West Yamba Flood Evacuation Plan

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Synopsis	A Flood Evacuation Plan for a development within the West Yamba Urban Release Area (WYURA) at Yamba, New South Wales

Author	Melissa Blum
Reviewed By	Barry Rodgers
Project Manager	Melissa Blum

Amendment Record

The Amendment Record below records the history and issue status of this document.

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1 Introduction

West Yamba Landowners Consortium through Mortons Urban Solutions (MUS) has commissioned BMT to undertake a Flood Evacuation Plan for the development within the West Yamba Urban Release Area (WYURA) at Yamba, New South Wales. The subject development consists of the following and is collectively termed 'the Site' for the purposes of this report:

- Lots 46 and 47 on DP751395, referred to as 'Yamba Gardens'.
- Lot 21 on DP1277589 fronting Carrs Drive, referred to as 'Northern Developments'.
- Lot 18 on DP1090409 fronting Miles and Golding Streets, also referred to as 'Northern Developments'.

The Flood Evacuation Plan has been requested by Clarence Valley Council (Council) '*to address the impacts of the proposed development on evacuation during flooding events'*. It should ensure that the proposal '*will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood'*. The assessment has been undertaken for riverine flooding only, for which evacuation is proposed. Non-riverine flood events, such as local catchment flooding or oceanic flooding are not included, as evacuation is not proposed for these types of events.

BMT has previously undertaken a Flood Impact Assessment (FIA) for the Site in 2021 (R.A11309.001.02_Final_Report.pdf). The FIA describes the baseline riverine flood behaviour and the changes to that behaviour due to the proposed development. The Flood Evacuation Plan should be read in conjunction with the FIA.

1.1 Site description

The West Yamba Local Environment Plan (LEP), gazetted 23/4/2010, identified part of the land at West Yamba as '2(C) Residential'. This land is referred to as R1 land in the Clarence Valley LEP (2011). The R1 residential land occupies the majority of the WYURA and covers approximately 116ha. The land is predominantly flat, low-lying land in close proximity to the tidal waters of the Clarence River, Oyster Channel and Lake Wooloweyah. Existing ground levels typically vary between 1 and 2m AHD and due to its elevation, the land is generally flood prone.

The Yamba Gardens and Northern Developments will include residential lots which will be filled to enable 'slab on ground' dwelling construction and provide appropriate flood immunity. The filling is to be undertaken to a sufficient level to enable minimum floor height requirements to be achieved. Minimum floor heights are based on relevant flood planning levels which, in turn, are based on the 1 in 100 Annual Exceedance Probability (AEP) design flood level with additional allowances for climate change and freeboard.

The 1 in 100 AEP flood hazard across most of the Site (undeveloped) has been classified as H3 as defined by the Australian Institute for Disaster Resilience (AIDR) in 2017. This indicates that during this event most of the area is considered unsafe for all vehicles, children, and the elderly, as defined in Table 1.1 and Figure 1.1.

Table 1.1 AIDR (2017) Flood Hazard Definitions

Hazard Classification	Description
H1	Relatively benign flood conditions. No vulnerability constraints.
H2	Unsafe for small vehicles.
H3	Unsafe for all vehicles, children, and the elderly.
H4	Unsafe for all people and 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.

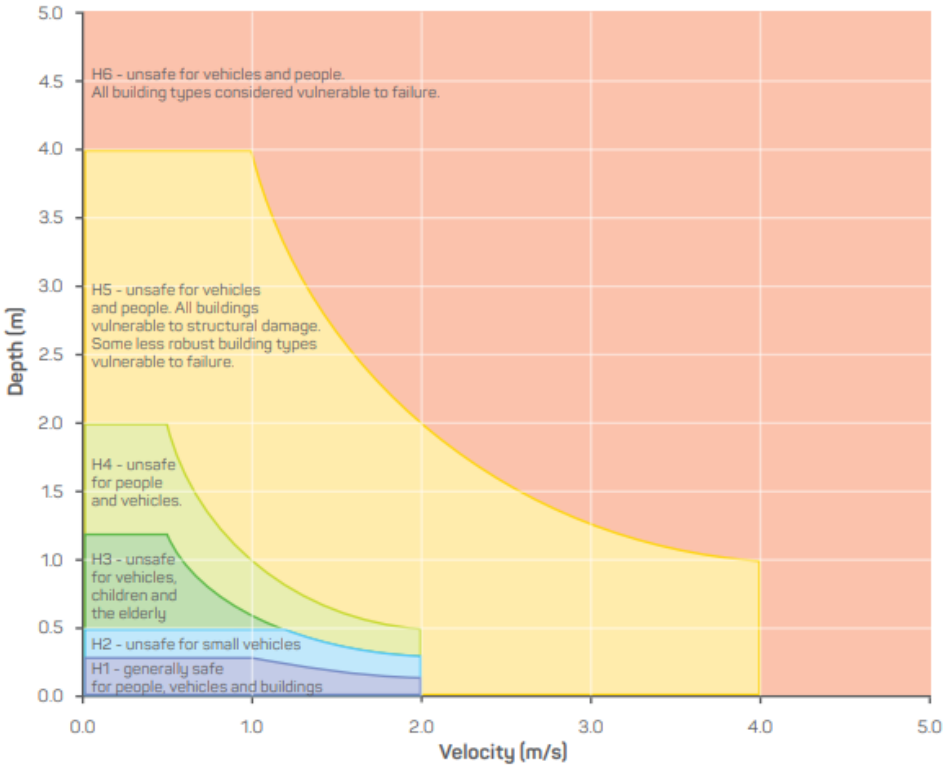


Figure 1.1 General flood hazard vulnerability curves (AIDR, 2017)

1.2 Overview of Assessment

The assessment consists of the following:

- Review of relevant legislation, guidelines and standards (Section 2).
- Assessment of evacuation routes (Section 3.2).
- Evacuation centre capacity (Section 3.3).
- Assessment of change in hydraulic risk with regard to evacuation capacity (Section 3.4).

  Evacuation timeline assessment (Section 3.5).

2 Document review

A review of existing relevant documentation relating to flood evacuation considerations has been undertaken. Key documents and key relevant points from within those documents are summarised below.

