site survey provided from a previous flood impact assessment completed for 41 Warriewood Road). The modelled reach of Narrabeen Creek was converted to a 2D representation based on the available survey data.

The refined model was used to determine flooding extents and behaviour for a range of design flood events, including the 20% AEP, 10% AEP, 5% AEP, 1% AEP and PMF events, as well as the 1% AEP design event with climate change (2100 sea level rise and 30% increase in rainfall intensity, herein referred to as 1% AEP+CC event).The 2-hour storm duration was identified as the critical design event duration at the site, with the exception of the PMF event which had a critical duration of 5-hours due to the backwater influence of Narrabeen Lagoon.

Baseline Flood Behaviour

The baseline model topography is a combination of LiDAR data and site survey provided by CMS Surveyors (15843detail 1.dwg), and also includes the finished landforms for the 29-31 Warriewood Road development as defined in 3D surface model 170925.dwg provided by Craig and Rhodes, 41 Warriewood Road development as defined in 3D surface model 063-16 Design DTM 170227.dwg provided by Craig and Rhodes, and 51C Warriewood Road development (based on PW5197583 Stamped Approved Plans provided by Council). In addition, modifications were made to the topography at 19-21 Lorikeet Grove, and the Anglicare Warriewood Retirement Village based on aerial imaging along with street view images. This baseline approach is consistent with previous flood impact assessments undertaken by BMT in the Narrabeen Creek corridor.

Modelled existing peak flood levels at selected locations (as presented in Figure 2) are provided in Table 3, for the full range of design flood events considered. The existing 20% AEP, 1% AEP, 1% AEP+CC and PMF design flood conditions are shown in Appendix A – Baseline/Existing Design Flood Behaviour (Figure A-1 – Figure A-3).



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Refined Model Configuration

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Table 3 Simulated Existing Peak Flood Levels

Design Event (AEP)	Peak Flood Level (m AHD)		
	Location 1 (L1)	Location 2 (L2)	Location 3 (L3)
2 Year ARI (50% AEP)	3.17	3.73	3.25
20%	3.44	3.90	3.47
10%	3.53	3.96	3.55
5%	3.61	4.04	3.63
2%	3.68	4.10	3.70
1%	3.74	4.15	3.76
1% + Climate Change	3.75	4.15	3.77
PMF	4.88	4.89	4.88

It is evident that the design peak flood levels are relatively consistent across L1 and L3, with increases in peak levels at L2 at the upstream boundary of the site. During all events the capacity of Narrabeen Creek is exceeded, causing overbank flows to fill low-lying floodplain storage areas. This includes a small portion of the proposed development area along the proposed Lorikeet Grove roadway at the southern extremity of the development.

The peak flood levels in the lower sections of Narrabeen Creek are dominated by the Narrabeen Lagoon water levels. The limit of the 1% AEP Narrabeen Lagoon water level influence on Narrabeen Creek is approximately Macpherson Street Bridge. Upstream of the bridge, peak flood levels are driven by the local Narrabeen Creek channel capacity and catchment flows. As such, it is evident that an increase in rainfall as modelled in the 1% AEP climate change scenario results in minor increases in peak flood levels across the site.

During the PMF event, more extensive inundation across the site and broader area occurs, filling overbank areas from the low-lying floodplain as the conveyance of the creek is exceeded. Gradual inundation of the southern portion of the site occurs before extending to the northern portion of the site.

Hydraulic Categorisation

Hydraulic categorisation is one of the tools used to identify flood behaviour and risk. Outcomes of the categorisation are primarily used to inform future land use planning.

There are no prescriptive methods for determining what parts of the floodplain constitute floodway, flood storages and flood fringes. Descriptions of these terms within the Floodplain Development Manual (FDM) (NSW Government, 2005) are essentially qualitative in nature and emphasis is placed on the need for site specific consideration when determining appropriate methods for hydraulic category classification. The hydraulic categories as defined in the FDM, and the advised general guidelines to assist in the delineation of flooding and flood storage areas, are:

- **Floodway -** Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.

- **Flood Storage -** Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges. Flood storage areas, if completely blocked would cause peak flood levels to increase by 0.1m and/or would cause the peak discharge to increase by more than 10%.
- **Flood Fringe -** Remaining area of flood prone land, after floodway and flood storage areas have been defined. Blockage or filling of this area will not significantly affect the flood pattern or flood levels.

The adopted hydraulic classification is consistent with Council's DCP and is defined in Table 4.

Table 4 Hydraulic Categories

Floodway	Velocity * Depth > 0.5	Areas and flow paths where a significant proportion of floodwaters are conveyed (including all bank-to-bank creek sections).
Flood Storage	Velocity * Depth < 0.5 and Depth > 0.5 metres	Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks.
Flood Fringe	Velocity * Depth < 0.5 and Depth < 0.5 metres	Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour.

The existing 1% AEP hydraulic categories are shown in Appendix A – Baseline/Existing Design Flood Behaviour (Figure A-5). As shown, most of the inundated portion of the study site is classified as flood storage, with some areas of flood fringe along the northern edge of the flood extent and western boundary and some localised areas of floodway in the southern section of the lot along Narrabeen Creek.

Flood Hazard Classification

Flood Hazard is defined in the Pittwater DCP as a determination of the safety of people and property and is based on a combination of flood depth (above ground level) and flood velocity for a particular sized flood.

Flood Hazard can be classified as either Low Hazard or High Hazard. In High Flood Hazard areas, there is a possible danger to personal safety, able-bodied adults would have difficulty wading and there is the potential for significant structural damage to buildings. In Low Flood Hazard areas, able-bodied adults would have little difficulty wading and nuisance damage to some structures would be possible.

The method for determining Provisional Low and High Hazard Categories is outlined in the NSW Government's Floodplain Development Manual (2005). The existing 1% AEP flood hazard map is shown in Appendix A – Baseline/Existing Design Flood Behaviour (Figure A-6). High flood hazard areas are located at the southern portion of the site, with low hazard areas located near the centre of the site for the 1% AEP Event.

Flood Impact Assessment

Modelling Approach

To represent the post-development catchment conditions, the TUFLOW model terrain was modified to include the finished ground levels for the proposed development. The surface was created using the design surface data (30949-CI-100 Warriewood BE (NO flood storage)_v2013.dwg) supplied by Wood & Grieve Engineers, as shown in Figure B-1 in Appendix B – Post-Development Design Flood Behaviour. The proposed earthworks include filling of the northern portion of the site for the construction of a residential subdivision including the associated roads. To the south of the lots, bordering the floodplain, is a proposed cycleway and Lorikeet Grove, road linking the study site to the neighbouring 41 Warriewood Road to the east. The low-lying floodplain area in the southern portion of the site is largely unchanged from existing conditions. Topographical modifications are largely isolated to the northern portion of the site, a comparison in topography between the existing and developed scenario is shown in Figure 3.

Modelling Results

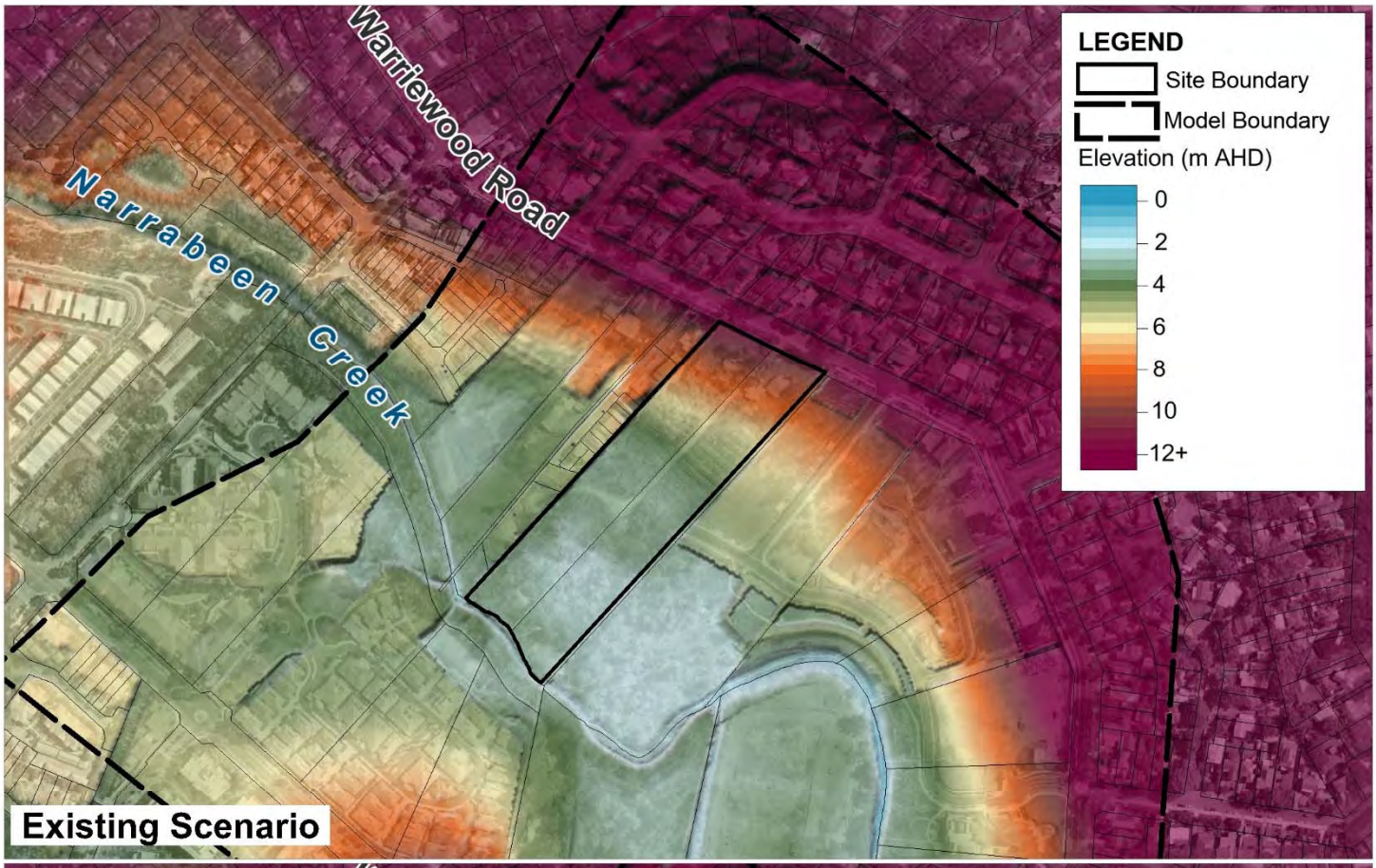
Modelled post-development peak flood levels at selected locations (as presented in Figure 2) are provided in Table 5, for the full range of design flood events considered. The post-development 20% AEP, 1% AEP, 1% AEP+CC and PMF design flood conditions at the site are presented in Appendix B – Post-Development Design Flood Behaviour (Figure B-1 – Figure B-4).

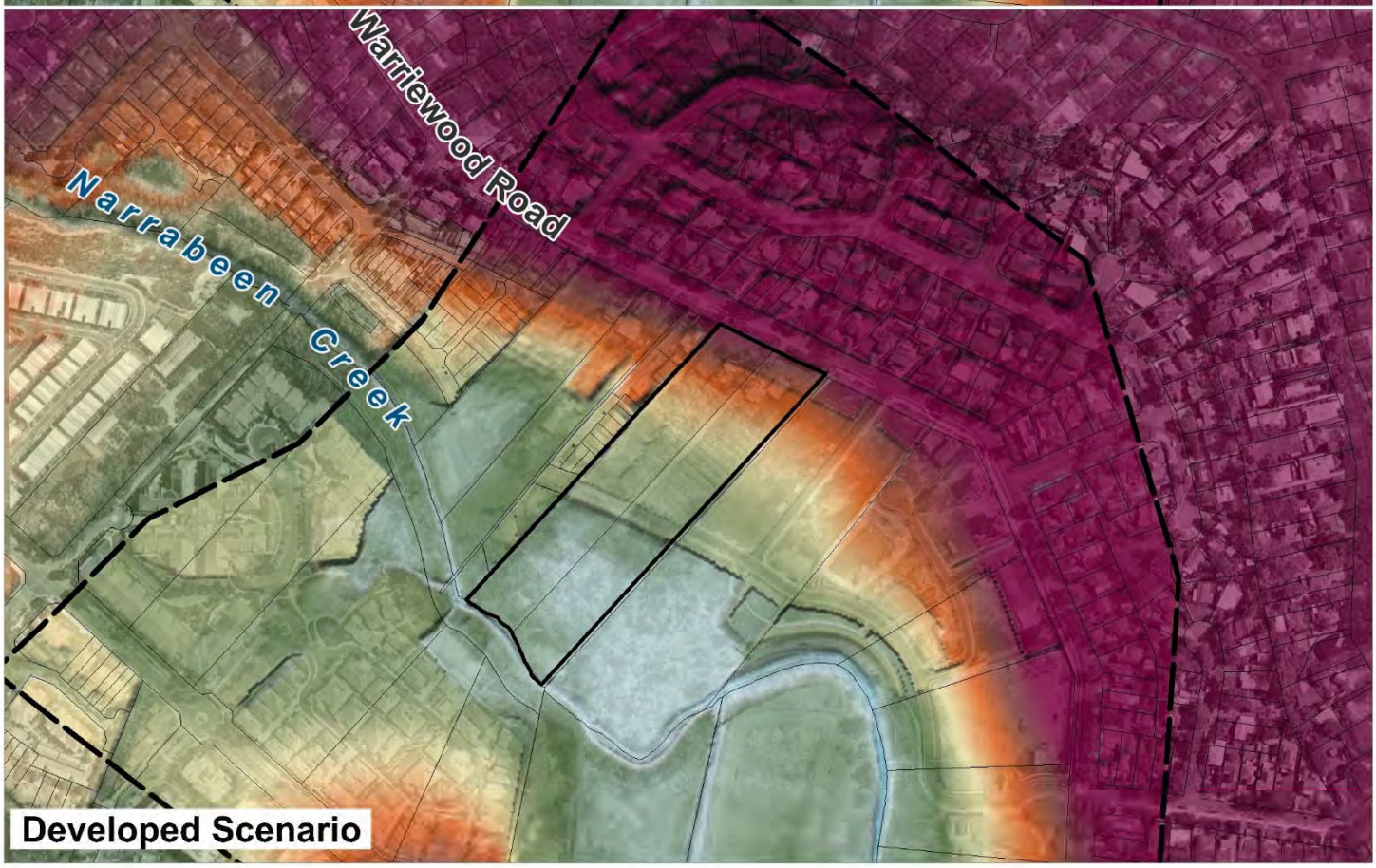
Table 5 Simulated Post-Development Peak Flood Levels

Design Event (AEP)	Peak Flood Level (m AHD)		
	Location 1 (L1)	Location 2 (L2)	Location 3 (L3)
2 Year ARI (50% AEP)	3.17 (0.00)	3.73 (0.00)	3.24 (-0.01)
20%	3.45 (+0.01)	3.90 (0.00)	3.47 (0.00)
10%	3.53 (0.00)	3.96 (0.00)	3.56 (+0.01)
5%	3.62 (+0.01)	4.04 (0.00)	3.64 (+0.01)
2%	3.68 (0.00)	4.10 (0.00)	3.70 (0.00)
1%	3.74 (+0.01)	4.15 (0.00)	3.76 (0.00)
1% + Climate Change	3.75 (0.00)	4.15 (0.00)	3.77 (0.00)
PMF	4.88 (0.00)	4.89 (0.00)	4.88 (0.00)

Note: Bracketed value is change in peak flood level from base design conditions

The peak flood level impacts for the 1% AEP, 1%AEP+CC and PMF design flood events are presented in Figure 4 to Figure 6, respectively. It is evident that the proposed development has negligible impacts on simulated existing condition peak design flood levels. Changes in modelled peak flood levels are generally limited to ±0.01m for all design events. The peak flood level impact for the 20% AEP event is presented in Appendix C – Change in Peak Design Flood Level (Figure C-1).





