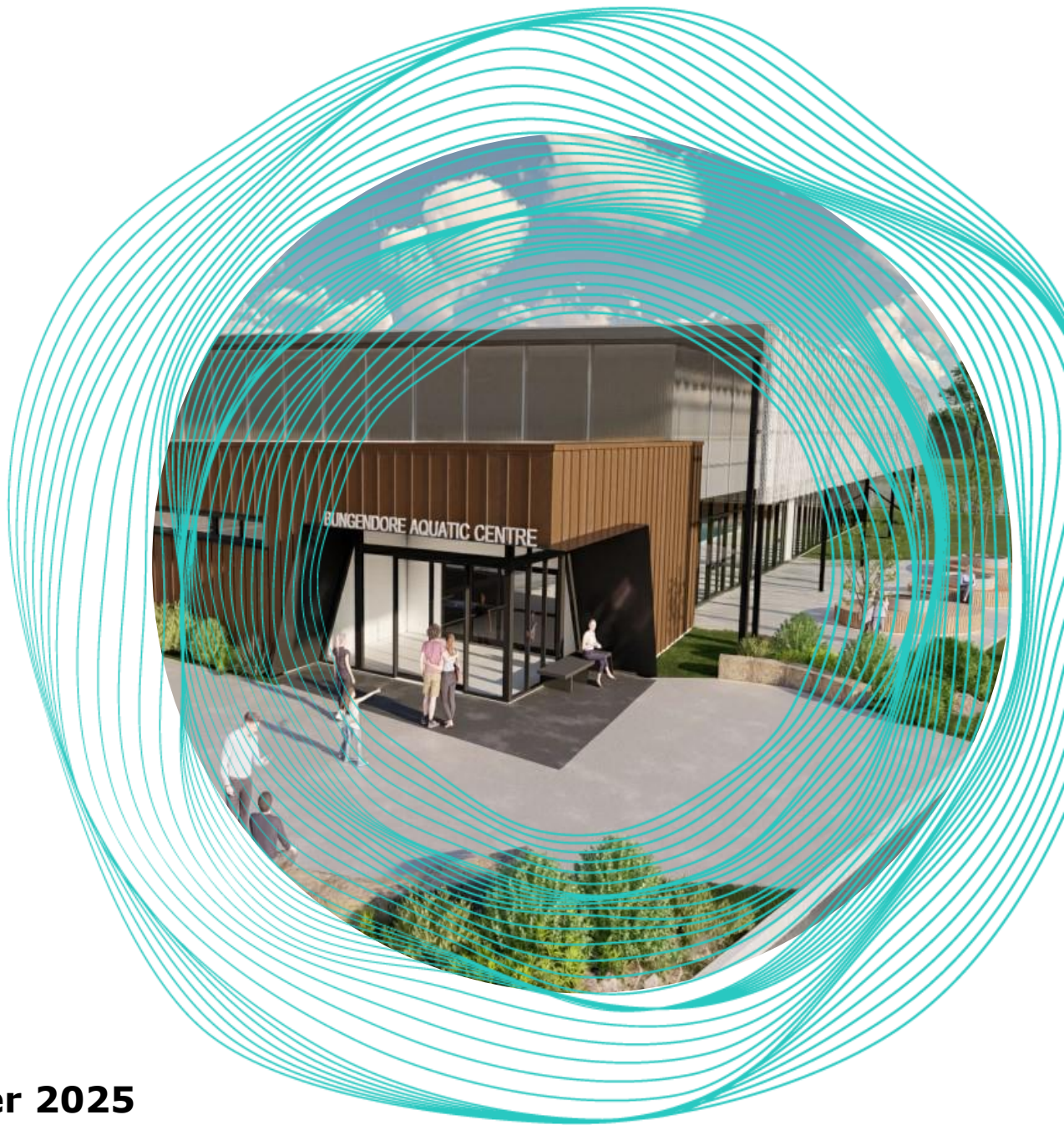


QUEANBEYAN-PALERANG REGIONAL COUNCIL

BUNGENDORE SPORTS HUB

Flood Impact and Risk Assessment



October 2025

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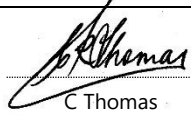
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Project No. 311015-00764: Bungendore Sports Hub Flood Impact and Risk Assessment

Rev	Description	Author	Reviewer	Approver	Revision Date
A	Draft for Internal Review	LT L To	RG R Golaszewski		21/08/2025
0	Draft Issued for Client Review	LT L To	RG R Golaszewski		22/08/2025
1	Final Draft Report	LT L To	RG R Golaszewski	 C Thomas	17/10/2025
2	Final Report	LT L To	RG R Golaszewski	 C Thomas	23/10/2025

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1. Introduction

Queanbeyan-Palerang Regional Council (**QPRC**) has completed investigations to understand and identify gaps in the provision of sporting facilities across the QPRC local government area. The town of Bungendore was identified as an area which lacked suitable sports facilities. The Queanbeyan-Palerang Sports Facilities Strategic Plan (QPRC, 2017) provides for the establishment of a sports hub, rather than a single standalone sports field. In accordance with the Plan, QPRC commenced investigations into the construction of a sports hub at Bungendore.

The land described as Lot 1 DP 1262898, and otherwise referred to as 15 Halfway Creek Road, Bungendore, was subsequently identified by QPRC as a suitable location for the Bungendore Sports Hub. Construction of the sports hub on this land commenced in 2020 and was completed in 2023. QPRC is now seeking to construct an indoor aquatic centre at the sports hub to expand on the existing sporting facilities which are currently available.

QPRC is also seeking to make amendments to the Queanbeyan-Palerang Regional Local Environmental Plan 2022 (**QPR-LEP 2022**) to rezone 15 Halfway Creek Road (Lot 1 DP 1262898) from RU1 Primary Production to RE1 Public Recreation. The rezoning is intended to recognise the recreational purpose of the land and to enable a wider range of recreational development, such as an indoor aquatic centre. It is noted that indoor recreational facilities are currently prohibited on land zoned as RU1 Primary Production under the QPR-LEP 2022.

The land at 15 Halfway Creek Road, Bungendore, is subject to flooding from Halfway Creek and/or Mill Post Creek. Flooding of these creeks is documented in the *Bungendore Floodplain Risk Management Study and Plan* (WorleyParsons, 2014). Worley Consulting is currently undertaking a review of this Plan and will soon publish a new flood risk management study for the town and its surrounds. Updated flood modelling that has been undertaken as part of the project confirms that the land at 15 Halfway Creek Road is flood prone.

Accordingly, a Flood Impact and Risk Assessment (**FIRA**) is required to quantify the potential impacts of the proposed aquatic centre development on existing flood behaviour, to assess the risk of flooding at the Bungendore Sports Hub and to address the requirements of *Section 9.1(2) Local Planning Direction 4.1 – Flooding* as well as QPRC's other planning instruments.

2. Background

2.1 Site Description

The Bungendore Sports Hub is located about 300 metres west of Bungendore and immediately south of the Bungendore Sewage Treatment Plant (STP). At the time of writing, the sports hub comprised four hard surface netball courts and two turf fields with flood lighting installed for all facilities. There is also a main pavilion building with changing rooms, a canteen, local amenities and some meeting rooms. It is understood that bulk earthworks for the sports hub were completed in 2022.

The Bungendore Sports Hub is located between Halfway Creek and Mill Post Creek, both of which flow in a northerly direction before discharging into Turallo Creek. The sports hub is accessed by Halfway Creek Road, which follows an east-west alignment from the Malbon Street / Molonglo Street intersection and crosses Halfway Creek via a recently constructed bridge.

Halfway Creek and Mill Post Creek are both ephemeral watercourses which hold some ponded water during dry conditions. The floodplains of these creeks are typically characterised by grassed pastureland with little riparian vegetation. Previous flood investigations have shown that these creeks have limited in-channel capacity, with floodwaters overtopping the creek banks during frequent storm events¹.

A plan of the site is shown in **Figure 2-1**, while land elevations in the vicinity of the site is shown in **Figure 2-2**.

Figure 2-2 shows that the land elevation in the vicinity of the sports hub is relatively flat. The finished surface of the playing fields and courts at the sports hub typically range from 691.5 to 692.0 mAHD. The eastern floodplain of Halfway Creek is at slightly lower elevations and typically ranges between 690.0 and 691.5 mAHD. The terrain generally slopes from south to north through the site. The land elevation at the site of the proposed aquatic centre site typically ranges from 690.7 mAHD to 691.7 mAHD.

2.2 Proposed Development

QPRC intends to construct an indoor aquatic centre and open carpark in the northern portion of the sports hub (refer **Figure 2-1**). Architectural drawings for the proposed development have been prepared by Mode Design and are included in **Appendix A**.

The indoor aquatic centre occupies a footprint of about 2000 m² and is located in the western half of the development site. The design for the aquatic centre comprises a 25-metre heated swimming pool with seven lanes, spectator seating, a pool store, a plant room, change rooms and showers as well as a café and an office space.

A paved open carpark is proposed for the eastern half of the development site, comprising 42 car spaces. The open carpark will also include a drop-off zone. The development layout has been extracted from the architectural drawings and is shown in **Figure 2-3**.

Council staff have indicated that construction of the aquatic centre and the carpark in accordance with the architectural design will require minimal earthworks.

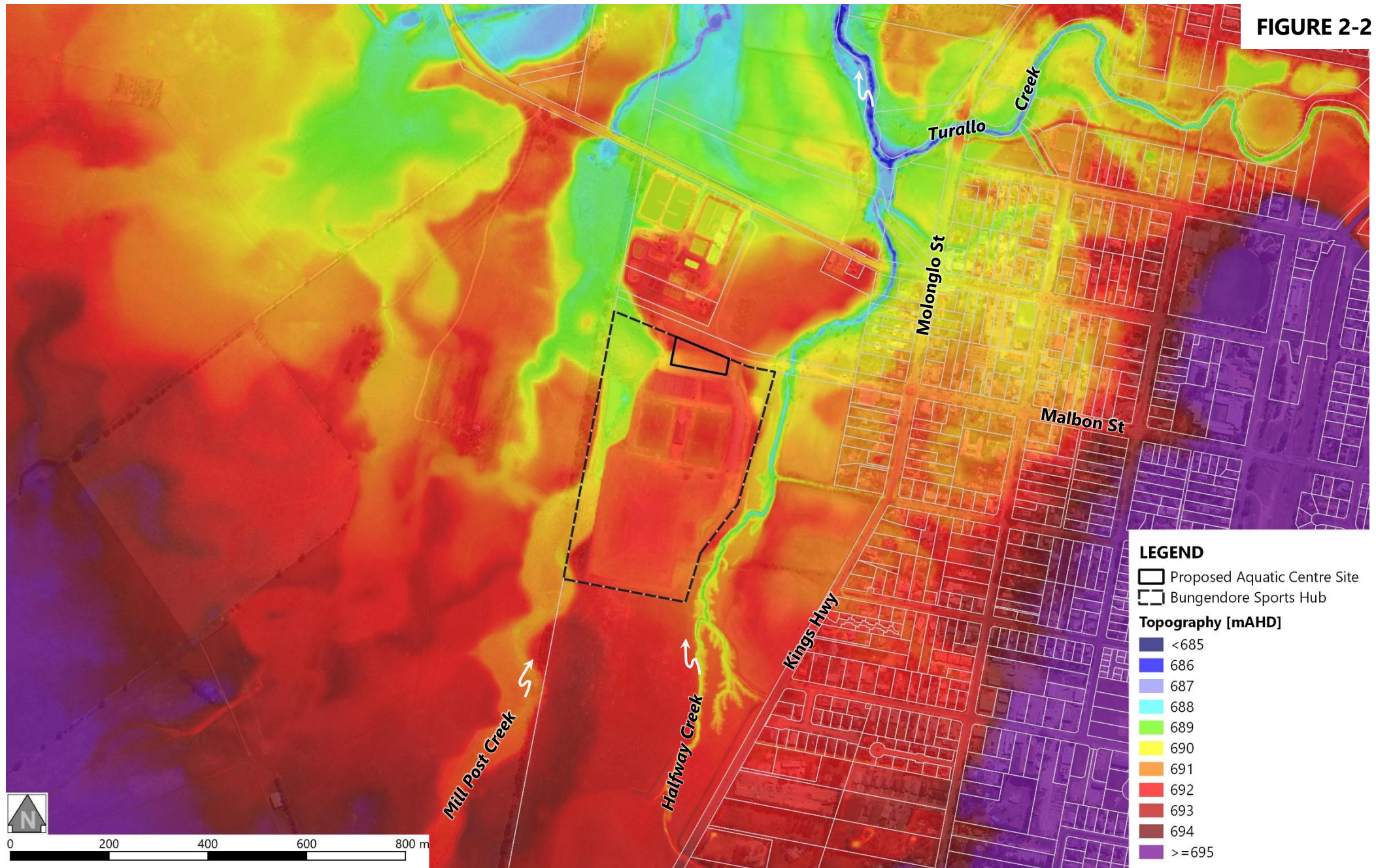
¹ Bungendore Floodplain Risk Management Study & Plan (2014)

