REPORT

Flood Management Plan

Muswellbrook Animal Care Facility - DA

Client: **Muswellbrook Shire Council**

Reference: PA2484
Status: Draft/1.01
Date: 10 July 2020

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Enhancing Society Together

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Document title:	Flood Management Plan
Document short title:	Muswellbrook Animal Care Facility - DA - FMP
Reference:	PA2484
Status:	1.01/Draft
Date:	10 July 2020
Project name:	Muswellbrook Animal Care FMP
Project number:	PA2484
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Date / initials:	
Approved by:	Rohan Hudson
Date / initials:	

Classification
Project related

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Table of Contents

Table of Tables

Table of Figures

1 Introduction

1.1 Background

This report provides a flood management/evacuation plan which has been undertaken to support the Development Application (DA) for a proposed Animal Care Facility at **125 Sydney Street Muswellbrook (Lot DP 1243931/2)**.

A separate Flood Impact Assessment (FIA) have already been provided. This identified the minimum floor level (i.e. flood planning level (FPL)) as being 144.8 m AHD.

1.2 Objective of this Report

The objective of this flood management/evacuation plan is to identify suitable evacuation options for the study site to reduce risk to people, animals and the environment if a Hunter River flood occurs.

The scope of the report is to consider technical flood related matters, with operational issues to be dealt with by Council and the facility operators.

2 Site Description

The study site is located at 125 Sydney Street, Muswellbrook. The site is located on the south-eastern bank of the Hunter River south of Muswellbrook east of the Greyhound Track. A plan of the site is provided in **Figure** 1. It is understood that the proposal includes a Council run animal care facility including a kennel and cattery as well as a veterinary service / animal adoption building.

Figure 1: Details of Proposed Development

Note: Development site is shown in black outline. Details of the proposed development footprint are included. Assumed fill extent in orange outline

The site is adjacent to the Barn Veterinary Services and Pursehouse Rural Agricultural Services which was constructed in January 2013.

The adjacent site consisting of a large shed and associated earthworks was constructed in January 2013 (so is absent from the LiDAR ground elevation data used in the Flood Study and FRMS&P). Development consent for the development is reported to have been granted in December 2011.

The details of the earthworks at construction were:

- Floor level of main building is 144.4 m AHD (i.e. just above the 100 yr ARI level)
- Land was filled around the building to accommodate roadway and car parks
- Land was also filled to an approximate level between the building and the river at 144.0m

3 Relevant Documents

3.1 Muswellbrook DCP

The following principles outlined in the Muswellbrook Shire Development Control Plan (DCP, April 2009) – Section 13 Flood Prone Land must be adhered to:

- Proposed development will not result in increased flood hazard or flood damage to other properties.
- Proposed development should be of a type, height and scale that is compatible with the existing urban and historic fabric of the area.
- Construction methods and materials for that part of the development below the 1% AEP flood levels should conform to the flood proofing code.
- Proposed development should be able to withstand the force of flowing floodwaters, including debris and buoyancy forces.
- Provision shall be made for the safe storage and/or timely removal of goods, material, plant and equipment in the event of a flood.

3.2 Hunter River Flood Study - Muswellbrook to Denman (Worley Parsons, 2014)

The Hunter River Flood Study (Muswellbrook to Denman) was produced by Worley Parsons in 2014 as part of the NSW Government's Floodplain Management Program. The study is informed by an integrated hydrologic and hydraulic model of the Upper Hunter River Floodplain Catchment. The model encompasses the entire extent of the Hunter River Floodplain that is located within the Muswellbrook Council Local Government Area (LGA). The upstream portion of the model (from the upstream LGA boundary to the Goulburn River) was developed in TUFLOW as a two-dimensional (2D) hydraulic model, while the lower portion of the model (from the Goulburn River to the downstream LGA boundary) was developed in TUFLOW as a one-dimensional (1D) hydraulic model dynamically linked to the upstream 2D model.

