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Our Ref: DJW: L.T2139.003.docx

11 March 2022
Catholic Diocese Maitland Newcastle
c/o SHAC
224 Maitland Road
Islington NSW 2296
Attention: Jessica Maher

Dear Jessica

RE: FLOOD IMPACT ASSESSMENT FOR PROPOSED MULTI PURPOSE CENTRE AT 20-24 HUNTER STREET, HORSESHOE BEND NSW

Background

Torrent Consulting was engaged to undertake a Flood Impact Assessment to assist in the DA process for the proposed Multi-Purpose Centre for the All Saints College at 20-24 Hunter Street, Horseshoe Bend, NSW (the Site). It is understood that a flood report is required by Maitland Council, as per the requirements of the Maitland DCP.

The Site is located on the right floodplain of the Hunter River, some 250 m south of the levee bank, as presented in Figure 1. Design flood information is contained within the Hunter River Branxton to Green Rocks Flood Study (WMA Water, 2010) and the Hunter River Floodplain Risk Management Study and Plan (WMA Water, 2015). Information within these studies will be used to inform the assessment.

The local floodplain topography is presented in Figure 2. Upstream of Oakhampton the Hunter River floodplain is relatively confined locally to the river channel. At Maitland the valley opens into a broad flat floodplain. The urban areas of Maitland and the neighbouring suburbs are situated on alluvial deposits that have formed over thousands of years of fluvial flooding. The levee embankments of the Hunter Valley Flood Mitigation Scheme, constructed following the 1955 flood, are also evident.

A TUFLOW model of the Hunter, Williams and Paterson Rivers has been developed by Torrent Consulting. The model has been calibrated against the 2007 and 2015 flood events and produces design flood results that are relatively consistent with those of the Williamtown – Salt Ash Floodplain Risk Management Study & Plan (BMT WBM, 2017) and the Hunter River Branxton to Green Rocks Flood Study (WMA Water, 2010). The TUFLOW model has a horizontal grid cell resolution of 20 m and enables a detailed understanding of the local flood velocities and hazards for floodplain risk management requirements. The model has been updated with details of the existing mound at the Site.

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.

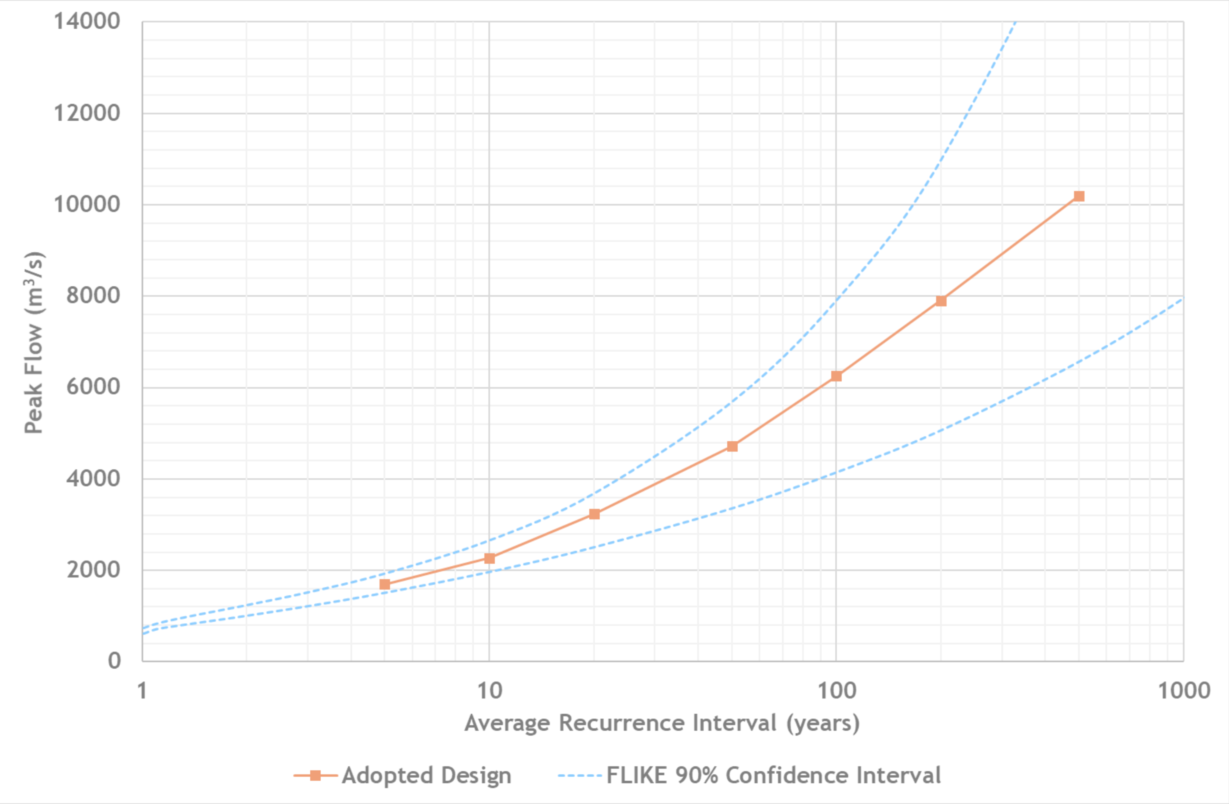


Chart 1 – Adopted Design Flood Flows at Raymond Terrace

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

For the purposes of this impact assessment the TUFLOW model was locally refined around the Site. Significant floodplain flows can occur along the Hight Street and through the Site during rare flood events, whilst the available floodplain storage is filling. Because of potential localised impacts to the flood flow and velocity distribution and the requirement to better represent flow between buildings, the model resolution was locally increased to 5 m.

The TUFLOW QPC quad-tree functionality was enabled, which allows an efficient transition between model grid cells of varying resolution. An area of some 13 ha covering Maitland Street, the Site and the adjacent buildings was assigned a model grid cell resolution of 5 m. TUFLOW then transitions the surrounding model cells to a 10 m resolution then back to the 20 m resolution throughout the broader model. This enables a more accurate representation of potential localised changes in the flood velocity distribution that the proposed development might have on local flooding.

Flood Modelling and Mapping

The design flood conditions at the Site are somewhat different between the model used for this assessment and the Hunter River Branxton to Green Rocks Flood Study adopted by Council. Whilst modelled flood flows and levels are similar within the Hunter River channel, the modelled flood depths within the large floodplain storages are around 1 m higher than those adopted by Council. The differences relate to both the simulated flood volumes and the adopted downstream model boundary in the Hunter River Branxton to Green Rocks Flood Study. Nevertheless, the range of flood levels simulated across the design flood events is similar and provides a suitable basis to undertake a relative flood impact assessment. However, the flood levels adopted by Council should still be used for flood planning purposes.

