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Memorandum

30 November 2022

To: Belinda Barrie (GYDE Consulting)

From: Jason O'Brien

Subject: Bylong Park flood warning and response plan

1 Introduction

1.1 Background

Greyhound Racing New South Wales (Greyhounds NSW) propose the development of an animal boarding and rehabilitation facility at 'Bylong Park' 1949 Martindale Road, Denman (the site). The facility will be used for boarding and rehabilitating greyhound dogs prior to their adoption and 'rehoming' via the NSW Greyhounds As Pets programme. The proposal requires the construction of facilities to accommodate and provide veterinary care for up to 400 dogs and includes:

- construction of 20 kennel blocks of 20 kennels/dogs;
- a new veterinary and supporting services building (the farmstead);
- renovation of existing stable building as an outdoor covered area; and
- sewerage, waste-treatment and plumbing works.

Once operational, the facility will be the first of its kind in NSW and will employ the equivalent of 24 full-time staff and volunteers.

EMM Consulting Pty Ltd (EMM) prepared a flood risk assessment (EMM 2020) to inform the location of the proposed kennels and other infrastructure and establish the 1% annual exceedance probability (AEP) flood extent and level for the site. The flood risk assessment was provided to Muswellbrook Shire Council (hereinafter referred to as Council) as part of the Development Application (DA) submission.

Council requested further information on flooding aspects of the proposed development in March 2022. Council's request for information (RFI) primarily related to providing further information on the proposed site access arrangement and the resulting flood risk. EMM subsequently provided an updated flood risk assessment (EMM 2022) to address Council's RFI. It was determined site access would be restricted multiple times per year for several hours to days at a time.

1.2 Report purpose and scope

Council has since requested (via correspondence dated 14 October 2022) further consideration be given to providing flood free access to the site and/or implementing a flood warning and response system. Greyhounds NSW preference is to implement a flood warning and response system.

This document describes a flood warning and response system that could be implemented at the site. It includes:

- a description of site access constraints (Section 2);
- a characterisation of the streamflow response to rainfall and estimated flood travel times along Martindale Creek upstream of the site (Section 3);
- a description of the flood warning and response system (Section 4); and
- a provisional flood warning and response plan that outlines the triggers and actions to manage access to and from the site prior to and while site access restrictions are occurring (Section 5).

This document reproduces relevant information from, and should be read in conjunction with, the flood risk assessment prepared by EMM (2022).

2 Site access constraints

2.1 Safe access thresholds

Site access is provided via an existing access road and concrete causeway across Martindale Creek. Flow conditions over the causeway were characterised using a hydraulic model of Martindale Creek. Safe access thresholds were calculated for small cars and large four-wheel drive vehicles, with small car access being the limiting factor.

As traffic to and from the site is expected to comprise of a range of vehicle types including small cars, the safe access threshold for small cars has been applied to define site access constraints for the flood warning and response system described in Section 4.

The safe access threshold was determined to occur at a streamflow rate of 1.6 m^3/s which corresponds to a flow depth of 0.28 m over the exiting concrete causeway. The limiting flow conditions for vehicle access across the existing causeway are summarised in Table 2.1.

