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27 October 2022

Michael Wood and Associates Pty Ltd
30 Second Avenue
East Lismore
NSW 2480

Attention: Michael Wood

Dear Michael

RE: Grafton Boatshed Redevelopment Flood Assessment

BMT has completed the flood assessment for the proposed redevelopment of the Grafton Boatshed at Lot 7001 Dp1054597, Price Street, Grafton. This letter contains a summary of the work undertaken to ensure the proposed use of the facility is compatible with the flood risk.

Site Description

The Site is located in Grafton, along the northern bank of the Clarence River, as shown in Figure 1.1 a. There is a levee located at the rear of the Site, which protects Grafton, but not the boatshed. The Grafton Bridge is located approximately 1km downstream of the Site. The land is zoned at RE1 – Public Recreation and covers an area of 0.8 ha. Located on the Site is the existing boatshed building, amphitheatre seating, a footpath and open space.

The ground levels across the Site typically fall towards the Clarence River, with elevations between 1m AHD and 8m AHD. The lowest portion of the Site is located at the boat ramp.

Proposed Works

The proposed redevelopment works include the following:

- The existing building will be reconfigured, with the mezzanine floor being raised approximately 395mm and the internal layout changed. The overall building footprint of this section is not proposed to change. The RL of the mezzanine floor is 4.775m. The lowest floor of boatshed is lower than the surrounding ground level, with a RL of between 1.410m and 1.625m.

- There will be a deck added above the existing building. This will include a mix of open and closed spaces, with a roofed area covering most of the existing building footprint and will extend to the edge of the existing footpath. The floor level of the deck is approximately 8.300m RL.

- The addition of stairs to the west of the Site, between the existing building and the amphitheatre seating. There is also a bridge extending from the stairs to the entry into the mezzanine floor. The RL of the bridge is 4.775m.

Legend

- Site Boundary
- Levee
- Cadastral Boundaries

Title:

Site Location

Drawing: 1.1

Rev: A

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Scope of Investigation

The scope of this investigation is as follows:

- Review of documents to inform the flood assessment, including
  - Clarence Valley Local Environmental Plan (LEP) 2011
  - Clarence Valley Development Control Plan (DCP) 2011
  - Clarence Valley Flood Study Update 2013
  - Clarence Valley Flood Risk Management Study and Plan 2007
  - Grafton and Maclean Flood Levee Overtopping Hydraulic Assessments 2010
  - Clarence Valley Local Flood Plan 2017
- Document the Flood Planning Levels relevant to the Site
- Discuss the existing and post-development flood risk and flood impacts to the surrounding properties
- Outline the relevant flood preparedness and evacuation requirements, including the triggers for enacting a Flood Action Plan.

It should be noted that no hydrologic or hydraulic modelling has been undertaken as part of this assessment.

Document Review

The following information was considered relevant from the document review. Further commentary on key aspects is presented in the sections below.

Clarence Valley LEP 2011

The Clarence Valley LEP outlines high level objectives in relation to flood planning, which are outlined below:

- To minimise the flood risk to life and property associated with the use of land.
- To allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change.
- To avoid adverse or cumulative impacts on flood behaviour and the environment.
- To enable the safe occupation and efficient evacuation of people in the event of a flood.

Clarence Valley DCP 2011

- All buildings be set back 3.5m from the toe of any levee wall.
- The proposed development should not result in any increased risk to human life.

- The proposal should only be permitted where effective warning time and reliable access is available for evacuation from an area potentially affected by floods to an area free of risk from flooding. Evacuation should be consistent with any relevant flood evacuation strategy.

- Development should not detrimentally increase the potential flood effects on other development or properties either individually or in combination with the cumulative impact of development that is likely to occur in the same floodplain.

- Motor vehicles are able to be relocated, undamaged, to an area with substantially less risk from flooding, within effective warning time.

- Procedures should be in place, if necessary, (such as warning systems, signage or evacuation drills) so that people are aware of the need to evacuate and relocate motor vehicles during a flood and are capable of identifying an appropriate evacuation route.

- No net filling of land is permitted in Grafton, South Grafton and the Heber Street Catchment within the Grafton floodplain below levels 4.2, 4.65 and 5.7m AHD respectively.

- The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood conveyancing; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.

Clarence Valley Local Flood Plan 2017

Note, this plan is scheduled for review.