2.1 Clarence Valley Council Development Control Plan 2011

Part D of Clarence Valley Council's Residential Zones Development Control Plan (2011) sets out floodplain management controls and performance criteria. Performance Criteria relevant to evacuation include the following:

- The proposed development should not result in any increased risk to human life (D3.1a).
- 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 (D3.1c).
- Motor vehicles are able to be relocated, undamaged, to an area with substantially less risk from flooding, within effective warning time (D3.1e).
- Procedures would 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 (D3.1f).

Schedule D4 of the Residential Zones DCP details prescriptive controls for floodplains, including the Yamba floodplain. Compliance with the prescriptive controls is deemed to demonstrate compliance with the performance criteria. The following prescriptive controls are relevant for flood evacuation for West Yamba.

1. Reliable access for pedestrians or vehicles required during a 100 year flood to a publicly accessible location above the Probable Maximum Flood (PMF).
2. Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF level, or at a minimum of 20% of the gross floor area of the dwelling to be above the PMF level.
3. The development is to be consistent with any relevant *flood evacuation strategy, Flood plan adopted by Council* or similar plan.
4. The evacuation requirements of the development are to be considered. An engineers report will be required if circumstances are possible where the evacuation of persons might not be achieved with the effective warning time.
5. Safe and orderly evacuation of the site (in any size flood) has been demonstrated in a regional evacuation assessment prepared to the satisfaction of Council and the SES. Where such an assessment has not been prepared, development will only be permitted where, in the opinion of Council, safe and orderly evacuation can occur (in any size flood).
6. Adequate flood warning is available to allow safe and orderly evacuation (in any size flood) without increased reliance upon the SES or other authorised emergency services personnel.

2.2 Clarence Valley Local Flood Plan (NSW SES, 2017)

The Clarence Valley Local Flood Plan was prepared by the NSW SES and covers issues relating to the preparedness, response and recovery from flooding within the Clarence Valley LGA. The current version of the plan was prepared in 2017 and it is scheduled for review. The following key relevant points are noted from the plan:

- Yamba is located at the mouth of the Clarence River on the coast, on the southern bank. It is considered an aged community, with 32% of people over 65 (refer Figure 2.1). It has 4.8% indigenous population.

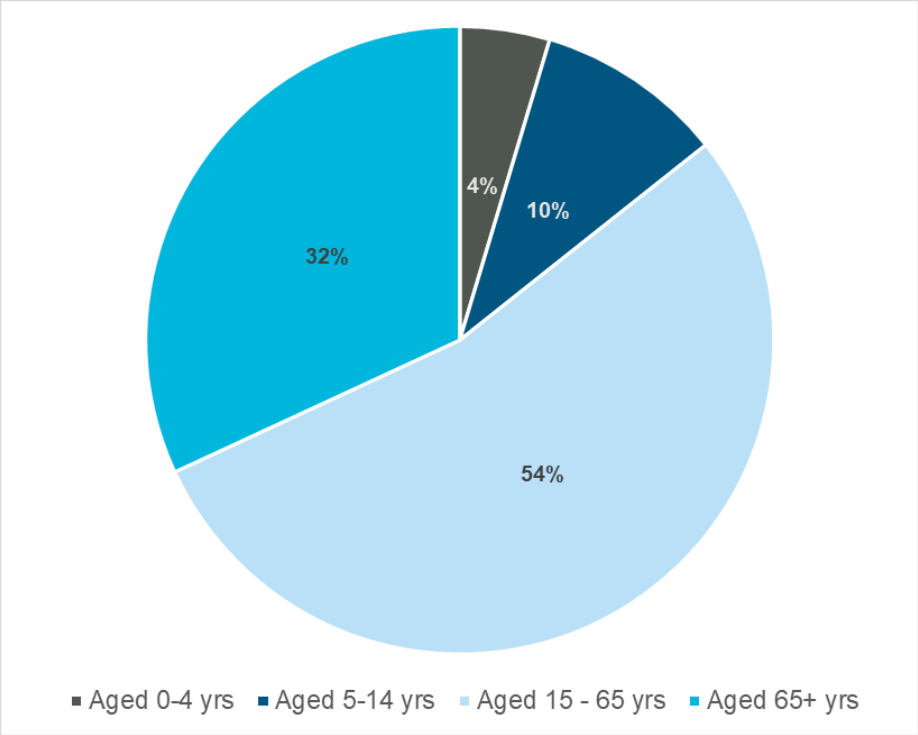


Figure 2.1 Age demographics of Yamba community

- The following location is suitable for use as a flood evacuation centre:
  - Yamba Bowling & Recreation Club
- Yamba is classified as a high flood island.
- The key flood warning gauge for Yamba is Maclean.
- Yamba has four peak seasons with a potential population increase of more than 100%:
  - School holiday tourist influx late December/January.
  - School holiday tourist influx April.
  - School holiday tourist influx July.
  - School holiday tourist influx September/October.

- Inundation can occur from 2.4m (1.5mAHD) on the Yamba gauge dependant on the tides. Streets affected include the Halyard, Telopea Street, Melalueca Drive, Wooli Street, Carrs Drive, Yamba Plaza, Endeavour Street, Deering Street, Golding Street, Cook Street and Shores Drive.
- Estimates from Clarence Valley Council indicate that up to 1,000 properties may be flooded in a 1% AEP flood (3.6m on the Maclean gauge) in Yamba and 2,400 in an extreme event (5.1m on the Maclean gauge).
- Access from Yamba to Maclean and Grafton is cut at Cloverleaf Harwood Bridge (Yamba Road) at 2.1m at the Maclean Gauge.
- At 2.4m at the Maclean gauge, Yamba is completely isolated.
- Except in very serious floods isolation tends to be short-term of up to five days and most people in the area are self-sufficient for this period of isolation.
- Maclean gauge flood classifications: Minor: 1.60m, Moderate: 2.20m, Major: 2.50m.
- Maclean gauge design flood levels: 20% AEP: 2.4m, 5% AEP: 3.1m, 2% AEP: 3.4m, 1% AEP: 3.6m, 0.5% AEP: 3.94m, Extreme: 5.1m.
- General strategy:
  - Evacuation of at-risk population.
  - Self-evacuation to friends/family outside of the impact area.
  - Establishment of an Assembly Area / Evacuation Centre at the Yamba Bowling Club Wooli Street, Yamba, where evacuees are able to gather while flood situation is monitored.
- Key risks / consequences:
  - Potential loss of life from rapid and potentially high velocity flooding inundation.
  - Potential isolation of thousands of people estimated to be for a number of days.
- Evacuation triggers: the effect of flooding on the town and outlying areas in this sector is very much dependant on tidal influences. Tidal levels will need to be identified at the onset of main Clarence River flooding. The key evacuation triggers based on BoM flood height predictions at the Maclean Gauge:
  1. **Prediction to reach and/or exceed 2.1m.** local warnings will commence. Yamba becomes isolated at the Cloverleaf and also the intersection of Yamba Road and Palmers Channel South Bank Road, depending on tidal conditions (at 760 Yamba Road).
  2. **Prediction to reach and/or exceed 2.4m.** Low lying areas of Shores Drive, the Halyard and 4 houses on Yamba Drive [1]near Coles are subject to flooding. Other areas affected are Golding Street, Cook Street, Endeavour Street and Deering Street.