FIGURE 2-1



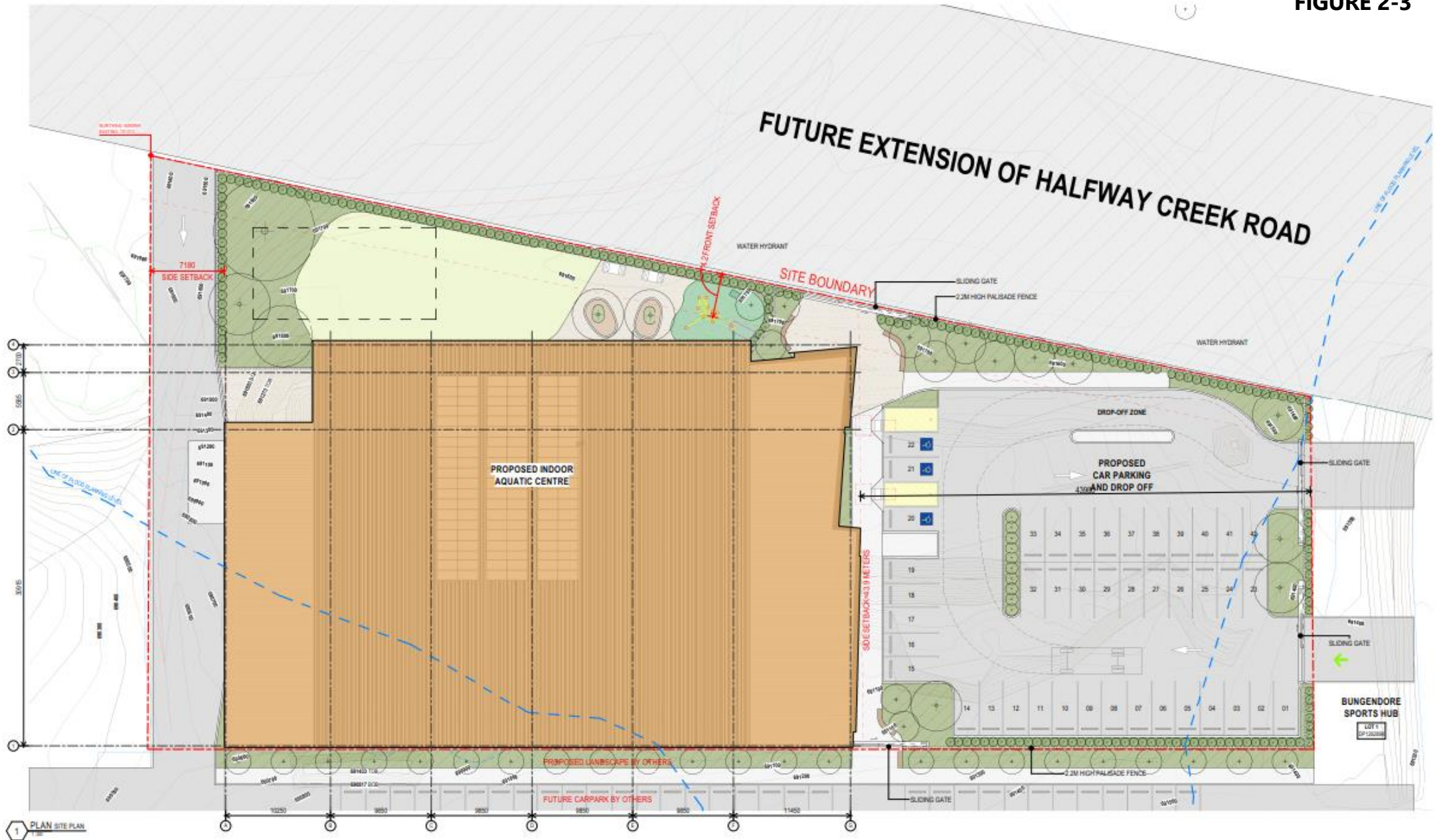
Prepared by:

FIGURE 2-2



Prepared by:

FIGURE 2-3



Prepared by:



**PROPOSED DEVELOPMENT LAYOUT FOR THE
INDOOR AQUATIC CENTRE
[SOURCE: MODE DESIGN]**

2.3 Proposed Rezoning

QPRC intends to rezone the sports hub (15 Halfway Creek Road) from RU1 Primary Production to RE1 Public Recreation. The rezoning is intended to recognise the recreational purpose of the land and to enable a wider range of recreational development such as the proposed indoor aquatic centre.

2.4 Previous Flood Studies

The characteristics of flooding of Turallo Creek, Halfway Creek and Mill Post Creek are documented in a number of government-funded reports prepared for Queanbeyan-Palerang Regional Council (previously Yarrowlumla Shire Council and Palerang Council). These reports include the following.

- '*Bungendore Flood Study*' (2002), prepared by Patterson Britton & Partners (subsequently acquired by WorleyParsons)
- '*Bungendore Floodplain Risk Management Study*' (2014), prepared by WorleyParsons
- '*Bungendore Floodplain Risk Management Plan*' (2014), prepared by WorleyParsons.

All of these reports have been prepared based on the results of flood modelling undertaken using a two-dimensional RMA-2 flood model that evolved over the 10-year period from 2002 to 2012.

This evolution involved progressive modifications to the flood model to incorporate updated topographic data as it became available. The latest topographic data used in the Bungendore Floodplain Risk Management Study and Plan (2014) was captured in 2012 and includes developments at the Elmslea Estate, the Darmody site and the upgraded Tarago Road bridge.

The design flood modelling for these studies had been completed using rainfall-runoff data, methodology and techniques from *Australian Rainfall and Runoff 1987* (ARR 1987) with a primary focus on mainstream flooding along Turallo, Halfway and Mill Post Creeks.

The previous flood investigations culminated in the recommendation of a number of flood, property and response modification measures to mitigate the flood risk at Bungendore.

2.5 Bungendore Floodplain Risk Management Study Review

Prior to the commencement of the Bungendore Sports Hub FIRA, Worley Consulting was engaged by Council to undertake a review of the Bungendore Floodplain Risk Management Study and Plan (the Bungendore FRMS&P Review). The project is being undertaken under the NSW Government's Floodplain Management Program. The scope of the review includes an updated assessment of flood characteristics along Turallo Creek, Halfway Creek and Mill Post Creek, as well as the identification and assessment of measures for mitigating the impacts of flooding on the existing community.

The existing Bungendore FRMS&P relies on the results of flood modelling that was completed in 2014. Due to improvements in the extent and reliability of topographic data and advancements in computer modelling tools since that time, the scope includes the development of new modelling tools and their use to determine revised flood characteristics for the various tributaries including updated design flood levels. A new WBNM hydrologic model and a new TUFLOW hydrodynamic model have been developed by Worley Consulting as part of the project (Worley Consulting, in draft 2025).

The Bungendore FRMS&P Review Project also incorporates the following updates to the 2014 studies:

- adoption of rainfall-runoff data, methodology and techniques from *Australian Rainfall and Runoff 2019* (ARR 2019);
- adoption of a 1-metre LiDAR DEM from NSW DFSI flown in 2014 as the primary dataset in defining the topography for existing conditions in the hydrodynamic model;
- inclusion of survey data for recently completed works in the study area, including several residential subdivisions, the Bungendore Sports Hub and clearing and reshaping works at the confluence of Turallo Creek and Halfway Creek;
- adoption of a fine-scale sub-catchment delineation to enable an assessment of overland flows as well as mainstream flooding; and.
- calibration and validation of the flood models to the June 2016, August 2020 and August 2022 historic flood events.

The new WBNM and TUFLOW models were adopted to characterise flooding at Bungendore for a range of design events including the 20%, 10%, 5%, 2%, 1%, 1 in 200 and 1 in 500 Annual Exceedance Probability (**AEP**) events as well as the Probable Maximum Flood (**PMF**).

3. Flood Impact Assessment

3.1 Existing Flood Conditions

Flood model results for existing conditions were extracted from the Bungendore FRMS&P Review Project and were assessed with reference to the elevation and physical features of the land where the indoor aquatic centre and adjacent carpark are to be sited.

The Bungendore FRMS&P Review Project involved a hydrologic analysis to determine the critical duration storm(s) along Turallo Creek, Halfway Creek and Mill Post Creek, as well as significant overland flow paths in the vicinity of Bungendore. **Table 3-1** summarises the storm durations for selected events which were simulated in the TUFLOW hydraulic model for the Bungendore FRMS&P Review Project.

Table 3-1 Summary of critical duration storms

Design Events	Critical Duration
20% AEP	2 hours 4.5 hours 12 hours
10% AEP	2 hours 9 hours
5% AEP	2 hours 9 hours
1% AEP	1.5 hours 6 hours 12 hours
1 in 500 AEP	1.5 hours 6 hours 12 hours
PMF	1 hour 2 hours 3 hours

Mapping of peak flood depths, levels, velocities and hazard categories in the vicinity of the sports hub for the 20%, 1% and 1 in 500 AEP events, as well as the PMF, are included in **Appendix B**. The flood mapping presented in **Appendix B** comprises peak flood conditions produced by a process known as 'flood enveloping'. For each design flood event and parameter (i.e., depth, level, velocity and hazard) this process combines maximum flood model results from the two or three selected durations (refer **Table 3-1**) to produce a 'design flood envelope'. Relevant mapping for each parameter is as follows.

- **Figure B-1 to Figure B-5:** Peak Flood Depths for Existing Conditions
- **Figure B-6 to Figure B-10:** Peak Flood Levels for Existing Conditions
- **Figure B-11 to Figure B-15:** Peak Flow Velocities for Existing Conditions
- **Figure B-16 to Figure B-20:** Flood Hazard Categories for Existing Conditions

It is noted that the flood hazard mapping shown in this report is based on the hazard curves documented in the '*Australian Disaster Resilience Guideline 7-3 Flood Hazard*' (AIDR, 2017). These hazard curves assess the vulnerability of people, vehicles and buildings to flooding based on the velocity and depth of flood flows (refer **Figure 3-1**).

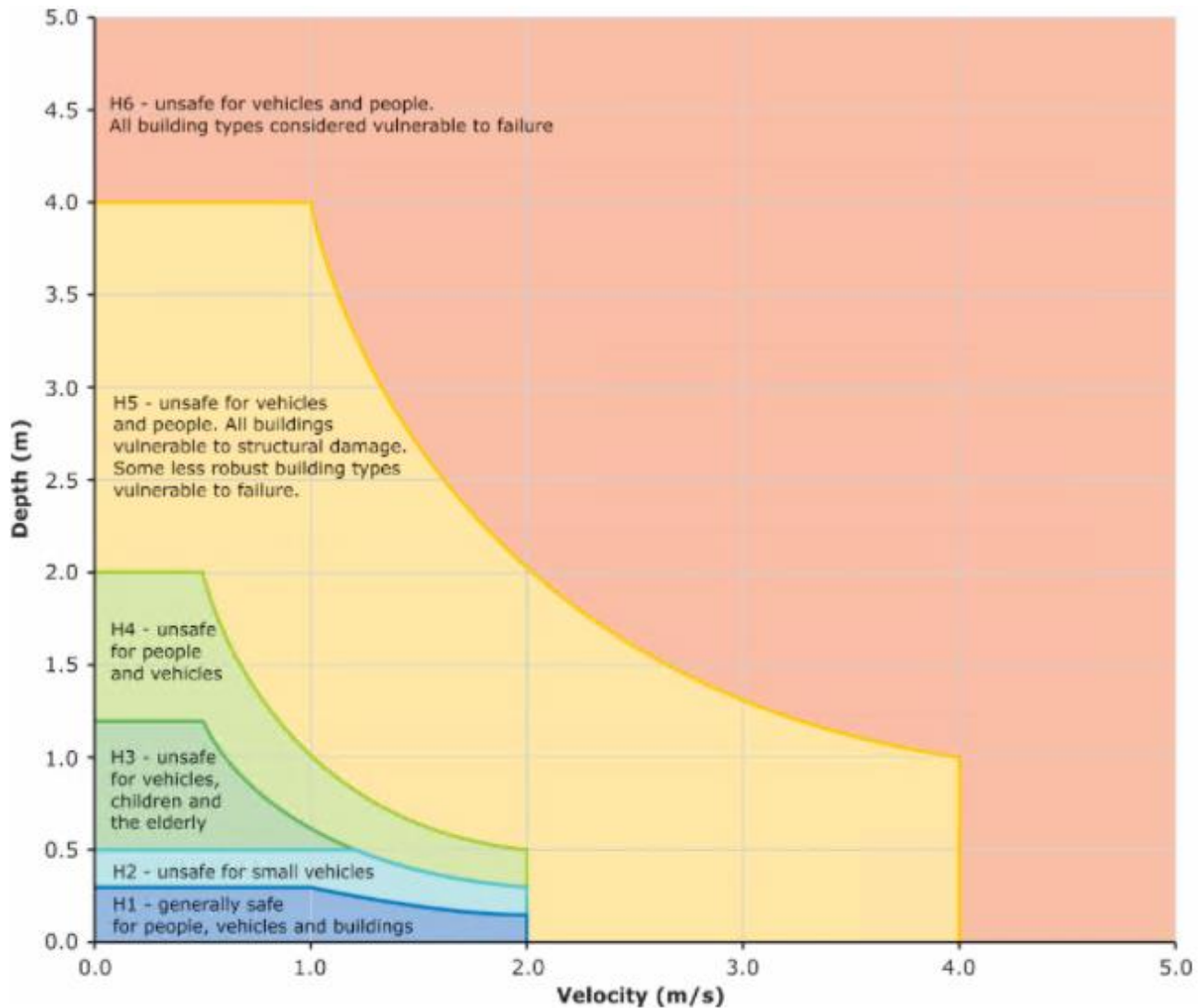


Figure 3-1 AIDR Flood Hazard Categories

Key findings from the existing conditions flood modelling are summarised in the following.

- During the 20% AEP event, Halfway Creek Road is inundated to depths of about 0.7 metres at the low point located to the west of the Halfway Creek bridge crossing. This indicates that the road would be frequently cut by floodwaters.
- Some floodwaters would encroach into the sports hub during a 20% AEP event, although the existing facilities at the site are flood free up to the peak level of the 10% AEP event.
- The two constructed playing fields are inundated in events rarer than the 10% AEP event, but the netball courts and pavilion building remain flood-free in events up to and including the 1 in 500 AEP event.
- The proposed development site for the indoor aquatic centre and carpark is also expected to be flood-free in events up to and including the 1 in 500 AEP event.
- At the peak of the PMF, the entire sports hub is affected by H5 flood hazard, with some areas of H6 flood hazard along the western boundary of the sports hub. The proposed development site for the indoor aquatic centre and carpark is also affected by H5 flood hazard, with flood depths and flow velocities reaching up to 1.9 metres and 1.3 m/s, respectively.

3.2 Predicted Flood Impacts

As discussed in **Section 3.1**, the site of the proposed aquatic centre and carpark is not expected to be inundated in events up to and including the 1 in 500 AEP event. Therefore, construction of the aquatic centre and carpark will not impact on existing flood behaviour in events up to and including the 1 in 500 AEP flood.

The Bungendore FRMS&P Review Project did not assess any events rarer than the 1 in 500 AEP event except the PMF. It is noted that the PMF is not typically generated for the purposes of assessing flood impacts, rather, it is used for assessing risk to life and determining emergency response management options. Notwithstanding, for the purposes of this flood impact assessment, the PMF was checked to estimate the potential impacts of the development on flood behaviour in events rarer than the 1 in 500 AEP event.

To quantify the potential impacts of the proposed development during the PMF, the TUFLOW hydraulic model which was developed for the Bungendore FRMS&P Review project was modified to incorporate the proposed footprint of the aquatic centre. The aquatic centre footprint was "blocked-out" of the model domain, meaning that the flood modelling of post-development conditions conservatively assumes that no flow can pass through the building. It is understood that minimal earthworks are proposed as part of the carpark development and accordingly the model terrain was not adjusted in that area for post-development conditions.