Title:
Comparison of Pre and Post-Development Topography

Figure: **3**

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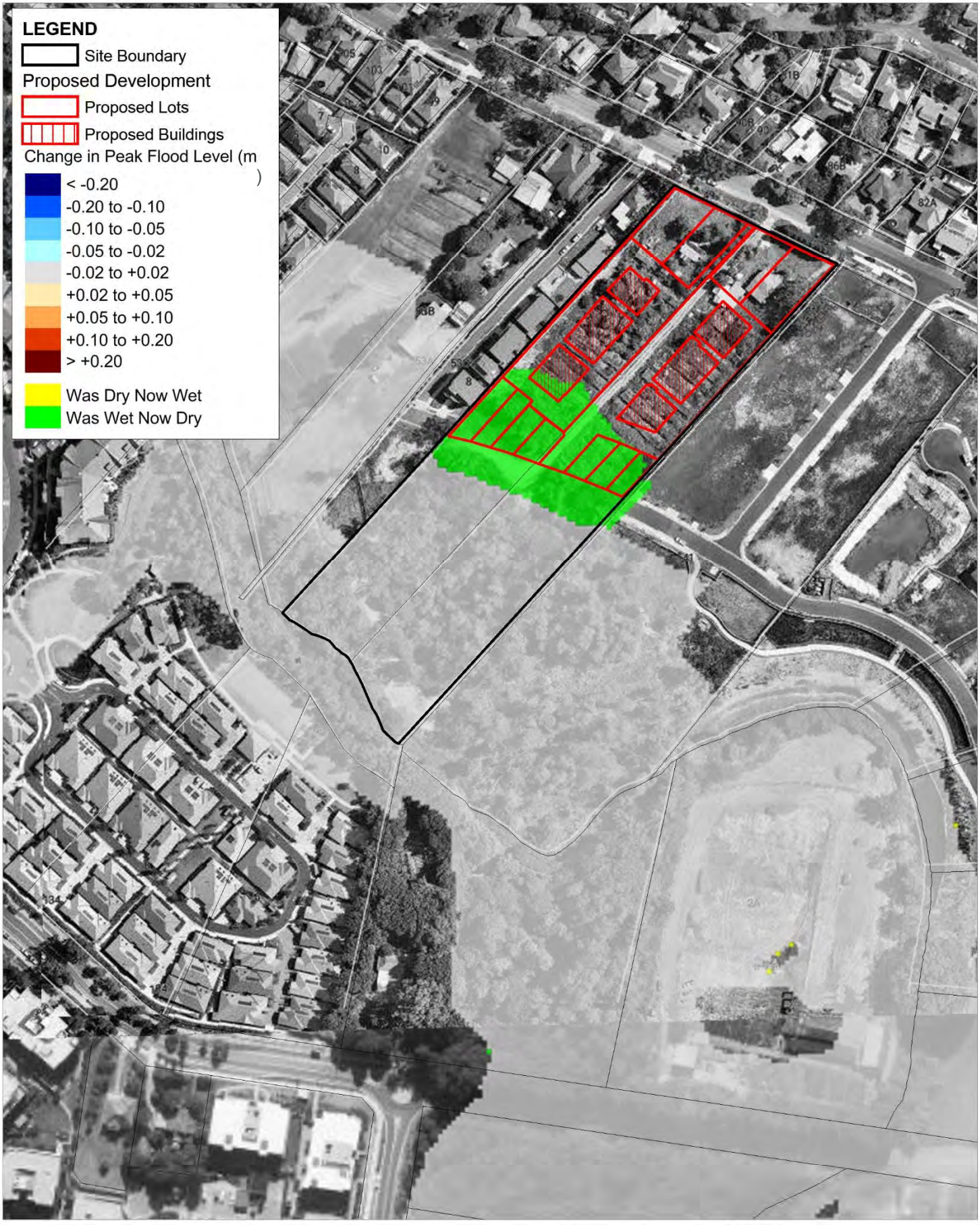

Title:

Change in Peak Flood Level
1% AEP Event

Figure: 4

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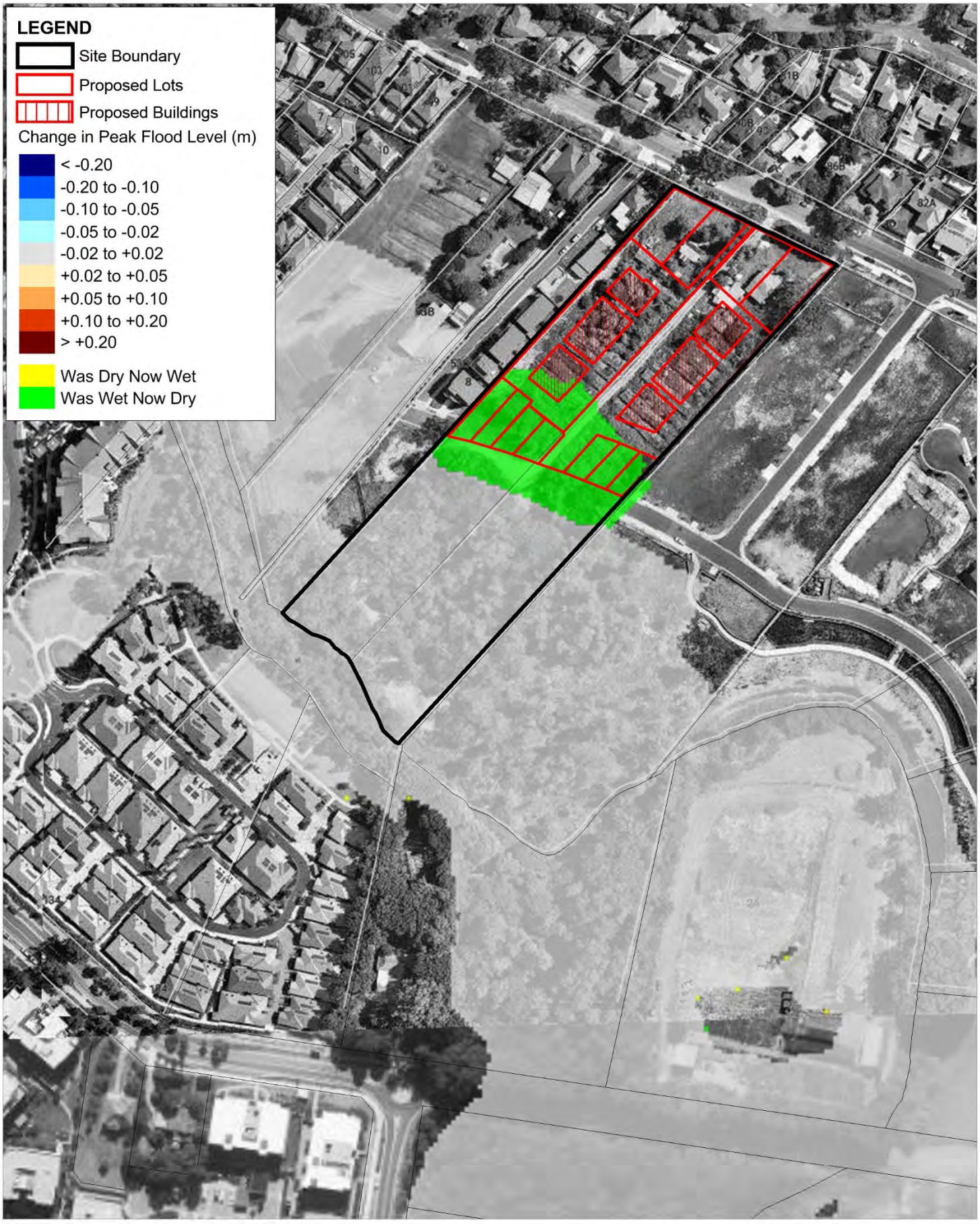

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Change in Peak Flood Level - 1% AEP Event +2100 Sea Level Rise +30% Increase in Rainfall Volume

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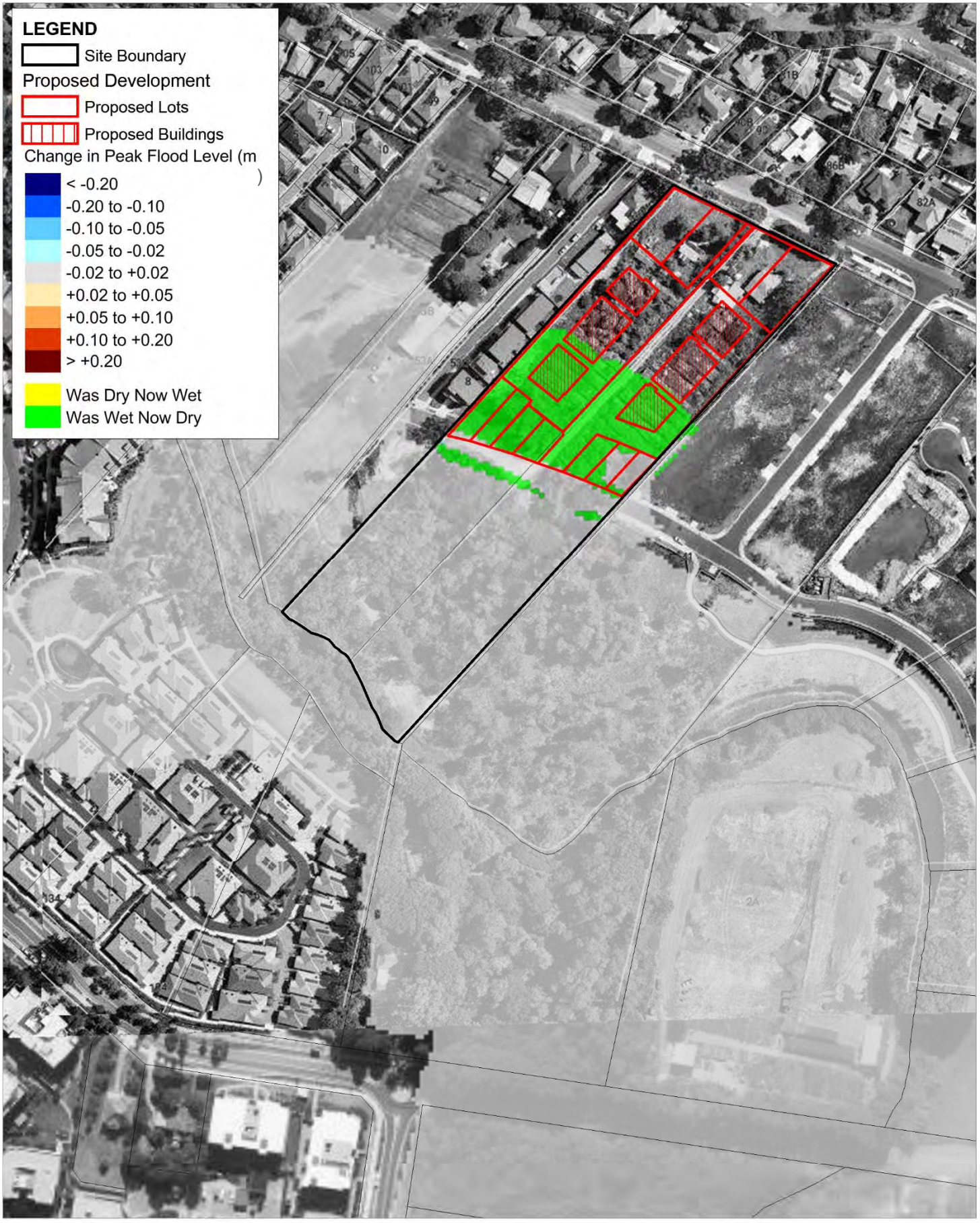

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Change in Peak Flood Level
PMF Event

Figure: 6

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1% AEP Event

The simulated 1% AEP post-development flood conditions are largely similar to the existing flood conditions in that floodwaters exceed the capacity of Narrabeen Creek and spill into the adjacent floodplain, inundating the southern portion of the site. As the proposed development does not encroach or modify the existing Narrabeen Creek channel or floodway alignments, there are no changes to the overall flow capacity of the channel. As noted above, the proposed earthworks include filling within the northern portion of the floodplain, along the northern fringe of inundation from Narrabeen Creek. The filling only encroaches on a small portion of flood storage within the northern floodplain and as such, the existing flood conditions are essentially preserved in the post-development modelling. This is evident in the flood impact mapping presented in Figure 4, whereby negligible changes to peak flood levels are demonstrated both upstream and downstream of the proposed development. Changes to the peak flood velocity outside of the site is localised in nature and occur mainly within the floodway and flood storage zones. The magnitude of these impacts is within the range of -0.1 to +0.1 m/s (Figure C-6).

There are minor changes to the hydraulic categorisation during the post-development 1% AEP flood conditions. As shown in Figure B-5 in Appendix B – Post-Development Design Flood Behaviour, there is a change in the extent of the flood fringe and flood storage area where development fill occurs. There is no additional flood storage or flood fringe areas as a result of this development. Similarly, the flood hazard classification shows a change in the extent of the flood hazards, the area where development fill occurs is not affected in the 1% AEP event. As a result, there is localised minor changes to flood hazards within the southern portion of the site as well as off site.

The total change in flood storage volume within the study site for the 1% AEP event resulted in a decrease of 19% or approximately 6500 m^3 (35,921 m^3 – 29,345 m^3). However this did not impact flood levels on surrounding properties.

1% AEP Event +CC

At the 1% AEP+CC event, the modelled impact shows negligible change in the peak flood levels (<0.01 m) at the site as shown in Figure 5, as the majority of the proposed development remains outside of the flood extent (similar to the 1% AEP flood behaviour detailed above). Minor increases in peak flood levels are experienced downstream of the proposed development (< 0.01 m) as a result of the loss in flood storage and altered flood extent. The conveyance dominated system allows for minor changes to the local topography outside of the creek/floodway alignment without significant impacts to peak flood levels, despite minor reductions to the available flood storage volume on-site. Changes to the peak flood velocity outside of the site is localised in nature with a within the range of -0.1 to +0.1 m/s (Figure C-7).

PMF Event

Flood impacts are not typically assessed at the PMF event, which is used principally to assess risk to life and flood emergency response requirements. However, the flood modelling indicates that the impacts of the proposed development on the PMF are negligible and do not adversely impact neighbouring properties, as shown in Figure 6. During the PMF event, the majority of the proposed development remains outside of the flood extent with the exception of the most south-eastern lot and the Lorikeet Grove roadway. Changes to the peak flood velocity outside of the site is localised in nature and occur mainly within the floodway and flood storage zones. The magnitude of these impacts is within the range of -0.2 to +0.2 m/s (Figure C-8).

Climate Change Impacts

The climate change analysis is carried out by assessing the flood conditions at the site under the scenario of sea level rise combined with an increase in rainfall volume. The 2100 sea level rise scenario (+0.9 m) has been adopted for this study, in combination with a 30% increase in rainfall volume. The climate change condition is applied to both the existing and the developed scenario and a comparison of the peak water level results at the site (and its surrounds) for the climate change scenarios are presented in Appendix D. As shown by these results, the application of sea level rise and increase in rainfall volume will not have adverse impacts at the development site.

Planning Considerations

With regard to the aforementioned flood planning considerations applicable to the site, the flood impact assessment has shown that (for the full range of planning considerations refer to Table 1 and Table 2):

- There are no adverse flood level impacts on surrounding properties or on flooding processes for any event up to the Probable Maximum Flood (PMF) event;
- There are no flood prone lots (i.e. lots located below the FPL) created within the proposed development during the modelled planning events;
- Development structures are located outside the floodway and therefore do not impede floodway;
- The climate change assessment of the 1% AEP Event plus 2100 sea level rise and an increase of 30% in rainfall intensity shows negligible change in the peak flood levels between the pre and post-development scenario;
- There are minor flood velocity impacts on surrounding areas for all events up to the Probable Maximum Flood (PMF) event. The area of impacts is localised in nature and occur within the floodway and flood storage zones. The magnitude of these impacts is in the range of -0.1 to +0.1 m/s, and as such no impacts with respect to sediment scour or habitat is expected to be ;
- There is a slight decrease in the combined 1% AEP event flood storage volume as a result of the proposed earthworks. However, this slight reduction in storage volume has a negligible impact on simulated peak flood levels; and
- The adopted Flood Planning Level (FPL) for the site was calculated by adding a 0.5m freeboard allowance to the simulated 1% AEP existing peak flood level at location L2 at the upstream limit of the site (refer Table 3 and Figure 2). The adopted FPL for the site is 4.65 m AHD (4.15 m AHD + 0.5 m freeboard). The adopted FPL for the climate change scenario for the site remains at 4.65 m AHD.

Flood Emergency Response

Given the small size of the upstream catchment there will be no practical flood warning available at the site. Therefore, people on-site will have to react and respond to flood events as and when they occur, which is similar for all other flood affected locations in the area. However, the proposed fill platform of the development means that flood inundation of the developed portion of the site is highly unlikely. From the range of design events considered within this assessment only the PMF event results in some flooding within the proposed development site. As demonstrated in Figure B-4, the vast majority of the lots and all of the likely building locations are flood-free at the PMF. The exception to this is the most south-eastern lot which results in some inundation during the PMF event, with up to 0.2 m of floodwater across two lots.

During the PMF event, Lorikeet Grove is inundated to a depth of up to 0.6 m. This does not occur during the 1% AEP or 1% AEP+CC events. This may impact on the evacuation of residents in the southernmost lots facing Lorikeet Dr via vehicle during the PMF event, however, these lots largely remain flood free at the PMF and the increasing elevations toward Warriewood Road would provide an uphill evacuation route for any flood affected residents.