[1] We understand this is likely to mean Yamba Road.

3. **Prediction to reach and/or exceed 3.6m.** Targeted Evacuation Warning / Order to be considered for Yamba based on local conditions.

- 1% AEP flood event is 3.23m (Harwood gauge) and 3.6m (Maclean gauge).

- Residents wishing to leave Yamba need to do so before a height of 2.1m is reached on the Maclean gauge.
- Road closures which may affect the isolation of the town:
  - Local roads around Yamba will open and close, depending on local rainfall and tidal conditions.
  - Yamba Road closes at 2.1m on the Maclean gauge.
  - Pacific Highway[2] closes at 2.1m on the Maclean gauge at the Cloverleaf bridge (southern approach to Harwood Bridge 5km north of Maclean).
  - Pacific Highway at Ferry Park, Maclean at 2.5m on the Maclean gauge.
  - Pacific Highway closes at Alipou Creek at 5.4m on the Prince Street (Grafton) gauge.
- Resupply will be provided by the NSW SES through the 132500 call out system. The Coles supermarket will be resupplied if required; this will ensure that Yamba residents are continually provided with essential food items.
- Helicopter landing zones: Pilot Hill, RSL Sub Branch Oval and Main Town Oval, Coldstream Street.

[2] Since the SES Local Flood Plan was published the Pacific Highway Upgrade has completed and the former Pacific Highway is now referred to as Big River Way.

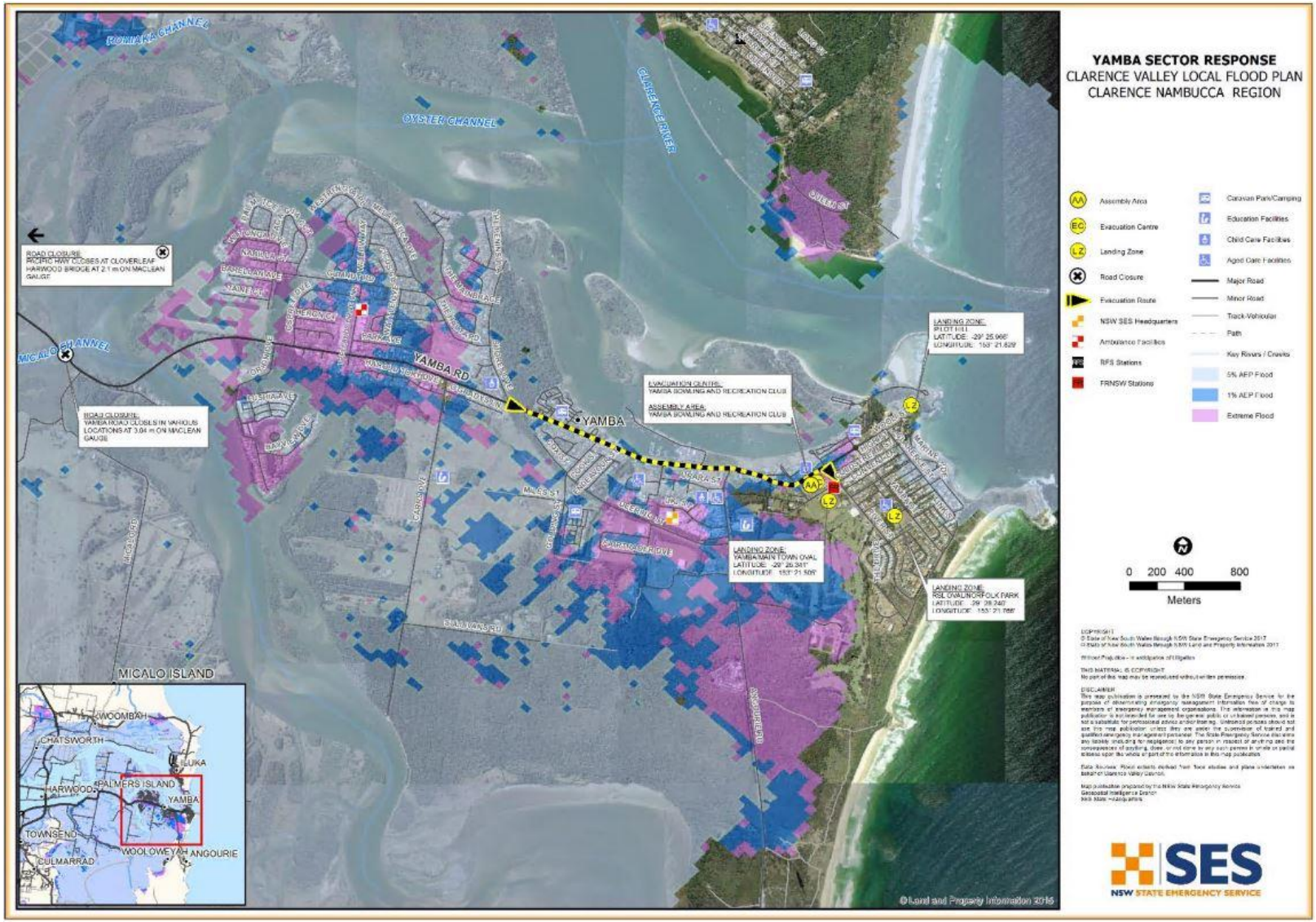


Figure 2.2 Yamba Sector Map (from Clarence Valley Local Flood Plan, SES, 2017)

2.1 Yamba Floodplain Risk Management Study (Webb, McKeown & Associates, 2008)

The Yamba Floodplain Risk Management Study considers the flood mechanisms and behaviour and assesses the potential for floodplain risk management measures to reduce the risk of flooding to the community. The study also included a section on the future proposed rezoning at West Yamba with consideration of specific management measures.