Surface elevations within the hydraulic model are informed by Light Detection and Ranging (LiDAR) data that was acquired by State Water in 2010 (i.e. prior to the development of the study site at 127 Sydney Street). The integrated hydrologic and hydraulic models were calibrated using available information from flood events that occurred in 1998, 2000 and 2007.

The hydrologic and hydraulic models developed as part of this study were provided to RHDHV for use in the below FRMS.

3.3 *Muswellbrook Floodplain Risk Management Study and Plan* (RHDHV, 2019)

As part of the Muswellbrook Floodplain Risk Management Study and Plan (FRMS&P), Royal HaskoningDHV (RHDHV) completed an update and upgrade to the WorleyParsons (2014) flood model based on a comprehensive review of flood information for the Hunter River, stream gauge review and analysis, revision of the hydraulic roughness parameters, flood frequency analysis using data from the Muswellbrook stream gauge, model re-calibration and revised design event models for a range of design flood events using the Australian Rainfall and Runoff (ARR) 2016 (Commonwealth of Australia) guidelines.

A key finding of that work was that the changes to the stream gauge rating curve has led to the rated channel capacity at the Muswellbrook stream gauge (no. 210002) being reduced to approximately 45% of its assessed 1990 capacity. The current estimate is that flood levels have been reduced by up to 350 mm for both the 1% and 5% Annual Exceedance Probability (AEP) flood events, with reductions of up to 45% for peak flows for corresponding events.

The Muswellbrook FRMS&P provides design levels used for setting of flood planning levels (FPL) used to assess development applications.

3.4 *Muswellbrook Animal Care Facility Flood Impact Assessment* (RHDHV, 2020)

A separate Flood Impact Assessment (FIA) has already been provided. This quantified the predicted flood impact of the development and identified the minimum floor level (i.e. flood planning level (FPL) as being 144.8 m AHD.

4 Flood Model Summary

4.1 Model Setup

The model developed within the *Muswellbrook Floodplain Risk Management Study* has been used as the basis for the flood modelling for the purpose of this FIA. Hydrologic modelling was undertaken using XP-RAFTS and two-dimensional hydraulic modelling was undertaken using TUFLOW-GPU.

4.2 Existing Scenario

The existing scenario was modelled utilising the base TUFLOW model prepared for the *Muswellbrook Floodplain Risk Management Study*, with the only modifications being the addition of the fill pad associated with the neighbouring Barn Veterinary Services and Pursehouse Rural Agricultural Services which was constructed in January 2013. To highlight the impact this development has made on flood behaviour and why the existing case differs to that presented in the FRMS results 1% AEP (100 yr ARI) for both scenarios are presented below.

Maps presenting flood depth and levels from the FRMS study are presented in RHDHV (2020), while **Figure 2** presents the Hydraulic Classification derived during the FRMS for the site.