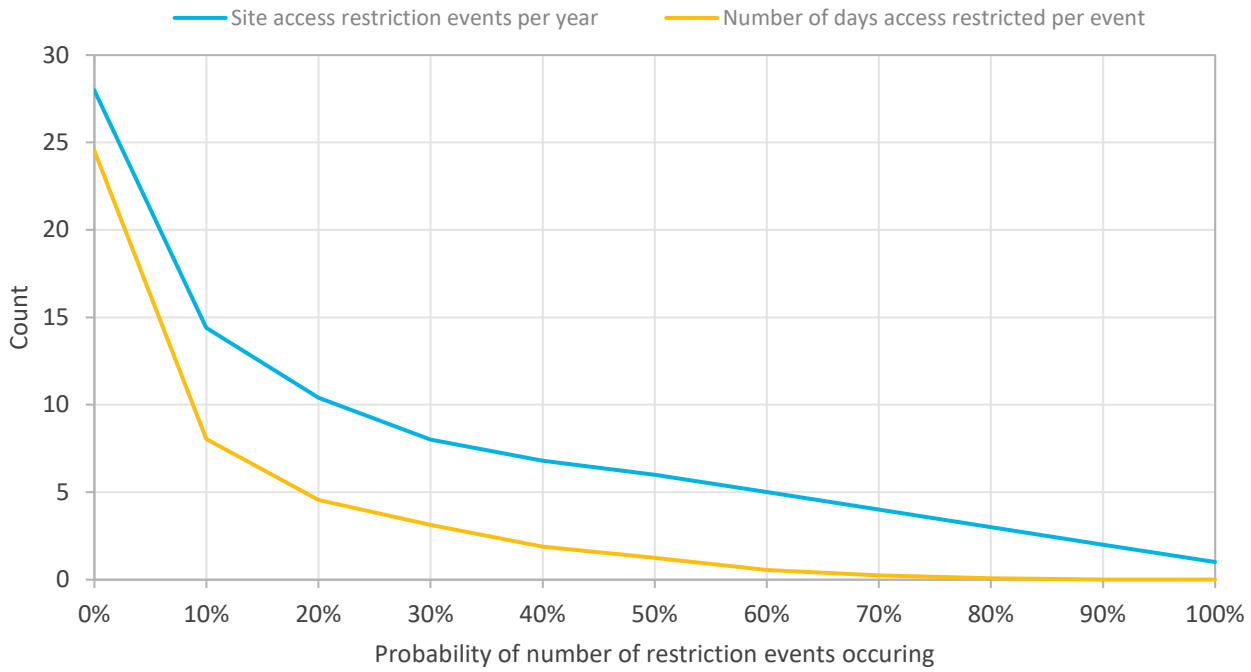
Table 2.1 Site access streamflow thresholds

Vehicle type	Depth		Velocity		Velocity x depth		Limiting flowrate (m^3/s)
	Limit (m)	Flowrate (m^3/s)	Limit (m/s)	Flowrate (m^3/s)	Limit (m^2/s)	Flowrate (m^3/s)	
Small car	0.3	2.2	2.0	N/A	≤0.3	1.6	1.6

Source: Bylong Park: flood risk assessment (EMM 2022)

2.2 Site access restrictions

The estimated frequency and duration of streamflow events that would restrict access to the site are shown in Table 2.1. Streamflow events that would restrict safe site access are estimated to occur more than six times per year in 50% of years. About 50% of site access restriction events will occur for approximately 1 day or less. Restrictions of more than 6 days occur in approximately 10% of events.



Source: Bylong Park: flood risk assessment (EMM 2022)

Figure 2.1 Number and duration of site access restricting streamflow events per year

3 Catchment response to rainfall

3.1 Context

The available flood warning time will depend on the rate of streamflow rise following rainfall, the location of any flood warning system relative to the site and the speed at which the resulting flood wave travels along Martindale Creek. The delay between when rainfall first occurs and the subsequent rise in streamflow provides an indication of the time available to prepare for and respond to potential site access restrictions.

This section characterises the streamflow response to rainfall within the Martindale Creek catchment and determines flood travel times in the creek upstream of the site. Information from this section is used to inform the key aspects of the flood warning and response system that is described in Section 4.

3.2 Streamflow response to rainfall

The streamflow response to rainfall in the Martindale Creek catchment is influenced by a range of factors including rainfall depth and intensity, spatial variation of rainfall across the catchment, antecedent soil moisture conditions and the storm direction.

As Martindale Creek is an ungauged catchment, the flood risk assessment (EMM 2022) characterised streamflow in Martindale Creek using stream gauge data from the adjoining Macdonald River catchment. Streamflow for the upper Macdonald River catchment is recorded at WaterNSW operated Macdonald River at Howes Valley (station number 212021) stream gauge.