Conclusions

The objective of the study was to undertake a detailed flood impact assessment for a proposed development at 45-49 Warriewood Road, Warriewood.

Central to this was the development of a refined 2D TUFLOW model with a 2 m grid resolution. The boundary conditions for the refined model were based on the TUFLOW model (6 m grid resolution) of the Narrabeen Lagoon catchment developed as part of the Narrabeen Lagoon Flood Study (BMT WBM, 2013).

Specifically, the modelling undertaken for the proposed development aimed to:

- Confirm existing flooding conditions across the site, including flood levels, flows and velocities, to establish baseline conditions for impact assessment, and the flood planning requirements for the proposed development; and
- Identify the potential flood impacts of the proposed development over a range of design flood magnitudes.

The results of the modelling and flood impact assessment have confirmed:

- There are negligible adverse flood impacts on surrounding properties or on flooding processes for any event up to the Probable Maximum Flood (PMF) event;
- Climate change conditions will not have any adverse impact on the development site for any event up to the Probable Maximum Flood (PMF) event;
- No additional flood prone lots are created within the proposed subdivision; and
- All lots, apart from the south eastern corner lot, are flood-free at the PMF event.

The proposed development does encroach on the 1% AEP flood storage area and results in a minor decrease in the overall 1% AEP flood storage volume on the site. However, the model results show that this minor loss of flood storage does not result in peak flood level impacts on surrounding properties.

We trust the above information satisfies your requirements. Please do not hesitate to contact the undersigned if further information is required.

Yours Faithfully
BMT WBM

Joshua Atkinson
Associate Principal Engineer

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References

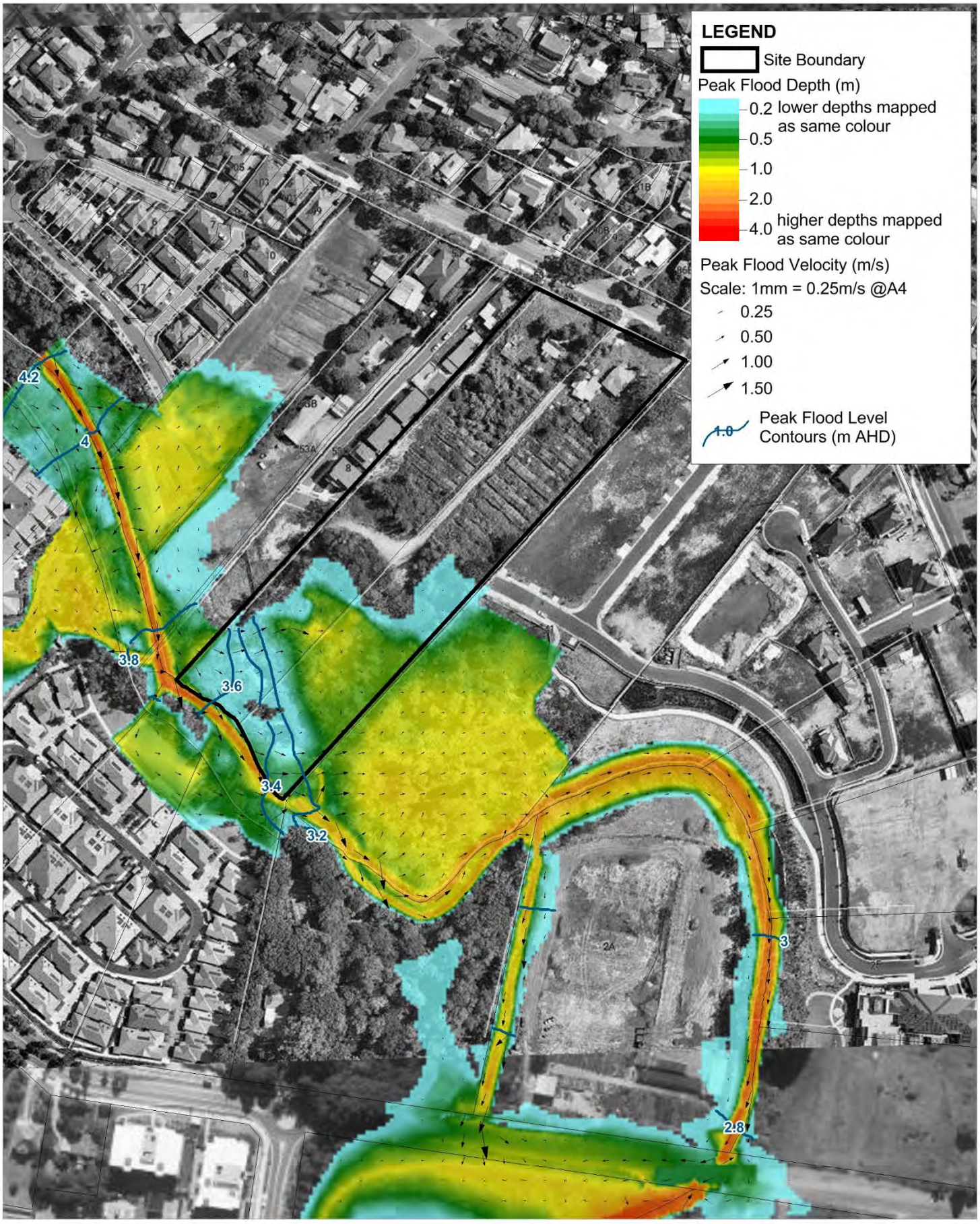
BMT WBM Pty Ltd, 2013, Narrabeen Lagoon Flood Study. NSW, BMT WBM.

NSW Department of Infrastructure, 2005, Planning and Natural Resources (DIPNR) Floodplain Development Manual.

Northern Beaches Council, 2019, Pittwater 21 Development Control Plan.

Northern Beaches Council, 2014, Pittwater Local Environmental Plan 2014.

Appendix A – Baseline/Existing Design Flood Behaviour



Title:

2 Year ARI Event - Existing Scenario Modelled Peak Flood Conditions

Figure: **A-1**

Rev: **-**

N

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Approx. Scale

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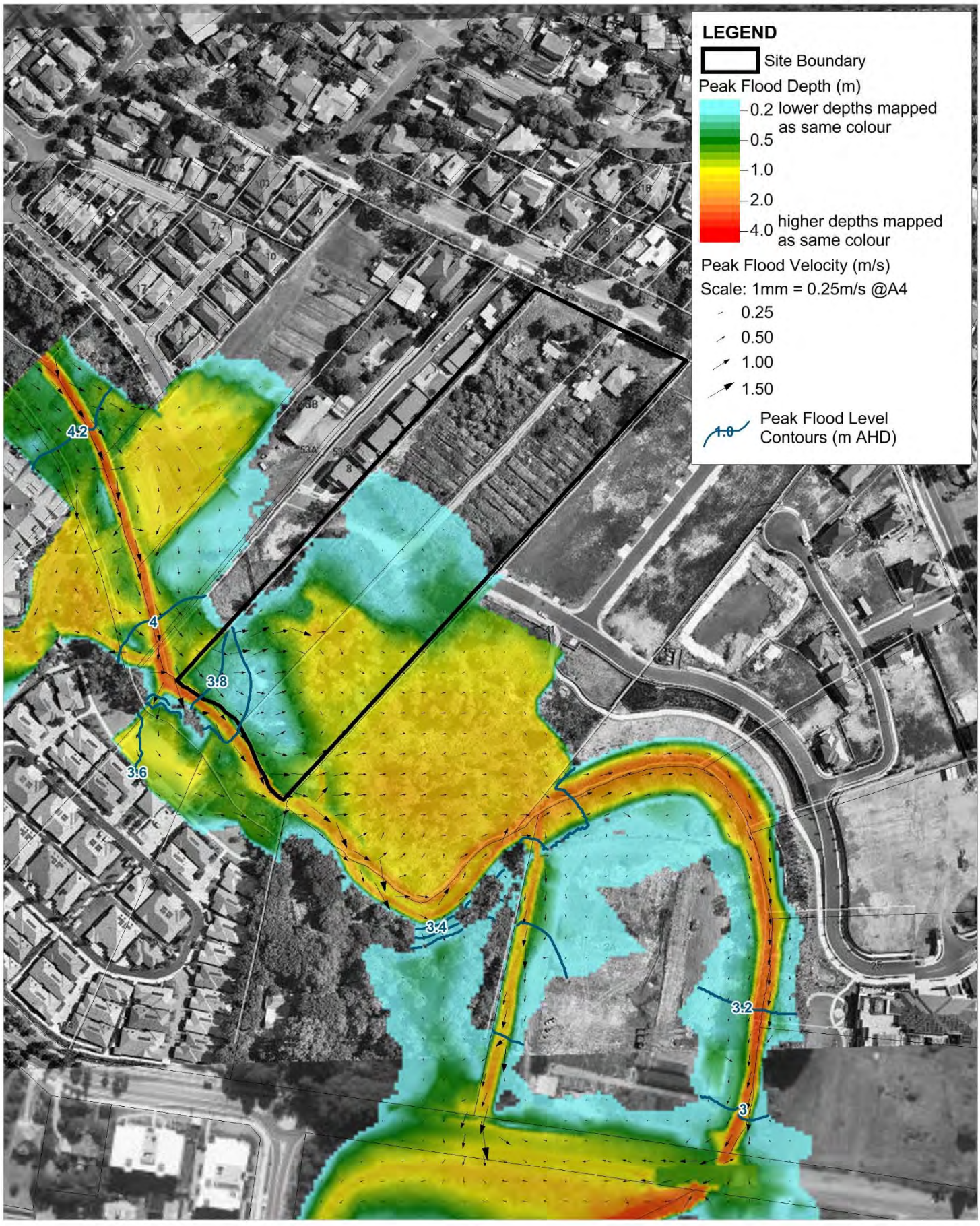

Title:

20% AEP Event - Existing Scenario Modelled Peak Flood Conditions

Figure: **A-2**

Rev: **-**

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0 50 100m

Approx. Scale

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www.bmt.org

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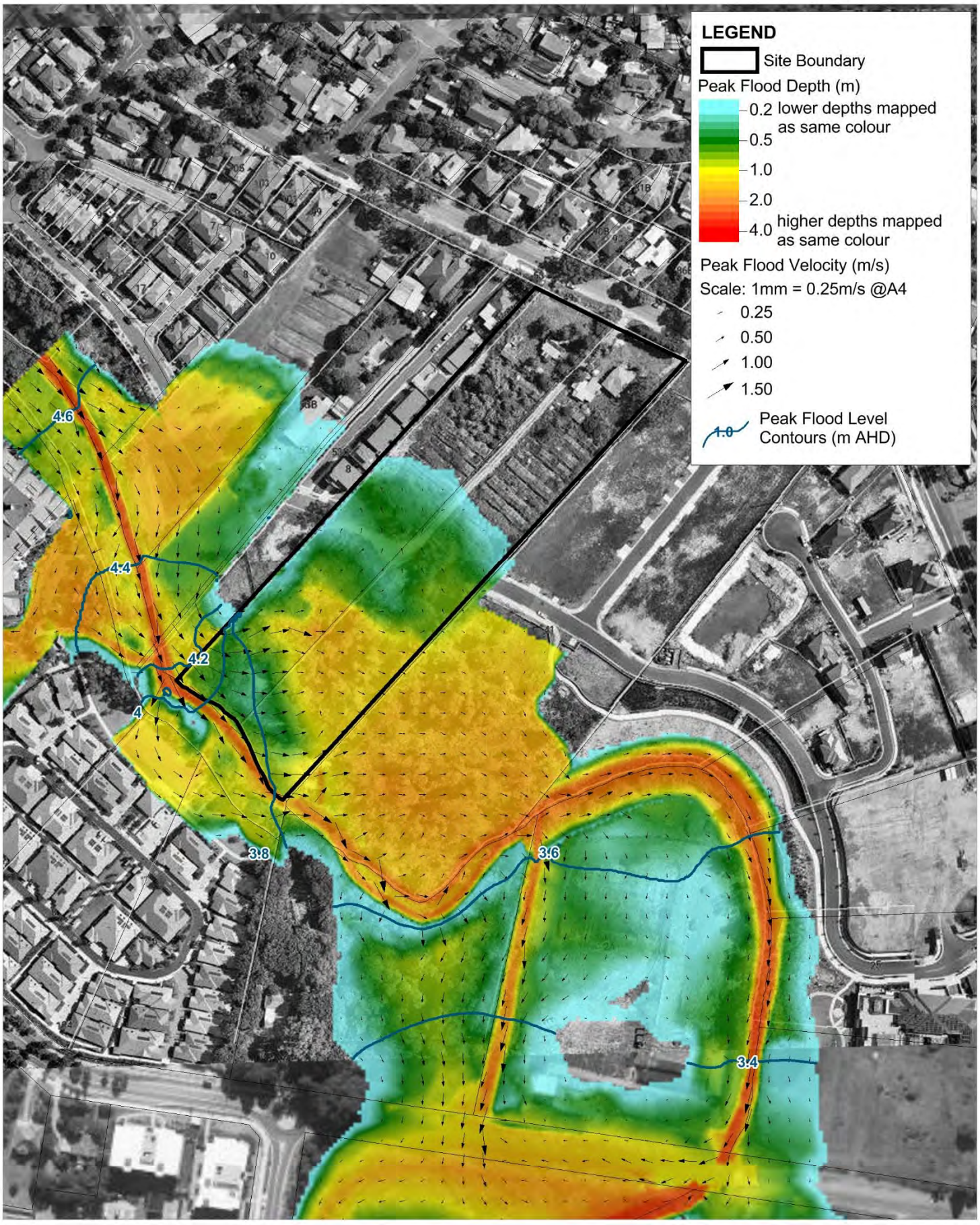

Title:

1% AEP Event - Existing Scenario Modelled Peak Flood Conditions

Figure: **A-3**

Rev: **-**

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Approx. Scale

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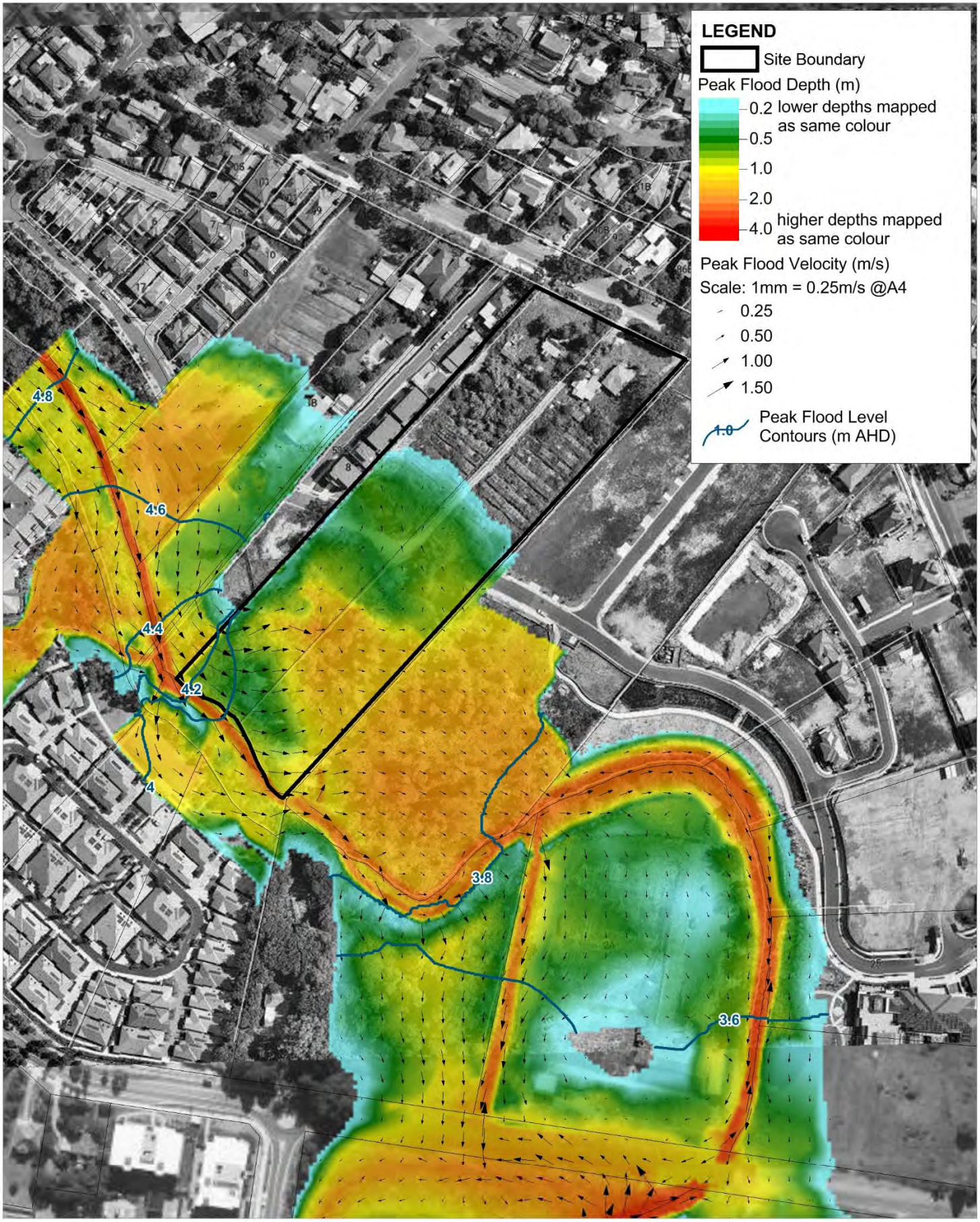