The TUFLOW model was simulated (using the HPC solver) for the 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 extents for the 5% AEP, 1% AEP and Extreme events are presented in Figure 4, together with the Site boundary. Figure 5 and Figure 6 present the flood hazard classification at the Site for the 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.

Flood Risk Management

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 5 presents the flood hazard classification at the Site for the 1% AEP event.

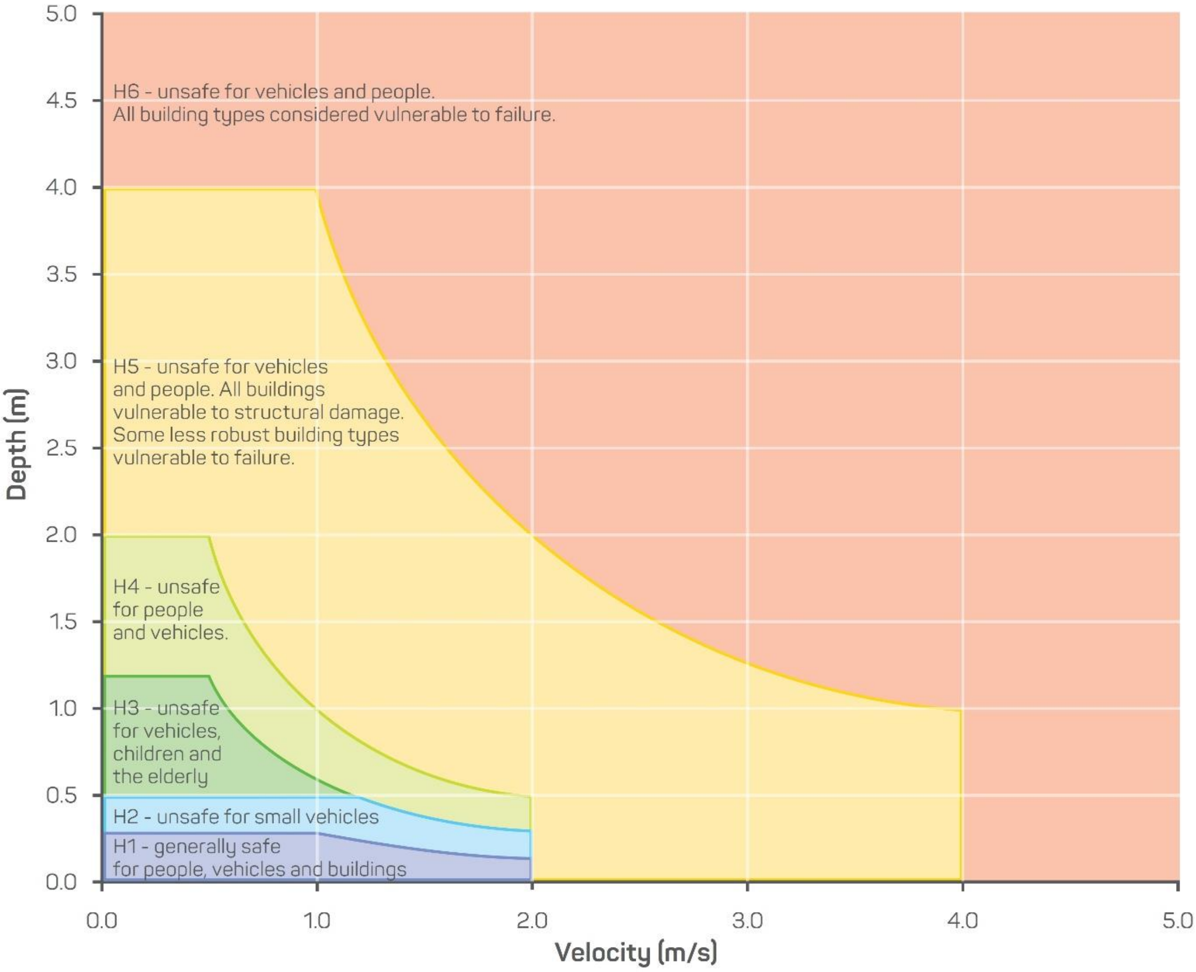


Chart 2 – General Flood Hazard Vulnerability Curves (AIDR, 2017)

The flood hazard mapping presented in Figure 5 shows that most of the Site is a high hazard (H5 and H6) area. The flood hazard is principally depth-driven, as flood velocities are typically low (< 1 m/s). Localised velocities can be higher, such as between buildings. However, these velocities occur prior to the peak of the flood event, whilst the floodplain storage is filling and would only be sustained for a few hours. The peak flood conditions are tailwater dominated, with lower velocities.

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 proposed design drawings, the ground floor level has an FFL of 9.72 m AHD. This is consistent with the 1% AEP flood level adopted by Council, as per the pre-lodgement meeting minutes dated 22 April 2021. This provides an FPL of 10.22 m AHD (the 1% AEP flood level plus a 0.5 m freeboard).

The standard development controls within Part B3 of the Maitland DCP state that an application for development below the FPL must demonstrate:

- the proposed development will not increase the flood hazard or flood damage or adversely increase flood affectation on other properties, as assessed by a suitably qualified hydraulic engineer;

- the design of the proposed development is such that the risks of structural failure or damage in the event of flooding (including damage to other property) up to the FPL would be minimal, as assessed by a suitably qualified structural engineer;
- the proposed development has been designed to withstand the effects of inundation of floodwaters up to the FPL, with contents or fittings susceptible to flood damage being located above this level;
- if levees are proposed to protect a development, the impact of the levees on flood behaviour must be assessed and the habitable floor level of the proposed development behind the levee must still be set at or above the FPL (assuming no levee is in place);
- the proposed measures to allow the timely, orderly and safe evacuation of people from the site (these measures should be permanent and maintenance free), and the measures proposed to safeguard goods, material, plant and equipment in a flood. These measures should be compatible with the Maitland City Local Flood Plan;
- in rural areas, the proposals for the evacuation of any livestock in a flood;
- the measures to reduce the risks that the development will allow the accumulation and build-up of debris being carried by floodwaters (particularly associated with fences in flood liable areas);
- the design complies with the Table 1: Flood Aware Design Requirements for Residential Development on Flood Prone Land; and
- Details of any proposed filling to be provided.

