Proposed Rezoning and Development Lot 2 DP 601094 & Lot 4 DP 825704 Mumford Street, Port Macquarie

Flood Impact and Risk Assessment

9th February 2018

Level 17, 141 Walker St
North Sydney NSW 2060
Australia

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Revision B

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Project: Proposed rezoning And Development of Lot 2 DP 601094 & Lot 4 DP 825704, Mumford Street, Port Macquarie
Flood Impact & Risk Assessment

Rev	Description	Author	Review	Advisian Approval	Date
A	**Draft Report** (***Issued for Internal Review***)	RG	CRT		8/02/2018
B	**Final Report** (***Issued for DA Submission***)	RG	CRT	Chris Thomas	9/02/2018

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Appendices

1 INTRODUCTION

East Coast Screw Piers plans to rezone and develop Lot 2 DP 601094 and Lot 4 DP 825704 at Mumford Street, Port Macquarie. Lot 2 is currently operated as a Christian Outreach Centre while Lot 4 is the Heritage Christian School. The location of the site is shown in **Figure 1**.

The proposal will see the capacity of the Heritage Christian School (*Lot 4*) increase through the construction of additional buildings to function as classrooms and for administration and additional car parking facilities. The function of Lot 2 is proposed to change from the Christian Outreach Centre to an automotive workshop and detailing business. The change will involve construction of additional buildings to act as workshops and spray facilities, as well as spaces for parking and vehicle storage. A bio-retention basin is proposed on Lot 2 to treat runoff from the development.

Filling is proposed across parts of both lots in order to meet minimum surface and floor level requirements outlined in the *Port Macquarie Hastings Council Flood Policy* (*2015*). Detailed plans for the proposed development have been prepared by AB3D Building Design and are included as **Appendix A**.

During significant flooding along the Hastings River there is potential for floodwaters to inundate parts of the site and the surrounding floodplain. The extent of flooding has been previously investigated in detail as part of a number of studies including:

- '*Hastings River Flood Study*' (*2006*), undertaken by Patterson Britton & Partners (*since acquired by WorleyParsons*);
- the '*Hastings River Floodplain Risk Management Study*' (*2012*), undertaken by WorleyParsons; and,
- the '*Hastings River Flood Study – Climate Change Assessment*' (*in draft, 2017*) undertaken by Advisian (*part of the WorleyParsons Group*).

All three studies were undertaken for Port Macquarie-Hastings Council.

There is potential for the proposed development of the site to have an impact on local flood characteristics including peak flood levels and flow velocities. Any filling as part of the proposed development will remove a small portion of the flood storage of the Hastings River floodplain. Therefore, there is a need to assess the potential impact of the proposed development on flooding.

This report outlines the findings from Advisians' investigation of flooding at the site including an assessment of the potential impact that the proposed development may have on local flood characteristics. The report also documents potential mechanisms for evacuating the site during major floods including details of available warning times and preferred evacuation routes. This includes a comparison against the requirements of the '*Port Macquarie-Hastings Council Flood Policy*' (*2015*) and the '*Port Macquarie-Hastings Local Flood Plan*' (*2015*).

FIGURE 1

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LOCATION OF THE SUBJECT SITE

2 ASSESSMENT OF LOCAL FLOOD BEHAVIOUR

2.1 Background

Hastings Council commissioned WorleyParsons (*incorporating the former Patterson Britton and Partners*) to develop a 2-Dimensional flood model for the Hastings River floodplain as part of work that was undertaken to prepare the *'Hastings River Flood Study'* (*Issue No.3, August 2006*) and the '*Hastings River Floodplain Risk Management Study*' (*2012*).

As part of the Floodplain Risk Management Study, WorleyParsons undertook investigations for Council to assess the impact of sea level rise and increased rainfall intensities associated with climate change on design 100 year Average Recurrence Interval (*ARI*) flood levels. The findings from these investigations are documented in Chapter 12 of the Hastings Floodplain Risk Management Study and have been used to define Year 2050 and Year 2100 design 100 year ARI flood levels for the lower Hastings River.

Both the Flood Study and Floodplain Risk Management Study describe the flood characteristics of the river system for existing topographic and development conditions. Both studies were based on the results of simulations undertaken using a detailed two-dimensional hydrodynamic model. The model was developed from hydrographic survey data (river cross-sections) and detailed topographic data.

The computer model was used to simulate a range of historical and design floods such as the 100 year ARI flood. The results from the modelling were used to define flood characteristics along the Hastings River, and specifically to establish peak flood levels and flow velocities.

The computer model was created using the RMA suite of software. RMA is a finite element modelling software that employs a variable grid geometry in which elements with irregular and curved boundaries can be modified as required without the need for regeneration of the entire grid.

Therefore, any proposed development on the floodplain can be incorporated into the existing model and the associated impacts can be quantified by comparing model results from simulations of "pre-development" and "post-development" scenarios.

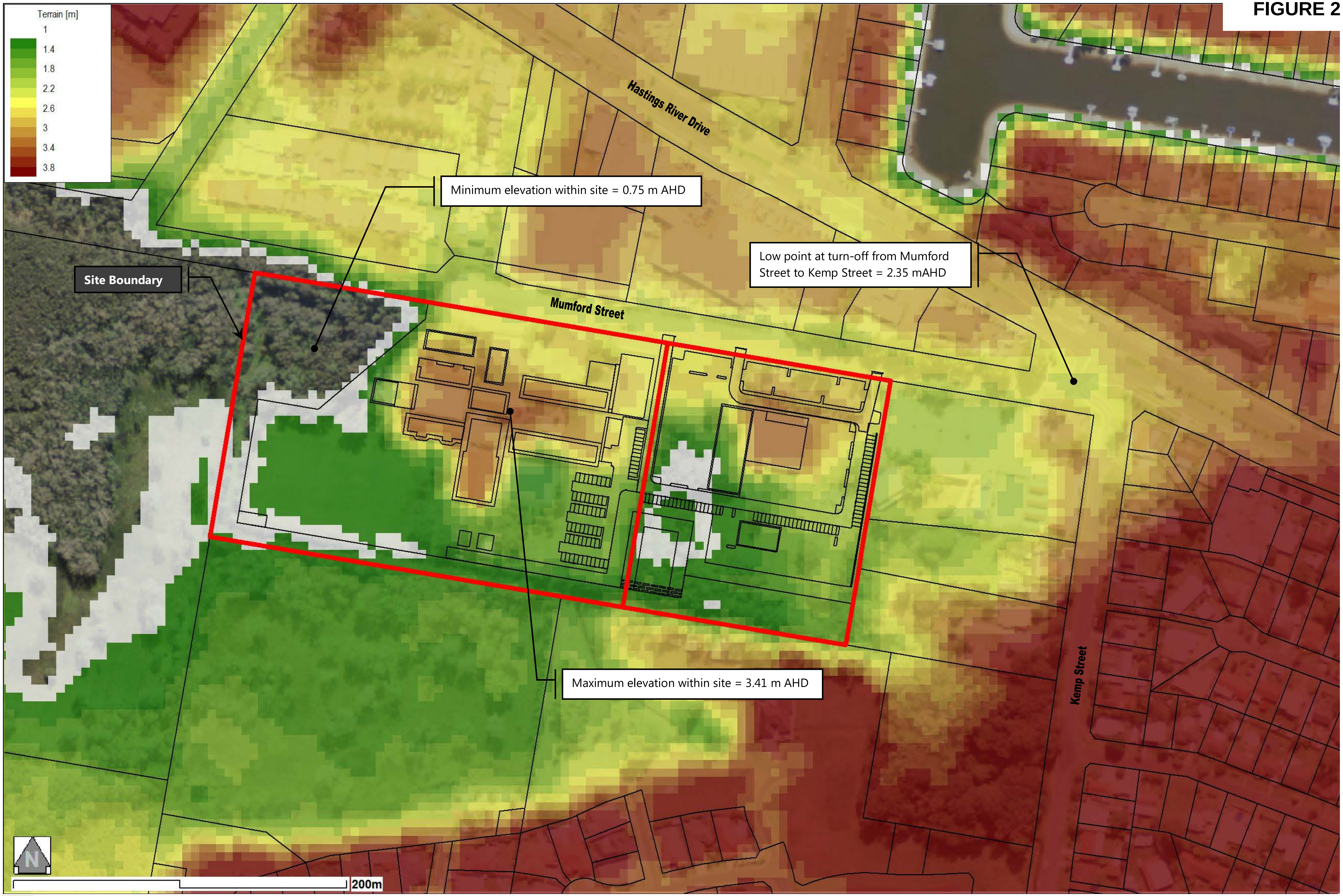
The RMA-2 model underwent upgrades recently as part of work completed by Advisian for Council as part of a detailed climate change impact assessment. The climate change assessment was to update the preliminary climate change assessment that had been completed as part of the FRMS (*2012*). The results of the climate change assessment are in draft at the time of preparing this report.

2.2 Description of the Development Site

Figure 1 shows that the site is located along the southern floodplain of the Hastings River just upstream of where the river turns to flow to the north and traverses around Settlement Point. The site is located on Mumford Street, to the west of Kemp Street and about 80-100 metres south of Hastings River Drive.

The existing topography in the vicinity of the site (refer **Figure 2**) is based on Light Detection and Ranging (*LiDAR*) survey obtained via the Geoscience Australia ELVIS portal. The LiDAR information is considered to provide the most reliable contemporary description of the variation in topography across the Port Macquarie-Hastings Council LGA.

FIGURE 2



TOPOGRAPHY IN THE VICINITY OF SUBJECT SITE AT MUMFORD STREET, PORT MACQUARIE

The elevations presented in **Figure 2** indicate that the topography across the site ranges between 0.75 mAHD and 3.41 mAHD. Elevations are shown to be typically lower in the western and southern areas of the site.

2.3 Existing Flood Characteristics at the Development Site

2.3.1 Hydraulic Modelling

The two-dimensional RMA-2 hydrodynamic model developed as part of the '*Lower Hastings River Flood Study*' (*2006*) and recently updated as part of the '*Hastings River Flood Study – Climate Change Assessment*' (*in draft, 2017*) was used to define flood characteristics at the development site.

In order to assess flooding on a "local scale" (*i.e., in the vicinity of Lot 2 and Lot 4*), the RMA-2 model that was developed for Council was modified and refined to incorporate additional network detail in the vicinity of the site. This involved modifying the network to incorporate additional elements and nodes to better represent the local topography.

2.3.2 Hydraulic Modelling Results

The refined RMA-2 hydrodynamic model was used to simulate the 1% Annual Exceedance Probability (*AEP*) flood for existing topographic conditions. The results of the modelling are presented in the following.

Peak Flood Levels and Depths

The results of the hydrodynamic modelling indicate that the peak 1% AEP flood level across the development site is predicted to be 3.13 mAHD (*refer* **Figure 3**). As discussed in **Section 2.2**, the topography within the extent of proposed development generally varies between 0.75 mAHD and 3.41 mAHD. Accordingly, the majority of the site is predicted to be inundated at the peak of the 1% AEP flood. Only the areas near the existing buildings on both lots remain flood free.