Streamflow characteristics at the Macdonald River gauge are expected to be similar to that of Martindale Creek at the site due to similar locations (adjacent catchments), catchment size (299 km^2 verse 247 km^2) and similarity of predominate land use (steep, undeveloped bushland).

Rainfall is also recorded at 15-minute intervals at the Macdonald River at Howes Valley gauge location. Comparison between the available streamflow and rainfall data from these gauges indicates:

- The streamflow response to rainfall is highly variable with observed streamflow not always being commensurate to the observed rainfall depth (ie significant streamflow from minimal rainfall and vice versa).
- Streamflow typically rises 4–6 hours following rainfall commencing at the gauge but may also take as little as 1–2 hours or as much as 12 hours or more. A quicker (ie 1–2 hours) streamflow response generally occurs if substantial rainfall is observed in the preceding 24-48 hours, resulting in a pre-saturated catchment.
- Once the streamflow rate starts to rise (ie 4–6 hours following rainfall commencing), the time it takes for the streamflow rate to exceed the safe access thresholds is also highly variable and can range from less than an hour to several hours following the initial rise.

The rainfall runoff response at the Macdonald River at Howes Valley gauge for the January 2022 event is shown in Figure 3.1 for context. The event comprised 17 mm of rainfall (as recorded at the gauge) over 12 hours. The streamflow rate at the gauge started to rise approximately 6 hours after rainfall commenced and peaked at approximately 19 m^3/s, 18 hours after rainfall commenced. The safe streamflow threshold would have been exceeded shortly after the streamflow rate began to rise.