The general building requirements of the Maitland DCP are that:

- All habitable finished floors are to be no lower than the FPL (Flood Planning Level).
- Parts of buildings and structures at or below the FPL shall be constructed in accordance with the Flood Aware Design Requirements for Residential Development on Flood Prone Land
- 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
- Sufficient storage space for household effects shall be provided above the FPL
- Electrical fixtures such as light fittings and switches shall be sited above the FPL unless they are on a separate circuit (with earth leakage protection) to the rest of the building

There is some overlap between requirements in the above. However, the relevant requirements applicable to the proposed development are addressed below and are generally concerned with three principles – the management of risk to property from flooding, the management of risk to life from flooding and the assessment of potential adverse impacts to existing property.

With regards to the management of risk to property from flooding, the ground floor of the proposed Multi-purpose Centre is being constructed some 3 m above the sub-floor area, raising the finished floor level of the building to 9.72 m AHD, which is the 1% AEP flood level adopted by Council. As the ground floor of the development does not comprise habitable rooms, the finished floor level is not required to be at the FPL of 10.22 m AHD.

However, the 0.5 m of the ground floor below the FPL and the entire sub-floor storage area needs to be flood-compatible and should be constructed and fitted out in accordance with the Flood Aware Design Requirements. Electrical fixtures such as light fittings and switches should also be sited above the FPL unless they are on a separate circuit (with earth leakage protection) to the rest of the building. Structural

Certification is also required to confirm that the proposed building can withstand the hydraulic forces expected during a flood at the level of the FPL, i.e. 10.22 m AHD.

With regards the management of risk to life from flooding, there is a 24-hour warning time available for the Hunter River at Maitland. The SES respond to flood warnings issued by the BoM and will issue Evacuation Warnings and Evacuation Notices for Maitland accordingly, as per the Maitland Local Flood Plan.

The Hunter River Branxton to Green Rocks Flood Study shows that Maitland and Horseshoe Bend can be evacuated via flood-free access at the 5% AEP event via the High Street and New England Highway to East Maitland and beyond. The proposed development is in a location that is consistent with the provisions of the Maitland Local Flood Plan and the existing risk to life from flooding within Maitland.

There are specific provisions within the Maitland DCP for development within floodways and/or flood storage areas. The 1% AEP hydraulic categorisation mapping in the Hunter River Floodplain Risk Management Study and Plan identifies the Site as being located within a flood storage area. The DCP therefore requires the development to be supported by a flood impact assessment based on fully dynamic computer modelling.

The impact of the proposed development to other properties is addressed within the subsequent Flood Impact Assessment section.

Flood Impact Assessment

In addition to the management of risk to property and risk to life from flooding, any proposed development within a flood flow path should consider the potential for adverse impacts to neighbouring properties. As such, the modelled pre- and post-development conditions have been used to undertake a flood impact assessment. For the post-development scenario, the proposed finished surface levels of the external landscaping and fill were incorporated into the TUFLOW model. The enclosed areas within the sub-floor were also raised above the floodplain to determine any local flood velocity impacts.

The impacts of the proposed development to the modelled peak flood levels are presented in Figure 7, Figure 8 and Figure 9 for the 2% AEP, 1% AEP and 0.5% AEP events respectively. Impacts to the modelled peak flood velocities are presented in Figure 10, Figure 11 and Figure 12.

The flood impact assessment shows that the proposed development does not result in any impacts to the modelled peak flood levels. This is because the peak flood level conditions are predominantly a tailwater driven by downstream hydraulic controls and the volume of water within the floodplain. This produces an almost flat hydraulic gradient at the Site with low velocity conditions. As the loss of potential storage volume of the proposed development is minimal in relation to that available across the floodplain, the modelled impacts are negligible.

The modelled flood velocity impacts indicate an overall reduction in peak flood velocities within the sub-floor area and external landscaped entrance area to the multi-purpose centre and within the adjacent roadway. There is a modelled increase in peak flood velocities to the north of the multi-purpose centre building and adjacent roadway and also to the south of the building. The modelled velocity impacts are a result of a local redistribution of flood flows around the proposed building, reducing the overall available flow width available and hence increasing the velocity between the proposed building and existing neighbouring buildings. This only occurs during the rising limb of a flood hydrograph, with upstream flows travelling through the roads of Maitland and filling the floodplain storage volume in the rural area downstream. This would only last for a period of around a few hours, with velocities reducing as the downstream floodplain fills.

At the modelled 2% AEP flood condition the impact to the peak flood velocities is minimal, with only around a 0.1 m/s increase just to the north-west of the proposed building, with local peak velocities increasing from around 0.7 m/s to around 0.8 m/s. At the modelled 1% AEP flood condition at this same location the peak velocities increase by around 0.2 m/s, locally increasing from around 1.1 m/s to around 1.3 m/s. There is a larger increase in localised velocities modelled along the southern edge of the proposed. At this location the existing peak velocities are only around 0.1-0.2 m/s but increase to around 1.0 m/s.

At the modelled 0.5% AEP flood condition, to the north-west of the proposed development the peak velocities increase by around 0.3 m/s, locally increasing from around 1.3 m/s to around 1.6 m/s. There is a larger increase in localised velocities modelled along the southern edge of the proposed building. At this location the existing peak velocities are only around 0.2 m/s but increase to around 1.3 m/s.

The modelled increase in velocities is to be expected, given the reduction in available flow width and resultant localised redistribution. However, the impact is localised in extent, with most contained within the Site and the duration of peak velocities is also relatively short, as discussed. The principal location of off-site impact is within Hunter Street to the north-west of the Site. Here the modelled peak flood velocities increase by around 0.1 m/s at the 2% AEP event, 0.2 m/s at the 1% AEP event and 0.3 m/s at the 0.5% AEP event. The velocities are generally below 1.5 m/s and so don't present a significant scour risk within the road. The area would also be evacuated in advance of a flood event and so there would also be no adverse impact to the risk to life from flooding.

Conclusion

The Site at All Saints College at 20-24 Hunter Street, Horseshoe Bend, NSW requires a flood assessment to accompany the DA for the proposed development, 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 management of risk to property from flooding requires the proposed development to be constructed and fitted out using flood-compatible materials below the FPL, which is 0.5 m above the proposed level of the ground floor. The building also requires Structural Certification for exposure to hydraulic forces at that level.

The management of risk to life from flooding is consistent with that of the existing area, with the SES evacuating Maitland in advance of a Hunter River flood event.

The flood impact assessment has found that the proposed development has a negligible impact to the modelled peak flood levels, but a minor impact to the peak flood velocities. The modelled increase in velocities is to be expected, given the reduction in available flow width and resultant localised redistribution. However, the impact is localised in extent, with most contained within the Site and the duration of peak velocities is also relatively short.

