Pacific Brook Christian School

Flood Emergency Response Plan

R.T2583.001.04

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Final

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Synopsis

Report documenting the development of a Flood Emergency Response Plan for the proposed Pacific Brook Christian School. The report details the flood behaviour at the Site, flood forecasts and flood warning availability, and formulates a Flood Emergency Response Plan for managing on-site flood risk incorporating school closure and evacuation.

Cover image NBRS Architecture

Revision History

Revision	Description	Date
01	Draft	22/07/2024
02	Final	06/08/2024
03	Final (revised)	16/01/2025
04	Final (revised)	03/06/2025

Disclaimer

Executive Summary

Torrent Consulting was engaged by Impact Group on behalf of Pacific Group of Christian Schools Ltd trading as Pacific Brook Christian School (PBCS) to prepare a Flood Emergency Response Plan (FERP) for the establishment of a new K-12 school (Pacific Brook Christian School) 72-74 Maitland Street, Muswellbrook (the Site).

The school will accommodate 140 students and 16 staff with School class operating hours Monday to Friday 8:50am to 3:10pm.

Flood Risk

Flood risk at the Site is principally from the mainstream flooding of the Muscle Creek channel and floodplain. During flood events, inundation is known to occur within the Muswellbrook Golf Course, which is located adjacent to the Site. Once the capacity of the Muscle Creek channel is exceeded, overbank flows are initiated through the Golf Course with floodwater spilling from the left bank on the creek channel. The key observations in this regard include:

- The Site is initially inundated only at the 1% AEP flood level with the inundation limited to the lowest parts of the Site in the north-east. There is no inundation in the vicinity of the school buildings at the 1% AEP flood level.
- The school buildings area remains flood free up to 0.2% AEP (1in 500) design flood magnitude. The elevated floor levels of the buildings provide for a flood immunity (no above floor flooding) up to 0.01% AEP (1in 10,000) design flood magnitude. Accordingly, the design flood immunity afforded to the Site represents a very low risk of exceedance.
- For extreme flood events in excess of these magnitude, up to the PMF event, the predicted high hazard flood conditions warrant the Site to not be occupied. The peak PMF level provides for flood depths across the Site more than 2m, with up to 1.2m depth above the proposed school building floor levels.

Flood Warning

The BoM has a number of generalised warning services that provide an indication of an increased likelihood of flooding, including:

- Severe Weather Warnings (including East Coast Lows)
- Severe Thunderstorm Warnings
- Flood Watches
- Flood Warnings

These warning services are to be monitored for forecasts of expected flood conditions that impact upcoming activities at the school. Such warnings can be issued a few days in advance and give the school the opportunity of closing prior to potential flood affectation.

School closure is proposed for any moderate to major flood warning for the Hunter River at Muswellbrook and local catchments. The expected lead warning time for these notifications include:

- Flood Watch – typically 24hours prior to flooding
- Flood Warning – typically 12hours prior to major flood level at Muswellbrook

The Flood Watch and Flood Warning products provide for the early opportunity for School closure prior to flooding with information resources on these services available at the BoM Flood Knowledge Centre http://www.bom.gov.au/australia/flood/knowledge-centre/. All staff and management responsible for flood risk management at the School should be familiar with these resources (and others included at Appendix G) and form part of ongoing training as part of the FERP.

Muswellbrook Shire Council has installed the Muscle Creek Flood Warning System (FWS) to provide continuous monitoring of water levels in Muscle Creek with a trigger-based alert and warning system. The infrastructure is located approximately 20m downstream of the Bell Street bridge and some 700m from the proposed school buildings. The site is configured to directly SMS Council, NSW State Emergency Services (SES) personnel and residents at various threshold levels. The initial alert and evacuation alert triggers and warnings to residents via automated SMS messaging provides direct flood warning intelligence to inform the School operations and underpin the flood emergency response.

Additional lead flood warning time based on the Site inundation is achievable in enacting early warning triggers based on recorded rainfall. Give the lack of existing rainfall gauges in the Muscle Creek catchment, the FERP proposes the installation of an automated weather station with pluviometer to record site rainfall and provide the basis for a rainfall trigger linked to an emergency response action plan. Additionally, an automatic flood alert level gauge is proposed at the Site low point providing a trigger for initial Site inundation for events at the 1% AEP (1 in 100) flood level and higher. It is noted that flood conditions triggering these Site gauges (>1% AEP) is expected to be forecast in advance as part of the Flood Watch and Flood Warning notifications. Notwithstanding, the Site gauges provide an additional level of redundancy in the flood warning and response.

Flood Emergency Response

The proposed Flood Emergency Response comprises:

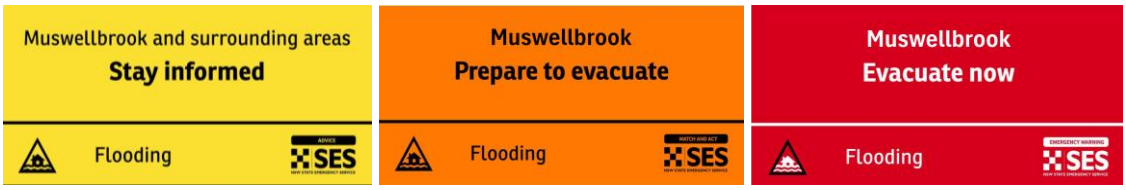
- Monitor Weather and Flood Warning information services
- School closure prior to Site flood affectation
- Evacuation to nominated flood refuge (Muswellbrook Sports Centre)

The BoM flood forecasting and warning services provides the pivotal information for early flood warning response and accordingly represents one of the key information sources to be monitoring.

An example “Flood Watch” and “Flood Warning” messaging for the Hunter River at Muswellbrook is included in the reference information in Appendix F.

There are multiple agencies with various roles and responsibilities for flood emergency response that may provide specific local flood information and messaging on the basis of the BoM forecasting and local intelligence.

The NSW SES will issue warnings for flooding using the Australian Warning System, including Advice, Watch and Act, and Emergency Warnings levels. For each level, there are a series of clear action statements to guide positive action by the community. These include ‘stay informed’, ‘prepare to evacuate’ and ‘evacuate now’ with indicative messaging below.



The Advice level “stay informed” warning will typically be associated with an initial Flood Watch and Flood Warning notifications from BoM. The proposed FERP provides for pre-emptive closure of the School under this initial advice level incorporating for moderate to major flooding forecasts.

Escalation to Watch and Act level provides for immediate school closure under a prepare to evacuate advice where there is no immediate threat. This is expected to provide sufficient time for School Closure without the requirement for evacuation. An Emergency Warning level with an evacuation order provides for immediate Site evacuation to the nominated flood refuge. The immediate evacuation incorporates any alert from the Muscle Creek FWS.

Example messaging for these alert levels from the NSW SES is included in the reference information in Appendix F.

The flood warning information may be received through multiple communication platforms as summarised below.

- BoM RSS Feeds (http://www.bom.gov.au/rss/rss-guide.shtml) - RSS (Really Simple Syndication) is an alternative way to receive the Warnings information released on the BoM website. Subscription to the warnings feed will provide immediate alerts on desktop or mobile device.
- Subscribe/follow social media accounts (Facebook/Instagram/X):
    - BoM
    - Hunter NSW SES / Muswellbrook Shire NSW SES
    - Hazards Near Me (https://www.nsw.gov.au/emergency/hazards-near-me-app) - provides real-time warnings for flood, severe weather and tsunami in NSW via mobile phone app and desktop HazardWatch map.
- Muscle Creek Flood Warning System Alerts – specific School mobile contact numbers should be incorporated in the automatic SMS alert notifications (if not already incorporated in the automated resident pushout of notifications).
- Muswellbrook Council Disaster Dashboard (https://muswellbrook.disasterdashboards.com) - This web application provides a collation of live/current emergency information from Council, BoM, NSW SES, NSW Rural Fires Service (RFS), Transport NSW, utility providers and other NSW Government Agencies.

The proposed subscriptions and alert notifications will incorporate multiple contact points across the School operation and administration. At a minimum this would include:

- School Principal (and/or other delegated on-site Staff)
- School Administration / Reception (on-site)
- PCBS Management Team (Head/Regional office)

The available flood warning opportunity is expected to limit flood risk exposure via initial flood avoidance through school closures. Given the length of the school day, school terms and the duration of Muscle Creek flood events, there is only around a 25% chance that any given flood peak event will fall within school hours. Further, the availability of flood warning intelligence to inform potential flood risk in advance of the peak flooding conditions provides significant opportunity for school closure and risk elimination. Accordingly, this represents the principal emergency response as demonstrated in the timeline as shown in Figure E1.

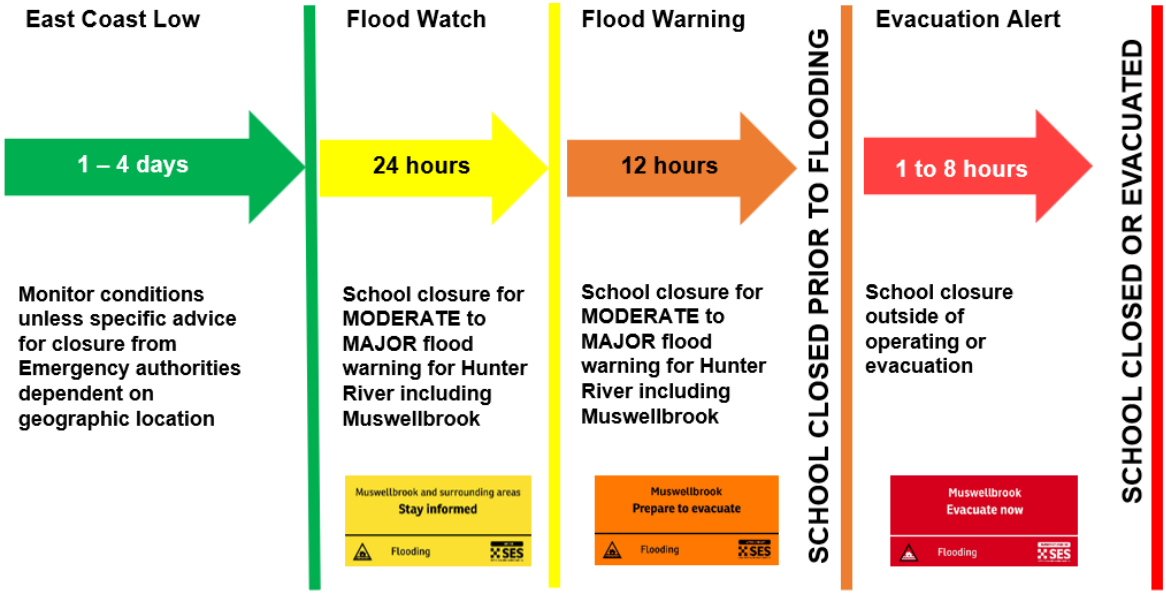


Figure E1 Timing of Early Flood Warning Services and School Closure

School closure prior to flooding of the Site will be under any of the following conditions:

- BoM Flood Watch issued including warning for moderate to major flooding (typical 24hours notice)
- BoM Flood Warning issued including warning for moderate to major flooding (typical 12hours notice)
- SES Watch and Act Flood Warning to prepare for evacuation (typically preceded by above warnings exceeding major flooding >12hours)
- SES Emergency Warning to evacuate (typically preceded by above warnings exceeding major flooding >6hours)
- Automatic Flood Alert from Muswellbrook FWS (variable warning time typically >6hours to 1hour in worst case PMF)

The School will also be closed following any direct recommendation from Emergency Services based on forecast conditions (e.g. early severe weather and flood warning associated with East Coast Low).

School closure is proposed for any flood alert from the Muswellbrook FWS. As noted, it is unlikely the School will be occupied given the expected early closure. In the unlikely event of a flood condition exceeding 0.2% AEP (1in 500) design flood magnitude within the hours of school operation, evacuation of the Site to the nominated flood refuge can be executed within available warning times.

The typical flood response times provide for the following evacuation window time period between receiving the flood alert and completing Site evacuation to the nominated flood refuge (Muswellbrook Sports Centre):

- Typical 8-hour window for major flood events including up to 0.2% AEP (1in 500 AEP)
- Minimum "worst case" 70-minute window for Probable Maximum Flood (PMF)

A flood evacuation timeline analysis as shown in Figure E2 demonstrates evacuation capability for all events up to and including the PMF event within initial inundation of the Site.

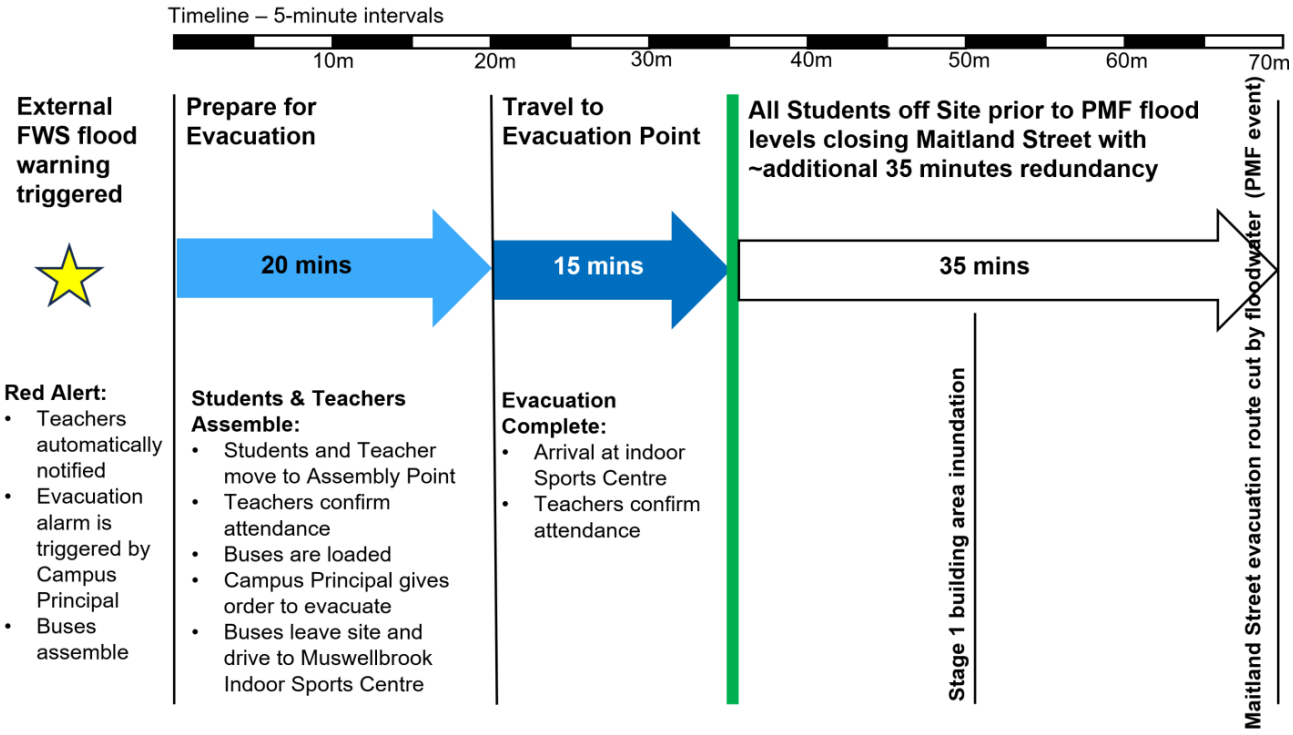


Figure E2 - Minimum Flood Warning and Emergency Response Timeline and Action Plan

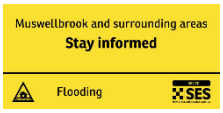
Site evacuation is to be initiated by any the following triggers:

- Flood Evacuation alert issued by SES or other emergency services
- Flood alert issued from the Muscle Creek Flood Warning System
- Flood alert via installed water level gauge at Site low point
- Recorded rainfall of 50mm or more in a 30-minute period via the installed rain gauge on-site or other monitored gauge locations
- Visual cue of Muscle Creek flood inundation

The responsibilities and actions for effective flood emergency response management are defined for the PBCS Management Team, School Principal, and School Staff. This will ensure that the structure, facilities and training are in place and adequately maintained, to enable effective execution of a flood emergency response.

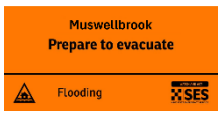
To assist in managing flood risks and communicating response actions, four flood Alert Modes have been developed:

- Yellow: flooding of the Site is possible in coming day (>12hrs warning)
    - Flood Watch or Flood Warning issued for minor to moderate flooding – heightened monitoring of developing situation
    - Flood Watch or Flood Warning issued for moderate to major flooding – pre-emptive school closure



Amber: flooding of the Site is possible within the hours of operation

    - Flood Watch or Flood Warning issued for major flooding – pre-emptive school closure outside of school hours or immediate school closure within school hours



- Red: imminent flooding of the Site is expected
    - Flood Evacuation alert issued by SES or other emergency services, or Flood alert issued from the Muscle Creek Flood Warning System - immediate initiation of Flood Evacuation Plan
    - Site water level or rainfall gauge alert - immediate initiation of Flood Evacuation Plan

- Green: all clear, floodwaters have receded and local access to the Site is available
    - Emergency service has cleared access to the Site
    - Review Site conditions and opportunity for normal operation

The Yellow Alert Mode is called following the issuing of a Flood Watch, or Flood Warning for Muswellbrook by the BoM (Bureau of Meteorology) and indicates an increased potential for flooding. An initial minor to moderate forecast level will not require School closure, but initiate a heightened monitoring of conditions and flood warnings for potential escalation. An initial or escalation to moderate or major flood warning will provide for pre-emptive school closure.

The Amber Alert Mode is triggered following the issuing of a major flood warning within the hours of school operation

The Red Alert Mode is triggered via evacuation order by SES, flood alert from the Muscle Creek Warning System or Site rainfall and water level gauges indicating that possible flooding of the Site is imminent.

The Green Alert Mode is called following a flood event, once flood waters have receded based on advice from Emergency Services. The return to normal school operation will be dependent on local Site conditions, including any outage of utilities, road closures and access, Site clean-up and repair if needed.

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1 Introduction

1.1 Background

Torrent Consulting was engaged by Impact Group on behalf of Pacific Group of Christian Schools Ltd trading as Pacific Brook Christian School (PBCS) to prepare a Flood Emergency Response Plan (FERP) to assist in the approval process for the proposed development at the 72-74 Maitland Street, Muswellbrook, NSW (the Site), as presented in Figure 1-1. The proposed development is for the establishment of a new K-12 school (Pacific Brook Christian School) on the Site.

This Site is located within the Muscle Creek catchment and is subject to potential flood inundation during extreme rainfall events. The design flood conditions at the Site are established in the Muscle Creek Flood Study (RHDHV, 2017) and Muswellbrook Floodplain Risk Management Study and Plan (RHDHV, 2019). It is understood the defined flood conditions has informed the development of an existing Flood Impact Assessment and Flood Emergency Management Plan for a previous Development Application. Impact Group has outlined a revised development application requiring preparation of updated/new documentation relevant to the modified proposal and considering previous advice/commentary provided by relevant authorities including Muswellbrook Shire Council (Council), State Emergency Service (SES) and Dept. of Climate Change, Energy, the Environment and Water (DCCEEW).

A Flood Impact Assessment has been completed by Torrent Consulting for the proposed development (R.T2583.002.02). The flood modelling undertaken for the impact assessment has been used to inform development of this FERP.

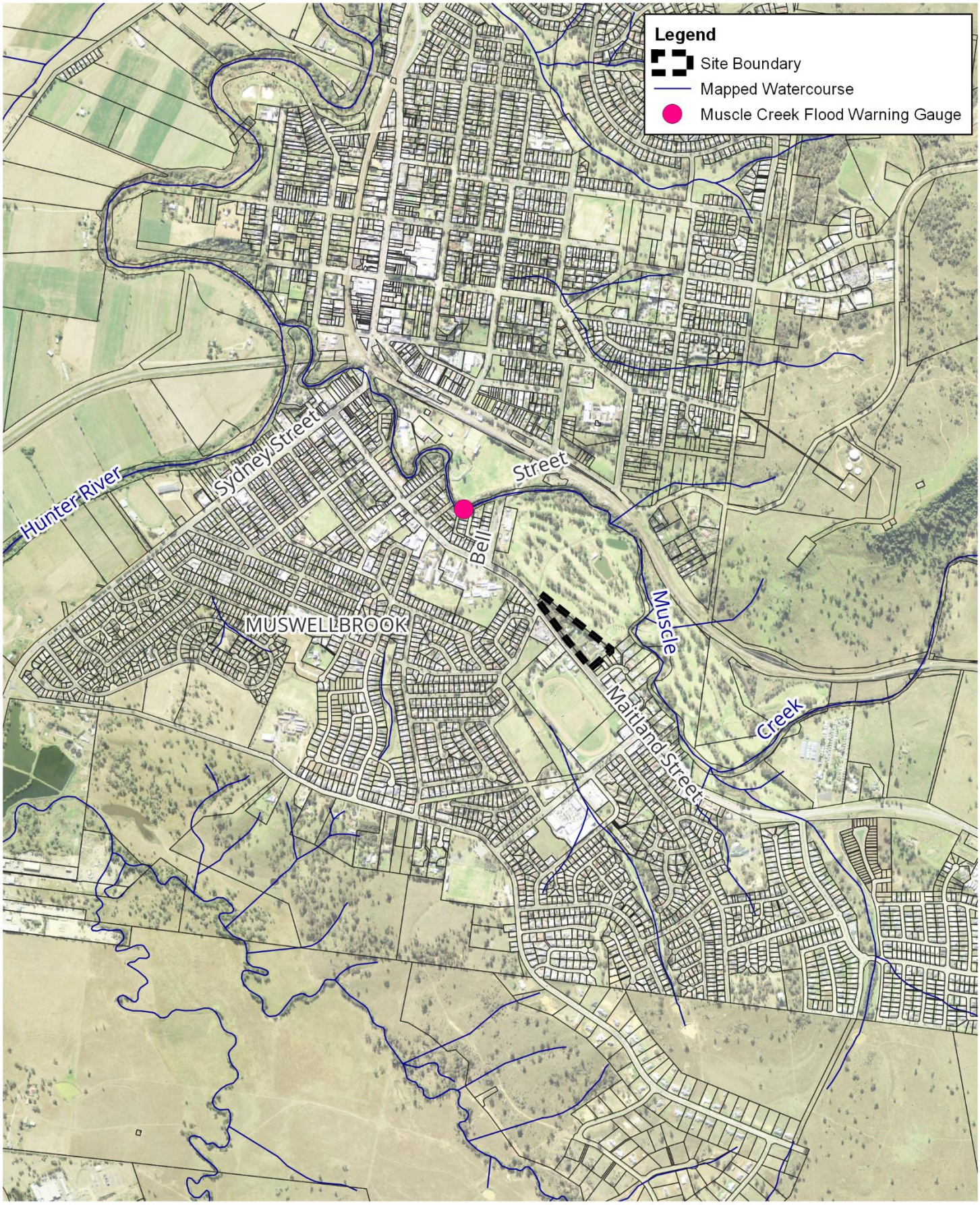
1.2 Site Overview

The proposed development will comprise site preparation and remediation, tree removal, construction of new school buildings, covered outdoor learning area, covered walkways, car parking, landscaping and associated works. The school will accommodate 140 students and 16 staff.

Specifically, the proposed development will deliver one (1) administration and staff area, five (5) General Learning Areas (GLA's), one (1) science classroom, one (1) staff and student amenities block, Covered Outdoor Learning Area (COLA) and ancillary step/ramp access to each.

The Site operation will house a mainstream Kindergarten to Year 12, and other normal activities associated with schooling. The nominal hours of operation are:

- Monday to Friday - 7.30am to 6.30pm, comprising:
  - School class operating hours Monday to Friday 8:50am to 3:10pm
- Saturdays, Sundays and Public Holidays – Nil



Title:

Site Locality

0 0.5 1 km

approx. scale

Figure: **1-1**

Revision: **A**

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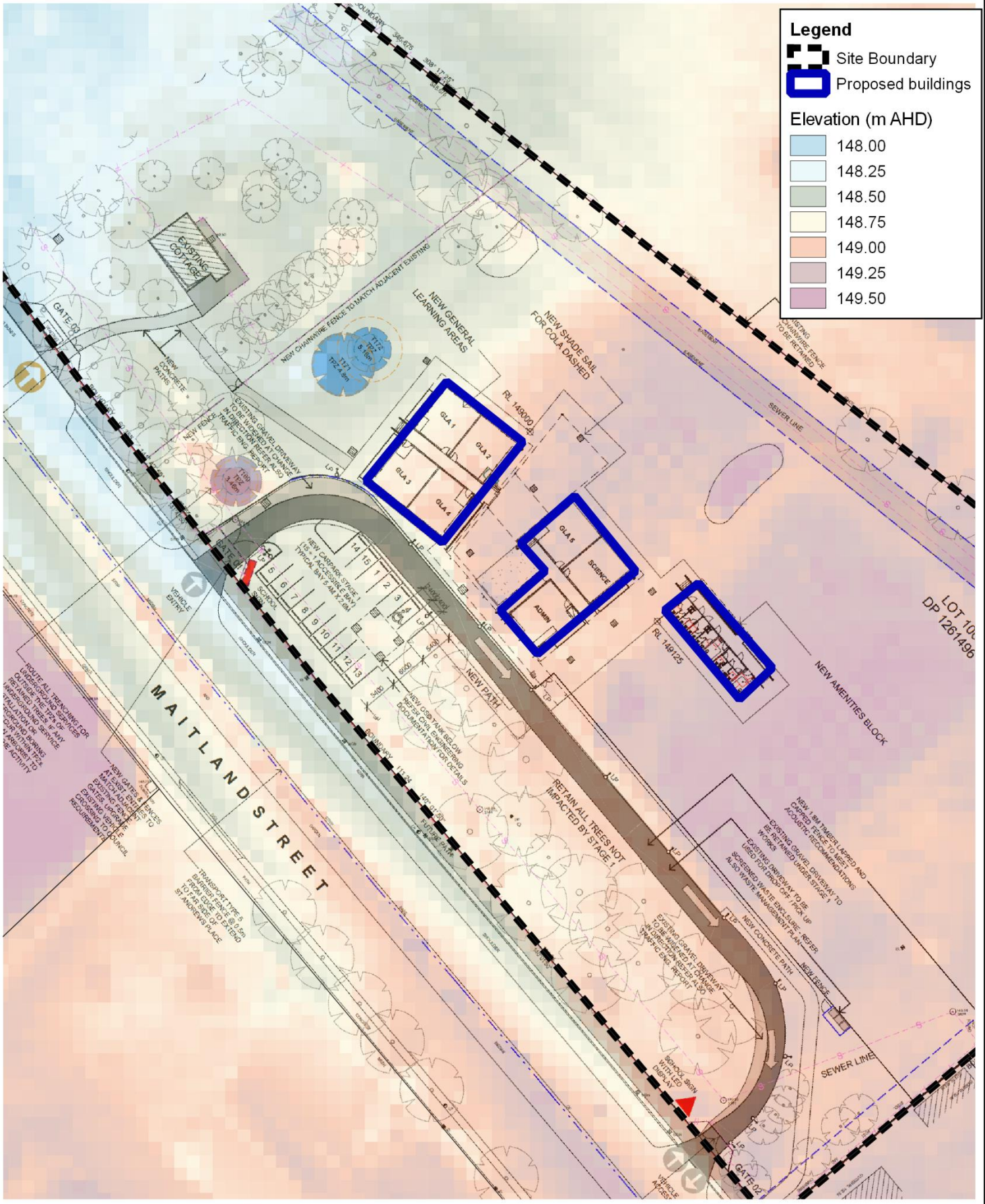

Title:

Site Layout and Topography

0 20 40 m

approx. scale

Figure: 1-2

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2 Flood Behaviour

2.1 Flood Probabilities

The Australian Rainfall and Runoff (ARR) 2019 guidelines describe two approaches that are typically used to express the probability of flood events:

- Annual Exceedance Probability (AEP) – the probability of an event being equalled or exceeded within a year. Typically, the AEP is estimated by extracting the annual maximum in each year to produce an Annual Maxima Series (AMS); and
- Average Recurrence Interval (ARI) – the average period between occurrences equalling or exceeding a given value. Usually, the ARI is derived from a Peak over Threshold series (PoTS) where every value over a chosen threshold is extracted from the period of record.