Peak floodwater depths and velocities were extracted from the results of the modelling for the 1% AEP flood and are presented in **Figure 4**.

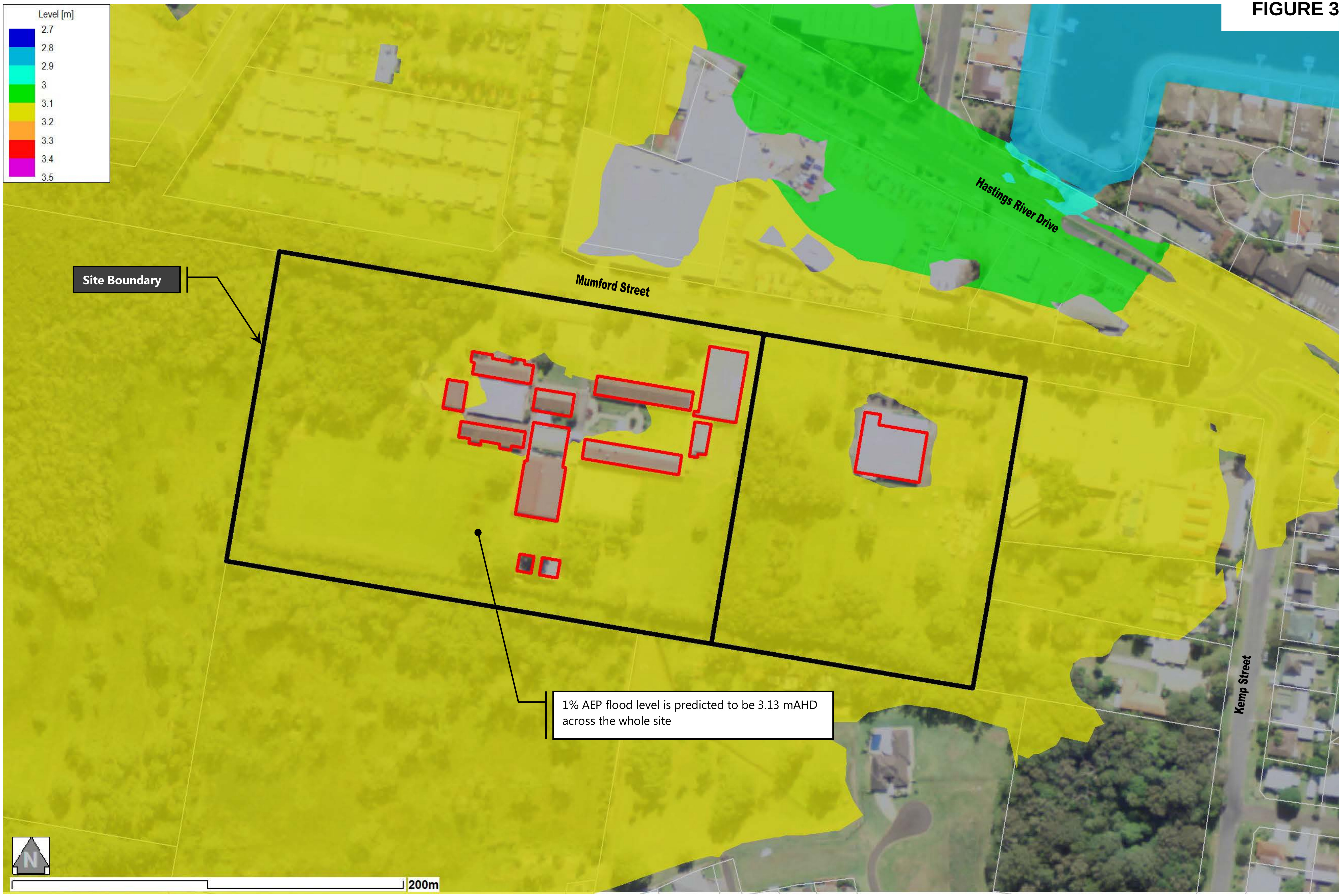
Figure 4 indicates that floodwater depths range from a maximum of 2.38 metres at the western boundary of the site, to zero as the terrain grades upwards towards the buildings in the centre of the site.

Peak Flow Velocities

Peak flow velocities for the 1% AEP flood event were also extracted from the results of the modelling and are presented in **Figure 4** as velocity vectors. The velocity vectors give an indication of the magnitude and direction of flow at the peak of the flood.

Peak flow velocities across the site are typically below 0.10 m/s. This is expected given the site is categorised as flood storage and flood fringe indicating there is minimal passage of floodwaters through the site. A maximum velocity of up to 0.19 m/s is predicted to occur within the site in an area immediately to the north of the school classrooms on Lot 4 near the Mumford Street boundary (*refer* **Figure 4**).

FIGURE 3



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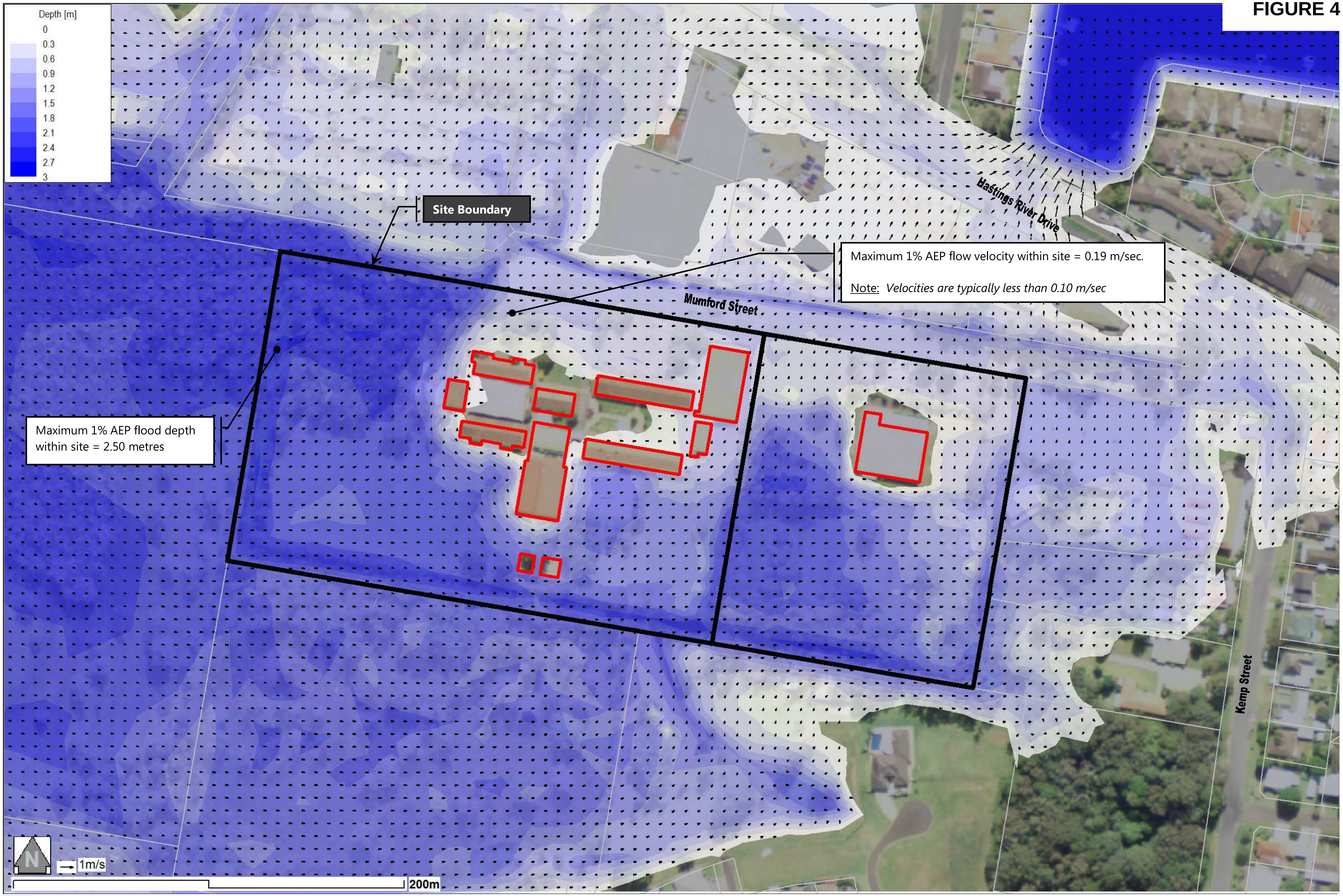
PREDICTED 1% AEP FLOOD LEVELS AT MUMFORD STREET, PORT MACQUARIE



PREDICTED 1% AEP FLOOD DEPTHS AND VELOCITIES AT MUMFORD STREET, PORT MACQUARIE

Provisional Flood Hazard

The flood hazard describes the potential impact that flooding would have on development and people in a particular area and reflects the risks to which people in that area could be exposed.

Flood hazard mapping for the Hastings River floodplain was prepared as part of the *'Hastings River Flood Study'* (*2006*). The criteria used to define the various hazard categories for the Flood Study are reproduced in **Table 1**.

Table 1 Definitions for Hazard Categories

HAZARD CATEGORY	CRITERIA	PRACTICAL APPLICATION
Low	• Depth (*d*) < 0.4m & Velocity (*v*) < 0.5m/s	• Suitable for cars
Medium	• exceeding Low criteria, and *d* ≤ 0.8m, *v* ≤ 2.0m/s, and *vxd* ≤ 0.5	• Suitable for heavy vehicles and wading by able bodied adults
High	• exceeding Medium criteria, and *d* ≤ 1.8m, *v* ≤ 2.0m/s, and *vxd* ≤ 1.5	• Suitable for light construction, timber frame, brick veneer etc
Very High	• exceeding High criteria, and 0.5m/s < velocity < 4m/s and *vxd* ≤ 2.5	• Suitable for heavy construction, steel frame, concrete etc
Extreme	• exceeding Very High criteria and v > 5m/s	• Unsuitable for development - indicates significant conveyance of flow or floodway

As discussed, peak floodwater depths within the site are predicted to vary between zero and 2.38 metres. Peak flow velocities across the site are predicted to typically be less than 0.1 m/s with a localised maximum of 0.19 m/s.