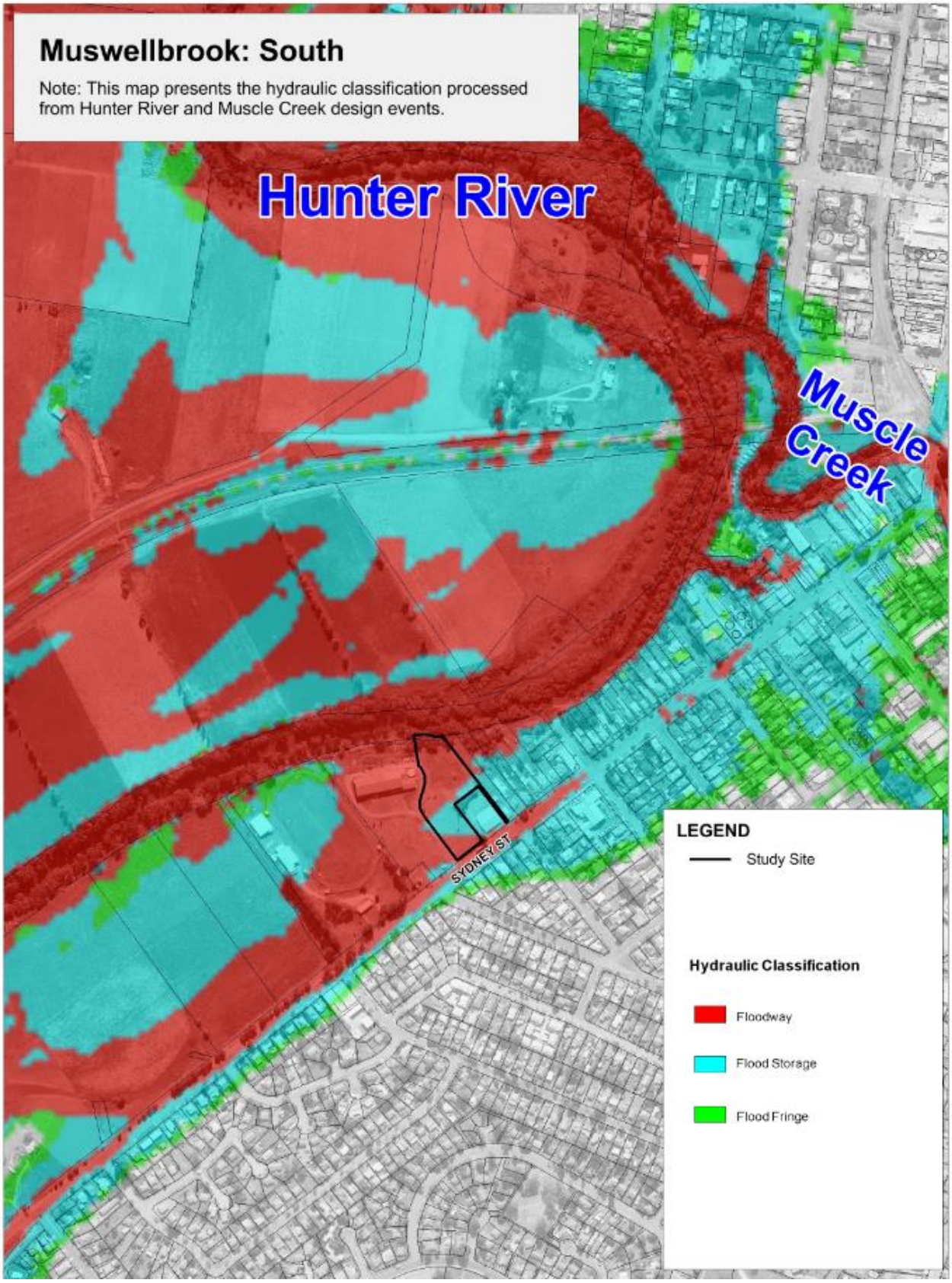

Figure 2: 100yr (1% AEP) Hydraulic Classification (in ~2010 - No Development)

4.3 Summary of FRMS&P Design Levels for the Study Site

Existing (pre-Barn development), peak 1 in 100yr ARI (average recurrence interval) flood levels for the study site are presented in **Figure 3**. It shows that the 100yr ARI flood levels range from 144.2 to 143.9 m AHD. Ground levels at the site are typically between 142.5 and 143.5 m AHD.