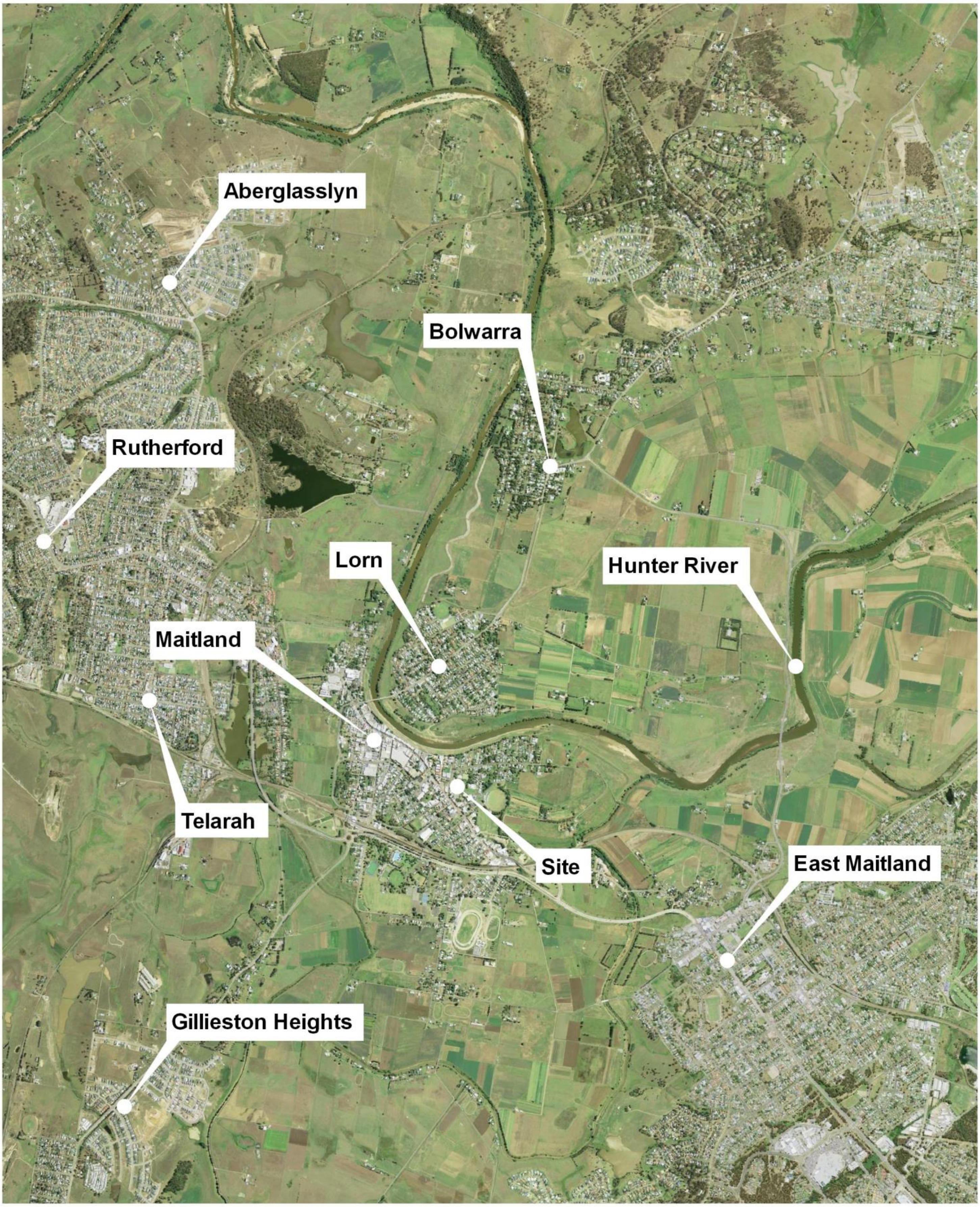
The principal location of off-site impact is within Hunter Street to the north-west of the Site. Here the modelled peak flood velocities increase by around 0.1 m/s at the 2% AEP event, 0.2 m/s at the 1% AEP event and 0.3 m/s at the 0.5% AEP event. The velocities are generally below 1.5 m/s and so don't present a significant scour risk within the road. The area would also be evacuated in advance of a flood event and so there would also be no adverse impact to the risk to life from flooding.

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

Yours faithfully

Torrent Consulting

Dan Williams
Director



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Study Locality

0 1 2 km

approx. scale

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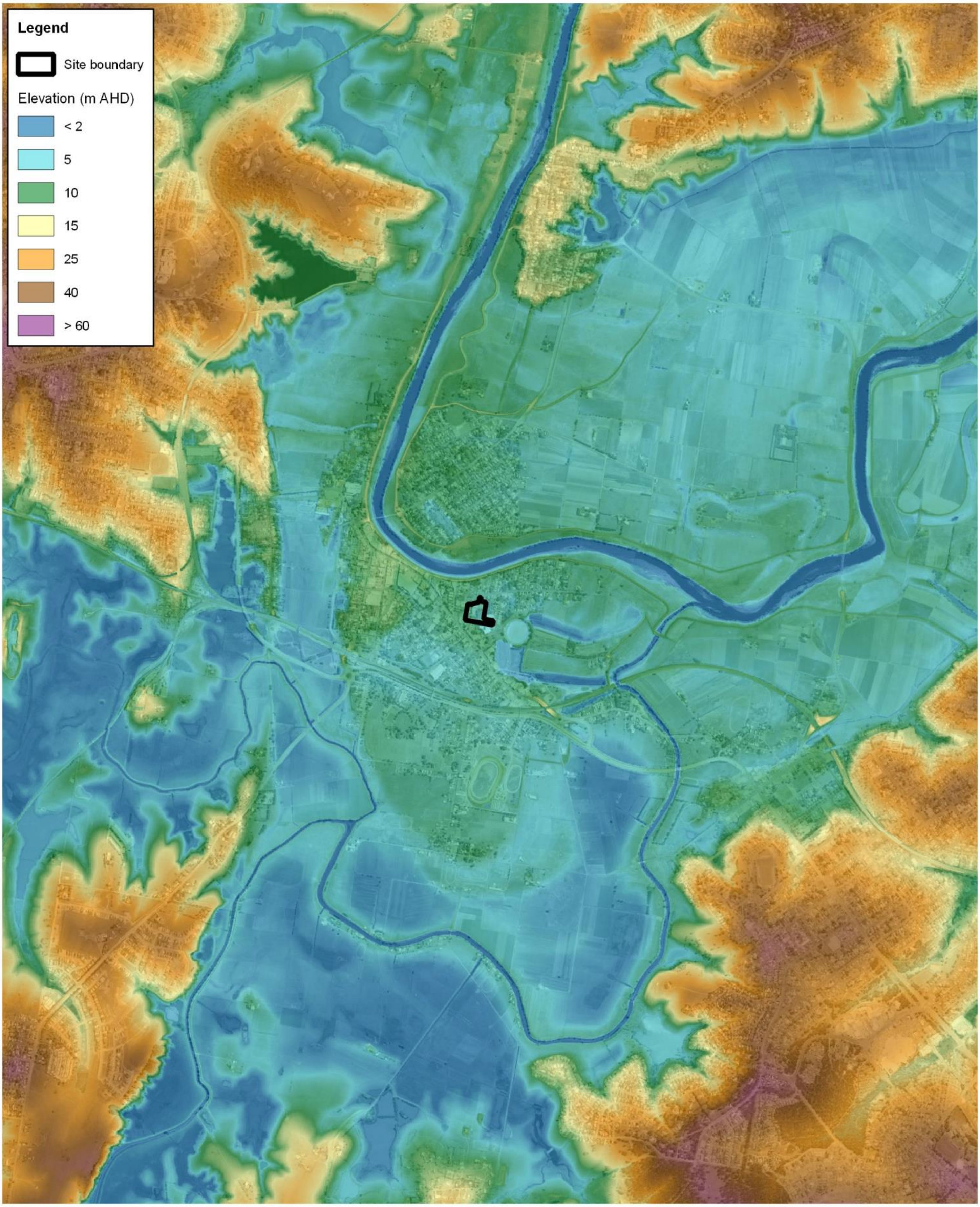