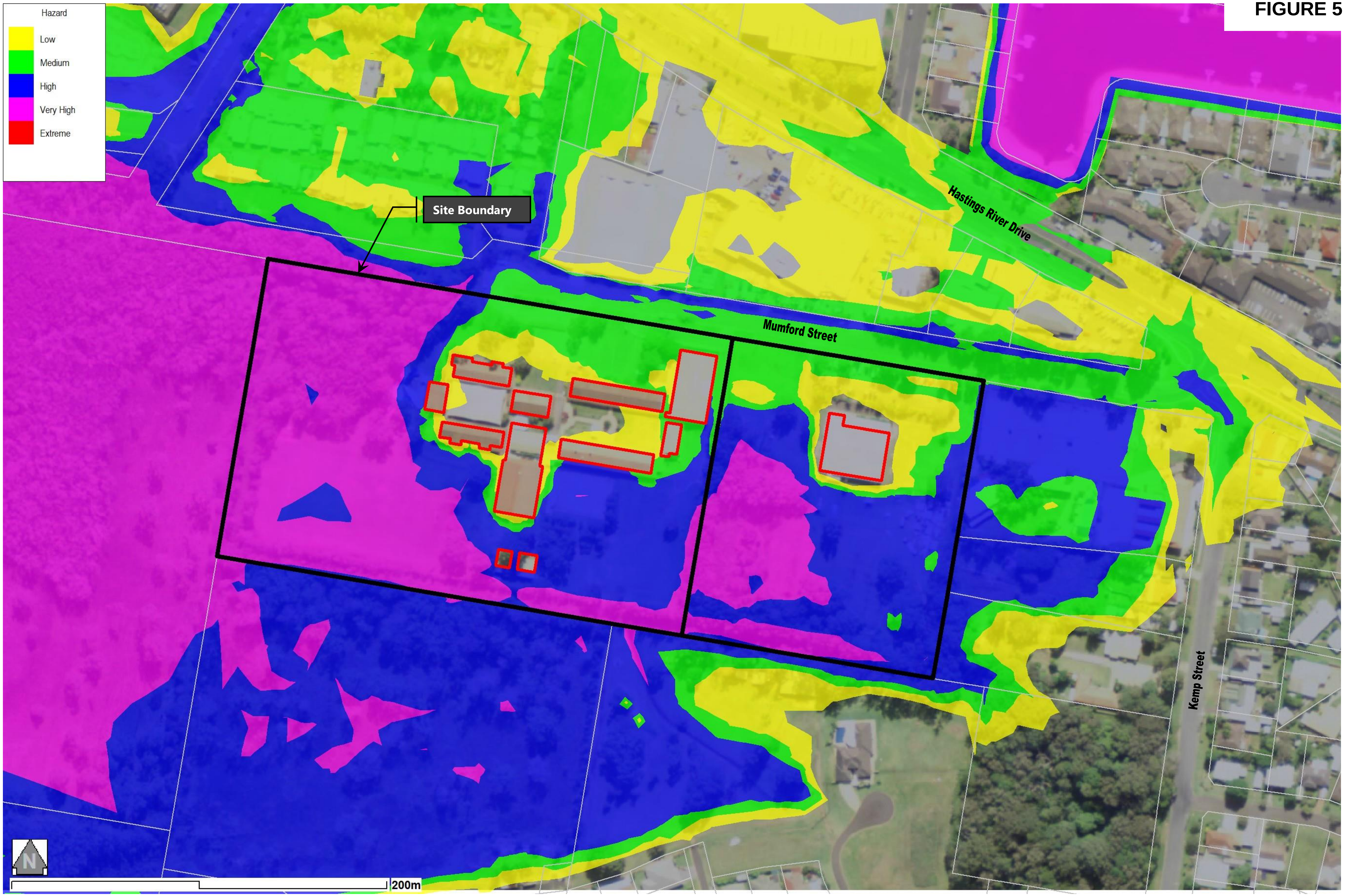
Figure 5 shows that hazards across the site are predicted to range between '*low*' and 'very *high*'. The variations in hazard is depth dominated given the variation in velocities is negligible across the site and within the '*low*' threshold at all locations. All areas classified as 'very high' hazard are located along the edges of the site away from the existing and proposed development.

Figure 5 also indicates that flood hazards along Mumford St vary along the length of the site. The eastern end of Mumford Street is generally a '*medium*' hazard zone, which increases towards the west, becoming a '*very high*' hazard zone at the western end of the site.

Hydraulic Categories

The hydraulic category for a site identifies the potential for development to impact on existing flood behaviour. The '*Floodplain Development Manual' (2005)* divides flood prone land into three hydraulic categories; namely Floodway, Flood Storage and Flood Fringe.

As part of the Hastings River Floodplain Risk Management Study (*FRMS*) (*2012*), Advisian (*then WorleyParsons*) prepared a detailed assessment of floodway, flood storage and flood fringe areas for the Lower Hastings River Floodplain. This involved a detailed encroachment assessment to identify the extent of the floodway.



1% AEP FLOOD HAZARD CATEGORIES AT MUMFORD STREET, PORT MACQUARIE

The relevant hydraulic category map for the site has been extracted from the FRMS (*2012*) and is included as **Appendix B**. The figure indicates that the hydraulic categories across the site are predicted to range between flood fringe near the eastern site boundary and flood storage for all remaining areas. The majority of the site, including those parts of the site on which development is proposed, is classified as flood storage.

Based on the hazard mapping and hydraulic category mapping the site is classified as low to high hazard flood storage. Those parts of the site on which development is proposed are low hazard flood storage.

3 IMPACT OF THE DEVELOPMENT ON LOCAL FLOOD BEHAVIOUR

3.1 Description of Proposed Development

East Coast Screw Piers plans to rezone and develop Lot 2 DP 601094 and Lot 4 DP 825704 at Mumford Street, Port Macquarie. Lot 2 is currently operated as a Christian Outreach Centre while Lot 4 is the Heritage Christian School.

The proposal will see the capacity of the Heritage Christian School (*Lot 4*) increase through the construction of additional buildings to function as classrooms and for administration and additional car parking facilities. The function of Lot 2 is proposed to change from the Christian Outreach Centre to an automotive workshop and detailing business. The change will involve construction of additional buildings to act as workshops and spray facilities, as well as spaces for parking and vehicle storage. A bio-retention basin is proposed on Lot 2 to treat runoff from the development (refer Figure 6).

Filling is proposed across parts of both lots in order to meet minimum surface and floor level requirements outlined in the *Port Macquarie Hastings Council Flood Policy* (*2015*); refer discussion under **Section 3.2**. Detailed plans for the proposed development have been prepared by AB3D Building Design and are included as **Appendix A**.

3.2 Flood Planning Level

The proposed rezoning of Lot 2 DP 601094 and the development of Lot 2 and Lot 4 will be required to comply with the minimum surface elevation and floor level requirements as specified in the Flood Policy (*2015*). The following criteria have been addressed for the proposed rezoning and development application:

- Rezoning of commercial/industrial land must have a minimum area of 400 m^2 at or above FPL2 – 3.53 mAHD; i.e., 1% AEP flood level (*3.13 mAHD*) + Climate Change Allowance (*400mm*).
- School buildings fall under '*Special Purpose Facilities*' which are required to be at or above FPL3 – 4.03 mAHD; i.e., 1% AEP flood level (*3.13 mAHD*) + Climate Change Allowance (*400mm*) + 500mm Freeboard.
- Minimum flood levels for industrial/commercial development to be at FPL2 (*3.53 mAHD*) with at least 25% of the ground floor area at or above FPL3 (*4.03 mAHD*).
- Open carparks must be at or above FPL1 (2.44 mAHD); the peak 5% AEP flood level.

3.3 Impacts of Proposed Development of Flood Behaviour

3.3.1 Model Modifications to Reflect Proposed Development

In order to quantify the potential impacts of the proposed development, the RMA-2 flood model that was developed to assess existing flood behaviour across the site was modified to incorporate the changed landform associated with the development proposal. In accordance with the development plans, new building footprints as well as existing building footprints were completely blocked-out of the model network. This means that no flow can pass through the extent of proposed works and that floodwaters cannot occupy that part of the site as temporary flood storage.

FIGURE 6

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PROPOSED DEVELOPMENT LAYOUT

All changes to surface elevations throughout the site were also incorporated into the model network by modifying the elevations of model nodes. This was particularly important throughout Lot 2 and the proposed parking and vehicle storage areas.

3.3.2 Hydraulic Modelling Results

The modified model was used to simulate the 1% AEP flood in order to assess whether the development will have any impacts on peak flood levels, extents and velocities. The magnitude and location of any changes arising from the proposed development was established by comparing model results from the existing and post-development model simulations.

Impact on Peak Flood Levels

To quantify any off-site impacts of development, flood level difference mapping was prepared. Difference maps are created by comparing peak flood level estimates at each node in the hydrodynamic model from simulations undertaken for both existing and post-development scenarios. This effectively creates a contour map of predicted changes in peak flood levels (*i.e., increases and decreases*) and allows visual assessment of the impact of the filling on existing peak flood levels.

Flood level difference mapping was developed and is presented in **Figure 7**. As shown by the legend in the top-left hand corner, increases in peak flood level are represented as different shades of red and decreases in peak flood level are represented as shades of blue. The white shading indicates changes in peak flood level of no more than +/- 10 mm.

As shown in **Figure 7**, the proposed development is not predicted to generate any changes to peak flood levels within or outside of the site.

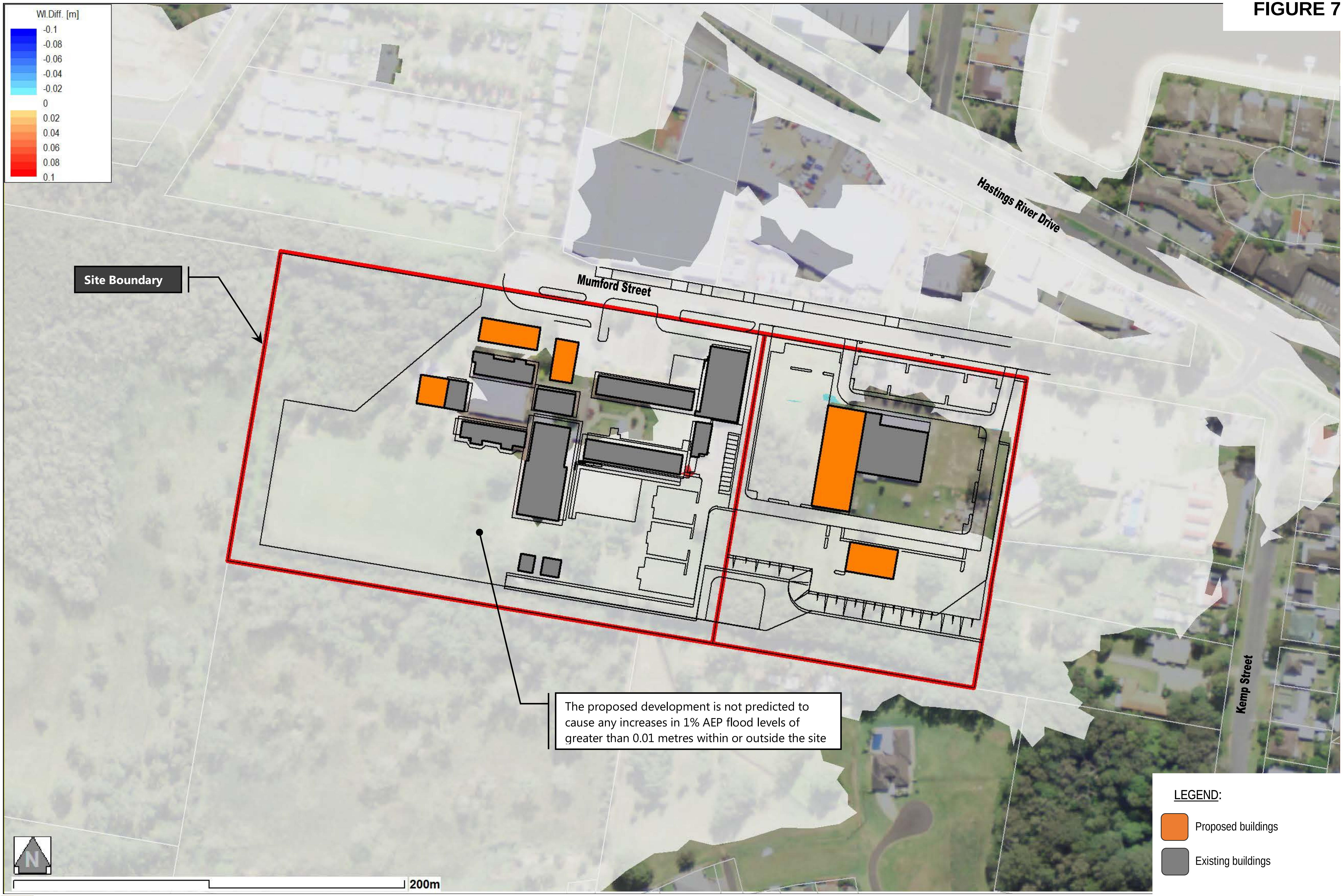
Impact on Peak Flow Velocity

A difference map was also created to quantify any changes in peak flow velocities associated with the proposed development. The velocity difference mapping that was developed for the 1% AEP flood is presented in **Figure 8**.

