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Our Ref: DJW: L.T2189.002.docx

21 November 2021
Drew Lumsden
c/o Perception Planning
PO Box 107
Clarence Town NSW 2321
Attention: Katrina Walker

Dear Katrina

RE: FLOOD IMPACT ASSESSMENT FOR PROPOSED SUBDIVISION AT 349 MCFARLANES ROAD, BERRY PARK NSW

Background

Torrent Consulting was engaged to undertake a Flood Impact Assessment to assist in the DA process for the proposed subdivision at 349 McFarlanes Road, Berry Park NSW (the Site). It is understood that flood assessment is required by Council to provide the required supporting information for the application.

This Site is located near Four Mile Creek, which forms part of the broader Hunter River floodplain, as presented in Figure 1. The catchment area of the Hunter River covers some 22 000 km^2. The topography of the local floodplain is flat and low-lying, characterised by alluvial deposition and raised flood levee embankments, as presented in Figure 2. Whilst the proposed development layout is largely situated outside of the floodplain, the earthworks required to raise the subdivision above the flood planning level (FPL) have some minor encroachment into the floodplain.

The existing design flood conditions at the Site are detailed in the Hunter River Branxton to Green Rocks Flood Study (WMA Water, 2010). Information contained in this study is used to summarise the context of existing flood conditions and risks in relation to the Site and the proposed development.

The assessment also includes the development of a TUFLOW model of the Lower Hunter River to simulate design flood conditions consistent with those of the existing flood studies. This model provides a platform to assess the potential flood impacts associated with the proposed development. It also enables a more detailed understanding of the local flood velocities and hazards.

Model Development

Torrent Consulting has developed a TUFLOW hydraulic model covering the entire floodplain of the Lower Hunter River downstream to the river mouth at the Tasman Sea, including upstream to: Luskintyre on the Hunter River, Vacy on the Paterson River and Glen Martin on the Williams River, as presented in Figure 3.

The catchment area of the Hunter River covers some 22 000 km^2, with the Paterson and Williams Rivers contributing around 1200 km^2 and 1300 km^2 respectively. The modelled area encompasses some 750 km^2.

The model utilised the NSW Spatial Services LiDAR data product, downloaded via the ELVIS Foundation Spatial Data portal to define the floodplain topography. The model was constructed using a 20 m grid cell resolution, sampling elevations from the LiDAR data. The modelled floodplain contains numerous embankments that function as hydraulic controls and are of too small a scale to be adequately captured by the 20 m grid cell model resolution. Therefore, a network of breaklines was digitised along some 820 km of embankments and the underlying LiDAR data interrogated to populate the breaklines with the elevations of the embankment crests. These were then incorporated into the TUFLOW model using the Z Shape representation, which modifies model cell elevations to match those of the breaklines.

A total of 26 floodplain mound constructions were identified as having been constructed since the LiDAR data was captured in 2012-13, using available aerial imagery in Google Earth. The approximate extent of these mounds was identified from the imagery and incorporated into the TUFLOW model with assumed mound heights being adopted to raise them above the 1% AEP flood level.

The Hunter River Hydrographic Survey (May 2005) was used to provide representative channel cross-section information of the lower Hunter, Paterson and Williams Rivers. An appropriate channel topography was incorporated into the model, with a full 2D representation of both channel and floodplain. Aerial imagery was used to define separate surface materials for areas of cleared floodplain, river channel and remnant vegetation. Modelling of key hydraulic structures within the study area is also included for the Fullerton Cove and Salt Ash floodgates and culverts under Nelson Bay Road.

Many estuarine vegetation communities are not well penetrated, and are subsequently poorly filtered in, the LiDAR data product. These include areas of mangroves, saltmarsh, phragmites, rank grassland, wet heath, and other swampy habitats. The modelled floodplain elevations in these areas have therefore had an elevation correction adjustment applied to the LiDAR data. Site survey for this study identified the grasslands of the western study Lots to be around 0.2 m lower than the LiDAR representation. The swampier habitat of the eastern Lots is around 0.35 m lower than the LiDAR. Vegetation across the Hunter Estuary has been treated in this way in the TUFLOW model, with LiDAR elevations being lowered between 0.2 m and 0.6 m, depending on vegetation cover. The extent of the modified LiDAR elevations is presented in Figure 3.

The upstream model inflow boundaries on the Hunter, Paterson and Williams Rivers were developed using information contained in the Hunter River Branxton to Green Rocks Flood Study (WMA Water, 2010), the Paterson River Flood Study Vacy to Hinton (WMA Water, 2017) and the Williams River Flood Study (BMT WBM, 2009) respectively. Local hydrological inputs for the 750 km^2 of model area were also accounted for, although they are not overly important for the derivation of the design flood conditions. The downstream boundary of the model was configured as a tidal cycle with a peak water level of 1.1 m AHD, which is approximately an annual peak condition.

The model was calibrated to provide consistency with the Hunter River Branxton to Green Rocks Flood Study and the Williamtown – Salt Ash Floodplain Risk Management Study through iterative adjustment of the Manning's 'n' roughness parameters for the digitised land use materials. The adopted Manning's 'n' values are provided in Table 1.

The TUFLOW model produced results at Maitland that closely match those of the Hunter River Branxton to Green Rocks Flood Study. Consistent results at Raymond Terrace were harder to achieve and were found to be significantly influenced by total inflow volumes more-so than peak flow rates alone.

Design flood levels at Oakhampton are driven principally by peak flows (with variations in volume effectively negligible). Flood Frequency Analysis (FFA) undertaken for the Hunter River Branxton to Green Rocks Flood Study and the Singleton Floodplain Risk Management Study (BMT, 2020) provide similar estimates of design flood flows for the Hunter River, which provides a good level of confidence in those estimates. The derivation of design flood flow estimates through FFA at Raymond Terrace is less certain, due to a shorter period of continuous record and a lack of a site rating curve. Using FLIKE to derive probabilistic estimates of design peak flows, the results for the rarer events were found to vary significantly depending on the assumptions made for data entry of historic flood thresholds. This is because there is less than 40 years of continuous record and the largest flood events all occurred before this period.

Table 1 – Adopted Manning's 'n' Values

Surface Material	Manning's 'n'
Cleared floodplain	0.040
Hunter River channel u/s Morpeth	0.030
Hunter River channel Morpeth to Raymond Terrace	0.025
Hunter River channel d/s Raymond Terrace	0.020
Paterson River channel	0.045
Williams River channel	0.025
Remnant vegetation	0.120
Mangroves	0.150

Rainfall-runoff modelling was undertaken for the entire Hunter River catchment using methods outlined in ARR 2019 to assist in establishing suitable design flow conditions at Raymond Terrace, specifically the relationship between modelled peak flow conditions at Oakhampton and Raymond Terrace. With flows on the Hunter River dominating volumes at Raymond Terrace, establishing a relationship between design flows at Oakhampton and expected design flows at Raymond Terrace provides a useful tool for validating design flood levels at Raymond Terrace. The Hunter River catchment rainfall-runoff modelling found the critical duration at Oakhampton to be 48 hours, whereas it was the 72-hour duration at Raymond Terrace – indicative of the additional reliance on overall flood volume to maintain peak flows and levels. Table 2 presents the design flows at Oakhampton and the estimated equivalent design flow condition at Raymond Terrace.

Table 2 – Hunter River Design Peak Flows (m^3/s)

Design Event	Oakhampton	Raymond Terrace
20% AEP	1700	1400
10% AEP	2600	2300
5% AEP	3800	3200
2% AEP	5800	4700
1% AEP	8000	6300
0.5% AEP	10 300	7900
0.2% AEP	13 500	10 200

Ultimately, design flow estimates were adopted from the FLIKE FFA for the 20% AEP and 10% AEP events and from the rainfall-runoff modelling analysis for the rarer flood events. Table 2 presents the design flows at Oakhampton and the estimated equivalent design flow condition at Raymond Terrace. A comparison of the adopted design flows at Raymond Terrace with the 90% confidence interval determined using FLIKE is presented in Chart 1.

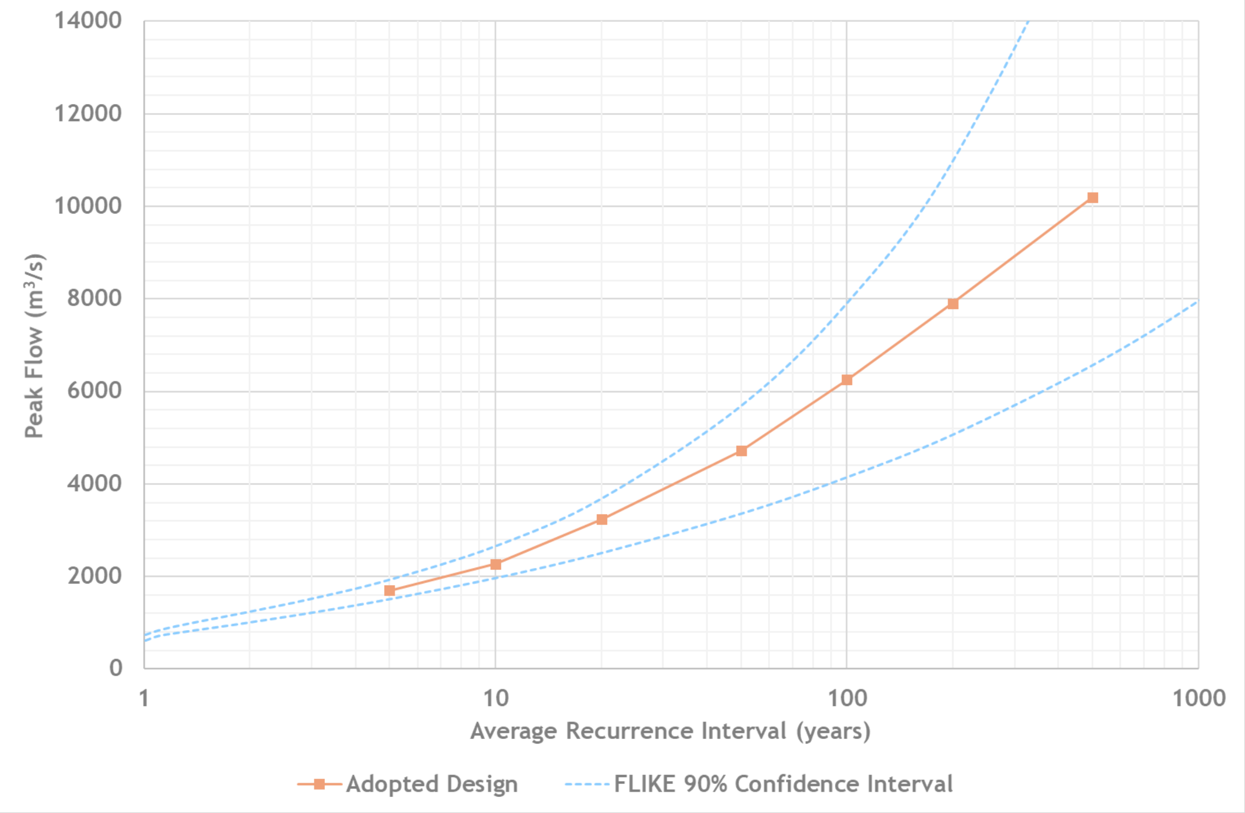


Chart 1 – Adopted Design Flood Flows at Raymond Terrace

Design flood flow hydrographs for the Hunter, Williams and Paterson Rivers were simulated in the TUFLOW model and the volumes of the flood recession were adjusted until the required peak flow conditions at Raymond Terrace were matched. The resultant peak flood levels at the Raymond Terrace gauge are presented in Table 3, together with those established for the Williamtown – Salt Ash Floodplain Risk Management Study. The overall consistency between the two is good and is well within the bounds of uncertainty of the FFA at Raymond Terrace.