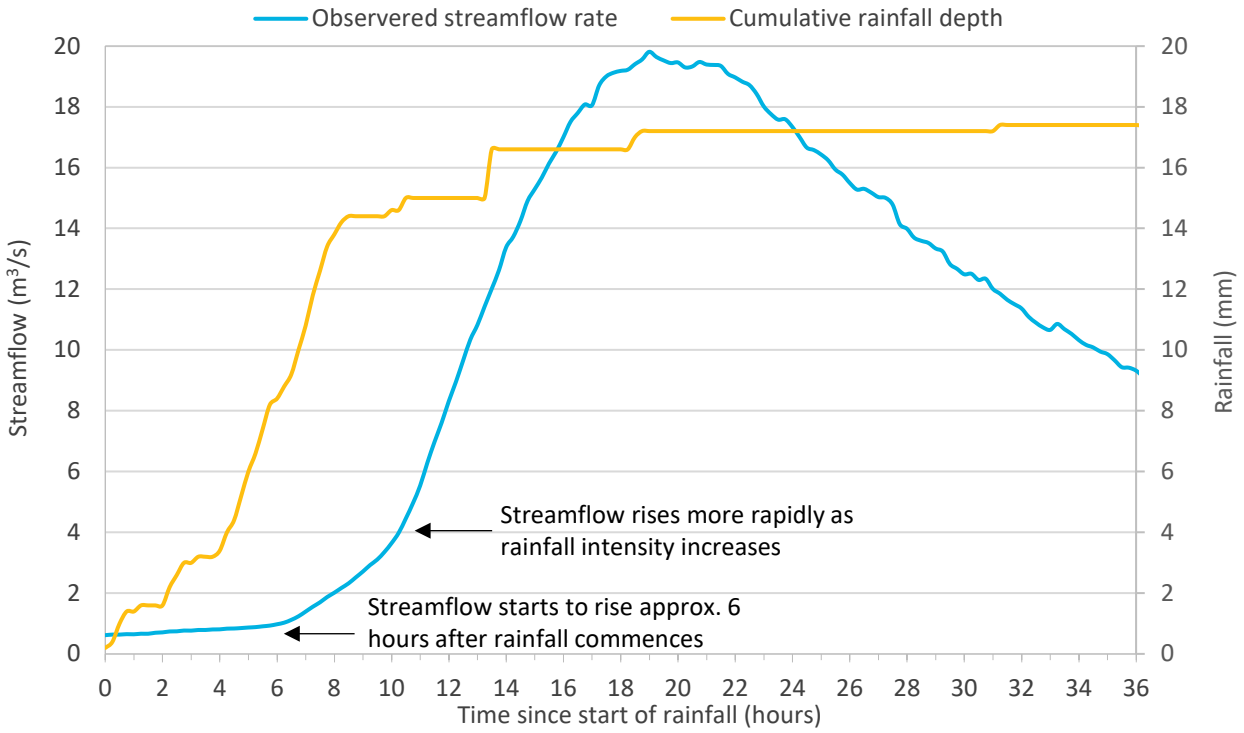


Figure 3.1 January 2022 rainfall and streamflow event – Macdonald River at Howes Valley

The data from the Macdonald River catchment demonstrates that:

- the streamflow response to rainfall is variable and cannot easily be predicted; and

- rainfall data from a single point in the catchment cannot be used to reliably predict elevated streamflow conditions.

3.3 Flood travel times

The speed at which a flood wave travels along a watercourse is dependent on several factors including channel dimensions and grade, initial streamflow rates, and the magnitude of streamflow. Determining how fast the flood wave travels along a particular watercourse is key to establishing available warning times that would be provided by a flood warning system that measures streamflow upstream of the site.

The hydraulic model developed for the flood risk assessment (EMM 2022) was extended approximately 6.5 km upstream of the site to:

- estimate the speed at which flooding travels along Martindale Creek; and
- provide an indication of available warning time that could be achieved by installing a stream monitoring gauge upstream of the site.

The hydraulic model was run for the 63.2 % AEP and 1% AEP flood design hydrographs established in the flood risk assessment (EMM 2022). The hydraulic model results were used to develop a lower and upper bound estimate for flood travel times along Martindale Creek. The lower and upper bound flood travel times are estimated at 2.0 km/hour (or 0.6 m/s) and 3.5 km/hour (or 1.0 m/s) respectively. The flood travel time estimates are shown alongside a plan view of the corresponding Martindale Creek chainages in Figure 3.2. The portion of the contributing catchment area upstream of the site is also shown at several chainage locations for context.