The development is predicted to result in a maximum increase in peak 1% AEP flow velocities of 0.11 m/s. As shown in **Figure 8**, this maximum increase is predicted to occur within the site in the immediate vicinity of the northernmost proposed building. Pre and post-development flow velocities at this location are predicted to be 0.10 and 0.21 m/sec. Although this represents a significant increase, the post-development velocities are still low and within the 'low' hazard range.

The maximum increase in peak flow velocity outside of the site boundary is 0.08 m/s and is predicted to occur along the eastern site boundary (*refer* **Figure 8**). Pre-development velocities during the 1% AEP flood are predicted to be 0.12 m/s at this location. As the velocities are low, an increase in velocity from 0.12 to 0.20 m/s would not result in any change in hazard categorisation at the site; i.e., velocities are still within the 'low' hazard range of values.

The maximum velocity increase across Mumford Street is predicted to be 0.05 m/s occurring to the north-east of the site.



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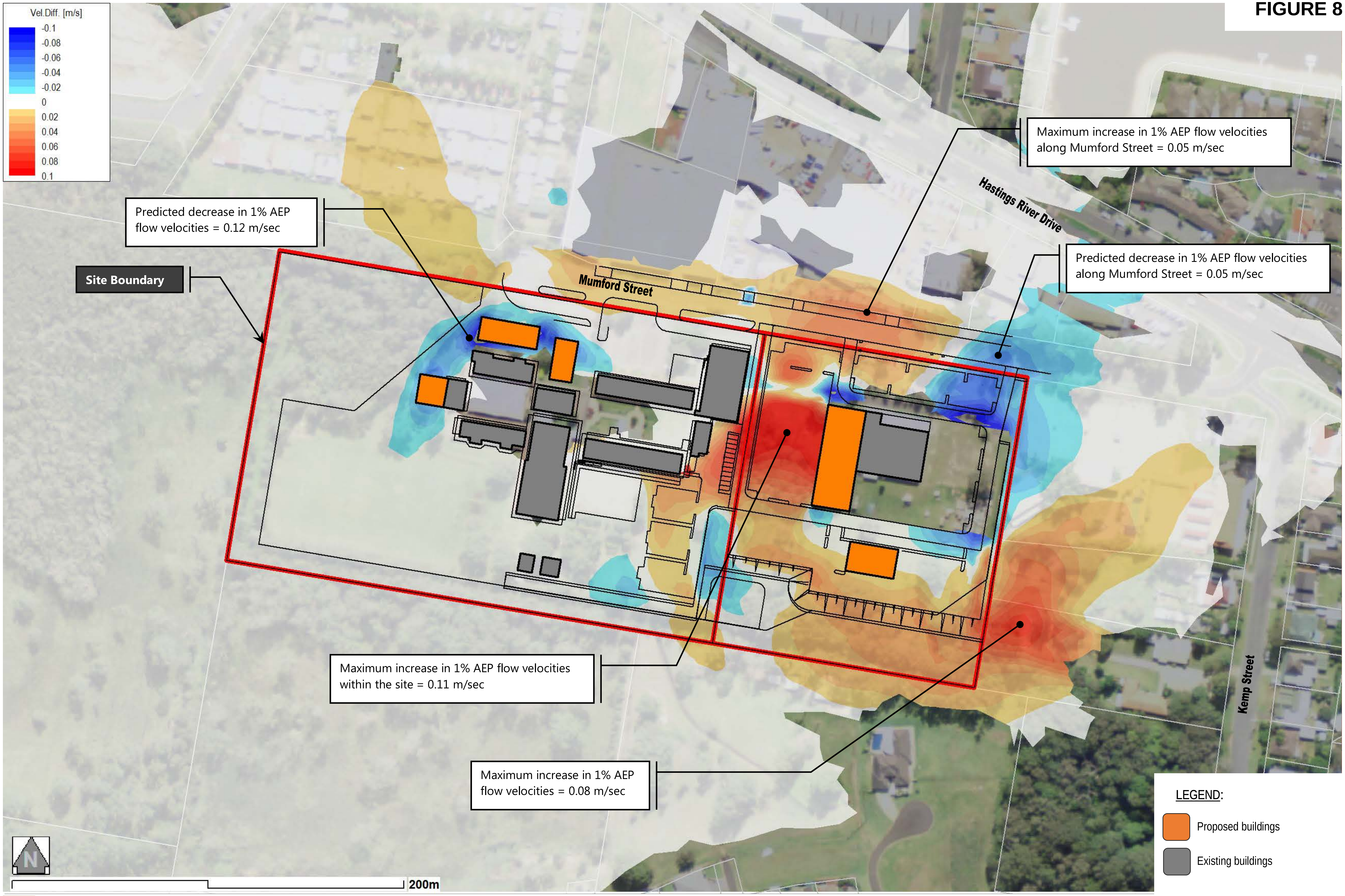
PREDICTED IMPACTS ON PEAK 1% AEP FLOOD LEVELS RESULTING FROM THE PROPOSED DEVELOPMENT

FIGURE 8



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PREDICTED IMPACTS ON PEAK 1% AEP FLOW VELOCITIES RESULTING FROM THE PROPOSED DEVELOPMENT

Impact on Flood Hazard

Peak 1% AEP flood hazard mapping was prepared for the post-development scenario and is shown in **Figure 9**. Comparison of **Figure 5** and **Figure 9** shows that the minor velocity increases of up to 0.08 m/s outside of the site would not result in any increase in the flood hazard classification across adjoining properties or within the Mumford Street road reserve.

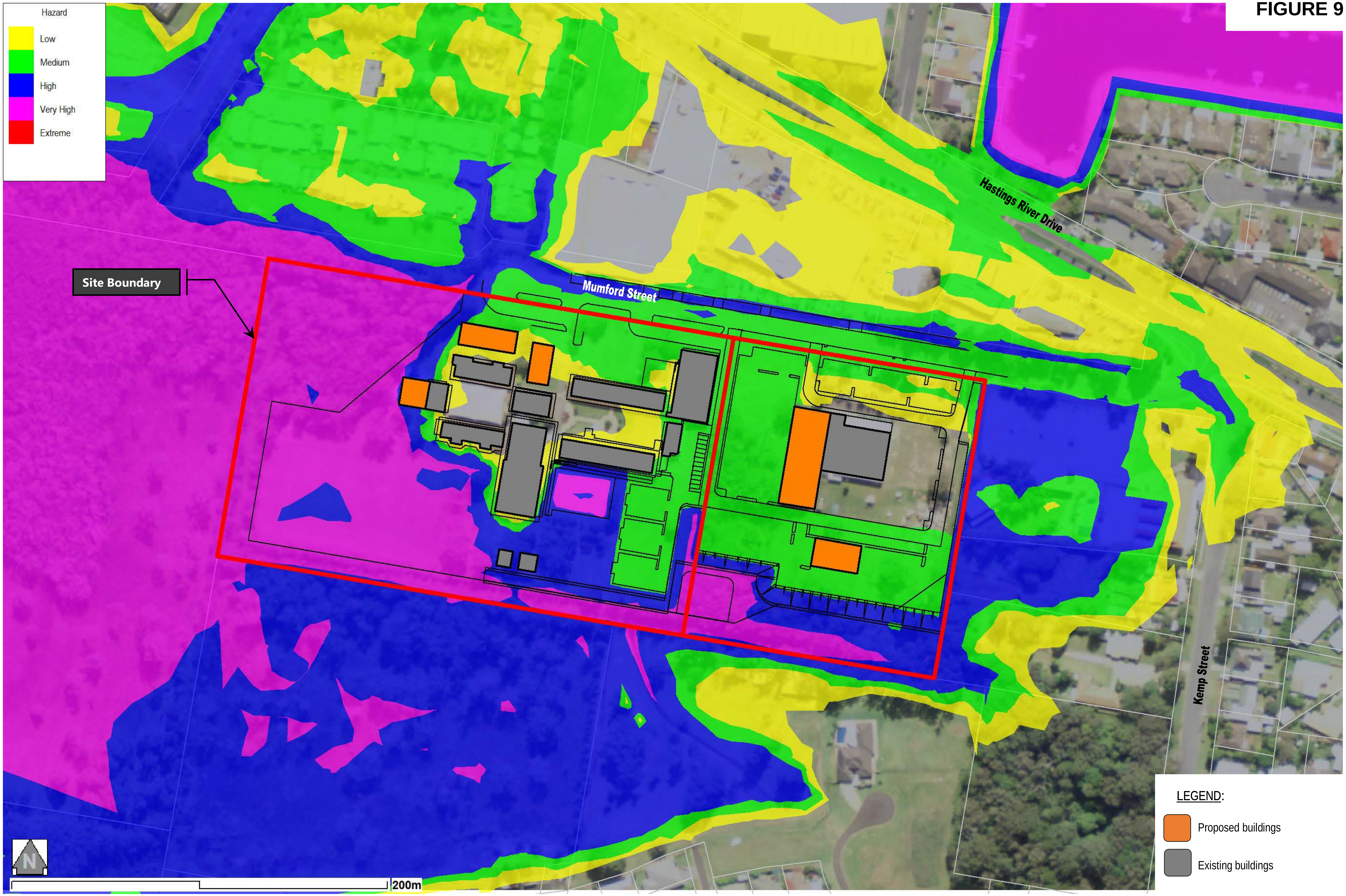
This outcome was expected given the development is not predicted to increase flood levels and is only predicted to cause minor velocity increases.