A summary of flood probability terminology from ARR 2019 is reproduced in Figure 2-1.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
Intermediate	0.11	10	10	9.49
	0.05	5	20	19.5
Rare	0.02	2	50	49.5
	0.01	1	100	99.5
Very Rare	0.005	0.5	200	199.5
	0.002	0.2	500	499.5
	0.001	0.1	1000	999.5
Extreme	0.0005	0.05	2000	1999.5
	0.0002	0.02	5000	4999.5
			↓	
			PMP/ PMP Flood	

Figure 2-1 Flood Probability Terminology

Very frequent flood events are expressed as exceedances per year (EY). At the other end of the probability spectrum, the Probable Maximum Flood (PMF) event is a function of the Probable Maximum Precipitation (PMP), which is the most rainfall that can be practically considered as being possible to occur over a given location or area. It is an extreme event with an approximate probability of between a 1-in-10,000 and a 1-in-10,000,000 AEP, dependant on catchment area. For small catchments up to 100km^2 such as Muscle Creek the approximate probability of the PMF event is a 1-in-10,000,000 AEP.

2.2 Flooding of the Site

The flood-producing weather events most-likely to affect the Site include East Coast Lows (ECL). The Bureau of Meteorology (BoM) defines ECLs as being very intense low-pressure systems characteristic of the eastern coastline of Australia, occurring on average several times each year. Although they can occur at any time of the year, they are more common during autumn and winter with a maximum frequency in June. East Coast Lows will often intensify rapidly over a period of 12-24 hours making them one of the more dangerous weather systems to affect the eastern coast.

Other weather systems that present a flood risk at the Site include ex-tropical cyclones that occasionally move south into NSW and severe thunderstorms that can develop quickly and affect relatively small areas.

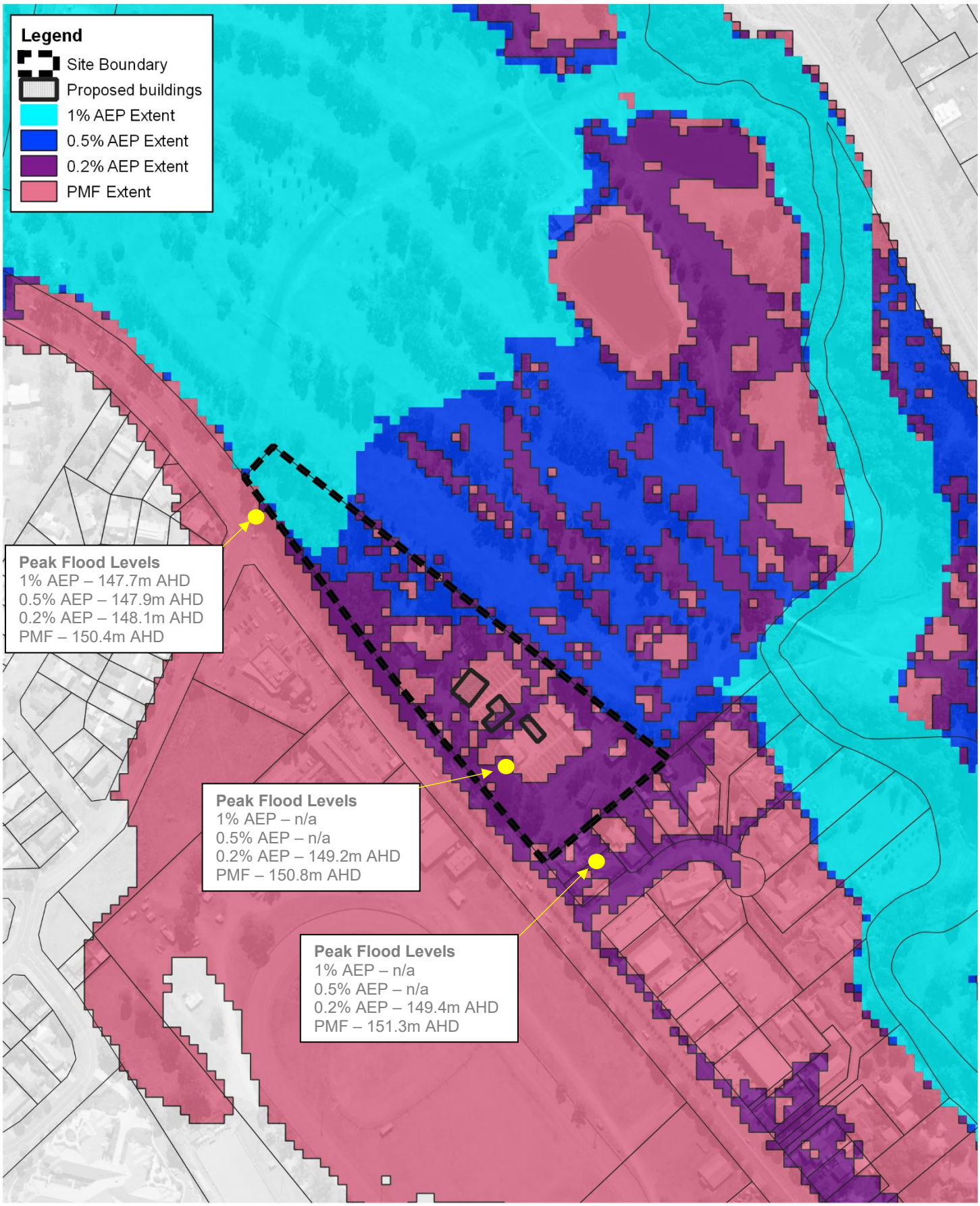
Muscle Creek drains 92 km^2 of catchment upstream of Muswellbrook covering predominantly undeveloped land east of the Site. The Muscle Creek channel alignment flows centrally through the township of Muswellbrook before joining the Hunter River.

During flood events, inundation is known to occur within the Muswellbrook Golf Course, which is located adjacent to the Site. Once the capacity of the Muscle Creek channel is exceeded, overbank flows are initiated through the Golf Course with floodwater spilling from the left bank on the creek channel. As flood flows increase, the flood inundation initially impacts the lower end of the Site at the 1% AEP level. Further channel breakouts are initiated upstream of the Site in extreme events, providing for flow directly through the Site and down Maitland Street in a general north westerly direction.

2.2.1 Flood Extent and Levels

The design flood extents for the 1% AEP, 0.5% AEP, 0.2% AEP and PMF events were modelled as part of the proposed development flood impact assessment and are representative of rare to extreme flood conditions. The simulated peak flood inundation extents are shown in Figure 2-2, with design peak flood levels annotated and various locations within the Site. Peak flood depth mapping for the simulated 1% AEP, 0.5% AEP, 0.2% AEP and PMF events is presented in Appendix A.

At the 1% AEP flood event inundation affects only the lower end of Site, with localised backwater flooding from upstream of the flow constriction at Bell Street. Similarly for the 0.5% AEP event, inundation is limited to the lower end of the Site albeit increasing in general extent across the Site. Flow through the Site, particularly in the location of the proposed building areas is firstly initiated at the 0.2% AEP flood magnitude. Overland flow paths are initiated from floodwater escaping the Muscle Creek channel upstream of the Site. At the 0.2% AEP flood magnitude, these overland flow paths through the Site are somewhat minor in terms of total convective flow, however, the flows increase considerably with increasing flood magnitude up to the PMF design event.



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Design Flood Extents

0 90 180 m

approx. scale

Figure: **2-2**

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The proposed buildings have nominal finished floor level of 149.62m AHD. These floor levels provide for flood immunity for the buildings in excess of the 0.2% AEP design flood magnitude. At this flood magnitude not all of the Site is flood affected, with areas of inundation typically limited to shallow overland flood depths <0.2m.

At the PMF flood event inundation affects the entire Site, including the ground floor levels of the buildings. The peak flood depth above floor level is of the order of 1.2m.

The design flood immunity for the buildings, i.e. event at which above floor inundation is initiated, is estimated at between a 1 in 10,000 (0.01%) AEP and 1 in 20,000 (0.005%) AEP. This estimate is derived from the flood frequency distribution shown in Figure 2-3 using the design flood flows summarised in Table 2-1. The flood modelling provides for an approximate Muscle Creek flow of 940m^3/s resulting in peak flood levels of 149.62m AHD to initiate above floor flooding. The corresponding frequency of this event is interpolated using the frequency distribution extended between the 1 in 500 (0.2%) AEP and the PMF event (nominally 1 in 10,000,00 AEP). The interpolation is dependent on the assigned probability of the PMF, such that a secondary flood frequency distribution is shown in Figure 2-3 with the PMF assigned as 1 in 1,000,00 AEP.

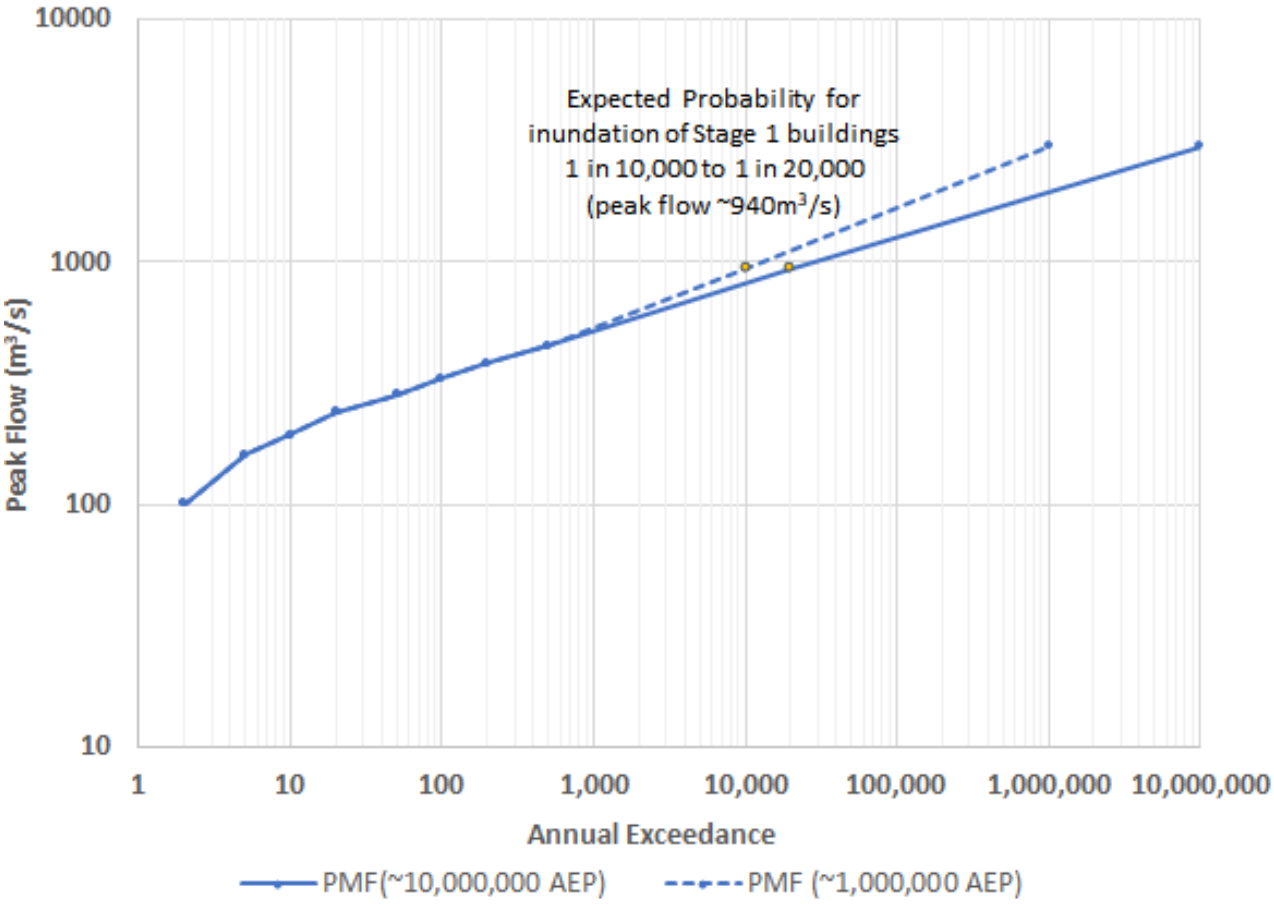


Figure 2-3 Flood Frequency Distribution for Muscle Creek Design Flows

Table 2-1 Design Flood Flows for Muscle Creek

Design Event	Peak Flow (m^3/s)
1 in 2 (50%) AEP	101
1 in 5 (20%) AEP	160
1 in 10 (10%) AEP	194
1 in 20 (5%) AEP	240
1 in 50 (2%) AEP	284
1 in 100 (1%) AEP	331
1 in 200 (0.5%) AEP	382
1 in 500 (0.2%) AEP	454
PMF	3000

2.2.2 Flood Hazard

The flood hazard conditions are a function of both flood depth and flood velocity and can be used to help understand the potential risk to people exposed to flooding at the Site.

The flood hazards have been determined in accordance with Guideline 7-3 of the Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR, 2017). This produces a six-tier hazard classification, based on modelled flood depths, velocities, and velocity-depth product. The hazard classes relate directly to the potential risk posed to people, vehicles, and buildings, as presented in Figure 2-4.

Flood hazard mapping for the simulated 1% AEP, 0.5% AEP, 0.2% AEP and PMF events is presented in Appendix B.

For all flood events up to the 0.2% AEP level, the hazard of inundation across the majority of the Site, and in particular the proposed building locations, is very low (H1) and does not present a significant risk to people located there. This low hazard is a function of the limited depth and velocity of areas inundated by the minor overland flows up to these design flood magnitudes. It is noted at the lower end of the Site there are localised areas of low to medium hazard (H3 to H4).

At the PMF event extensive high hazard (H5 to H6) flood waters are present throughout the Site and surrounding area. This presents a significant risk to people, vehicles, and buildings.

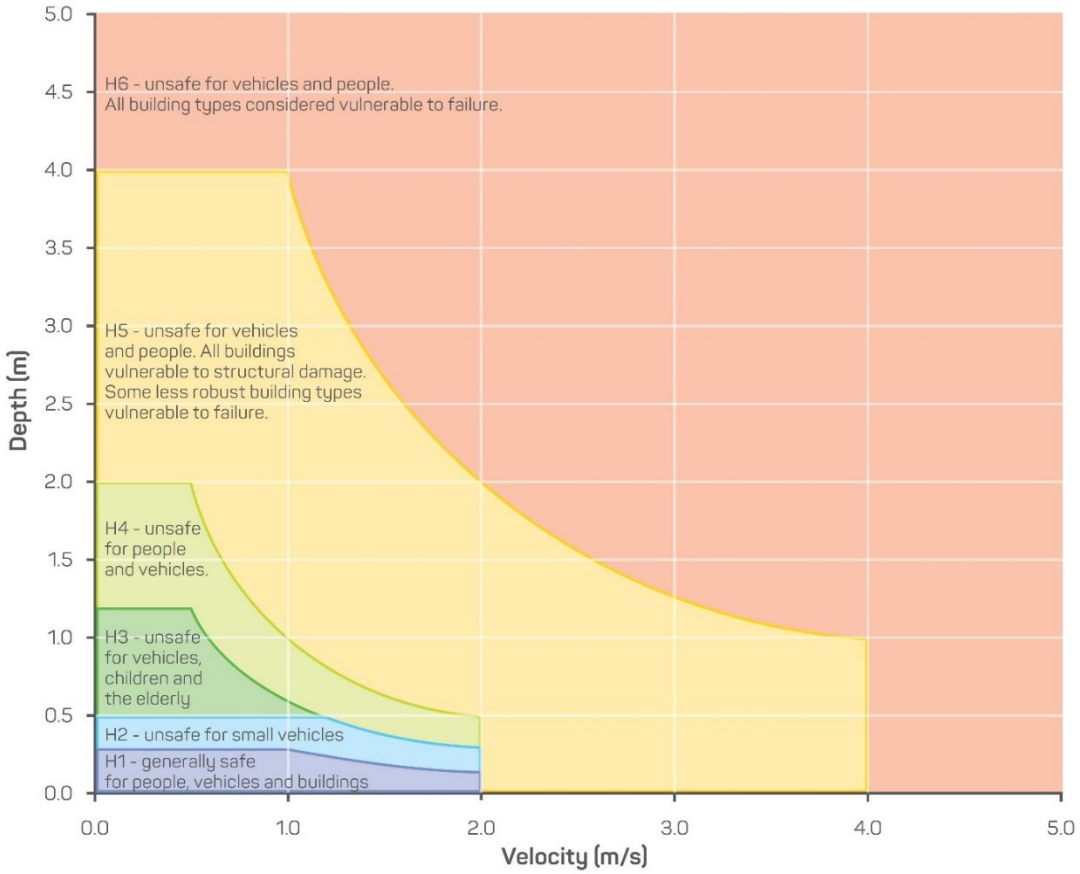


Figure 2-4 General Flood Hazard Vulnerability Curves (AIDR, 2017)

2.2.3 Flood Rate of Rise and Duration

Because of the nature of the local flood environment the rate of rise of flood waters can be rapid, particularly in an extreme event. However, this environment also produces floods of a relatively short duration, with flood waters quickly receding following the peak conditions.

For events up to the 0.2% AEP event, flood levels in Muscle Creek rise gradually over a period of hours. The approximate timing from initial inundation at the lower end of the Site to initiation of overland flow paths through the upstream part of the Site in the 0.2% AEP event is over a number of hours. Peak flood conditions typically occur within 2 to 6 hours of initial Site inundation.

The potential rate of rise in the PMF event is more significant with potentially less than 2 hours from initial Site inundation to the peak flood level condition. However, it is noted that flood access and evacuation routes are cut well below the peak PMF level, providing for a significantly shorter evacuation window.

The duration of floodplain inundation will vary on an event-specific basis but is expected to be in the order of between 2 to 6 hours.

Additional detail regarding timing of Site inundation and assessment of evacuation timelines is provided in Section 3.4.

3 Flood Forecasts and Warnings

3.1 Bureau of Meteorology

The BoM has a few generalised warning services that can provide an indication of an increased likelihood of flooding, including:

- Severe Weather Warnings
- Severe Thunderstorm Warnings
- Flood Watches
- Flood Warnings

These warning types are summarised below.

3.1.1 Severe Weather Warnings

The BoM issues Severe Weather Warnings whenever severe weather is occurring in an area or is expected to develop or move into an area. The warnings describe the area under threat and the expected hazards. Warnings are issued with varying lead-times, depending on the weather situation, and range from just an hour or two to 24 hours or sometimes more.

Severe Weather Warnings are issued for:

- Sustained winds of gale force (63 km/h) or more
- Wind gusts of 90 km/h or more (100 km/h or more in Tasmania)
- Very heavy rain that may lead to flash flooding
- Abnormally high tides (or storm tides) expected to exceed highest astronomical tide
- Unusually large surf waves expected to cause dangerous conditions on the coast
- Widespread blizzards in Alpine areas

3.1.2 Severe Thunderstorm Warnings

The BoM issues Severe Thunderstorm Warnings to alert communities of the threat of these more dangerous thunderstorms. A severe thunderstorm is one that produces any of the following:

- Large hail (20 mm in diameter or larger)
- Giant hail (50 mm in diameter or larger)
- Damaging or destructive wind gusts (generally wind gusts exceeding 90 km/h)
- Heavy rainfall which may cause flash flooding
- Tornadoes

Most thunderstorms do not reach the level of intensity needed to produce these dangerous phenomena, so the BoM does not warn for all thunderstorms.

Standard public forecasts will include information when there is a reasonable risk of severe storms. This information will allow people to prepare for the potential severe weather. Severe thunderstorms can be quite localised and can develop quickly. The exact location of severe thunderstorms can be hard to predict. As it is difficult to forecast the precise location and movement of severe storms before they have started to develop, detailed warnings will generally be provided once they have been observed or detected. The detailed warnings are usually issued without much lead-time before the event.

3.1.3 Flood Watches

The BoM issues a Flood Watch to provide early advice of a developing situation that may lead to flooding. A Flood Watch is not a warning of imminent flooding.

A Flood Watch provides information about a developing weather situation including forecast rainfall totals, catchments at risk of flooding, and indicative severity where required. The product also provides links to weather warnings, other BoM flood-related products, and contact details and information of relevant emergency services.

Although there is uncertainty attached to a Flood Watch, its early dissemination can help individuals and communities to be better prepared should flooding eventuate. A Flood Watch may discuss possible snowmelt, local flooding, or tidal impacts but a Flood Watch will not be issued solely based on these phenomena.

A Flood Watch is generally issued up to four days in advance of the expected onset of flooding. A Flood Watch can be issued before, during and after the rainfall has occurred, depending on the level of maturity of the flood warning systems and services, and flood impact information made available from the local emergency services or state agency.

Flood Watches are updated at least daily and finalised once all areas are covered by flood warnings or the risk of flooding has passed.

3.1.4 Flood Warnings

Flood Warnings are issued by the BoM to advise that flooding is occurring or expected to occur in a geographical area based on defined criteria. Flood Warnings may include either qualitative or quantitative predictions or may include a statement about future flooding that is more generalised. The type of prediction provided depends on the quality of real-time rainfall and river level data, the capability of rainfall and hydrological forecast models and the level of service required.

A quantitative or qualitative flood warning of Minor, Moderate or Major flooding is provided in areas where the BoM has specialised warning systems. They provide advanced warning about the locations along river valleys where flooding is expected, the likely class of flooding and when it is likely to occur. Predictions of expected water levels and the timing of flood peaks are provided at key forecast locations.

The BoM also provides generalised flood warnings when there is not enough data to make specific predictions or in the developing stages of a flood. They typically rely on forecast rainfall and knowledge of historical flood response. Generalised warnings contain statements advising that flooding is expected in particular river valleys but do not provide information about flood class nor precise locations.

As part of its Severe Weather Warning Service, the BoM also provides warnings for severe weather that may cause flash flooding. State emergency services or local authorities may provide flash flood warnings in some locations.