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Local Floodplain Topography

0 0.9 1.8 km

approx. scale

Figure: **2**

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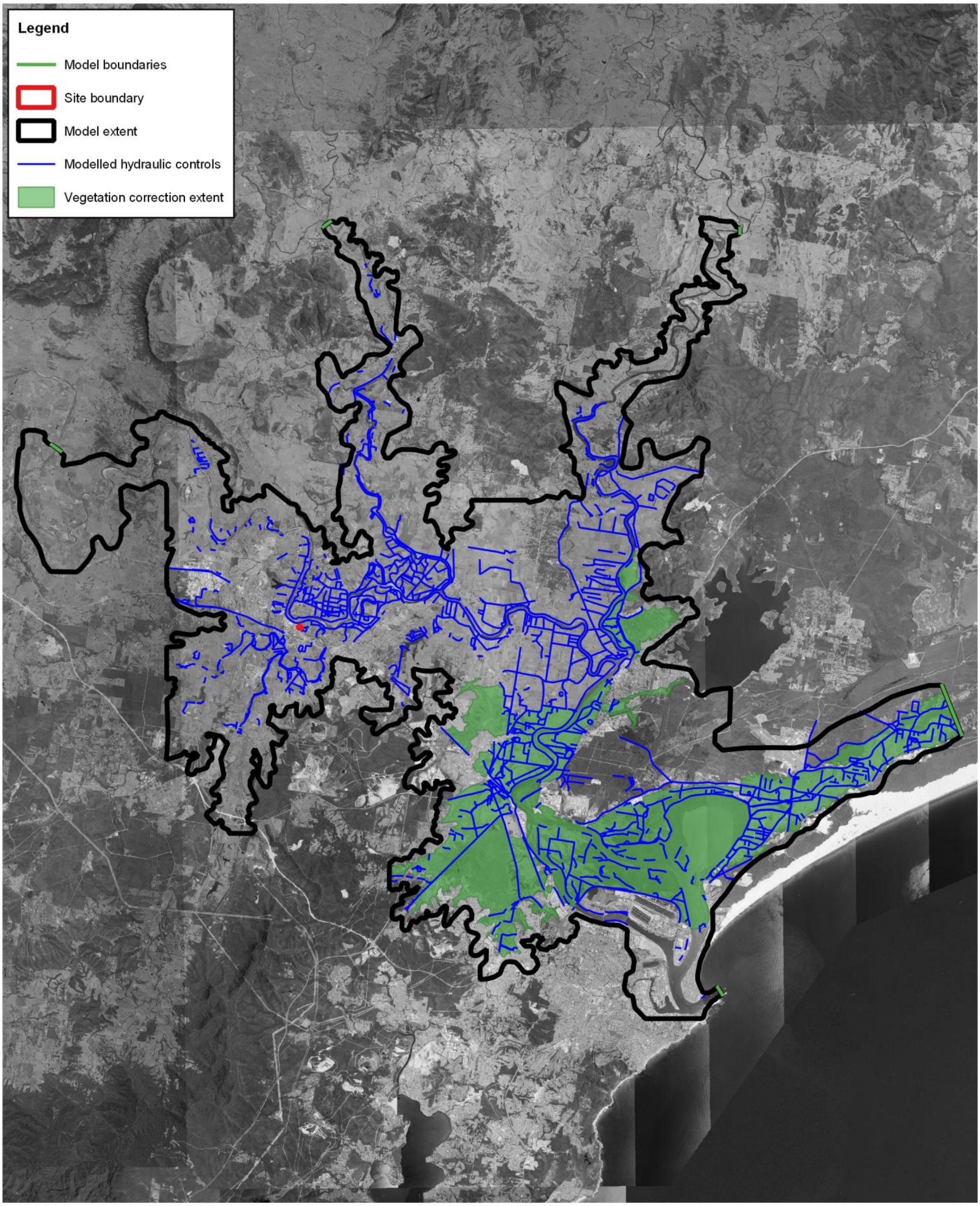