The modified TUFLOW model was then used to simulate the PMF event in order to assess whether the development could impact on peak PMF levels, extents and velocities. Flood level and flow velocity difference mapping was prepared from the modelling results to quantify any off-site impacts that could be caused by the proposed development. Difference maps are created by comparing peak level and velocity estimates from the results of simulations undertaken for both existing and post-development scenarios. This effectively creates a contour map of predicted changes in flood levels and flow velocities (i.e., increases and decreases) and allows visual assessment of the impact of the development on existing flood behaviour.

The difference mapping is presented in **Figure B-21** and **Figure B-22** in **Appendix B**. As shown by the legend, increases in peak flood levels and flow velocities are represented as different shades of yellow and red, while decreases are represented as shades of blue. The white shading indicates changes in peak flood levels and flow velocities that are ± 0.01 metres and ± 0.1 m/s, respectively.

The difference mapping indicates that the construction of the aquatic centre would lead to increases in peak PMF levels of between 0.01 and 0.02 metres along Halfway Creek Road to the east and a localised area of the Bungendore Sewage Treatment Plant to the north-west. A flood level increase of 0.02 metres could be considered as a negligible impact, based on the extremely low probability of the event occurring, the accuracy of the data used to build and calibrate the flood model, and the mathematical approximations made during model simulations. For example, the LiDAR data used to develop the Digital Terrain Model (DTM) for the flood model has a horizontal and vertical spatial accuracy of 0.25 metres and 0.15 metres, respectively.

The construction of the aquatic centre is also predicted to increase peak PMF flow velocities by up to 0.4 m/s in a localised area of undeveloped land between the aquatic centre and the sewage treatment plant. Results for existing conditions indicate flow velocities are up to 0.9 m/s at this location. Accordingly, a change to flow velocities of 0.4 m/s reflects a percentage increase of about 44%. While this percentage increase is high, the impact of the increase in velocity is considered to be minor when accounting for the extreme rarity of the event during which it is predicted to occur.

Overall, the proposed aquatic centre and carpark are not expected to have any material adverse impact on existing flood behaviour. The development is only expected to lead to minor localised increases in peak flood levels and flow velocities during the PMF event. These PMF impacts are considered immaterial given that the entire area is predicted to be inundated by H5-H6 floodwaters during this event under existing conditions.

4. Flood Risk Assessment

As noted previously, the proposed development site of the aquatic centre and carpark remains flood-free in events up to and including the 1 in 500 AEP event. During the PMF event, the entirety of the sports hub as well as the wider floodplains of Halfway Creek and Mill Post Creek are completely inundated. The design flood extents for selected events are shown in **Figure 4-1**.

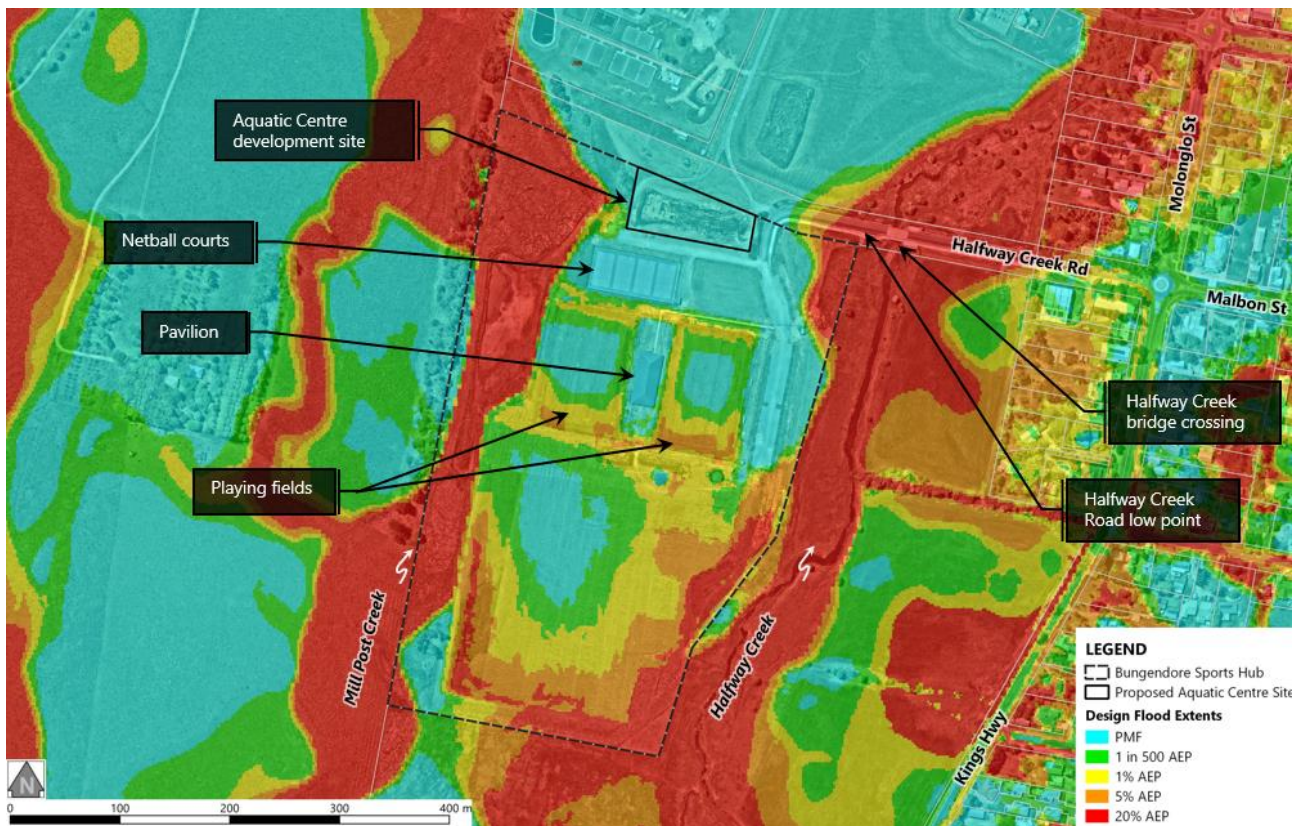


Figure 4-1 Design flood extents at the Bungendore Sports Hub

Given that the aquatic centre is only inundated in events rarer than the 1 in 500 AEP, there is a relatively low risk of floodwaters inundating the facility and placing staff and visitors directly at risk from floodwaters.

However, the roads leading to the sports hub and aquatic centre are expected to be inundated frequently. The analysis in the forthcoming sections indicate that the existing access roads can be inundated in events as frequent as the 1 EY (Exceedance per Year) event.

Accordingly, there is significant risk that visitors and staff at the aquatic centre and sports hub could be trapped at the site once floodwaters inundate the access roads, or otherwise expose themselves to significant risk by entering floodwaters in an attempt to leave the site. Therefore, the risk of isolation is the focus of this flood risk assessment.

Further information on potential evacuation routes, available warning times and duration of isolation are provided in the following sections.

4.1 Existing Evacuation Routes

There are three existing evacuation routes that patrons and staff could use to leave the site of the proposed aquatic centre and travel to safe refuge. These are shown in **Figure 4-2** and **Figure 4-3**.

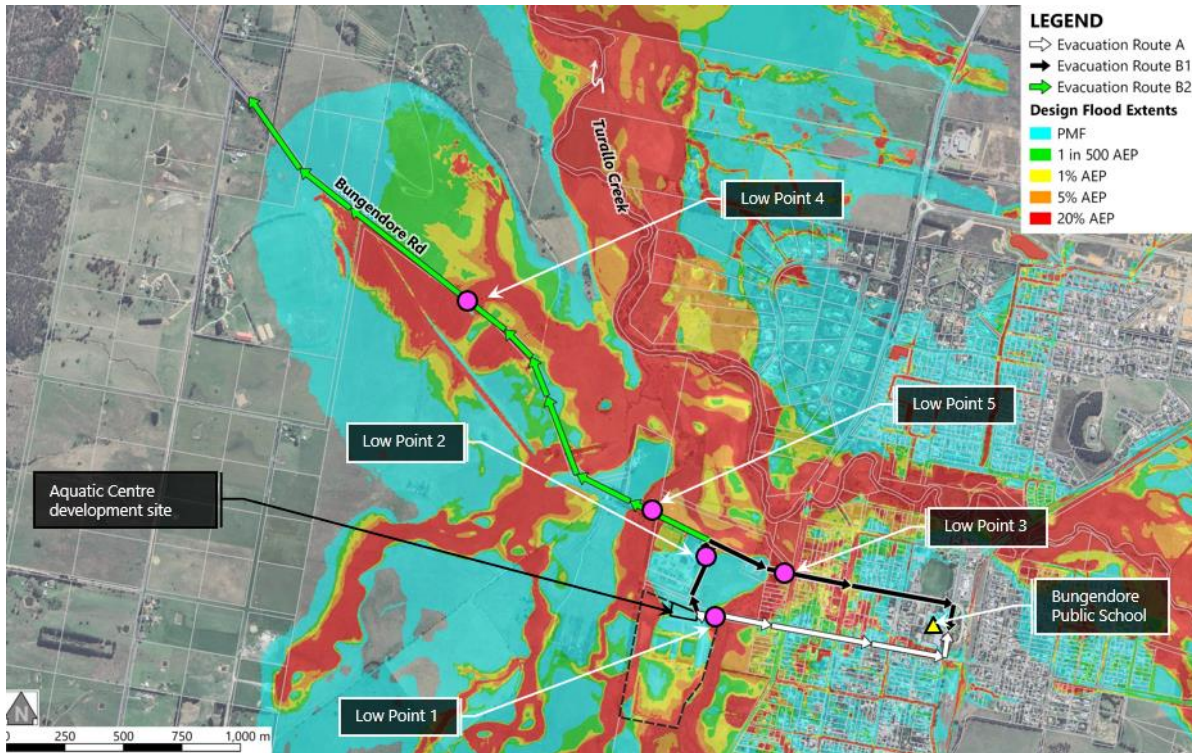


Figure 4-2 Overview of potential evacuation routes and low points (regional)

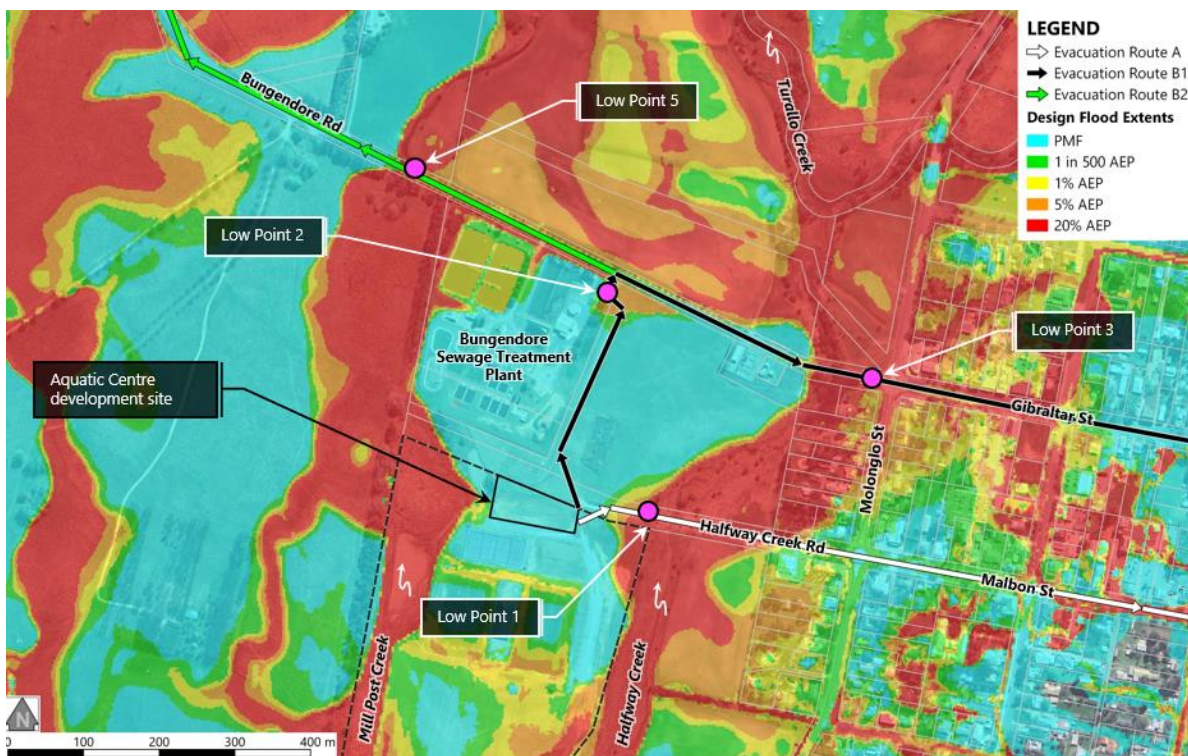


Figure 4-3 Overview of potential evacuation routes and low points (near Bungendore Village)

Descriptions of the potential evacuation routes are provided in the following.

- **Route A:** travelling eastward along Halfway Creek Road, crossing Halfway Creek and continuing onto Malbon Street and into the main urban areas of Bungendore. Bungendore Public School could be used as an evacuation centre as it is flood-free during the PMF. There is a low point along this route on Halfway Creek Road at a point immediately west of the Halfway Creek bridge (Low Point 1).
- **Route B1:** travelling northward past the Bungendore Sewage Treatment Plant (STP), turning east onto Bungendore Road, crossing Halfway Creek and continuing eastward and onto Gibraltar St which provides access to the main urban areas of Bungendore. Bungendore Public School could be used as an evacuation centre as it is flood-free during the PMF. There is a low point along this route on the STP road near the Bungendore Road junction (Low Point 2) as well as the Bungendore Road crossing of Halfway Creek (Low Point 3).
- **Route B2:** travelling northward past the Bungendore Sewage Treatment Plant (STP), turning west onto Bungendore Road and continuing towards Wamboin, the Federal Highway or Canberra. There is a low point along this route on the STP road near the Bungendore Road junction (Low Point 2) as well as two locations along Bungendore Road (Low Points 4 and 5).

Longitudinal sections along the evacuation routes are shown in **Figure 4-4** to **Figure 4-6**. The low points which are expected to be "cut off" first along each of the routes are shown in these longitudinal sections as well as in **Figure 4-2** and **Figure 4-3**.