3.1.5 Accessibility of BoM Warning Services

The current BoM Warnings active in NSW can be accessed at http://www.bom.gov.au/nsw/warnings/

The rainfall recently recorded by rainfall warning gauge locations across the Hunter region can be accessed at http://www.bom.gov.au/nsw/flood/midnorth.shtml

Current rainfall radar monitoring for the Newcastle (Williamtown Airport) 128 km radius loop can be accessed at http://www.bom.gov.au/products/IDR043.loop.shtml#skip

Figure 3-1 shows the location of relevant rainfall and water level gauges to the Muscle Creek catchment. Whilst there are no specific gauges in the Muscle Creek catchment, gauges in neighbouring catchments may be useful for monitoring regional rainfall conditions and potential flood response. The relevant gauges include:

Rainfall Gauges: (1 Hour Rainfall Bulletin - Mid North Coast (NSW) (bom.gov.au))

- Aberdeen
- Denman
- Rouchel Brook
- Upper Rouchel
- Antiene Creek (Lidell)

Water Level gauges:

- Rouchel Brook (River Height data for Rouchel Bk at Rouchel Brook (bom.gov.au))
- Muswellbrook (River Height data for Hunter R at Muswellbrook (bom.gov.au))

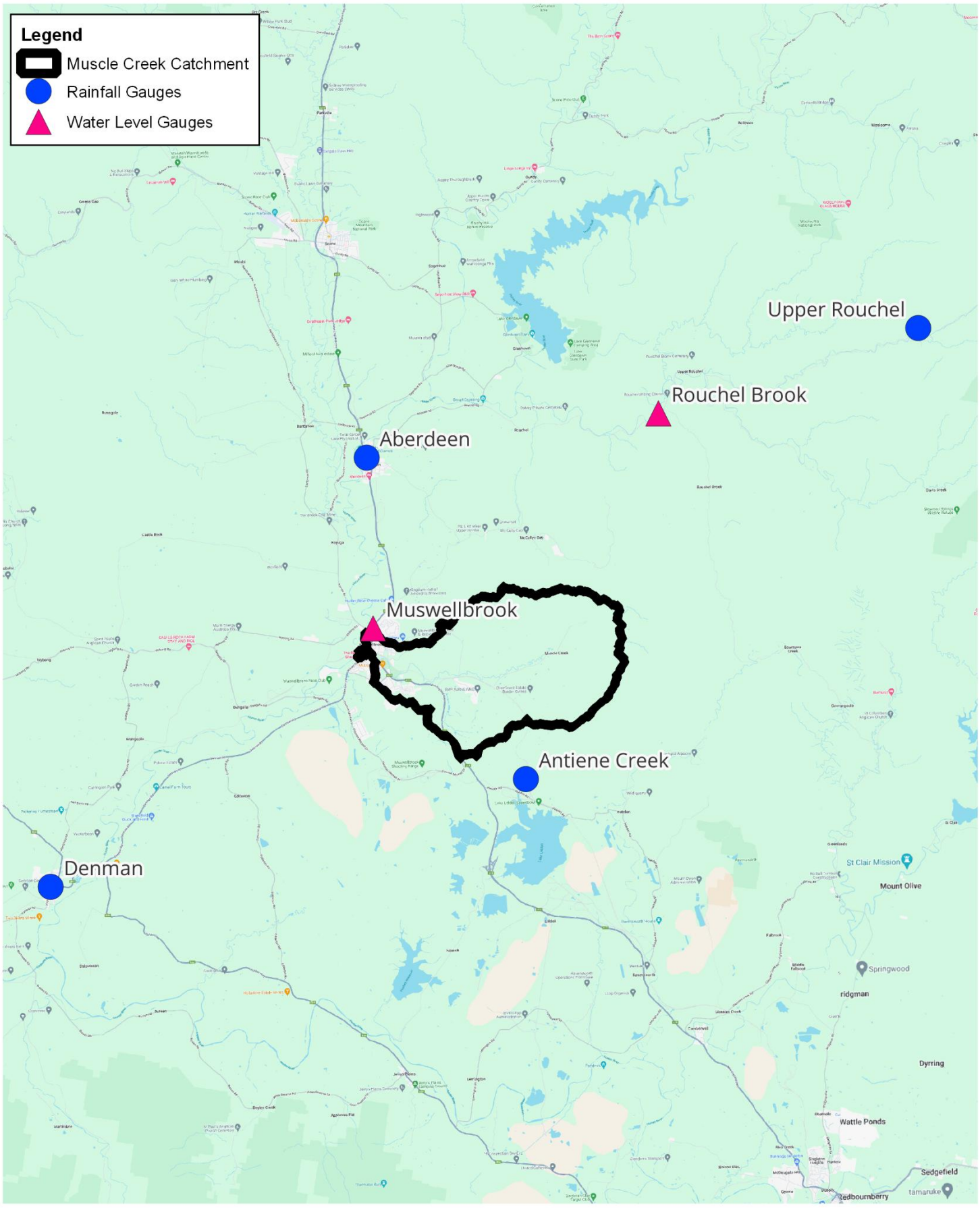
Notwithstanding the Muscle Creek Flood Warning System discussed below, given the lack of relevant gauges in close proximity to the Site it is recommended Site specific rainfall and flood level alert gauges are installed on the Site to use for flood monitoring and emergency response as part of the FERP. The BoM gauges as noted above will remain useful monitoring locations to assess broader regional rainfall conditions.

3.2 Hunter River Flood Warning

There are several gauges throughout the Hunter River system that the BoM incorporate into its operational flood warning network, including Muswellbrook.

Flood emergency response is initiated with relevant flood warnings issued by the BoM. Flood classifications in the form of locally defined flood levels are used in flood warnings to give an indication of the severity of flooding (minor, moderate or major) expected. These levels are used by the SES and BoM in flood bulletins and flood warnings. The flood classification levels are described by:

- **Minor flooding:** Causes inconvenience. Low-lying areas next to water courses are inundated. Minor roads may be closed and low-level bridges submerged. In urban areas inundation may affect some backyards and buildings below the floor level as well as bicycle and pedestrian paths. In rural areas removal of stock and equipment may be required.
- **Moderate flooding:** In addition to the above, the area of inundation is more substantial. Main traffic routes may be affected. Some buildings may be affected above the floor level. Evacuation of flood affected areas may be required. In rural areas removal of stock is required.
- **Major flooding:** In addition to the above, extensive rural areas and/or urban areas are inundated. Many buildings may be affected above the floor level. Properties and towns are likely to be isolated and major rail and traffic routes closed. Evacuation of flood affected areas may be required. Utility services may be impacted.



Title:

Rainfall and Water Level Gauge Locations

0 8 16 km

approx. scale

Figure: **3-1**

Revision: **A**

Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

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The Muswellbrook gauge is used for flood level classification and the issue of formal flood warnings in this reach of the Lower Hunter River. The Minor, Moderate and Major flood warning levels are summarised in Table 3-1 including the gauge height and conversion to flood level (m AHD). The design peak flood levels (after RHDHV, 2019) at the gauge summarised in Table 3-2 for reference.

Table 3-1 Flood Classification Levels for Hunter River at Muswellbrook

Flood Classification Gauge Reading (and level m AHD)		
Minor	Moderate	Major
7.2m (143.44m AHD)	8.0m (144.24m AHD)	10.0m (146.24m AHD)

Table 3-2 Design Peak Flood Levels (m AHD) Hunter River at Muswellbrook

Design Event	Flood Level (m AHD)
50% AEP	141.36
20% AEP	144.89
10% AEP	146.50
5% AEP	147.38
2% AEP	148.06
1% AEP	148.32

The minor flood level threshold represents an event between a 50% AEP and 20% AEP magnitude. This is also the case for the moderate flood level threshold which is approaching an equivalent 20% AEP magnitude. The major flood level threshold below the 10% AEP magnitude.

The New England Highway crossing of the Muscle Creek channel (Bridge Street subway) connecting north and south Muswellbrook is inundated tailwater from the Hunter River in as little at the 50% AEP (1 in 2yr). Accordingly, the minor flood level threshold exceedance indicates early loss of this access. Once this route is closed the only other main cross-town access road is the Bell Street crossing. The Bell Street crossing has approximately 5% AEP (1 in 20yr) which would correspond to major flood level threshold.

It is important to note that the minor flood level threshold can be exceeded only due to Muscle Creek floodwater contribution. A 2% AEP Muscle Creek flood event is sufficient to trigger a minor flood level in the Hunter River at Muswellbrook without any significant Hunter River flows. However, in reality a major event in the Muscle Creek catchment would coincide with some level of flood condition within the broader Hunter River catchment.

The BoM *Service Level Specification for Flood Forecasting and Warning Services for New South Wales and the Australian Capital Territory* (2024) provides a target flood warning time for quantitative flood level predictions at Muswellbrook of:

- 4 hours prior to reaching 7.2m AHD threshold level (Minor flood event classification)
- 12 hours prior to reaching 10.0m AHD threshold level (Major flood level classification).

Figure 3-2 shows the continuous flood level record for the Hunter River at Muswellbrook between 1961 and 2025. Over this 65-year period, the number of exceedances for the Minor, Moderate and Major flood level thresholds are 12, 8, and 3 respectively.

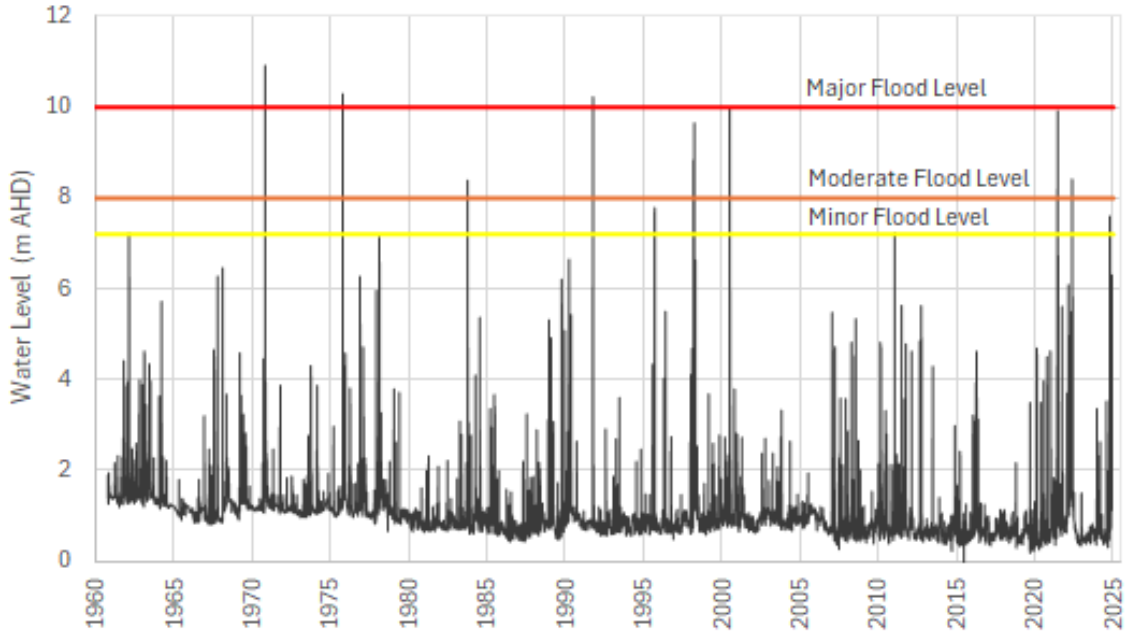


Figure 3-2 Hunter River at Muswellbrook Flood Level Record (1961-2025)

3.3 Muscle Creek Flood Warning System

Muswellbrook Shire Council has installed the Muscle Creek Flood Warning System (FWS) to provide continuous monitoring of water levels in Muscle Creek with a trigger-based alert and warning system. Aquamonix (2024) prepared the installation report and manual with relevant extracts included in Appendix C for reference. The infrastructure is located in the Olympic Park playing fields adjacent to Muscle Creek, approximately 20m downstream of the Bell Street bridge and some 700m from the proposed school buildings (refer to location in Figure 1-1. The installed infrastructure includes:

- water level pressure sensor and data logger
- automated flood warning siren
- wireless telemetry

The gauging station is tower mounted within Olympic Park with a fully automated electronic siren and 2-way SMS capability including control. It is installed at a catchment location to provide audible public warning for those in the most flood prone area between Bell Street and Wilder Street on the left bank of Muscle Creek. The site is configured to directly SMS Council and NSW State Emergency Services (SES) personnel at various threshold levels. Authorised users can also manually control the siren state and query the site for the current station status (Aquamonix 2024).

The design peak flood levels at the warning gauge location are summarised in Table 3-3.

Table 3-3 Design Peak Flood Levels (m AHD) Muscle Creek at Flood Warning Gauge

Design Event	Flood Level (m AHD)
50% AEP	144.5
20% AEP	145.2
10% AEP	145.6
5% AEP	146.1
2% AEP	146.4
1% AEP	146.5
0.5% AEP	146.7
0.2% AEP	146.8
PMF	148.9

A summary of the alert triggers adopted for the FWS are included in Appendix C with reference to the live recorded water level at the gauging station. The key triggers for the Site emergency response include:

- Initial warning to Council / SES - water level 143.5m AHD
- Initial alert to residents – water level 144.1m AHD (SMS to residents)
- Evacuate now alert to residents – water level 144.8m AHD (SMS to residents and siren activation)

The Site appears to be close to the limit of the range of the installed siren and may not be audible depending on weather conditions. Notwithstanding, the public SMS messaging accompanying both the initial and evacuation alerts will inform school staff accordingly.

The proposed PBCS Flood Emergency Response Plan is not totally dependent on the FWS, but flood warning messaging and communication protocols within the FWS does provide for increased warning times for the Site. Redundancy is provided by other rainfall and water level gauge data providing additional intelligence on local flood conditions to inform the trigger points for school closure and evacuation.

This FERP should be reviewed and updated with relevant flood intelligence data from the FWS following activation events.

3.4 Flood Warning Triggers and Timeline Analysis

The availability of flood warning intelligence provides opportunity for school closure and risk avoidance in advance of potential site inundation. Given the sequence of warning products available

and typical lead times as detailed below, School closure is expected to occur in the day preceding or prior to start of school day.

East Coast Low Warning

Major flooding in the Lower Hunter including the local Muscle Creek catchment is typically driven by East Coast Low weather systems. Early warning forecasts of East Coast Lows will be in place multiple days prior to event. East Coast Lows often intensify quickly over 12–24 hours and initial warnings will escalate to flood watch and flood warning specific to predicted severity of event and geographic location.

The proposed action for an early East Coast Low warning is to monitor conditions unless the specific advice for closure from Emergency authorities is provided. This will be dependent on geographic location and expected severity of event.

Flood Watch

The BoM issues a Flood Watch to provide early advice of a developing situation that may lead to flooding including information on forecast rainfall totals, catchments at risk of flooding, and indicative severity where required. A Flood Watch will typically be in place at least 24-hours prior to flooding event.

The proposed action for a Flood Watch is to monitor conditions unless:

- Moderate to major flooding for Hunter River at Muswellbrook is predicted at which point a pre-emptive school closure is undertaken.
- the specific advice for closure from Emergency authorities is provided.

Flood Warning

The BoM issues a Flood Warning to advise that flooding is occurring or expected to occur in Hunter River at Muswellbrook as part of its formal forecast and warning network. The target lead warning time for exceedance of the Major flood threshold is 12-hours.

The proposed action for a Flood Warning is to monitor conditions unless:

- Moderate to major flooding for Hunter River at Muswellbrook is predicted at which point a pre-emptive school closure is undertaken.
- the specific advice for closure from Emergency authorities is provided.

Flood Evacuation Alert

Flood alert is triggered from the Muscle Creek Flood Warning System (received via automatic SMS alert). Note that major flooding in Muscle Creek triggers Hunter River warning thresholds such that this occurrence will be preceded by above warnings such that prior School closure has likely occurred.

The proposed action for a Flood Evacuation Alert

- School closure if outside of operating hours.
- Enact Site Evacuation to nominated flood refuge at Muswellbrook Sports Centre if inside operating hours.

Figure 3-3 shows an indicative timeline in the escalation of these flood warning services.

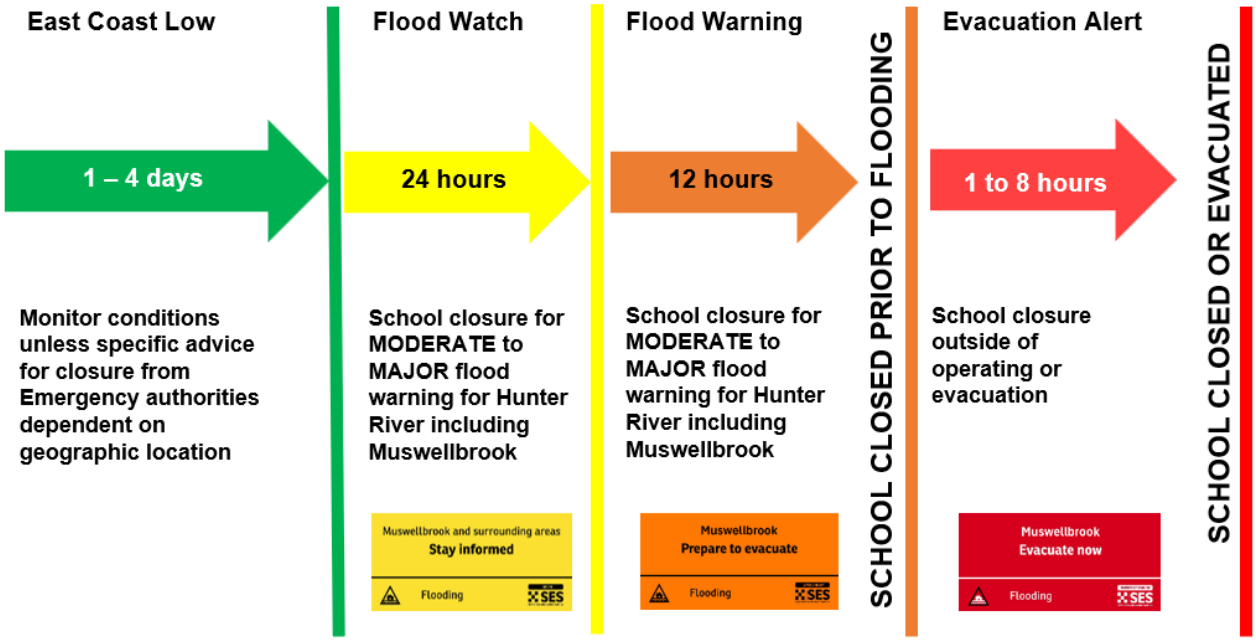


Figure 3-3 Timing of Early Flood Warning Services and School Closure

The early warning services detailed above is expected to result in the precautionary closure of the School prior to flood affectation of the Site. Therefore, it is only rapidly developing, localised intense storms that might require an emergency evacuation response whilst the Site is occupied.

It is significant to reiterate that the building areas are subject to inundation only for events of the 0.2% AEP (1 in 500) and above, with the buildings having floor levels up to a 0.01% AEP (1 in 10,000). Weather systems of this magnitude and across the 100km^2 scale of the Muscle Creek catchment would be subject to early warning services from the BoM. Put simply, these rainfall systems would not suddenly appear and restrict emergency response to short periods of less than an hour. Moreover, the advance warning associated with rainfall systems of this magnitude would invariably provide for the appropriate school closure in advance of the flood affectation of the Site.

Notwithstanding this likelihood of considerable lead warning time to close the school, the following timeline analysis of the 0.2% AEP and PMF events represents a reactive response in the event the Site is occupied.

Figure 3-4 shows the simulated flood level response for the 0.2% AEP event at the following reference points:

- Muscle Creek channel at the New England Highway crossing connecting north and south Muswellbrook - this location is to identify overtopping of the New England Highway and loss of flood access
- Muscle Creek channel at the FWS gauge location – this location provides for the general rise in flood level in the creek channel relevant to the trigger levels adopted for the FWS
- Muscle Creek channel at the Bell Street bridge crossing connecting - this location is to identify overtopping of Bell Street and loss of flood access
- Site low point – the lowest existing ground level at the north-east Site boundary and initial point of inundation of the Site for events of 1% AEP magnitude and above (no Site flooding for lower order events)

- Proposed building area – representing above ground water levels at Stage 1 and provides for the onset of overland flooding in the location of the buildings (note: references ground level, not floor level)

The timing of the water level rise in Figure 3-4 is from time zero (0-hours) at the commencement of the simulated design rainfall. The timing of the FWS initial alert (141.1m AHD) and evacuation alert (141.8m AHD) trigger levels being reached is shown on the gauging station water level profile.

In addition to the FWS trigger levels, four key reference points are identified on Figure 3-4:

1. Initial inundation of the Site at the low point which occurs at similar time to Bell Street overtopping – occurs some 17 hours into the simulation and 3 hours after the initial FWS alert.
2. Initial inundation of ground levels surrounding the proposed building locations - occurs some 6 hours after the initial FWS alert.
3. Maitland Street unviable as evacuation route due – occurs some 8 hours after the initial FWS alert corresponding approximately to the peak level of the 0.2% event (noting at 0.2% AEP peak flood hazard route remains trafficable)
4. Peak flood condition which corresponds to shallow inundation around buildings at more than 0.4m below floor level buildings – 8 hours after the initial FWS alert.

An indicative evacuation window of around 8 hours is shown for the 0.2% AEP event. This corresponds to the time between the initial FWS public alert and the peak of the event at above which the Maitland Street evacuation route starts to become unviable.

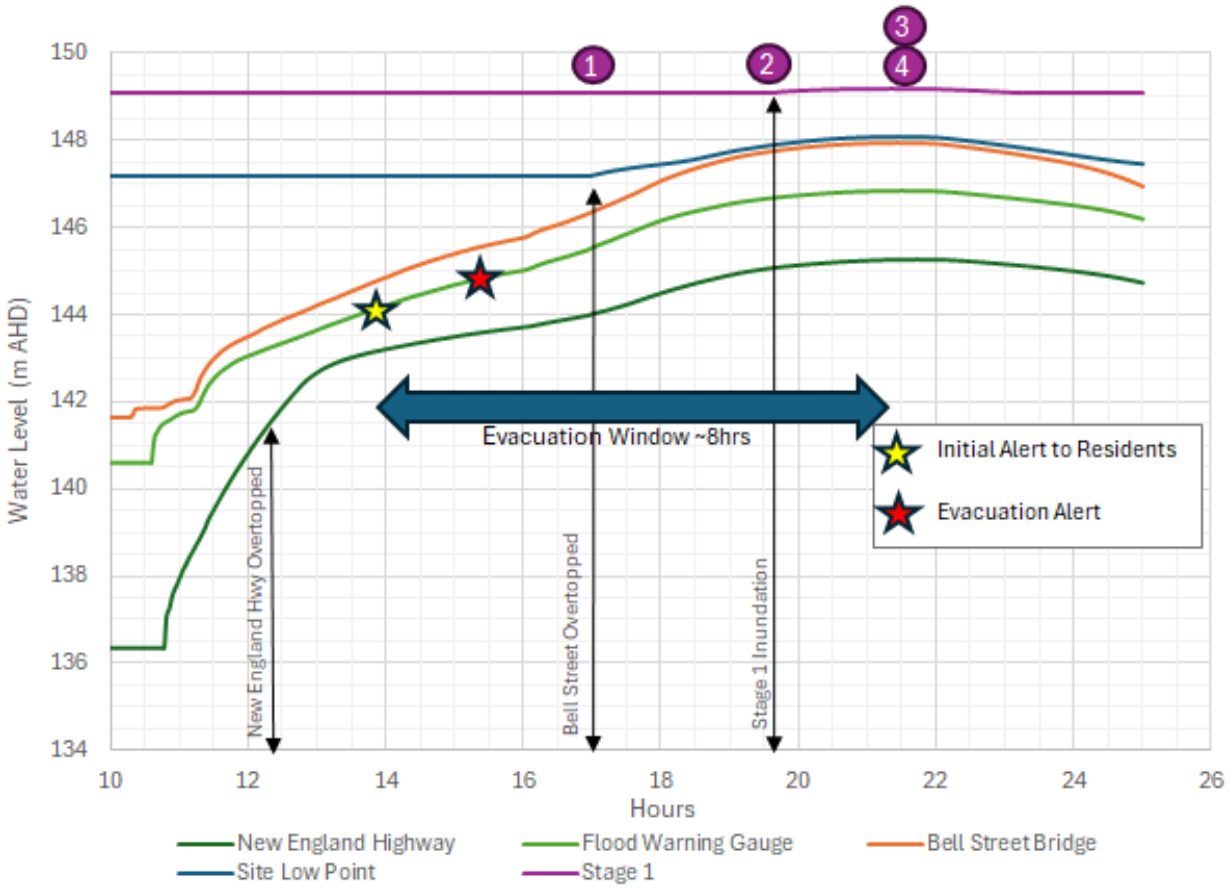


Figure 3-4 Timing of Flood Level Response - 0.2% AEP Event

A similar timeline assessment for the PMF event is shown in Figure 3-5. The timing of the FWS initial alert trigger (141.1m AHD) occurs approximately 50 minutes after the commencement of the simulated design rainfall. Similarly, the evacuation alert trigger (141.8m AHD) occurs just after 60 minutes.

The flood conditions relative to the four key reference points identified on Figure 3-4 are noted as:

1. Initial inundation of the Site at the low point which occurs at similar time to Bell Street overtopping –occurs approximately 30 minutes after the initial FWS alert.
2. Initial inundation of ground levels surrounding the proposed building locations - occurs approximately 50 minutes after the initial FWS alert.
3. Maitland Street unviable as evacuation route due – occurs approximately 70 minutes after the initial FWS alert.
4. Peak flood condition which corresponds to ~1.2m depth of above floor flooding in proposed buildings – occurs at time 4 hours into the simulation.

An indicative evacuation window of around 70 minutes is shown for the PMF event. This corresponds to the time between the initial FWS public alert and the timing at which the Maitland Street evacuation route starts to become unviable.

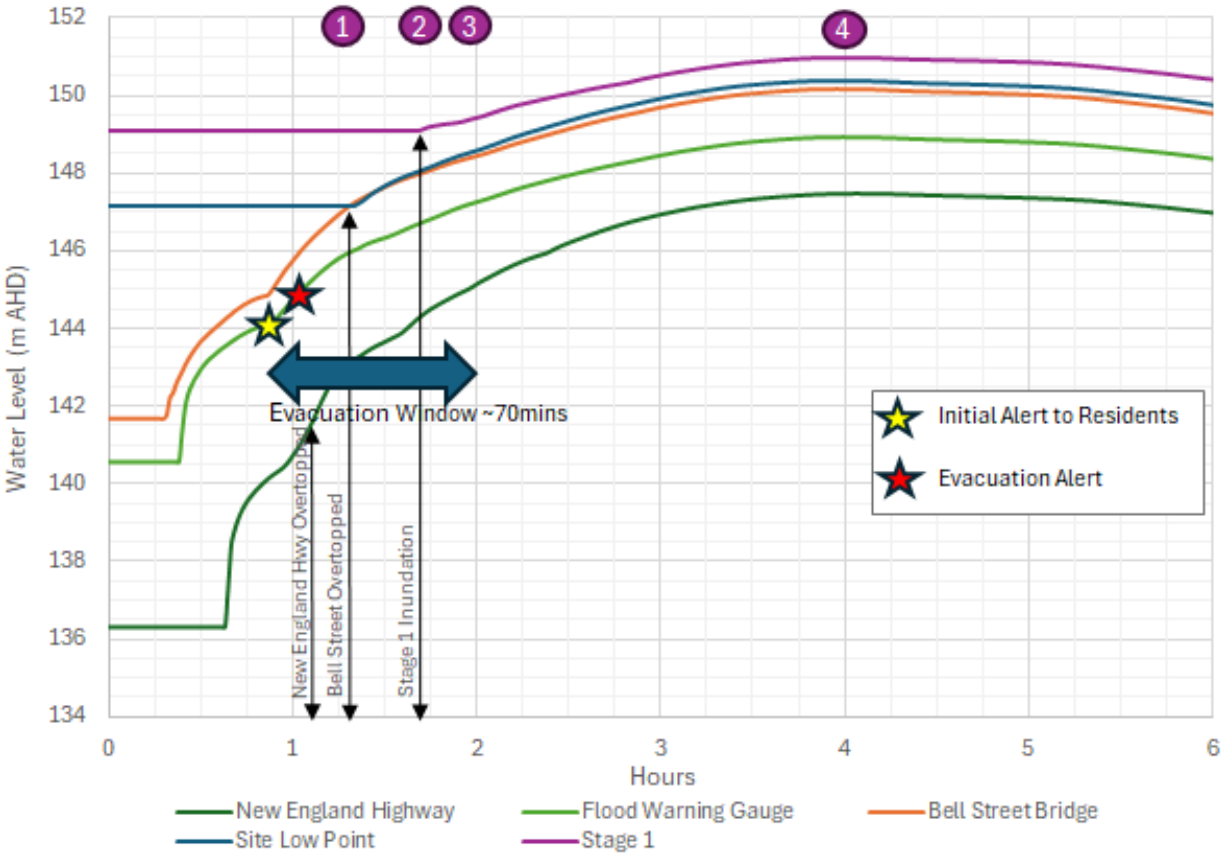


Figure 3-5 Timing of Flood Level Response - PMF Event

Even in the absence of FWS alerts, there is a reasonable evacuation window of 35 minutes from the initial inundation of the Site.