3.3.3 Assessment Criteria

Section 5.6 of Council's Flood Policy (*2015*) requires impacts associated with development within flood storage areas to be within the following limits:

- Flood level increases are to be less than 10 mm (*0.01 metres*) for the 1% AEP flood; and,
- Flow velocity increases are less than 0.1 m/s for the 1% AEP event for all locations outside of the subject site.

The predicted impacts as shown in **Figure 7** and **8** are within the allowances outlined above. In that regard, the proposed development is not predicted to result in any increases in peak 1% AEP flood levels greater than or equal to 0.01 metres across areas outside of the site. The maximum increase in 1% AEP flow velocity outside of the site is also within the maximum limit outlined above.



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1% AEP FLOOD HAZARD CATEGORIES AT MUMFORD STREET, PORT MACQUARIE FOR POST-DEVELOPMENT CONDITIONS

4 FLOOD RISK ASSESSMENT

The flood risk assessment for the proposed development is based on consideration of the relevant guideline documents and flood characteristics at the site and its surrounds for the full range of design events. The risk assessment also considers potential evacuation routes and any constraints such as low-points in roadways and whether or not there is adequate warning time available to safely effect evacuation.

4.1 Guideline Documents

4.1.1 Port Macquarie-Hastings Flood Policy (2015)

Port Macquarie-Hastings Council (*PMHC*) has indicated via pre lodgement advice that a Flood Risk Assessment (*FRA*) will be necessary for the development proposal that demonstrates that the requirements of Council's Flood Policy (*2015*) are met and that safe and reliable evacuation is provided. Section 5 of the policy applies to the proposed development given its location in an area designated as flood storage.

Section 5.4 applies to commercial development and specifies the following *Site Access and Flood Evacuation Requirements* (*refer* Section 5.4 (*d*)):

- A minimum of 8 hours warning time must be available.
- The flood immunity level for a '*safe reliable evacuation route*' must be no lower than FPL1 (*5% Annual Exceedance Probability AEP flood level*).
- The '*safe reliable evacuation route*' must grade upwards towards land above the peak level of the PMF, and preferably to an approved Flood Evacuation Centre.

4.1.2 Port Macquarie-Hastings Flood Emergency Sub-Plan (2015)

The Port Macquarie-Hastings Local Flood Plan (*2015*) was reviewed as part of investigations completed for the development of this FRA. The sub plan outlines the preparedness measures and the conduct of response and recovery operations from flooding within the Port Macquarie-Hastings Area.

The proposed development site falls within the Hibbard South Sub-Sector, which sits within the greater Hibbard Sector (*Sector 3*). The Hibbard South Sub-Sector is classified as an '*Area with Rising Road Access*', meaning the area has access roads that can be used for evacuation that steadily rise with distance away from floodwaters. Areas classified as having rising road access cannot be completely isolated in events up to and including the PMF. The extents of the Hibbard Sector and the Hibbard South Sub-Sector are shown in **Appendix C**.

The Settlement Point Gauge (*ARWC 207418*) (*refer* **Figure 1**) is monitored by the SES and relied upon for issuing flood warnings and managing evacuation and road closures in the lower Hastings Valley. The following gauge heights are important for flood warnings and closure of roads nearby to Hibbard:

- Gauge Height of 1.2 mAHD – Minor Flood Warning
- Gauge Height of 1.5 mAHD – Moderate Flood Warning
- Gauge Height of 1.75 mAHD – Major Flood Warning

- Gauge Height of 1.8 mAHD – Closure of Hastings River Drive at the Boundary Rd Intersection
- Gauge Height of 2.8 mAHD – Closure of Hastings River Drive at the Hibbard Drive (*East*) Intersection

Although the SES relies primarily on the Settlement Point Gauge to manage and co-ordinate flood evacuation in the Hibbard Sector, the sub-plan also references the Kindee Bridge Gauge (*ARWC 207004*) and Wauchope Railway Bridge Gauge (*ARWC 207041*) as options for advanced warning. In that regard, the sub plan indicates that approximately 14 hours and 8 hours advanced warning could be achieved if flood levels are monitored at Kindee and Wauchope, respectively.

The Westport High School on Finlay Avenue at Port Macquarie is assigned as the Evacuation Centre/Assembly area for the Hibbard South Sub-Sector (*refer* **Figure 1**). Evacuation to the High School would occur by directing evacuees east along Mumford Street to the Kemp Street intersection.

4.2 Predicted Flood Behaviour

Section 2 and **Section 3** of this report discuss the flood behaviour across the site and surrounds during a 1% AEP flood. The modelling and figures show that floodwaters inundate the site via the wetland located to the south-west. Once flood levels within the wetland reach 2.0 mAHD, floodwaters will start to enter the site near the south-west corner. Once flood levels within the wetland reach approximately 2.4 mAHD, they will start to overtop Mumford Street and parts of Kemp Street (*refer* **Figure 4**).

In order to understand the potential flood risks for the site and proposed development it is necessary to consider the full range of flood events and not just the 1% AEP flood. Detailed flood modelling of the full range of design flood events has been undertaken for the lower Hastings River as part of the *'Hastings River Flood Study'* (*WorleyParsons, 2006*), *'Hastings River Floodplain Risk Management Study'* (*WorleyParsons, 2012*) and more recently as part of the *'Hastings River Climate Change Assessment'* (*in draft, 2017*). The modelling for each of these studies has been based on the use of the RMA-2 two-dimensional flood model discussed in **Section 2**.

Predicted peak flood levels in the vicinity of the site as generated from the modelling, are listed overleaf in **Table 2**.

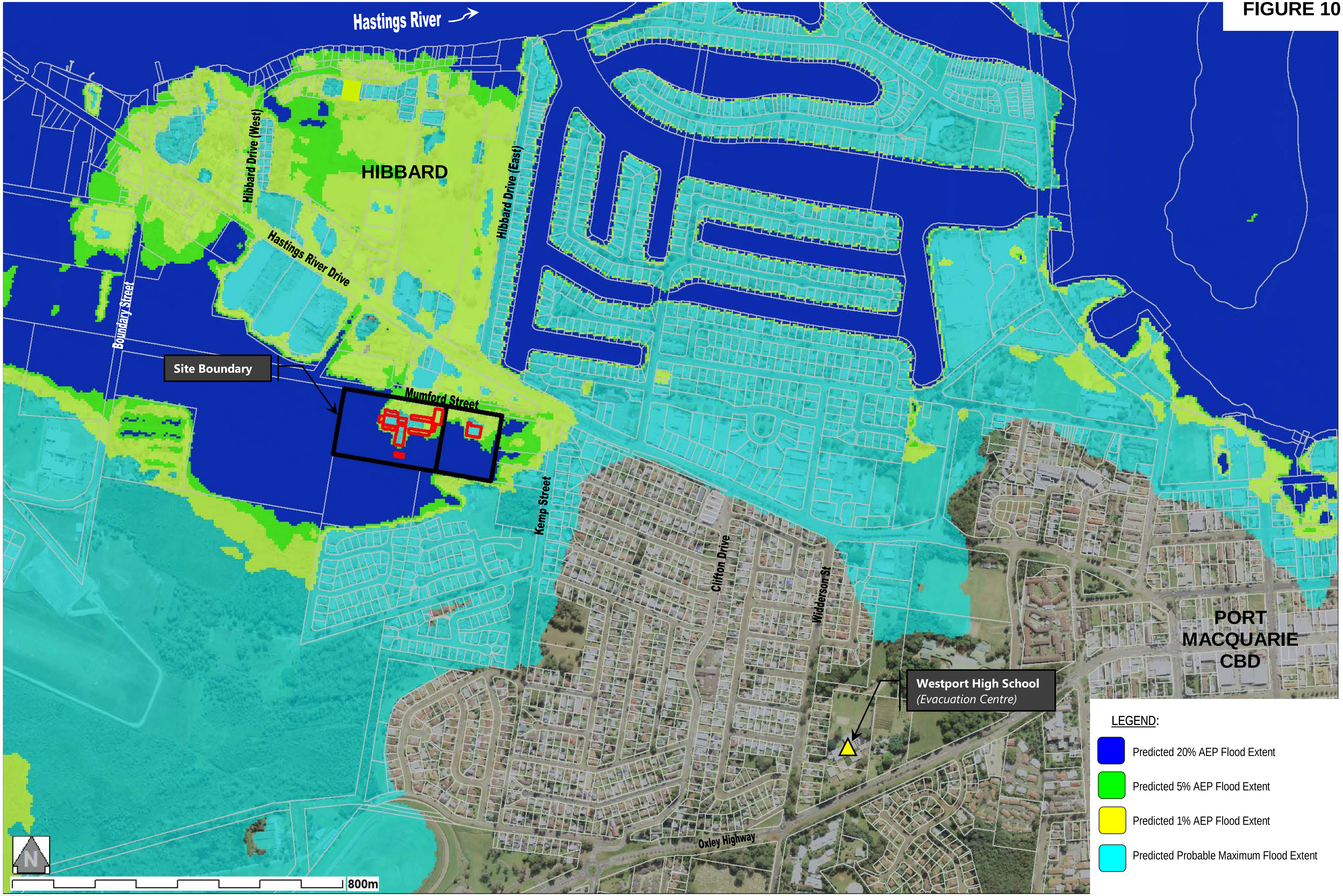
Existing terrain elevations across the site vary between 0.75 mAHD and 3.41 mAHD (*refer* **Figure 2**). Therefore, based on the data presented in **Table 2** parts of the site will be inundated to depths of up to 1.35 metres once flooding in the Hastings River reached the 20% AEP flood level (*2.10 mAHD*). Those areas that would be inundated are limited to the low-lying and undeveloped parts of the site.

In addition, the proposed development would raise elevations across the site to at least FPL1 which is at the peak flood level for the 5% AEP flood of 2.44 mAHD. Accordingly, all school buildings and workshop areas and surrounds would be at or above the peak 5% AEP level.

The central parts of Lot 2 will be raised to an elevation at or above FPL2 of 3.53 mAHD. At this elevation these areas would remain "*flood free*" at the peak of the 1% AEP flood and could be used for vehicle and machinery storage.

Peak flood extents for the 20%, 5%, and 1% AEP events and the PMF are shown in **Figure 10** for development site and its surrounds.

FIGURE 10



PREDICTED FLOOD EXTENTS IN THE VICINITY OF THE SITE

Table 2 Design Flood Levels in the vicinity of the Subject Site

DESIGN EVENT *(AEP)*	PEAK FLOOD LEVEL *(mAHD)*	
	FLOOD STUDY (2006) & FRMS (2012)	CLIMATE CHANGE ASSESSMENT (*in draft, 2017*)
20%	2.10	/
5%	2.44	/
2%	2.82	/
1%	3.09	3.13
0.2%	3.87	/
1% *With Provision for Climate Change (Year 2100)*	/	3.75
Probable Maximum Flood	6.28	/

4.3 Evacuation Route

The proposed evacuation route from the development to high ground to the south-east of the site is shown in **Figure 11**. The evacuation route can be followed to reach the evacuation centre at Westport High School (*location shown on* **Figure 1**).