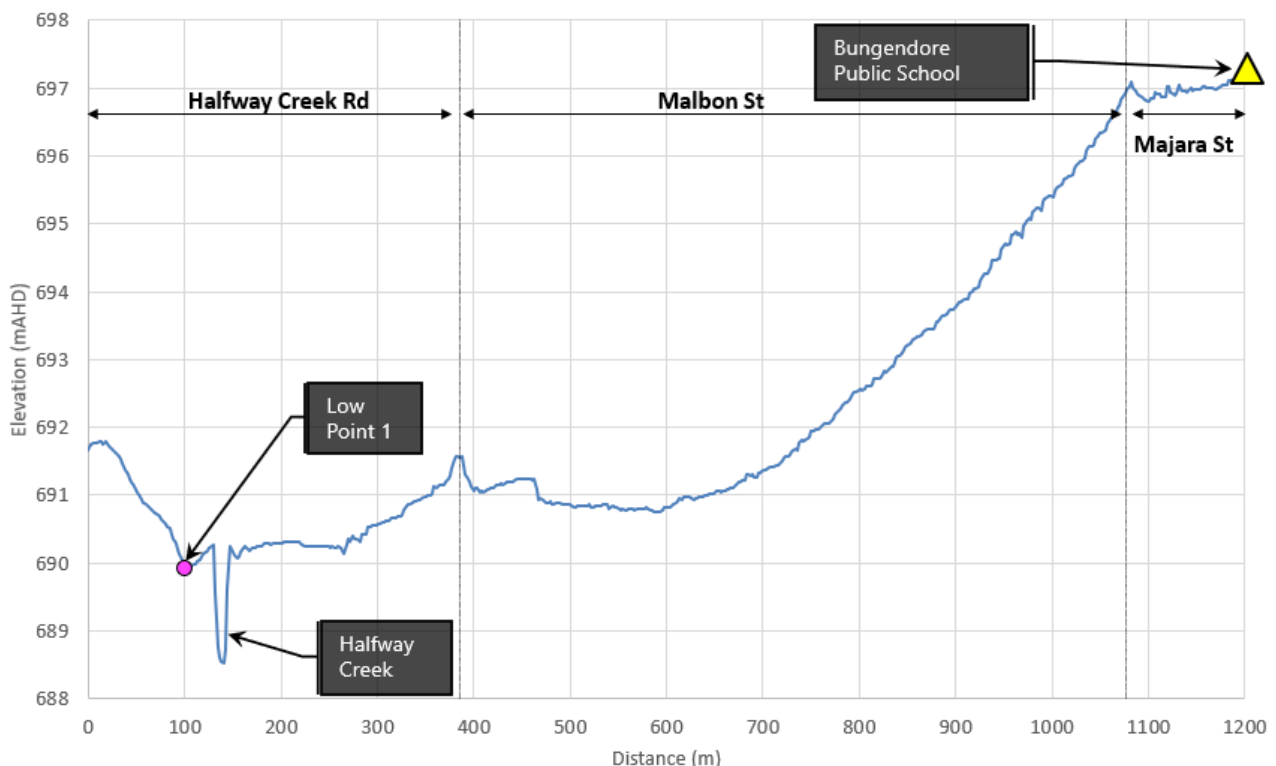


Figure 4-4 Longitudinal section of evacuation route A

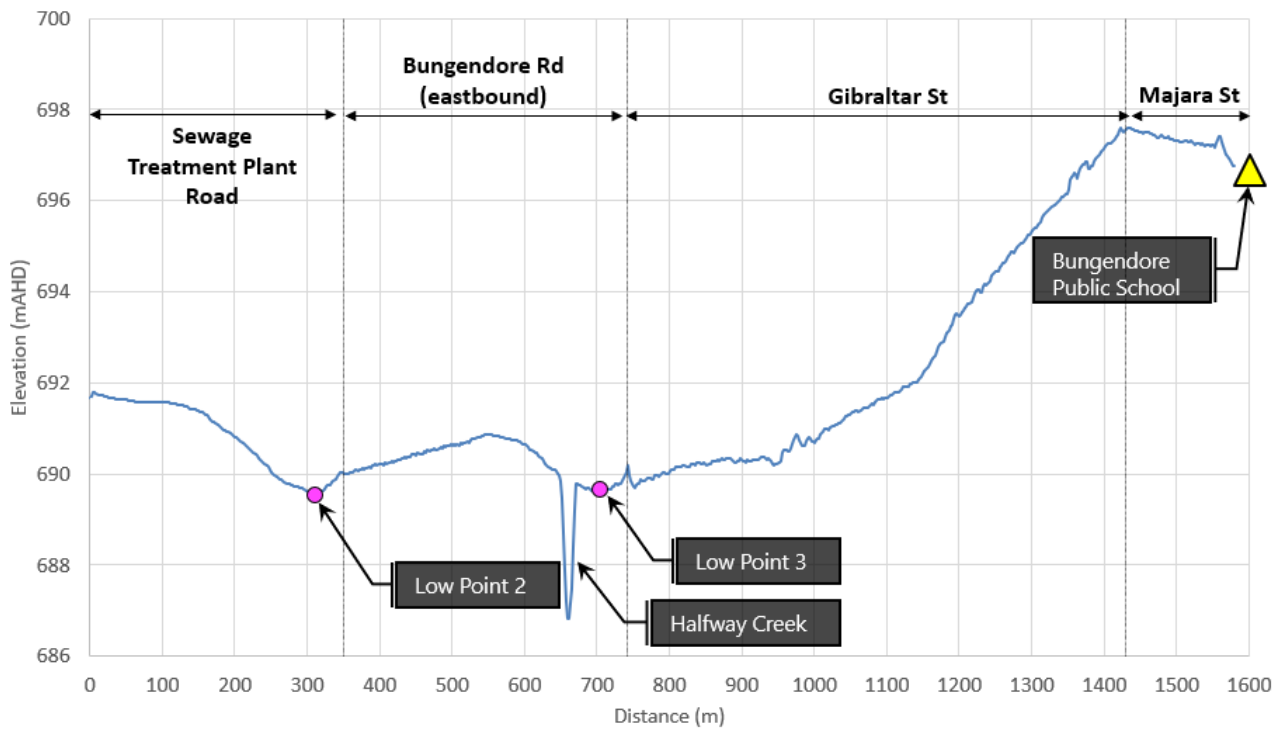


Figure 4-5 Longitudinal section of evacuation route B1

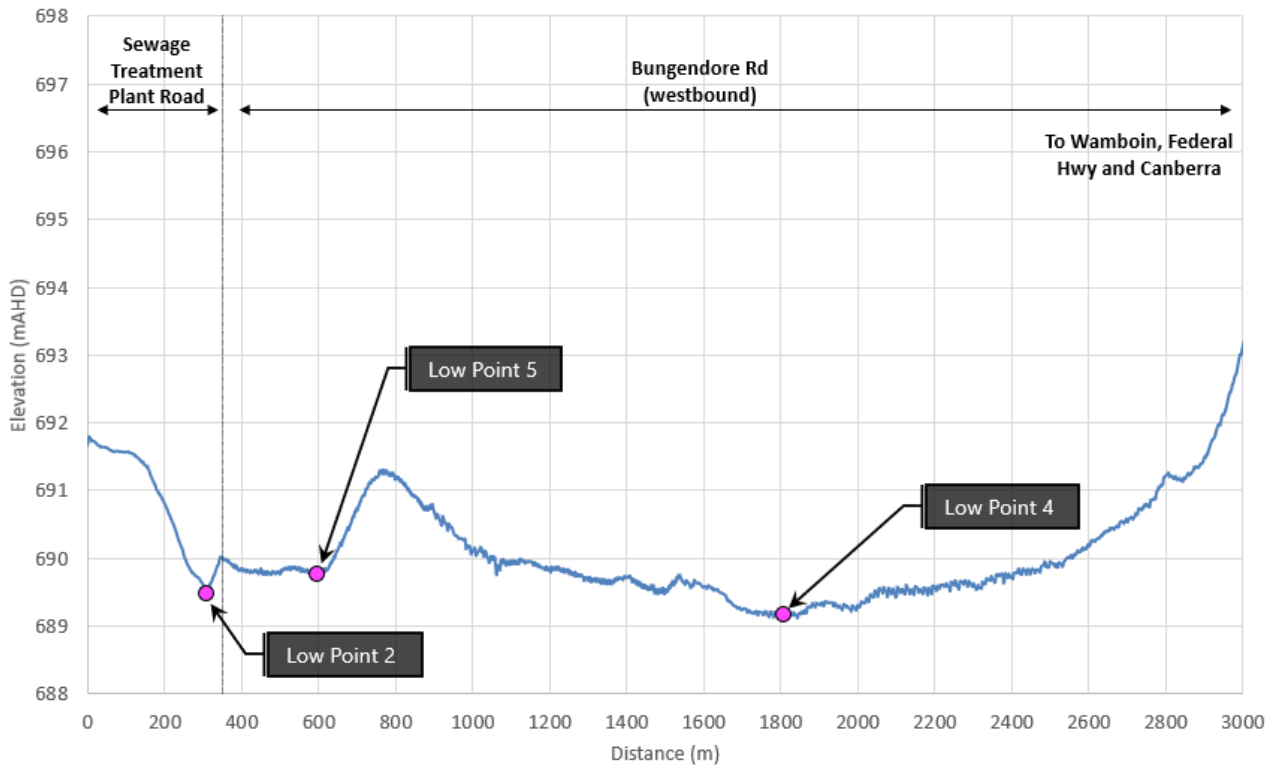


Figure 4-6 Longitudinal section of evacuation route B2

4.2 Time to Inundation and Duration of Inundation

The risk of isolation at the proposed aquatic centre as well as the wider Bungendore Sports Hub was assessed by analysing the predicted rate-of-rise of floodwaters and the duration of inundation for each of the existing evacuation routes described in **Section 4.1**. The depth and hazard of flooding as well as available warning times and duration of inundation for each of the evacuation routes are summarised in **Table 4-1**.

Table 4-1 Summary of inundation of evacuation routes

Design Events		Low Point 1 (Evacuation Route A)	Low Point 2 (Evacuation Route B1 & B2)	Low Point 3 (Evacuation Route B1)	Low Point 4 (Evacuation Route B2)	Low Point 5 (Evacuation Route B2)
20% AEP	Peak Depth	0.69 m	-	0.43 m	0.09 m	-
	Flood Hazard	H3	-	H2	H1	-
	Time to Inundation	3.5 hrs	-	3.5 hrs	2.25 hrs	-
	Duration of inundation	7.0 hrs	-	5.75 hrs	2.0 hrs	-
10% AEP	Peak Depth	0.87 m	0.29 m	0.58 m	0.11 m	0.11 m
	Flood Hazard	H3	H1	H3	H1	H1
	Time to Inundation	3.0 hrs	3.25 hrs	2.25 hrs	1.75 hrs	3.0 hrs
	Duration of inundation	8.0 hrs	12+ hours	7.0 hrs	4.0 hrs	2.0 hrs
5% AEP	Peak Depth	1.00 m	0.38 m	0.70 m	0.11 m	0.18 m
	Flood Hazard	H4	H2	H4	H1	H1
	Time to Inundation	2.75 hrs	3.0 hrs	2.0 hrs	1.75 hrs	2.75 hrs
	Duration of inundation	9.25 hrs	12+ hours	8.50 hrs	5.75 hrs	4.0 hrs
1% AEP	Peak Depth	1.24 m	0.40 m	0.98 m	0.13 m	0.33 m
	Flood Hazard	H4	H2	H5	H1	H2
	Time to Inundation	2.0 hrs	2.25 hrs	1.50 hrs	1.25 hrs	2.0 hrs
	Duration of inundation	13.50 hrs	12+ hours	12.75 hrs	7.5 hrs	5.75 hrs
1 in 500 AEP	Peak Depth	1.53 m	0.63 m	1.28 m	0.26 m	0.51 m
	Flood Hazard	H5	H3	H5	H1	H5
	Time to Inundation	1.75 hrs	2.0 hrs	1.25 hrs	1.0	1.75 hrs
	Duration of inundation	14.5 hrs	12+ hours	14.25 hrs	8.75 hrs	7.25 hrs
PMF	Peak Depth	3.00 m	2.99 m	3.13 m	2.54 m	2.57 m
	Flood Hazard	H5	H5	H5	H5	H6
	Time to Inundation	0.5 hrs	1.0 hrs	0.5 hrs	0.25 hrs	0.75 hrs
	Duration of inundation	9.0 hrs	12+ hours	9.25 hrs	8.0 hrs	6.75 hrs

The time to inundation or overtopping has been determined for these existing evacuation routes based on the elevation of key low points and the rate-of-rise of floodwaters at the site. The time to inundation is calculated from the commencement of the flood producing rainfall event. The time to inundation was estimated based on the short duration storms which were analysed for the Bungendore FRMS&P Review project (refer **Section 3.1**), and which present the worst case scenario given that there is less time for flood emergency response actions to be implemented.

Duration of inundation of the key low points was assessed based on the long duration storms which were analysed for the Bungendore FRMS&P Review project (refer **Section 3.1**), which present an estimate of the upper range of time for which evacuation routes could be cut.

A discussion of the implications for each potential evacuation route is provided in the following.

- General
 - The analysis presented in **Table 4-1** is based on the critical storm durations determined as part of the Bungendore FRMS&P Review project.
 - Duration of inundation and time to inundation were estimated assuming that the existing evacuation routes are cut once the depth of flooding exceeds 50 mm. The estimates for duration of inundation and time to inundation are rounded to the nearest 15 minutes.
- Evacuation Route A
 - The low point along this evacuation route (Low Point 1) is flooded during the 20% AEP event. The depth of flooding reaches up to 0.69 metres in the 20% AEP event, with a flood hazard category of H3 (unsafe for all vehicles, children and the elderly).
 - The time to inundation is fast, with the road inundated within 3½ hours from the onset of rainfall during the 20% AEP event. The time to inundation decreases with increasing flood magnitude, with overtopping of Low Point 1 predicted within 2 hours and 0.5 hours in the 1% AEP event and the PMF, respectively.
 - The road is cut off for significant durations in all design events tested. It is possible for the road to be inundated for 13½ hours during the 1% AEP event and 14½ hours during the 1 in 500 AEP event.
- Evacuation Route B1
 - The low point along the STP road (Low Point 2) is inundated in events equal to or rarer than the 10% AEP event. The low point is affected by ponded water which drains away slowly after a flood event. The water is expected to pond in this low point for more than 12 hours.
 - The flood hazard category at Low Point 2 remains at H1 in events up to and including the 10% AEP event. The hazard increases to H2 during the 5% and 1% AEP events.
 - The second low point along this evacuation route near the Bungendore Road crossing of Halfway Creek (Low Point 3) is flooded during the 20% AEP event. The depth of flooding reaches up to 0.43 metres in the 20% AEP event, with a flood hazard category of H2 (unsafe for small vehicles).
 - The time to inundation is fast, with Low Point 3 inundated within 3½ hours from the onset of rainfall during the 20% AEP event. The time to inundation decreases with increasing flood magnitude, with overtopping of Low Point 3 predicted within 1½ hours and 0.5 hours in the 1% AEP event and the PMF, respectively.
 - Low Point 3 is cut off for significant durations in all design events that were tested. The road is inundated for 12.75 hours during the 1% AEP event and 14.25 hours during the 1 in 500 AEP event.