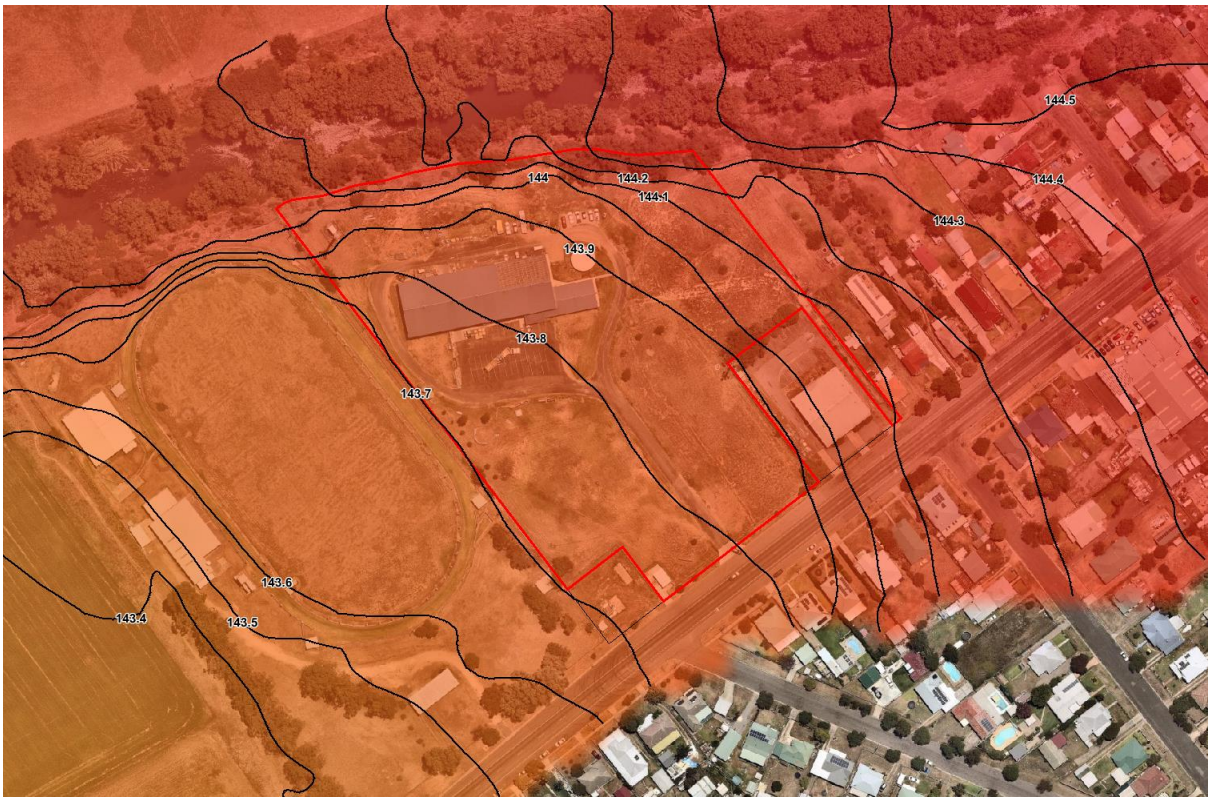

Figure 3: 100yr (1% AEP) Peak Flood Levels (in ~2010 - No Development)
Note: Image shows the 100yr flood extent, contours of peak flood level and the study site boundary.

Peak flood levels for the study site and two other locations for a range of design events are presented in **Table 1**. The location of the points used to extract the peak water levels from the model results are provided in **Figure 4**.

While the site is expected to be flood free (i.e. dry) in the 1 in 10 yr ARI event, it is flooded by approximately 0.7m in the 20yr ARI event. The 100yr ARI level at the site is approximately 144.2 m AHD. This results in a flood planning level of 144.7 m AHD, though does not consider the impact of the Barn pad described in **Section 4**.

The Kayuga Road Bridge (WL gauge) (presented in **Table 1**) is a Bureau of Meteorology (BoM) Flood Level Gauge. Flood levels are available at the below link and can be used to potentially estimate flood magnitude at the study site. (http://www.bom.gov.au/fwo/IDN60232/IDN60232.561005.plt.shtml)

Using data in **Table 1** and noting that Kayuga Road gauge zero is 136.24 m AHD, flooding of the low ground of the site is expected for floods approximately higher than 11m above gauge zero (i.e. 1m above the major flood (10m) rating). An approximate 100yr ARI event occurs when flood levels are ~12m above gauge zero. It would be wise to evacuate the study site if a major flood was predicted at the Muswellbrook gauge.