- The first evacuation warnings issued in the Clarence Valley Council area can be expected under the following flood height predictions at Prince Street gauge:

    - Predicted to reach or exceed 7.8m of greater – Targeted Evacuation Warning issued for Grafton Sub Sector A.

    - Predicted to reach or exceed 7.9 to 8.0m – based on monitoring and assessment of levee condition, A Targeted Evacuation Order will be issued for Sub Sector A Dovendale and surrounds (area bounded by Clarence Street, Bacon Street, Prince Street and the Clarence River) and other low lying areas. Targeted Evacuation Warning issued for Grafton Sub Sectors B, C, D.

    - Predicted to reach or exceed 8.2m or greater – Targeted Evacuation Order for Sub Sectors B, C, D and all low lying areas in North and South Grafton.

- The estimated peak height flow times are as follows. Travel times of flood peaks can vary significantly from flood to flood, therefore the times listed below should be regarded as approximations only.

    - Tabulam to Grafton: 16-20 hours travel time.

    - Towgan Grange to Grafton: 6-14 hours travel time.

- North Grafton Levee - The current accepted safe flood height by Council is 7.9-8.0 m at the Prince Street gauge, however the freeboard level is not known.

    - In a 1 in 20 AEP event (7.9m at the Price Street gauge), there is approximately 15.5 hours to overtopping. There is minimal overtopping at the low points on the levee.

- In a 1 in 50 AEP event (8.2m at the Prince Street gauge) and a 1 in 100 AEP event (8.3m at the Prince Street gauge) there is approximately 14 hours and 13.5 hours from the major flood level until there is major overtopping at low points on the levee respectively.

- Table 1.2 lists the relevant roads liable to flooding

Table 1.2 Roads liable to flooding

Road	Closure Location	Indicative gauge height Prince Street gauge	Approximate time to flooding from levee overtopping
Clarence Street	Between Fitzroy and Pound Streets	8.2-8.3m	4.0-4.8 hours
Clarence Street	Between Pound and Hoof Streets	8.0-8.2m	3.2-4.0 hours
Fitzroy Street	Between Prince and Clarence Streets	8.0-8.2m	2.0-2.5 hours
Pound Street	Between Prince and Clarence Streets	8.0-8.2m	2.5-3.0 hours
Prince Street	Between Fitzroy and Pound Streets	8.0-8.2m	3.6-5.8 hours
Prince Street	Between Pound and Oliver Streets	8.0-8.2m	3.5-5.6 hours
Prince Street	Between Oliver and Dobie Streets	8.0-8.2m	4.4-5.8 hours
Prince Street	Between Dobie and Hoof Streets	8.0-8.2m	4.6-6.2 hours
Oliver Street	Between Queen and King Streets	8.0-8.2m	4.0-6.2 hours
Dobie Street	Between Queen and King Streets	8.0-8.2m	4.0-6.2 hours
Bent Street	At the intersection with Charles Street	8.2-8.3m	6.6-11.1 hours

Grafton and Maclean flood levee overtopping: hydraulic assessments 2010

- 1 in 100 AEP overtopping locations: Grafton levee between Prince and Dobie Streets, timing – 43hrs, Prince St gauge level = 8.05m AHD – major overtopping. Peak flood level = 8.36m AHD
- 1 in 50 AEP overtopping locations: Grafton levee between Prince and Dobie Streets, timing – 44hrs, Prince St gauge level = 8.02m AHD – major overtopping. Peak flood level = 8.30m AHD
- 1 in 20 AEP overtopping locations: Grafton levee between Prince and Dobie Streets, timing – 48hrs, Prince St gauge level = 7.89m AHD – minor overtopping.

Flood Planning Levels

The Flood Planning Levels (FPL) are stipulated in the Development Control Plan 2011. The Site is the RE1 – Public Recreation land use planning zone. The DCP stipulates that the *habitable floor level* is to be no lower than the 1 in 100 AEP flood level plus freeboard, where the freeboard equals an additional heigh of 500mm. Furthermore, all floor levels are to be no lower than the 1 in 5 AEP flood level plus freeboard, unless justified by the site specific assessment.

Note, the DCP defines *habitable floor level* as:

- In an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.

According to Council's online mapping, the maximum 1 in 100 AEP flood level experienced on-site is between 8.22-8.32m AHD. Therefore the FPL for the habitable floor levels on Site will be a maximum of 8.82m AHD.