Evacuation Route B2

- This evacuation route also requires vehicles to travel northward along the STP road towards Bungendore Road. It is also inundated when Low Point 2 is overtopped (refer to discussion above).

- There are two low points along Bungendore Road. Low Point 4 is located about 1½ kilometres west of the STP road, while Low Point 5 is located about 250 metres west of the STP road. Low Point 4 is affected by an overland flow path which spills over Bungendore Road, while Low Point 5 is affected by floodwaters from Mill Post Creek which overtop Bungendore Road.
 - Low Point 4 is affected by relatively shallow flooding that is less than 0.3 metres deep in events up to and including the 1 in 500 AEP event, although it is inundated as frequently as the 20% AEP event. Flood hazard at this location remains at H1 (generally safe) in events up to and including the 1 in 500 AEP event.
 - Low Point 5 is affected by relatively benign flooding up to the 5% AEP event. However, the depth of flooding increases to 0.33 metres and 0.51 metres during the 1% AEP event and the 1 in 500 AEP event, respectively. During these two events, the flood hazard category rises to H2 (unsafe for small vehicles) and H5 (unsafe for vehicles and people).
 - Similar to the other two evacuation routes, the time to inundation is fast. Low Point 4 is inundated within 2.25 hours from the onset of rainfall during the 20% AEP event. The time to inundation decreases with increasing flood magnitude, with overtopping of Low Point 4 predicted within 1.25 hours and 0.25 hours in the 1% AEP event and the PMF, respectively.
 - Low Points 4 and 5 are cut off for shorter durations than the other two evacuation routes, although the duration of inundation is not insignificant. The road is inundated for 7½ hours during the 1% AEP event and 8.75 hours during the 1 in 500 AEP event.
 - This evacuation route is not recommended for the following reasons:
 - It is a significant distance to travel back to Bungendore on a westbound route along Bungendore Road. Motorists would be required to travel back to Bungendore via Norton Road, Sutton Road and Yass Road, before turning east on Kings Highway and following this road back to Bungendore, comprising a total distance of about 57 kilometres.
 - Such a lengthy evacuation route would be undesirable for most visitors to the aquatic centre and Sports Hub, as it is likely that a significant proportion of these visitors would reside in Bungendore. This could promote risky behaviour during a flood event, whereby visitors would be more inclined to take a risk by trying to travel east with a view to getting more directly to Bungendore Village but in so doing entering floodwaters.
 - This evacuation route includes the Yass Road crossing of the Molonglo River. The *Queanbeyan Floodplain Risk Management Study and Plan* (Lyal & Associates, 2019) indicates that this crossing is inundated in events rarer than the 5% AEP event. The evacuation route also requires motorists to travel northward along the Kings Highway immediately south of Bungendore. Flood modelling from the Bungendore FRMS&P Review Project indicates that floodwaters from Halfway Creek overtop this section of the highway to shallow depths during the 10% and 5% AEP events. Notwithstanding, Evacuation Route B2 cannot be considered a reliable evacuation route given that there are several other watercourse crossings which have not been assessed.
- Shelter-in-Place (SIP)
- In 2024, the NSW Government released a guideline titled '*Shelter in place guideline for flash flooding*' (NSW DPHI, 2024) (**the SIP Guideline**) which aims to assist consent authorities with site specific risk-based assessments to determine if shelter in place is a suitable emergency management strategy for development proposed in flash flood environments.
 - One of the criteria specified in the guideline is that SIP is not supported at sites where isolation durations are greater than 12 hours. Accordingly, the long duration of inundation (> 12 hours) of Evacuation Route A and B1 would preclude the adoption of Shelter in Place (SIP) as a primary

emergency response strategy for the aquatic centre and the Sports Hub if the SIP Guideline is strictly enforced.

- The aquatic centre building would be subject to H5 hazard during the PMF. The SIP Guideline recommends that SIP should not be implemented for developments which are subject to high hazard flooding (H5 to H6).

4.3 Flood Immunity of Existing Evacuation Routes

As noted in **Section 4.2**, the two remaining potential evacuation routes (Route A and Route B1) are flood prone and could be inundated to depths of up to 0.7 metres and 0.4 metres respectively during the 20% AEP event.

The 20% AEP event is the most frequent event which was analysed as part of the Bungendore FRMS&P Review project. To provide a better understanding of the flood immunity of the available evacuation routes, an assessment of more frequent flood events along Halfway Creek was undertaken. This comprised analysis of the 50% AEP event as well as the 1, 2 and 3 Exceedances per Year (EY) events.

Design rainfall depths for the 50% AEP, 1 EY, 2 EY and 3 EY events were obtained from the Bureau of Meteorology (BoM) online Intensity-Frequency-Duration (IFD) data tool. The design rainfall depths for a range of storm durations for these four design events are presented in **Appendix C**.

The WBNM model which was developed for the Bungendore FRMS&P Review project was used to simulate a range of durations for the 50% AEP, 1 EY, 2 EY and 3 EY events to estimate the storm event and duration at which the two available evacuation routes remain flood free.

Analysis of time-series information which was available from the existing flood modelling results of the Bungendore FRMS&P Review project indicates that the low points along Evacuation Route A and Evacuation Route B1 (Low Point 1 and Low Point 3, respectively) are inundated when flows along Halfway Creek reach 22 m³/s and 29 m³/s, respectively. It is noted that Low Point 2 (adjacent to the sewage treatment plant) is only inundated in events rarer than the 20% AEP event.

The flood immunity of Evacuation Route A and Evacuation Route B1 for a range of storm durations for the 50% AEP, 1 EY, 2 EY and 3 EY events are presented in **Table 4-2**. Based on the information presented in **Table 4-2**, there is flood free access to the sports hub in events up to and including the 2 EY event. Access remains available during short duration 1 EY and 50% AEP events.

Table 4-2 Summary of Halfway Creek peak flow rates and inundation of evacuation routes

Duration	Peak Flow Rate along Halfway Creek (m ³ /s)				
	3EY	2EY	1EY	50% AEP	20% AEP
1 hr	0.8 Route A OPEN Route B1 OPEN	3.4 Route A OPEN Route B1 OPEN	11.1 Route A OPEN Route B1 OPEN	16.1 Route A OPEN Route B1 OPEN	33.9 Route A CLOSED Route B1 CLOSED
1.5 hrs	3.2 Route A OPEN Route B1 OPEN	7.5 Route A OPEN Route B1 OPEN	17.2 Route A OPEN Route B1 OPEN	23.6 Route A CLOSED Route B1 OPEN	44.4 Route A CLOSED Route B1 CLOSED
2 hrs	5.5 Route A OPEN Route B1 OPEN	10.5 Route A OPEN Route B1 OPEN	21.9 Route A OPEN Route B1 OPEN	29.2 Route A CLOSED Route B1 CLOSED	51.8 Route A CLOSED Route B1 CLOSED

Duration	Peak Flow Rate along Halfway Creek (m ³ /s)				
	3EY	2EY	1EY	50% AEP	20% AEP
3 hrs	9.1 Route A OPEN Route B1 OPEN	14.9 Route A OPEN Route B1 OPEN	28.9 Route A CLOSED Route B1 OPEN	36.0 Route A CLOSED Route B1 CLOSED	61.0 Route A CLOSED Route B1 CLOSED
4.5 hrs	12.4 Route A OPEN Route B1 OPEN	19.0 Route A OPEN Route B1 OPEN	32.0 Route A CLOSED Route B1 CLOSED	39.5 Route A CLOSED Route B1 CLOSED	64.0 Route A CLOSED Route B1 CLOSED
6 hrs	12.2 Route A OPEN Route B1 OPEN	19.6 Route A OPEN Route B1 OPEN	32.0 Route A CLOSED Route B1 CLOSED	39.6 Route A CLOSED Route B1 CLOSED	63.9 Route A CLOSED Route B1 CLOSED
9 hrs	12.8 Route A OPEN Route B1 OPEN	19.2 Route A OPEN Route B1 OPEN	32.9 Route A CLOSED Route B1 CLOSED	38.8 Route A CLOSED Route B1 CLOSED	59.0 Route A CLOSED Route B1 CLOSED
12 hrs	14.2 Route A OPEN Route B1 OPEN	20.9 Route A OPEN Route B1 OPEN	32.0 Route A CLOSED Route B1 CLOSED	38.2 Route A CLOSED Route B1 CLOSED	60.0 Route A CLOSED Route B1 CLOSED
18 hrs	12.3 Route A OPEN Route B1 OPEN	18.9 Route A OPEN Route B1 OPEN	26.8 Route A CLOSED Route B1 CLOSED	32.2 Route A CLOSED Route B1 CLOSED	51.7 Route A CLOSED Route B1 CLOSED
24 hrs	12.2 Route A OPEN Route B1 OPEN	17.0 Route A OPEN Route B1 OPEN	26.9 Route A CLOSED Route B1 CLOSED	34.1 Route A CLOSED Route B1 CLOSED	60.8 Route A CLOSED Route B1 CLOSED

The analysis for Evacuation Route A and Evacuation Route B1 indicates that these two potential evacuation routes have a low flood immunity and could be inundated in events as frequent as the 1 EY event. Additionally, there is insufficient warning time for visitors and staff at the aquatic centre and sports hub to evacuate in a timely manner, with these routes predicted to be inundated within two hours from the commencement of rainfall.

Therefore, Evacuation Route A and Evacuation Route B1 cannot be considered as reliable evacuation routes for the sports hub.

4.4 Sports Hub Closure

4.4.1 Possible Closure Criteria

The analysis presented in **Section 4.2** indicates that there is a significant risk that patrons attending the proposed aquatic centre site and the wider sports hub facility could be isolated in the occurrence of flash flooding of Mill Post and Halfway Creeks. The analysis also indicates that access to the sports hub can be cut with minimal warning time. For example, the available evacuation routes are inundated within 2 hours from the onset of rainfall during the 1% AEP storm.

Furthermore, there are no rainfall gauges or water level gauges located in the Halfway and Mill Post Creek catchments. Accordingly, any proposal to implement evacuation of the sports hub and aquatic centre cannot rely on warning times based on gauge levels.

In order to minimise the risk of isolation at the sports hub and inundation during the PMF, and in lieu of reliable evacuation triggers based on stream gauge measurements, a potential risk mitigation measure could

be to adopt a protocol whereby the sports hub is forcibly closed prior to the onset of major rainfall events. The trigger for closure could be based on a specified forecast rainfall depth.

An example is that the sports hub should be closed when either of the following criteria is met:

- more than 25 mm of rain is forecast over a 3-hour period; or,
- more than 40 mm of rain is forecast over a 24-hour period.

These rainfall depth thresholds correspond to the 3-hour 1 EY event and the 24-hour 2 EY event, respectively, which are the events that would leave at least one of the available evacuation routes accessible; that is, not overtopped (refer **Table 4-2**).

In order for this approach to be implemented, it would be necessary for a flood warden to be appointed by Council for the sports hub. The flood warden would be responsible for monitoring rainfall forecasts and closing the facilities when the specified thresholds are expected to be met. The facilities should ideally be closed at the start of the day prior to opening hours, as it would be difficult to reliably evacuate the site during the course of the day due to the short catchment response time.

The flood warden would also be required to monitor weather conditions on days when the sports hub is being used. The flood warden would be responsible for initiating evacuation should there be sudden changes in the weather that had not been forecast prior to the centre opening.

Rainfall forecasts would need to be monitored via the Bureau of Meteorology website (<http://www.bom.gov.au/places/nsw/bungendore/>). The site provides rainfall forecasts for a seven-day period, including possible rainfall over three-hour periods. An example is shown in **Figure 4-7**.

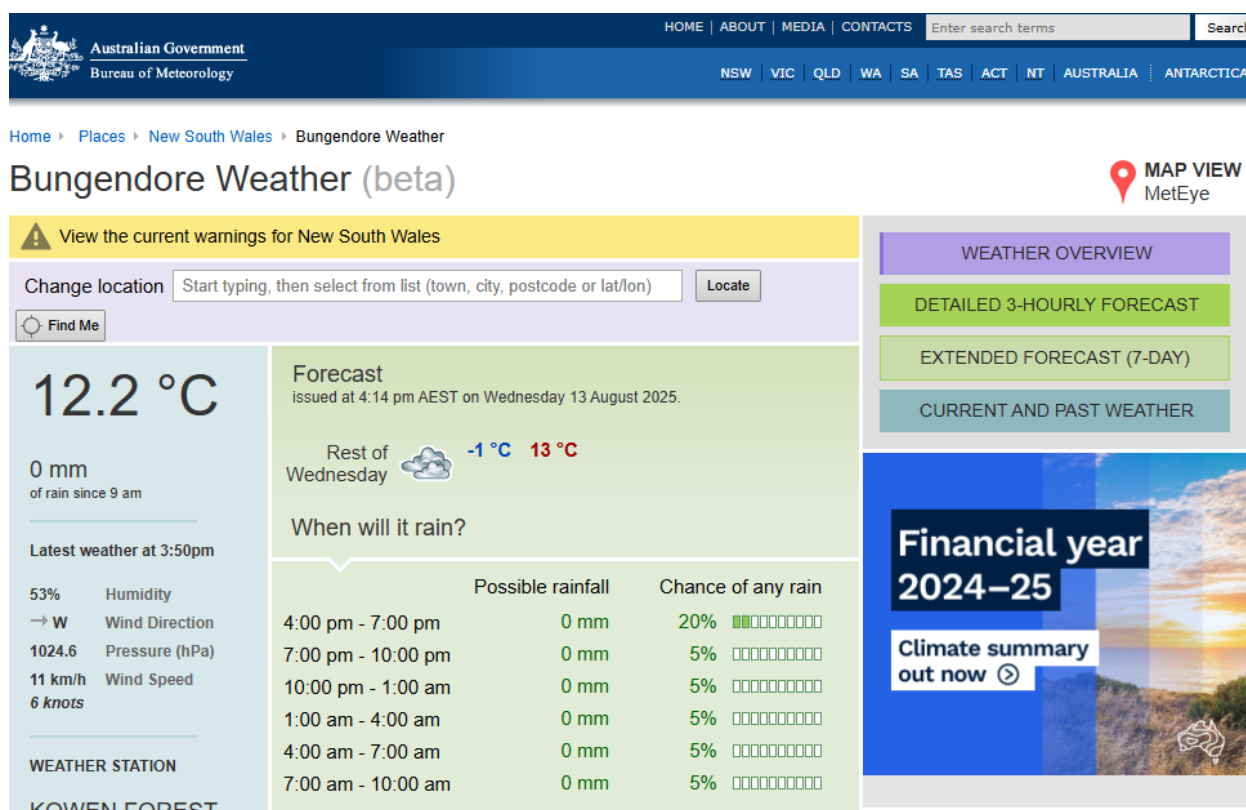


Figure 4-7 Example of rainfall forecast for Bungendore (source: Bureau of Meteorology)

4.4.2 Potential Shortcomings of Closure

Adoption of the closure criteria specified in **Section 4.4.1** could reduce the risk of isolation at the sports hub and aquatic centre. However, there are limitations to this approach. These limitations are listed in the following.