As shown in **Figure 11**, evacuation commences along Mumford Street to the north of the site via the proposed entry and exit locations to the carparks. Once on Mumford Street, evacuees would be directed to the east and onto Kemp Street, and then onto The Bulkhead approximately 400 metres to the south of the site.

As shown in **Figure 11**, Mumford Street, Kemp Street and a short distance of The Bulkhead, are at risk of flooding during events up to and including the PMF. A longitudinal profile along the proposed evacuation route is shown in **Figure 12** and indicates that there is a low-point along the route at the turn-off from Mumford Street onto Kemp Street. The low-point has an elevation of 2.35 mAHD (*based on the ELVIS LiDAR*) which is 0.25 metres above the peak flood level for the 20% AEP flood and 0.09 metres below the peak 5% AEP flood level (*refer* **Figure 12**).

It is important to note that the low-point at the turn-off from Mumford Street to Kemp Street is surrounded by higher surface elevations that would prevent floodwaters reaching the low-point until flood levels exceed 2.45 mAHD (*refer* **Figure 2**). These higher surface elevations would act to increase the flood immunity of the evacuation route bringing it closer to the 5% AEP flood.

4.4 Available Flood Warning

The available flood warning has been determined for the evacuation route based on the elevation of the low-point and the rate-of-rise of floodwaters at the site and at the Settlement Point and Wauchope Railway Bridge Gauges. As discussed in **Section 4.1.2**, the Settlement Point Gauge is relied upon by the SES for the Hibbard Sector to issue flood warnings and to monitor and action road closures.

FIGURE 11

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301015-03852 – Mumford Street, Port Macquarie
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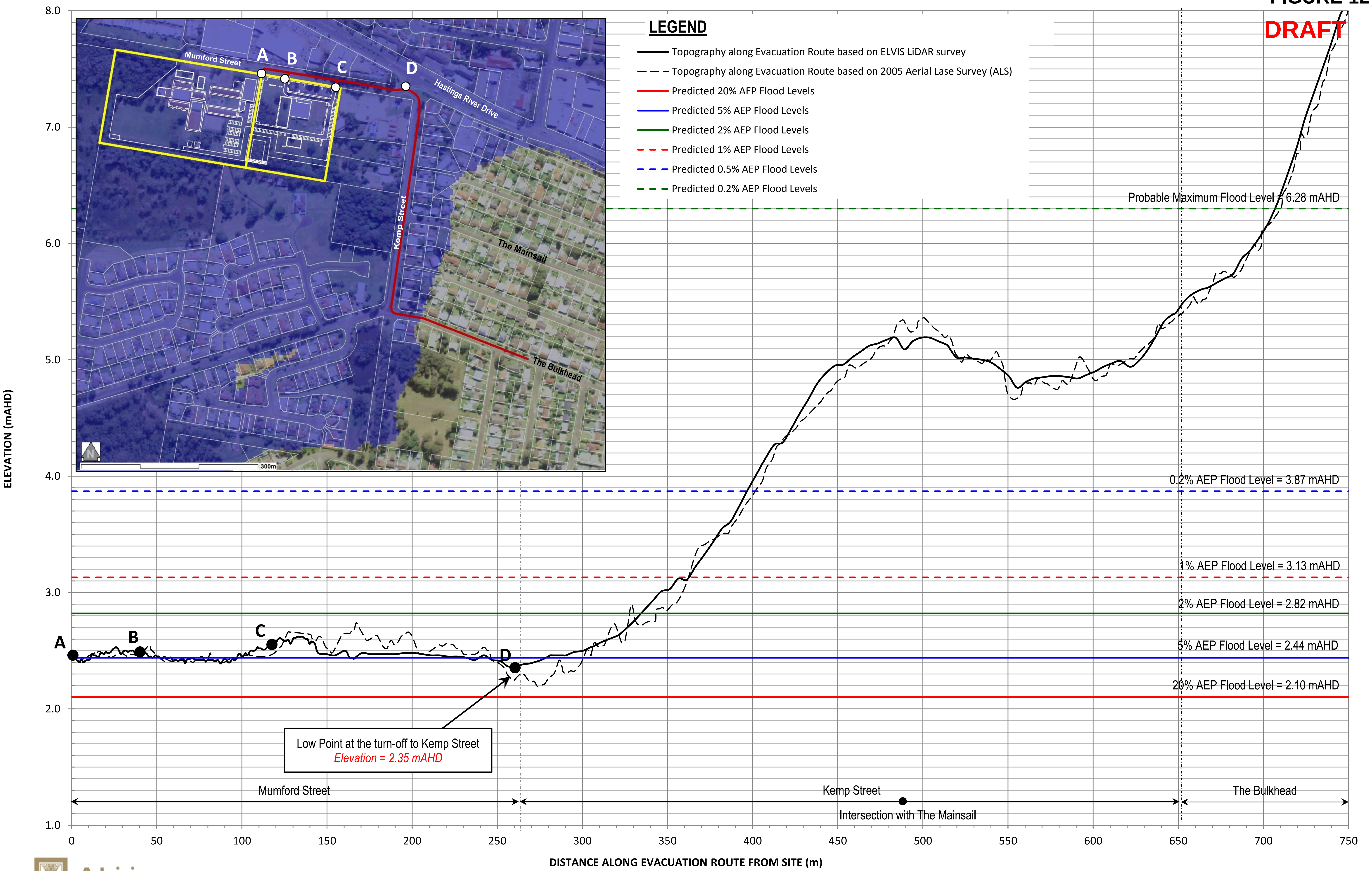
PROPOSED EVACUATION ROUTE FROM THE SITE TO LAND ABOVE THE PMF

FIGURE 12



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WorleyParsons Group

Mumford Street, Port Macquarie
fg301015-03852rg180207_Fig 12 - Evacuation Route.xlsx

ELEVATIONS BASED ON ELVIS LIDAR AND ALS (2005) DATA FOR THE EVACUATION ROUTE

Nonetheless, the Wauchope Gauge is still relevant as it would also be monitored to give advanced warning of rising flood levels and information defining the rate-of-rise of floodwaters.

It is worth noting that even longer warning times could be achieved if flood levels were also monitored at the Kindee Bridge Gauge. The risk with this approach is that it increases the potential for false warnings due to the greater potential of differences in rainfall patterns and intensities in the upper and lower catchments. There is also the potential to miss rising water levels associated with flooding along the Wilson and Maria Rivers.

Flood level hydrographs at the site and the Wauchope and Settlement Point Gauges are plotted on **Figures 13**. Level hydrographs are included for both the 1% AEP flood and the PMF. It is important to note that all flood warning times indicated on the figure are based on stage hydrographs generated for the PMF. Consideration of the PMF ensures that a conservative assessment is applied because the rate-of-rise in the PMF is substantially faster than for the lower and more frequent floods such as the 1% AEP flood. Accordingly, the flood warning times presented for the PMF are considered to represent a worst-case assessment; i.e., they would typically be longer for smaller or more frequent events.

As shown in **Figure 13**, the rate-of-rise of flood levels at the site and in the vicinity of the evacuation route for the PMF event is closely mirrored by the rate of rise predicted at the Settlement Point Gauge, which reflects the closeness of the gauge to the site need to verify. In contrast, the Wauchope Gauge is located over 20 kilometres upstream of the site. This results in a substantial lag in the flood wave arriving at Hibbard, which is typically in the order of 8 hours.

Table 3 provides a summary of the predicted warning times for a PMF event before the evacuation route is inundated and then cut (*once inundation depths reach 0.2 metres*). The warning times are based on recorded flood level data for each of the Settlement Point and Wauchope Gauges. SES issues warning times when the minor, moderate and major flood warning levels are reached at these gauges.

Table 3 Flood Warning Assessment Based on Monitoring Flood Levels at the Settlement Point and Wauchope Gauges for the PMF

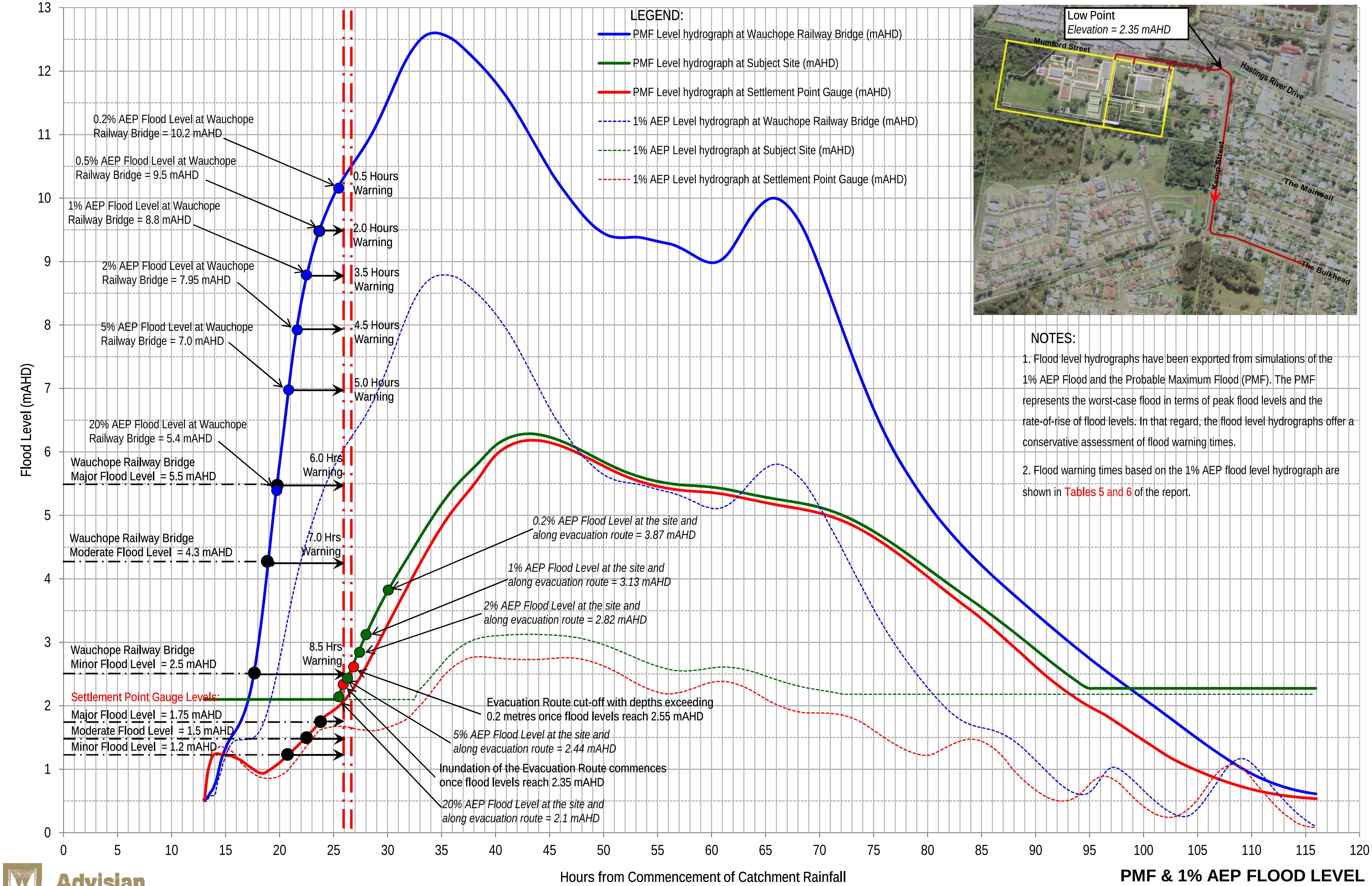
Gauge	Available Warning Time Based on PMF Hydrograph *(hrs)*^					
	Minor Flood level Reached		Moderate Flood level Reached		Major Flood level Reached	
	Before Inundation	Evacuation Route Cut^^	Before Inundation	Evacuation Route Cut^^	Before Inundation	Evacuation Route Cut^^
Settlement Point	5.5	6.0	3.5	4.0	2.5	3.0
Wauchope	8.5	9.0	7.0	7.5	6.0	6.5