The following relevant points are summarised. *Note, any modelling results used to inform the assessment are based upon the 2004 model, which has since been superseded.*

- The original township developed near the mouth of the Clarence River, on "Yamba Hill". For the most part development in this area, and in general, east of Angourie Road, is flood free. There is a significant area of residential development adjacent to the boat harbour along Yamba Road (referred to here as "Middle Yamba") which has occurred over the last 30 years. A large portion of this area is on low-lying land and is flood liable.
- Flooding at Yamba can occur as a result of four main mechanisms:
  - Inundation due to high flows in the Clarence River during times of flood.
  - Inundation from the Clarence River during times of high ocean levels (storm surge activity and/or high tides).
  - Wind/wave action along the southern foreshore of the Clarence River. This mechanism is largely outside the scope of this present investigation.
  - Intense rain over the township of Yamba causing ponding in low lying areas as a result of inadequate local drainage. This mechanism is largely outside the scope of this present investigation.
- The flood warning/time till inundation for the first two mechanisms are of the similar magnitude, approximately 24 hours. However, as with all forms of warning it will vary from event to event and be dependent upon the circumstances at the time.
- Yamba Road is the sole access into the township and it becomes inundated in approximately the 10y ARI or greater events. An additional access road into the town (from east of Oyster Channel to Yamba Hill) has been proposed (Yamba Bypass). However, it remains in the concept stages and details regarding length, capacity, road level etc., have not yet been determined. As at November 2007 it is assumed that the bypass will not be flood free. A number of internal roads west of Angourie Road also become inundated during significant flooding events (10y ARI and greater).
- The only major creek system linking the Clarence River to the floodplain south of Yamba Road is the unnamed creek between Endeavour and Freeburn Streets. However the capacity of this creek to convey significant flows across Yamba Road is severely restricted due to the small culvert capacity under Yamba Road, the height of Yamba Road at this point (approximately 1.5 m AHD[3]) and the surrounding buildings and fences.
- The height of Yamba Road (lowest point 1.4 m AHD and highest point 2 m AHD) and adjoining buildings on either side means that there is no clearly defined floodway taking a significant amount of flow across Yamba Road in events up to the 100y ARI.
- The amount of time for evacuation of low lying communities to high ground depends on the available warning time. This is critical for Yamba as access out of the township to the Pacific Highway has been cut in the past due to flooding and local roads have been inundated. Providing sufficient warning time has the potential to reduce the social impacts of the flood as well as reducing the strain on emergency services.

[3] Based on more recent LiDAR data the road elevation at this location is closer to 2.0mAHD.

- Flood warning, and the implementation of evacuation procedures by the SES, are widely used throughout NSW to reduce flood damages and protect lives. The Bureau of Meteorology (BoM) is responsible for flood warnings on major river systems such as the Clarence River. The flood warning system is based on stations which automatically record rainfall or river levels at upstream locations and telemeter the information to a central location. Consideration is also given to ocean storm surge (where applicable) by the use of a simple tidal algorithm. Analysis is then undertaken to determine the expected time, duration and height of the flood peak.
- At Yamba there are two critical stages for receiving flood warnings. The first is before the main access road into Yamba from the Pacific Highway is cut and the second is before inundation of the township itself.
- Whilst in general one would expect Yamba to have up to 24 hours of an approaching flood (either from the ocean or from Clarence River flooding) this should not be taken as a definitive timeframe. In the absence of oceanic effects, 24 hours is realistic, taking into account the time for the flood wave to travel down the river from upstream. However in the majority of floods there is an associated oceanic effect, as a result of the same meteorological conditions that caused the flood producing rainfall. The magnitude and timing of this effect are very difficult to predict and can develop in less than 12 hours. The situation is further compounded as most residents will be “unfamiliar” with the likely impacts of oceanic effects and are therefore unlikely to respond in the same manner as they might if given advanced warning of river flooding.
- It is impossible therefore to provide a definitive timeframe of the available flood warning time. At a minimum this is likely to be 6 hours and a maximum of over 24 hours. However each flood will respond in a different manner.
- The existing flood warning program for Yamba is considered to be sufficient. However possible improvements include providing advice on the deadline when Yamba residents can evacuate the township to high ground and ensuring best practice is employed on providing advice on ocean storm surge and wave runup activity. The program should be reviewed every two years (or after a significant flood event) so as to ensure it remains the best practice available.
- Yamba Road is the sole evacuation route out of Yamba to the Pacific Highway and it becomes inundated during flood events (10y ARI or greater). Similarly there are a number of internal roads which are also inundated in flood events. This means evacuation from the town is problematic and can only occur prior to Yamba Road being cut by floodwaters. There is a permanent SES team located within Yamba however they also service the neighbouring towns which are often affected by the same flood events.
- It is accepted that in a major flood the township of Yamba (and many other urban centres in the region) will be isolated and will need to be able to “survive” without outside assistance for 2-3 days. Yamba is large enough that it has sufficient accommodation, medical services and food for this period. The only exception would be a major medical disaster. The aim of evacuation planning for Yamba is to ensure that the community is “together” on “dry” ground and can obtain the use of the facilities in Yamba. It is not proposed that the population be moved elsewhere during a flood.
- It is difficult to identify the critical point or stage in a flood where access along Yamba Road will be cut, as it is likely to depend upon a combination of ponding of local runoff, Clarence River floodwaters and ocean inundation. The importance of each contributor will vary for each event. Based on the available survey the lowest points (1.5 m AHD) on Yamba Road are between Goldings and Freeburn Streets in the east and near Treelands Drive in the west. Yamba Road has a maximum height variation of approximately 0.5m west of Angourie Road. To the east of Angourie Road, Yamba Road rises to high ground.

- Ocean inundation and high flows in the Clarence River can be produced from the same meteorological event. However, in some events the ocean inundation occurs first, prior to the peak rainfall and thus peak Clarence River flood level while in other events it occurs later. Thus it is possible that flooding from ocean inundation may occur well before the peak of the Clarence River flooding occurs. For this reason it is essential that the flood warning predictions take account of ocean effects. Generally a 12 hour warning should be available for an impending ocean event.