Table 3 – Design Flood Levels at Raymond Terrace

Design Event	This Assessment	BMT WBM (2017)
20% AEP	2.6	2.2
10% AEP	2.9	3.0
5% AEP	3.3	3.3
2% AEP	4.0	4.1
1% AEP	4.7	4.8
0.5% AEP	5.3	5.2
0.2% AEP	6.1	N/A

Flood Modelling and Mapping

The design flood conditions at the Site are not best represented by the existing flood study. The Hunter River Branxton to Green Rocks Flood Study provides design flood conditions at the Site. However, the modelling used for the study does not represent design tailwater levels at Green Rocks. Whilst this does not impact the flood levels at Maitland (which was the focus of the study), the reduced backwater influence provides an underestimation of design flood levels downstream of Maitland, including at the Site.

The TUFLOW model was simulated (using the HPC solver) for the 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP and 0.5% AEP events to define baseline flood conditions for the purposes of assessing flood risk and as the basis for subsequent flood impact assessment. The Extreme Flood event was also simulated. The modelled peak flood levels at the Site are summarised in Table 4.

The modelling undertaken by Torrent Consulting provides consistently higher flood levels than the Hunter River Branxton to Green Rocks Flood Study at the Site, except for the 2% AEP event, at which the modelled peak flood level is similar.

The modelled peak flood extents for the 5% AEP, 1% AEP and Extreme events are presented in Figure 4, together with the Site lot boundary and building location. Figure 5, Figure 6, and Figure 7 are presented for additional flooding context and show the modelled peak flood depths for the 5% AEP, 1% AEP and Extreme events, respectively.

Table 4 – Modelled Peak Design Flood Levels at the Site (m AHD)

Design Event	This Assessment	Flood Study
20% AEP	4.8	3.4
10% AEP	5.1	4.2
5% AEP	5.4	4.7
2% AEP	5.7	5.7
1% AEP	6.5	5.9
0.5% AEP	7.1	6.3
Extreme	9.9	8.1

Flood Risk Management

Figure 8, Figure 9, and Figure 10 present the flood hazard classification at the Site for the 5% AEP, 1% AEP and Extreme Flood events, respectively. The flood hazards have been determined in accordance with 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). This produces a six-tier hazard classification, based on modelled flood depths, velocities, and velocity-depth product. The hazard classes relate directly to the potential risk posed to people, vehicles, and buildings, as presented in Chart 2.

The flood hazard mapping is useful for providing context to the nature of the modelled flood risk and to identify potential constraints for development of the Site with regards to floodplain risk management. The principal consideration of good practice floodplain risk management is to ensure compatibility of the proposed development with the flood hazard of the land, including the risk to life and risk to property.

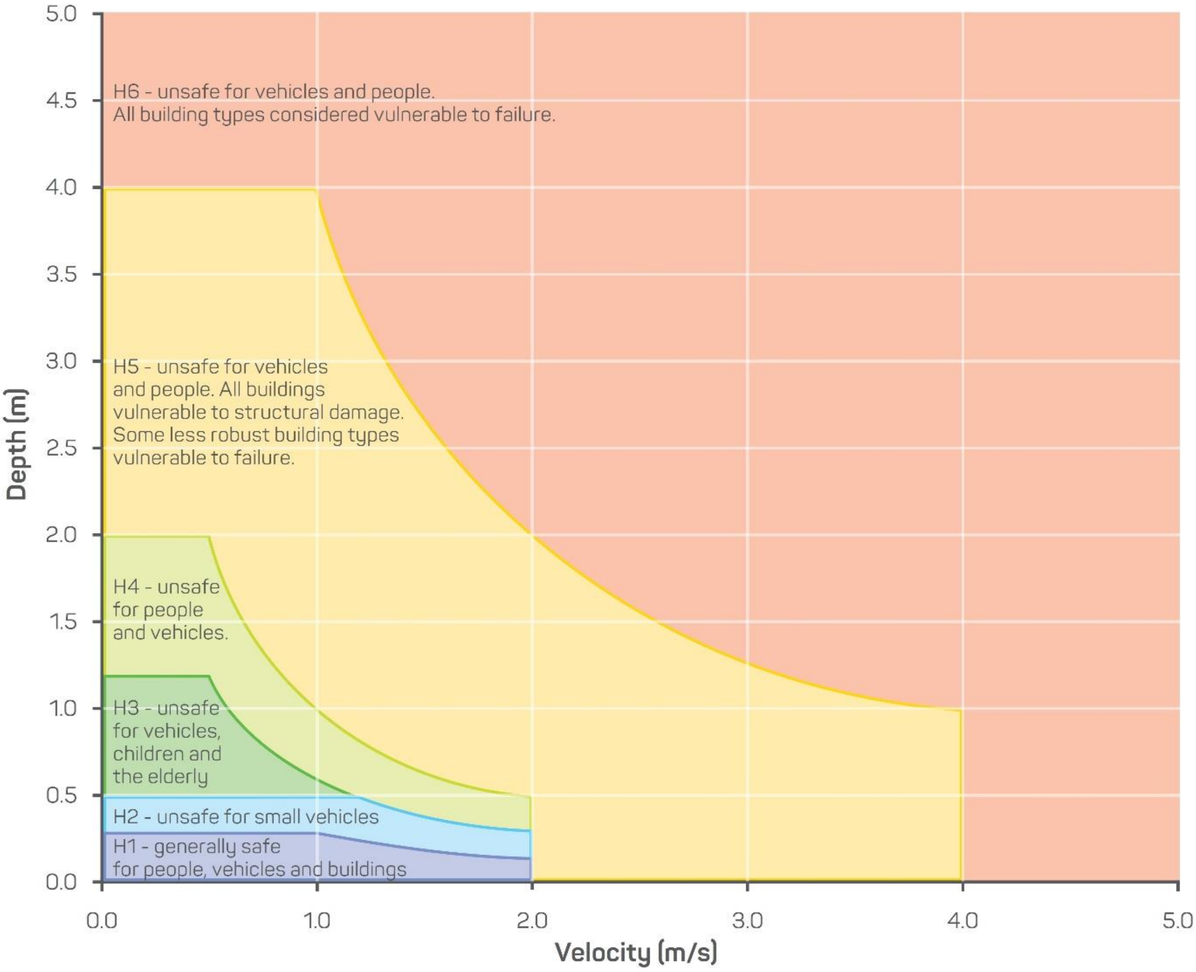


Chart 2 – General Flood Hazard Vulnerability Curves (AIDR, 2017)

The objective of the management of risk to property is to minimise the damages that would be incurred in the event of a flood. This includes potential damage to future building structures and their contents. Risk to property is typically managed to the 1% AEP design flood event. Figure 9 presents the flood hazard classification at the Site for the 1% AEP event.

The flood hazard mapping presented in Figure 9 shows that the lots of the proposed subdivision are largely flood free or a low to medium flood hazard classification, with high hazard flooding within the extent of proposed earthworks. However, the earthworks will raise the proposed subdivided lots above the 1% AEP flood level, as presented in Figure 11.

The principal mechanism for Councils to manage the risk to property is the application of an appropriate Flood Planning Level (FPL) to set the minimum height of finished floor levels (FFL) and/or critical services. With reference to the Hunter River Branxton to Green Rocks Flood Study, the FPL at the Site is around 6.4 m AHD, being the 1% AEP flood level plus a 0.5 m freeboard. However, as discussed previously, this is considered an underestimation and an FPL of around 7.0 m AHD is recommended.

With subdivision levels set at or above the FPL, the management of risk to property requirements of the Maitland DCP (outlined in item 3.3 of Part B – Environmental Guidelines) are inherently satisfied.

The objective of the management of risk to life is to minimise the likelihood of deaths in the event of a flood and is typically considered for rarer flood events than the 1% AEP, up to the PMF (or Extreme Flood). Figure 10 shows that only a few of the subdivided lots are flood free in an Extreme Flood event. The flood emergency response to manage risk to life typically adopts either a flood evacuation or a shelter-in-place policy.

Flood evacuation is usually the preferable option in large catchments with adequate warning time, whereas a shelter-in-place policy is often required for sites where insufficient warning is available to make flood evacuation a practical option. Being flood-affected by a large river system with a local flood warning gauge, there is ample opportunity to evacuate the Site prior to a major flood event. A shelter-in-place policy with on-site flood-free refuge is therefore not required (or recommended, given the high hazard flood conditions). It is recommended that a Flood Emergency Response Plan is developed for the Site to provide relevant intelligence to assist in the event of flood evacuation.

Specific requirements within the Maitland DCP considering risk to life from flooding are that:

- Flood-free access shall be provided from the development to an appropriate evacuation facility (as identified in the Maitland Local Flood Plan), at the 5% AEP flood level or higher
- Provision shall be made for the safe evacuation of people from the development in accordance with the Maitland Local Flood Plan

In relation to the management of risk to life, the following aspects of the proposed development relate to the DCP requirements:

- The provision of flood-free access at or above the 5% AEP flood level is not possible, as it is constrained by the inundation of the low-lying floodplain areas along the alignment of McFarlanes Road. However, this is consistent with other properties in the area and is mitigated by the available flood warning time
- Safe evacuation is addressed in the Flood Emergency Response section of this report.

The area of the Site proposed for subdivision is not located within the mapped floodway extent at the 1% AEP event, as per the Hunter River Floodplain Risk Management Study and Plan (WMA Water, 2015). It is also not classified as floodway when applying the criteria used to define the floodway in the Floodplain Risk Management Study to the 1% AEP flood conditions modelled for this assessment. Therefore requirements relating to the development of floodways in item 3.1 of Part B – Environmental Guidelines of the Maitland DCP do not apply.

Flood Impact Assessment

As per item 3.2 of Part B – Environmental Guidelines of the Maitland DCP, a flood impact assessment supported by fully dynamic computer modelling is required when more than 7000 m^3 of fill is proposed within flood storage and flood fringe areas.

To assess the potential for flood impacts on existing flood behaviour resulting from the proposed development, the associated earthworks were incorporated into the TUFLOW model, raising the subdivision above the recommended FPL of 7 m AHD. The design flood events were then re-simulated, and the results compared to the baseline flood conditions for the purposes of relative flood impact assessment.

The modelled peak flood level impacts for the 5% AEP and 1% AEP events are presented in Figure 12 and Figure 13 respectively. The modelled peak flood velocity impacts for the 5% AEP and 1% AEP events are presented in Figure 14 and Figure 15 respectively. The mapping shows that the proposed filling of the floodplain has a negligible impact to the existing flood conditions.

To consider the potential for cumulative impacts of filling the floodplain to a similar degree to that proposed for this development, a TUFLOW model was simulated in which the entire area around the edge of the Four Mile Creek and Saltwater Gully floodplains with surface levels at or above 3.2 m AHD was filled to a level of 7.0 m AHD. The results for the modelled impact on the 1% AEP flood event peak flood levels are presented in Figure 16. The area around the edge of the floodplain is mapped as being free from flood inundation, but the impact on modelled peak flood levels across the broader floodplain is negligible (being only around 7 mm within the Four Mile Creek floodplain).