The 1 in 5 AEP flood level experienced on-site is shown to be between 6.03-6.11m AHD. Therefore, the floor levels in the non-habitable areas are to be no lower than 6.61m AHD.

The existing building has floor levels below the FPL. The new upper deck area would be considered as non-habitable floor level, and therefore meets the FPL requirements.

Flood Risk

Figure 1.2 to Figure 1.5 show the peak flood elevations for the 1 in 5 AEP, 1 in 20 AEP, 1 in 100 AEP and PMF design flood events respectively. The flood mapping shows that the existing buildings on Site begin to get inundated in a 1 in 5 AEP design flood event and are fully inundated during a 1 in 20 AEP design flood event and higher. Information on Council's interactive mapping show that the flood levels on Site range from a minimum of 6.03m AHD in a 1 in 5 AEP event, 8.32m AHD in a 1 in 100 AEP event, to a maximum of 9.64m AHD in a PMF event.

In relation to the building, the boatshed area and mezzanine floor are likely to be impacted from a 1 in 5 AEP design flood event. The upper deck is likely to be impacted from a 1 in 100 AEP design flood event.

The Prince Street Gauge is located in close proximity to the Site, therefore flood levels at the Gauge are assumed to be reflective of flood levels at the Site. Note that a Minor flood (2.1m AHD) at the Prince Street Gauge is likely to begin impacting the boatshed area (ground floor). The proposed mezzanine floor will be impacted between a Moderate (3.6m AHD) and Major (5.4m AHD) flood classification.

Council's online mapping provides information on flood hazard, with the flood hazard classification being defined by the Australian Emergency Management Institute in 2014. Table 1.3 provides a definition of these hazard categories and Figure 1.7 shows the flood hazard across the Site. Close to the Clarence River, there is an extreme flood hazard (H6). Where the existing building is located, the flood hazard is between H5 and H2. The development on-site will need to ensure that they are designed to be able to withstand the expected hydraulic forces of floodwater during flooding events.

Table 1.3 Flood Hazard Definitions

Hazard Classification	Description
H1	Relatively benign flow conditions. No vulnerability constraints.
H2	Unsafe for small vehicles.
H3	Unsafe for all vehicles, children and the elderly.
H4	Unsafe for all people and all vehicles.
H5	Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
H6	Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building types considered vulnerable to failure.

During the 1 in 20 AEP event, velocities across the site range from 0.05m/s to 1.18m/s. During a 1 in 100 AEP event the velocities (refer Figure 1.6) across the site range from 0.46m/s to 1.35m/s, with velocities between 0.73m/s and 0.93m/s around the existing building.

Legend

- Site Boundary
- Levee
- Cadastral Boundaries

Title:

1 in 5 AEP Design Event Peak Flood Elevation

Drawing: 1-2

Rev: A

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- Site Boundary
- Levee
- Cadastral Boundaries

Title:

1 in 20 AEP Design Event Peak Flood Elevation

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- Site Boundary
- Levee
- Cadastral Boundaries

Title:

1 in 100 AEP Design Event Peak Flood Elevation

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- Site Boundary
- Levee
- Cadastral Boundaries

Title:

PMF Design Event Peak Flood Elevation

Drawing: 1-5

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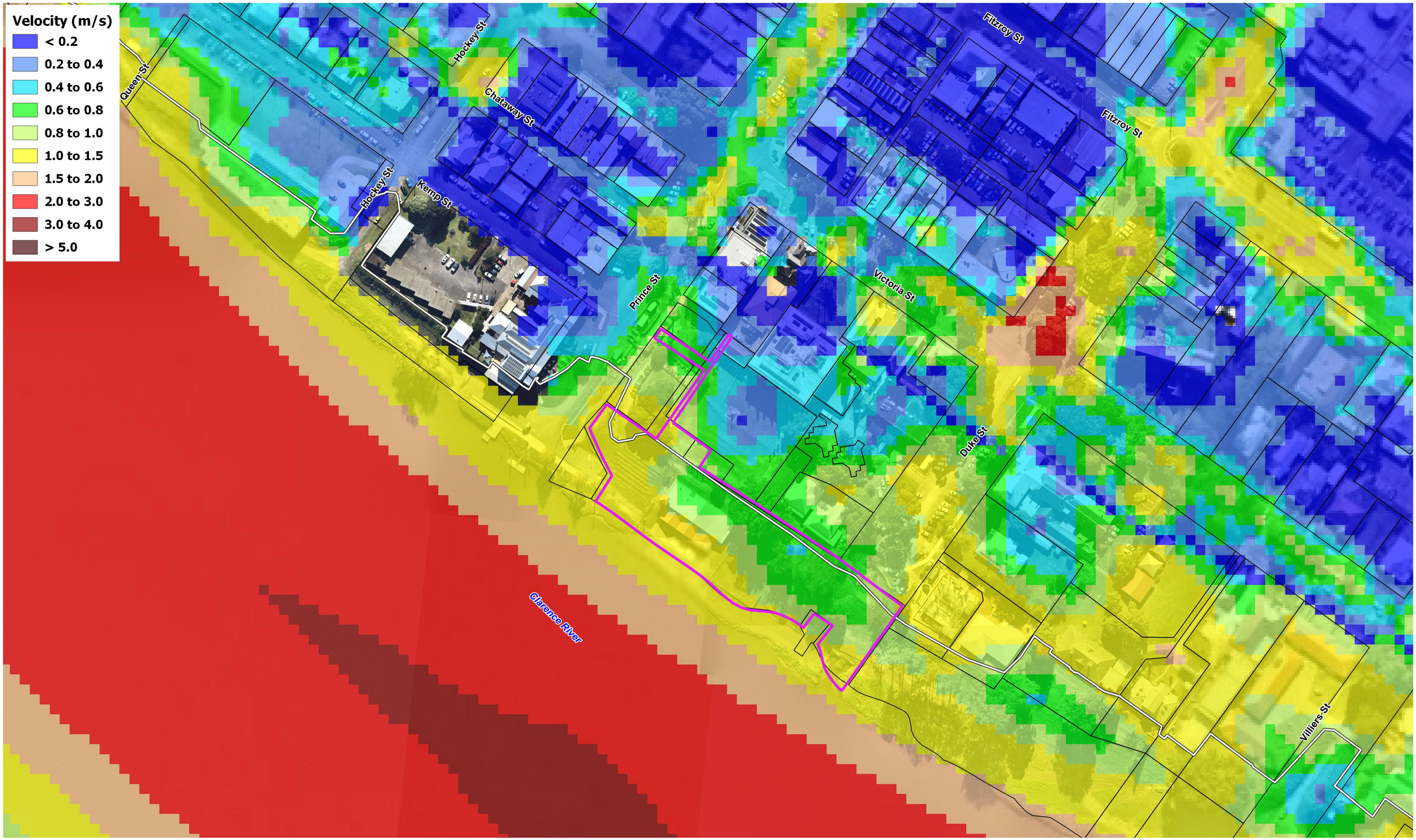

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- Site Boundary
- Levee
- Cadastral Boundaries

Title:

1 in 100 AEP Design Event Peak Flood Velocity

Drawing: 1-6

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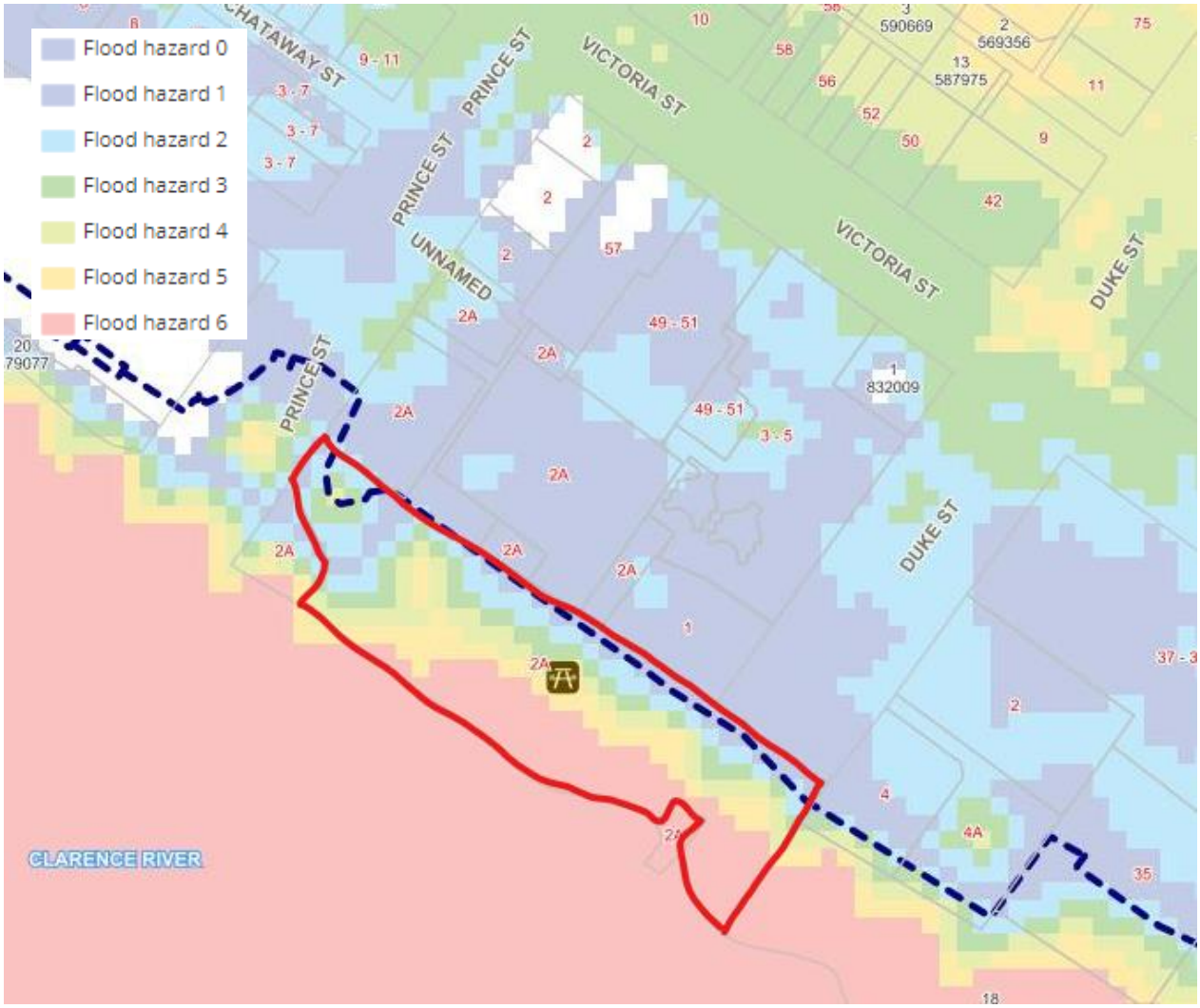

Figure 1.7 Flood Hazard (Source: Clarence Valley Council's Interactive Mapping)

Flood Impact

It is expected that the proposed development will have minimal flood impact to the surrounding area. There will be an addition of approximately 245m^2 enclosed floorspace located within the Upper Deck as well as 264m^2 of covered deck area. The upper deck area will begin to get above floor flooding during the 1 in 100 AEP design flood event, with a maximum flood depth of 20mm. Therefore, the additional floor space will not greatly change the flood storage of the 1 in 100 AEP design flood event, likely resulting in minimal flood impact.

Flood Preparedness Requirements

A staged approached to flood preparedness is recommended, depending on the predicted flood level at the Prince Street gauge.

Consideration needs to be given for the security of the equipment if it is stored on the open parts of the deck. There is also a risk that if equipment is stored on the open parts of the deck, and the flooding is higher than predicted, leading to the equipment being washed away and unable to be recovered.

It is also recommended that a procedure be developed outlining what equipment requires removal, where things will be relocated to, the best route between the locations and any WHS requirements.

Stage 1 – Ground level preparations

The ground level of the boatshed begins to get inundated when the Prince Street Gauge exceeds the Minor flood classification (2.1m AHD). It is therefore recommended to begin relocating equipment when the gauge is predicted to meet or exceed the Minor flood classification.

If there is confidence that this prediction is not going to be revised higher, then equipment from the ground floor can be moved to higher levels of the building. If equipment is placed on the Mezzanine floor and the gauge is expected to exceed the Moderate flood classification, then Stage 2 will need to be enacted. If equipment is placed on the deck and the flood level at the gauge is expected to exceed 8.3m AHD, then Stage 3 will need to be enacted.

Stage 2 – Mezzanine floor preparations

The mezzanine floor, which is the first habitable floor, becomes inundated between the Prince Street gauge reaching the Moderate and Major flood classifications, at approximately 4.8m AHD. It is therefore recommended to begin relocating equipment when the gauge is predicted to exceed the Moderate flood classification. If equipment is placed on the deck and the flood level at the gauge is expected to exceed the Major flood classification, then Stage 3 will need to be enacted.