2.2 Lower Clarence Flood Model Update (BMT WBM, 2013)

The Lower Clarence Flood Model Update defines design flood extents and levels currently adopted by Council. The model was used to map design flood events for the 20%, 5%, 2% and 1% AEPs. The Extreme Event was also modelled using a 1% AEP scaling factor of 1.53 which was retained from the 2004 study.

The study includes three 1% AEP climate change scenarios, all with a 10% increase in rainfall and with varying allowances for sea level rise. The sea level rise amounts of 0.4m and 0.9m were applied on top of the 1% AEP storm tide peak of 2.6mAHD. Many of the assumptions in relation to design floods were retained from earlier studies. This includes the significant ocean storm surge which has been retained in the model since a study undertaken in 1988.

2.3 Draft Shelter in Place Guideline (DPE, 2022)

The Draft Shelter in Place Guideline aims to provide clear and consistent guidance to councils and consent authorities about when shelter in place can be used as an alternative to off-site evacuation for emergency management in flood events. The draft guideline notes that the primary strategy for the NSW SES is to evacuate people to an area outside of the flood affected area that has adequate facilities to maintain the safety of the community. However, during flash floods, this may not be possible due to the short warning timeframes.

The West Yamba Flood Evacuation Plan is not advocating shelter in place as the intention is that people would be evacuated during a significant riverine flood.

2.4 Support for Emergency Management Planning Flood Risk Management Guideline EM01 (DPE, 2022)

This guideline is comprehensive and is focused more at a council level than a development level. Relevant information to developments and evacuations is summarised below:

In some circumstances site-specific flood response plans have been developed in an attempt to manage the emergency management risks to the future community to support development proposals. The NSW SES does not consider plans developed in this context to be an effective measure for addressing continuing risk to users of new development, nor suitable for addressing the impacts the development may have on the EM risks to the existing community.

These plans do not have the same strategic intent nor scope as emergency management planning undertaken by the NSW SES for communities. In addition, they generally do not consider the emergency management needs and implications for the community and the NSW SES in the lead-up to and during flooding.

Whilst evacuation is identified as the most effective strategy for community safety during flooding, the time available to undertake evacuation can be a key limitation in ensuring the strategy can be effectively carried out. This is primarily assessed based on warning time and time available to enact the evacuation before evacuation routes are cut, or evacuees and emergency services are overwhelmed by floodwaters.

The primary strategy for the NSW SES is evacuation of people to an area outside of the effects of flooding that has adequate facilities to maintain the safety of the community. This is reflected in flood plans developed by the NSW SES in collaboration with councils considering evacuation constraints and logistics.

However, it is acknowledged that there are situations where attempting to evacuate may be more dangerous than not, such as in flash flooding areas. Time to onset of flooding is a key factor in considering evacuation capability and subsequent controls as a risk management measure in these areas. Controls can be placed on development to ensure occupants can have a refuge above even the highest flood level with adequate structural building controls. However, it is recognised that there is no evidence-based method for determining a safe or tolerable duration of isolation that may result from flooding. This is primarily due to the potential for other issues to emerge, including medical emergencies and fire either due to power surges or makeshift lighting or heating.

2.5 Major Evacuation Centres: Public Health Considerations (NSW Health, 2018)

This document provides guidance regarding public health matters that may be considered in the establishment and monitoring of a major evacuation centre, summarised below:

- Where possible and safe, evacuees should be accommodated near their homes.
- People should have sufficient covered living space providing thermal comfort, fresh air and protection from the climate, ensuring privacy, safety and health.
- A covered floor area in excess of 3.5m^2 per person will often be required to meet these considerations. This excludes cooking space, bathing area and sanitation facilities.
- The internal floor-to-ceiling height should be no less than two metres.
- The ambient temperature of the building should ideally be 15-19°C.
- In an absolute emergency, 7L of water should be provided per person per day. Ideally 15L should be supplied, per person per day for drinking, cooking and personal hygiene requirements.
- A ratio of one shower facility per 50 people is suggested if the weather is temperate and one shower facility per 30 people in hot weather.
- Ideally there should be a maximum of 20 people for each available toilet. In the initial phases of an emergency, 50 people per toilet may be used until additional facilities are available.
- There should be an adequate number of wash basins available, the Sphere Project[4] recommends a minimum of one basin per 100 people.
- If laundry facilities are provided, there should be one wash stand per 50 people.
- A safe, secure recreation area should be put aside for children and adults.

[4] The Sphere Project was initiated in 1997 to develop a set of universal minimum standards in core areas of humanitarian response, including shelter and settlement.

3 Flood Evacuation Plan

3.1 Introduction

The flood evacuation plan considers the evacuation routes, evacuation centres and a timeline assessment to provide information on how the development impacts on the evacuation capacity of the area. This assessment is for riverine flooding, where evacuation is proposed. Non-riverine flood events, such as local catchment flooding or oceanic flooding are not included, as evacuation is not proposed for these types of events.

3.2 Evacuation routes

There are four evacuation routes that are being assessed in terms of flood immunity, as outlined below. Routes 1 is currently available, while routes 2, 3 and 4 would require additional works to become functional.

1. Carrs Drive to Yamba Road.
2. Miles Street, Golding Street to Yamba Road.
3. Miles Street, Golding Street, Deering Street (section of road to be constructed) to Angourie Road.
4. Future Bypass.

Investigating when the roads first become inundated, it was found that evacuation routes 1 to 3 are impacted by flooding from the 5% AEP design flood event. Note, the 5% AEP event is the smallest event modelled as part of the FIA, therefore the evacuation route may be inundated in more frequent events.

It is assumed that the future bypass will have a higher flood immunity of at minimum the 1% AEP design flood event.

It should be noted that for the timeline assessment in Section 3.5, only one route was considered. The reasoning for using only one route in the timeline assessment, is that all the proposed evacuation routes eventually utilise Yamba Road. Therefore, the capacity of Yamba Road is the constraining factor during an evacuation.

3.3 Evacuation centre capacity

The SES local flood plan directs people to the Yamba Bowling & Recreation Club as a suitable location for an evacuation centre. BMT does not have details of this facility to be able to assess its suitability for the number of people that this facility may be able to support. This report assumes sufficient capacity can be made available.