Flood Emergency Response

The Site access can be impacted by flooding of the Hunter River. The BoM incorporates the Maitland (at Belmore Bridge) gauge into its operational flood warning network. Water level data can be accessed at: http://www.bom.gov.au/fwo/IDN60232/IDN60232.061268.plt.shtml. The data presents the current recorded water level at the gauge together with the recorded data over the past five days. The Minor, Moderate and Major flood warning levels are also provided and are summarised in Table 5. The gauge height in metres corresponds to the elevation in metres above Australian Height Datum (AHD).

Table 5 – Flood Warning Levels (m)

Warning Level	Maitland
Minor	5.9
Moderate	8.9
Major	10.5

The Site access via McFarlanes Road becomes inundated at around a 20% AEP flood event on the Hunter River (as modelled for this assessment). The peak flood level of a 20% AEP flood is between the Moderate and Major flood levels at the Maitland gauge. Evacuation from the Site to prevent becoming isolated by flood waters is therefore only required when a Moderate Flood warning is issued for the Maitland gauge.

The NSW State Flood Plan (2015) provides a target flood warning time of 24 hours prior to a Moderate flood event at Maitland. For a 1% AEP flood event condition the modelling undertaken for this assessment indicates around a ten-hour time difference between the Moderate flood level being reached at Maitland and McFarlanes Road being inundated. Therefore, in the event of a Hunter River flood, more than a 24-hour warning time is expected to be available prior to the Site access being cut.

The recommended flood evacuation route from the Site is north along McFarlanes Road to Morpeth. As well as the option to relocate from the Site during a period of flooding, the advanced flood warning afforded by the Maitland gauge would also enable the option to leave the Site to acquire essential provisions, returning prior to the Site becoming isolated.

In the event of residents being trapped on Site by flood waters inundating McFarlanes Road, the residential lots would remain flood free for all but very rare to extreme flood events. There is also rising road access available to flood free land outside of the Extreme Flood extent just to the south of the Site, so becoming isolated at the Site by flood waters is more of an inconvenience than a risk to life.

Homeowners in flood-affected areas are encouraged to prepare a Flood Emergency Response Plan (FERP). The NSW SES (State Emergency Service) provides an online tool (http://www.seshomeemergencyplan.com.au/) for homeowners to complete a Home Emergency Plan, covering risks such as floods, storms, tsunamis and bushfires. Most of the content can (and should) be completed by the homeowner. However, details relating to the specific hazards cannot be readily produced, with information suggested to be sourced from government authorities where available. However, this document provides relevant flood information to support the development of a Home Emergency Plan to manage flood risk.

Residents at the Site should pay attention to any Flood Watch or Flood Warnings issued by the Australian Bureau of Meteorology (BoM). In the event of a flood emergency response being initiated by the SES, residents and guests should follow the instructions given accordingly. This may include an order to evacuate to a designated flood evacuation centre, if required. However, during such an event State emergency services would likely be stretched, and homeowners should be prepared to respond to a flood emergency without assistance.

To ensure timely flood warning in advance of a required evacuation, homeowners should set themselves up to receive RSS (Really Simple Syndication) feeds from the BoM New South Wales & ACT Warning service. Alerts are automatically provided to subscribed devices when the feed is updated. This can be set up for both home computers and mobile phones and is customisable (refer http://www.bom.gov.au/rss/rss-guide.shtml). Warnings issued for Maitland can then be monitored, with real-time gauge data available for viewing at http://www.bom.gov.au/fwo/IDN60232/IDN60232.061268.plt.shtml.

In the event of a Moderate flood warning for Maitland being issued by the BoM, homeowners should actively monitor the gauge levels and be prepared for evacuation from the Site. Even if the resultant flood is not rare enough to present a risk to life and property, the Site access could be cut for several days. Residents should make alternative accommodation arrangements so that they have somewhere to stay until flood waters recede and road access to the Site is available.

The frequency of a Moderate flood event is effectively a 20% AEP (long-term average of once every five years) at Maitland, so false alarms represent an opportunity to practice a flood emergency response, rather than being an excessively frequent nuisance.

Conclusion

The Site at 349 McFarlanes Road, Berry Park, NSW requires a flood assessment to accompany the DA for the proposed subdivision, being located within the Hunter River floodplain. The flood impact assessment has included development of a TUFLOW hydraulic model to simulate design flood conditions at the Site, whilst maintaining a reasonable consistency with the results of the previous studies.

The flood assessment has determined that the Hunter River Branxton to Green Rocks Flood Study underestimates flood levels at the Site and so an FPL of around 7.0 m AHD is recommended to manage the potential risk to property from flooding. With subdivision levels set at or above the FPL, the management of risk to property requirements of the Maitland DCP (outlined in item 3.3 of Part B – Environmental Guidelines) are inherently satisfied.

The risk to life from flooding can be readily managed by the long period of advanced flood warning (over 24 hours) afforded by the Maitland gauge at Belmore Bridge.

It is recommended that a Flood Emergency Response Plan is developed for the Site. The Flood Emergency Response section of this report provides the relevant intelligence to assist in the event of flood evacuation and manage the potential risk to life.

The recommended flood evacuation route from the Site is north along McFarlanes Road to Morpeth, with options to relocate from the Site during a period of flooding or obtain necessary provisions for a period of anticipated isolation.

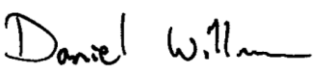
In the event of residents being trapped on Site by flood waters inundating McFarlanes Road, the residential lots would remain flood free for all but very rare to extreme flood events. There is also rising road access available to flood free land outside of the Extreme Flood extent just to the south of the Site, so becoming isolated at the Site by flood waters is more of an inconvenience than a risk to life.

The potential for off-site flood impacts associated with the proposed development are negligible – both when considered in isolation or in the context of potential cumulative impacts.

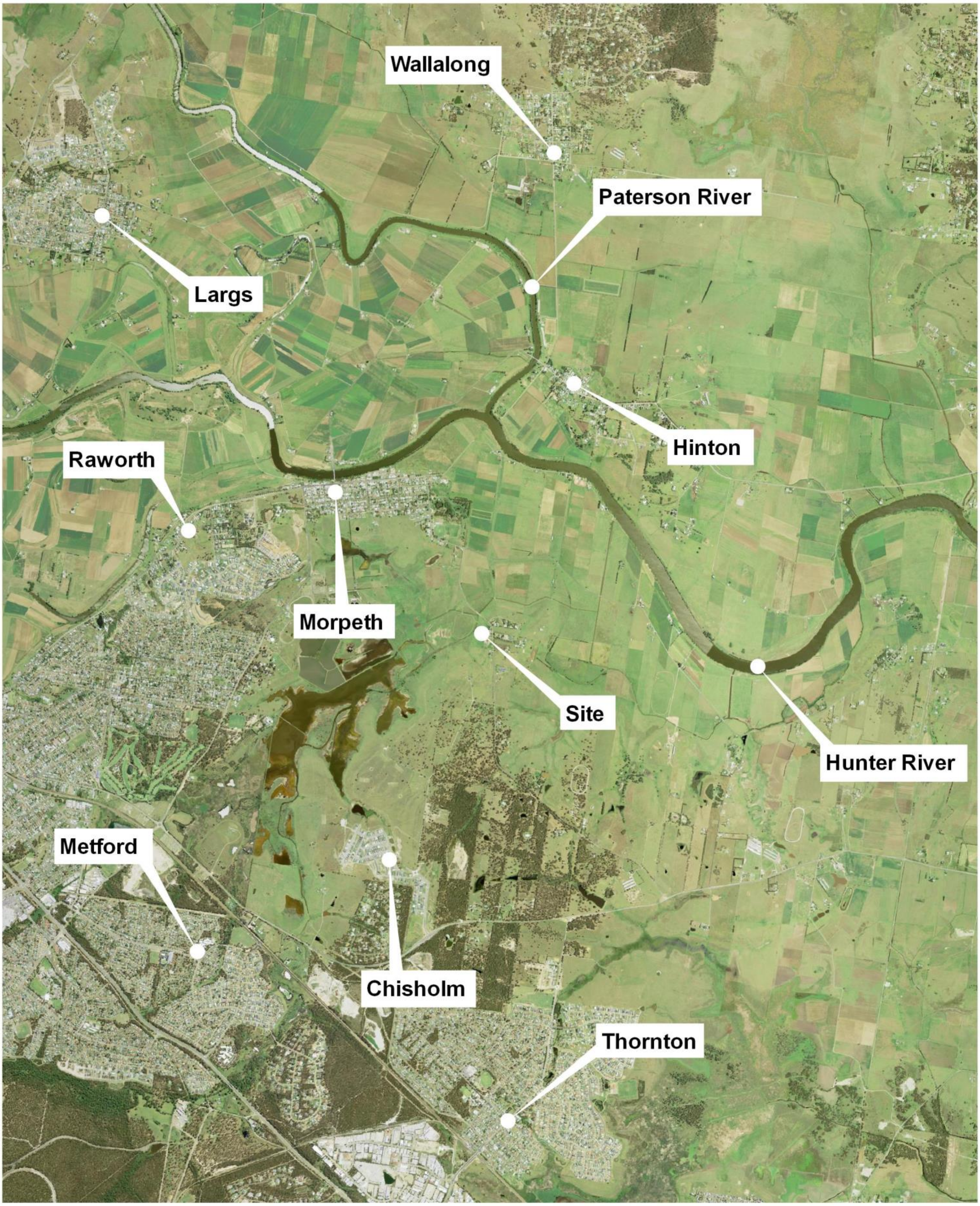
We trust that this report meets your requirements. For further information or clarification please contact the undersigned.