Title:

1% AEP with Climate Change Event - Existing Scenario Modelled Peak Flood Conditions

Figure: **A-4**

Rev: **-**

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Approx. Scale

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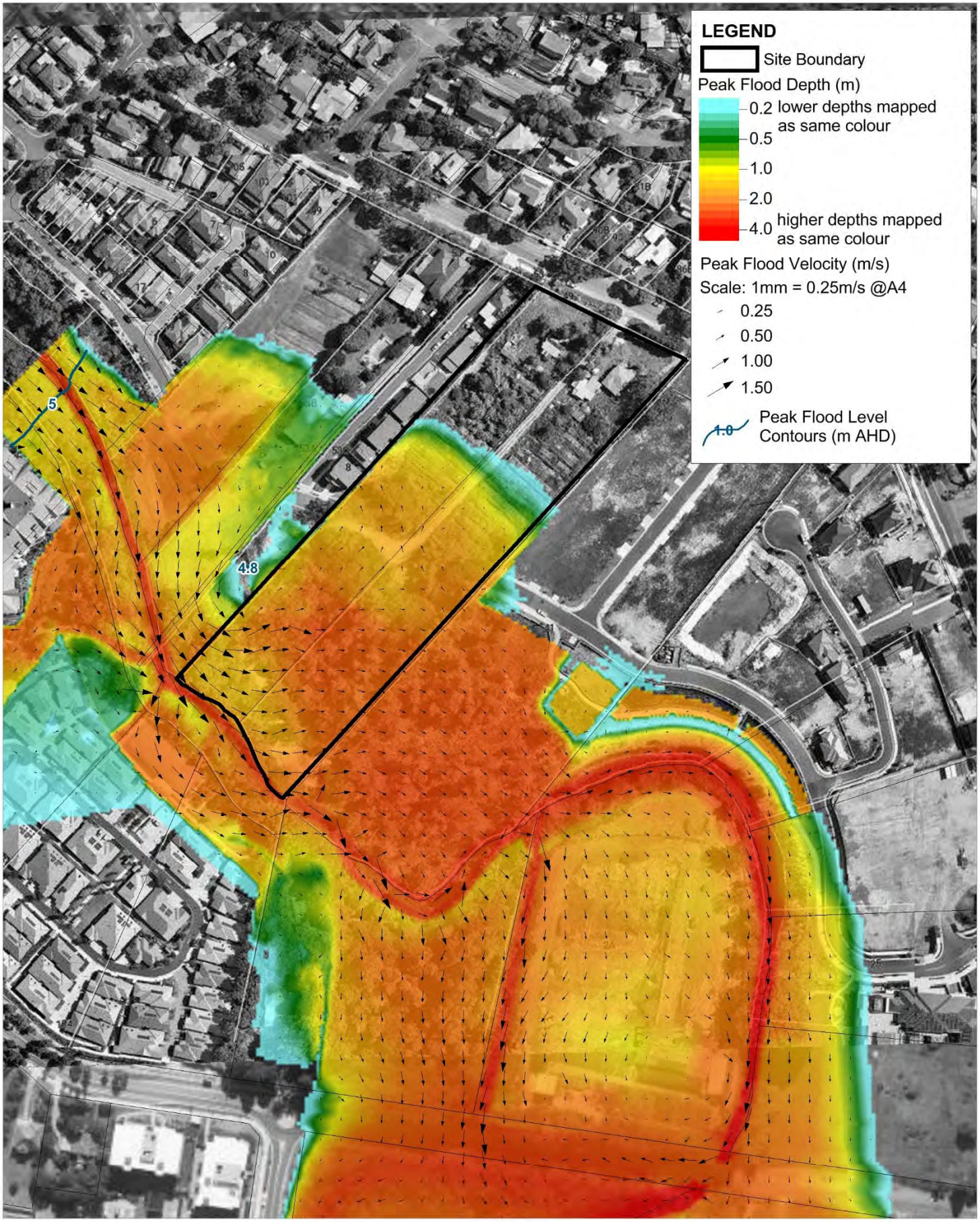

Title:

PMF Event - Existing Scenario Modelled Peak Flood Conditions

Figure: **A-5**

Rev: **-**

N

0 50 100m

Approx. Scale

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Title:

1% AEP Event - Existing Scenario Hydraulic Categories

Figure: A-6

Rev: -

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Approx. Scale

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Filepath: K:N20951_45WarriewoodRd_FIAMapInfoWorkspaces0200731_Figures

Title:

1% AEP Event - Existing Scenario Hazard Classification

Figure: **A-7**

Rev: **-**

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Approx. Scale

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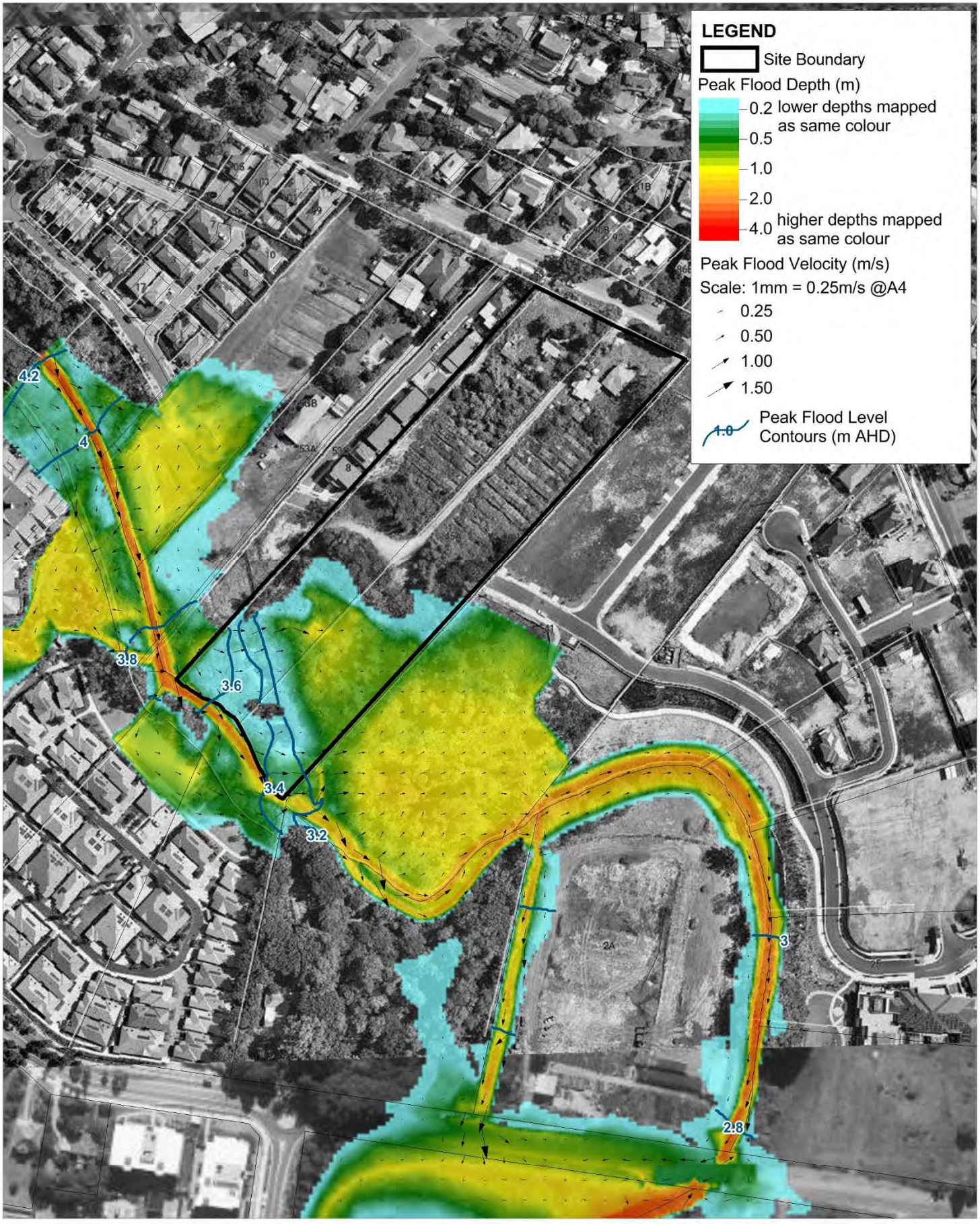
Appendix B – Post-Development Design Flood Behaviour



Title:

2 Year ARI Event - Developed Scenario Modelled Peak Flood Conditions

Figure: **B-1**

Rev: **-**

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Approx. Scale

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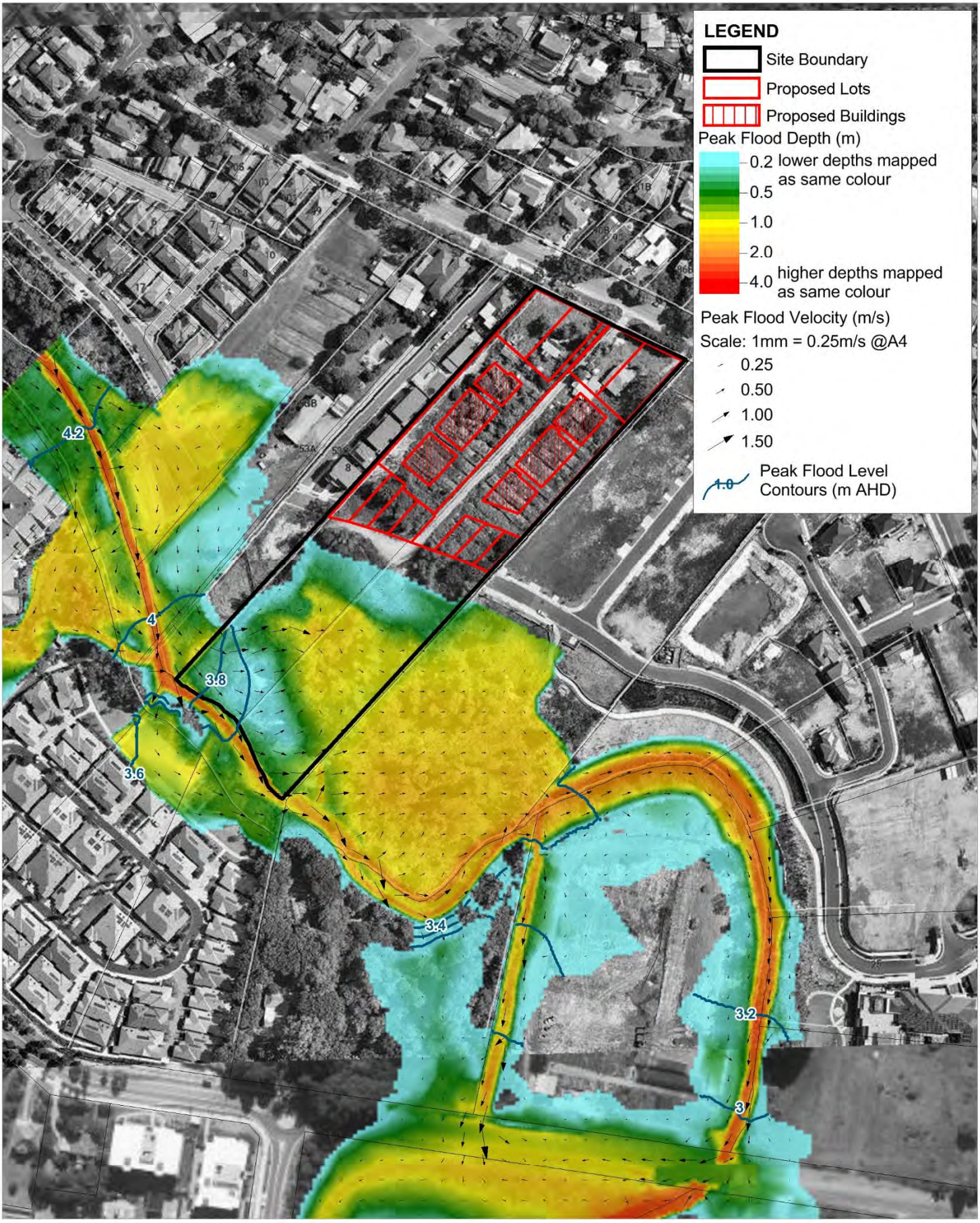

Title:

20% AEP Event - Developed Scenario Modelled Peak Flood Conditions

Figure: **B-2**

Rev: **-**

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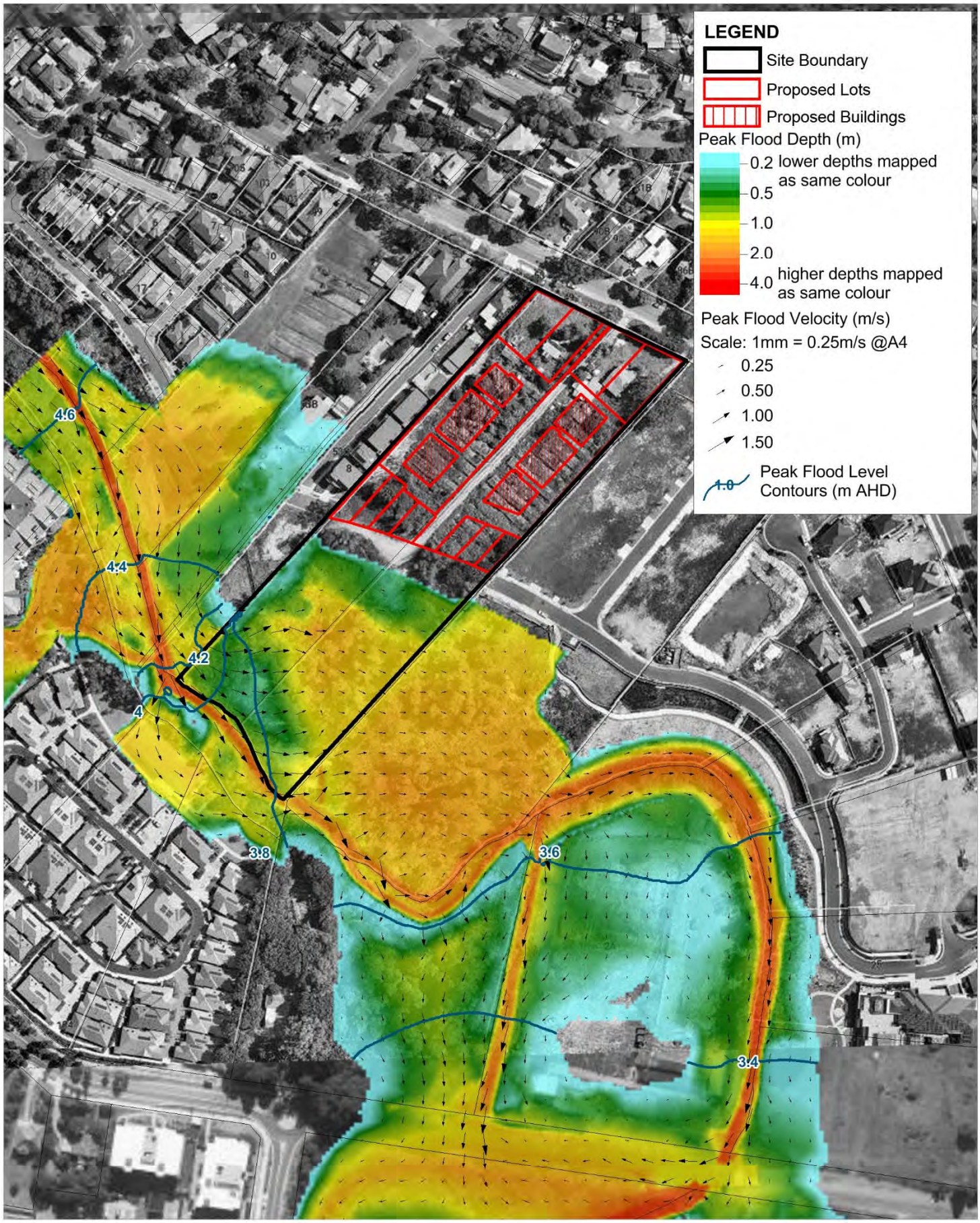