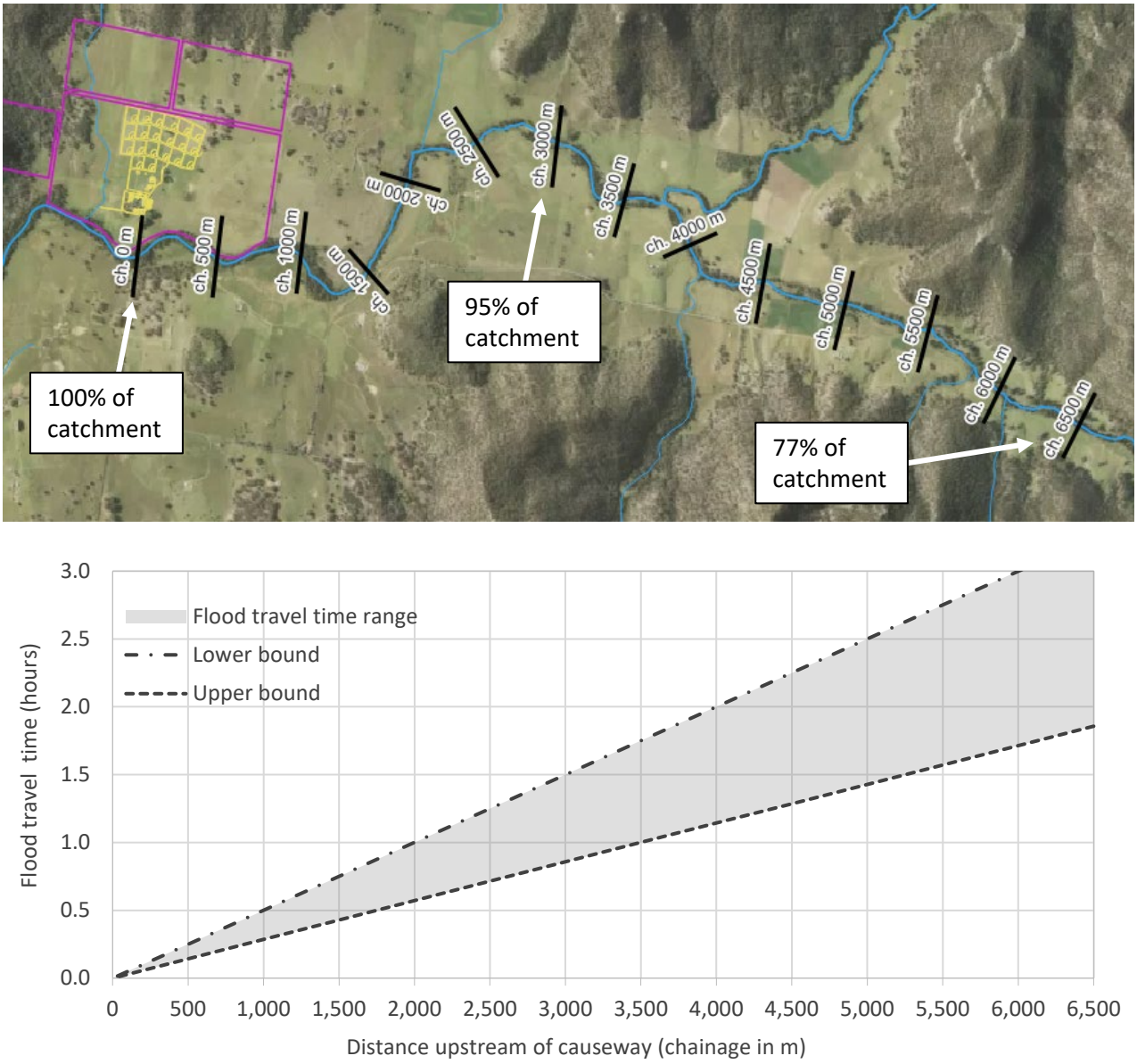


Figure 3.2 **Flood travel time along Martindale Creek – upstream of the site**

3.4 Conclusion

The streamflow response to rainfall in the Martindale Creek catchment is expected to be variable and hard to predict. The variability in rainfall distribution across the catchment in any given event means rainfall data from a single point cannot be used to reliably predict elevated streamflow conditions. Accordingly, catchment wide rainfall forecasts combined with real-time water level monitoring are considered to be the most reliable methods of identifying and responding to elevated streamflow conditions in Martindale Creek.

4 Flood warning and response system

4.1 Approach

A flood warning and response system is proposed to provide early identification of weather and streamflow conditions that may lead to site access restrictions and allow for flood response plan to be implemented. The primary objectives of the flood warning and response system are to:

- prepare the site for potential access restrictions;
- provide early warning to allow non-essential personnel to leave prior to site access restrictions occurring; and
- prevent access to and from the site via Martindale Creek when the safe access thresholds are exceeded.

The proposed system will comprise:

- monitoring rainfall forecasts to provide early identification of weather systems that have potential to cause access restrictions; and
- streamflow monitoring upstream of the site and at the causeway to provide warning of rising streamflow conditions and identify unsafe conditions.

The flood warning aspect of the system will significantly reduce the occurrence of personnel being stranded on site when access is restricted while the response measures will avoid exposure to risks during elevated streamflow conditions. Greyhounds NSW propose to charter a helicopter to provide access and essential services during extended periods of access restrictions which will occasionally occur.

4.2 System components

The flood warning and response system will comprise of several key elements including monitoring of rainfall forecasts, real-time stream monitoring, automated boom gates and flood level markers. Each component of the flood warning and response system is described in Table 4.1. A conceptual layout of the flood warning and response system is shown in Figure 4.1.