Yours faithfully

Torrent Consulting



Dan Williams
Director



Title: **Study Locality**	0 1 2 km approx. scale

Figure: **1**

Revision: **A**

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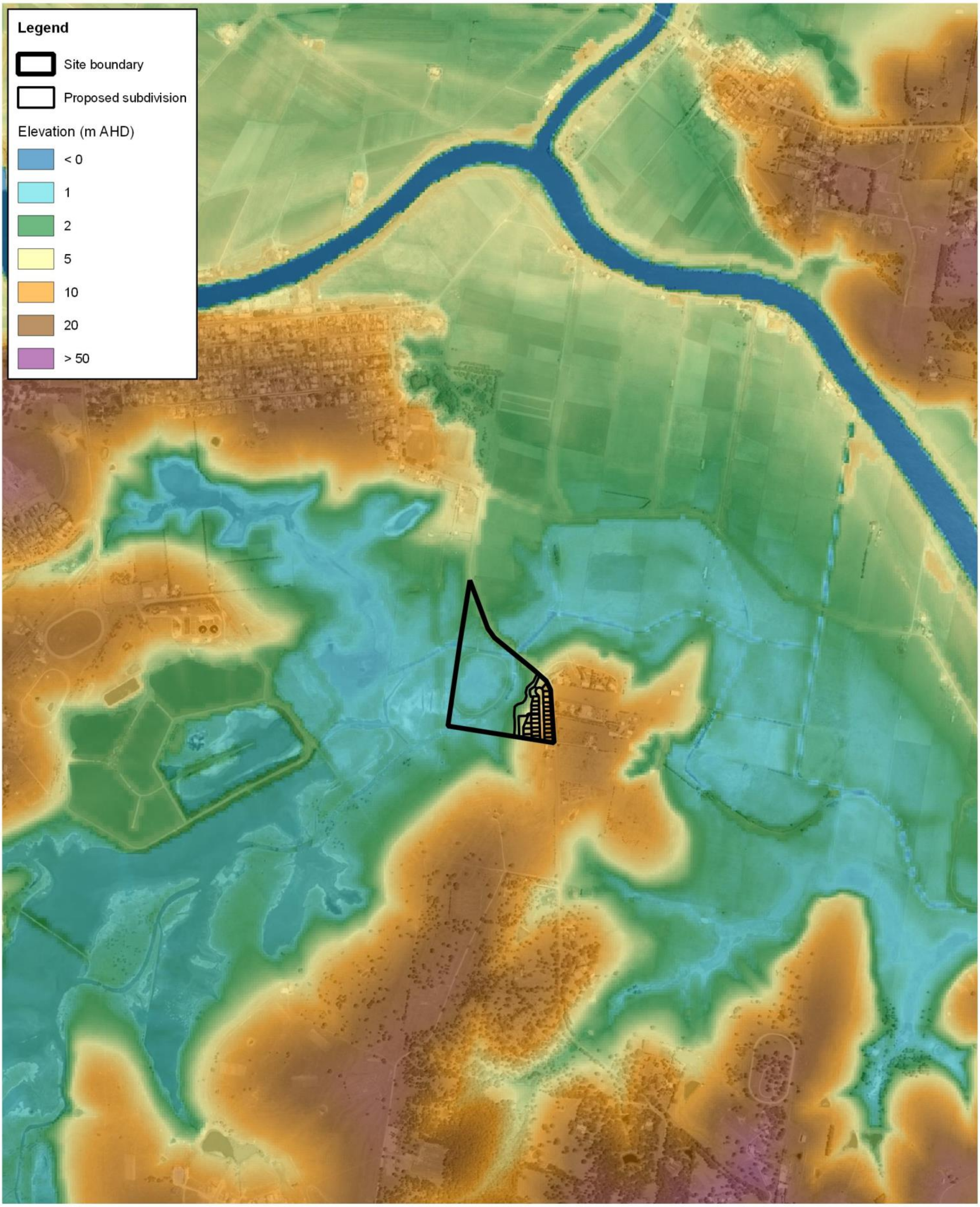

Title:

Local Floodplain Topography

Figure:	2
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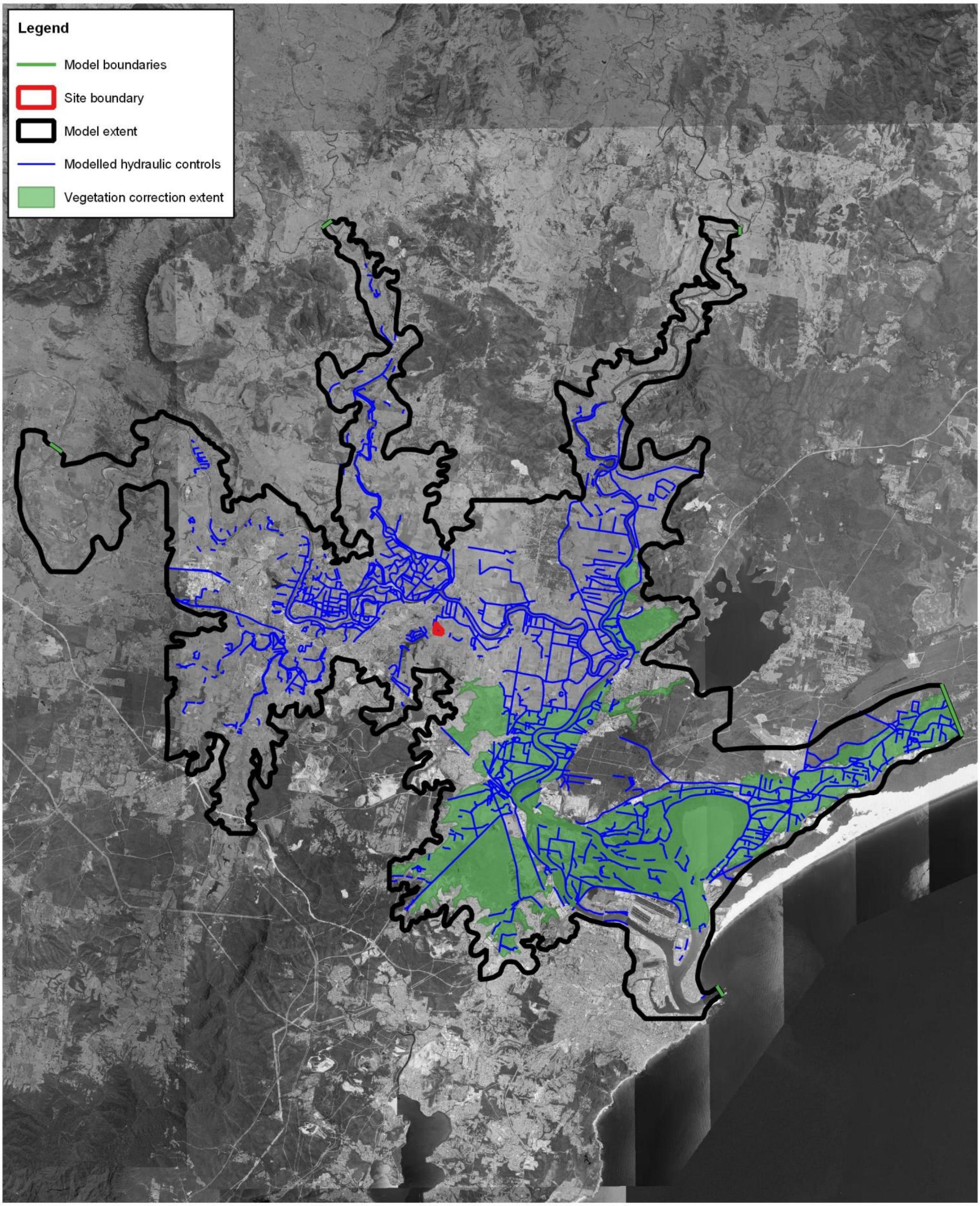

Title:

TUFLOW Model Components

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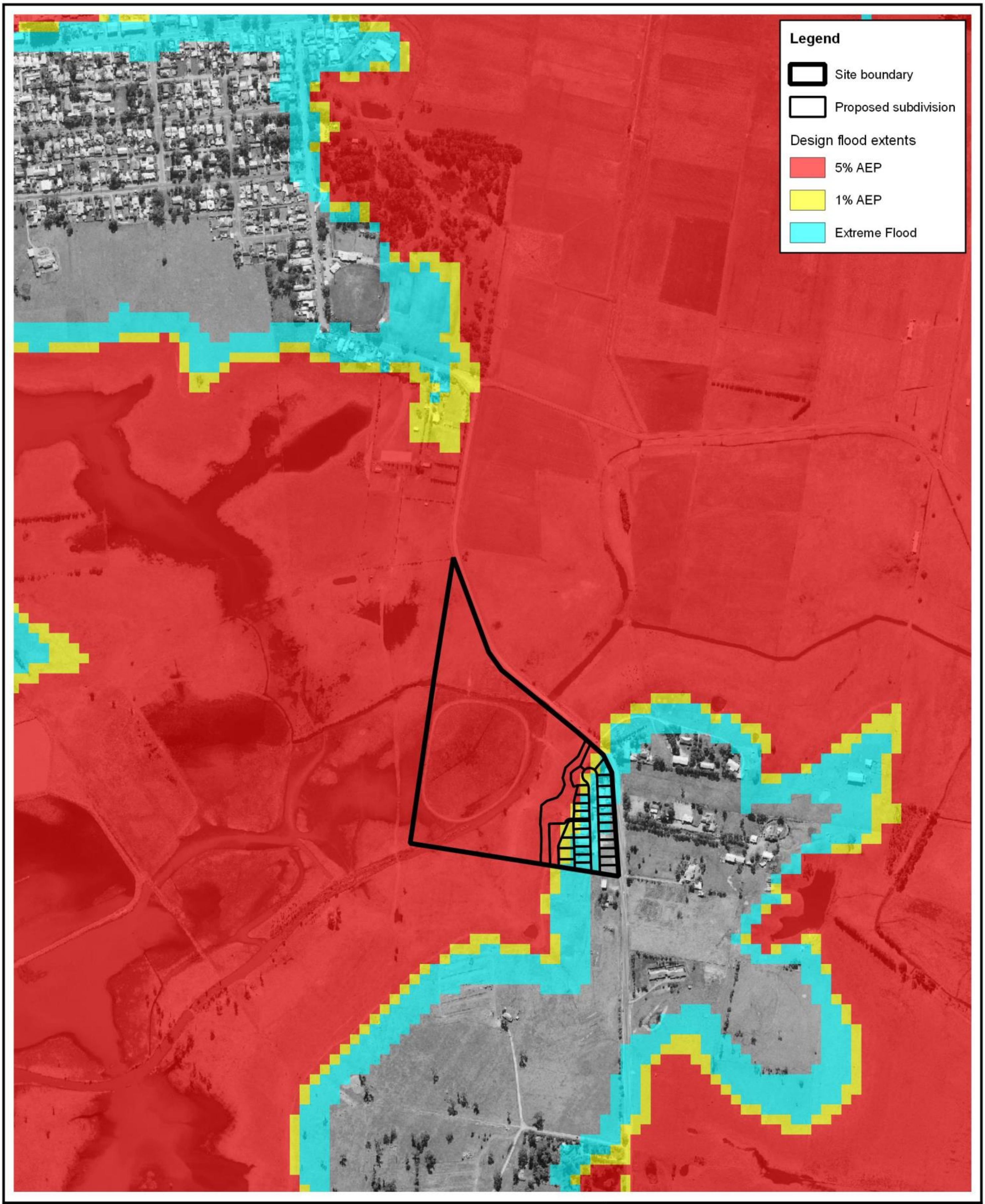

Title:

Modelled Flood Extents and Site Layout

Figure: **4**

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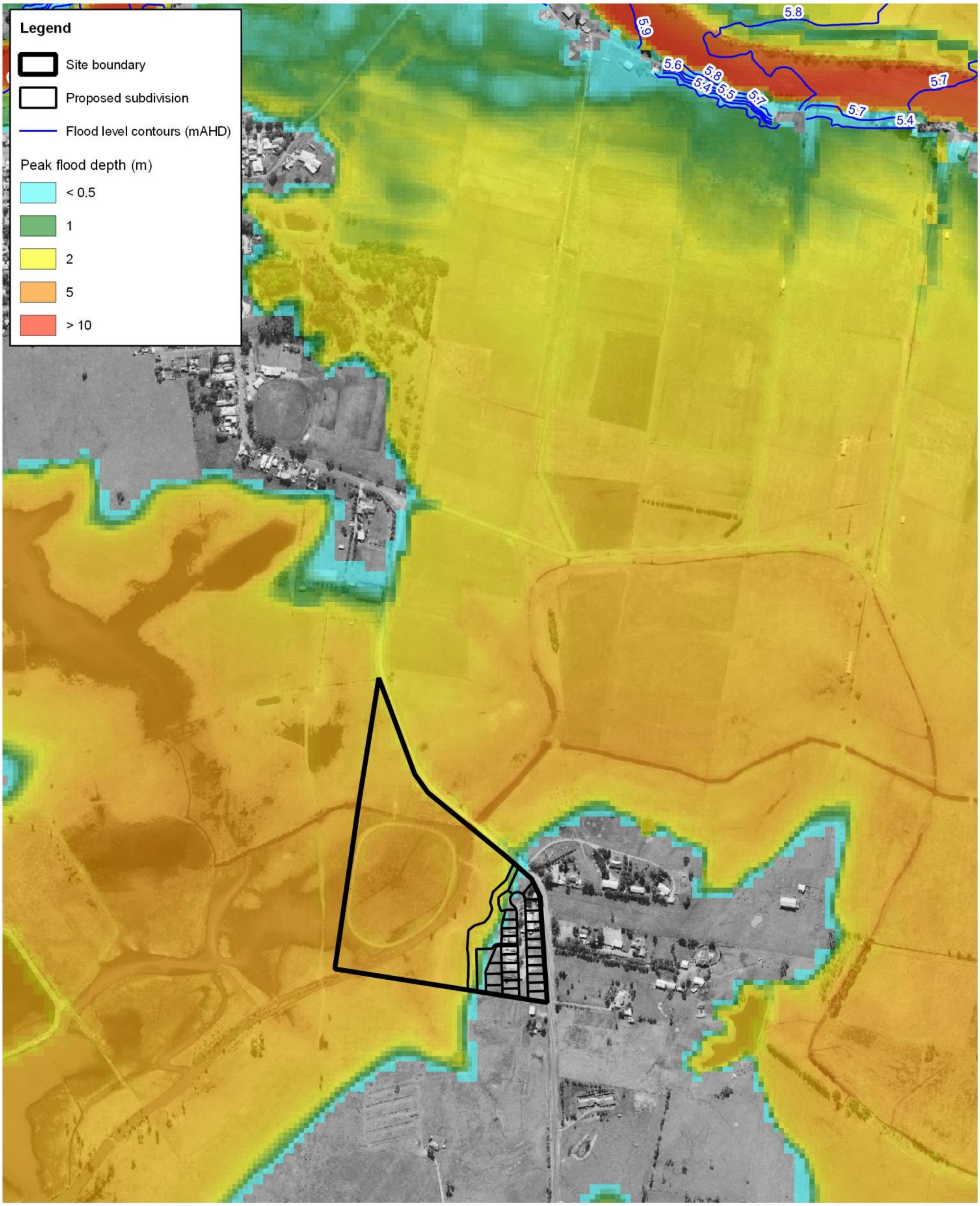

Title:

Modelled 5% AEP Flood Depths and Levels

0 200 400 m

approx. scale

Figure: 5

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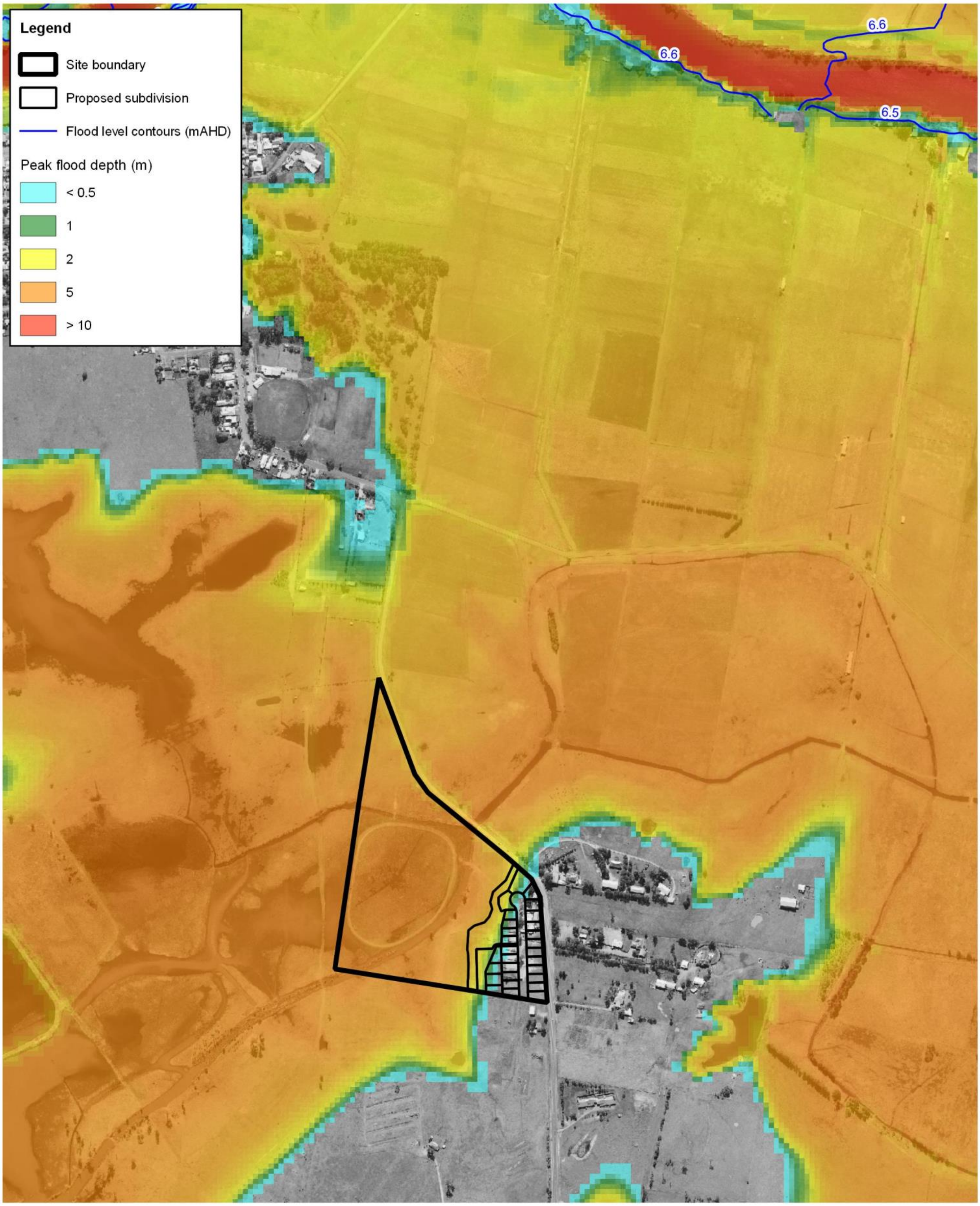

Title:

Modelled 1% AEP Flood Depths and Levels

Figure: **6**

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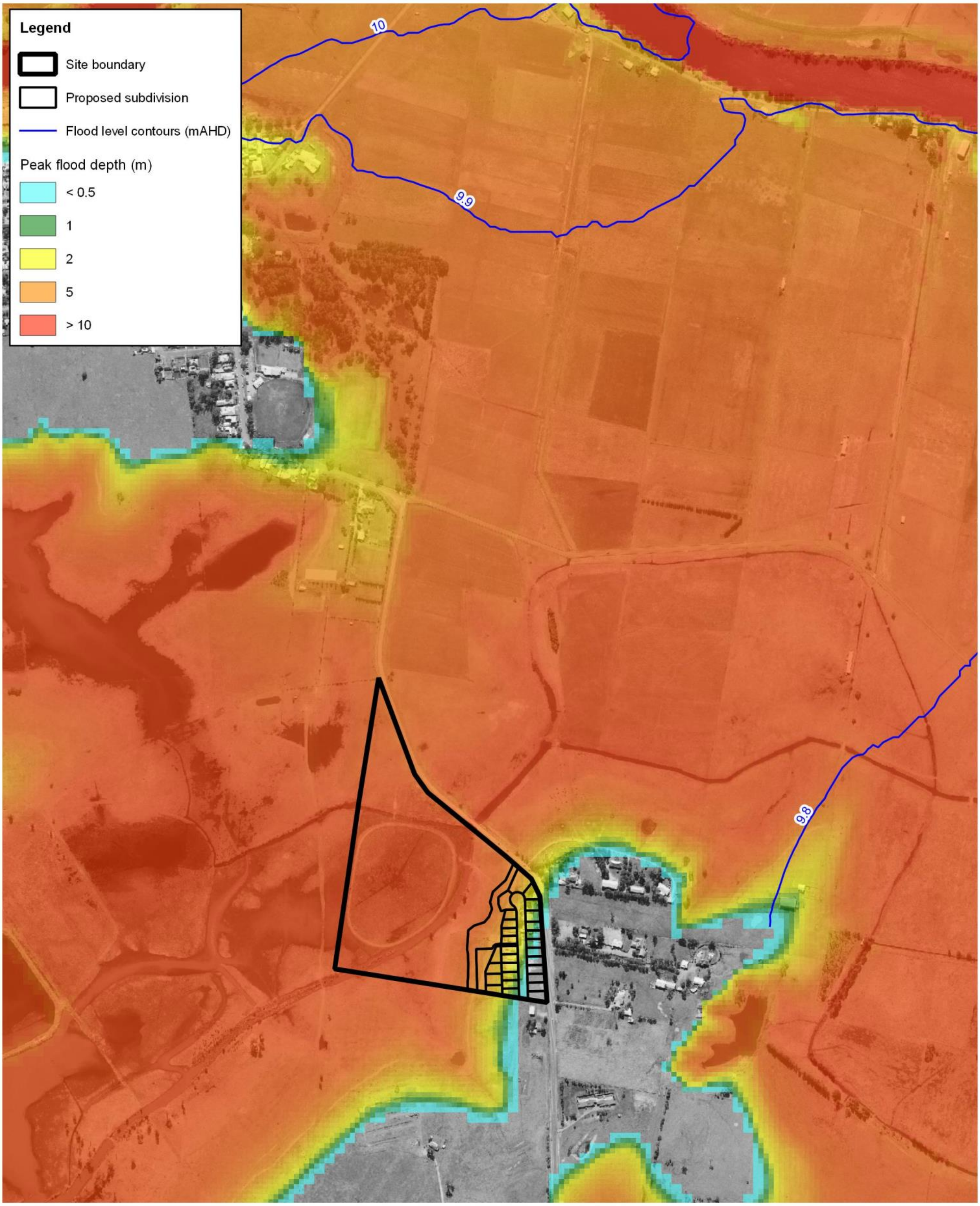

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Modelled Extreme Flood Depths and Levels