^ *Warning times have been determined based on a comparison of the predicted rate-of-rise of floodwaters along each evacuation route to those at the Settlement Point Gauge (ARWC 207418) and Wauchope Railway Bridge Gauge (ARWC 207401).*

^^ *The evacuation route is considered to be 'cut' once floodwaters reach 0.2 metres at the low-point (low-point has an elevation of 2.35 mAHD).*

Table 3 indicates that during a PMF event 5½ hours warning time would be available after the Minor flood level is reached at the Settlement Point Gauge to when floodwaters would start to inundate the low-point along the evacuation route.

FIGURE 13



NOTES:

1. Flood level hydrographs have been exported from simulations of the 1% AEP Flood and the Probable Maximum Flood (PMF). The PMF represents the worst-case flood in terms of peak flood levels and the rate-of-rise of flood levels. In that regard, the flood level hydrographs offer a conservative assessment of flood warning times.

2. Flood warning times based on the 1% AEP flood level hydrograph are shown in Tables 5 and 6 of the report.

PMF & 1% AEP FLOOD LEVEL HYDROGRAPHS FOR THE THE EVACUATION ROUTE AND LOCAL GAUGES

The warning time increases to 6 hours if a depth of 0.2 metres over the low-point is assumed to define when the evacuation route would be "*cut*". Evacuation would need to be completed before this time.

Evacuation would still be possible once the Moderate and Major flood levels are reached at Settlement Point. However, the available warning times are much less and would typically be no more than 2 to 3 hours (*refer* **Table 3**). Based on this it is recommended that evacuation commence once the Minor flood level is reached and a Minor flood warning is issued by the SES.

The flood warnings presented in **Table 3** for the Wauchope Gauge indicate that between 3 and 3½ hours of additional warning time could be gained in addition to the warning times available from monitoring the Settlement Point Gauge alone. In that regard, there would be approximately 8½ hours warning available once the Minor flood level is reached at Wauchope.

As discussed above, the flood warning assessment presented in **Figure 13** and **Table 3** is based on assessment of warning times derived from flood level hydrographs for the PMF event; that is, for the worst-case flood scenario. The rate-of-rise of floodwaters is at its steepest and the resulting flood warning time at its shortest for this event.

A comparison of warning times for the 1% AEP event is also possible based on the 1% AEP flood level hydrographs that are also superimposed on **Figure 13**. As shown, the 1% AEP level hydrographs have a more gradual rate-of-rise and longer travel times between gauges leading to longer warning times for effecting evacuation. This is confirmed by the data in **Table 4** which lists available flood warning times as derived from the stage hydrograph for the 1% AEP flood at the Settlement Point and Wauchope Gauge.

Table 4 Flood Warning Assessment Based on Monitoring Flood Levels at the Settlement Point and Wauchope Gauges for the 1% AEP Flood

Gauge	Available Warning Time Based on 1% AEP Hydrograph *(hrs)*^					
	Minor Flood level Reached		Moderate Flood level Reached		Major Flood level Reached	
	Before Inundation	Evacuation Route Cut^^	Before Inundation	Evacuation Route Cut^^	Before Inundation	Evacuation Route Cut^^
Settlement Point	11.5	12.5	11.0	12.0	2.5	3.5
Wauchope	13.5	14.5	11.5	12.5	9.5	10.5

^ *Warning times have been determined based on a comparison of the predicted rate-of-rise of floodwaters along each evacuation route to those at the Settlement Point Gauge (ARWC 207418) and Wauchope Railway Bridge Gauge (ARWC 207401).*

^^ *The evacuation route is considered to be 'cut' once floodwaters reach 0.2 metres at the low-point (low-point has an elevation of 2.35 mAHD).*

Comparison of data in **Table 3** with corresponding data in **Table 4** indicates that on average, 5 hours of additional warning time would be available if the stage hydrographs for a 1% AEP flood were adopted.

4.5 Flood Policy Compliance

As outlined in **Section 4.1**, Council's Flood Policy (*2015*) outlines a set of criteria that is required to be met for all new commercial/industrial developments and special purpose facilities located on land designated as flood storage. This criteria is reviewed below with specific reference to the proposed development and whether or not the criteria is or can be satisfied.

Criteria 1 A minimum of 8 hours warning time must be available

The flood warning assessment presented in **Section 4.4** shows that:

- 8.5 hours warning time is available before the low-point along the proposed evacuation route begins to be inundated. This warning time is based on the time between the Minor flood level being reached at the Wauchope Gauge.
- 9 hours warning time is available before the evacuation route is "cut" by floodwaters to depths of 0.2 metres.
- If the 1% AEP flood hydrograph is adopted, more than 8 hours warning time is available after a Minor (*11.5 hours*) and Moderate (*11 hours*) flood level is reached at the Settlement Point Gauge. The available warning time increases slightly if monitoring is based on the Wauchope Gauge with 13.5 hours and 11.5 hours relative to Minor and Moderate warning, respectively.

As the PMF represents the worst-case scenario it is recommended that the flood warning times documented for the PMF be used for the assessment of evacuation potential. This recognises that although the warning time will for the majority of events be longer, residents will not be at risk of a flood rising at a faster rate.

Criteria 2 The flood immunity level for a 'safe reliable evacuation route' must be no lower than FPL1 (5% AEP flood level)

A terrain and flood level profile plot is presented as **Figure 12** for the proposed evacuation route. The profile plot indicates that there is a 30 metre length of Mumford and Kemp Streets that is 0.09 metres below the peak 5% AEP flood level. However, because depths of inundation would be less than 0.20 metres and the velocity of flow is low, the evacuation route could still be traversed by vehicle at the peak of the 5% AEP flood with guidance from emergency services personnel.

Although the low-point in the evacuation route is below the peak 5% AEP flood level, depths of inundation are less than 0.20 metres and hence the evacuation route would not be "cut".

It is also worth noting that the low-point at the turn-off from Mumford Street to Kemp Street is surrounded by higher surface elevations that would prevent floodwaters reaching the low-point until flood levels exceed 2.45 mAHD (*refer* **Figure 2**). These higher surface elevations would act to increase the flood immunity of the evacuation route bringing it closer to and marginally above the 5% AEP flood.

Criteria 3 The 'safe reliable evacuation route' must grade upwards towards land above the PMF, preferably to an approved Flood Evacuation Centre

The terrain and flood level profile for the evacuation route shows that the route generally grades upwards towards flood free land and to the evacuation centre at Westport High School.

Figure 12 shows the profile of the land surface along the route which indicates that it is not upwardly grading along its entire length. However, as the "dips" are gradual and the low-points get progressively higher they are not considered to be detrimental to the safe evacuation of the site.

5 CONCLUSIONS

Results extracted from the *Hastings River Flood Study* (*2006*) indicate that the development site lies within the 1% AEP flood extent of the Hastings River. Therefore, there is potential for the site to be inundated during large flood events. Accordingly, the effects of the proposed rezoning and development on local flood characteristics and the provision of adequate flood warning and evacuation for future occupants has been assessed.

The assessment has been based on the results of computer modelling undertaken using the RMA-2 hydrodynamic model that was originally developed for the Hastings River Flood Study. The model has been modified to better represent the topography local to the site and used to assess flood characteristics for both existing and post-development conditions (*i.e., incorporating the fill proposal and building footprint*). The results have been compared to establish whether any change in peak flood level or flow velocity can be expected at any location across the floodplain of the Hastings River.

The following conclusions can be drawn from the results of the modelling:

- The peak 1% AEP flood level in the vicinity of the site is predicted to be 3.13 mAHD.
- Under existing topographic conditions, the majority of the development site is predicted to be inundated during the 1% AEP flood. Peak floodwater depths are predicted to be up to 2.38 metres (*refer* **Figure 4**).
- Peak 1% AEP flow velocities across the site are low, with a maximum of 0.19 m/s which occurs in an area adjacent to the proposed building footprint. Velocities are typically less than 0.10 m/s elsewhere throughout the site (*refer* **Figure 4**).
- Flood hazards across the site for the 1% AEP event are predicted to range between Low and Very High hazard (*refer* **Figure 5**). This is largely a consequence of the depth of floodwaters with flow velocities at all locations within the 'low' hazard range.
- Hydraulic category mapping for the site as documented in the Hastings River Floodplain Risk Management Study (*2012*) shows that the majority of the site is categorised as flood storage with the exception of the eastern most parts of the site which are flood fringe. Those parts of the site on which the works are proposed are classified as flood storage (*refer* **Appendix B**).
- The proposed development is not predicted to result in any change to peak 1% AEP flood levels within or outside of the development site (*refer* **Figure 7**). This complies with Council's Flood Policy (*2015*) which requires off-site flood level increases to be less than 10 mm.
- The proposed development is predicted to cause a maximum increase in peak 1% AEP flow velocities of 0.11 m/s and 0.08 m/s for areas within and outside of the site, respectively (*refer* **Figure 8**). This complies with Councils Flood Policy (*2015*) which requires that any off-site increases in velocities are less than 0.1 m/s.
- The proposed development is predicted to cause no change in 1% AEP flood hazards across adjoining properties (*compare* **Figure 5** *and* **Figure 9**).

The proposed development meets the flood risk requirements of Port-Macquarie-Hastings Council as outlined in Council's Flood Policy (*2015*) and taking into consideration the evacuation protocols outlined in the SES Local Flood Plan (*2015*).

The flood risk assessment for the site determined the following:

- The proposed evacuation route is generally upwardly grading to land that is flood free (*above the PMF level*). Only one localised 'dip' occurs along the evacuation route. This occurs at the turn-off from Mumford Street onto Kemp Street (*refer* **Figure 12**) where elevations at the low-point are 0.09 metres below the peak 5% AEP flood level. The low-point is however shielded from flooding by higher terrain with elevations of at least 2.45 mAHD. On this basis, the low-point would be shielded from flooding during events up to and including the 5% AEP flood.