Table 1: Hunter River Design Flood Levels (ARR2016)

Location	Elev (mAHD)	50% AEP 2yr ARI	20% AEP 5yr ARI	10% AEP 10yr ARI	5% AEP 20yr ARI	2% AEP 50yr ARI	1% AEP 100yr ARI	0.5% AEP 200yr ARI	0.5% AEP 500yr ARI	PMF Event
Kayuga Road Bridge (WL Gauge), Muswellbrook	137.43	141.36	144.89	146.50	147.38	148.06	**148.32**	148.51	148.76	150.82
Kayuga Road Bridge (BoM Gauge*),	Gauge Zero = 136.24	5.12	8.65	10.26	11.14	11.82	**12.08**	12.27	12.52	14.58
Greyhound Track	132.31	137.38	141.51	143.22	143.73	143.95	**144.04**	144.12	144.25	146.88
127 Sydney Street	142.86	Dry	Dry	Dry	143.45	143.73	**143.87**	144.01	144.20	146.94

* Note – these are the same gauge (BoM 561005 and WaterNSW 210002)

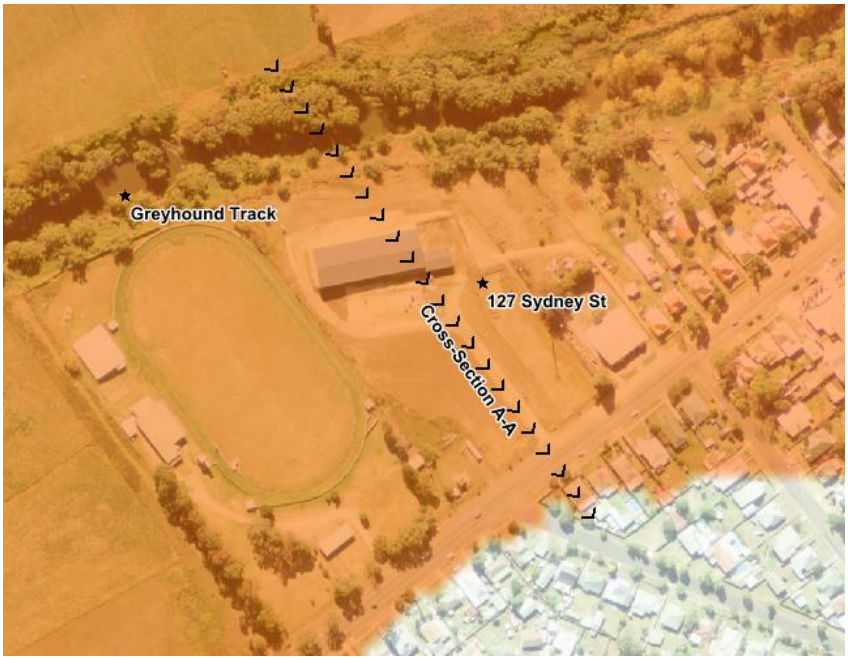

Figure 4: Location of Water Level Output Points and Lines

A cross-section presenting pre-development ground levels and design flood levels is presented in **Figure 5**. It shows that the site is flood free in the 2, 5 and 10yr ARI and that flood levels at the site are typically 0.5 to 0.1 m lower than levels in the Hunter River, except for in the PMF (probable maximum flood). In the PMF, flood depths greater than 3 to 4m are expected at the site. This high PMF level would make shelter in place or vertical evacuation extremely difficult.

In the 100yr ARI flood, depths above 1m are predicted at low parts of the site. In the 20yr ARI flood, depths above 0.5m may make evacuation difficult.

While the existing (i.e. ~2010, pre-development) 100yr ARI flood levels are below 144 m AHD, it is important to consider the impact of the previous filling on flood levels at the study site. This is described in the following Section.