To further appreciate the changing risk profile on the Site as the flooding increases, Figure 3-6 shows the progression of the flood inundation extents and flood hazard classification surrounding the Site for the PMF event. The four images correspond to the reference/trigger points noted above.

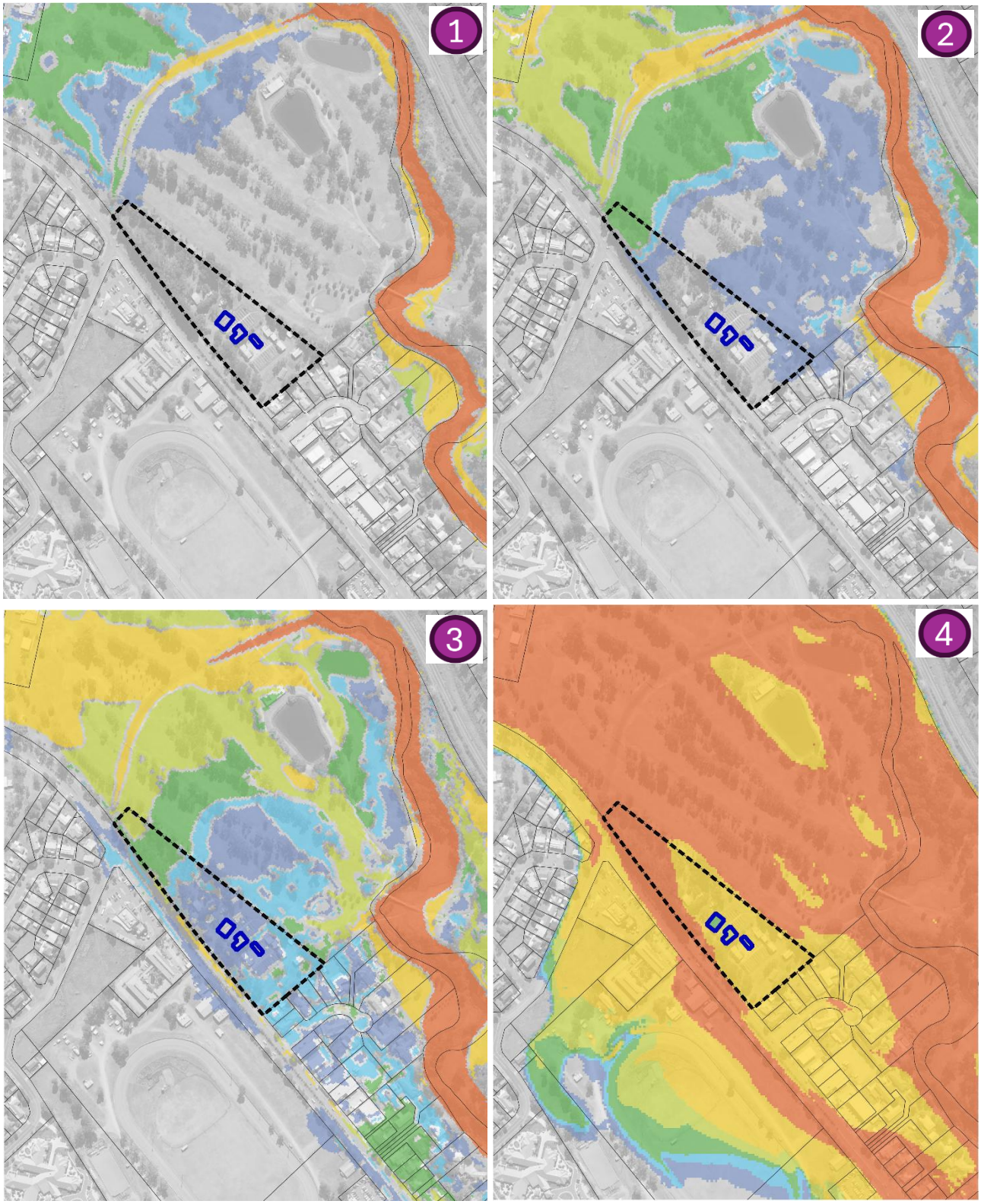


Figure 3-6 Progression of Flood Hazard - PMF Event

Inundation of the Site at the low point at trigger 1 is preceded by the adjacent Muscle Creek channel experiencing a rise in flood level of over 3.5m (approaching the 1% AEP peak flood level). These elevated creek levels, also corresponding to a flooded width in excess of 100m, would provide a relevant visual cue for a flooding condition to initiate a flood response.

Broader floodplain inundation across the Golf Course and the start of proposed building area inundation at trigger 2 is initiated by the overland breakout flows from Muscle Creek upstream of the Site. These overland flows increase through to trigger 3 with flows initiated down Maitland Street and providing flood hazard conditions that require evacuation to have been effected from this point.

The peak flood condition represented as trigger 4 shows extensive floodplain inundation and typically high hazard classes H5 and H6 across the majority of inundation area, except the floodplain fringes. The nominal evacuation centre (refer to Section 0) is located outside the PMF extent. During this flood event access to the Site will be impacted, both locally within the surrounding roadways, but potentially more broadly through impacts to other transport routes across Muswellbrook.

Peak flood hazard surrounding the proposed buildings is at H5 level, and accordingly the typical building construction would provide for structural integrity of these buildings at the peak PMF flood condition.

Long response timelines up to 6 hours are typically available for major flood events including up the 0.2% AEP event. Figure 3-7 shows a representative minimum response timeline available for the Site to achieve an appropriate evacuation for the PMF event. The timeline commences at receipt of initial flood alert from the Muscle Creek FWS. Further early warning opportunity may be provided from official BoM and SES emergency warnings, live rainfall gauge triggers (refer to Section 0) and visual references such as Muscle Creek water levels.

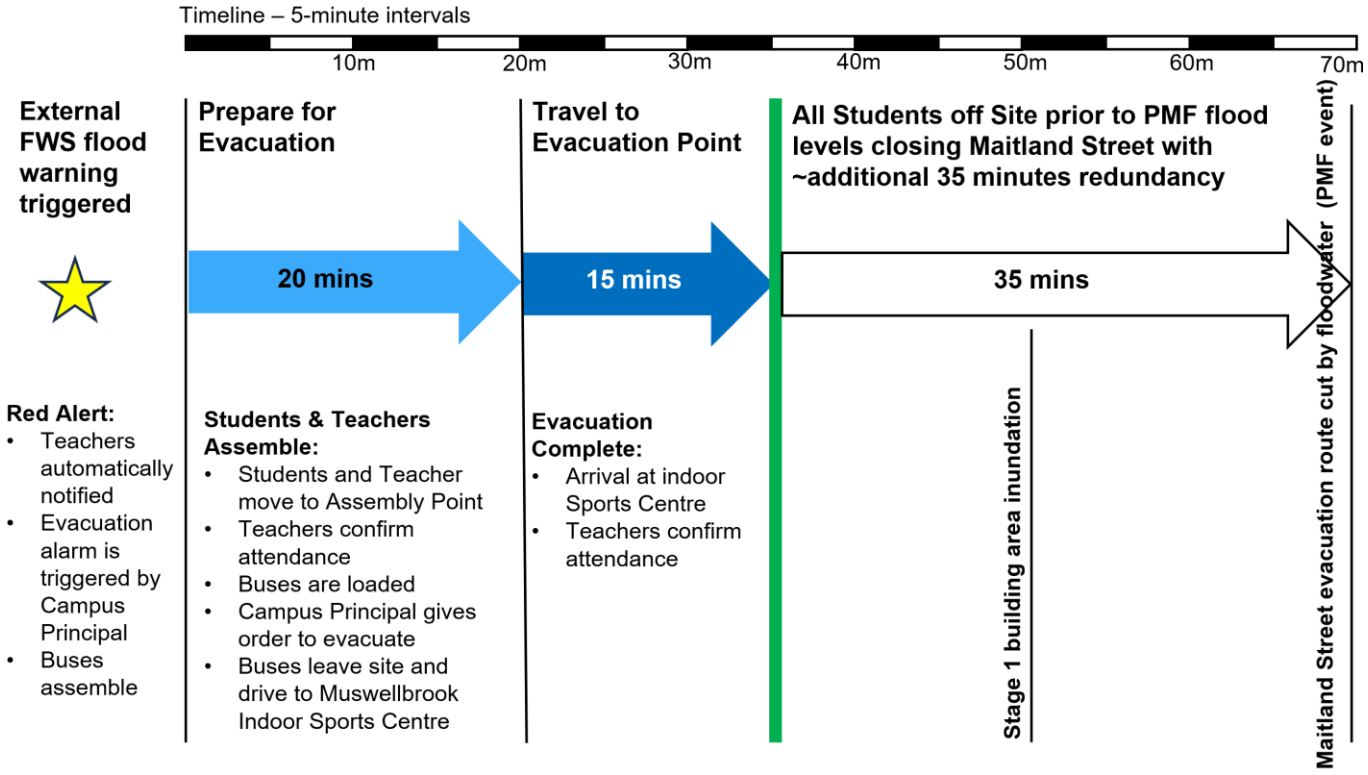


Figure 3-7 Minimum Flood Warning and Emergency Response Timeline and Action Plan

It is further noted that the initial Site inundation occurs at approximately 30 minutes after the initial FWS alert. The proposed water level gauge at the low point of the Site would provide additional redundancy to the FWS operation. A warning based on initial Site inundation still provides a 35-minute window to execute an evacuation prior to the evacuation route being compromised.

3.4.1 Rainfall Evacuation Triggers

The initial trigger point for the evacuation timeline is linked to initiation of flood inundation at the low point of the Site at the northeast corner. This FERP recommends the installation of an on-site water level gauge at this location with flood alert capability linked to the school's emergency systems.

Additional lead flood warning time prior to an evacuation response based on the Site inundation is achievable in enacting early warning triggers based on recorded rainfall. Give the lack of existing rainfall gauges in the Muscle Creek catchment, the FERP recommends the installation of an automated weather station with pluviometer to record site rainfall and provide the basis for a rainfall trigger.

Design rainfall depths were sourced from the BoM IFD portal and are summarised in Table 3-4 for various design event magnitudes and storm durations. A nominal 50mm rainfall in 30minutes is equivalent to a 1in 2000 AEP event (noting the buildings have a representative design flood immunity of 1in 10,0000 AEP). Accordingly, this threshold of rainfall trigger would provide appropriate warning time for all of the events up to the very rare categorisation.

The frequency this rainfall threshold of 50mm is reached is demonstrated in the highlighted cells in Table 3-4. For example, the design 1% AEP rainfall depth of 50mm would occur over a longer 2-hour duration. Similarly, a 50mm rainfall depth for the 10% AEP occurs over 6-hour period.

The design PMF event provides for some 540mm of rainfall in 4-hours, representing an average intensity of 140mm/hour or an equivalent 70mm in 30 minutes. The adopted 50mm in 30-minute rainfall threshold effectively captures this intensity and would be an appropriate trigger to initiate evacuation in the event the PMF rainfall intensities are sustained for a longer duration.

Table 3-4 Design IFD Rainfall

Duration (mins)	10% AEP	5% AEP	2% AEP	1% AEP	1 in 200	1 in 500	1 in 1000	1 in 2000
30	21	24.2	28.8	32.2	35.4	40.3	44.1	48.1
45	25.3	29.1	34.2	38.3	42.1	47.8	52.4	57.1
60	28.4	32.5	38.1	42.5	46.6	53	57.9	63.1
90	32.8	37.5	43.6	48.4	53	60	65.5	71.1
120	36.1	41.1	47.7	52.7	57.5	64.9	70.7	76.7
180	41.5	47.1	54.4	59.9	65.1	73.2	79.6	86.3
270	48.4	54.9	63.8	70.5	76.6	86.5	94.1	102.1
360	54.5	62.3	73	81.2	88.2	101	110.4	120.4

4 Flood Emergency Response Plan

4.1 The Emergency Response Strategy

The recommended flood emergency response strategy is derived from the understanding of flood risk for the Site. The key observations in this regard include:

- The proposed building area remains flood free up to 0.2% AEP (1in 500) design flood magnitude. The elevated floor levels of the buildings provide for a flood immunity (no above floor flooding) up to 0.01% AEP (1in 10,000) design flood magnitude. Accordingly, the design flood immunity afforded to the Site represents a very low risk of exceedance.
- For extreme flood events in excess of these magnitude, up to the PMF event, the predicted flood conditions warrant the Site to not be occupied. For the scale and magnitude of such flood events, it is expected that flood and emergency warnings will be in place for not only the Muscle Creek catchment, but the broader mid-Hunter region. These advance warnings are expected to facilitate school closure prior to any on-site flooding exposure.
- In the unlikely event of flood condition exceeding 0.2% AEP (1in 500) design flood magnitude within the hours of school operation, evacuation of the Site to a nominated flood refuge can be executed within available warning times. A flood evacuation timeline analysis has demonstrated evacuation capability for all events up to and including the PMF event within initial inundation of the Site. Lead warning times are enhanced with alerts from the Muscle Creek Flood Warning System and installation of rainfall and water level gauges within the Site.

The available flood warning opportunity is expected to limit flood risk exposure via initial flood avoidance through school closures. In the unlikely event the Site is occupied during an extreme flood event, effective site evacuation procedures enable relocation from Site to the nominated flood refuge prior to potential flood inundation of the buildings. The recommended flood emergency response comprises:

- School closure
- Evacuation to nominated flood refuge

The responsibilities and actions for effective flood emergency response management at the Site are outlined in this FERP. The FERP forms part of the broader Risk and Emergency Management framework of Pacific Brook Christian School (PBCS).

4.1.1 School Closure

Given the length of the school day (say 8:30am-3:30pm) and the number of school days outside holiday periods, there is only around a 15% chance that any given flood event will coincide with potential occupation of the Site. The availability of flood warning intelligence to inform potential flood risk in advance of the peak flooding conditions provides significant opportunity for school closure and risk elimination. Accordingly, this represents the principal emergency response.

As noted, the events providing for inundation of the buildings are well in excess of the 1% AEP flood magnitude. Accordingly, flood events requiring Site closure are expected to be preceded by official BoM warnings. In most circumstances these warnings will allow for the school closure prior to start of the school day, or provide appropriate lead warning time during school operation to facilitate a closure prior to flood affectation.

School closure prior to flooding of the Site will be under any of the following conditions:

- BoM Flood Watch issued including warning for moderate to major flooding (typical 24hours notice)
- BoM Flood Warning issued including warning for moderate to major flooding (typical 12hours notice)
- SES Watch and Act Flood Warning to prepare for evacuation (typically preceded by above warnings exceeding major flooding >12hours)
- SES Emergency Warning to evacuate (typically preceded by above warnings exceeding major flooding >6hours)
- Automatic Flood Alert from Muswellbrook FWS (variable warning time typically >6hours to 1hour in worst case PMF)

4.1.2 Evacuation

Site evacuation is to be initiated by any the following triggers:

- Flood alert issued from the Muscle Creek Flood Warning System
- Order by SES or other emergency services
- Flood alert via installed water level gauge at Site low point
- Recorded rainfall of 50mm or more in a 30-minute period via the installed rain gauge on-site or other monitored gauge locations
- Visual cue of Muscle Creek flood inundation

The flood hazard within the local and regional road network can be higher than within the Site and so leaving the Site at an inappropriate time, outside of the Flood emergency Response Plan would increase the level of risk, particularly given the context of the local “flash flood” environment. Coupled with a relatively short warning time, these conditions make evacuation from the Site during an unlikely PMF event challenging, from both a logistical and risk-based perspective.

Notwithstanding these potential challenges, the evacuation assessment provides for an effective route within an appropriate timeline to evacuate the Site.

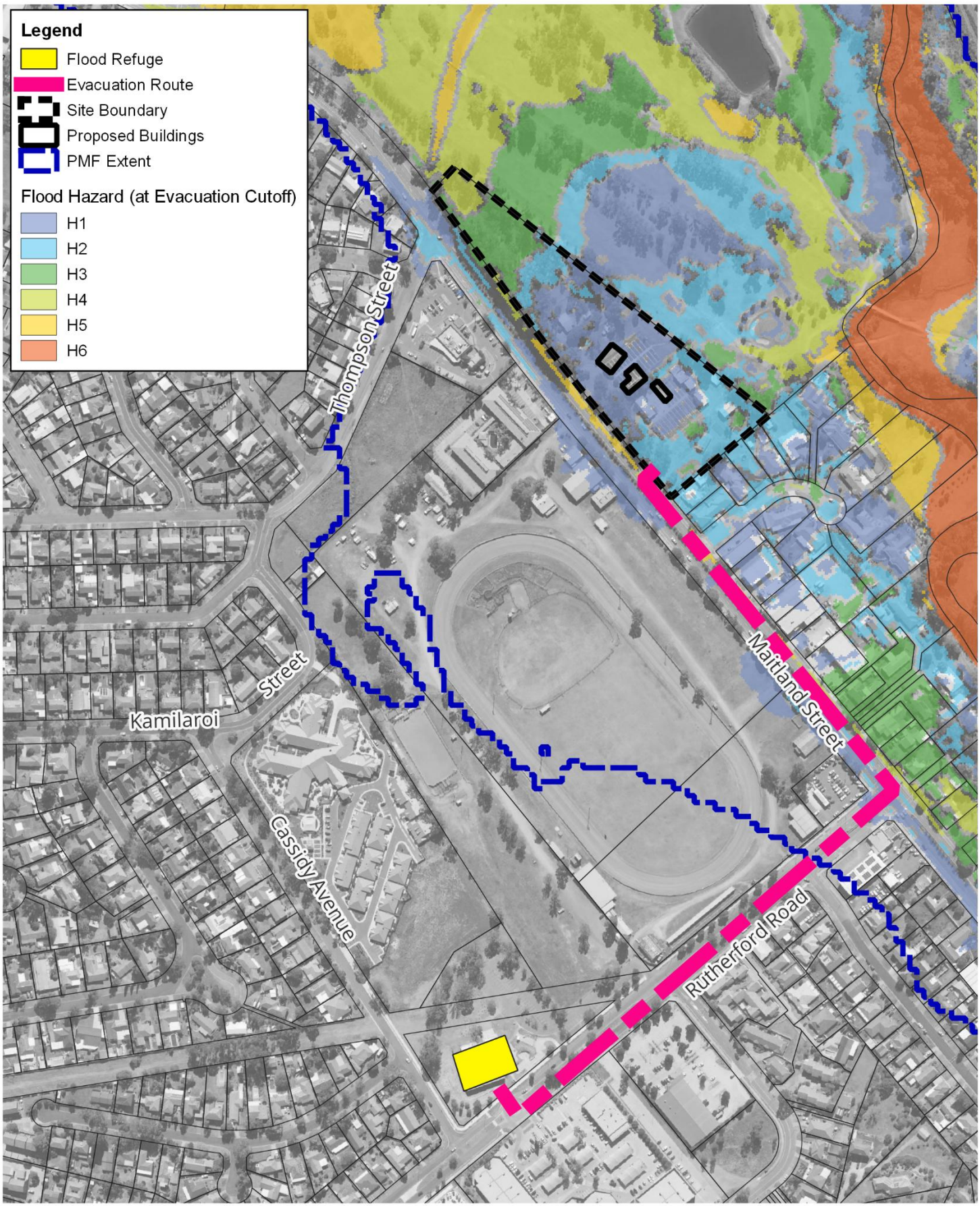
The evacuation centre/flood refuge is identified as Muswellbrook Indoor Sports Centre (corner of Rutherford Road and Cassidy Avenue. The Sports Centre is located outside the PMF extent with operating hours Monday to Saturday 9am to 9pm, compatible with school opening hours.

PBCS has confirmation from Council (refer Appendix D) that Muswellbrook Indoor Sports Centre is the appropriate flood refuge in accordance with existing emergency management arrangements.

The nominal evacuation route is via Maitland Street and Rutherford Road as shown in Figure 4-1 and represents a distance of some 900m.

The flood risk profile along the potential evacuation routes and evacuation timeline analysis was discussed in Section 0.

The proposed method of evacuation is via school buses stationed on the school premises. This type of heavy vehicle transport provides additional protection for staff and students during the relocation to the Flood Refuge. In the event bus transport is not available (e.g. off-site, inoperable) the same evacuation triggers enable pedestrian evacuation via the same route within the available warning times.



Title:

Flood Evacuation Route

0 100 200 m

approx. scale

Figure: **4-1**

Revision: **A**

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4.2 Responsibilities

Roles and responsibilities in case of an emergency are defined in the School Work Safe Polices. This section provides an overview of the key information that is relevant to a flood emergency.

The responsibility of successful implementation of the FERP sits with PBCS (specifically the Chief Warden), however, the NSW SES as the State combat agency for flood events and the NSW Police Force have right to and may intervene before, after or during a flood to provide guidance or prescriptive directions to PBCS.

PBCS will provide the following staff resources to coordinate the management of flood emergencies:

- Chief Warden (currently nominated as School Principal) – will be present on Site and responsible for decision making during an event and for assisting in communication and management of stakeholders, and have access to the resources necessary to manage an incident (e.g. flood alert triggers, CCTV cameras, PA system).
- PBCS Management - responsible for overseeing review, maintenance and training for equipment and procedures required to implement the FERP, including the Warden structure
- Flood Wardens (nominated School Staff) - will be present on Site and have access to the resources necessary to manage an incident (e.g. flood alert triggers, CCTV cameras, PA system). A Warden will be delegated as acting Chief Warden when the Chief Warden is absent from the Site

Wardens will be trained to deal with flood emergencies and will follow the directions of the Chief Warden. A total of at least three Wardens will always be present onsite.

4.2.1 NSW State Emergency Services

The NSW State Emergency Service (SES) is the lead combat agency for flooding in NSW. It can command resources from other government organisations including local Councils, Transport for NSW, and the Police to assist in flood operations under its command.

Under the State Emergency and Rescue Management Act, 1989, the SES has the power to direct any citizen or organisation to take actions in response to flooding. This includes the power to order evacuations.

Any flood response directive issued by the SES or by delegated authority to others acting on its behalf must be followed by PBCS staff, students, and visitors. This includes any order to evacuate the Site or not evacuate the Site, irrespective of what decisions have been made by management in accordance with this FERP.

4.2.2 PBCS Management Team

In the event of a critical incident, an action plan will be implemented. Both the plan and its implementation are the responsibility of the PBCS Management Team, under the direction of the Chief Warden (School Principal). The Team will decide on the specifics of the action plan and how it will be implemented, depending upon the extent, nature, and complexity of the incident. A flood emergency response will activate the Team whether on duty or otherwise.

The PBCS Management Team will not need to meet to discuss or make a decision during a flood emergency response. However, they are all aware of the requirements and process and will be available to support the Warden structure, as required.

The PBCS Management Team (or other group with delegated emergency management function) will be responsible for ensuring that this FERP is:

- reviewed annually or after any flood event to reflect any lessons learnt or changes in the Site layout, features, or operations or to incorporate new data on flood behaviour as this becomes available
- is included in induction and training of Site staff (i.e. Chief Wardens, Wardens, etc.) to a level appropriate to their responsibilities under the FERP

The PBCS Management Team will also be responsible for the following tasks:

- Ensure that the Chief Warden or delegates are aware of flood risks and of the risk management actions and responsibilities detailed in this FERP
- Ensure that there are enough Wardens to coordinate the FERP
- Ensure that a maintenance schedule for the on-site flood level alert and rainfall gauge is kept and maintained
- Organise an annual drill of the flood emergency response procedures
- Document FERP reviews, flood emergency response drills and post-event reviews of actual flood emergency responses
- Support the Chief Warden and Wardens in their duties
- Ensure an annual audit is undertaken of the resources necessary to implement this FERP

4.2.3 Chief Warden

During a flood emergency response, the Chief Warden is responsible for:

- High-level decision making relating to flood emergency response
- External stakeholder communication (parents and carers, State Emergency Services, etc.).

The Chief Warden will be responsible for the following tasks:

- Monitoring of flood warning network services
- Support the PBCS Management Team in its duties
- Ensure that the Wardens receive the required training to assist in the implementation of the FERP.

The Chief Warden (or delegate) will:

- Ensure that all Wardens who are on Site are aware of the flood risks and the flood management procedures detailed in this FERP
- Support the Wardens in their duties
- Ensure that the Site flood management measures and infrastructure are functional
- Lead the annual drill of the flood emergency response procedures
- Monitor Warnings and Alert Mode triggers in accordance with this FERP
- Escalate Alert Modes in accordance with the relevant triggers set in this FERP
- Assist, coordinate and communicate flood response messages to Wardens, staff, students, and visitors in accordance with this FERP
- Coordinate all flood emergency procedures
- Participate in a review of this FERP annually and following a flood event

4.2.4 Wardens

The Wardens will:

- Assist the Chief Warden implement flood emergency response procedures, as required
- Participate in the annual test of the flood emergency response procedures
- Participate in a review of this FERP annually and following a flood event

4.2.5 Staff, Students and Visitors

Staff, students, and visitors will:

- Follow the directions of the Chief Warden, Wardens, or PA announcements
- Report any concerns

4.2.6 Training

All staff with FERP responsibilities are to undertake the required training. Ensuring that this training is provided is the responsibility of the PBCS Management Team. Most training is consistent with the broader Emergency Management Planning and Critical Incident Management requirements and not specific to the FERP. This includes standard training for Wardens and First Aid Officers, etc.