0 200 400 m

approx. scale

Figure: 7

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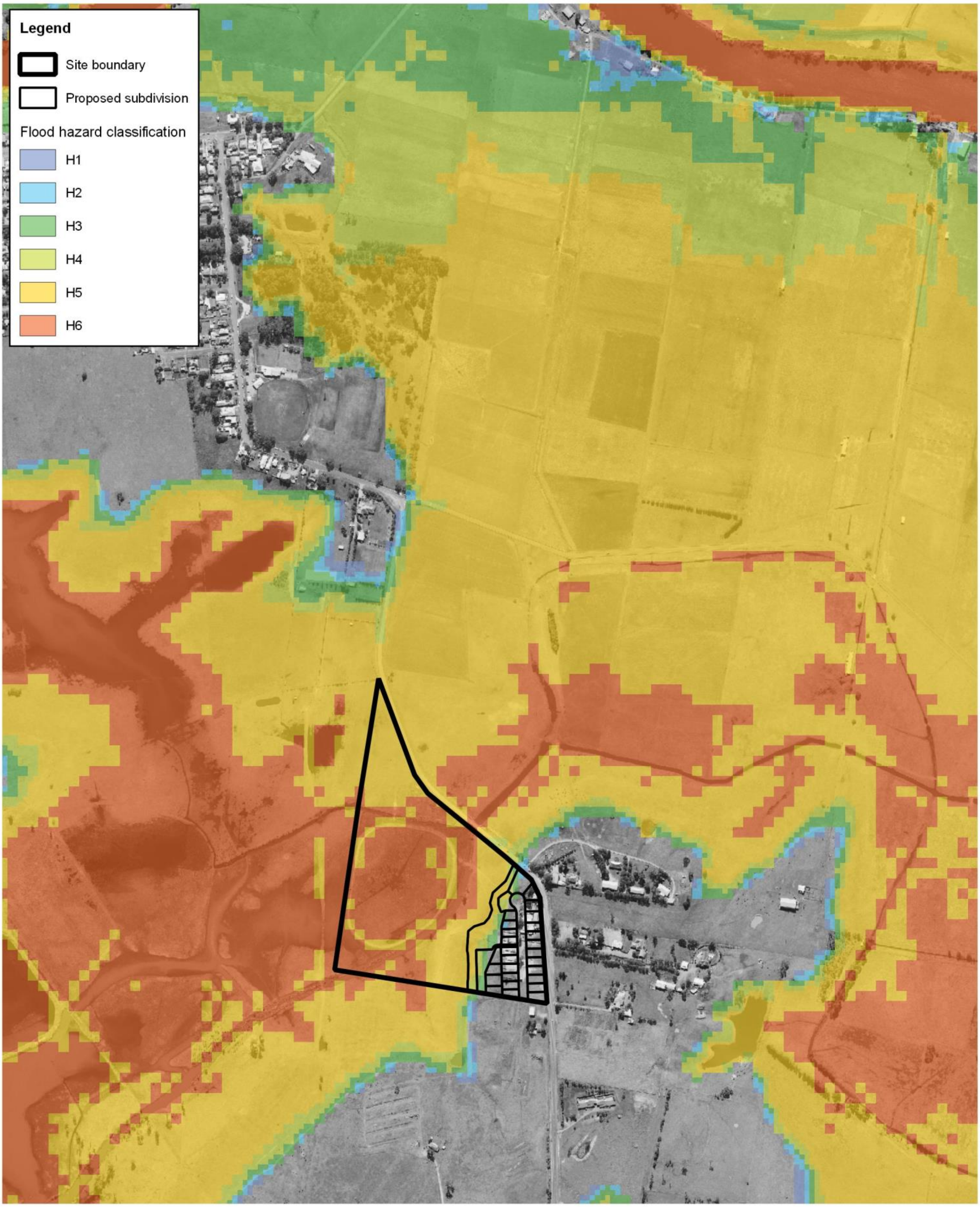

Title:

5% AEP Flood Hazard Classification

Figure: **8**

Revision: **A**

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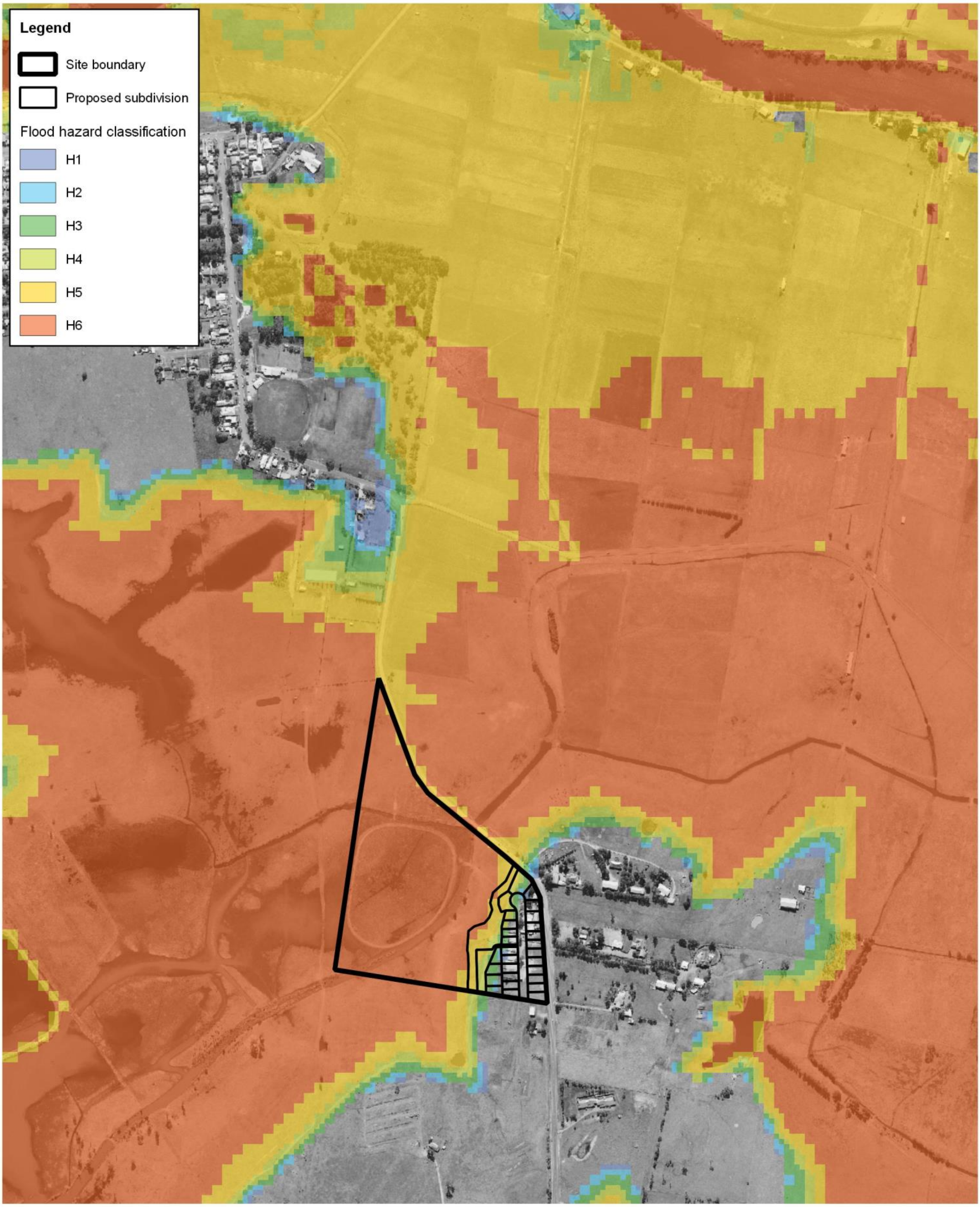

Title:

1% AEP Flood Hazard Classification

0 200 400 m

approx. scale

Figure: 9

Revision: A

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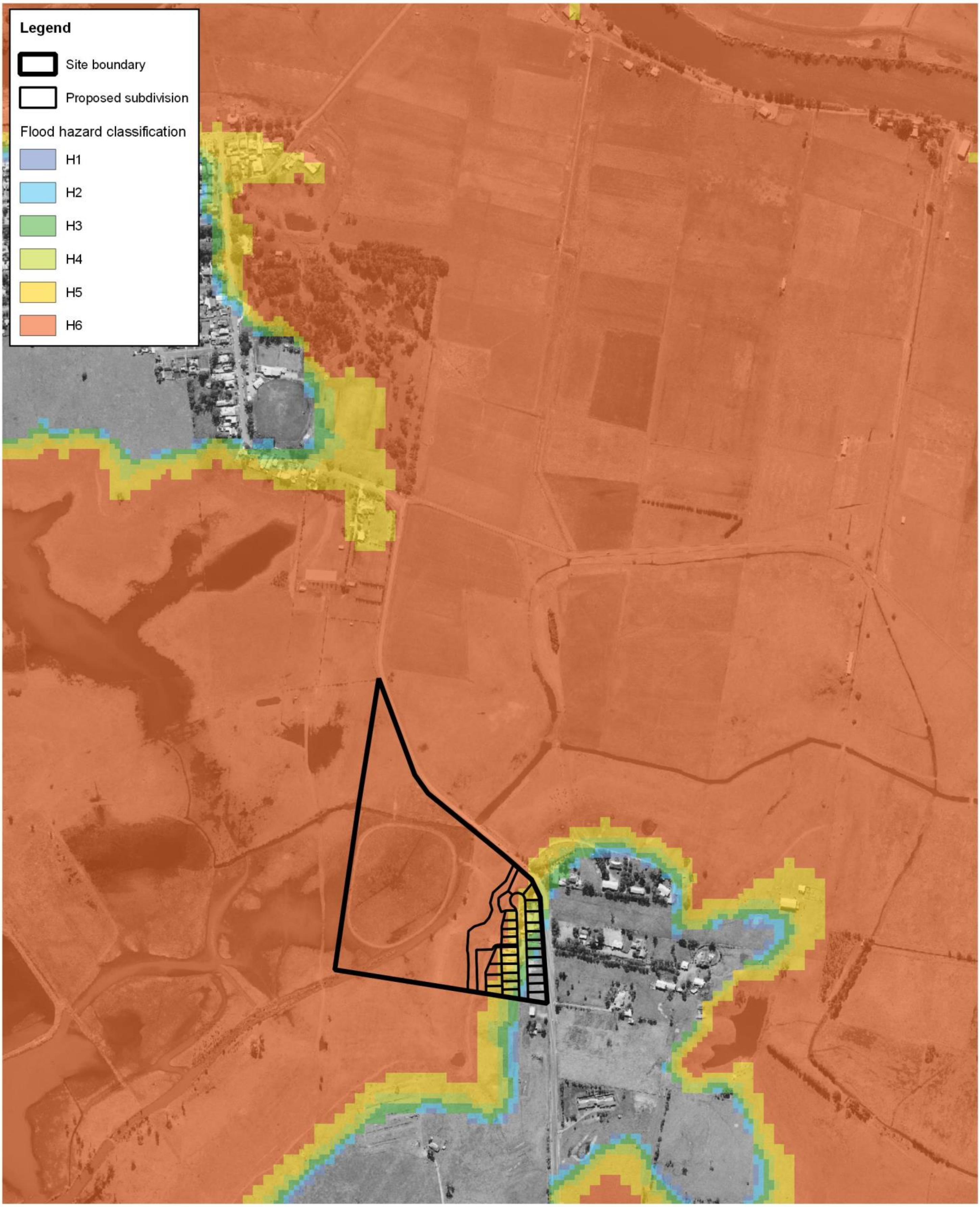

Title:

Extreme Flood Hazard Classification

0 200 400 m

approx. scale

Figure: **10**

Revision: **A**

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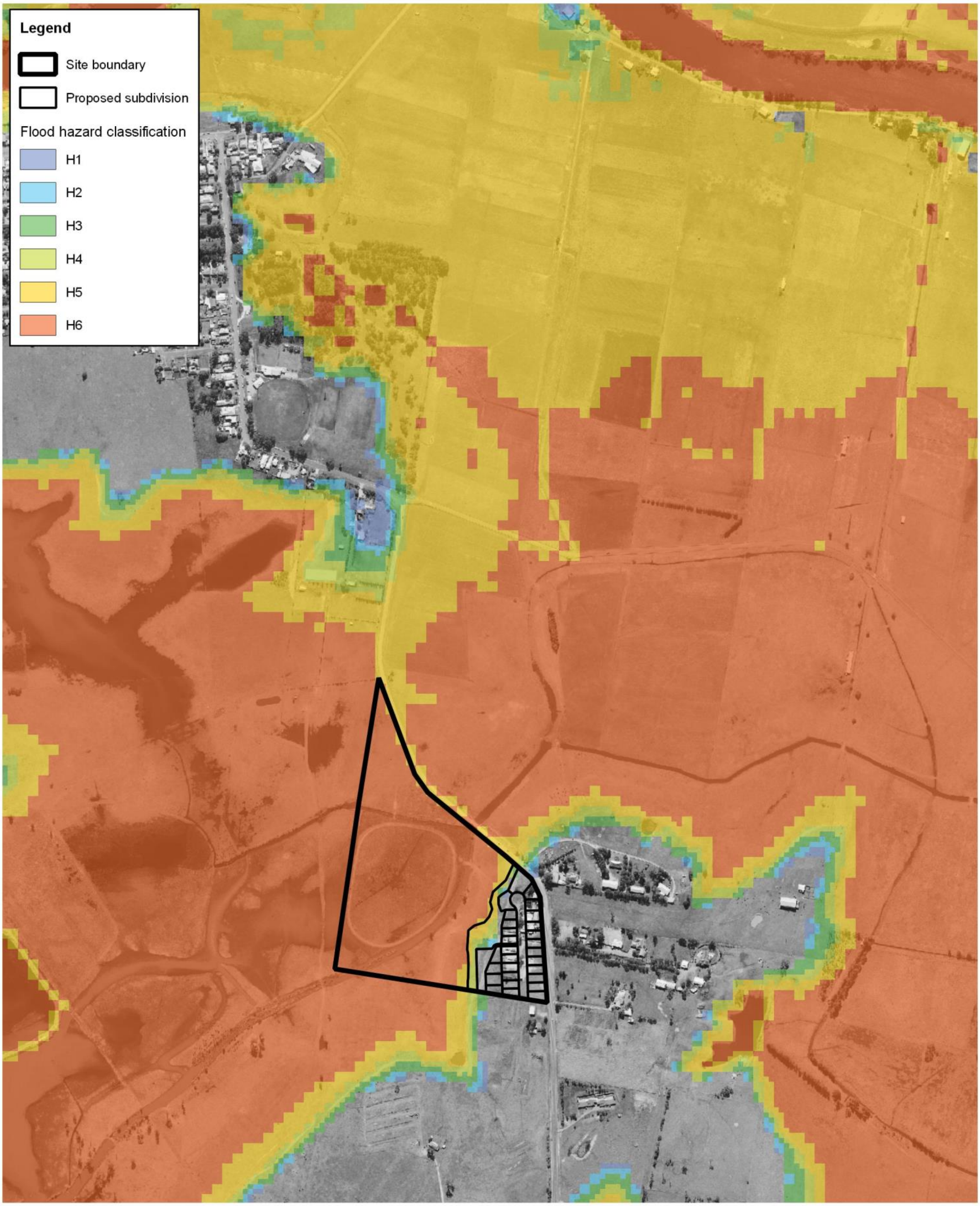

Title:

1% AEP Flood Hazard Classification
Post-development Conditions

0 200 400 m

approx. scale

Figure: **11**

Revision: **A**

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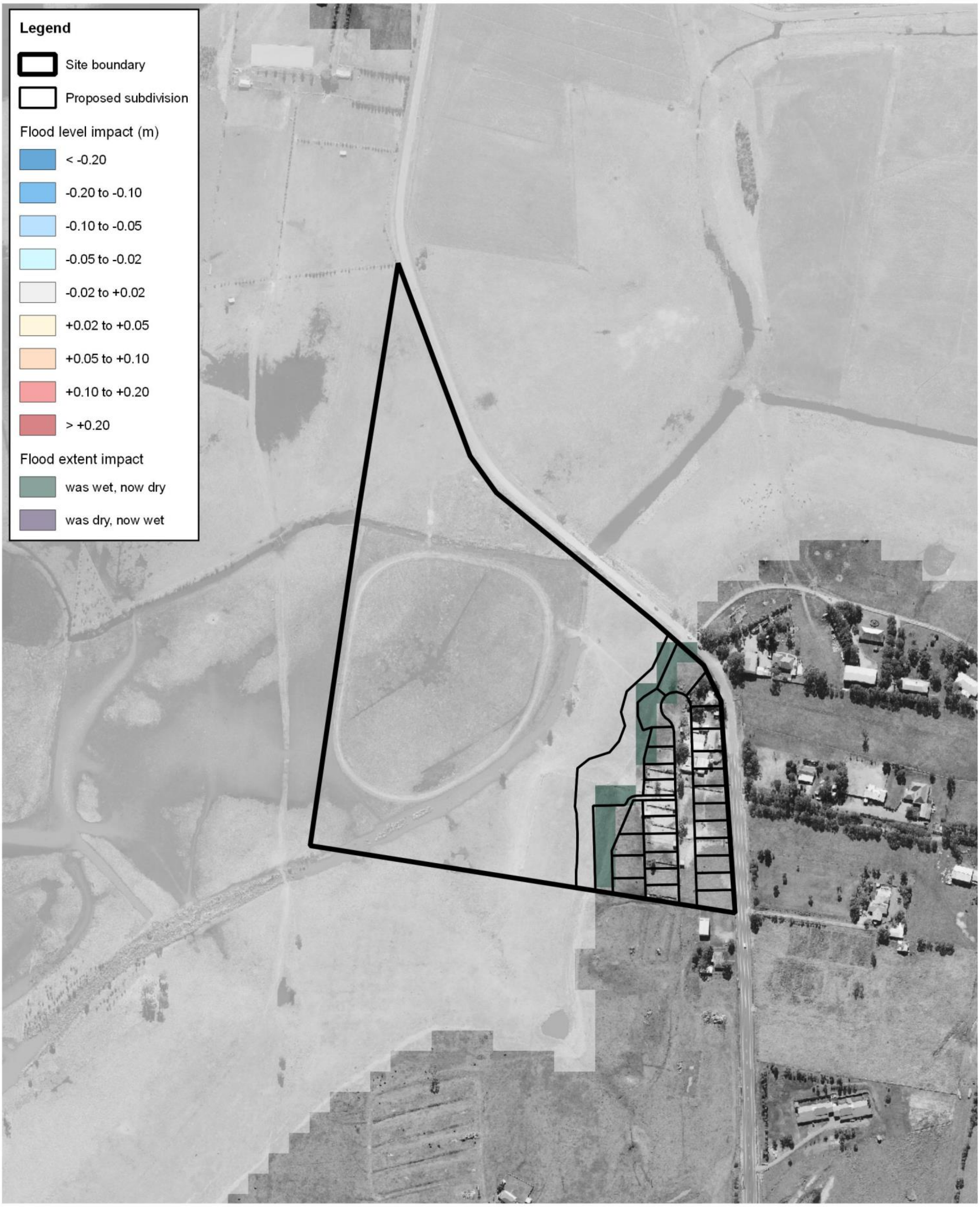

Title:

Modelled 5% AEP Peak Flood Level Impact

Figure: **12**

Revision: **A**

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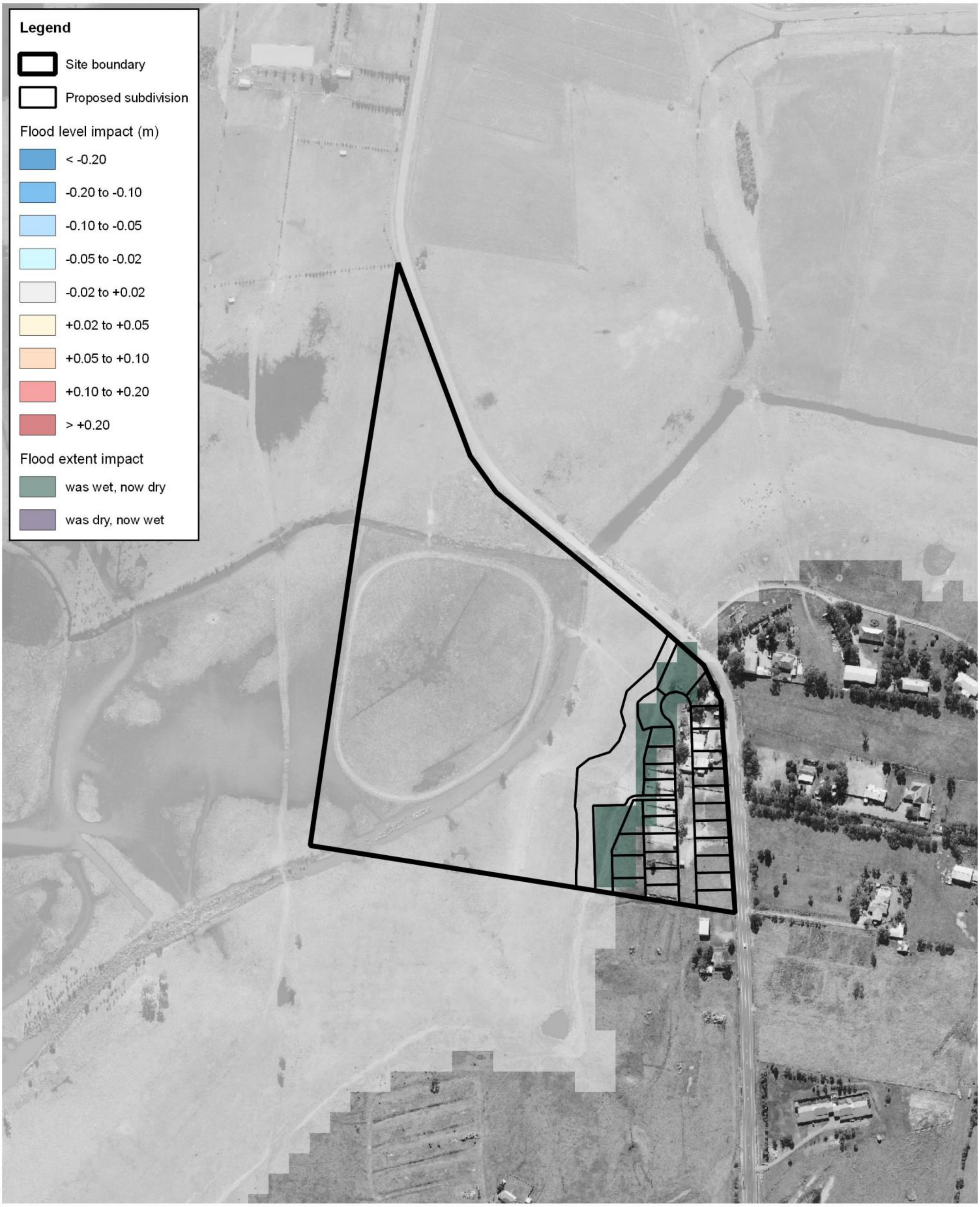

Title:

Modelled 1% AEP Peak Flood Level Impact

Figure: **13**

Revision: **A**

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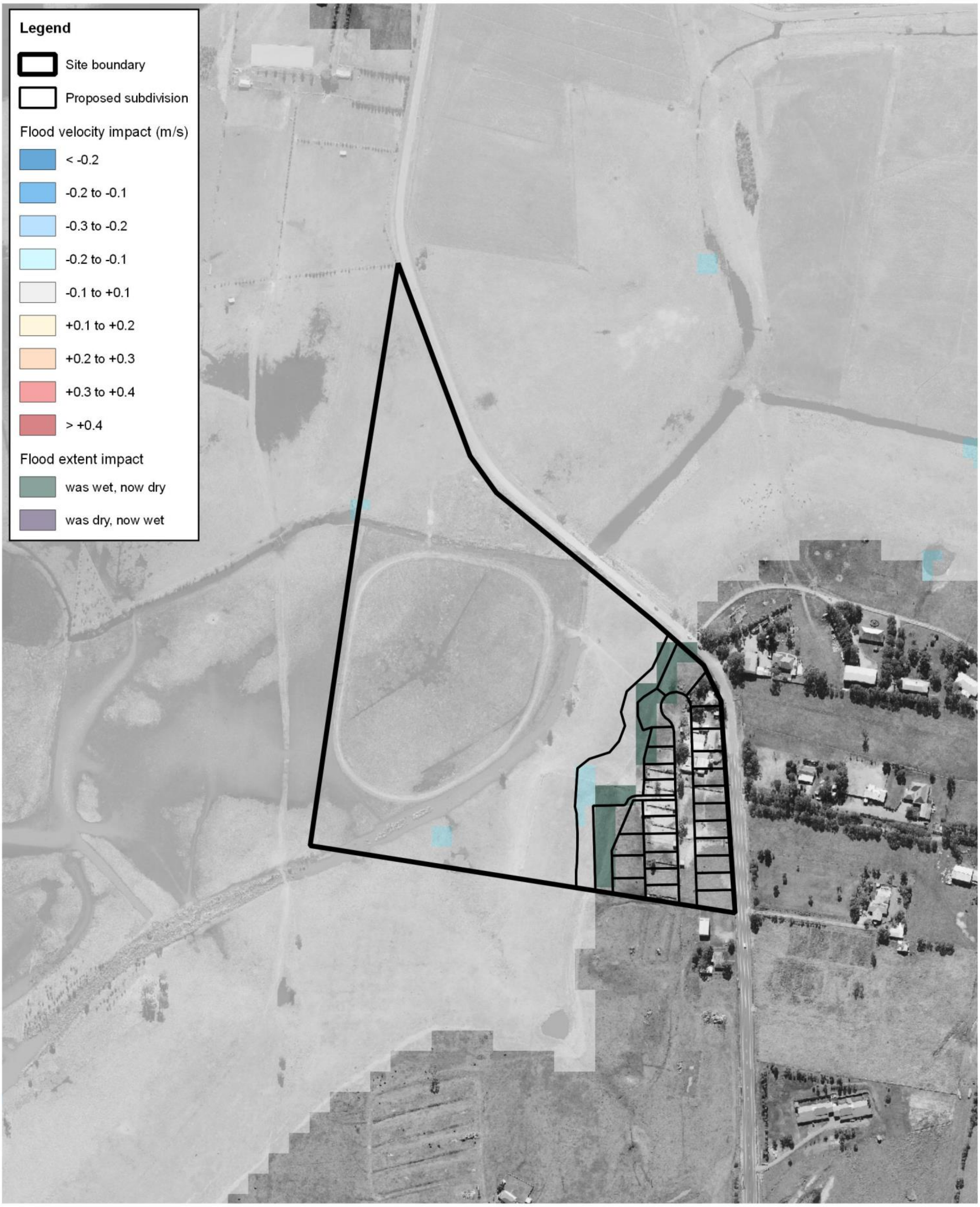

Title:

Modelled 5% AEP Peak Flood Velocity Impact

0 100 200 m

approx. scale

Figure:	14
Revision:	A

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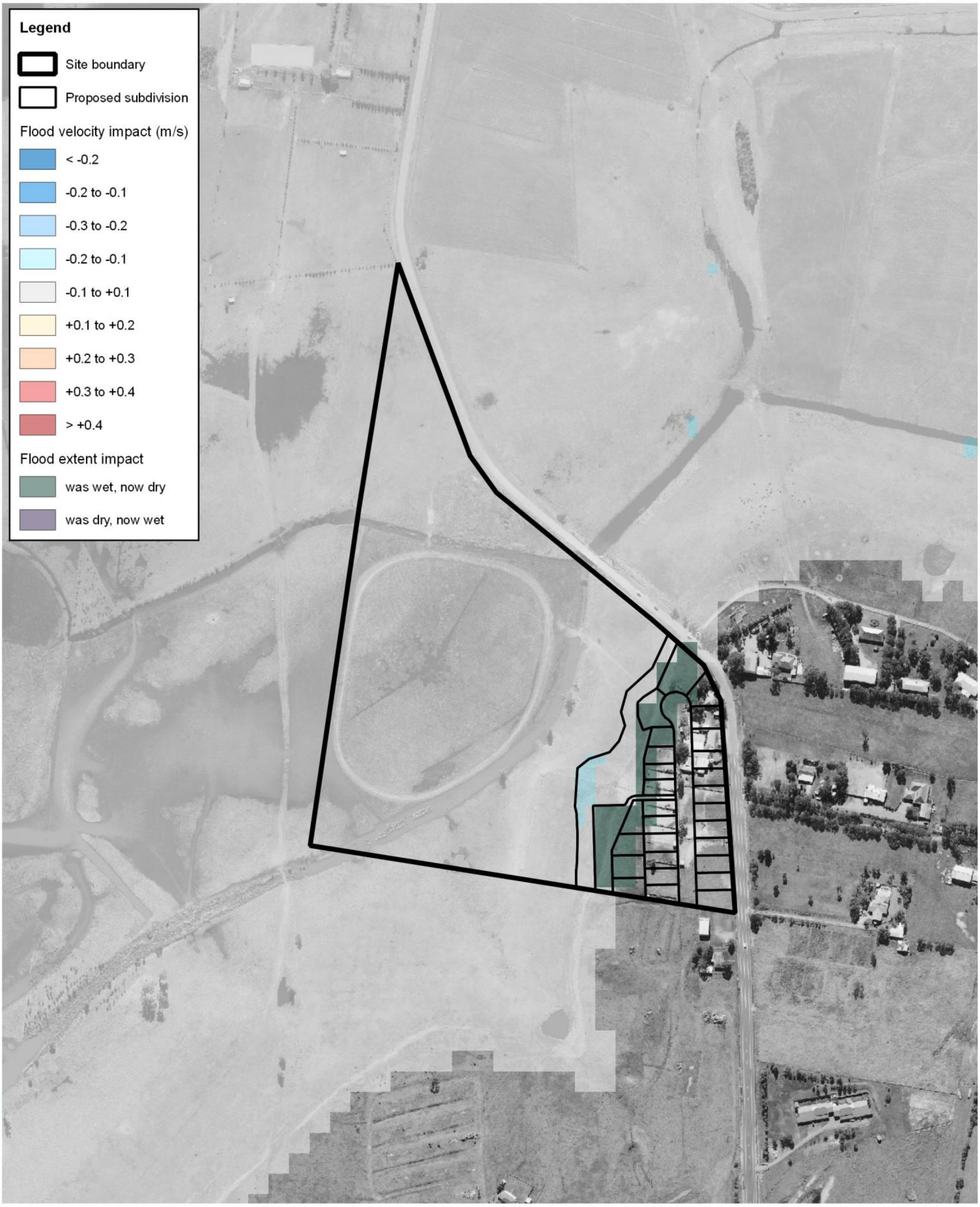

Title:

Modelled 1% AEP Peak Flood Velocity Impact

0 100 200 m

approx. scale

Figure: 15

Revision: A

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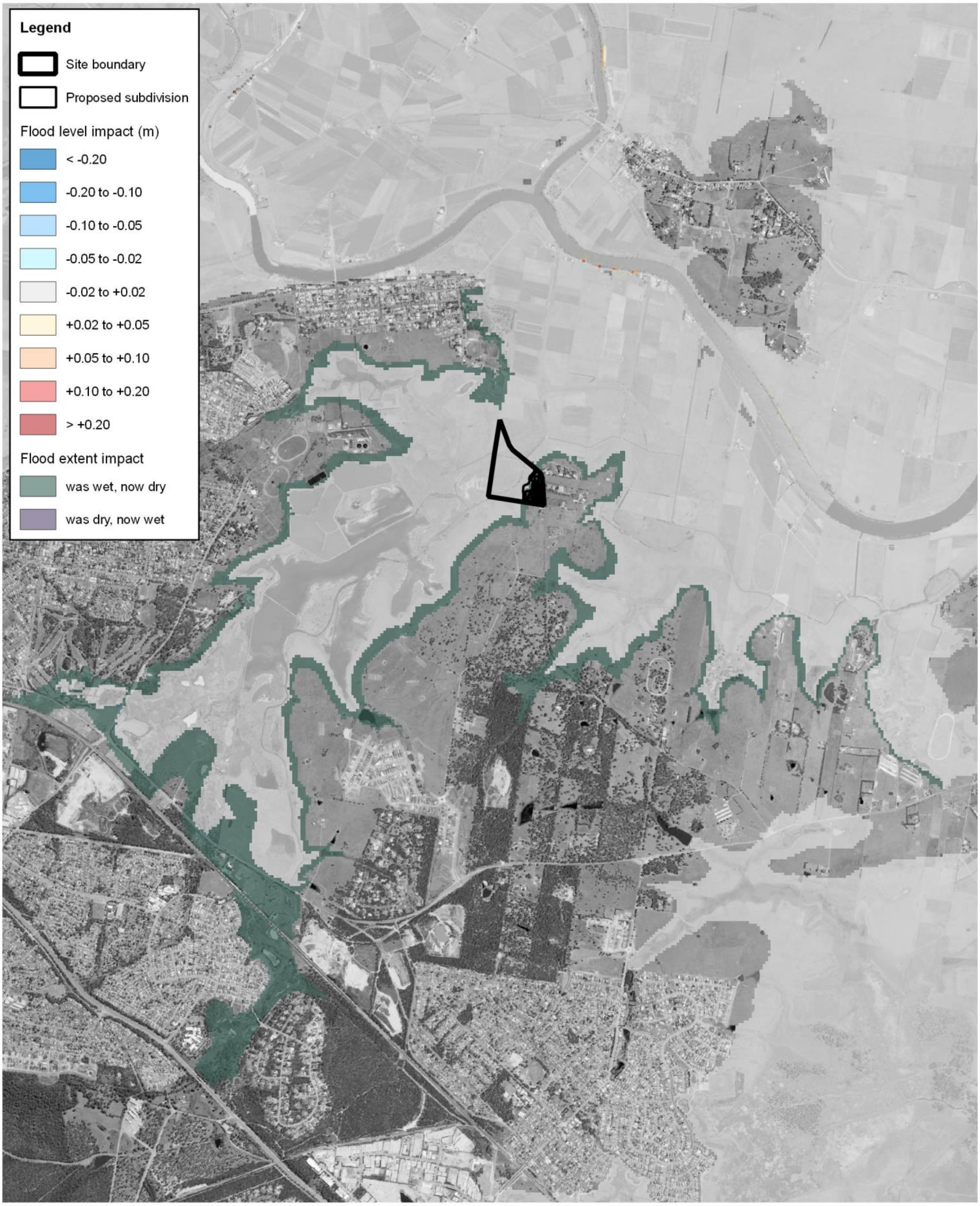

Title:

Modelled 1% AEP Peak Flood Level Impact
Cumulative Impact of Floodplain Fill

Figure: **16**

Revision: **A**

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