- The rainfall forecast may not be completely reliable. While unlikely, it is possible for rainfall to be forecast with short warning (e.g., local thunderstorms) where previously the forecast had indicated dry weather. Therefore, the flood warden will be required to regularly monitor weather forecast on days where the facilities are open, and to initiate evacuation if the rainfall forecast thresholds are met. This would place a high level of responsibility and require continuous monitoring by the flood warden which could increase the risk of human error (refer below).
- On the other hand, there may be numerous occasions where the actual rainfall is less than the forecast rainfall, leading to instances where the facilities are closed while the access roads remain flood free. This may lead to disgruntled community members, particularly businesses which operate at the aquatic centre. Additionally, repeated false alarms could eventually result in complacency within the community and compromise the capacity of the flood warden to act according to the recommended and adopted procedures.
- The element of human error should also be considered. This could comprise inaccurate interpretations of the forecast by the flood warden, or failure of the flood warden to initiate closure or evacuation because of illness or other unavailability.

On this basis, it is difficult to support advance closure of the facilities by a dedicated flood warden as a viable emergency response management measure for the proposed aquatic centre development. This conclusion also takes into consideration the very short warning times available which would place further burden on those in a decision making position which could further increase the potential for human error.

Notwithstanding, closure of the sports hub by a dedicated flood warden would be beneficial in reducing the flood risk at the site to existing users of the facilities, who are affected by the risk of isolation once Bungendore Road and Halfway Creek Road are cut off by floodwaters.

4.5 Other Mitigation Measures

Alternative measures which could be implemented to reduce the significant flood risk at the site are described below. These measures may also be beneficial for users of the existing sports hub facilities and workers at the sewage treatment plant.

4.5.1 Construction of Alternative Evacuation Route

Construction of an alternative evacuation route with a greater flood immunity would reduce the flood risk at the site. One potential option could be to construct a new evacuation route to the south of Halfway Creek Road which connects to the Kings Highway. It may be possible to construct this new route without adverse flood impacts at nearby properties, given that these properties would be downstream of the creek crossing. A potential alignment for the new evacuation route is shown in **Figure 4-8**.

This new evacuation route would require the construction of a second bridge crossing of Halfway Creek to an area of high ground to the east of Halfway Creek. The potential alignment passes through some areas of shallow inundation in the 1% AEP event before connecting to Kings Highway (refer **Figure 4-8**).

The proposed alignment shown in **Figure 4-8**, inclusive of an appropriately designed bridge crossing, could provide an evacuation route which is flood free in events up to and including the 1% AEP event. The flood hydraulics predicted for existing conditions indicates that this route, including the new bridge, is unlikely to

cause adverse flood impacts. Notwithstanding, it will be necessary for this to be confirmed by flood modelling if this option is or were to be pursued.

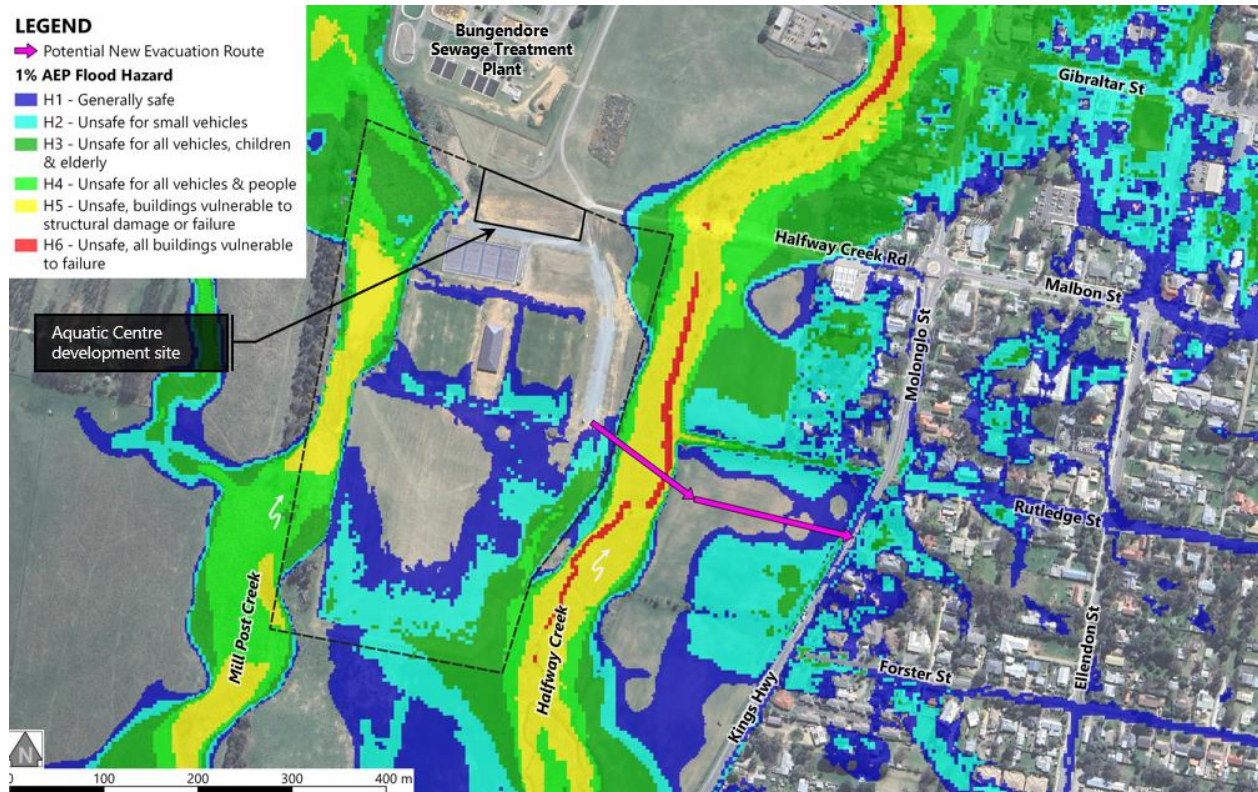


Figure 4-8 Alignment of potential new evacuation route

4.5.2 First Floor Refuge in the Aquatic Centre

Inclusion of a first-floor refuge in the aquatic centre as a failsafe measure would also reduce the existing flood risk at the site. Visitors and staff could Shelter-in-Place on the first floor of the aquatic centre in the event that advance closure of the facility does not occur or safe evacuation cannot be effected.

Shelter-in-Place is not recommended as the primary flood risk mitigation strategy at this site given the predicted duration of isolation in most events where evacuation routes are cut by floodwaters.

It is noted that peak PMF depths at the aquatic centre are less than 2 metres and accordingly floodwaters would not reach the first floor. However, if this flood emergency response measure is to be pursued, then the aquatic centre will need to be designed to withstand the forces associated with flooding and debris impact loading during a PMF.

4.5.3 Construction of a Refuge at the Sewage Treatment Plant

An alternative location for a refuge above the peak PMF level could be at the Bungendore Sewage Treatment Plant (STP), which is located immediately north of the proposed aquatic centre site. There is open space with an area greater than 1000 m² at the southern end of the STP which is only affected by H3 flood hazards at the peak of the PMF, with peak PMF depths expected to be about 0.8 metres. This space is about 100 metres north of the proposed aquatic centre site.

As per the previous mitigation measure, this alternative mitigation measure could only be adopted as a failsafe measure for visitors and staff as it would invoke a Shelter-in-Place approach that is not consistent with criteria specified in the SIP Guideline. As noted previously, inundation of the three potential evacuation routes early in most floods would result in the site being isolated for longer than the 12 hour maximum

duration of isolation period specified in the SIP Guideline. In addition, it is questionable whether a dedicated flood warden would have the necessary gravitas and authority to keep people from trying to evacuate the site by travelling through floodwaters.

4.5.4 Evacuation Centre at Bungendore Showground

As noted previously, the existing potential evacuation routes (evacuation route A and B1) to the possible evacuation centre at Bungendore Public School are inundated during flood events as frequent as the 1EY event. Accordingly, in its existing condition, these routes cannot be considered as reliable evacuation routes.

Access to an alternative evacuation centre along an evacuation route with a higher flood immunity would reduce the substantial existing flood risk at the sports hub as well as the sewage treatment plant.

Bungendore Showground is located about 3 kilometres west of the sports hub and can be accessed by travelling in a westerly direction along Bungendore Road before turning south onto Matthews Lane. Flood modelling from the Bungendore FRMS&P Review Project indicates that the western portion of the showground is flood-free in events up to and including the PMF. An overview of the design flood extents and the route from the sports hub to the showground is shown in **Figure 4-9**.

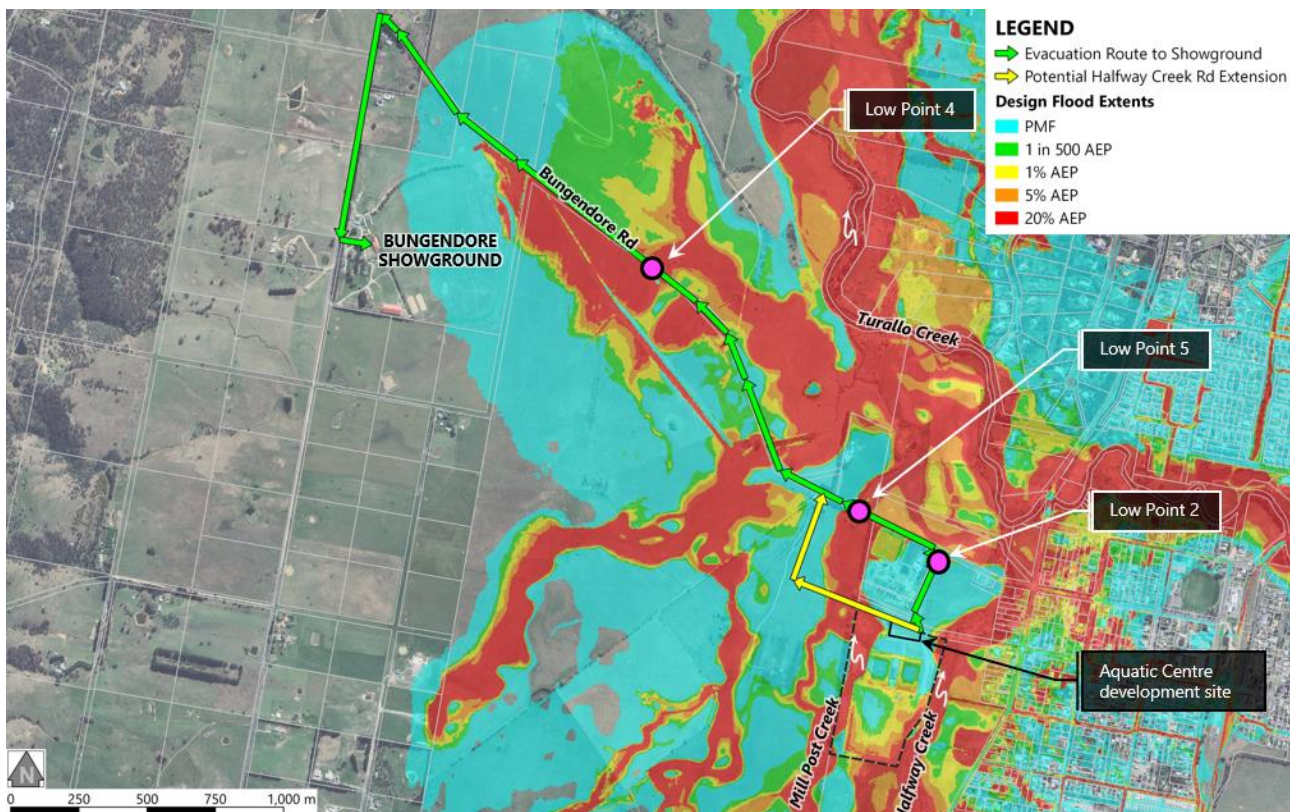


Figure 4-9 Overview of evacuation route to Bungendore Showground

Access to a potential evacuation centre at the showground would require motorists to pass through Low Points 2, 4 and 5 (refer route denoted by the green arrows in **Figure 4-9**). The flood immunity, flood hazard, time to and duration of inundation of these low points are summarised in **Table 4-1**. QPRC has indicated that it would be relatively easy to remove Low Point 2 by realigning the sewage treatment plant access track. Assuming that this can be done as part of the evacuation centre setup, the evacuation route to the showground would be trafficable in events up to and including the 5% AEP event.

QPRC has also indicated that Halfway Creek Road may be extended to connect with Bungendore Road to the west of Mill Post Creek as part of the future Bungendore Bypass works. The potential extension of Halfway

Creek Road is shown by the yellow arrows in **Figure 4-9**. This alternative route would bypass Low Points 2 and 5.

Assuming that the Halfway Creek Road extension can be constructed to provide a 1% AEP event level of flood immunity, then access to the showground would remain trafficable in events up to and including the 1% AEP event. Should this potential future alternative route be adopted, clear signage should be installed around the sports hub and sewage treatment plant to direct people along this route during a flood emergency. This could also be supplemented by flood awareness education programs for these facilities.