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TUFLOW Model Components

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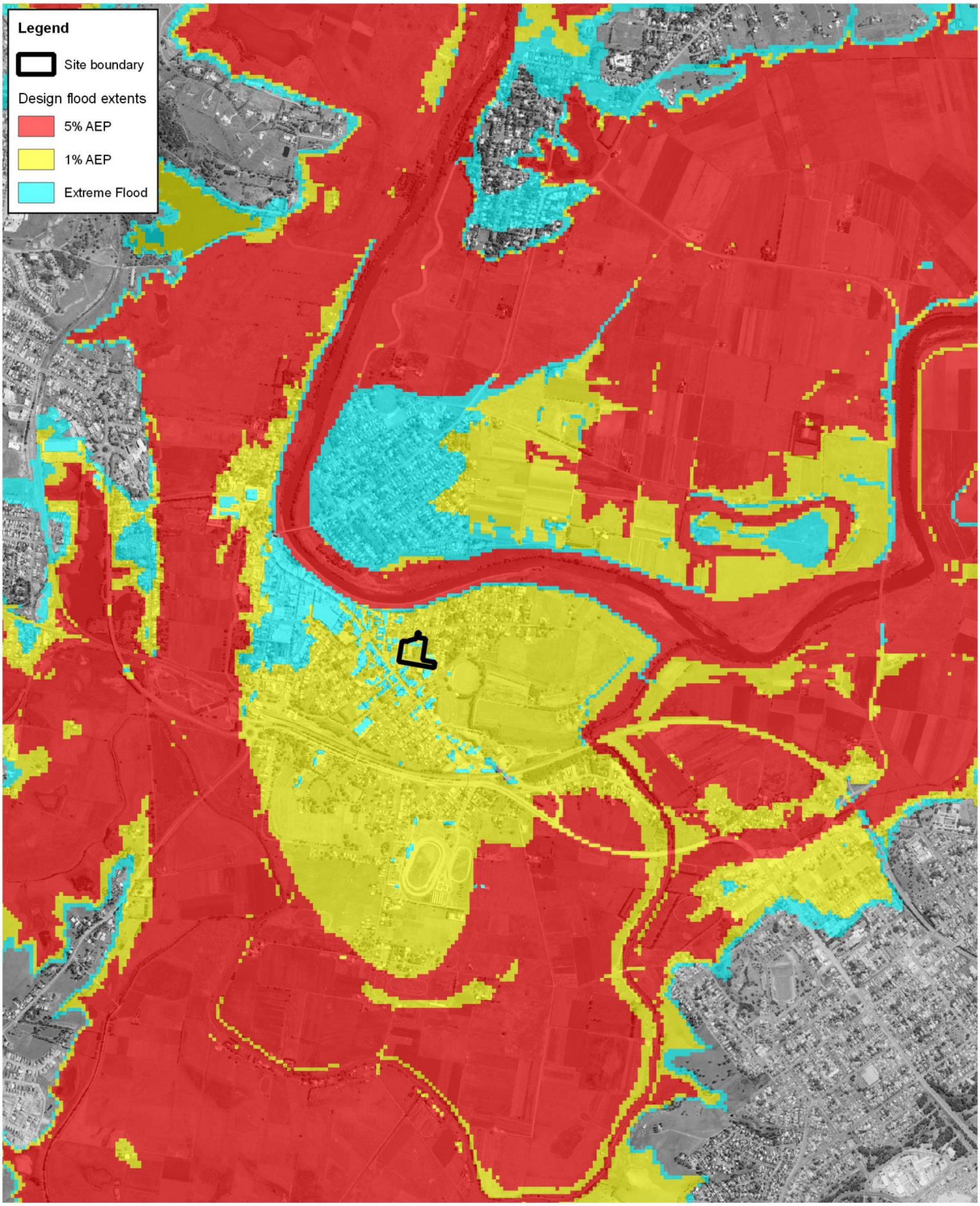

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Design Flood Extents

Figure: **4**

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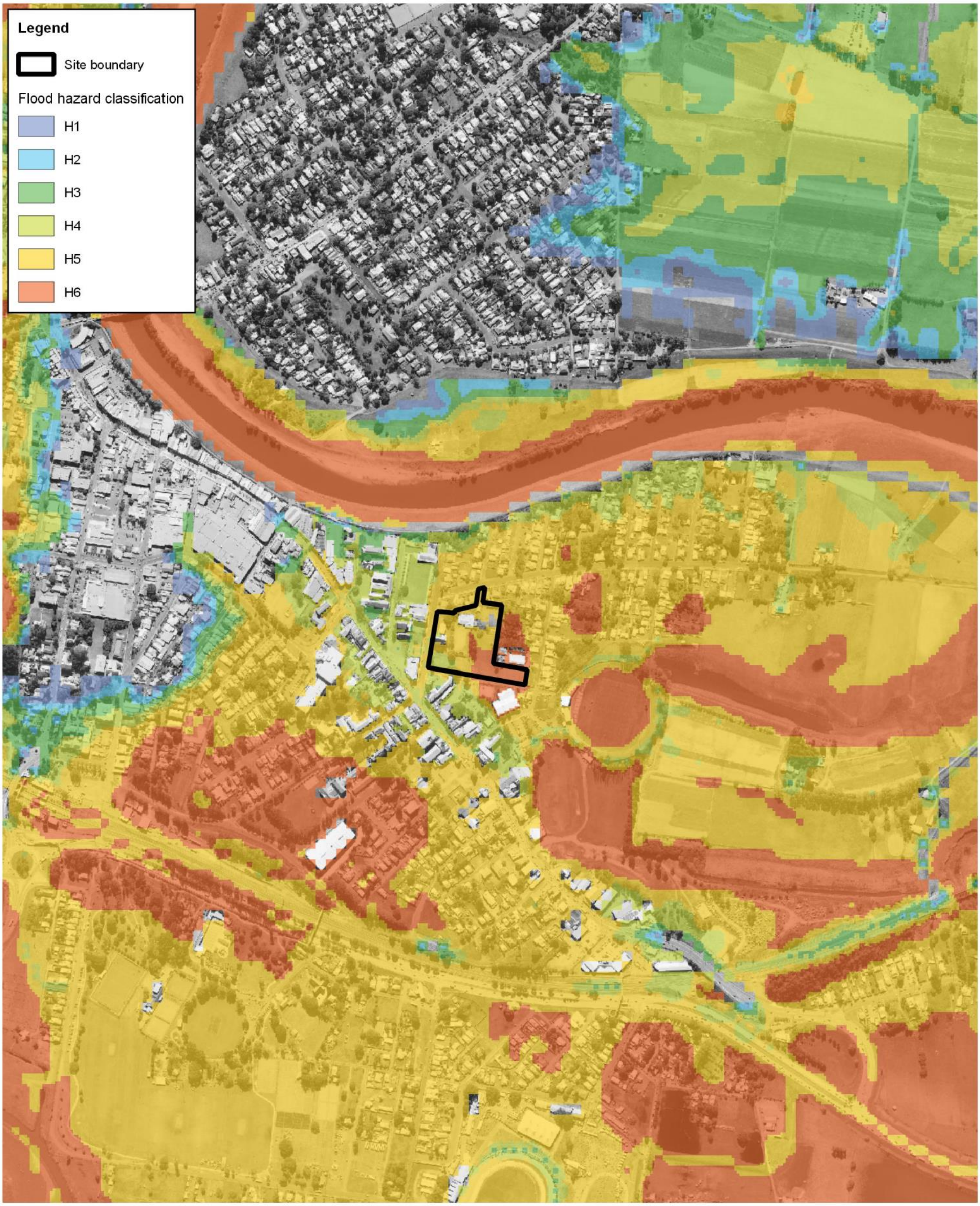