Familiarisation with the FERP should form part of the induction and regular training for relevant staff. In addition, a full drill of a flood emergency response will be undertaken annually. The performance outcomes of the drill will be reviewed by the PBCS Management Team.

Specific training is also to be provided to the Chief Warden and members of the PBCS Management Team as to the accessibility and interpretation of the available flood warning information and how this can improve the decision-making process during the management of a flood emergency response. Sample flood awareness and training resources are included in Appendix G.

Annual communications will be provided by PBCS to parents and carers, educating them about the FERP and their requirement not to attempt to collect their children during a flood emergency response, until advised to do so.

4.3 Communication Methods

The Chief Warden / PBCS Management Team is responsible for communications with external stakeholders during a flood emergency response.

In situations where a potential flood event is identified by the BoM via a Warning being issued, the PBCS Management Team and Chief Warden will communicate with one another using their standard means. If the decision is made to close the school in advance of an expected flood event, then this will be communicated by PBCS to students, parents and carers, the morning of the event or the day prior.

In situations where the Site is currently in use and a flood event is imminently expected (i.e. a Red Alert Mode) then communication is made, advising occupants as to the need for responsive action. This will be done as per the PBCS standard procedure for lockdown situations and drills, i.e. via pre-recorded messaging in the phone system being broadcast to phones and the playground amp. A siren will be sounded via the PA system (unless the Site is locked and not in use). The PBCS Management Team, Chief Warden and Wardens can continue to communicate via mobile phone if those systems are still operational, or by using the two-way radios, as required.

When a Red Alert Mode is activated then automatic messaging will be issued to parents and carers via the standard communication procedures. This will inform them that the school is in refuge for potential flood isolation and that they will be notified again when the flood risk concern at the Site has passed. It is important that parents and carers are instructed not to attempt collection of students from the Site prior to the subsequent advice to do so. Annual communications will be provided by PBCS to parents and carers, educating them about the FERP and this requirement, led by the PBCS Management Team. This will include examples of the standardised messaging that will be received.

In situations where the Site has been subject to a flood event and the event has subsequently receded (i.e. a Green Alert Mode) then the PBCS Management Team, Chief Warden and Wardens can continue to communicate via mobile phone if those systems are still operational, or by using the two-way radios, as required.

Once normal operations are resumed then this will be communicated by the PBCS Management Team to parents and carers, via the standard communication procedures, including arrangements for collection of the students from the Site, as required. It is important that those being asked to collect people from Site are advised to first check for any road closures due to flooding. Whilst the roads local to the Site will have re-opened, others across the broader school catchment area could still be affected.

The Flood Refuge will inherently contain numerous laptops and mobile phones that can be used to facilitate communication with external stakeholders. Many of these will likely have sufficient charge to last throughout the duration of emergency response. However, as a contingency the Flood Refuge will contain external battery sources capable of powering a laptop and mobile phone.

The members of the PBCS Management Team and Chief Warden are each to have ready access to this FERP, both through the online cloud storage and as hardcopies located in the Administration Office and Staff Rooms. Broader access to the FERP will be provided through having a printed and laminated copy of the Summary FERP document (refer Appendix E) available within each classroom and other appropriate locations across the Site.

4.4 What to do Before, During and After a Flood

4.4.1 Normal Operation

During normal day-to-day operations, when the Site is not in a state of flood alert, the PBCS Management Team will:

- Ensure that this FERP is reviewed annually or after any flood event to reflect any lessons learnt or changes in the Site layout, features, or operations or to incorporate new data on flood behaviour as this becomes available
- Ensure that this FERP is included in induction and training of Site staff (i.e. Chief Wardens, Wardens, etc.) to a level appropriate to their responsibilities under the FERP
- Ensure that the Chief Warden or delegates are aware of flood risks and of the risk management actions and responsibilities detailed in this FERP
- Ensure that there are enough Wardens to coordinate the FERP
- Organise a drill of the flood emergency response procedures annually

The Chief Warden (or delegate) will:

- Daily monitor the sources of information for the triggers of the Alert Modes

- Ensure that all Wardens who are on Site are aware of the flood risks and the flood management procedures detailed in this FERP
- Maintain a register of the staff, students, and visitors present on Site, including contact details and emergency contacts
- Ensure that the Site flood management measures and infrastructure are functional
- Lead the annual drill of the flood emergency response procedures
- Participate in a review of this FERP annually and following a flood event

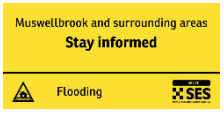
The Wardens will:

- Participate in the annual test of the flood emergency response procedures
- Participate in a review of this FERP annually and following a flood event

4.4.2 Alert Modes

To assist in managing flood risks and communicating response actions, four flood Alert Modes have been developed:

- Yellow: flooding of the Site is possible in coming day (>12hrs warning)
  - Flood Watch or Flood Warning issued for minor to moderate flooding – heightened monitoring of developing situation
  - Flood Watch or Flood Warning issued for moderate to major flooding – pre-emptive school closure



- Amber: flooding of the Site is possible within the hours of operation
  - Flood Watch or Flood Warning issued for major flooding – pre-emptive school closure outside of school hours or immediate school closure within school hours

- Red: imminent flooding of the Site is expected
  - Flood Evacuation alert issued by SES or other emergency services, or Flood alert issued from the Muscle Creek Flood Warning System - immediate initiation of Flood Evacuation Plan
  - Site water level or rainfall gauge alert - immediate initiation of Flood Evacuation Plan

- Green: all clear, floodwaters have receded and local access to the Site is available
  - Emergency service has cleared access to the Site
  - Review Site conditions and opportunity for normal operation

The Yellow Alert Mode is called following the issuing of a Flood Watch, or Flood Warning for Muswellbrook by the BoM (Bureau of Meteorology) and indicates an increased potential for flooding. An initial minor to moderate forecast level will not require School closure, but initiate a heightened monitoring of conditions and flood warnings for potential escalation. An initial or escalation to moderate or major flood warning will provide for pre-emptive school closure.

The Amber Alert Mode is triggered following the issuing of a major flood warning within the hours of school operation

The Red Alert Mode is triggered via evacuation order by SES, flood alert from the Muscle Creek Warning System or Site rainfall and water level gauges indicating that possible flooding of the Site is imminent.

The Green Alert Mode is called following a flood event, once flood waters have receded based on advice from Emergency Services. The return to normal school operation will be dependent on local Site conditions, including any outage of utilities, road closures and access, Site clean-up and repair if needed.

4.4.3 Yellow Alert Mode

The Yellow Alert Mode is called by the PBCS Management Team/Chief Warden in advance of school hours, or by the Chief Warden during school hours, if any of the relevant triggers are detected. Under the Yellow Alert Mode, a flood affecting the Site within the hours of operation is possible. The management actions to be undertaken will depend on when the Yellow Alert Mode is called and are reported below.

Triggers to call an Yellow Alert Mode

The following Warnings issued by the BoM for Muswellbrook may trigger a Yellow Alert Mode:

- BoM Severe Weather Warning
- BoM Flood Watch
- BoM Flood Warning
- SES Advice level alert to stay informed

Any of the above Warnings listed on the BoM Warnings page that reference a geographical area that includes Muswellbrook will be accessed and reviewed. The Warnings are often descriptive in nature and will elaborate on the weather conditions that are expected to occur. Key indicators to be aware of are Severe Weather or Thunderstorm Warnings that include references to heavy rainfall, particularly if local catchment and/or flash flooding is mentioned.

Flood Watches and Flood Warnings tend to be issued for larger river catchments with flood level gauge locations and longer warning times, such as the Hunter River. However, they could potentially be issued for local catchment and/or flash flooding within local areas such as Muswellbrook, and neighbouring catchments such as Rouchel Brook.

Prior to commencement of a regular school day or out of hours event

Details regarding any applicable BoM Warnings are reviewed by the Chief Warden (in consultation with the PBCS Management Team) as to the potential for flooding to occur during the upcoming hours of operation for the Site. The Warnings can be issued days in advance, in which case they will be periodically updated as the forecast event approaches.

Warnings that indicate heavy rainfall with a likelihood of local catchment and/or flash flooding and have an expected coincidence with upcoming hours of operation at the Site indicate an increased likelihood that a Amber or Red Alert Mode might be triggered. Depending on the nature of planned activity at the Site and the expected severity of the weather event, the PBCS Management Team will consider closing the Site, suspending the planned activities, or using alternative remote access arrangements, if possible. This decision will need to be taken 12-24 hours in advance to effectively communicate closure of the school.

During a regular school day or out of hours event

Most BoM Warnings are provided at least a day in advance and so the issuing of a Warning that impacts a current school day or event without prior notice would be limited to rapidly developing, localised storm systems such as thunderstorms.

If a BoM Warning is issued that impacts the current school day or event, then the Chief Warden and PBCS Management Team will determine whether it is appropriate to continue with the planned operations, with the Wardens being notified of such and prepared for an increased likelihood that a Amber Alert Mode might be triggered.

4.4.4 Amber Alert Mode

The Amber Alert Mode is called immediately upon issue of a Major Flood warning by the BoM and/or Watch and Act alert level issued by SES. Under the Amber Alert Mode, a flood potentially affecting the Site is imminently expected. The Amber alert will likely follow a Yellow Alert due to intensification or worsening of predicted flood conditions.

Triggers to call a Amber Alert Mode

The following triggers are used to call an Amber Alert Mode:

- BoM Flood Warning for major flooding
- SES Watch and Act level alert to prepare for Evacuation

Prior to commencement of a regular school day or out of hours event

Any planned use of the Site will be suspended immediately by the Chief Warden. Once the flood event has passed and safe access to the Site is possible, the Chief Warden will inspect the Site to check for any flood damage or associated hazards that need addressing. The Site can then be re-opened, and planned activities resumed once it is safe to do so. Communication is to be issued to parents and carers advising students not to travel to school.

During a regular school day or out of hours event

All Site activities will be suspended immediately by the Chief Warden and School prepared for closure. Current emergency services advice regarding potential timing of flood inundation and availability of Site access will be reviewed to determine appropriate course of action. Communication protocols with parents/carers/public transport providers to be established to transport students/staff off-site.

An escalation to Red Alert Mode during school shut down process will revert to Evacuation Plan.

4.4.5 Red Alert Mode

The Red Alert Mode is called immediately upon the school receiving notification that the Flood Alert Service has triggered a Flood Warning. Under the Red Alert Mode, a flood potentially affecting the Site is imminently expected. The Red Alert calls for immediate school closure and initiation of Flood Evacuation to nominated flood refuge.

Triggers to call a Red Alert Mode

The following triggers are used to call a Red Alert Mode:

- Flood alert issued from the Muscle Creek Flood Warning System
- An evacuation warning issued by the NSW SES or other emergency response agency.

- 50mm of rainfall recorded in 30-minutes or less at on-site rainfall gauge.
- On-site floodwater alarm from flood level alter gauge indicating inundation of the Site.

Other supporting trigger mechanisms can include visual indication of Muscle Creek flooding and recorded rainfall in neighbouring catchment gauges (refer Figure 3-1).

If the Chief Warden is concerned about intense rainfall that is being experienced but a Flood Warning alert has not been issued, then they can consider initiating a flood emergency response and relocate staff and students to the Flood Refuge before an official warning has been received.

Prior to commencement of a regular school day or out of hours event

Any planned use of the Site will be suspended immediately by the Chief Warden. Once the flood event has passed and safe access to the Site is possible, the Chief Warden will inspect the Site to check for any flood damage or associated hazards that need addressing. The Site can then be re-opened, and planned activities resumed once it is safe to do so. Communication is to be issued to parents and carers advising students not to travel to school.

During a regular school day or out of hours event

If a Red Alert Mode is triggered shortly after an Amber Alert Mode is called, then the following actions should be completed if not already done so:

- Wardens are to equip themselves with the available two-way radios and high-vis vests
- A hardcopy list of current day Site attendees will be printed out in the Flood Refuge from the online cloud services

When a Red Alert Mode is triggered, then the following actions are also to be undertaken:

- Communication is made, advising occupants as to the need for responsive action, via pre-recorded messaging in the phone system being broadcast to phones and the playground amp. A siren will be sounded via the PA system (unless the Site is locked and not in use)
- Messaging is issued, advising parents and carers of the situation, advising them not to attempt collection of students from the Site prior to receiving subsequent advice to do so
- The Chief Warden will coordinate the Wardens in relocating staff, students, and visitors to the Flood Refuge location
- Staff, students, and visitors are to remain within the Flood Refuge until it is safe to resume normal operation of the Site.

4.4.6 Green Alert Mode

The Green Alert Mode is called by the Chief Warden (in consultation with the PBCS Management Team), once flood waters are receding and the flood emergency has passed. For minor, localised events this will be evident from observation of conditions surrounding the Flood Refuge. However, for major flood events consultation with the NSW SES will be required, to ensure that conditions more broadly across Muswellbrook are safe to begin vacating the Flood Refuge and further flooding is not expected. The management actions to be undertaken are reported below.

The Chief Warden (or delegate) will:

- Communicate to the Wardens that the flood emergency has now passed
- Keep monitoring the sources of information for the triggers of the Alert Modes

- Listen to the local radio station for updates on the weather / flood situation
- If the Site has experienced any flooding, then inspect the Site and adjacent roads for signs of any potential hazards that could present a risk for access to and from the Site
- Audit that all refuge supplies are returned to their resident locations

The Wardens will:

- Help people exit the Flood Refuge when the Chief Warden has confirmed that this can be undertaken
- Provide support while students leave the Site
- Help address any concerns of students arising from their potential collection from the Site, if required
- Identify any medical concerns and report them to the first aid team

The PBCS Management Team will:

- Coordinate with parents and carers of the students to facilitate their collection from the Site, as required
- Arrange subsequent inspection of the school buildings by a Structural Engineer if they have been inundated by flood waters
- Review this FERP to reflect any lessons learnt or changes in the Site layout, features, or operations or to incorporate new data on flood behaviour as this becomes available

5 References

AIDR (2017) *Guideline 7-3, Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*

Aquamonix (2024) *Muscle Creek Flood Warning System Installation Final Report and Manual*

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) *Australian Rainfall and Runoff: A Guide to Flood Estimation*, © Commonwealth of Australia (Geoscience Australia), 2019.

BoM of Meteorology (2003) *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method*

BoM of Meteorology (2016) *Intensity-Frequency-Duration (IFD) design rainfalls.*

Bureau of Meteorology (2024) *Service Level Specification for Flood Forecasting and Warning Services for New South Wales and the Australian Capital Territory – Version 3.15.*

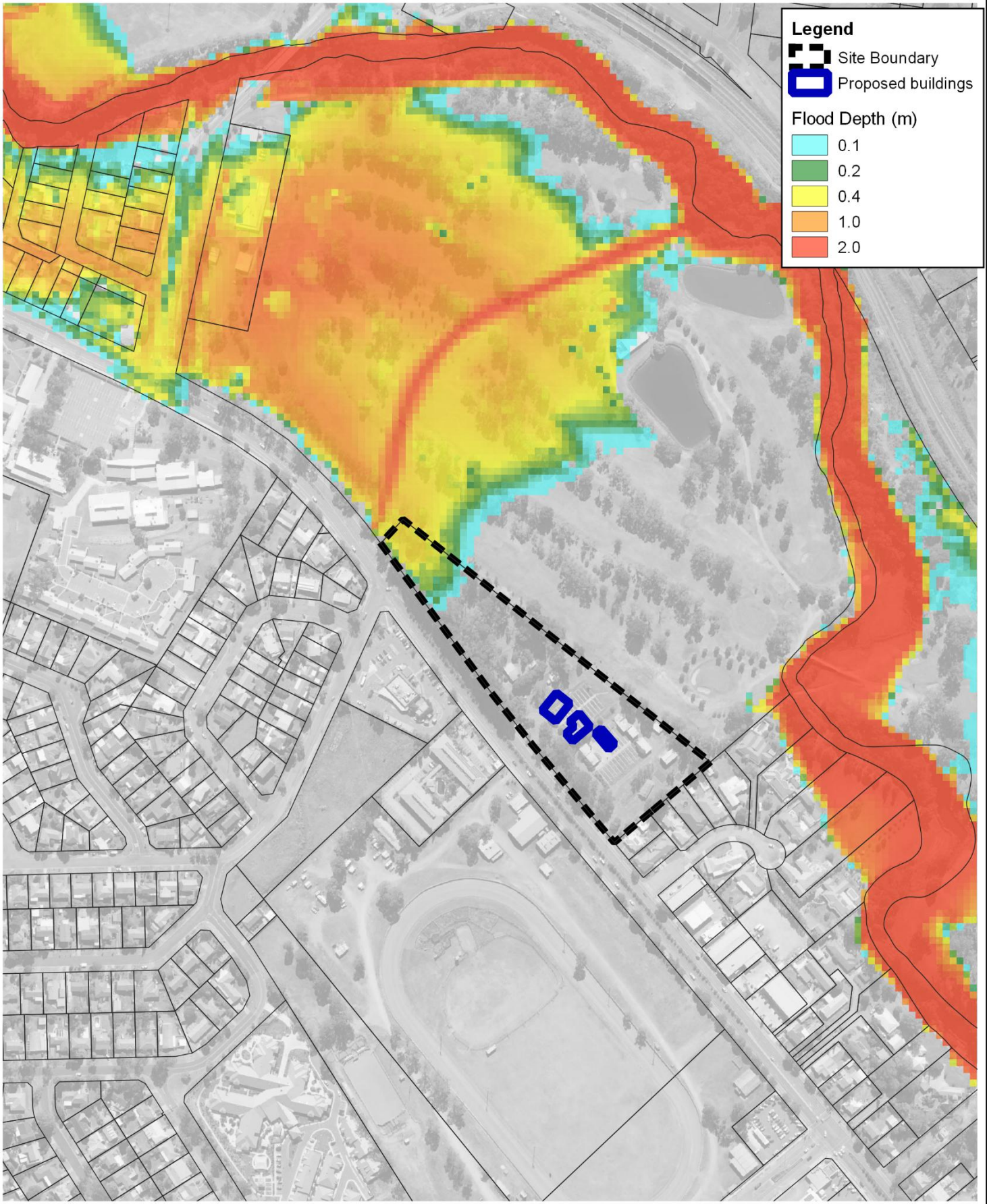
Muswellbrook Shire Council (2012) *Development Control Plan*

Royal Haskoning DHV (2017) *Muscle Creek Flood Study*

Royal Haskoning DHV (2019) *Muswellbrook Floodplain Risk Management Study and Plan*

Torrent Consulting (2024) *Pacific Brook Christian School Flood Impact Assessment*

Appendix A Design Flood Depth Mapping



Title:

Peak Flood Depth - 1% AEP Event

0 100 200 m

approx. scale

Figure: **A-1**

Revision: **A**

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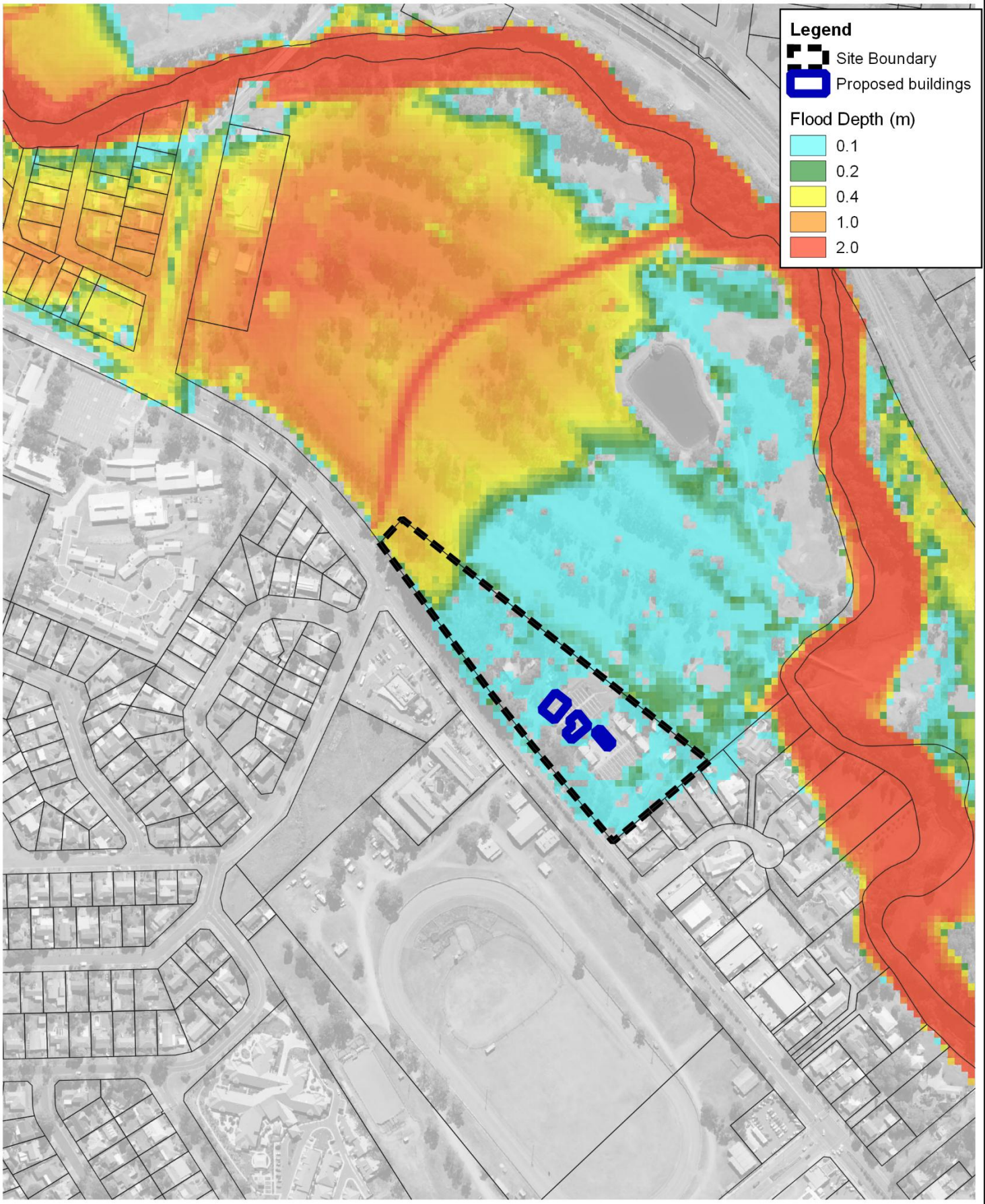

Title:

Peak Flood Depth - 0.5% AEP Event

0 100 200 m

approx. scale

Figure: **A-2**

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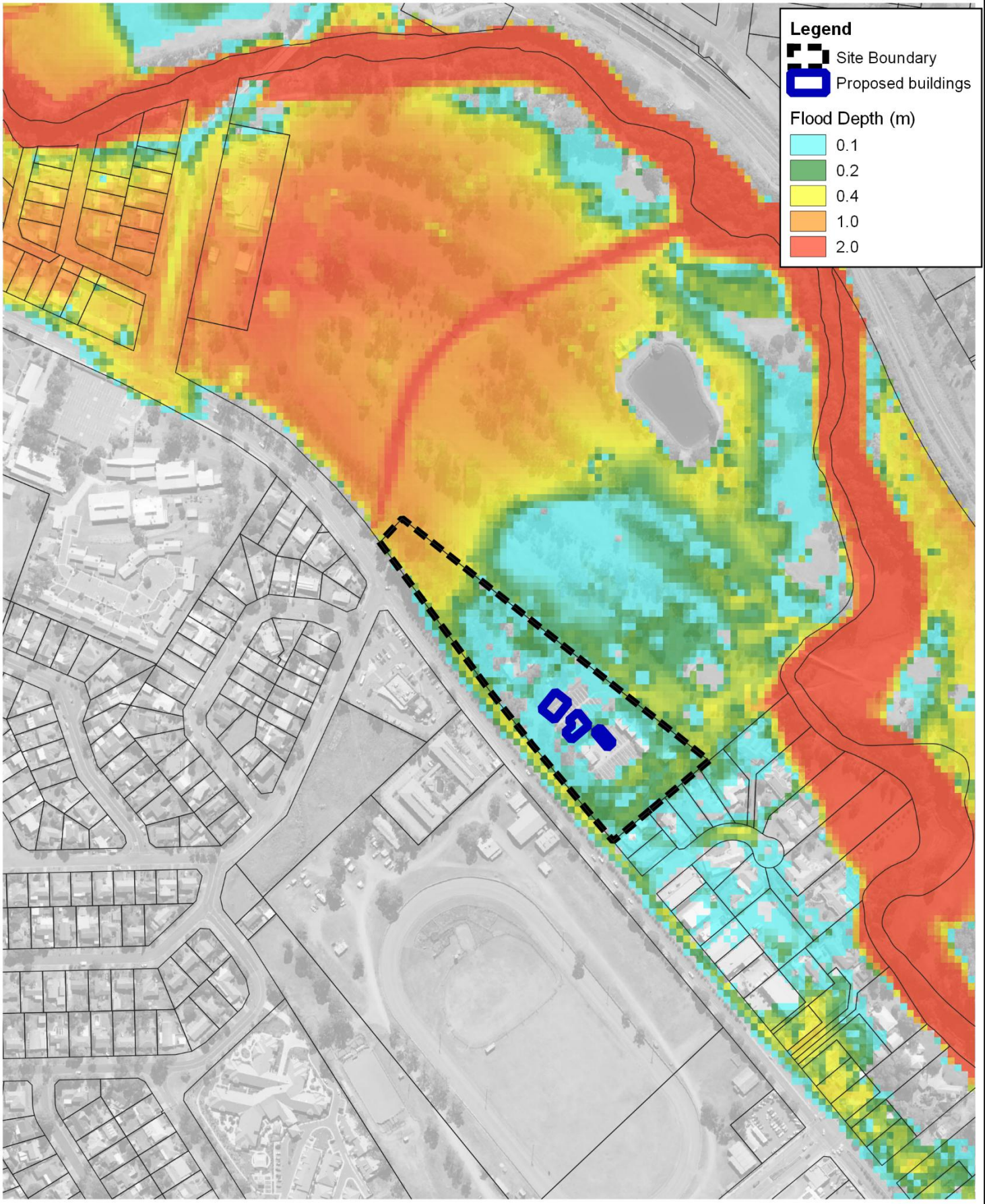