Title:

1% AEP Event - Developed Scenario Modelled Peak Flood Conditions

Figure: **B-3**

Rev: **-**

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Approx. Scale

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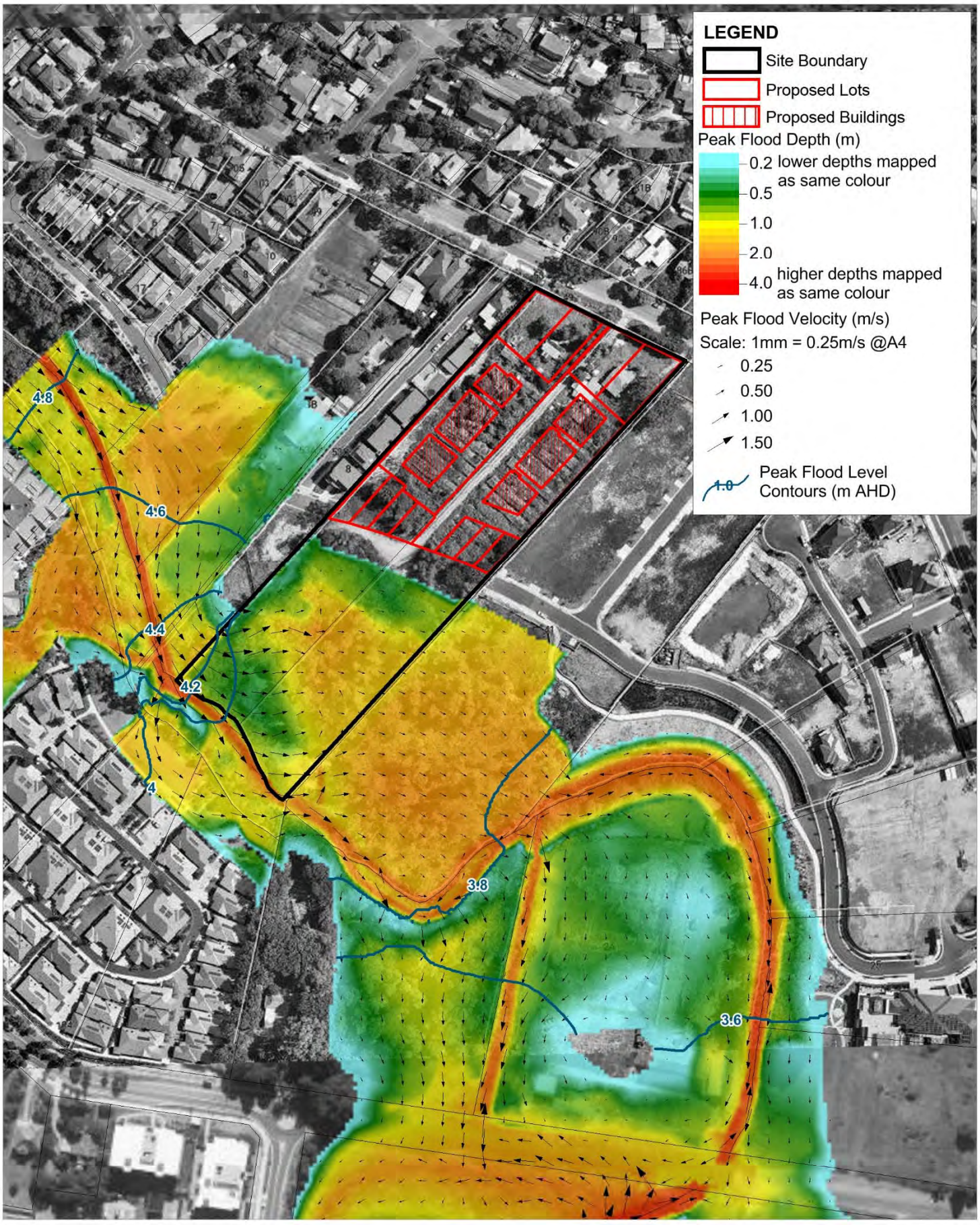

Title:

1% AEP with Climate Change Event - Developed Scenario Modelled Peak Flood Conditions

Figure: **B-4**

Rev: **-**

N

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Approx. Scale

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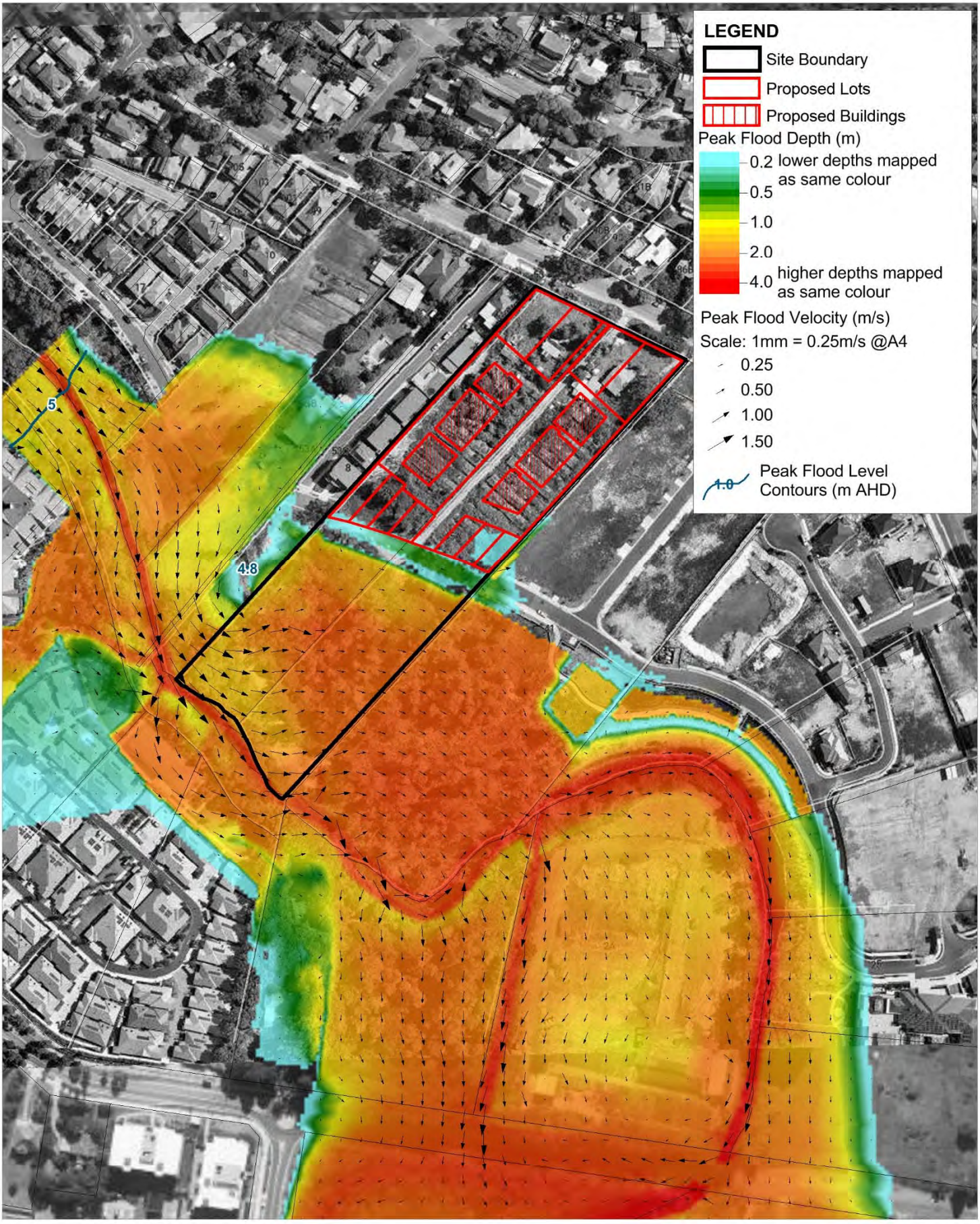

Title:

PMF Event - Developed Scenario Modelled Peak Flood Conditions

Figure: **B-5**

Rev: **-**

N

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Approx. Scale

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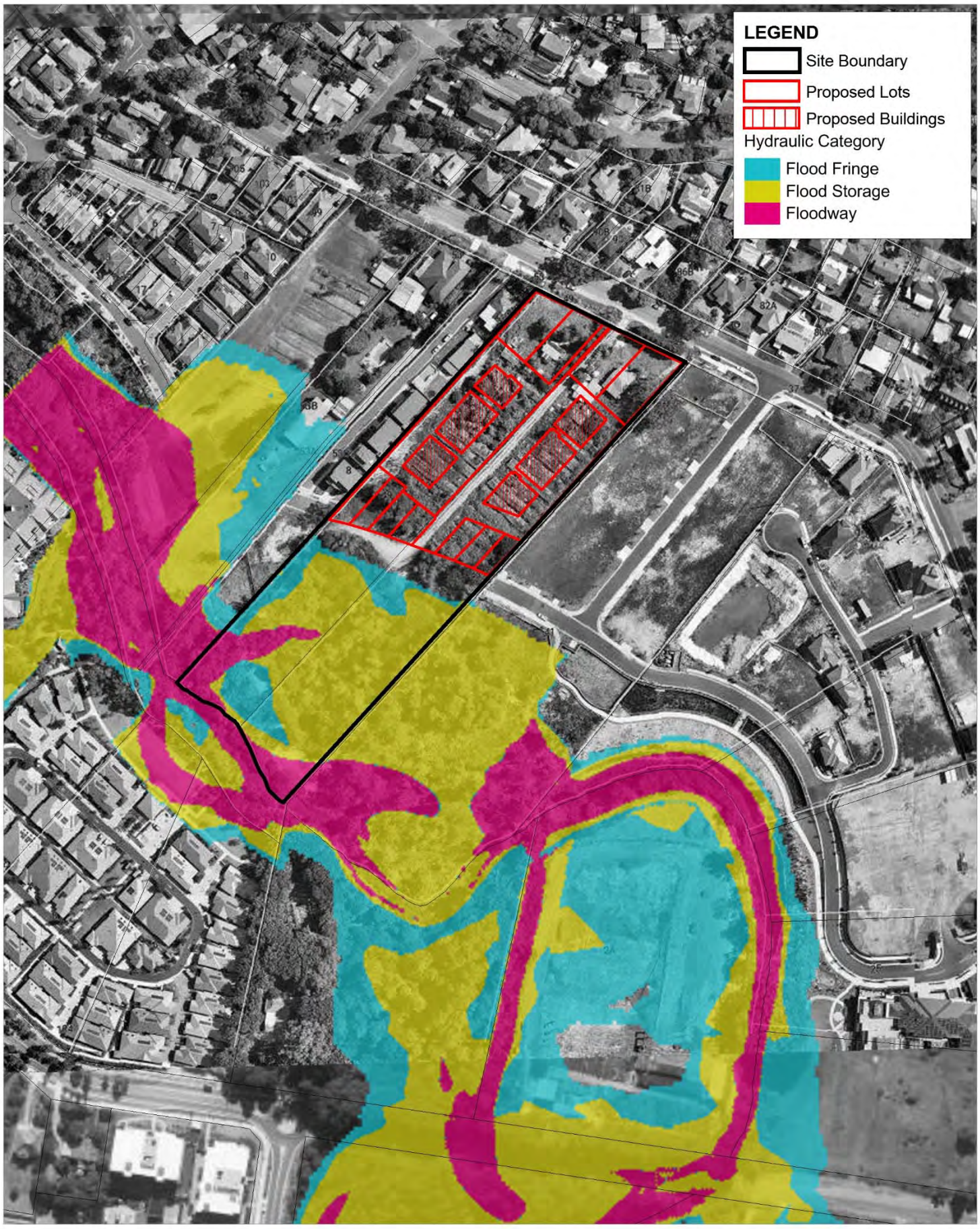

Title:

1% AEP Event - Developed Scenario Hydraulic Categories

Figure: **B-6**

Rev: **-**

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Approx. Scale

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Title:

1% AEP Event - Developed Scenario Hazard Classification

Figure: **B-7**

Rev: **-**

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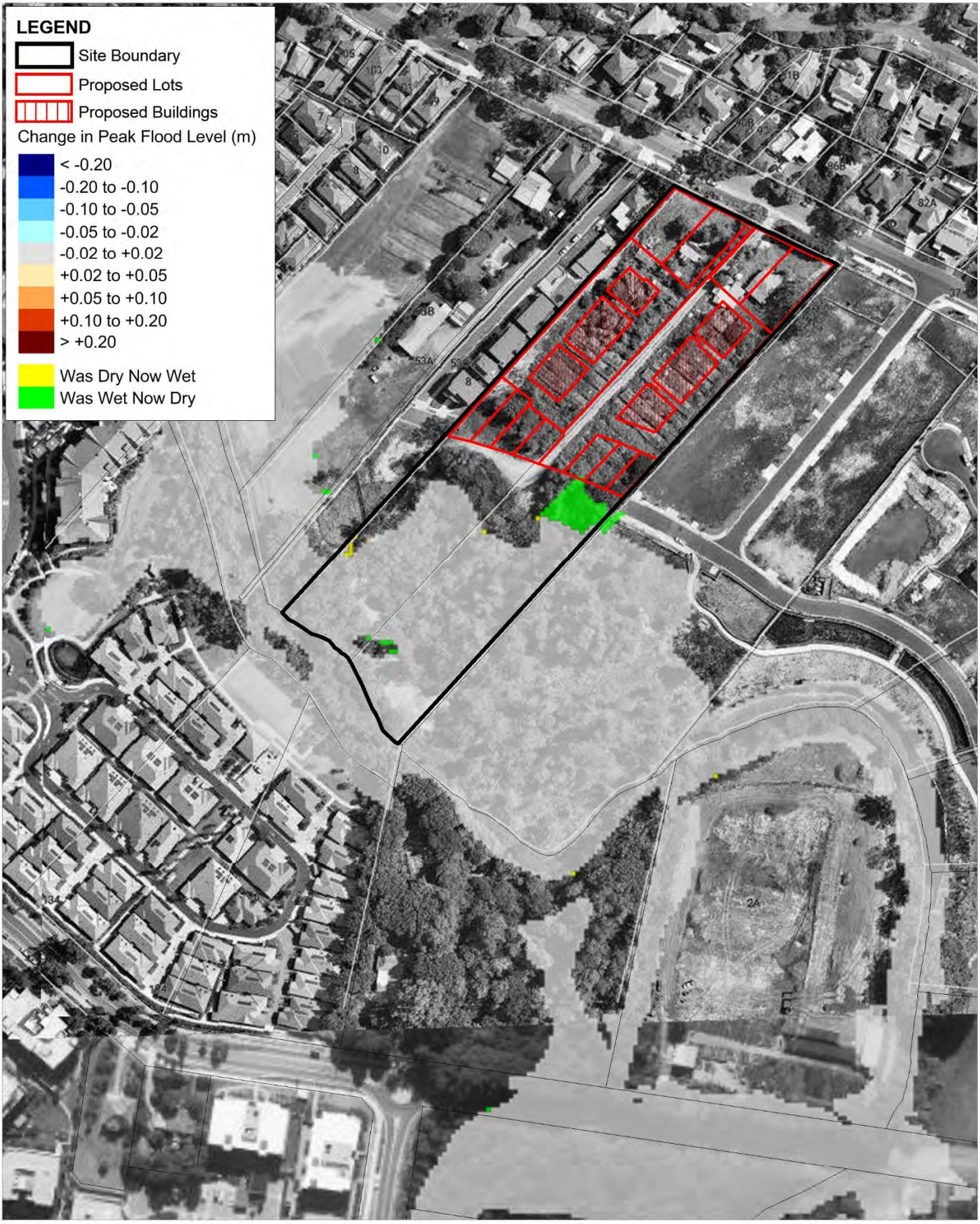
Appendix C – Change in Peak Design Flood Levels and Velocities



Title:

2 Year ARI Event
Change in Peak Flood Level

Figure: **C-1**

Rev: **-**

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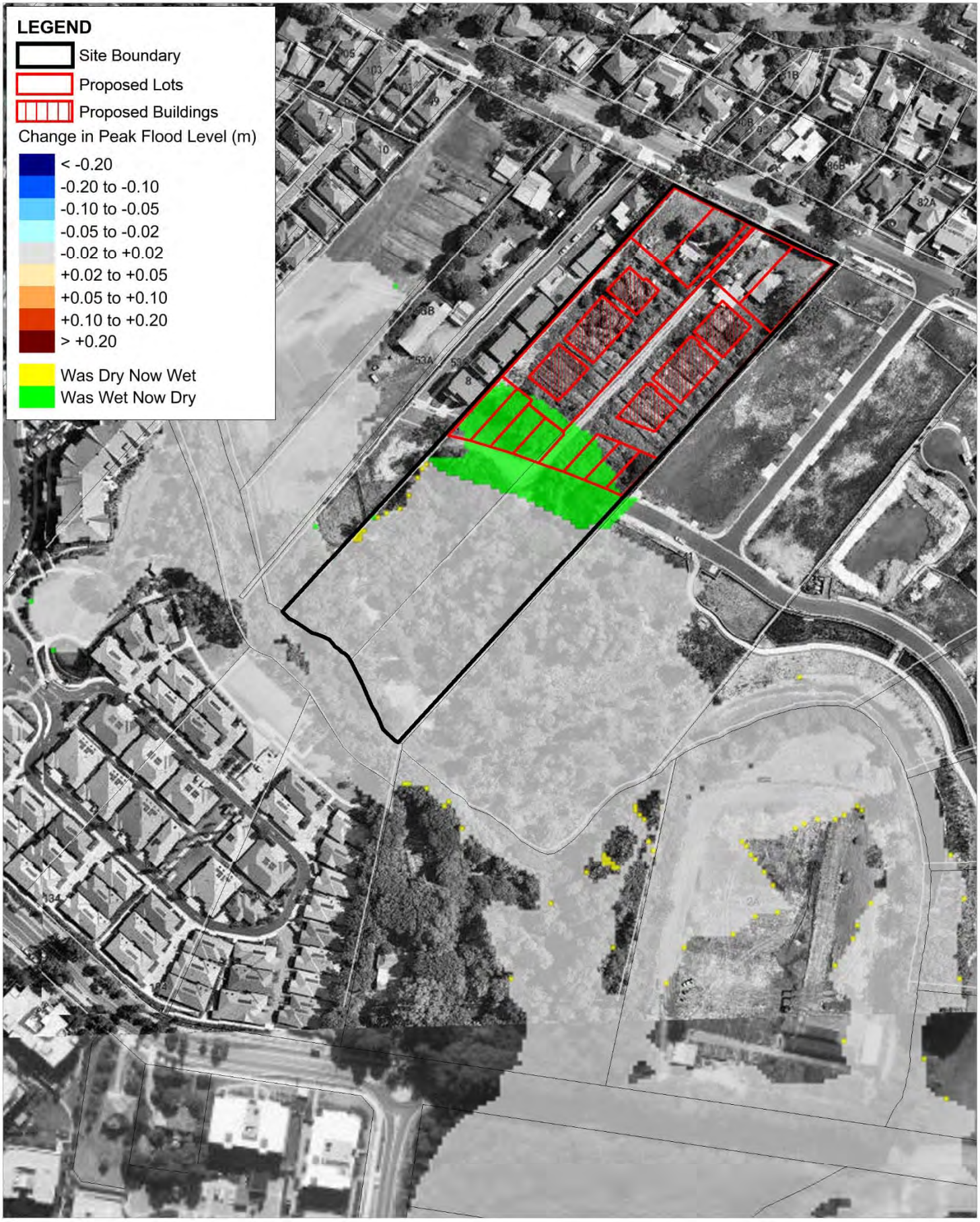

Title:

20% AEP Event
Change in Peak Flood Level

Figure: C-2

Rev: -

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Approx. Scale

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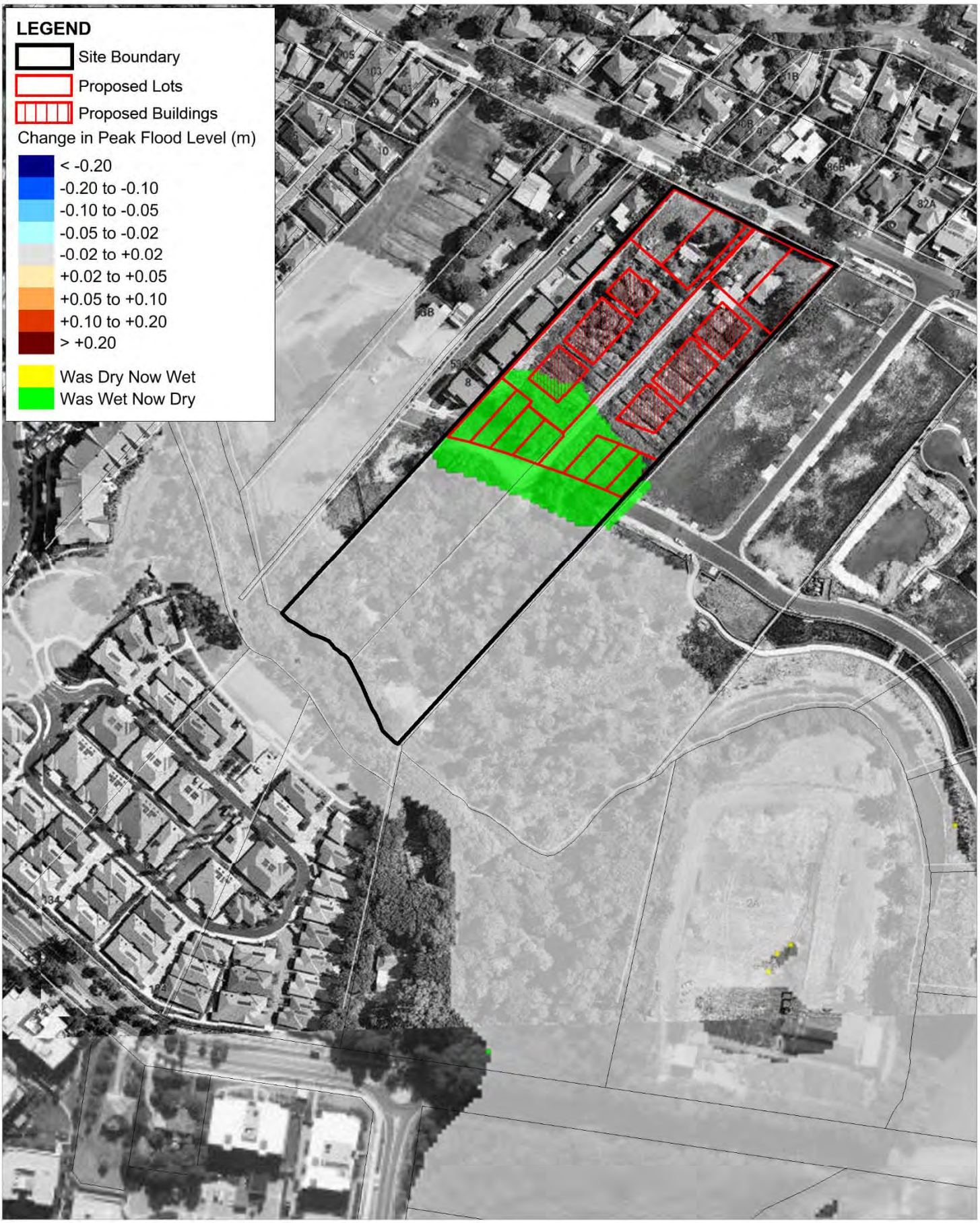

Title:

1% AEP Event
Change in Peak Flood Level

Figure: C-3

Rev: -

N

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Approx. Scale

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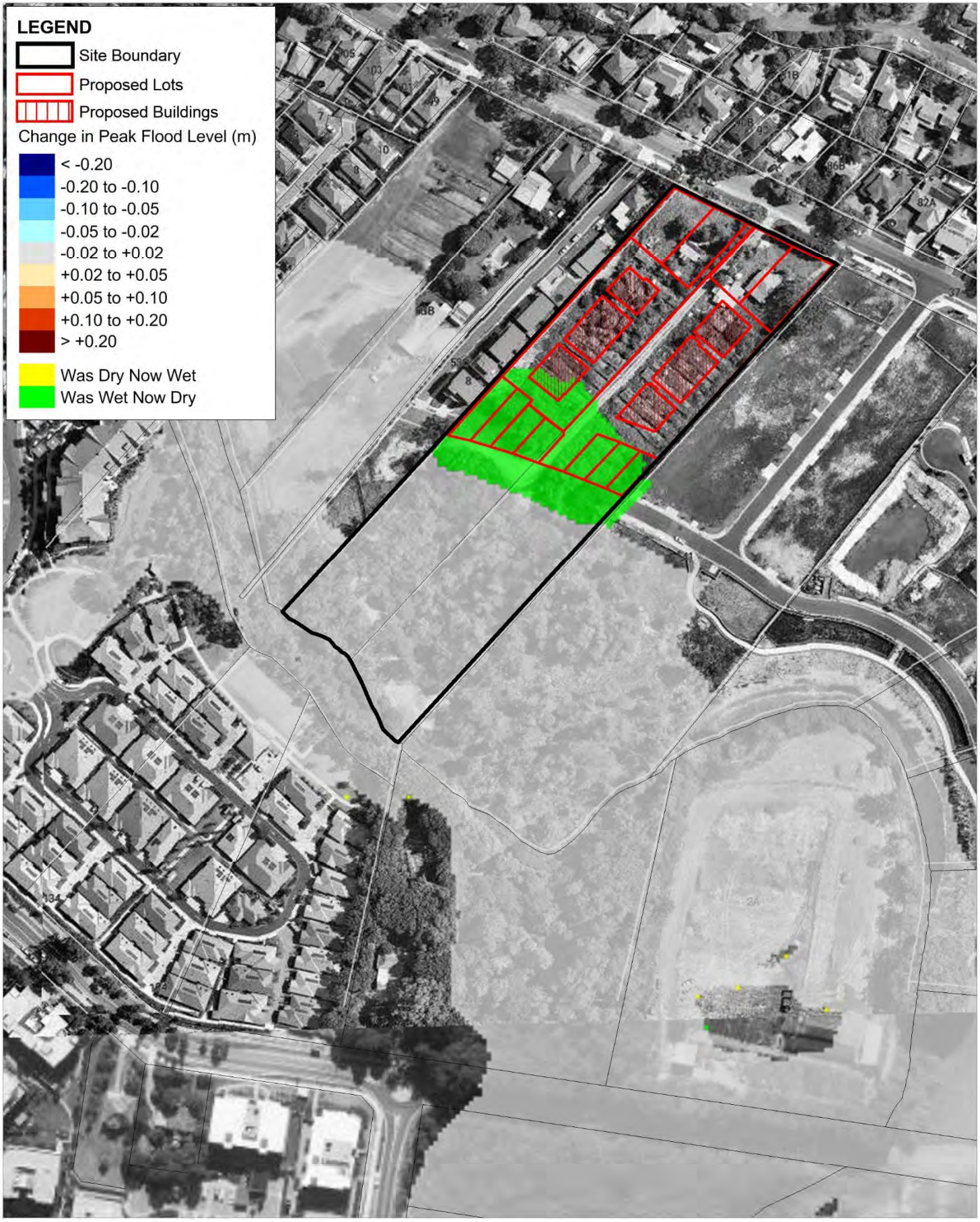

Title:

1% AEP with Climate Change Event Change in Peak Flood Level

Figure: C-4

Rev: -

N

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Approx. Scale

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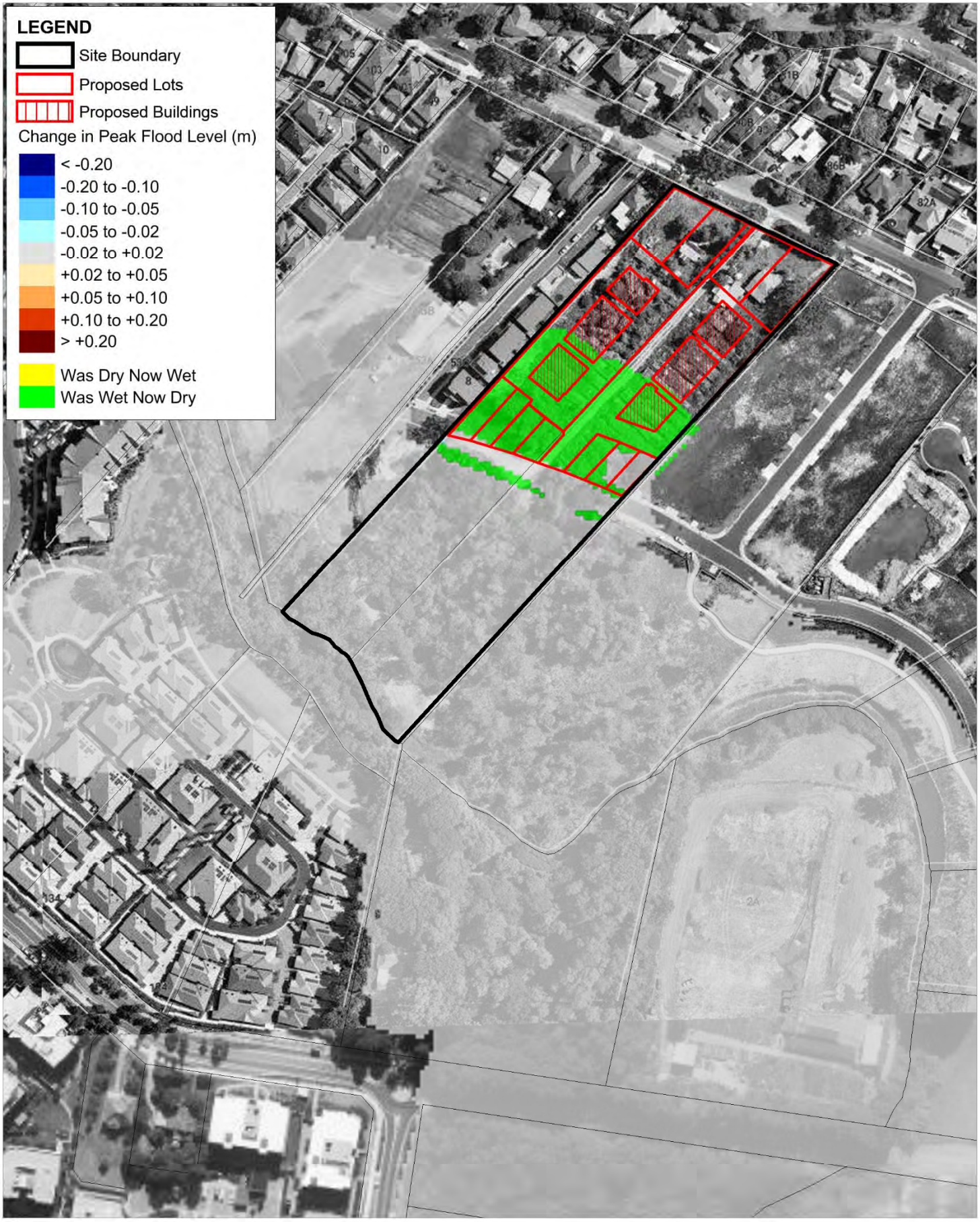

Title:

PMF Event
Change in Peak Flood Level

Figure: **C-5**

Rev: **-**

N

0 50 100m

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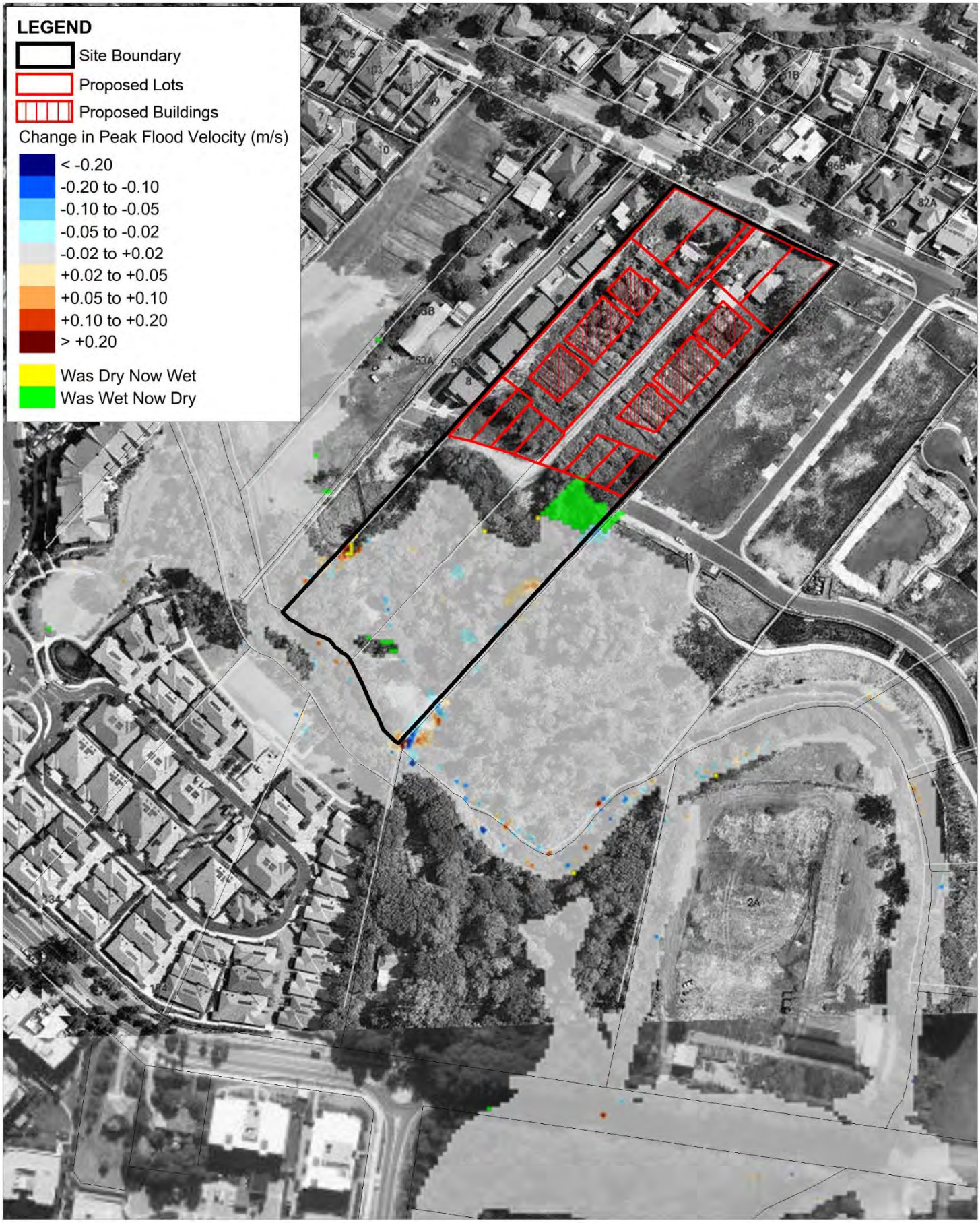