Information from the Census and the expected increase in population as a result of the proposed development indicates that there would be 6,396 people (see Section 3.4) that would be required to evacuate during an extreme flood event in this area. It is acknowledged that not all of the people evacuated will make use of the evacuation centre, as some people may choose to stay with family and friends outside of the flooded area.

In lieu of information around the suitability of the Yamba Bowling & Recreation Club as an evacuation centre, the minimum requirements of a suitable evacuation centre, as outlined in the Major Evacuations Centres: Public Health Considerations (NSW Health, 2018) should include:

- A minimum floor space of 3.5m^2 per person, excluding areas for cooking, bathing and sanitation.
- An internal floor-to-ceiling height of 2 metres.
- Provision for 15L of water per person per day, to cover drinking, cooking and hygiene.
- One shower facility for between 30-50 people, depending on the weather.
- One toilet per 20 people.
- One wash basin per 100 people.

It is acknowledged that existing buildings may not meet the toilet/shower requirements. There is provision to initially have 50 people per toilet in the initial stages of an emergency, until additional facilities can be deployed. It is noted from the local flood plan that isolation from a flood in this area would usually be no more than 5 days.

3.4 Changes to flood behaviour and impact on evacuation

The focus of this assessment is to consider how the flood behaviour has changed along key evacuation routes as a result of the development and if these changes impact on the ability to evacuate. Change in flood behaviour as a result of the proposed development is included with the separate FIA report (BMT, 2021) and is summarised below.

- **Yamba Road** –
  - there is no significant change in flood depths, velocities or hazard along Yamba Road in any modelled flood event as a result of the development.
  - There will be no change in the capacity to evacuate as a result of the development.
- **Carrs Drive** –
  - In events up to the 1 in 50 AEP, there are sections along the road that have an increased immunity as a result of the development.
  - There is an increase in flood depth of up to 0.06m in the 1 in 100 AEP event between Miles Street and Lot 21 of DP277589. There is a decrease in flood depths of up to 0.5m between Lot 21 of DP277589 to Yamba Road.
  - There is an increase in flood velocities of up to 0.5m/s along Carrs Drive, from the southern end of Lot 46 to Harold Tory Drive in the 1 in 100 AEP event.
  - There is a decrease in hazard category from H3 to H2 and H1 during the 1 in 100 AEP event.
  - While there is an increase in velocity along the road, there is a decrease in depth and hazard. Therefore the development will improve the evacuation capacity of Carrs Drive.

- **Miles Street** – the road between Carrs Drive and Golding Street is currently a dirt road.
  - There is an overall decrease in depth along Miles Street of up to 0.35m. There is a localised increase in flood depth of up to 0.4m at the intersection with Golding Lane.
  - There is overall a decrease in hazard category along the road.
- **Deering Street** – there is part of Deering Street that would require construction prior to use.
  - There is minimal change in depth, velocity and hazard along Deering Street.
  - There will be no change in the capacity to evacuate as a result of the development.
- **Golding Street** –
  - there is an increase in flood depth of up to 0.1m between Grevillea Waters and Deering Street.
- **Angourie Road** – There is minimal change in depth, velocity and hazard along Angourie Road.
  - There will be no change in the capacity to evacuate as a result of the development.

3.5 Evacuation timeline assessment

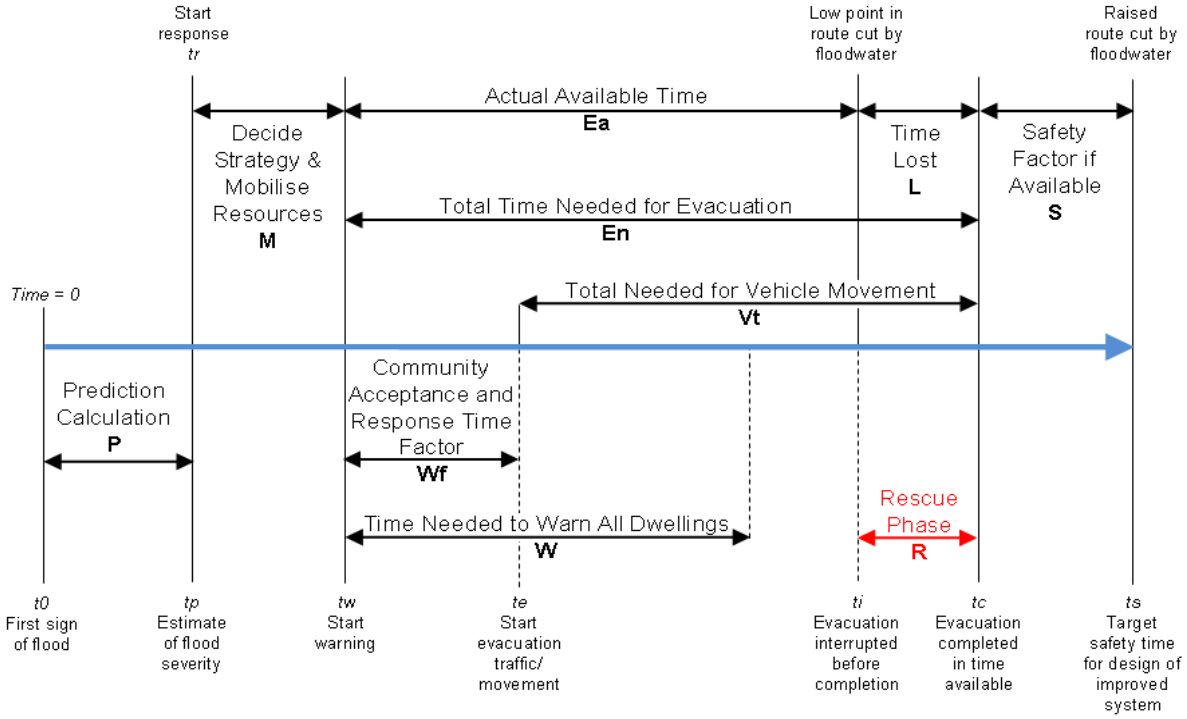
3.5.1 Introduction

This section provides an estimate of the time needed to evacuate by using the NSW SES Evacuation Timeline Model (Opper, 2009). The assessment methodology combines information on flood behaviour with human behavioural factors, vehicle flow rates and safety allowances. It also considers the time taken to warn people and for people to respond and the total available warning time.