Stage 3 – Deck preparations

The deck becomes inundated when the Prince Street gauge reaches a flood level of 8.3m AHD. If flood levels reach this level, it is likely that the SES would have issued an evacuation order for the Site, as per the Local Flood Plan (SES, 2017). It is recommended to consider moving equipment off Site if the flood level is expected to exceed the Major classification.

Evacuation Requirements

The Site gets impacted by flooding during frequent flood events and does not have an area that is flood free in flood events from the 1 in 100 AEP design flood event. This means that there is no flood-free refuge on Site, evacuation is the preferred option for the Site.

Rate of Rise

Based on the information available in the Local Flood Plan (SES, 2017), the flood waters are estimated to have an approximate rate of rise of 0.2m/hour. It therefore takes approximately 7.5 hours between the Prince Street gauge reaching the Minor and Moderate flood classifications and 9 hours between the Moderate and Major flood classifications.

Site Access

There is no dedicated parking on-site. People visiting the Site are likely to park on either Prince or Duke Streets. The parking along Duke Street is protected by the levee, as is some parking on Prince Street, located approximately 60m away from the Clarence River. The levee protects against flooding up to a level of approximately 8.1m AHD, which equates to approximately the 1 in 20 AEP design flood event. There is a section of parking in Prince Street along the Clarence River that is unprotected by the levee, which is inundated in a 1 in 5 AEP design flood event, with flood levels at approximately 6.08m AHD.

Evacuation Route

The preferred SES evacuation route from the Site is shown in Figure 1.8 - the Site is located in Sector A. As can be seen, the evacuation route where cars leaving the Site would join is along Fitzroy Street, approximately 2 blocks to the north of the Site. This evacuation route crosses the Clarence River at the Grafton Bridge (Craig Street), following Bent Street until turning right onto Tyson Street to reach the evacuation centre at the South Grafton High School. The first road closure along this route occurs at the intersection of Craig and Clarence Streets, which occurs when the water level at Prince Street gauge reaches 8.2m AHD, approximately 18.4 hours after the gauge reaches the Major flood classification.

Note, Grafton will not begin to be evacuated until after the Boatshed has been inundated, due to the protection of the levee. Therefore, when the Boatshed is evacuated, an evacuation centre is not likely to be established or in operation. People evacuating the Site are likely to be able to return to their residences until the SES initiate the evacuation of the town.

Evacuation Timeline

The current information indicates that there is adequate time to evacuate the Site before the mezzanine floor is inundated and before the first closure of the evacuation route. It is recommended to begin evacuation preparations if the Prince Street gauge is expected to exceed the Moderate flood classification. This will give approximately 5 hours to organise evacuation before the mezzanine floor is inundated. It is recommended to ensure that visitors to the Site are evacuated before the mezzanine floor is inundated. .

Note: as the lower parts of the Site are inundated prior to the Prince Street gauge reaching the Minor classification, staff will already be enacting flood preparedness actions.