Title:

2 Year ARI Event
Change in Peak Flood Velocity

Figure: **C-6**

Rev: **-**

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Approx. Scale

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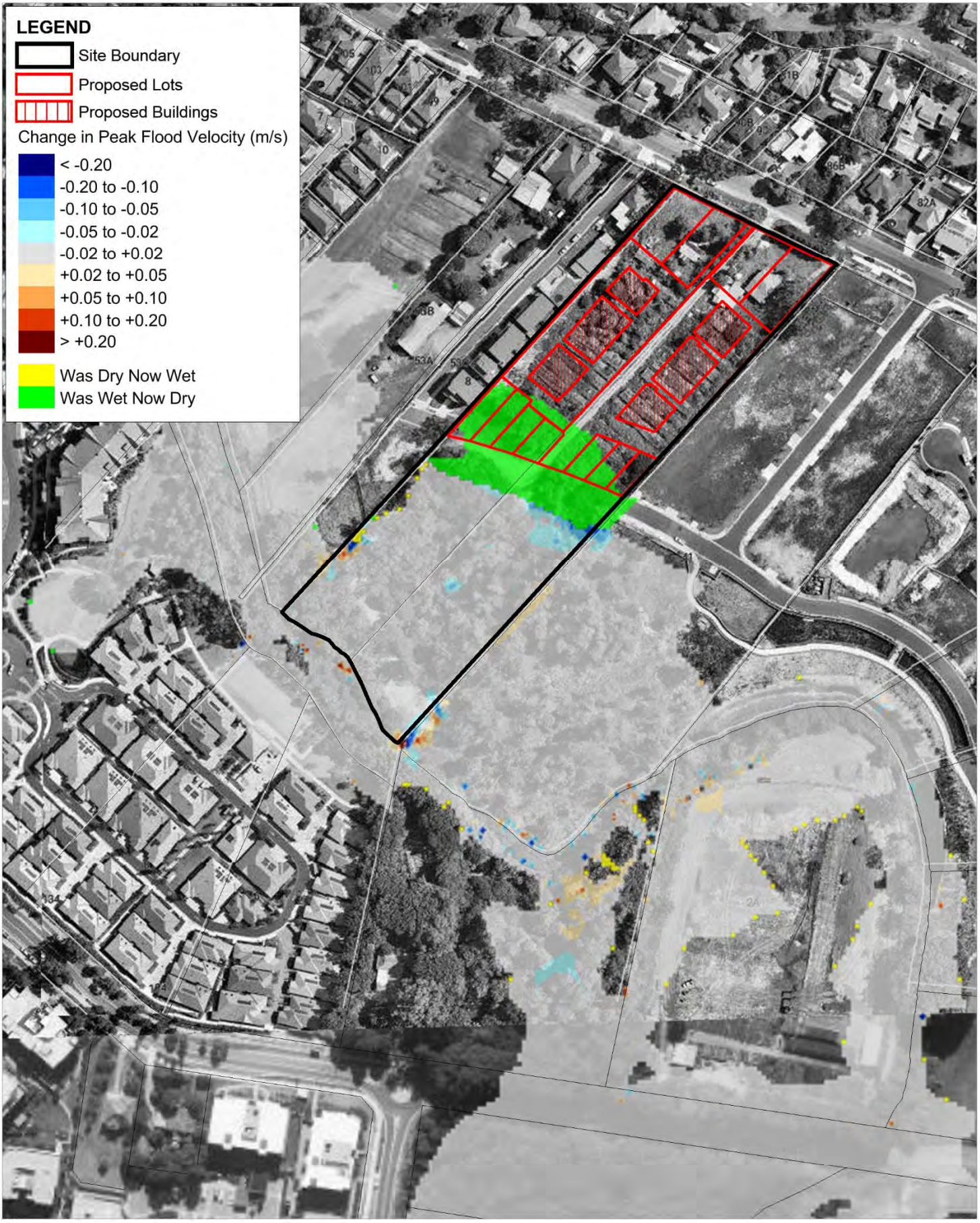

Title:

20% AEP Event
Change in Peak Flood Velocity

Figure: **C-7**

Rev: **-**

N

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Approx. Scale

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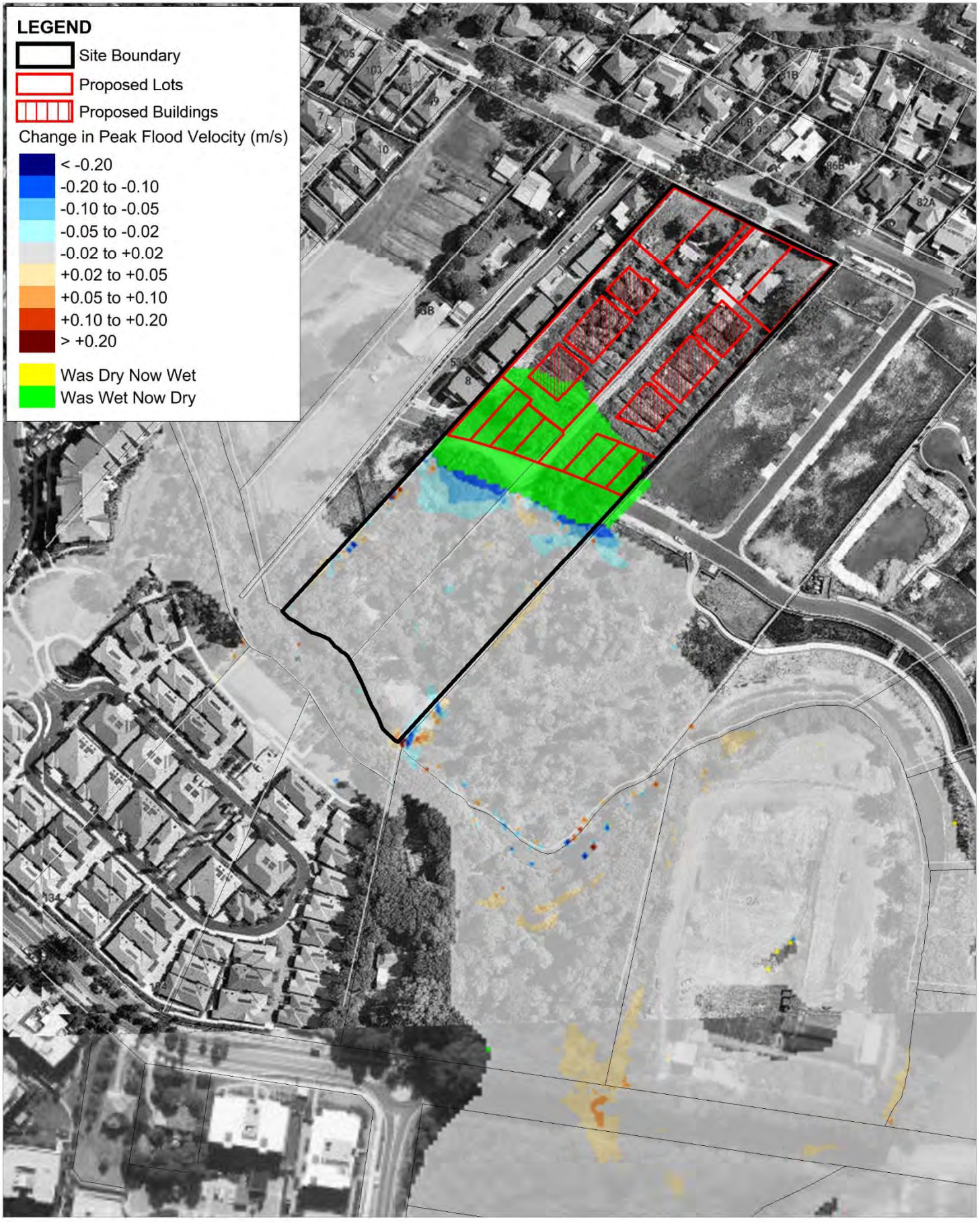

Title:

1% AEP Event
Change in Peak Flood Velocity

Figure: **C-8**

Rev: **-**

N

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Approx. Scale

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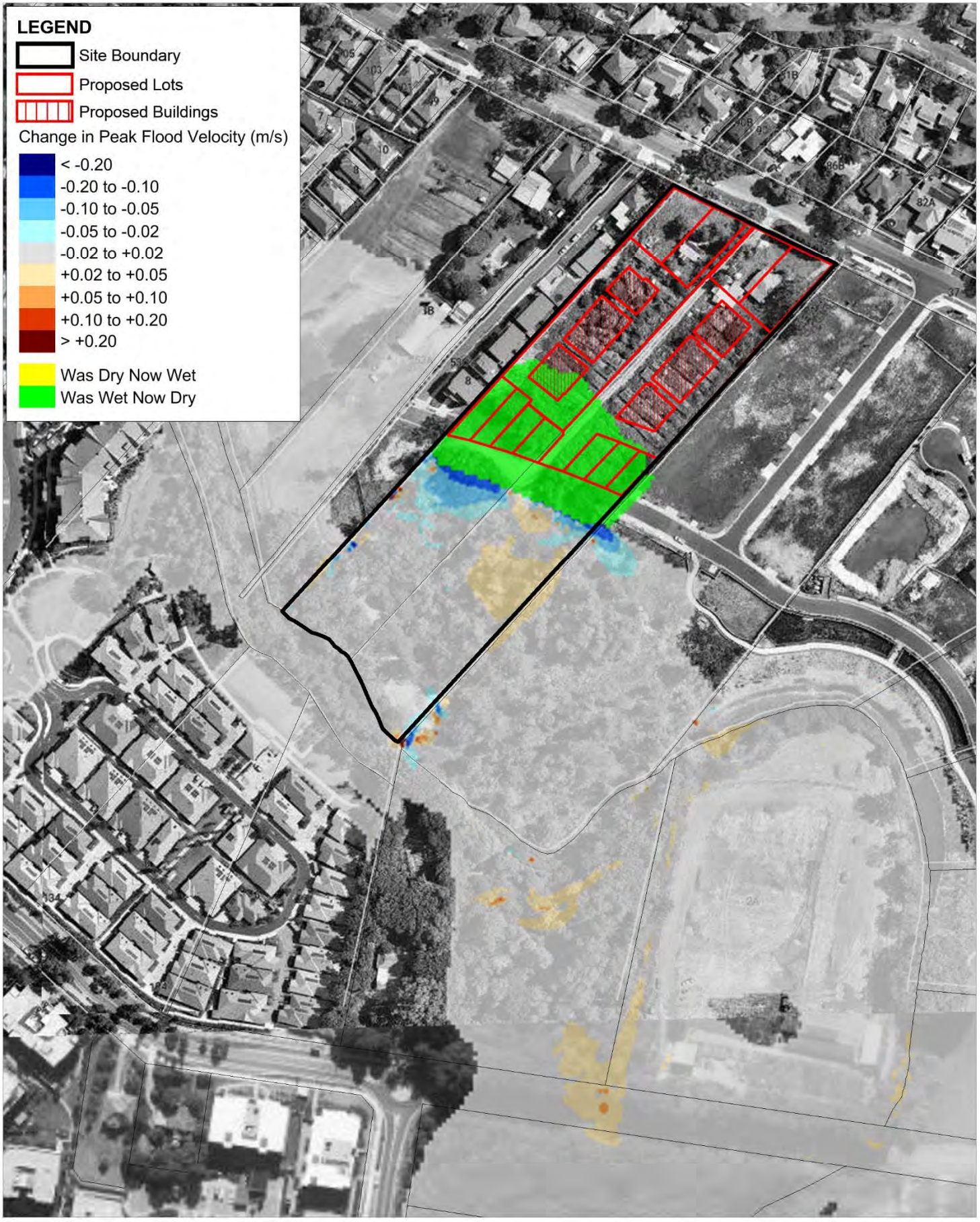

Title:

1% AEP with Climate Change Event Change in Peak Flood Velocity

Figure: **C-9**

Rev: **-**

N

0 50 100m

Approx. Scale

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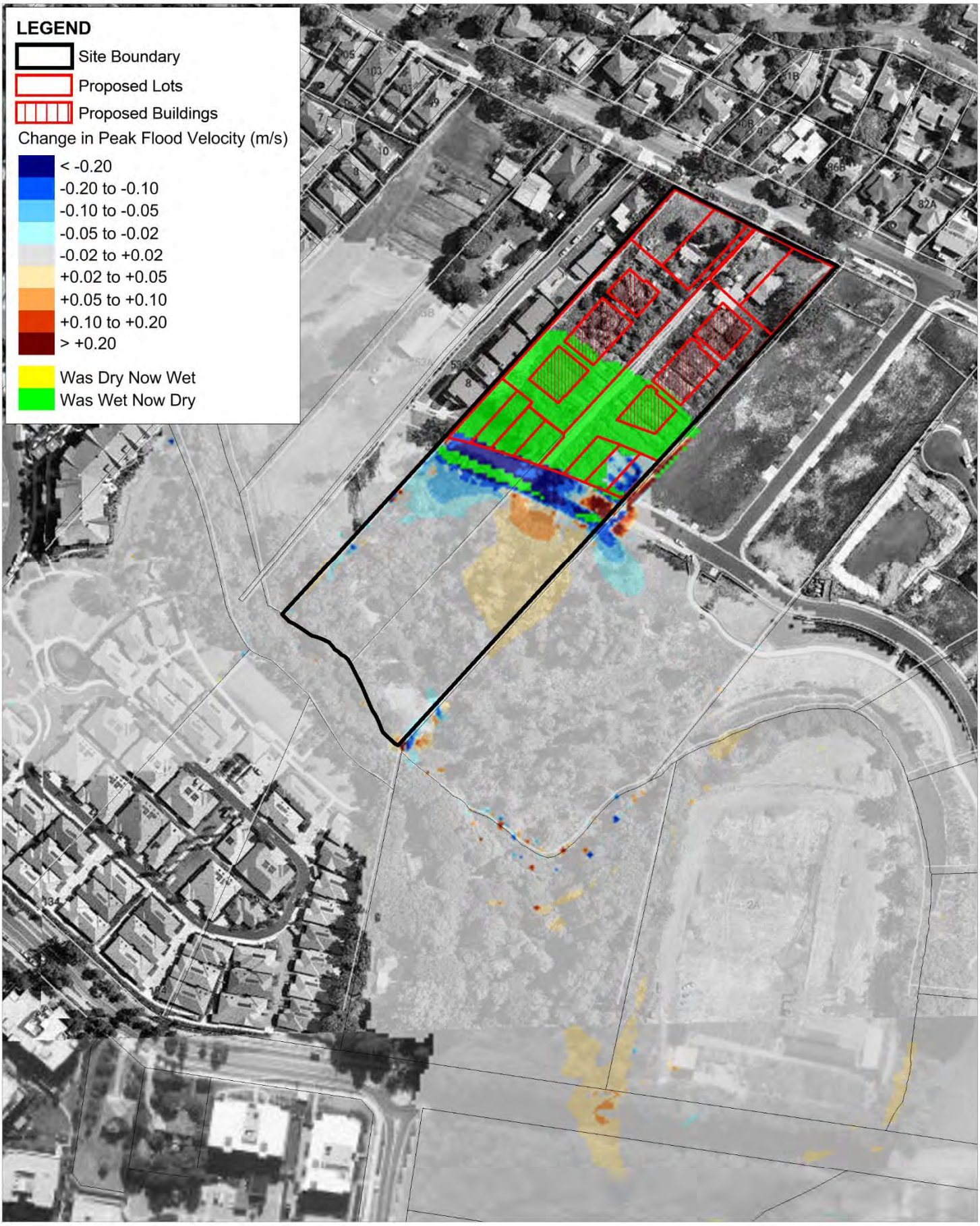