Access to a nearby evacuation centre along a route which remains trafficable in events up to and including the 5% AEP event or the 1% AEP event would be a considerable upgrade on the existing evacuation options which are available to users of the existing sports hub facilities as well as workers at the sewage treatment plant.

However, it is noted that any potential evacuation route to the showground can be cut off with minimal warning time due to the rapid catchment response times. Accordingly, any evacuation to the showground would also be reliant on evacuation triggers which are based on forecast rainfall depths. As discussed in **Section 4.4.2**, there are several shortcomings with a flood emergency response management approach that relies on evacuation based on forecast rainfall depths.

Therefore, these new potential evacuation routes to the showground are considered to have limited reliability, even if a 1% AEP flood immunity is achieved.

4.5.5 Halfway Creek Diversion Channel

The *Bungendore Floodplain Risk Management Study* (WorleyParsons, 2014) investigated the construction of a diversion channel in an area upstream of the sports hub, which would serve to divert a portion of the floodwaters along Halfway Creek into Mill Post Creek. Modelling of the diversion channel option completed as part of the 2014 FRMS indicates that its implementation would decrease flood levels along Halfway Creek by up to 0.4 metres. The layout and expected benefits of this mitigation measure have been extracted from Figure 25 of the 2014 FRMS and is reproduced in **Figure 4-10**.

However, at the time of the previous study, this mitigation measure was not recommended for implementation due to its low economic viability. It was not recommended as the expected reduction in flood damages is less than the cost associated with implementing the mitigation measure. This mitigation measure was also expected to lead to flood level increases along Mill Post Creek, which would affect the private property located on the western floodplain of Mill Post Creek (refer **Figure 4-10**).

Notwithstanding, this mitigation measure could be reconsidered and re-evaluated as part of future floodplain management activities at Bungendore due to its likely benefits in improving the flood immunity of the existing access routes to the sports hub, as well as the reduction in peak flood levels in the vicinity of Bungendore Village.

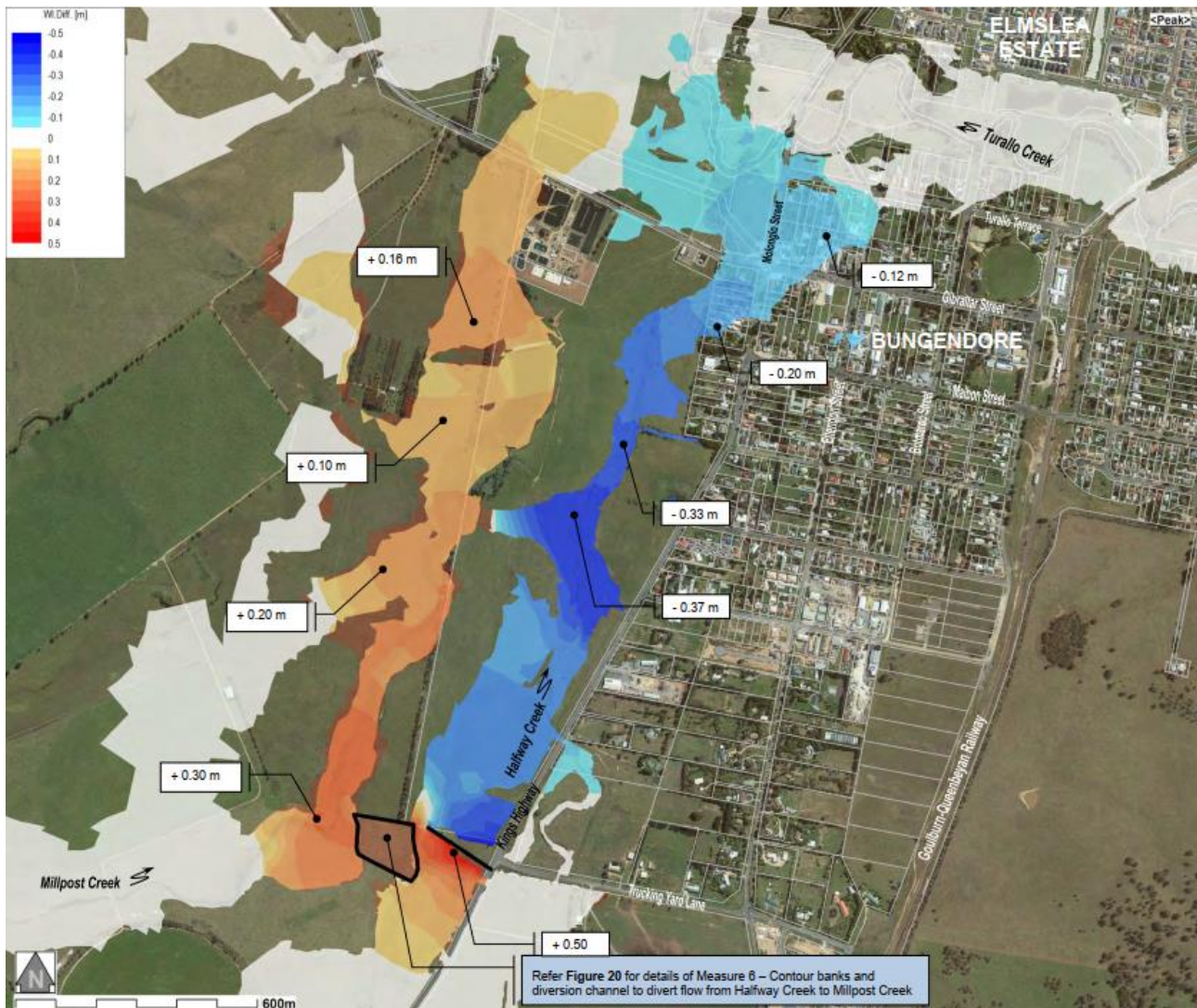


Figure 4-10 Layout and expected flood level impacts of the Halfway Creek diversion channel
source: *Bungendore Floodplain Risk Management Study (WorleyParsons, 2014)*

4.5.6 Installation of Automated Flood Warning System

An automated flood warning system could be installed at the site if new rainfall and water level gauges are located in the catchments of Halfway and Mill Post Creeks. QPRC indicated that new gauges are already being considered for installation in the vicinity of Bungendore as part of separate floodplain risk management activities.

An automated flood warning system would issue automated alerts based on live gauge measurements. Another key benefit of an automated flood warning system is the ability of the system to provide constant monitoring of weather conditions, which would be more reliable in issuing warnings when compared to dependence on a flood warden to undertake manual checks of the weather at regular intervals.

However, as discussed in **Section 4.2**, flooding along Halfway Creek is characterised by rapid catchment response times. The existing available evacuation routes from the sports hub could be cut off within 2 hours from the commencement of rainfall during the 1% AEP event. Therefore, despite the benefit that might be afforded by an automated flood warning system, the flood risk at the site would still be significant due to the rapid catchment response time and the associated limited flood warning time.

4.6 Consideration of Vulnerable Visitors

It is possible that the aquatic centre development would introduce a significant additional number of visitors to the sports hub. This would include vulnerable members of the community; for example, young children attending swimming classes or school swimming carnivals and elderly citizens attending aqua aerobics sessions.

Children and the elderly may require additional assistance if required to evacuate at short notice. These visitors may not be able to drive and would require transport away from the sports hub. Efficient and safe evacuation of these members of the community could be difficult during short duration rare flood events, where the available warning time is minimal. For example, the available evacuation routes are inundated within 2 hours from the onset of rainfall during the 1% AEP event (refer **Table 4-1**). Therefore, if rainfall of this severity occurred it would not be possible to realistically identify the risk, implement an evacuation order, extract the children, load them onto buses and take them to high ground, in the available time.

4.7 SES Flood Emergency Response Preferences

The NSW State Emergency Services (NSW SES) typically prefers the adoption of an evacuation strategy as the primary emergency response option during a flood emergency where the subject site could be inundated by floodwaters.

However, it is understood that the NSW SES may not support the adoption of evacuation to a dedicated evacuation centre as the preferred strategy. Worley Consulting understands that the NSW SES advocates for evacuees to travel to the residence of family and friends who live outside the floodplain as the preferred response strategy during a flood emergency.

It is possible that visitors or staff at the sports hub could reside in areas to the north of Turallo Creek (referred to as Bungendore North), given that there are a substantial number of residential lots in this area. Accordingly, in order to travel home from the sports hub, these residents would be required to cross Halfway Creek as well as Turallo Creek.

Flooding of Turallo Creek is analysed in the Bungendore FRMS&P Review project (Worley Consulting, in draft 2025). The analysis indicates that the creek crossings are also flood prone and are expected to be cut off in events as frequent as the 20% AEP event. Therefore, people who are required to travel from the sports hub to Bungendore North could be isolated both by flooding of Halfway Creek as well as Turallo Creek.

Anecdotal reports from QPRC staff as well as community responses gathered during the consultation period for the Bungendore FRMS&P Review project indicate that access between Bungendore Village and Bungendore North is frequently cut, which presents an existing flood risk independent of the proposed rezoning of the sports hub or any potential future developments at that site. For example, it is understood that there have been instances where school children could not return home to Bungendore North due to flooding of Turallo Creek.

Therefore, while evacuation to a dedicated evacuation centre may not typically be supported by NSW SES, it is noted that the establishment of a dedicated evacuation centre either at Bungendore Public School or Bungendore Showground would be beneficial in reducing the flood risk which faces the existing residents of Bungendore as well as existing users of the sports hub and the Bungendore Sewage Treatment Plant. A publication titled '*Public Health Considerations for Major Evacuation Centres*' (NSW Health, 2024) provides guidance and key principles in the setup of new evacuation centres

5. Assessment Criteria

The Planning Proposal to rezone 15 Halfway Creek Road as well as the proposed aquatic centre development has been assessed against the relevant flood-related clauses in Section 9.1(2) Local Planning Direction 4.1 Flooding, the Palerang Development Control Plan 2015 (**PDCP 2015**) as well as the Queanbeyan-Palerang Regional Local Environmental Plan 2022 (**QPRLEP 2022**).

The relevant clauses from these planning documents are included in **Appendix D**.

Based on this assessment, the proposed development does not satisfy all of the flood planning objectives, performance criteria and prescriptive standards specified in the three applicable planning documents.

5.1 Areas of Compliance

Features and design elements of the proposed rezoning and aquatic centre development which comply with the flood-related clauses of the three planning instruments listed above are as follows.

- Flooding at the site has been assessed using calibrated flood models which have been developed for the Bungendore FRMS&P Review project, which is being undertaken as part of the NSW Floodplain Management Program. The study is being undertaken in accordance with the NSW Flood Prone Land Policy as well as the recently updated *Flood Risk Management Manual* (NSW DPE, 2023). This is consistent with the stated objectives of Local Planning Direction 4.1 Flooding and the PDCP 2015.
- The aquatic centre development is not located on land classified as floodway as defined consideration of the 1% AEP flood and events up to the 1 in 500 AEP flood. This is consistent with Clause (3) of Local Planning Direction 4.1 Flooding.
- The aquatic centre development is not expected to result in significant flood impacts to other properties in events up to and including the PMF. This is consistent with the objectives of the PDCP 2015 and the QPRLEP 2022, as well as Clause (3) of Local Planning Direction 4.1 Flooding.
- The Planning Proposal does not propose to rezone the land to Residential, Employment, Mixed Use, W4 Working Waterfront or Special Purpose Zones. The planning proposal proposes to rezone the land to Public Recreation. This is consistent with Clause (2) of Local Planning Direction 4.1 Flooding.
- The planning proposal would not allow for the development of residential accommodation in high hazard areas. This is consistent with Clause (3) of Local Planning Direction 4.1 Flooding.
- It is understood that the planning proposal would not permit significant increases in the development and/or dwelling density of the land. It is understood that any future works at the sports hub will comprise only sports facilities. This is consistent with Clause (3) of Local Planning Direction 4.1 Flooding.
- It is understood that hazardous industries or hazardous materials would not be stored within the aquatic centre or the sports hub. This is consistent with Clause (3) of Local Planning Direction 4.1 Flooding.

5.2 Areas of Non-Compliance

Features and design elements of the proposed rezoning and aquatic centre development which do not comply with key flood-related clauses of the three planning instruments listed above are listed in the following.

- Flood safe access and emergency egress up to the 1 in 100 ARI event (i.e., the 1% AEP event) plus 500 mm freeboard is not available. As noted in **Section 4.3**, the two available evacuation routes which provide access to the sports hub and aquatic centre are inundated in events as frequent as the 1 EY event. Safe and efficient evacuation of the site is not possible under existing conditions. This

contravenes provisions in the relevant planning documents which specify the requirement for safe and efficient evacuation of a site in the event of a flood, including:

- Clause 4e of Section 9.1(2) Local Planning Direction 4.1 Flooding.
- Clause B9.5.2 in Section B9 (Flood Planning) of the Palarang Development Control Plan 2015.
- Section 5.21 Clause 1d of the Queanbeyan-Palarang Regional Local Environmental Plan 2022.
- Section 5.21 Clause 2c of the Queanbeyan-Palarang Regional Local Environmental Plan 2022
- The development of an aquatic centre at the proposed location would not 'minimise flood risk to life and property', as it would introduce a significant number of additional visitors to the floodplain, some of whom may require assistance if evacuation of the site is initiated. Visitors to the sports hub and aquatic centre could be isolated at short notice, with potential durations of isolation exceeding 12 hours in some rarer flood events. People who are trapped at the site during a PMF would then be inundated by high hazard floodwaters that could pose a risk to life. This contravenes provisions in the relevant planning documents which aim to minimise the flood risk to life and property, including:
 - Section 5.21 Clause 1d of the Queanbeyan-Palarang Regional Local Environmental Plan 2022.
 - Objective (f) of Section B9 (Flood Planning) of the Palarang Development Control Plan 2015.

The first of the two primary areas of non-compliance listed above could be addressed by the construction of an alternative evacuation route which delivered a higher level of flood immunity that was at or above the level of the 1% AEP design flood. Construction of refuge space above the peak PMF level, either a first floor at the aquatic centre or a new building at the southern end of the Bungendore STP, in addition to a new evacuation route, could minimise the remaining risk to life should any patrons or staff be isolated on the site.