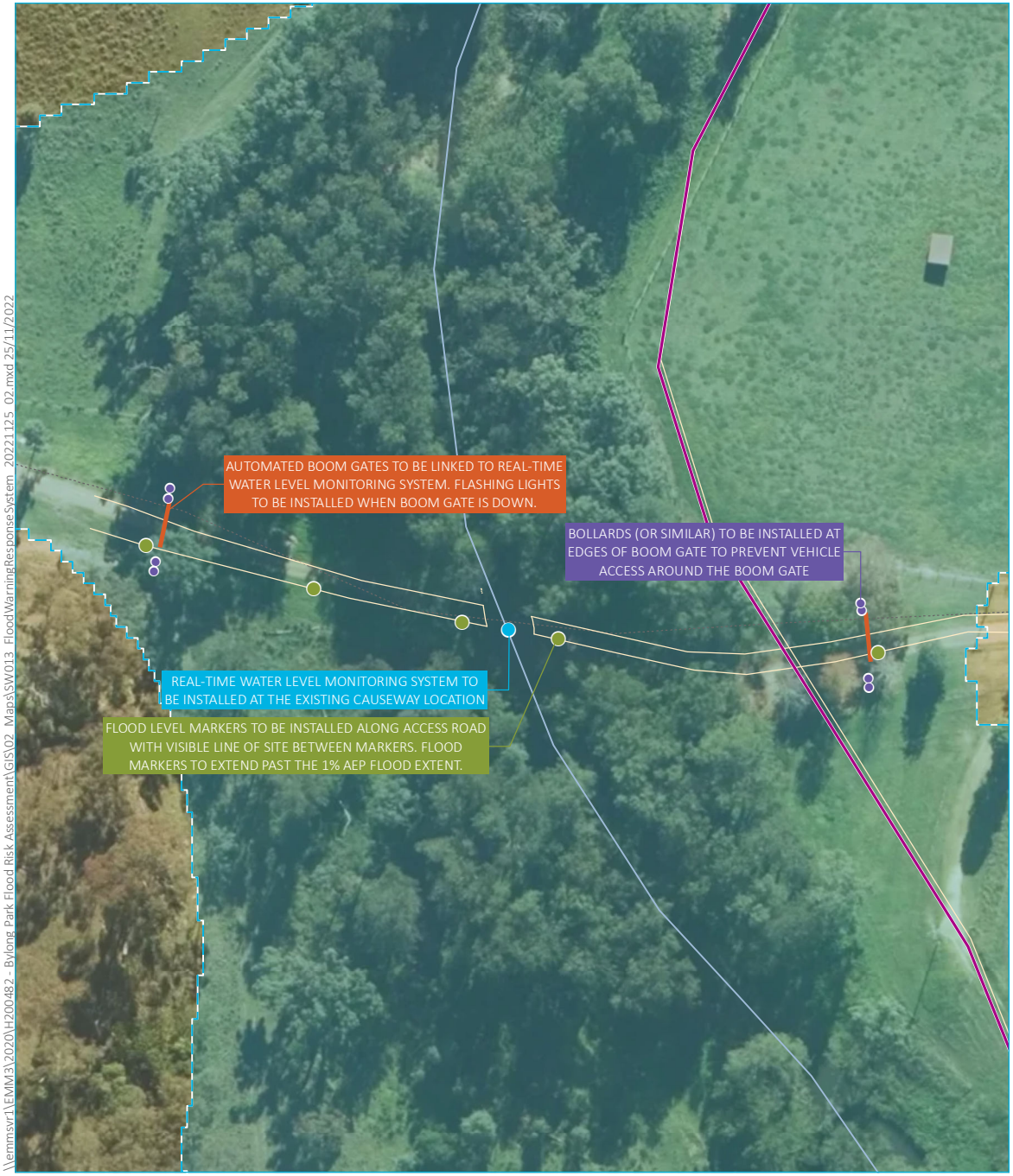
The trigger values and actions associated with each component of the flood warning and response system are described in the provisional flood warning and response plan in Appendix A. These details will be further developed once a detailed design of the flood warning and response system is completed.