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1% AEP Flood Hazard Classification

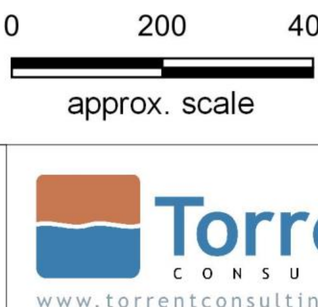

Figure: **5**

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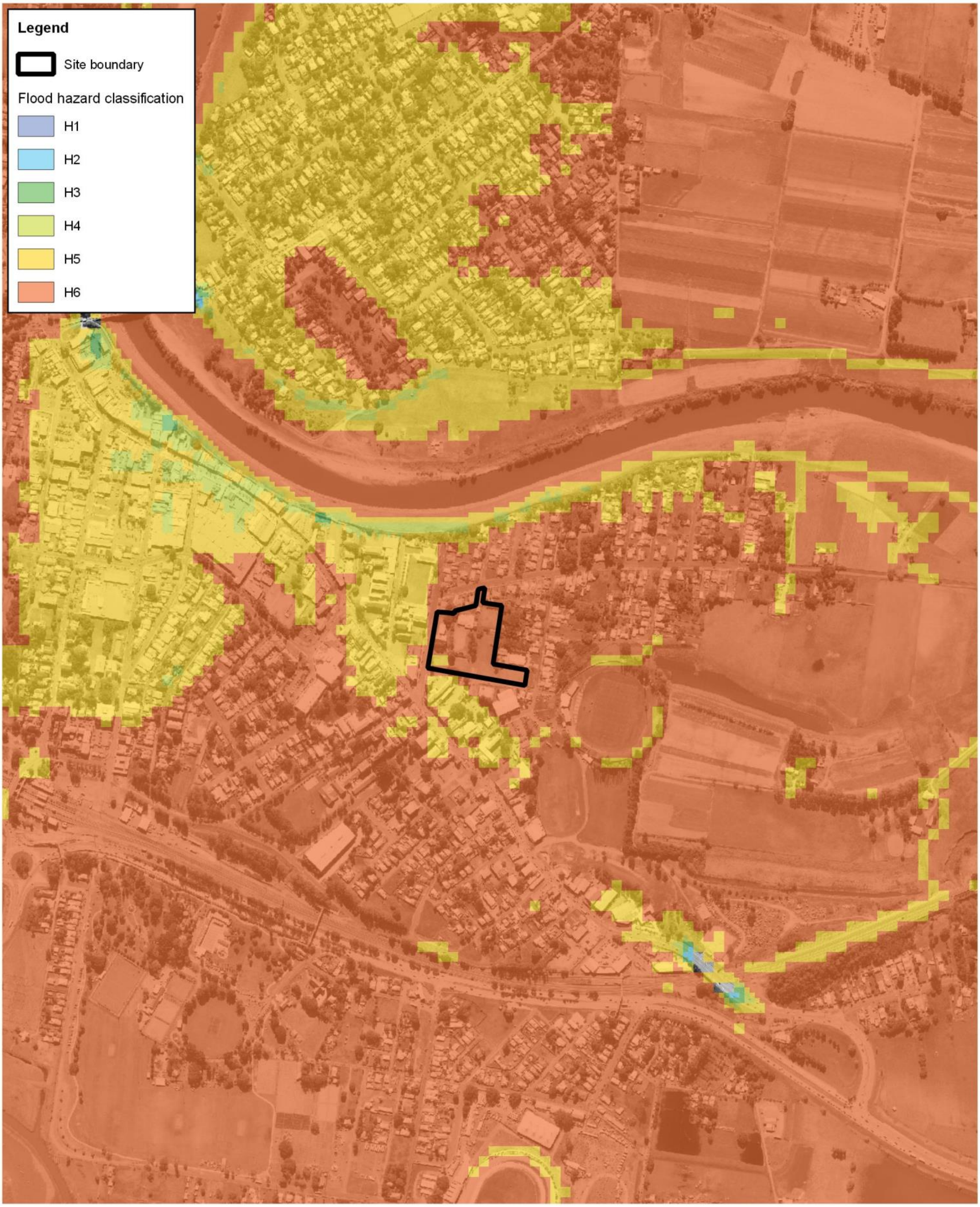

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Extreme Flood Hazard Classification

0 200 400 m
approx. scale

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Modelled 2% AEP Peak Flood Level Impact

0 50 100 m

approx. scale

Figure: 7

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Modelled 1% AEP Peak Flood Level Impact

0 50 100 m

approx. scale

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Filepath: \Projects\T2136_ASC_MPC_FIA\GIS\T2136_008_220307_100y_h_impact.qgz

Title:

Modelled 0.5% AEP Peak Flood Level Impact

0 50 100 m

approx. scale

Figure: **9**

Revision: **A**

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Title:

Modelled 2% AEP Peak Flood Velocity Impact

0 50 100 m

approx. scale

Figure: **10**

Revision: **A**

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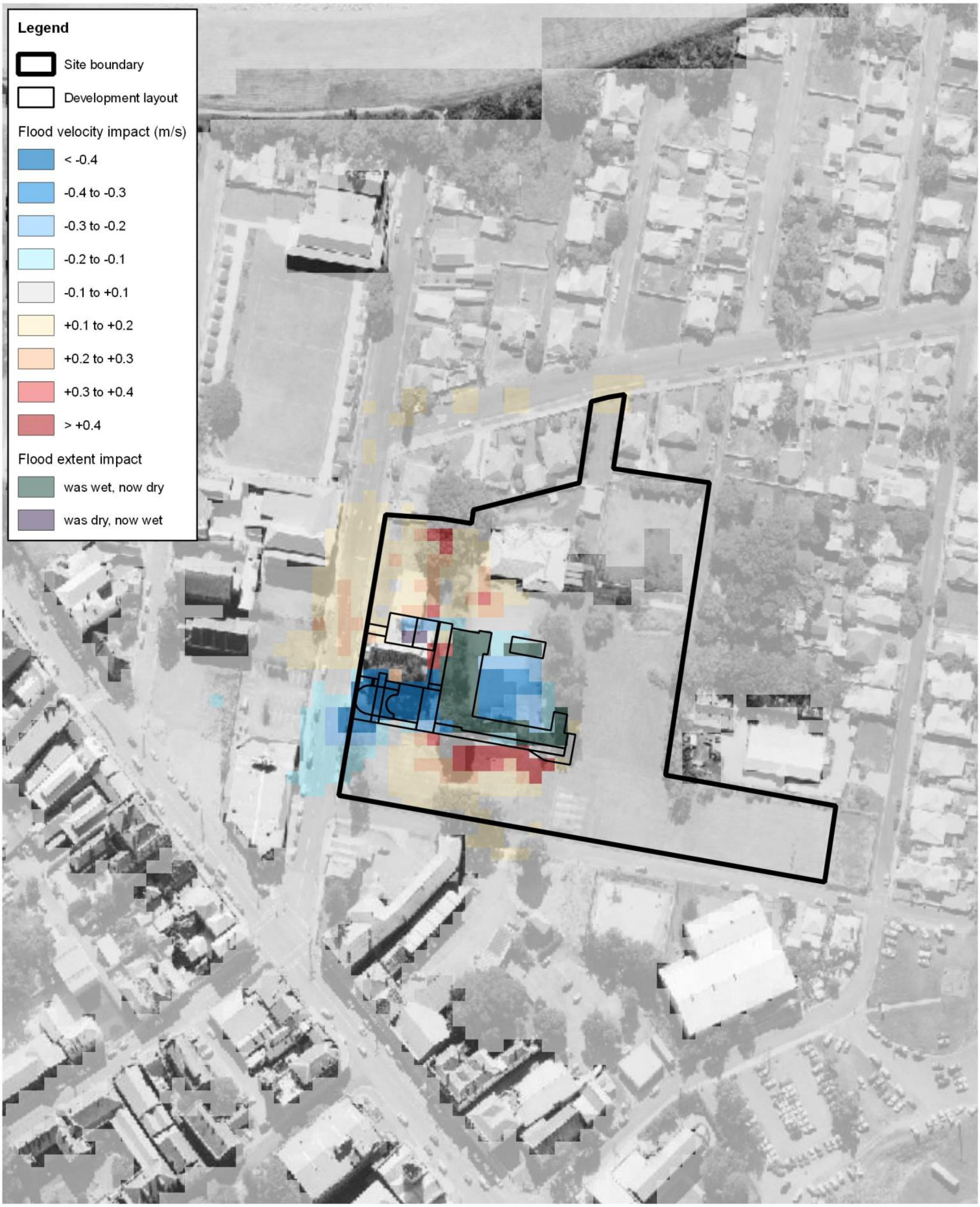
Filepath: \Projects\T2136_ASC_MPC_FIA\GIS\T2136_010_220307_50y_v_impact.qgz



Title:

Modelled 1% AEP Peak Flood Velocity Impact

0 50 100 m

approx. scale

Figure: 11

Revision: A

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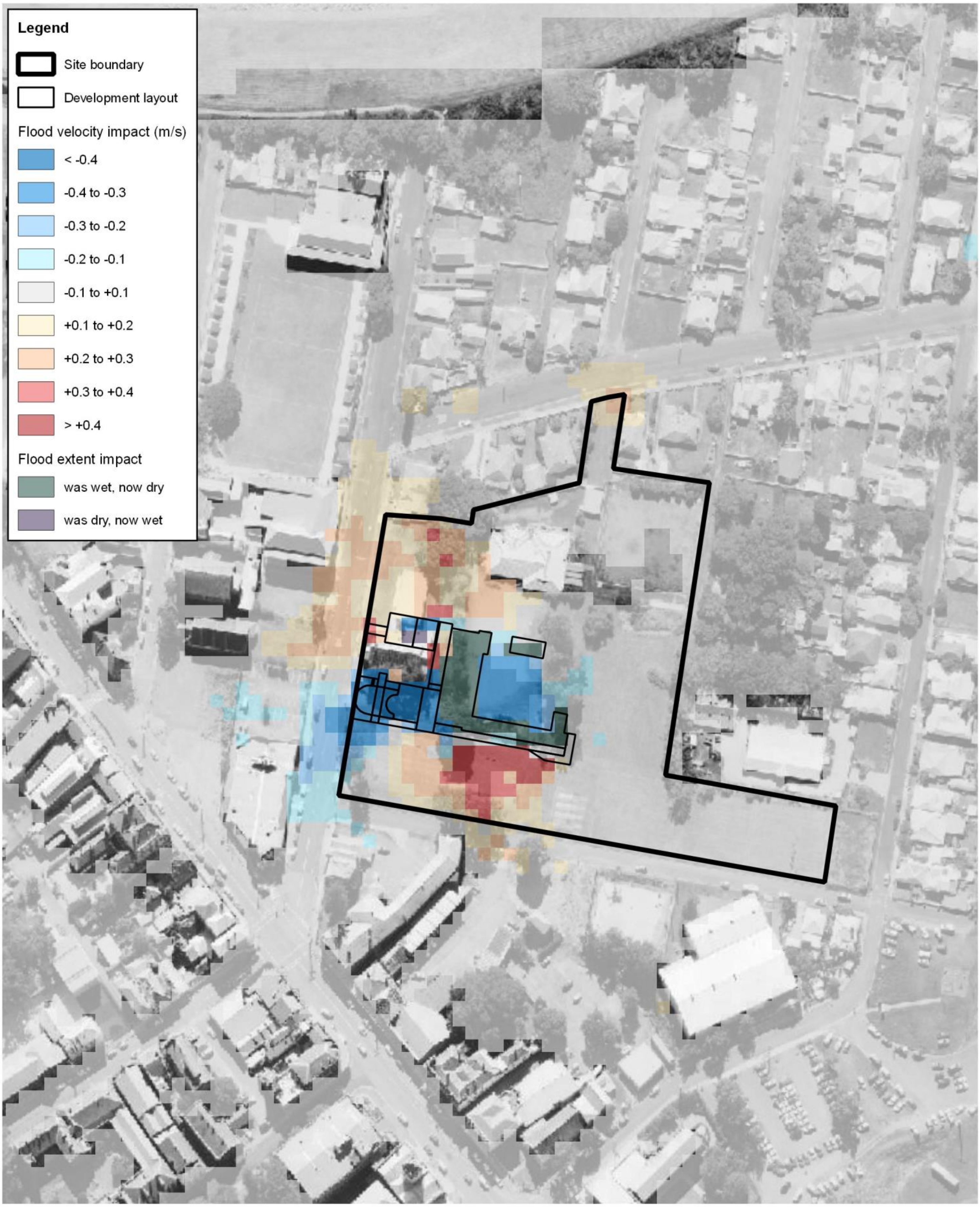

Title:

Modelled 0.5% AEP Peak Flood Velocity Impact

0 50 100 m

approx. scale

Figure: **12**

Revision: **A**

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