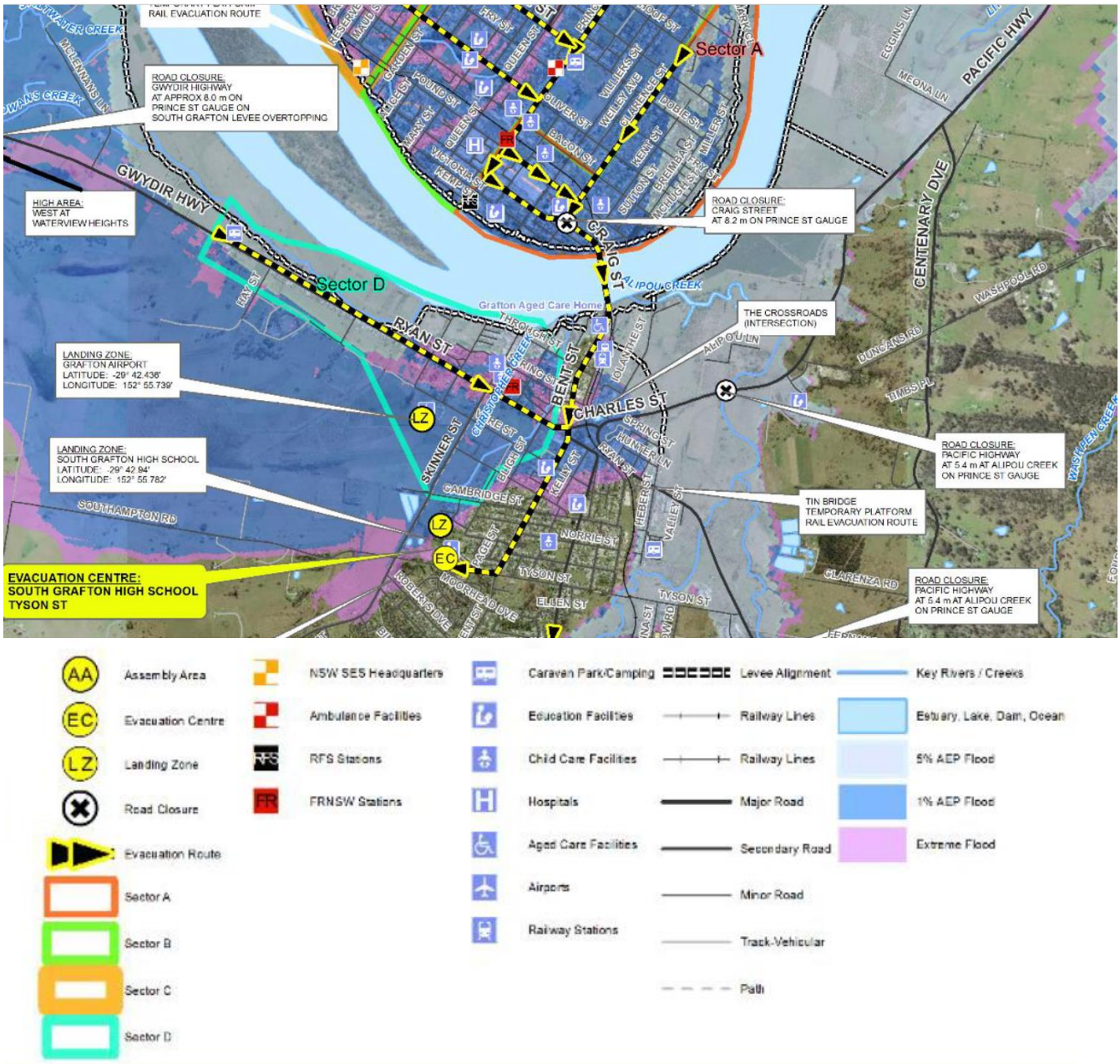

Figure 1.8 Evacuation Route for Site (Source: Clarence Valley Local Flood Plan, 2017)

Triggers for enacting a Flood Action Plan

Table 1.4 provides a summary of the triggers for enacting different components of the flood action plan. It also shows the gauge heights that different parts of the Site are inundated and the approximate time between the action and the inundation of the relevant part of the Site.

Table 1.4 Flood Action Triggers Summary

Prince Street Gauge Level (m AHD)	Flood Classification	Part of Site Inundated	Stage	Flood Action	Approximate time to inundation (hrs)
1.0	Below Minor		Flood Preparedness – Stage 1	Relocate equipment from boatshed (ground level)	2
1.41	Below Minor	Ground floor boatshed inundated			
3.6	Moderate		Flood Preparedness – Stage 2	Relocate equipment from mezzanine floor	6
			Evacuation	Prepare to evacuate	
4.0	Exceeding Moderate		Evacuation	Begin evacuation	4
4.775	Exceeding Moderate	Mezzanine floor inundated			
5.4	Major		Flood Preparedness – Stage 3	Relocate equipment from deck	3hrs to carpark inundation 14.5hrs to deck inundation
6.08	Exceeding Major	Car park in Prince Street inundated			
8.3	Exceeding Major	Deck inundated			

Conclusion

The proposed redevelopment of the Grafton Boatshed is not expected to cause significant impact to flood behaviour in the surrounding areas.

The Site is impacted during frequent flood events, with the boatshed and mezzanine levels being impacted from the 1 in 5 AEP design event, and the proposed Upper Deck from the 1 in 100 AEP design event. Due to the fact that the Site is in front of the flood levee, the Site becomes fully inundated before the SES evacuation triggers. Therefore, it is recommended that the Site has their own Flood Action Plan, encompassing elements discussed in this document, and in line with Section D.3.1.f of the Clarence Valley DCP (2011). The Flood Action Plan should be discussed with the Local NSW SES and Council to ensure its suitability.

Yours Sincerely,

BMT

Melissa Blum
Senior Flood Engineer