- At least 8.0 hours warning time is available for flood evacuation. This is based on the time taken for inundation of the low point to occur relative to the time when a Minor Flood Warning would be issued at Wauchope (based on the Wauchope Railway Bridge Gauge, refer **Figure 13** and **Table 3**). This is based on worst-case conditions which would occur during a PMF event. During a 1% AEP event the warning time is predicted to increase to over 13 hours (*refer* **Table 4**).

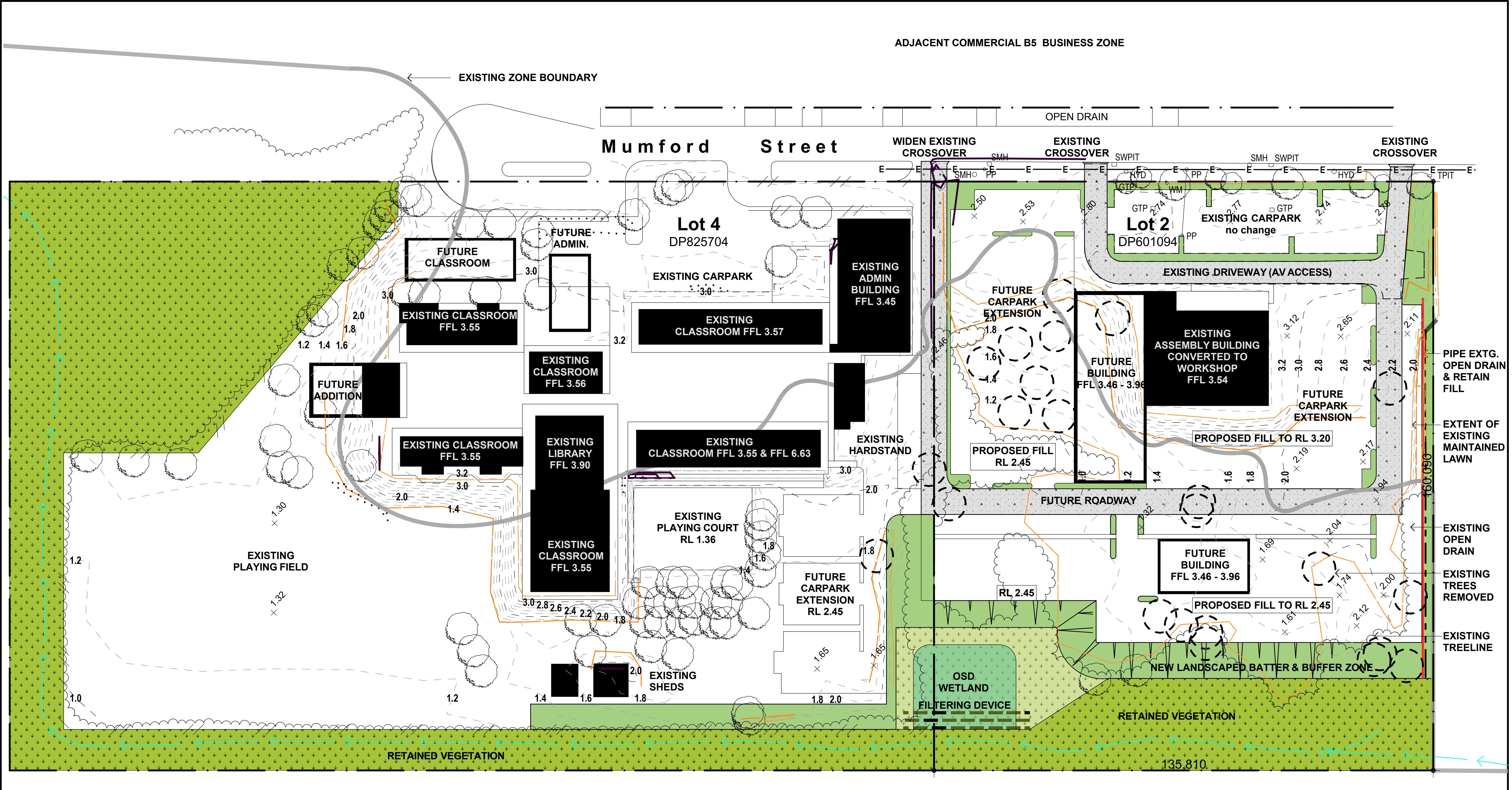
6 References

- Department of Environment & Climate Change (*October 2007*), *'Practical Consideration of Climate Change'*; DECC Floodplain Risk Management Guideline.
- Department of Environment & Climate Change (*2007*), '*SES Requirements from the Floodplain Risk Management Process*' DECC Floodplain Risk Management Guideline.
- Department of Environment & Climate Change (2007), '*Flood Emergency Response Planning Classification of Communities*'.
- Department of Infrastructure, Planning & Natural Resources (*May 2005*), *'Floodplain Risk Management Guideline No 5 – Ocean Boundary Conditions'*; Developed by the State Urban Flood Unit.
- Institution of Engineers (*1987*), *'Australian Rainfall and Runoff – A Guide to Flood Estimation'*; edited by DH Pilgrim.
- NSW Government (*April 2005*), *'Floodplain Development Manual: the management of flood liable land'*; ISBN 0 7347 5476 0.
- New South Wales Government (*2005*), *'Floodplain Development Manual: the management of flood liable land'*; ISBN 0 7347 5476 0.
- '*Hastings River Flood Study*' (2006) Port Macquarie-Hastings Council (*August, 2006*), *'Hastings River Flood Study'*; prepared by Patterson Britton & Partners Pty Ltd.
- The '*Hastings River Floodplain Risk Management Study*' Port Macquarie-Hastings Council (*2012*), prepared by WorleyParsons.
- Port Macquarie – Hastings Council (*2007*), *'Interim Port Macquarie-Hastings LGA Flood Policy'* (*adopted April 2007*)
- Port Macquarie – Hastings Council (*2015*), *'Port Macquarie-Hastings LGA Flood Policy'* (*adopted October 2015*)
- NSW State Emergency Service '*Port Macquarie-Hastings Local Flood Plan*' (*2015*).
- '*Hastings River Climate Change Assessment*' (*in draft, 2017*) Port Macquarie-Hastings Council; prepared by Advisian Pty Ltd.

Appendix A

Development Plans

Source: AB3D Building Design



<u>Site Plan</u>

Proposed Rezoning
Lot 2 DP601094 & Lot 4 DP825704
Mumford Street PORT MACQUARIE

A B 3 D
Building Design
0438 499629 ab3d@bigpond.com

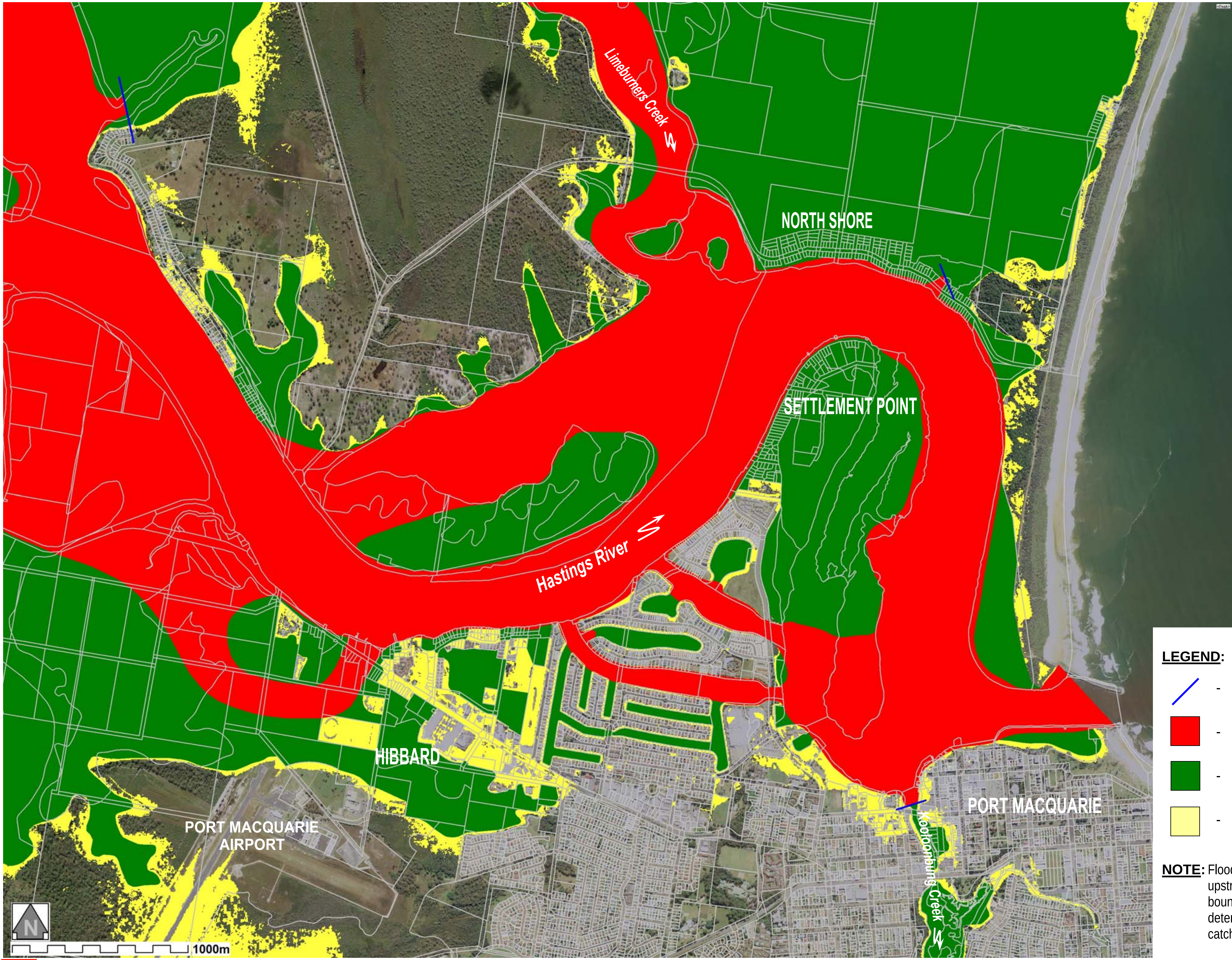
Site Plan
Scale 1:1000
Date 5/02/2018
Drawing No
A01 B

Appendix B

Hydraulic Category Mapping

Source: Hastings River Floodplain Risk Management Study (2012)

FIGURE 9.5



LEGEND:

- Boundary of Hastings River floodway investigations.
- Floodway
- Flood Storage
- Flood Fringe

NOTE: Floodway corridors for tributaries extending upstream from the floodway investigation boundaries are not shown and should be determined as an outcome of independent local catchment investigations.

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Rp3577_00 – Hastings FPRMS
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HYDRAULIC CATEGORIES FOR THE 100 YEAR ARI FLOOD [ZONE 4]

Appendix C

Hibbard Sector Map

Source: Port Macquarie-Hastings Local Flood Plan (2015)

HIBBARD SECTOR MAP