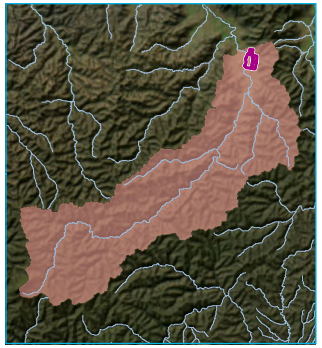
Table 4.1 Flood warning and response system components

Component	Description
Rainfall forecasts	• Local and regional rainfall forecasts will be monitored daily during dry conditions and as needed (eg hourly) during wet weather conditions to adequately track and respond to any updates to the forecasted weather conditions. • Monitoring rainfall forecasts will provide early identification of significant weather systems to allow the site and personnel to prepare for site access restrictions ahead of time.
Stream monitoring (upstream of the site)	• A streamflow monitoring system will be installed on a third-party property approximately 3 km upstream of the site to monitor real-time flow conditions. A formal agreement between Greyhounds NSW and the third party has been sought and will be signed to allow ongoing and future use of the streamflow monitoring system. • The system would provide between 50 to 90 minutes warning time before site access restrictions are applied. The final placement of the stream monitoring system will be determined by a specialist flood warning and response system contractor as part of the detailed design and installation process. An indicative location for the proposed streamflow monitoring location is shown in Figure 4.1. • The system will provide automated notifications to site personnel and relevant staff once streamflow conditions exceed a trigger level to allow non-essential personnel to safely leave the site. The trigger levels will be developed by the flood warning and response system contractor based on the specific creek characterises (ie cross-section) at the monitoring location and will be verified overtime. • The proposed streamflow monitoring location captures rainfall and runoff from 95% of the contributing catchment upstream of the existing site access causeway.
Stream monitoring (at the site)	• A real-time water level monitoring system will be installed to measure water levels at the existing concrete causeway. • The water level monitoring system will be connected to automated boom gates that will restrict access to the causeway when the safe access thresholds are exceeded. Stream depth markers and appropriate signage will also be applied.
Automated boom gates	• Automated boom gates will be installed either side of the existing causeway to prevent personnel driving through Martindale Creek when access restrictions are in place. The boom gates will be triggered by the water level monitoring sensor described above. • The boom gates will likely be located within the 1% AEP flood extent but outside of the main flood way. Hence, the risk of damage from debris or localised flood impacts are considered low. The final location of the boom gates will be determined by the flood warning and response system contractor with consideration of access to power and • Flashing lights will be installed on the top of or near the boom gates and operate when the boom gates are in operations (ie down).
Exclusion barriers	• Exclusion barriers are proposed to prevent errant drivers from bypassing the boom gates and attempting to cross Martindale Creek during unsafe streamflow conditions. • Exclusion barriers may comprise of bollards, sandstone logs, barrier gates, or other appropriate vehicle prevention devices. Exclusion barriers will be installed at 1.2–1.5 m spacing to allow flood waters to pass through and around the structures but still prevent vehicle access. • The exclusion barriers are not anticipated to result in any material impacts to flood conditions. Any residual impacts would be highly localised (ie immediately adjacent to the barrier).
Flood markers	• Permanent flood markers will be installed along the access road on each side of Martindale Creek. At a minimum, the flood markers will be installed either side of the causeway, at the boom gate location and at the 1% AEP flood extent. Intermediate flood markers may be required if line of site is not possible between the boom gate and causeway.

Table 4.1 Flood warning and response system components

Component	Description
Alternative access	• While the proposed flood warning and response system is expected to reduce the risk of non-essential personnel remaining on site during elevated streamflow conditions, an alternative flood free access arrangement is required to provide redundancy if streamflow conditions exceed the safe access thresholds unexpectedly or more rapidly than predicted. Flood free access will also be required to rotate essential staff, resupply the operations, and provide medical assistance (if required) when site access restrictions occur for extended periods of time. • Greyhounds NSW propose to provide alternative flood free access via a charted helicopter. An area of the site will be maintained to allow helicopter access on an as needs basis. It is noted that helicopter access would be weather dependent and may take some time to arrange. Accordingly, the flood preparedness aspects of the response plan will be essential to minimise risks and potential inconveniences for staff.