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Peak Flood Depth - 0.2% AEP Event

0 100 200 m

approx. scale

Figure: **A-3**

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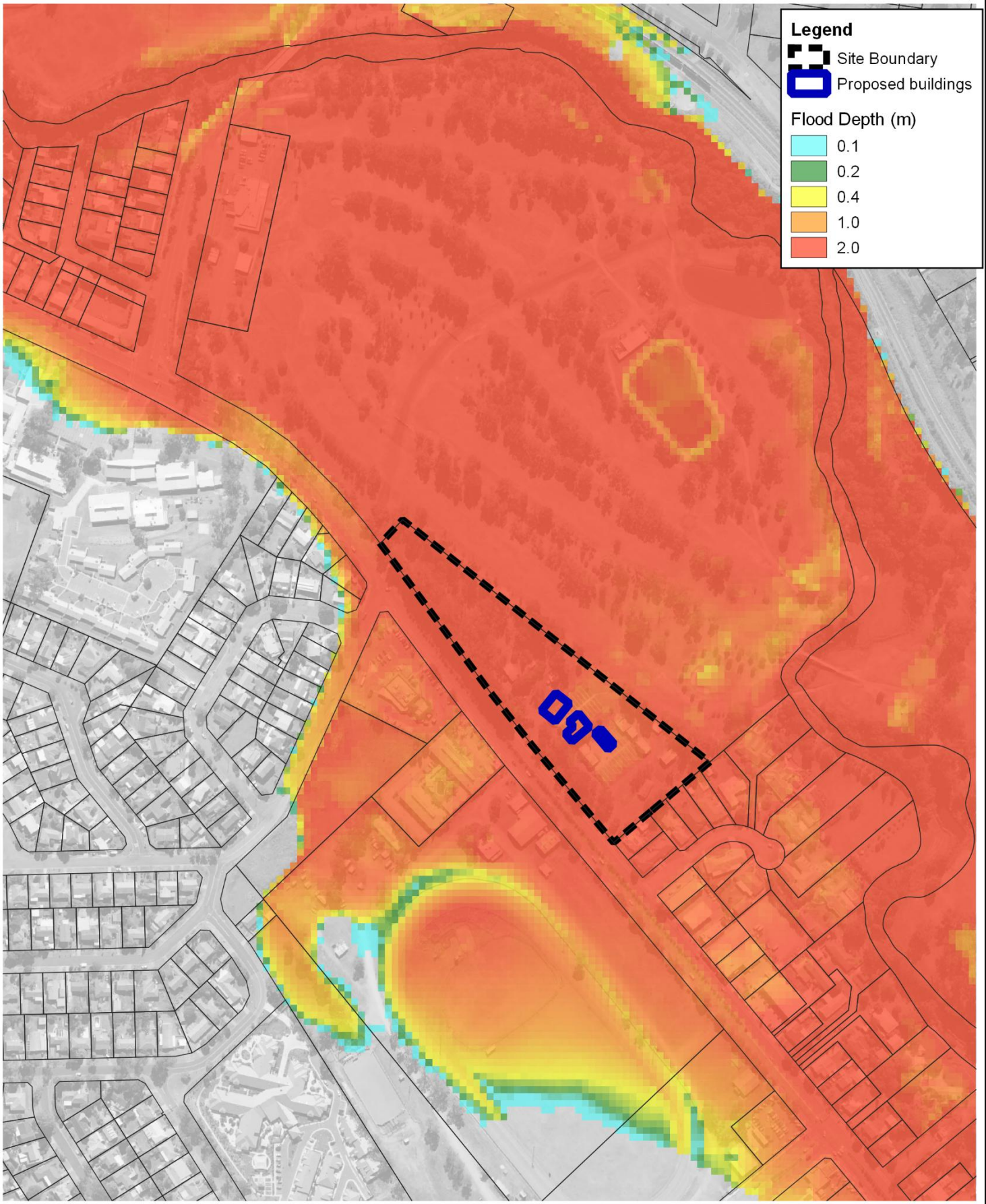


Title:

Peak Flood Depth - PMF Event

0 100 200 m

approx. scale

Figure: **A-4**

Revision: **A**

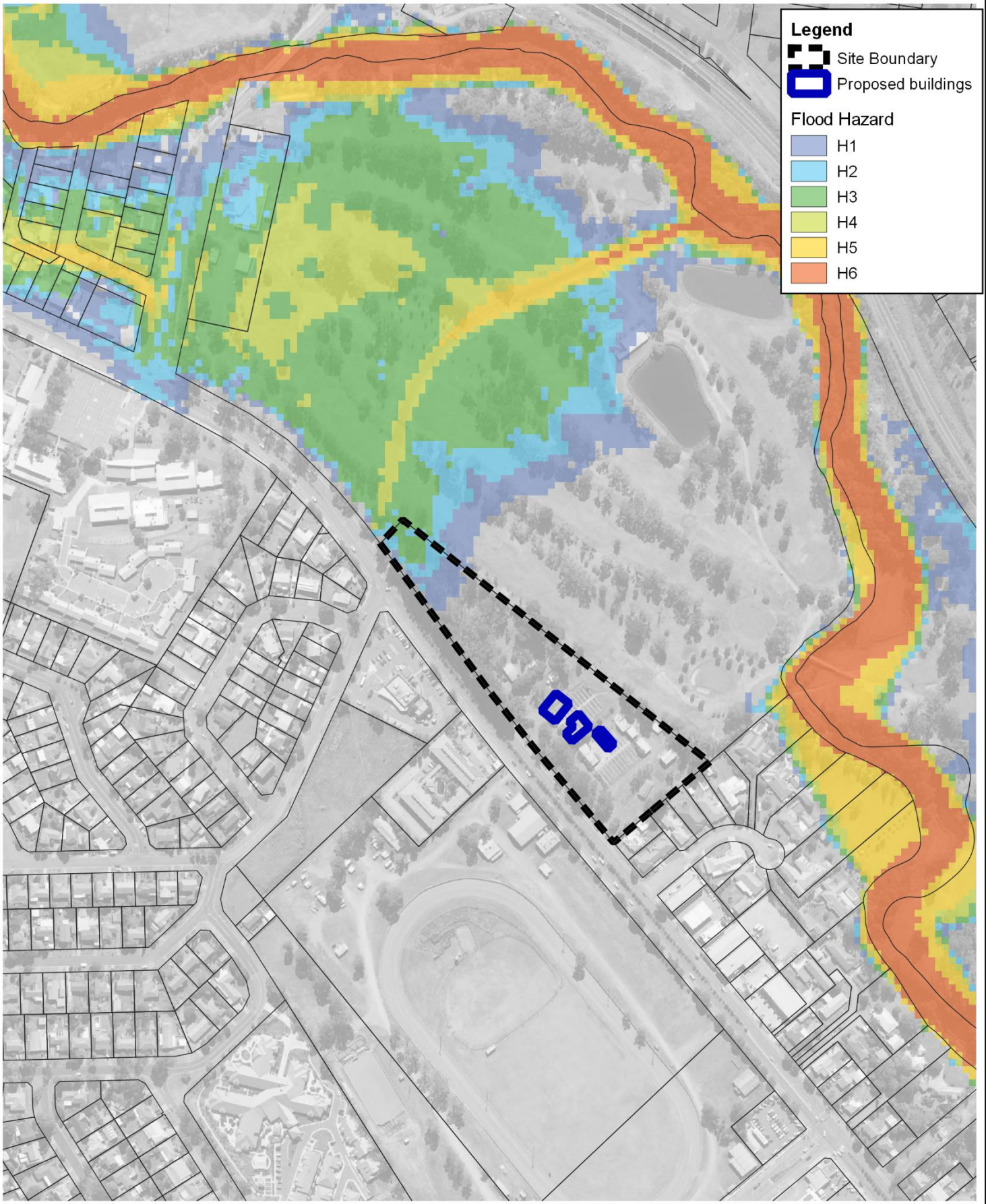
Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING
www.torrentconsulting.com.au

Filepath: Z:\Projects\T2583_Pacific_Brook\GIS\T2583_010_240701_PMF_Depth.qgz

Appendix B Design Flood Hazard Mapping



Title:

Peak Flood Hazard - 1% AEP Event

0 100 200 m

approx. scale

Figure: **B-1**

Revision: **A**

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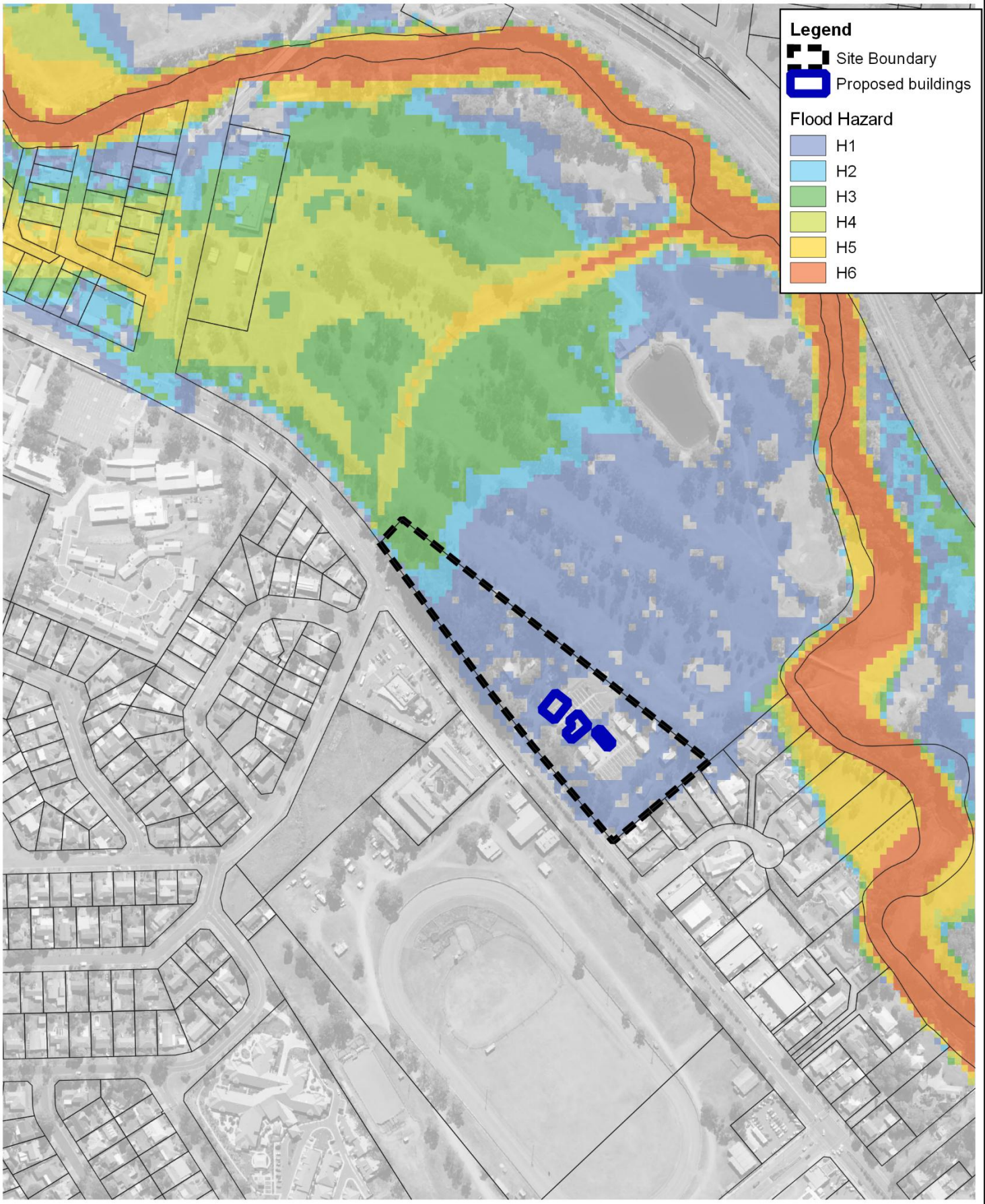
Filepath: Z:\Projects\T2583_Pacific_Brook\GIS\T2583_006_240701_100y_Hazard.qgz



Title:

Peak Flood Hazard - 0.5% AEP Event

0 100 200 m

approx. scale

Figure: **B-2**

Revision: **A**

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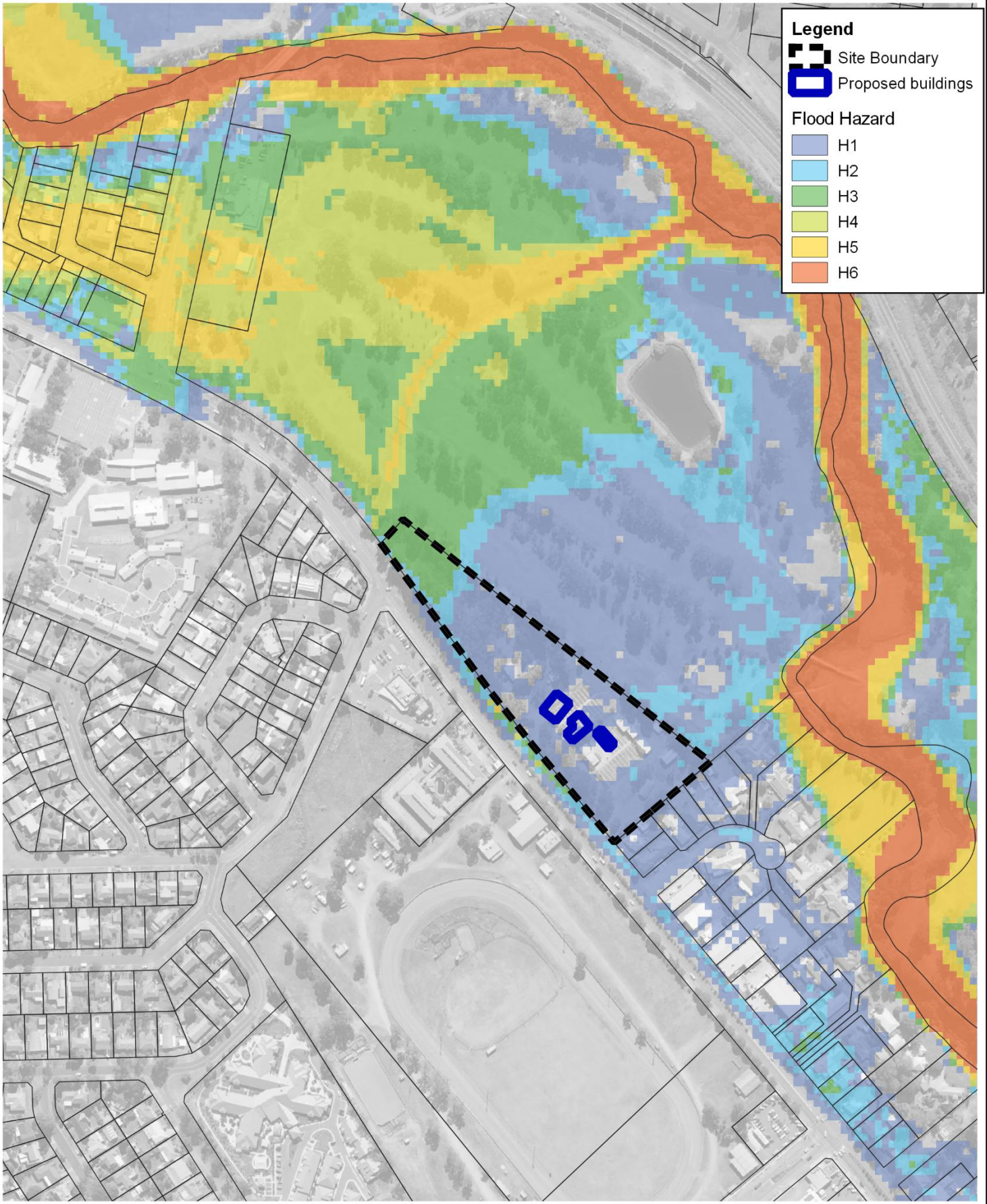
Filepath: Z:\Projects\T2583_Pacific_Brook\GIS\T2583_004_240701_200y_Hazard.qgz



Title:

Peak Flood Hazard - 0.2% AEP Event

0 100 200 m

approx. scale

Figure: **B-3**

Revision: **A**

Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

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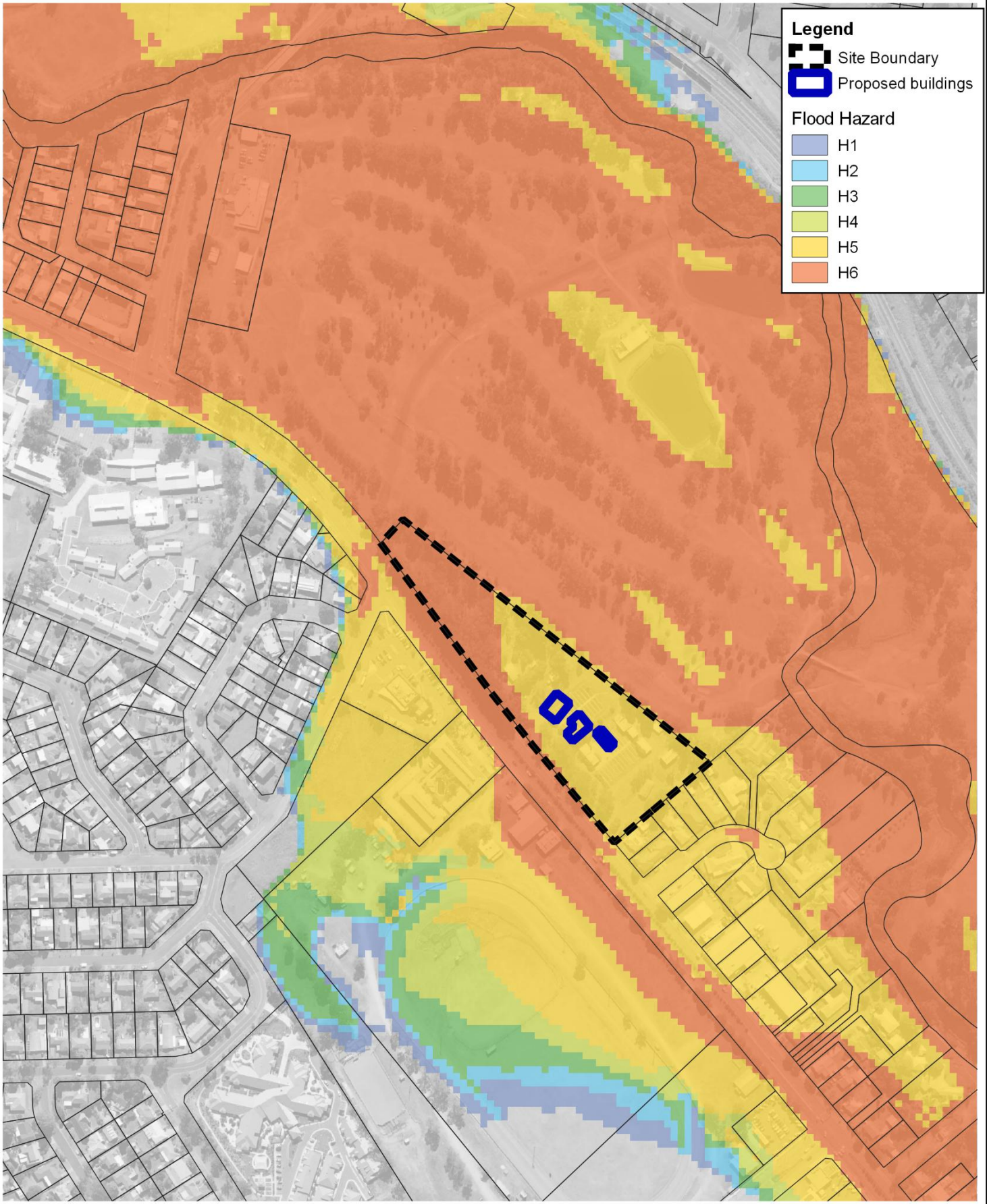
Filepath: Z:\Projects\T2583_Pacific_Brook\GIS\T2583_004_240701_500y_Hazard.qgz



Title:

Peak Flood Hazard - PMF Event

0 100 200 m

approx. scale

Figure: **B-4**

Revision: **A**

Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

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Filepath: Z:\Projects\T2583_Pacific_Brook\GIS\T2583_003_240701_PMF_Hazard.qgz

Appendix C Muscle Creek FWS

AQUAMONIX
Measure. Monitor. Master.

Site Photos
Muscle Creek, Muswellbrook

AQUAMONIX
Measure. Monitor. Master.

Alarm Triggers

Muscle Creek Flood Warning System (FWS): Summary of Alert Triggers

Feature	Muswellbrook FRMS&P Model Results - 0.2% AEP (500yr ARI) Water Levels [m AHD]		Category by Aquamonix	Station actions when trigger level reached	Comments
	Originally-proposed FWS location (adjacent golf course)	Translated WL at updated FWS location (d/s Bell St)			
Warning to Council & SES	146.0	143.5	White	Warning SMSs to Council/SES etc	As per recipient list
Alert to Residents	146.5	144.1			
Floodwater Spills onto Golf Course	146.7	144.4			
Alert to residents - evacuate now	147.0	144.8	Red	Siren activates + SMSs	As per recipient list
Floodwater spills across Bell Street	147.3	145.3			
Overland flow path down Clifford St makes evacuation hazardous	147.4	145.4			
Above flood flooding of up to 17 properties (approx 5% AEP event)	147.5	145.5			
Above flood flooding of up to 38 properties (approx 1% AEP event)	148.0	146.1			
Above flood flooding of up to 71 properties (approx 0.2% AEP event)	148.5	146.5			

AQUAMONIX
Measure. Monitor. Master.

Above flood flooding of up to 168 properties (approx PMF event)	150.6	N/A			
Alert to Council and NSW SES - flood level has dropped below Bell St	146.0	143.5	None – transition from white (or red)	Warning downgrade SMS to Council/SES	This needs to be below the White level by 0.100 m so 143.4 AHD

Appendix D Muswellbrook Sports Centre Confirmation

From: Lee Pratt <lpratt@pacifichills.nsw.edu.au>
Sent: Wednesday, 16 August 2023 4:57 PM
To: Chris Baldry
Cc: Tracey Young
Subject: FW: Pacific Brook Christian School, 72-74 Maitland Street Muswellbrook - Evacuation point

Hi Chris,

Here you are.

Cheers,

Lee Pratt
Pacific Group Property Manager

Pacific Hills
Christian School

Junior, Middle & Senior School (Est 1979) Wisdom and Knowledge in Christ
Phone +61 2 9651 0700 **Address** 9 - 15 Quarry Road Dural NSW 2158
Pacific Group of Christian Schools Limited **ABN** 11 001 832 828
Web www.pacifichills.nsw.edu.au **CRICOS No.** 02340G

From: Derek Finnigan <Derek.Finnigan@muswellbrook.nsw.gov.au>
Sent: Wednesday, August 16, 2023 3:49 PM
To: Lee Pratt <lpratt@pacifichills.nsw.edu.au>
Cc: Sharon Pope <Sharon.Pope@muswellbrook.nsw.gov.au>; Matthew Lysaught <Matthew.Lysaught@muswellbrook.nsw.gov.au>; Peter Ball <Peter.Ball@muswellbrook.nsw.gov.au>
Subject: RE: Pacific Brook Christian School, 72-74 Maitland Street Muswellbrook - Evacuation point

Dear Mr Pratt,

Thank you for your email.

in relation to your request, I can confirm that the Muswellbrook Indoor Sports Centre has suitable space and amenities to provide short term accommodation for Pacific Brook School in a flood event that requires evacuation of your students and staff.

1

The Muswellbrook Indoor Sports Centre is one of two evacuation centres for Muswellbrook, under the endorsed Muswellbrook Shire Council Local Emergency Management Plan 2022.

I hope this is of assistance. If you need any further information, please let me know.

Kind regards,

Derek Finnigan | General Manager | Muswellbrook Shire Council
T: 02 6549 3750 **I M**: 0419 465 572 **I E**: derek.finnigan@muswellbrook.nsw.gov.au **I**
www.muswellbrook.nsw.gov.au

I respectfully acknowledge the local Aboriginal people who are the Traditional Owners and Custodians of the land on which I work.

From: Lee Pratt <lpratt@pacifichills.nsw.edu.au>
Sent: Tuesday, August 15, 2023 2:39 PM
To: Derek Finnigan <Derek.Finnigan@muswellbrook.nsw.gov.au>
Subject: Pacific Brook Christian School, 72-74 Maitland Street Muswellbrook - Evacuation point

CAUTION: This email originated from outside of the organisation. Do not click links or open attachments unless you recognise the sender and know the content is safe.

Hello Mr Finnigan,

As the Group Property Manager for our schools, I am writing regarding our property at 72-74 Maitland Street Muswellbrook NSW.

In the process of our SSDA we have been developing a comprehensive Flood Evacuation/ Management Plan (attached). In this process we have been advised verbally that in a very extreme weather event, the Muswellbrook Indoor Sports Centre on Rutherford Street would be council's preferred "Identified Evacuation Point" for Pacific Brook Christian School once we are operating from 72-74 Maitland Street. While evacuation needs to be considered, our primary risk mitigation strategies (prior to evacuation) involve early closure of the school.

Our student numbers to begin with, will be approximately 140 with the maximum of 656 if our site is fully developed. Would you know the current capacity of the Muswellbrook Indoor Sports Centre? We are seeking confirmation that the Muswellbrook Indoor Sports Centre will be a suitable evacuation point, in the case where fast evacuation is necessary.

If you have any questions or need further clarification, please do not hesitate to contact me. My mobile number is 0431 842 498.

Thank you for your time. I look forward to hearing from you.