The evacuation timeline (Opper, 2009) is shown in Figure 3.1 and the evacuation timeline provided in this assessment commences at the start of a warning (i.e., tw) by BOM/SES.

The timeline assessment is based on riverine flooding and has not taken into account local catchment flooding or storm surge. It is likely that the timeframes for local catchment flooding and storm surge will be less than 6 hours, and evacuation is not proposed.

The remainder of this section sets out the timeline analysis including details of the various timeline components.



Note: S will be negative value (safety factor <0) when *ti* occurs earlier than *tc*. S will be zero when all available time needed (En) is used. Only when *ti* occurs after *tc* does a Safety Factor begin to accrue. The magnitude of S has to be determined by reference to the capacity to cope with uncertainty and interruptions. The time elements are not drawn to scale in this diagram,

Figure 3.1 Flood Site Evacuation Timeline Schematic (Source: Opper, 2009)

3.5.2 Assessment Assumptions

Key timeline assumptions used in this assessment are based on those used in a previous assessment for Grafton prepared for Clarence Valley Council (Molino Stewart, 2011) and are typically applied in evacuation timeline assessments. These key assumptions are as follows:

- The evacuation route will only have one outward bound lane for evacuation and one inward bound lane for emergency service vehicles;
- Vehicles will travel at a maximum average rate of 600 vehicles per hour along the route;
- There will be sufficient doorknockers to generate an evacuation stream of 600 vehicles per hour (see Section 3.5.5);
- It will take evacuees one hour to accept the warning;
- It will take evacuees one hour to respond and prepare to evacuate; and
- A travel safety factor is applied to the estimated time taken to evacuate vehicles. This factor increases for increasing evacuation time and allows for potential disruption. Travel safety factors are taken from Opper, 2009 and are presented Table 3.1 below.

Table 3.1 Travel Safety Factors

Base Time (hours)	Traffic Safety Factor (hours)	Total Travel Time (hours)
1 to 3	1	2 to 4
4 to 6	1.5	5.5 to 7.5
7 to 9	2	9 to 11
10 to 12	2.5	12.5 to 14.5
13 to 15	3	16 to 18
16	3.5	19.5

3.5.3 Properties to evacuate

According to the Australian Bureau of Statistics census data (2021) for Yamba (excluding Yamba Hill – properties to the west of River Street), there are currently 2,775 dwellings. There are approximately 5,199 people currently located in this area. The SES Local Flood Plan states 2,400 existing properties would be inundated above floor in an extreme event although this is based on older census data. For the purposes of this assessment a precautionary approach has been undertaken whereby all 2,775 existing dwellings will be factored into the evacuation assessment.

The current and proposed development includes approximately 570 lots, bringing the total number of dwellings in the area that may require evacuation to **3,345**. This equates to an estimated 6,396 people, assuming that there will be 2.1 residents per dwelling in the new development (ABS, 2021).

3.5.4 Response Initiation (decision making & mobilisation, M)

The response initiation phase is the time taken to assess the likely impact of the coming flood and decide on a course of action using the appropriate flood plan as a guide. It will then be necessary to mobilise the resources needed and to communicate the planned intentions to the community (warning).

The decision to evacuate an entire community should ideally be made only when the need to do so is indicated by the prediction of a coming flood which has a high level of confidence. If the decision is frequently made on the basis of flood predictions with high uncertainty, i.e., low confidence, then there are likely to be unnecessary evacuations.

Based on field exercise and experience in actual operations, the SES nominally adopts a period of **6 hours** for decision and mobilisation in an operational planning context. A period of 6 hours has therefore been assumed although noting that this does not form part of the calculated total time needed for evacuation which occurs once an evacuation warning has been issued.

3.5.5 Warning delivery (W)

Warning time accounts for the time required to inform all dwellings that evacuation from the Site or movement to a location where people can shelter in place is required. During flood events there are many external warning dissemination methods available. These mass broadcasts may include the following from BoM, Council or SES:

1. Radio;
2. Television;
3. Telephone; and
4. SMS notification;

5. Floods Near Me NSW app.

With one-way warning methods (e.g. radio, television) there is no direct feedback mechanism to determine if a warning message has been received or understood. It may only be apparent that warning has failed when it is observed that people are not responding to the warning as expected. While warning technology does hold great promise in terms of broadening the arsenal of warning methods, the SES is confident that door knocking provides a high degree of warning reliability and practicality in the context of planning the time frame for flood evacuation and executing this in real time. The estimated warning time should not be reduced by relying on technological approaches or the uncertain outcomes of public flood education without reliable evidence justifying this reduction.

Door knocking is likely to be the slowest and most resource intensive warning method but it is the most certain warning method and it is possible to estimate the time it will take. The SES has tested door knocking in the field and the results indicate the need to allow a time of 5 minutes per team (two members) per door, which equates to 12 houses/hour/team.

In order to generate a traffic flow equivalent to 600 vehicles per hour this would require 50 teams (100 people) to undertake doorknocking.

Currently we have no information about the number of teams who may be available to undertake door knocking duty. It is acknowledged that if the SES do not have adequate resources, they may call upon staff from other emergency services, such as NSW Police or Council to provide adequate teams. Volunteering Australia presented Key Volunteering Statistics (2021), which indicate that on average throughout Australia, 4.7% of the population volunteer in an Emergency Service. NSW has the fourth highest formal volunteering rate in Australia (28.9%).

An assumption of 50 teams (100 people) undertaking doorknocking is considered reasonable as it is approximately 2% of the existing population.

Existing warning delivery time
2,775 dwellings may require door knocking / (12 houses per hour x 50 teams) = **approx. 5 hours**

Proposed warning delivery time
3,345 dwellings may require door knocking / (12 houses per hour x 50 teams) = **approx. 6 hours**

3.5.6 Community acceptance and response time factors (Wf)

Following the delivery of a site evacuation warning, experience has shown that people require time to firstly accept the warning and secondly organise themselves prior to evacuating the Site. To account for this the ‘Evacuation Timeline’ methodology includes both warning acceptance and warning lag factors. As prescribed by Opper (2009), 1 hour has been adopted for both the warning acceptance and warning lag factors.