Title:

PMF Event
Change in Peak Flood Velocity

Figure: **C-10**

Rev: **-**

N

0 50 100m

Approx. Scale

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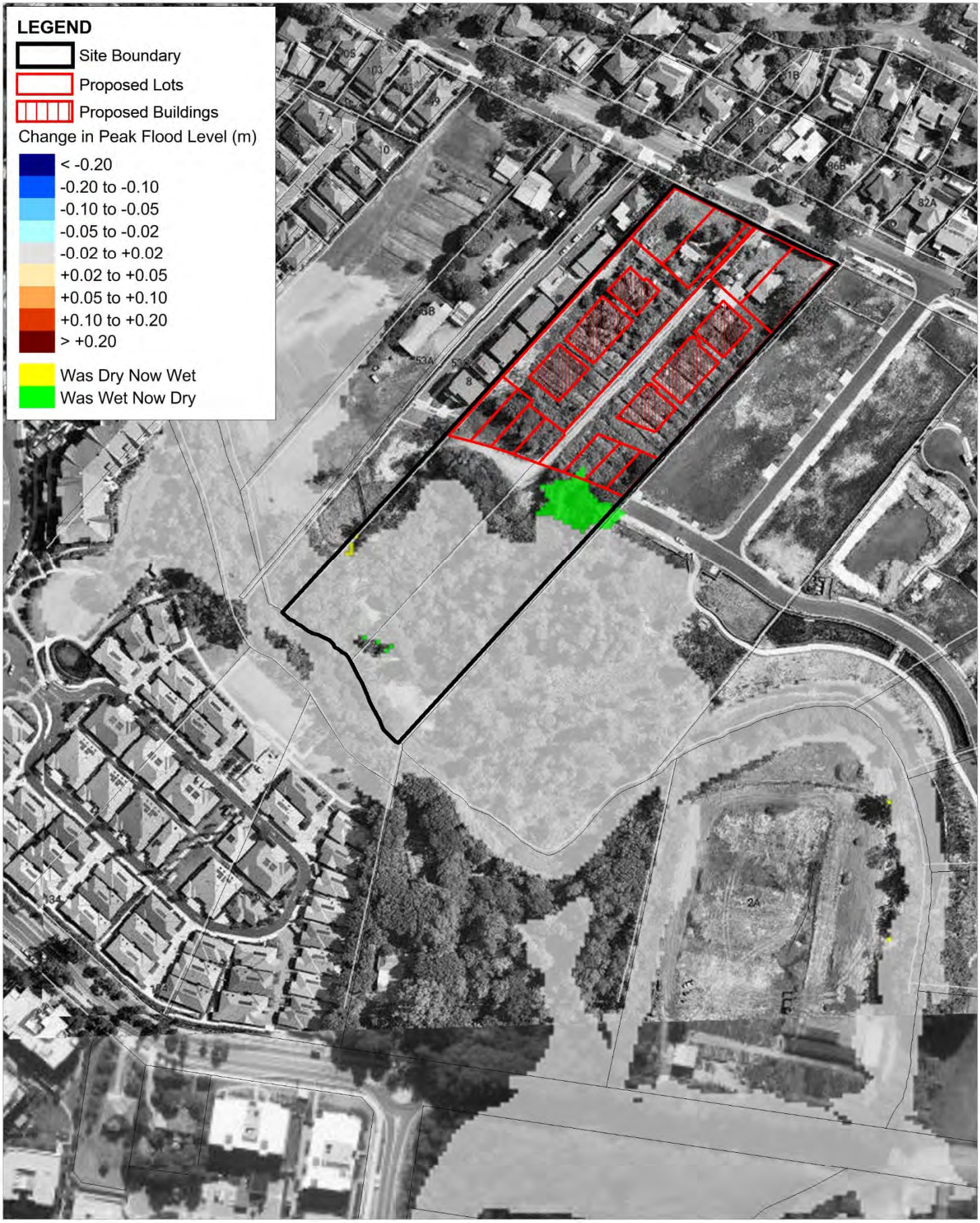
Filepath: K:N20951_45WarriewoodRd_FIAMapInfoWorkspaces0200731_Figures

Appendix D – Change in Peak Design Flood Level for Climate Change Events



Title:

2 Year ARI with Climate Change Event Change in Peak Flood Level

Figure: **D-1**

Rev: **-**

N

0 50 100m

Approx. Scale

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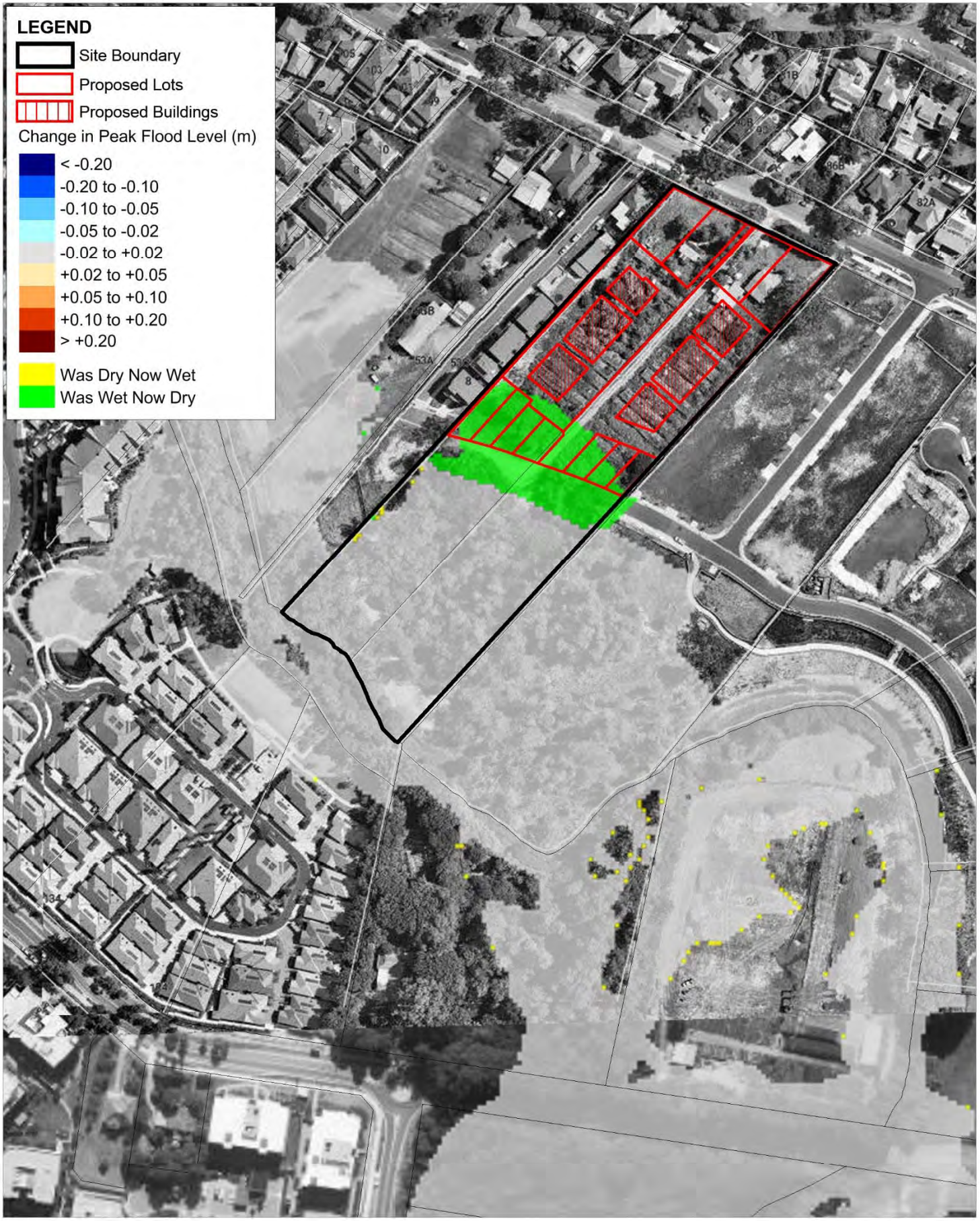

Title:

20% AEP with Climate Change Event Change in Peak Flood Level

Figure: D-2

Rev: -

N

0 50 100m

Approx. Scale

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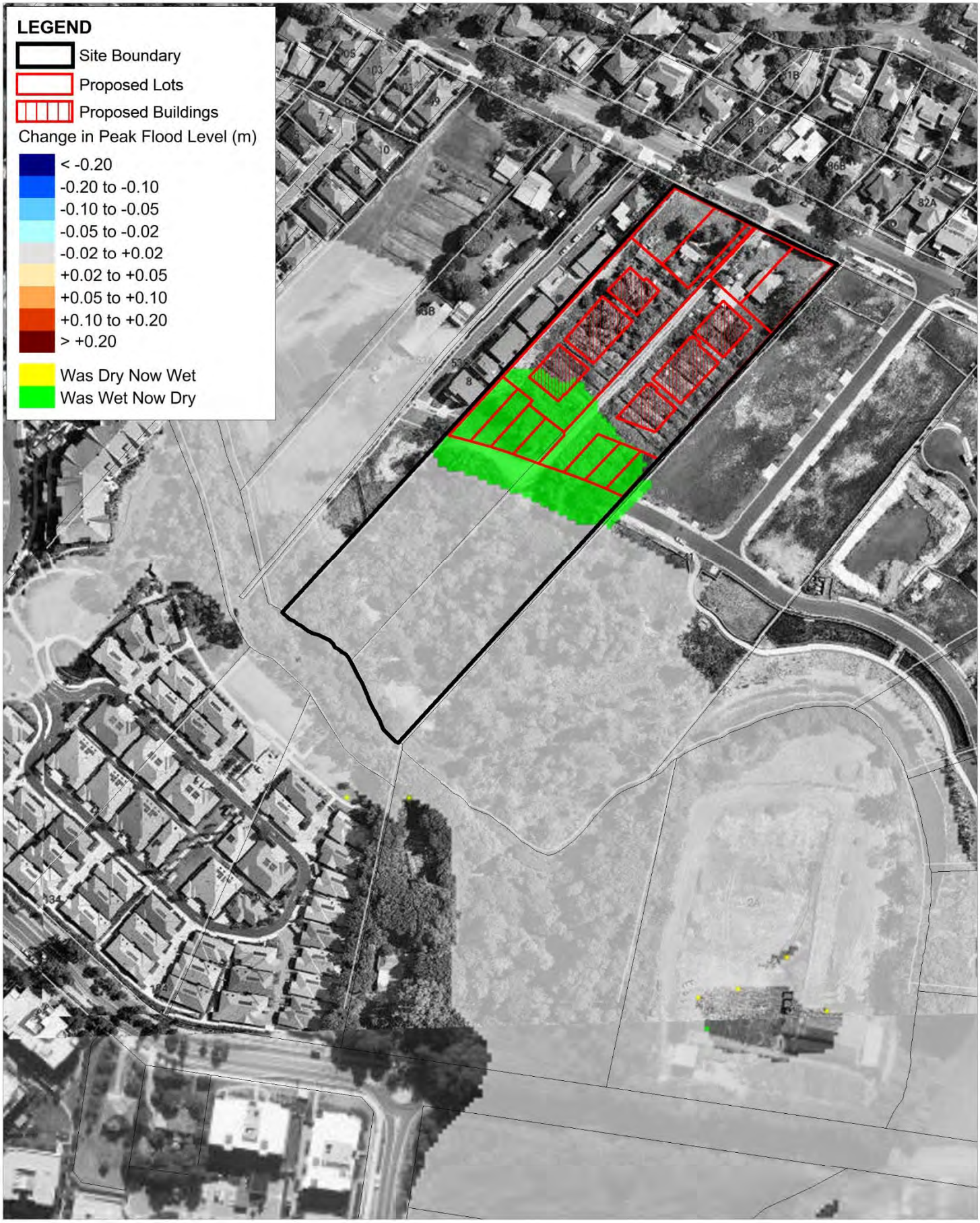

Title:

1% AEP with Climate Change Event Change in Peak Flood Level

Figure: **D-3**

Rev: **-**

N

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Approx. Scale

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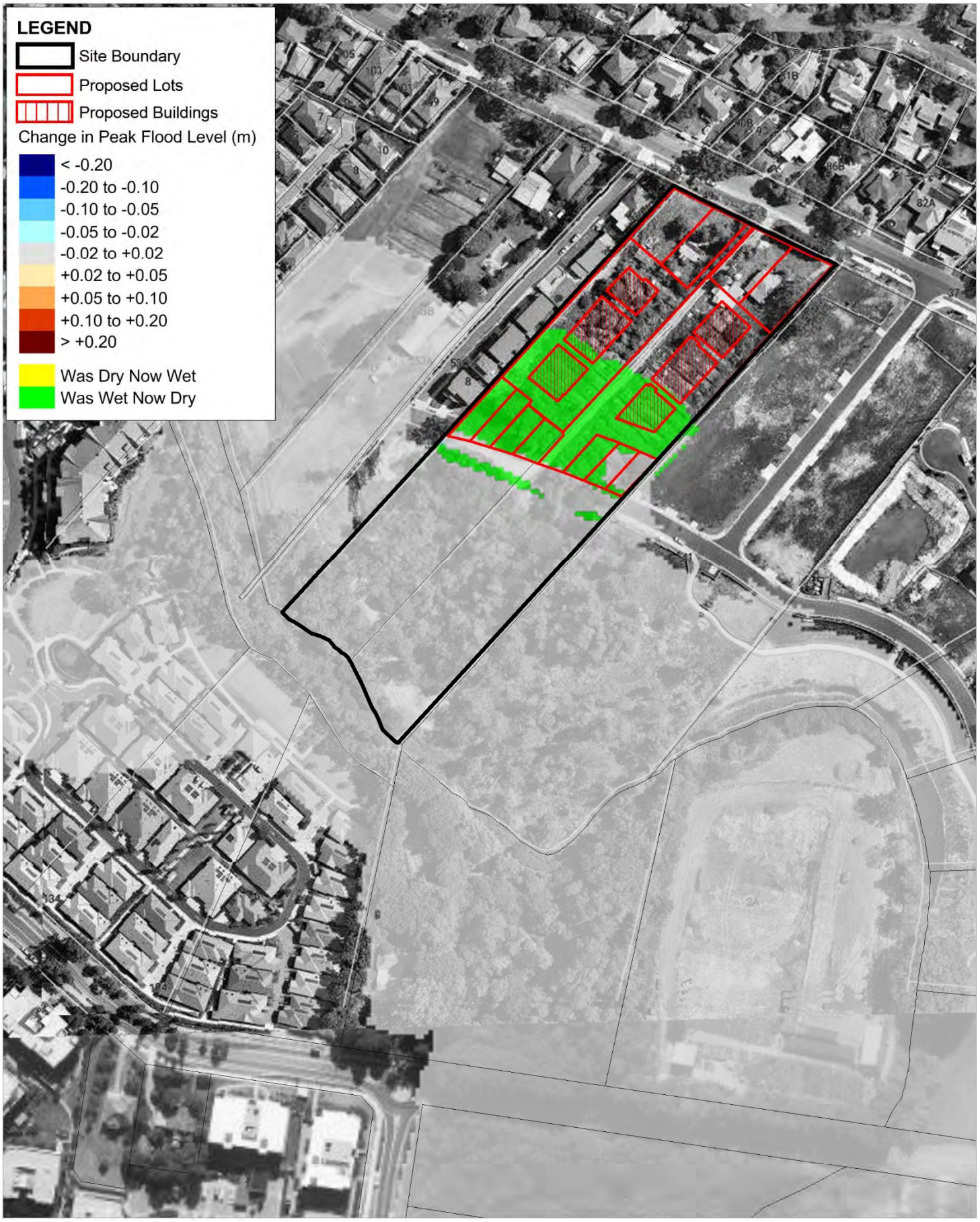

Title:

PMF with Climate Change Event Change in Peak Flood Level

Figure: **D-4**

Rev: **-**

N

0 50 100m

Approx. Scale

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