Best Regards,

Lee Pratt
Pacific Group Property Manager

2

Pacific Hills Christian School

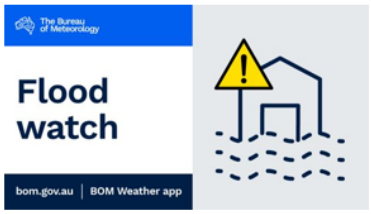
Junior, Middle & Senior School (Est 1979) Wisdom and Knowledge in Christ
Phone +61 2 9651 0700 **Address** 9 - 15 Quarry Road Dural NSW 2158
Pacific Group of Christian Schools Limited **ABN** 11 001 832 828
Web www.pacifichills.nsw.edu.au **CRICOS No.** 02340G

3

Appendix E Summary FERP

PBCS Flood Action Plan

Bureau of Meteorology Flood Warning



A Flood Watch provides early advice of a developing situation that may lead to flooding including information on forecast rainfall totals, catchments at risk of flooding, and indicative severity where required. A Flood Watch will typically be in place at least 24-hours prior to flooding event.

- Action: Minor to Moderate Flooding – no closure, heightened monitoring of developing situation
- Action: Moderate to Major Flooding – pre-emptive school closure in advance of flooding

A Flood Warning advises that flooding is occurring or expected to occur in the Upper Hunter including the Hunter River at Muswellbrook and its tributaries such as Muscle Creek. The target lead warning time for exceedance of the Major flood threshold is 12-hours.

- Action: Minor to Moderate Flooding – no closure, heightened monitoring of developing situation
- Action: Moderate to Major Flooding – pre-emptive school closure in advance of flooding

NSW State Emergency Service Flood Warning

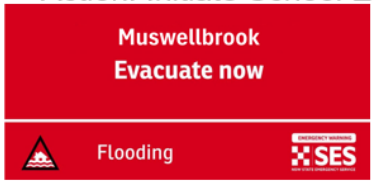
NSW SES will issue warnings for flooding using the Australian Warning System, including **Advice**, **Watch and Act**, and **Emergency** Warnings levels

The “Stay Informed” warning will typically be associated with the initial Flood Watch and Flood Warning notifications from BoM. Pre-emptive closure of the School to be undertaken for this initial advice level incorporating for moderate to major flooding forecasts.

- Action: Minor to Moderate Flooding – no closure, heightened monitoring of developing situation
- Action: Moderate to Major Flooding – pre-emptive school closure in advance of flooding

Escalation to Watch and Act level for expected major flood level conditions provides for immediate school closure under a prepare to evacuate advice. Pre-emptive or normal school closure (if within school hours) where there is no immediate threat.

- Action: Pre-emptive or Normal School closure if warning indicates no imminent threat (>6hours)
- Action: Initiate School Evacuation Plan if warning indicates imminent threat (<6 hours)



Escalation to Watch and Act level for expected major flood level conditions provides for immediate school closure under a prepare to evacuate advice. Pre-emptive or normal school closure (if within school hours) where there is no immediate threat.

- Action: Pre-emptive or Normal School closure if warning indicates no imminent threat (>6hours)
- Action: Initiate Flood Evacuation Plan if warning indicates imminent threat (<6 hours)

Muscle Creek Flood Warning System

Flood emergency alert received from warning system (message or siren activation) or on-site water level or rainfall trigger reached. Immediate activation of Flood Evacuation Plan.

- Action: Initiate Flood Evacuation Plan for any warning or trigger alert received

Flood Warning Sequence for PBCS School Closure

East Coast Low

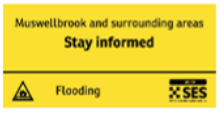
1 – 4 days

Monitor conditions unless specific advice for closure from Emergency authorities dependent on geographic location

Flood Watch

24 hours

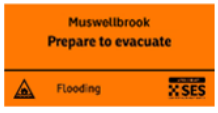
School closure for MODERATE to MAJOR flood warning for Hunter River including Muswellbrook



Flood Warning

12 hours

School closure for MODERATE to MAJOR flood warning for Hunter River including Muswellbrook

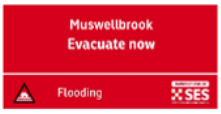


SCHOOL CLOSED PRIOR TO FLOODING

Evacuation Alert

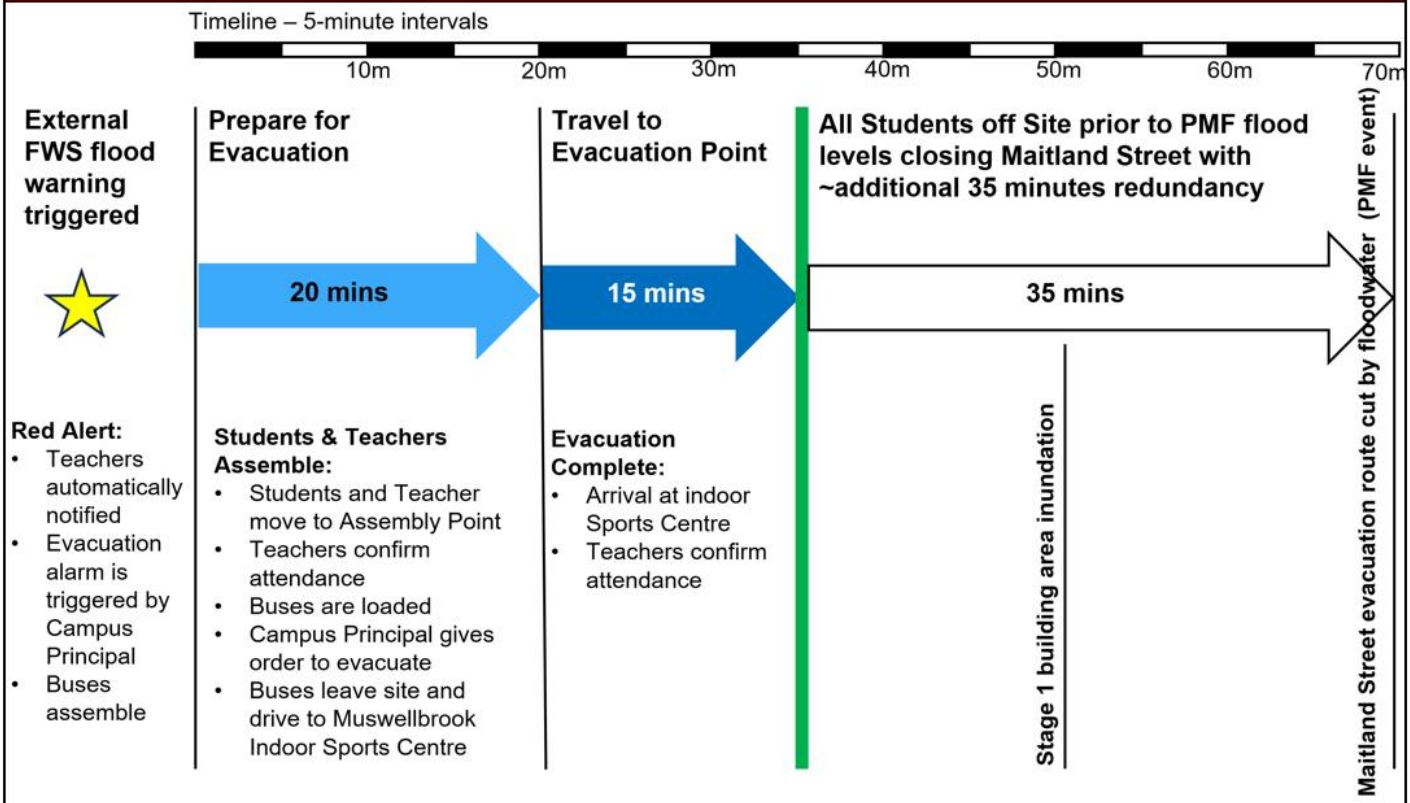
1 to 8 hours

School closure outside of operating or evacuation

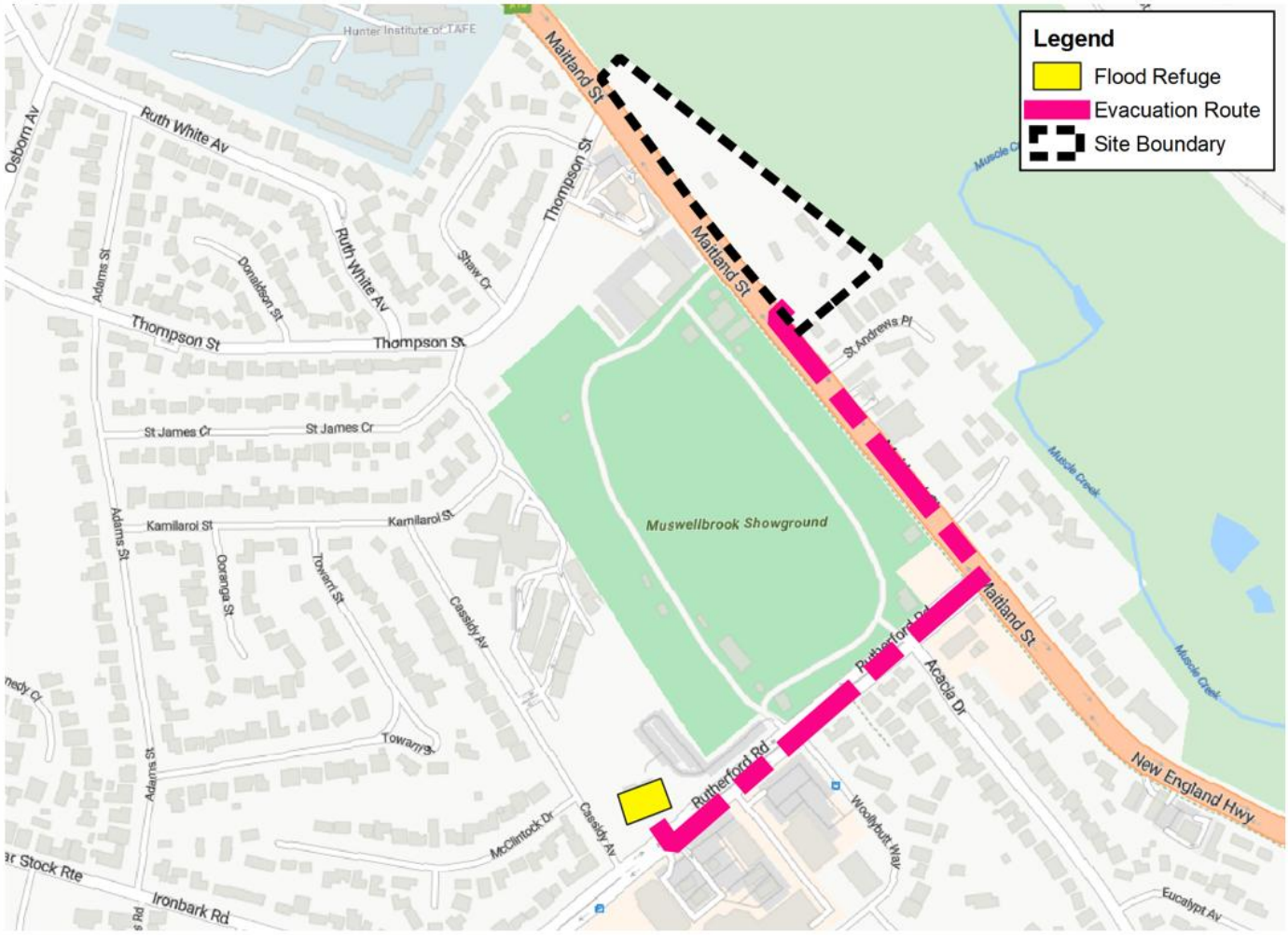


SCHOOL CLOSED OR EVACUATED

PBCS Flood Evacuation Plan



Evacuation Route to the Flood Refuge:



Appendix F Example Flood Warning Messaging

- BoM Flood Watch for Upper Hunter
- BoM Flood Warning for Upper Hunter
- SES Advice Level Warning (Stay Informed) for Muswellbrook
- SES Watch and Act Level Warning (Prepare to Evacuate) for Raymond Terrace (example)
- SES Emergency Level Warning (Evacuate BEFORE) for Dungog (example)
- SES Emergency Level Warning (Evacuate NOW) for Ferndale (example)

BoM FLOOD WATCH FOR UPPER HUNTER

IDN36503

Australian Government Bureau of Meteorology

This Flood Watch provides early advice of possible flooding within the specified catchments.

Flood Watch for parts of the Northern Rivers, Hunter and Mid North Coast

Issued at 12:32 pm EST on Monday 19 May 2025

Flood Watch Number: 4

MINOR TO MODERATE FLOODING LIKELY IN PARTS OF THE NORTHERN RIVERS, HUNTER AND MID NORTH COAST FROM MONDAY EVENING, WITH ISOLATED MAJOR FLOODING POSSIBLE

A coastal trough is positioned about the southern Mid North Coast, and is forecast to slowly track northwards into Tuesday. This trough is expected to bring multiple days of widespread moderate to heavy rainfall about central parts of the NSW coast and is likely to cause minor to moderate flooding from Monday evening.

Catchments in the Flood Watch area are relatively wet.

The exact location and timing of the heaviest falls is uncertain. However, isolated major flooding, alongside localised river level rises, and flash flooding are likely within the areas of heaviest rainfall.

Flood Classes (minor, moderate, major) are only defined for catchments where the Bureau provides a flood warning service.

A severe weather warning is current for Mid North Coast and parts of Hunter, Northern Tablelands and North West Slopes and Plains Forecast Districts.

Catchments likely to be affected include:

Orara River	minor flooding
Bellinger and Kalang Rivers	minor to moderate flooding
Nambucca River	minor to moderate flooding
Macleay River	minor flooding
Hastings River	minor to moderate flooding
Camden Haven River	minor flooding
Manning and Gloucester Rivers	moderate to major flooding
Wallis Lake	minor flooding
Karuah River	
Goulburn and Upper Hunter Rivers	moderate to major flooding
Wollombi Brook and Lower Hunter River	moderate to major flooding
Newcastle Area	
Lake Macquarie	minor flooding

Flood warnings current in the following catchments: Warrego, Darling, Paterson and Williams, Myall and Tuggerah Lake.

For the latest flood and weather warnings see www.bom.gov.au/nsw/warnings/

For the latest rainfall and weather forecasts see www.bom.gov.au/australia/meteye/

For the latest rainfall and river level information see www.bom.gov.au/nsw/flood

Flood Safety Advice:

This Flood Watch means that people living or working along rivers and streams must monitor the latest weather forecasts and warnings and be ready to move to higher ground should flooding develop.

Flood Warnings will be issued if Minor Flood Level is expected to be exceeded at key sites along the main rivers for which the Bureau of Meteorology provides a flood warning service.

Severe Weather Warnings will be issued or updated if very heavy rain is forecast or observed.

For more information on the Flood Watch Service:
http://www.bom.gov.au/water/floods/floodWarningServices.shtml

FloodSafe advice is available at www.ses.nsw.gov.au

For emergency assistance call the SES on telephone number 132 500

For life threatening emergencies, call 000 immediately

Next Issue:

The next Flood Watch will be issued by 01:00 pm EST on Tuesday 20 May 2025.

BoM FLOOD WARNING FOR UPPER HUNTER

IDN36608

Australian Government Bureau of Meteorology

Minor Flood Warning for the Hunter River and Moderate Flood Warning for Wollombi Brook

At Muswellbrook, Denman, Wollombi, Bulga, Maitland and Raymond Terrace

Issued at 9:58 am EST on Tuesday 20 May 2025

Flood Warning Number: 3

MODERATE FLOODING POSSIBLE AT WOLLOMBI AND BULGA OVERNIGHT TUESDAY INTO WEDNESDAY

MINOR FLOODING OCCURRING AT MAITLAND AND RAYMOND TERRACE

MINOR FLOODING POSSIBLE AT MUSWELLBROOK AND DENMAN FROM TUESDAY AFTERNOON

Moderate to heavy rainfall since Sunday has caused river and creek level rise along parts of the Hunter River and its tributaries.

A Severe Weather Warning for heavy, locally intense rainfall is current for parts of the Hunter and Mid North Coast.

A major flood warning is current for the Paterson and Williams Rivers.

The situation is being closely monitored, and this warning will be update as required. Peak forecasts will be refined as upstream peaks are observed.

Upper Hunter:

Minor flooding is possible along the Upper Hunter.

The Hunter River at Muswellbrook is currently at 4.46 metres and rising, below the minor flood level (7.20 m). The Hunter River at Muswellbrook may reach the minor flood level (7.20 m) around Tuesday afternoon.

The Hunter River at Denman is currently at 4.10 metres and rising, below the minor flood level (6.50 m). The Hunter River at Denman may reach the minor flood level (6.50 m) around Tuesday evening.

Wollombi Brook:

Moderate flooding may occur along the Wollombi Brook.

The Wollombi Brook at Wollombi is currently at 2.93 metres and rising, below the minor flood level (6.70 m). The Wollombi Brook at Wollombi may exceed the minor flood level around Tuesday afternoon. The river level may reach the moderate flood level (8.60 m) overnight Tuesday into Wednesday. Further rises are possible with forecast rainfall.

The Wollombi Brook at Bulga is currently at 1.36 metres and steady, below the minor flood level. The Wollombi Brook at Bulga is likely to exceed the minor flood level (3.00 m) around Tuesday afternoon. The river level may reach the moderate flood level (3.70 m) overnight Tuesday into Wednesday. Further rises are possible with forecast rainfall.

Lower Hunter:

Moderate flooding may occur along the Lower Hunter at Maitland and minor flooding is expected at Raymond Terrace.

The Hunter River at Maitland (Belmore Bridge) is currently at 6.87 metres and rising, above the minor flood level (5.90 m). The Hunter River at Maitland (Belmore Bridge) is likely to peak near 8.00 metres Tuesday evening, with minor flooding. Renewed rises above the minor flood level are possible later this week as flows from upstream tributaries arrive.

The Hunter River at Raymond Terrace is currently at 2.70 metres and rising, above the minor flood level (2.50 m). The Hunter River at Raymond Terrace may reach around 2.90 metres Tuesday evening. Renewed rises above the minor flood level are possible later this week as flows from upstream tributaries arrive.

Flood Safety Advice:

In life threatening emergencies, call 000 (triple zero) immediately. If you require rescue, assistance to evacuate or other emergency help, ring NSW SES on 132 500.

- * Avoid drowning. Stay out of rising water, seek refuge in the highest available place.
- * Prevent damage to your vehicle. Move it under cover, away from areas likely to flood.
- * Avoid being swept away. Stay out of fast-flowing creeks and storm drains.
- * Never drive, ride or walk through flood water. Flood water can be deceptive and dangerous.

For more emergency information, advice, and access to the latest river heights and rainfall observations and forecasts:

* NSW SES: www.ses.nsw.gov.au

* RMS Live Traffic: www.livetraffic.com

* Latest River Heights and Rainfall Observations: www.bom.gov.au/nsw/flood/midnorth.shtml

* Latest NSW Warnings: www.bom.gov.au/nsw/warnings/

* Rainfall Forecasts: www.bom.gov.au/australia/meteye/

* BOM NSW Twitter: www.twitter.com/BOM_NSW

Next Issue:

The next warning will be issued by 02:00 pm EST on Tuesday 20 May 2025.

Latest River Heights:

Location	Height of River (m)	Tendency	Date/Time of Observation
Kingdon Ponds at Scone	0.29	Steady	08:37 AM TUE 20/05/25
Hunter River at Aberdeen	6.62	Falling	09:30 AM TUE 20/05/25
Hunter River at Muswellbrook	5.46	Rising	09:30 AM TUE 20/05/25
Hunter River at Denman	4.10	Rising	09:30 AM TUE 20/05/25
Goulburn River at Sandy Hollow	1.02	Steady	09:00 AM TUE 20/05/25
Hunter River at Liddell	5.54	Steady	09:45 AM TUE 20/05/25
Wollombi Brook at Bulga	1.36	Steady	09:15 AM TUE 20/05/25
Hunter River at Singleton	5.06	Rising	09:00 AM TUE 20/05/25
Hunter River at Greta	8.25	Falling	09:30 AM TUE 20/05/25
Hunter River at Maitland (Belmore Bridge)	6.87	Rising	09:45 AM TUE 20/05/25
Hunter River at Raymond Terrace	2.70	Steady	09:45 AM TUE 20/05/25

This advice is also available by dialling 1300 659 210. Warning, rainfall and river information are available at www.bom.gov.au/nsw/flood. The latest weather forecast is available at www.bom.gov.au/nsw/forecasts.

SES ADVICE LEVEL (STAY INFORMED) FLOOD WARNING FOR MUSWELLBROOK

NSW SES - Muswellbrook Shire
Yesterday at 12:12 PM ·

Muswellbrook and surrounding areas flooding
Stay informed
Advice

The NSW SES advises people in the following area(s) to STAY INFORMED about predicted minor flooding on the Hunter River:

- Low lying areas of Muswellbrook.

You should stay informed by monitoring warnings issued by NSW SES on their website and Facebook page, listening to your local ABC radio station, and checking the latest weather information from the Bureau of Meteorology online.

What are we expecting?

The Bureau of Meteorology advises The Hunter River at Muswellbrook is currently at 4.46 metres and rising, below the minor flood level (7.20 m).

The Hunter River at Muswellbrook may reach the minor flood level (7.20 m) around Tuesday afternoon.

Based on predictions from the Bureau of Meteorology, the following areas may be impacted by dangerous floodwaters:

- Low lying areas, roads and causeways around Muswellbrook and surrounds along the Hunter River.

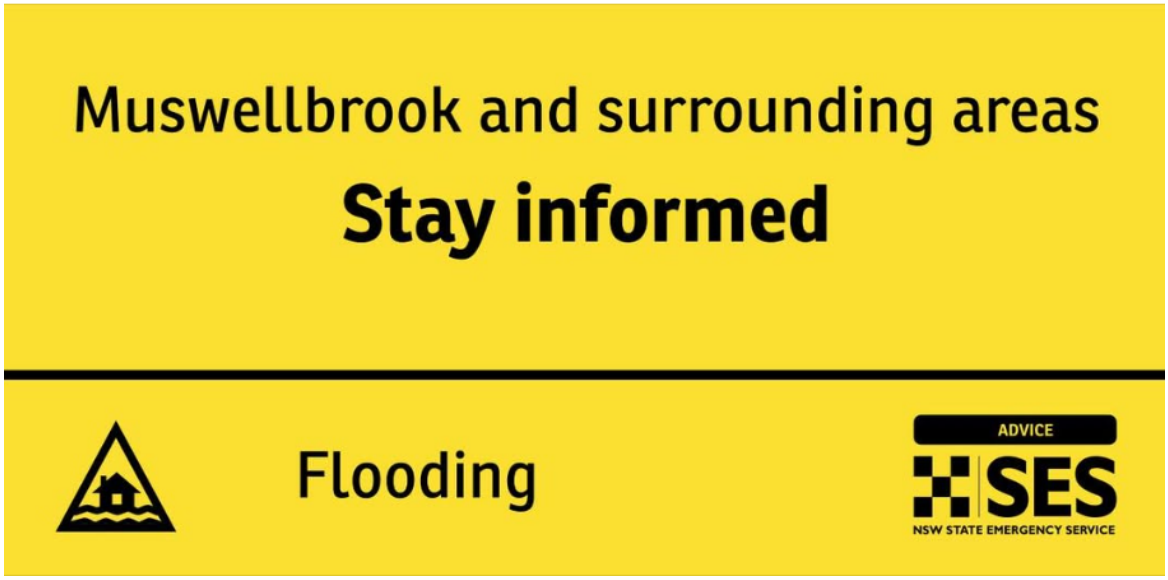
View the full warning: https://hazardwatch.gov.au/a/DsNR8J

Download the Hazards Near Me App and set up 'Watch Zones' to receive warnings in real time. https://www.nsw.gov.au/emergency/hazards-near-me-app

For emergency assistance during a flood, storm or tsunami, call the NSW SES on 132 500. In a life-threatening emergency, call Triple Zero (000).

Post current at 12:11pm on Tuesday 20th May 2025.

#NSWSES #HunterRiver



SES WATCH AND ACT LEVEL (PREPARE TO EVACUATE) WARNING (EXAMPLE)

Hunter NSW SES
21h ·

Raymond Terrace flooding
Prepare to evacuate
Watch and Act

The NSW SES advises people in the following area(s) to PREPARE TO EVACUATE due to current rising minor flooding:

- Hunter Street
- Port Stephens
- Swan Street
- Sturgeon Street
- Glenelg Street
- Williams Street
- King Street
- Bourke Street
- Peter Dron Street
- Kangaroo Street

You should monitor the situation and prepare to evacuate so that you can safely evacuate when instructed to do so by NSW SES. Wherever possible, you should prepare to stay with family or friends, or make other accommodation arrangements.

If you remain in the area, you may become trapped without power, water, and other essential services. It may be too dangerous for NSW SES to rescue you.

What are we expecting?

The Bureau of Meteorology advises the Hunter River at Raymond Terrace is currently at 2.75 metres and rising, above the minor flood level (2.50 m). The Hunter River at Raymond Terrace may reach around 3.00 metres overnight Tuesday into Wednesday, with minor flooding. Renewed rises above the minor flood level are possible later this week as flows from upstream tributaries arrive.

Based on predictions from the Bureau of Meteorology, the following areas may be impacted by dangerous floodwaters:

- Low-lying roads and bridges
- Low-lying parklands along the river

This event may change quickly. NSW SES will monitor the situation and update warnings if the situation changes.

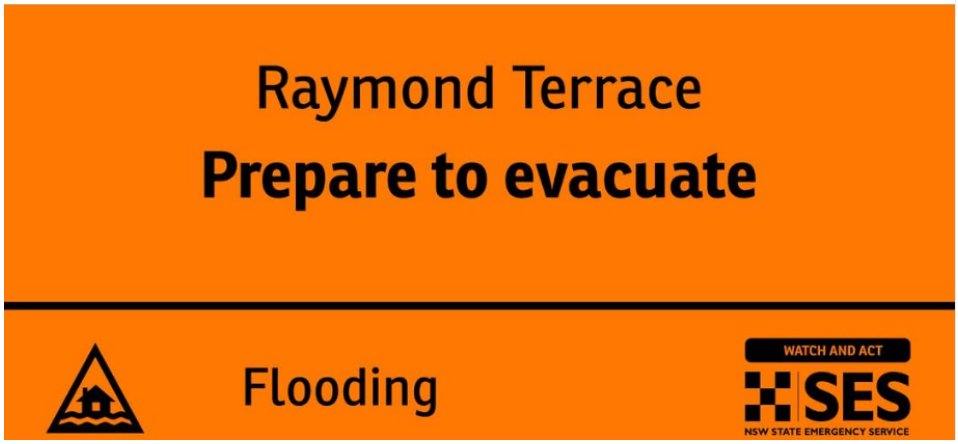
View the full warning: https://hazardwatch.gov.au/a/ZLWiSA

Download the Hazards Near Me App and set up 'Watch Zones' to receive warnings in real time.
https://www.nsw.gov.au/emergency/hazards-near-me-app

For emergency assistance during a flood, storm or tsunami, call the NSW SES on 132 500. In a life-threatening emergency, call Triple Zero (000).