KEY

- Site boundary
- Proposed site plan
- Exclusion barriers
- Water level monitoring system
- Flood depth marker
- Indicative upstream monitoring location
- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- Flood warning chainages
- Boom gate
- 1% AEP flood extent
- Martindale Creek catchment

Conceptual flood warning and response system

Bylong Park, NSW
Flood warning and response system
Figure 4.1

EMM creating opportunities

Source: EMM (2022); DFSI (2020, 2021); ESRI (2022); GA (2011)

0 25 50 m

0 0.5 1 km

GDA 1994 MGA Zone 56

N

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5 Flood warning and response plan

A provisional flood warning and response plan that outlines the flood warning triggers and associated actions to manage access to and from the site prior to, and while site access restrictions are occurring is provided in Appendix A.

The provisional flood warning and response plan will be finalised once the detailed design of the flood warning and response system is completed. The plan will be progressively updated as required to capture ongoing changes and improvements to site operations, flooding conditions, and the flood warning and response system.

The provisional flood warning and response plan could be applied to both construction and operational phases of the development. As limited facilities will be available during construction, the flood warning and response triggers could be modified to allow non-essential personnel to leave the site earlier during construction.

Appendix A
Flood warning and response plan

EMM
creating opportunities

Table A.1 Provisional flood warning and response plan

Stage	Trigger	Action required	Timing	Follow up actions
Flood preparedness	Rainfall forecasts are to be monitored on a regular basis to identify the likelihood and extent and magnitude of access restrictions occurring in the next five days.	If minor short-term restrictions are considered likely to occur: • Inform relevant staff that site access may be restricted for short periods of time in the coming days. • Prepare staff for possibility that non-essential staff may need to be leave the site in the coming days. • Prepare operations for short term access restrictions. • Continue to monitor rainfall forecasts.	Immediately once rainfall in the catchment is predicted.	• Nil
		If more extensive restrictions are considered likely to occur or weather is predicted to limit alternative access arrangements (helicopter) for several days: • Inform staff that site access may be restricted for more than a day at a time. • Non-essential staff are to leave the site prior to predicted start of rainfall. • Prepare operations for longer term restrictions. • Continue to monitor rainfall forecasts.	Immediately once rainfall in the catchment is predicted.	• Provide regular updates to relevant staff.
Flood warning system	Observed streamflow at the upstream monitoring location exceeds **1.6 m^3/s** and is continuing to rise.	• Automated messaging to inform site personnel and staff that site access restrictions are predicted to occur. • Any non-essential staff to leave the site prior to site access restrictions occurring.	Immediately once streamflow conditions exceed the trigger value.	• Continue to monitor rainfall forecasts and streamflow observations to identify potential variation in expected flood warning times. • Provide regular updates to relevant staff.

Table A.1 Provisional flood warning and response plan

Stage	Trigger	Action required	Timing	Follow up actions
Flood response system	Streamflow at the existing causeway exceeds a flow depth of **0.28 m**.	• Automated boom gates will be initiated and access to and from the site will be restricted. • Essential staff to shelter in place until site access is re-established.	Immediately once the safe access threshold has been exceeded.	• Continue to monitor rainfall forecasts to identify when site access may be re-established. • Provide regular updates to relevant staff.
Site access restricted	Alternative flood free access is required.	• Helicopter to be charted to provide access to and from site.	As soon as practical once need for alternative access is identified.	• Nil
Post event	Flow depth recedes below 0.28 m (and not expected to immediately rise again)	• Inform staff site access has been re-established.	As required to allow staff to enter or leave site.	• Monitor rainfall forecasts and observed streamflow conditions to confirm streamflow will continue to fall. • Provide regular updates to relevant staff.