However, the implementation of these measures would be very expensive, which contravenes Clause 3g and Clause 4f of Section 9.1 (2) Local Planning Direction 4.1 Flooding, which states that a planning proposal must not contain provisions which are likely to result in significantly increased requirement for government spending on emergency management services and flood mitigation / emergency response measures.

6. Commentary on Proposed Rezoning

The Planning Proposal seeks to rezone the Bungendore Sports Hub site at 15 Halfway Creek Road from RU1 Primary Production to RE1 Public Recreation. A zoning of RE1 Public Recreation permits the following developments.

Table 6-1 Developments permitted on land with RE1 Public Recreation zoning (QPRLEP 2022)

Permitted without consent	Permitted with consent	
Extensive agriculture	Aquaculture	Building identification signs
	Business identification signs	Camping grounds
	Car parks	Caravan parks
	Cemeteries	Centre-based child care facilities
	Community facilities	Entertainment facilities
	Environmental protection works	Information and education facilities
	Kiosks	Markets
	Public administration buildings	Recreation areas
	Recreation facilities (indoor)	Recreation facilities (major)
	Recreation facilities (outdoor)	Respite day care centres
	Restaurants	Cafes
	Roads	Water recreation structures

It is noted that several outdoor recreation facilities have already been constructed at the sports hub site, along with a car parking area and a pavilion building. It is understood that further space has been set aside for additional sporting facilities with significant financial outlay already invested in the sports hub. Therefore, the proposal to rezone the land would be "in keeping" with the existing and intended use of the land at 15 Halfway Creek Road.

Further development at the sports hub should be considered holistically to ensure that there are safe and reliable measures in place to safeguard and evacuate all potential visitors to the site. This would ensure that the total number of people that could visit the site at any one time could safely evacuate within the available timeframes, if required.

Developments which would introduce regular visitors who are also vulnerable members of the community (i.e., children and the elderly) are not recommended. For example, this would include developments such as childcare facilities or respite day care centres.

Developments which could provide temporary accommodation (e.g., camping grounds and caravan parks) are also not recommended given that people could be stranded at the sports hub should a flash flood event occur in the middle of the night with little warning. There is also a greater potential for temporary accommodation to attract people from outside the community who will be unfamiliar with the flood risks and evacuation constraints.

Each potential future development at the sports hub should carefully consider the flood risk against the nature of the development and the demographic of potential users of the development.

7. Conclusions and Recommendations

Queanbeyan-Palerang Regional Council (**QPRC**) is seeking to make amendments to the Queanbeyan-Palerang Regional Local Environmental Plan 2022 (**QPR-LEP 2022**) to rezone 15 Halfway Creek Road (Lot 1 DP 1262898) from RU1 Primary Production to RE1 Public Recreation. Sporting fields and infrastructure has been part constructed on the land which is colloquially referred to as the Bungendore Sports Hub. The rezoning is intended to recognise the existing recreational use of the land and to enable a wider range of recreational development.

QPRC is also seeking to construct an indoor aquatic centre and associated car park at the northern end of the sports hub site.

The sports hub site is subject to flooding from Halfway Creek and/or Mill Post Creek. Flooding of these creeks is documented in a report titled, *Bungendore Floodplain Risk Management Study and Plan* (WorleyParsons, 2014). Worley Consulting is currently undertaking a review of the 2014 Study which includes updated flood modelling of the Halfway and Mill Post Creek catchments. The review will be documented in a report titled, *Bungendore Floodplain Risk Management Study and Plan Review* (in draft, 2025).

On the basis of this knowledge of flood risk in the Bungendore area, Council engaged Worley Consulting to undertake a Flood Impact and Risk Assessment (FIRA) to assess the risk of flooding at the Bungendore Sports Hub site. The assessment has considered the flood impacts that could arise from construction of the proposed aquatic centre and the flood risks that current users of the sports hub could be exposed to. This has involved adoption and application of the flood models developed for the Bungendore Floodplain Risk Management Study and Plan Review (in draft, 2025). The proposed aquatic centre development and rezoning has also been assessed against relevant planning instruments such as Section 9.1(2) Local Planning Direction 4.1 – Flooding, the Palerang Development Control Plan 2015 (**PDCP 2015**) as well as the Queanbeyan-Palerang Regional Local Environmental Plan 2022 (**QPRLEP 2022**).

7.1 Conclusions

The following key outcomes are concluded from the FIRA.

1. The rezoning of the sports hub to RE1 Public Recreation would be in line with the existing and intended use of the land for sporting facilities.
2. The land on which the aquatic centre is to be sited is not inundated in events up to and including the 1 in 500 AEP event. It follows that the aquatic centre development is not expected to lead to any material adverse flood impacts. This is consistent with the objectives of the **PDCP 2015** and the **QPRLEP 2022**, as well as Clause (3) of Local Planning Direction 4.1 Flooding. However, there are significant flood evacuation and isolation issues.
3. The two available evacuation routes along Halfway Creek Road (Evacuation Route A) and eastbound along Bungendore Road (Evacuation Route B1) are inundated in events as frequent as the 1 EY event. This does not comply with Clause B9.5 of the **PDCP 2015**. Additionally, there is insufficient warning time before these two evacuation routes are inundated. Accordingly, these two routes cannot be considered as reliable evacuation routes.
4. The evacuation route westbound along Bungendore Road (Evacuation Route B2) offers a greater level of flood immunity than afforded by Evacuation Routes A and B1, however, this route is not recommended as it would require evacuees to travel in the order of 57 km to drive back to Bungendore. The adoption of this evacuation route could induce risk-taking behaviour in visitors who would risk entering floodwaters to drive the shorter distance in an easterly direction back into Bungendore. Additionally, the flood immunity of Evacuation Route B2 has not been fully assessed, as there are numerous other watercourse crossings along the 57 km route including the Yass River and the Molonglo River.

5. There are no rainfall or water level gauges in the Halfway Creek and Mill Post Creek catchments. Analysis of flood modelling results from the Bungendore FRMS&P Review Project indicates that the two available evacuation routes (A and B1) are 'cut' by floodwaters within 2 hours from the onset of rainfall in the 1% AEP event and that the subsequent duration of isolation for those that might be stranded at the sports hub can exceed 12 hours. Therefore, these two existing routes cannot be considered as reliable evacuation routes.
6. The entire sports hub facility will be inundated to high flood hazard (H5) during the PMF. The available evacuation routes would be cut by floodwaters early in the event which would leave staff and visitors trapped at the sports hub prior to the eventual inundation during the PMF.
7. One option to reduce the flood risk at the site is to close the facilities in advance based on forecast rainfall. The analysis of frequent flood events indicates that the available evacuation routes remain flood free during the 3-hour 1 EY event or the 24-hour 2 EY event (refer **Table 4-2**). Design rainfall depths for these events are 25 mm and 40 mm, respectively.

While closure of the facilities based on forecast rainfall would reduce the flood risk, there are several shortcomings with this approach that mean that it is not possible to guarantee that risk to life is suitably mitigated as per the requirements of Section 9.1(2) Local Planning Direction 4.1 – Flooding and **QPRLEP 2022**. This includes potential inaccuracies in weather forecasts, the risk of repeated false alarms as well as the potential for human error in wrongly interpreting the forecast or failure to initiate facility closure or evacuation.

8. Other mitigation measures which could further reduce the flood risk at the site include the construction of an alternative evacuation route with a greater level of flood immunity and the construction of a refuge space on-site that is above the peak PMF level as a failsafe measure in the event that people are trapped at the sports hub during floods rarer than a 1 in 500 AEP event. Any such building would also need to be designed to withstand the forces of floodwaters and flood-borne debris during flood events up to and including the PMF.

The construction of a refuge space on-site above the peak PMF level could only be adopted as a failsafe measure for visitors and staff in the event that the site is not effectively evacuated, as it would invoke a Shelter-in-Place approach that is not consistent with criteria specified in the SIP Guideline. The inundation of the three potential evacuation routes early in most floods would result in the site being isolated for longer than the 12 hour maximum duration of isolation period specified in the SIP Guideline. In addition, it is questionable whether a dedicated flood warden would have the necessary gravitas and authority to keep people from trying to evacuate the site by travelling through floodwaters.

The implementation of these measures would require significant expenditure and may not be feasible.

9. The development of the aquatic centre is likely to introduce a significant number of additional visitors to the floodplain, some of whom would require additional assistance and time to safely evacuate the site if required. The facility may also be used by the community including local schools for events such as swimming carnivals. Attendance at such events may be facilitated by buses and alternate transport arrangements which may make evacuation based on minimal warning difficult. Therefore, this potential introduction of vulnerable members of the community into a high flood risk area contradicts the objectives of Section 5.21 Flood Planning of the **QPRLEP 2022**.

Based on the conclusions above, it is demonstrated that the proposed aquatic centre and rezoning planning proposal partially complies with the relevant flood-related clauses of Section 9.1(2) Local Planning Direction 4.1 Flooding, the **PDCP 2015** as well as the **QPRLEP 2022**. Key areas of non-compliance are the lack of existing reliable flood evacuation routes and the potential for the aquatic centre development to introduce significant numbers of children / the elderly into the floodplain, which cannot be considered as 'minimising risk to life and property'.

7.2 Recommendations

The following key recommendations arise from the findings of the FIRA.

- R1 It is recommended that an alternate location for the aquatic centre be identified that does not have the flood risk and evacuation constraints that this report has identified for the site currently being considered by Council.
- R2 Should Council wish to continue with planning for the aquatic centre development, it is critical that the following mitigation works be implemented to reduce the flood risk at the site. This could include:
- (i) The construction of an alternative evacuation route with a greater level of flood immunity and a redesign of the aquatic centre to include a refuge space above the peak PMF level, either as a first floor in the aquatic centre or a new building at the southern end of the Bungendore STP (refer **Sections 4.5.1, 4.5.2 and 4.5.3**). These buildings would need to be designed to withstand the forces of floodwaters and flood-borne debris during a PMF event.
 - (ii) Setting up an evacuation centre in the western portion of Bungendore Showground, which is expected to be flood-free in events up to and including the PMF. This should be done in conjunction with the upgrade and extension of Halfway Creek Road, comprising a new crossing over Mill Post Creek which would be flood free in events up to and including the 1% AEP event (refer **Section 4.5.4**). This would then provide a viable evacuation route to a flood-free evacuation centre which would be trafficable in events up to and including the 1% AEP event.
- R3 Additional mitigation measures which would reduce the existing flood risk at the site are listed in the following. It is noted that these mitigation measures would not reduce the flood risk for the proposed aquatic centre to an acceptable level, however, it would offer benefits to existing workers at the Bungendore STP as well as existing users of the sports hub, who would also be affected by the flood risk issues outlined in this FIRA.
- (i) Set up of the aforementioned evacuation centre at Bungendore Showground without the construction of a new crossing over Mill Post Creek which would be flood-free in events up to and including the 1% AEP event. QPRC have indicated that Low Point 2 could be readily removed, which would allow users of the sports hub as well as staff at the STP to travel to the showgrounds via a route which would be trafficable in events up to and including the 5% AEP event (refer **Section 4.5.4**).
 - a. Construction of a diversion channel along Halfway Creek upstream of the sports hub to divert a portion of the flow along Halfway Creek into Mill Post Creek (refer **Section 4.5.5**). This would reduce flood levels along Halfway Creek, thereby improving the flood immunity of the existing evacuation routes from the sports hub.
 - b. Installation of an automated flood warning system (refer **Section 4.5.6**).
 - (ii) It is important to reinforce that the modelling indicates that access to the facilities may be cut for extended periods which exceed 12 hours. Shelter-in-place guidelines released by the NSW State Government (2024) do not support shelter-in-place where isolation periods exceed 12 hours. Therefore, a refuge space above the PMF should not be adopted as a flood risk mitigation strategy in isolation. Notwithstanding, the construction of a refuge space above the PMF would reduce the existing flood risk if adopted as a failsafe measure in the event that closure / evacuation of the site is not initiated.
 - (iii) Closure of the facilities based on rainfall forecasts would also reduce the significant flood risk. However, this flood risk mitigation strategy in isolation would not sufficiently reduce the flood risk for the proposed aquatic centre development to an acceptable level, given the previously discussed shortcomings to this approach and the potential vulnerable users of this development.

- R4 Notwithstanding, the closure of the sports hub based on the rainfall forecast thresholds should be implemented to reduce the flood risk at the site to existing users of the facilities in lieu of a reliable evacuation route. Based on an analysis of more frequent flood events, the sports hub should be closed if more than 25 mm is forecast within a 3-hour period or if more than 40 mm is forecast within a 24-hour period. These rainfall thresholds correspond to the 3-hour 1 EY event or the 24-hour 2 EY event, which are the events at which flood free access to the sports hub is predicted to still be available.
- R5 The flood evacuation plan would also require the appointment of a flood warden for the sports hub to close the facilities prior to opening hours. The flood warden would also be required to monitor weather conditions on days where the sports hub is being used and to initiate evacuation if there are sudden changes in the forecast. A detailed Flood Emergency Response Plan (FERP) would be required that outlines the specific steps and procedures to be followed in preparation for, during and after a flood event.
- R6 Should the site be rezoned to RE1 Public Recreation, any future developments at the site should carefully consider the flood risk against the nature of the development and the demographic of potential users of the development.
- R7 Developments should be considered on a case-by-case basis. Developments which introduce vulnerable people (i.e., children or the elderly) onto the floodplain on a regular basis are not recommended. Developments which could provide temporary overnight accommodation are also not recommended.

Ultimately, it is responsible floodplain management to avoid the placement of development, whether residential, commercial or recreational, on parts of the floodplain where there are known flood risks that could result in isolation and in extreme cases, a risk to life. Inclusion of the mitigation measures outlined above will reduce the risks associated with the development making evacuation possible during floods up to and including a 1% AEP event and as a failsafe, include a refuge that is above the peak level of the PMF in the event that the site is not evacuated in time. The flood risks to the aquatic centre and its future patrons are considered to be too significant without these mitigation measures. This takes into consideration the potential number of people that could attend the aquatic centre, which includes vulnerable members of the community such as children and the elderly.

8. References

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- Worley Consulting (in draft, 2025), 'Bungendore Floodplain Risk Management Study and Plan Review'.
- WorleyParsons (2014), 'Bungendore Floodplain Risk Management Study'.
- WorleyParsons (2014), 'Bungendore Floodplain Risk Management Plan'.

Appendix A. Aquatic Centre Design Drawings

Appendix B. Design Flood Mapping

Appendix C. ARR 2019 Intensity-Frequency-Duration Data

Appendix D. Relevant Flood Planning Instruments