Post current at 5:03pm on Tuesday 20th May 2025.

#NSWSES #HunterRiver



SES EMERGENCY LEVEL (EVACUATE BEFORE) WARNING (EXAMPLE)

Hunter NSW SES
10h ·

Parts of Dungog flooding
Evacuate before 11:30 pm Mon 19 May
Emergency Warning

The NSW SES is directing people in the following area(s) to EVACUATE BEFORE 11:30 pm Mon 19 May due to major flooding:

- Properties on parts of Windeyer Street, Crolls Mill Lane, Hooke Street, Abelard Street, Lord Street and Brown Street
- Allison Court Retirement Village, Brown Street

You must evacuate before this time because floodwaters are now impacting the area.

You should evacuate to stay with family, friends, or alternate accommodation in areas unaffected by flooding. If you are unable to find accommodation, Evacuation centres have been set up at:

- Dungog Memorial RSL Club, 96 Lord St, Dungog NSW 2420

If you remain in the area, you may become trapped without power, water, and other essential services. It may be too dangerous for NSW SES to rescue you, and buildings may not be able to withstand the impact of flood water.

What are we expecting?

The Williams River at Dungog is currently at 6.53 metres and rising, above the minor flood level (4.90 m).

The Williams River at Dungog may exceed the moderate flood level (7.60 m) late Monday evening.

The river level may reach the major flood level (8.50 m) early Tuesday morning.

Further rises are possible.

This event may change quickly. NSW SES will monitor the situation and update warnings if the situation changes.

View the full warning: https://hazardwatch.gov.au/a/KaHH-G

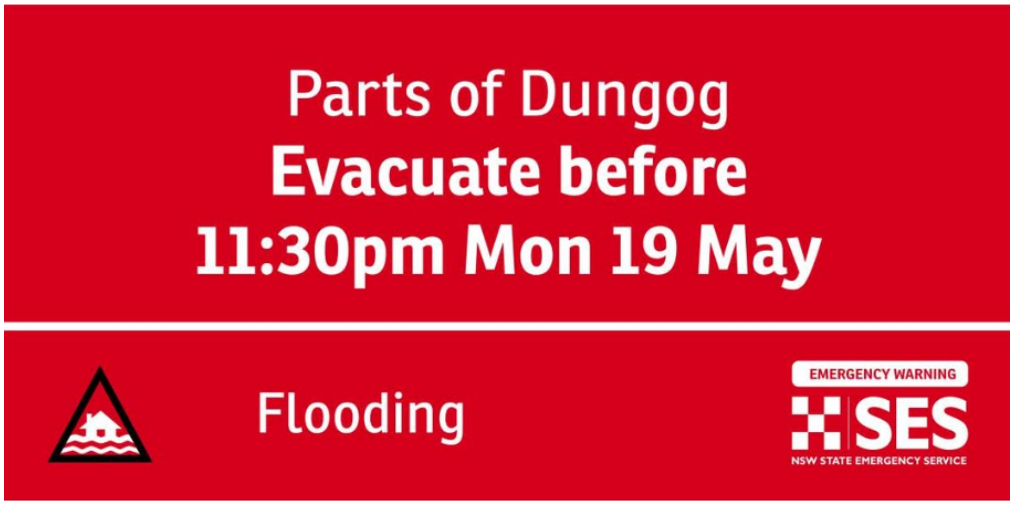
Download the Hazards Near Me App and set up 'Watch Zones' to receive warnings in real time. https://www.nsw.gov.au/emergency/hazards-near-me-app

For emergency assistance during a flood, storm or tsunami, call the NSW SES on 132 500. In a life-threatening emergency, call Triple Zero (000).

Post current at 10:20pm on Monday 19th May 2025.

#NSWSES #PatersonRiver #WilliamsRiver

Dave Layzell



SES EMERGENCY LEVEL (EVACUATE NOW) WARNING (EXAMPLE)

Hunter NSW SES
May 19 at 11:07 PM ·

Ferndale Caravan Park flooding
Evacuate now
Emergency Warning

The NSW SES is directing people in the following area(s) to EVACUATE NOW due to increased flows from Chichester Dam into the Williams River causing major flooding:

- Ferndale Caravan Park

You must evacuate now because floodwaters are now impacting the area.

You should evacuate to stay with family, friends, or alternate accommodation in areas unaffected by flooding.

If you remain in the area, you may become trapped without power, water, and other essential services. It may be too dangerous for NSW SES to rescue you, and buildings may not be able to withstand the impact of flood water.

What are we expecting?

Increased flows from Chichester Dam into the area are expected in the coming hours, resulting in major flooding.

Further rises are possible.

This event may change quickly. NSW SES will monitor the situation and update warnings if the situation changes.

View the full warning: https://hazardwatch.gov.au/a/Y5NM8M

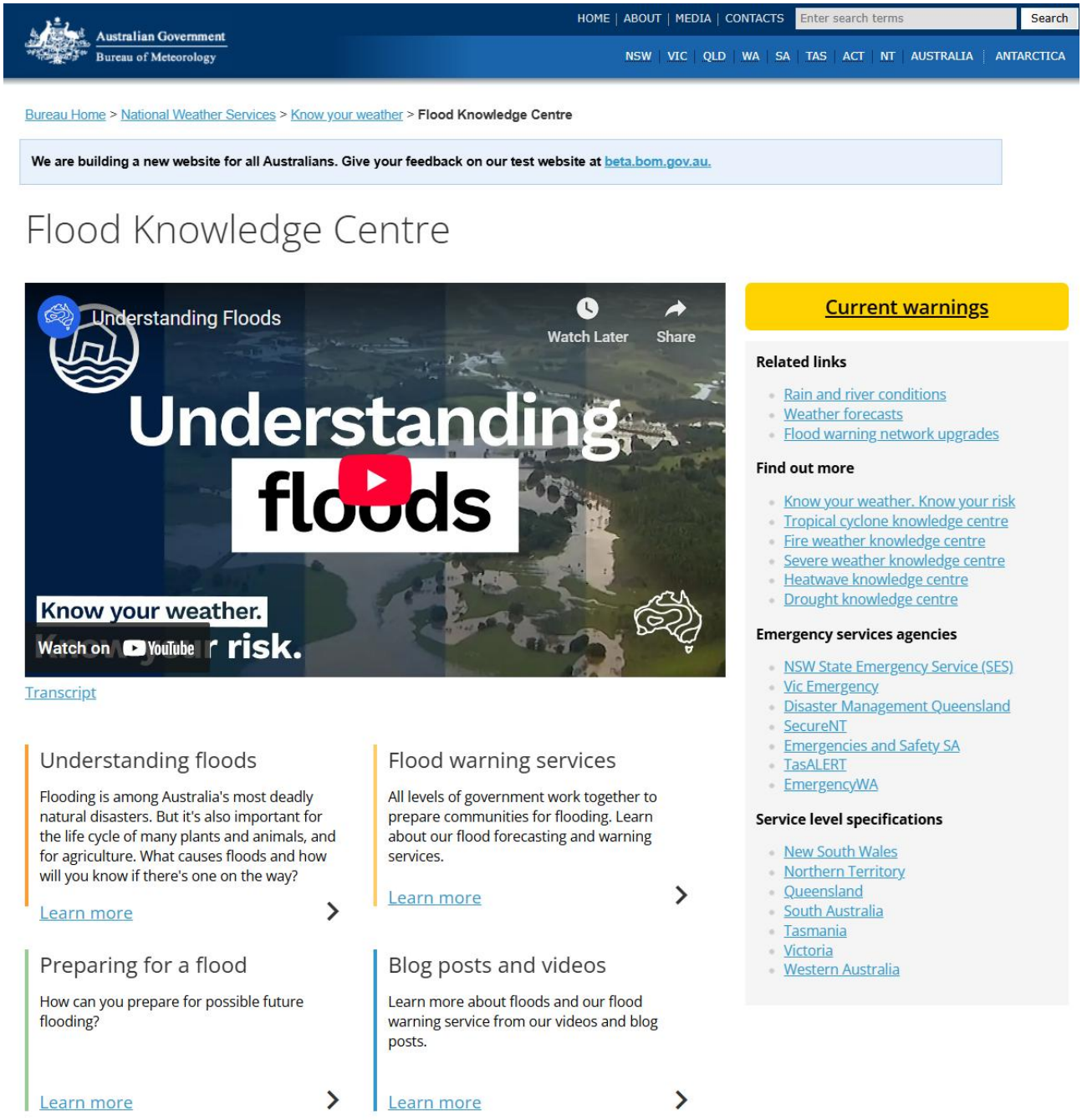
Download the Hazards Near Me App and set up 'Watch Zones' to receive warnings in real time. https://www.nsw.gov.au/emergency/hazards-near-me-app

For emergency assistance during a flood, storm or tsunami, call the NSW SES on 132 500. In a life-threatening emergency, call Triple Zero (000).

Post current at 11:05pm on Monday 19th May 2025.

#NSWSES

Appendix G Flood Intelligence Resources



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Bureau Home > National Weather Services > Know your weather > Flood Knowledge Centre

We are building a new website for all Australians. Give your feedback on our test website at beta.bom.gov.au.

Flood Knowledge Centre

Transcript

Understanding floods

Flooding is among Australia's most deadly natural disasters. But it's also important for the life cycle of many plants and animals, and for agriculture. What causes floods and how will you know if there's one on the way?

Learn more >

Flood warning services

All levels of government work together to prepare communities for flooding. Learn about our flood forecasting and warning services.

Learn more >

Preparing for a flood

How can you prepare for possible future flooding?

Learn more >

Blog posts and videos

Learn more about floods and our flood warning service from our videos and blog posts.

Learn more >

Current warnings

Related links

- Rain and river conditions
- Weather forecasts
- Flood warning network upgrades

Find out more

- Know your weather. Know your risk
- Tropical cyclone knowledge centre
- Fire weather knowledge centre
- Severe weather knowledge centre
- Heatwave knowledge centre
- Drought knowledge centre

Emergency services agencies

- NSW State Emergency Service (SES)
- Vic Emergency
- Disaster Management Queensland
- SecureNT
- Emergencies and Safety SA
- TasALERT
- EmergencyWA

Service level specifications

- New South Wales
- Northern Territory
- Queensland
- South Australia
- Tasmania
- Victoria
- Western Australia

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Understanding floods

In Australia, flooding is the second most deadly natural disaster after heatwaves. So, what causes floods and how will you know if there's one on the way?

What is a flood?

A flood is an overflow of water beyond the normal limits of a watercourse. Flooding occurs when water extends over what is usually dry land. This can happen when it escapes from a natural watercourse, such as a lake, river or creek. It can also happen when water is released from a reservoir, canal or dam.

There are two types of flooding, riverine and flash.

Riverine flooding is where rivers break their banks and water covers the surrounding land. It's mostly caused by heavy rainfall, but can also be caused by king tides, storm surge, snowmelt and dam releases.

In inland parts of Queensland, New South Wales and Western Australia, riverine flooding can affect thousands of square kilometres for weeks or even months at a time.

Flash flooding occurs within six hours of rain falling. It can happen after a short burst of heavy rain, such as from a thunderstorm.

Flash floods can be a serious problem in urban areas if drainage systems can't cope and tend to affect a localised area.

What causes floods?

Heavy rainfall

The most common cause of riverine and flash flooding is heavy rainfall.

Rivers are formed over thousands of years. Every river is different and forms in response to:

- the usual amount of local rainfall and runoff
- the local topography, vegetation and soil types.

These features stay relatively constant through time, with only rainfall varying.

Rivers have a maximum capacity to carry water. More rainfall than usual, creates more runoff than usual. This runoff can't be carried by the river channel, so it spills out onto the land. When the time between rainfall and flooding is longer than six hours, this is a riverine flood.

Riverine floods can happen shortly after rainfall, in localised areas. River flood peaks are often reached within days of rain falling. But given many Australian rivers are long, floods can also occur weeks or months after rain, sometimes hundreds of kilometres away. For example, flood water in the upper Murray River, Australia's longest at over 2,500 km, may take months to reach the river mouth in South Australia.

King tide

The term 'king tide' is widely used to describe an exceptionally high tide. These tides are a natural and predictable part of the tidal cycle. The time of year they occur varies by location and between years. They can have very noticeable effects where the ocean meets the land at beaches, estuaries, harbours and other coastal locations.

King tides can increase the impact and extent of riverine flooding. Imagine a town near the coast that lies beside a coastal river. If the river is in flood, parts of that town may be inundated. If the flood occurs at the same time as a high king tide, floodwater will have less opportunity to drain to the sea. More of that town is likely to be flooded and to a higher level.

Storm surge

A storm surge is a rise above the normal seawater level along a shore caused by a storm. The storm often brings strong onshore winds and typically results from reduced atmospheric pressure. Storm surges often accompany a tropical cyclone. Away from the tropics, storm surge can occur due to an intense low pressure system.

Coastal flooding is likely during a storm surge. And if storm surge combines with a riverine flood the area and extent of flooding can increase.

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Snowmelt

Snow can be thought of as a reservoir of water, waiting for enough warmth to run down the hill. When conditions warm rapidly, snow can melt quickly. When this happens it can release volumes of water too great for the downstream river channels, causing riverine flooding.

Dam releases

Dams can hold vast amounts of water, but all dams have a capacity. If a dam is close to capacity, dam operators may release water and sometimes this can cause flooding. We work closely with dam operators in times of flood to ensure they have the latest weather information. Operators use this information to manage their dams in a way that minimises impacts on communities downstream.

How dangerous is floodwater?

People don't think of floodwater as dangerous, compared to raging fires, or the howling gales of a tropical cyclone. Yet flooding is a serious threat – it's Australia's second-most deadly natural disaster (Haynes 2017). The danger is often underestimated, with devastating consequences. People have lost their lives when entering floodwaters on foot or in their car. Sadly, most flood injuries and fatalities are preventable.

Most people are shocked to learn how dangerous it is to drive into floodwater. A small car weighing about 1 tonne can be moved by floodwater which is only 15 cm deep, flowing at a rate of 1 m per second. In 60 cm of floodwater a small car will completely float away. This is because of the car's buoyancy from airtight doors and inflated tyres.

Reference

Haynes K, 2017, 'An analysis of building losses and human fatalities from natural disasters', reported in 'Where, why and how are Australians dying in floods?', accessed 27 August 2020.

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Bureau Home > National Weather Services > Flood Knowledge Centre > **About our flood warning services**

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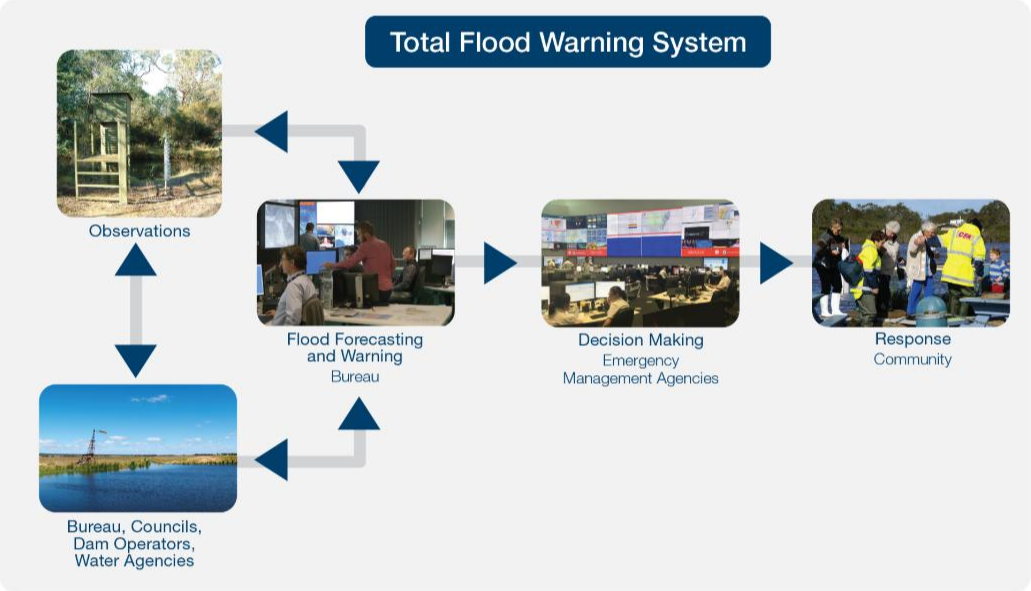
About our flood warning services

Flood warning services

We provide flood forecasting and warning services in each Australian state and territory as part of the Total Flood Warning System. Our partners in this system include:

- emergency management agencies
- government departments with responsibility for water management
- water authorities
- local councils.

National Arrangements for Flood Forecasting and Warning outlines the roles and responsibilities of each level of government. It also describes the arrangements and agency roles that apply in each jurisdiction.



There are many aspects to flood forecasting and warning. These include weather observations, dam operator information, modelling likely scenarios, decision-making and response.

We're responsible for monitoring and predicting a flood. We also work closely with state and territory governments, local councils and state emergency services (SES) to interpret the data and communicate the key messages to the community.

In this process, we could issue a Flood Watch or a Flood Warning.

Transcript

Flood Watch

We issue a Flood Watch when forecast rainfall suggests that local and riverine flooding is possible. Its purpose is to provide early advice of a developing situation that may lead to flooding. A Flood Watch isn't a warning of imminent flooding.

A Flood Watch provides information about a developing weather situation including forecast rainfall totals and catchments at risk of flooding. It can also indicate how severe a possible flood might be. It provides links to weather warnings, other flood-related information, and contact details of relevant emergency services.

A Flood Watch can be issued up to four days in advance of expected flooding. They are updated at least daily and finalised once all areas are covered by Flood Warnings or the risk of flooding has passed.

If a Flood Watch is issued for your area, look out for future updates and possible Flood Warnings. Follow the advice of your local emergency services. If flooding develops, consider moving livestock, family and possessions to higher ground.

The Flood Watch service covers the whole country. Flood Watch areas are defined and reviewed in partnership with key agencies in each state and territory to ensure they are locally relevant.

View the Flood Watch area for your region:

- New South Wales
- Northern Territory
- Queensland
- South Australia
- Tasmania
- Victoria
- Western Australia

Flood Warning

We issue a Flood Warning when we're more certain that flooding is expected at a particular location. Flood Warnings are more targeted and are issued for specific catchments and locations within catchments. We forecast how severe the flood is expected to be in each Flood Warning.

Flood Warnings typically include predictions about the level we expect the river to rise to. Where less data are available, Flood Warnings may include a statement about future flooding that is more general. For example, 'River levels are elevated along the Coal River around Richmond and are expected to remain elevated into Wednesday'. The type of information we provide depends on the:

- quality of real-time rainfall and river-level data available
- capability of rainfall and hydrological forecast models
- level of service agreed with partner organisations.

When there are insufficient data to make specific predictions, or in the developing stages of a flood, we provide generalised flood warnings. These are based on forecast rainfall and knowledge of historical flood response. Generalised warnings advise that flooding is expected in particular river valleys but don't provide information about how severe the flood may be or precise locations.

In the case of flash floods our response is different, and the best warning advice comes in the form of a Severe Weather Warning. Our flood warnings cover larger rivers that take more than six hours to respond to rainfall. The reason they're treated differently is because the longer lead time enables a different response. We can work with our government partners to collect data, run prediction models, interpret flood mapping and determine potential consequences, as well as issue and communicate warnings. Flash floods typically happen so quickly that there isn't time to run these processes.

While we don't warn for flash floods, we do provide forecasts and warnings for severe weather conditions and potential heavy rainfall that can cause flash flooding.

Flood classifications

The emergency services use a three-tiered scheme that classifies flooding as minor, moderate or major at key river height stations. Classification levels at each station are decided by local community and SES. They're defined by the water level that causes certain impacts.

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Transcript

Minor flooding

If the water level reaches the minor flood level, it causes inconvenience. Low-lying areas next to water courses are inundated. Minor roads may be closed and low-level bridges submerged. In urban areas flooding may affect some backyards and buildings below floor level as well as bicycle and pedestrian paths. In rural areas removal of livestock and equipment may be required.

Moderate flooding

If the water level reaches the moderate flood level, the area of inundation is larger. Main traffic routes may be affected. Some buildings may be affected above floor level. Evacuation may be required. In rural areas removal of livestock is necessary.

Major flooding

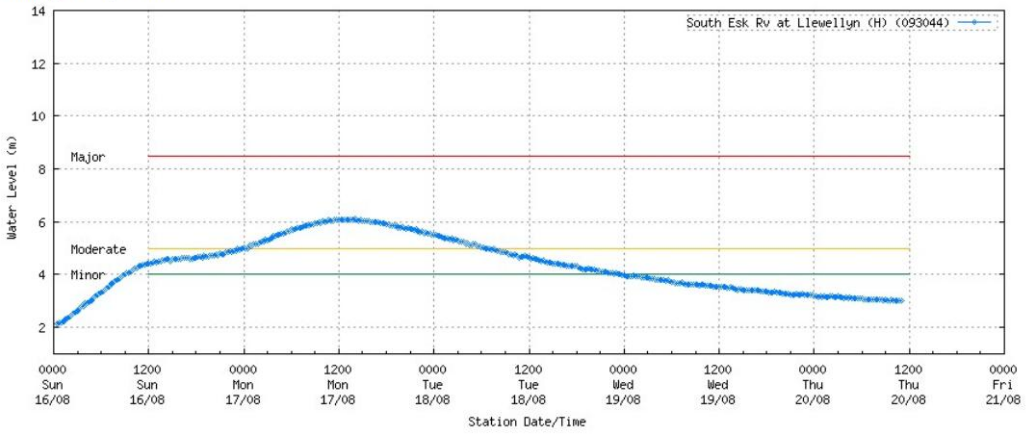
If the water level reaches the major flood level large areas are inundated. Many buildings may be affected above floor level. Properties and towns are likely to be isolated and major rail and traffic routes closed. Evacuation may be required. Utility services may be affected.

River heights

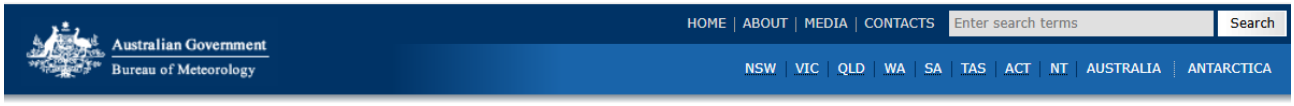
You'll see these terms used to describe river heights in our Flood Warnings. River heights are measured in metres.

Observed river height
This is the depth of water at a river height measuring gauge. In most cases, observed river height is measured relative to a local reference point. For example, a typical river height might be 'the South Esk River at Llewellyn in Tasmania, is at 1.60 metres'. In many tidal areas, as well as a few inland areas, river levels are expressed in metres above sea level or Australian Height Datum (AHD).

Peak river height
This is the highest river height observed during a flood event at the specified site on the river.
You can view a river's observed height over time through our Australia Rainfall and River Conditions page. This chart shows the level of the South Esk River at Llewellyn during a flood in August 2020. The highest water level (peak river height) was observed to be 6.11 m at 2 pm on Monday 17 August 2020.



Predicted river height
This is the height to which the river is predicted to rise at the gauge referred to in the warning. The actual depth of floodwater will vary across the floodplain. Local councils, emergency services and landowners use the predicted river height to determine which areas are likely to flood. They use their knowledge of past flood events and estimates from flood studies to assess this. The accuracy of river height predictions depends on various factors, including the type of flood forecasting model and its input data. Predicted river heights are regularly updated as more information becomes available.



Bureau Home > National Weather Services > Flood Knowledge Centre > **Preparing for a flood**

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Preparing for a flood

How to prepare for a flood

Floods can cause enormous damage very quickly. They can cut off communication and transport options and they can happen anywhere in Australia.

In an emergency, the situation can change rapidly. So, before a flood arrives, it's important to:

1. ask
2. learn
3. plan and prepare.

Ask

Ask questions about flooding in your neighborhood. Your local SES and council are good places to start.

- When did floods previously affect the area?
- How high were they?
- How quickly did the water rise?
- How long did flooding last?
- Is there a flood plan for my area?
- At what point do I need to evacuate my house?
- If I need to evacuate, where do I go?
- Will my house become isolated?

Learn

Before floods threaten your area, learn how the Total Flood Warning System works and familiarise yourself with these important terms:

- **Flood Watch** – issued to advise of possible future flooding if the rain forecast suggests it may happen in the next few days.
- **Flood Warning** – issued when flooding is expected in a particular location or catchment.
- **Flash flooding** – happens less than six hours after rainfall. When flash flooding is expected, we issue a Severe Weather Warning.
- **Minor flooding** – causes inconvenience. Low-lying areas next to water courses are inundated.
- **Moderate flooding** – the area of inundation is more substantial. Main traffic routes may be affected. Some buildings may be affected above floor level.
- **Major flooding** – extensive areas are inundated. Many buildings may be affected above floor level. Properties and towns are likely to be isolated and major rail and traffic routes closed.

Plan and prepare

If your local area has a history of flooding you should prepare a flood action plan. The plan should include an evacuation plan and a flood preparation checklist.

Key points of information for each State and Territory are:

- Australian Capital Territory Emergency Service Agency: Floods
- New South Wales State Emergency Service: Flood
- Northern Territory Government: SecureNT
- Queensland Government: Flood
- South Australian State Emergency Service: Be prepared for a flood
- Tasmania State Emergency Service: Flood preparation
- Victoria State Emergency Service: Get ready for flood
- Western Australia Government: EmergencyWA Flood
- Australian Red Cross: How to prepare for a flood