Within the context of this assessment, the combination of these warning factors mean that the residents do not leave their dwellings until **2 hours** after being issued a warning via door knocking to evacuate the Site or relocate to the shelter in place location.

3.5.7 Site evaluation time allowance (Vt)

Following community acceptance of a warning to evacuate the Site, the time required for evacuating off-site represents the time needed to complete a full evacuation of all people, using vehicles as the primary means of transport.

Vehicle Movement (Vt)

Assuming that roadways are at their vehicle flow rate capacity, calculation of vehicle movement time (i.e., Vt) requires consideration of the number of cars moving, the vehicle flow rate along a given route and an additional traffic safety factor, allowing for the time needed to attend to a serious traffic incident.

A single lane of traffic has been assumed, as all evacuation routes converge onto Yamba Road, making this road the constraining factor.

The average vehicle flow rate assumed is 600 vehicles/hour/lane (Opper, 2009). For the existing 2,775 dwellings in the area[5], the traffic movement durations would be approximately 8.3 hours for a single lane of traffic.

For the 3,345 dwellings in the area, including the proposed dwellings the traffic movement durations would be approximately 10.0 hours for a single lane of traffic.

In addition to this, Opper (2009) recommends a travel safety factor (TSF) to be added to the calculated traffic movement duration (see Table 3.1). A TSF of 2 hours applies to the existing case and 2.5 hours with the additional proposed dwellings.

Therefore, the evacuation time of **10.5 hours** has been adopted for the existing area and an evacuation time of **12.5 hours** has been adopted for the area including the proposed development.

3.5.8 Time available to evacuate

Based on the information in Section 2, it is expected that there will be at least **24 hours**[6] warning time prior to Yamba being isolated due to a riverine flood event.

3.5.9 Total site evacuation summary

A summary of the evacuation time components are provided in Table 3.2 for the existing case and Table 3.1 for the proposed development case (including existing dwellings). The total evacuation time required is derived from the addition of the response initiation (M), warning delivery (W), community acceptance (Wf) and evacuation time (Vt).

Table 3.2 Evacuation times - Existing

Component	Time (hours)
Community acceptance (Wf)	2.0
Evacuation Time (Vt)	10.5
Total Time Needed for Evacuation (En)	12.5
Actual Available Time (for riverine flooding) (Ea)	24.0

Note, refer to Figure 3.1 for a description of the timeline schematic

[5] Based on 1.8 cars /dwelling as shown for Statistical Area Level 2 (Maclean-Yamba-Iluka) (ABS, 2021)
[6] According to the SES Local Flood Plan

Table 3.1 Evacuation times – with proposed development

Component	Time (hours)
Community acceptance (Wf)	2.0
Evacuation Time (Vt)	12.5
Total Time Needed for Evacuation (En)	14.5
Actual Available Time (for riverine flooding) (Ea)	24.0

Note, refer to Figure 3.1 for a description of the timeline schematic

3.5.10 Evacuation timeline conclusion

The proposed development results in an additional 2 hours to evacuate, going from 12.5 hours to evacuate in the existing case to 14.5 hours in the developed case.

During a riverine flood, there is approximately 24 hours of warning time until the evacuation routes are compromised. Therefore, in a riverine flood event, there is sufficient available time to evacuate the existing community and the residents in the proposed development.

During a storm tide event the flooding is considered flash flooding, as there is approximately 6 hours of warning time[7]. There is therefore not enough time for the existing community to evacuate in a storm surge event and so evacuation is not proposed.

3.6 Evacuation Timeline of full WYURA Development

The full WYURA Development includes a total of 1,200 dwellings (including the 570 dwellings for Yamba Gardens and the northern developments). When considering these dwellings along with existing dwellings a total of 3,975 dwellings require evacuation. Table 3.2 shows the timeline assessment for the full WYURA development.

Table 3.2 Evacuation times – with full WYURA proposed development

Component	Time (hours)
Community acceptance (Wf)	2.0
Evacuation Time (Vt)	14.5
Total Time Needed for Evacuation (En)	16.5
Actual Available Time (for riverine flooding) (Ea)	24.0

Note, refer to Figure 3.1 for a description of the timeline schematic

It can be seen from Table 3.1 that the total time required remains less than the time available for evacuation when considering the full WYURA.

[7] As discussed in the SES Local Flood Plan

4 Conclusion

The proposed development, comprising Yamba Gardens and the northern developments will increase the number of dwellings that may require evacuation from 2,775 to 3,345. An assessment of the time needed for evacuation has been undertaken using the NSW SES evacuation timeline approach. This has been compared to the available warning time. This demonstrates that the total number of dwellings (including the proposed development) have sufficient time to evacuate when required. When considering the full WYURA there also remains sufficient time to evacuate.

The assessment is based on the SES timeline methodology and contains a number of simplifying assumptions. In particular, BMT has not assessed the suitability of the existing proposed evacuation centre on Yamba Hill, as details of the facility were not available. Rather, the requirements for a suitable evacuation centre/s have been provided for consideration.

5 References

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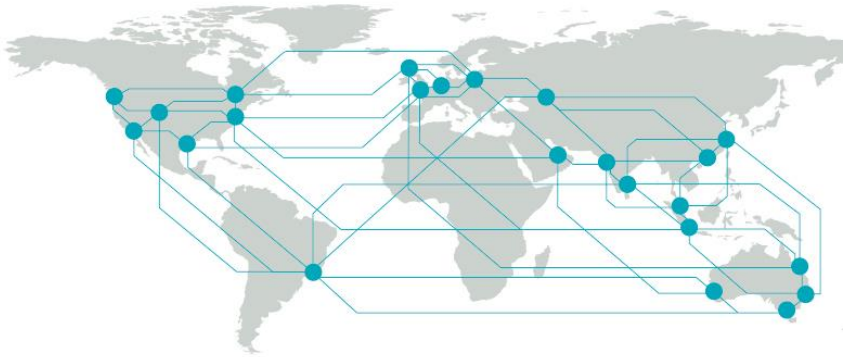

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Level 5
348 Edward Street
Brisbane
QLD 4000
Australia
+61 7 3831 6744

Registered in Australia
Registered no. 010 830 421
Registered office
Level 5, 348 Edward Street,
Brisbane QLD 4000 Australia

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