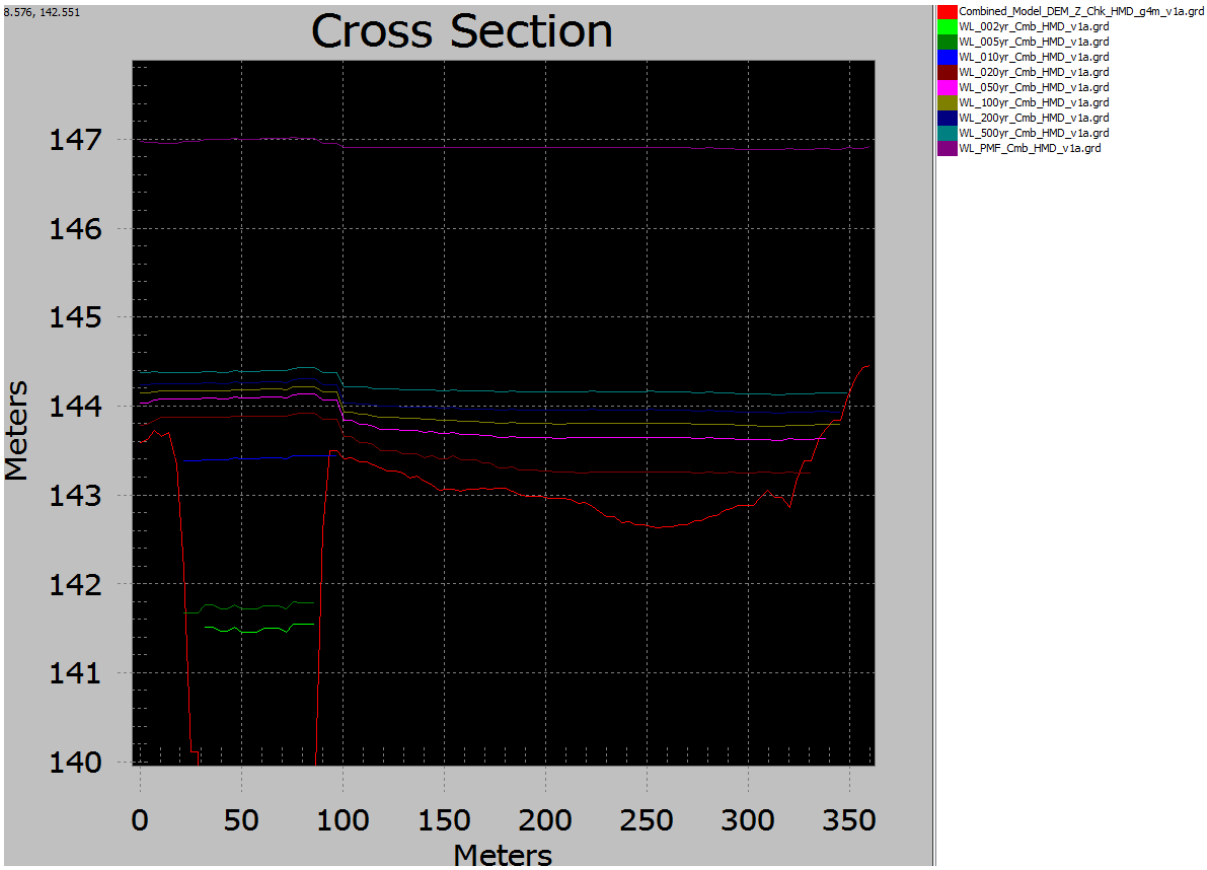

Figure 5: Ground and Design Flood Levels (Cross-Section (A-A))

Note: Image shows the ground levels and design flood levels between the Hunter River and area to the south of Sydney Street (refer Figure 4 for location of Section).

4.4 Proposed Scenario

The proposed scenario flood model was developed based on the proposed design provided by Council in Drawing DA01, reproduced below as **Figure 6**. This information was also provided in a GIS compatible format as presented in **Figure 1**.

It was assumed that both the building and animal runs would be raised above the FPL. This was incorporated into the model using a z-shape that raised the area (as indicated in **Figure 1**) above the FPL.

Existing ground levels for the area to be raised are between 143.3 and 143.8mAHD. An initial indication of FPL (and hence fill level) was provided above as being 144.7 m AHD indicating up to 1.4m of fill will be required. The footprint of the pad will be shaped by retaining walls on the eastern and western side of the facility whilst the northern and southern sides would be tapered down to meet existing ground levels at these extremities of the development footprint.

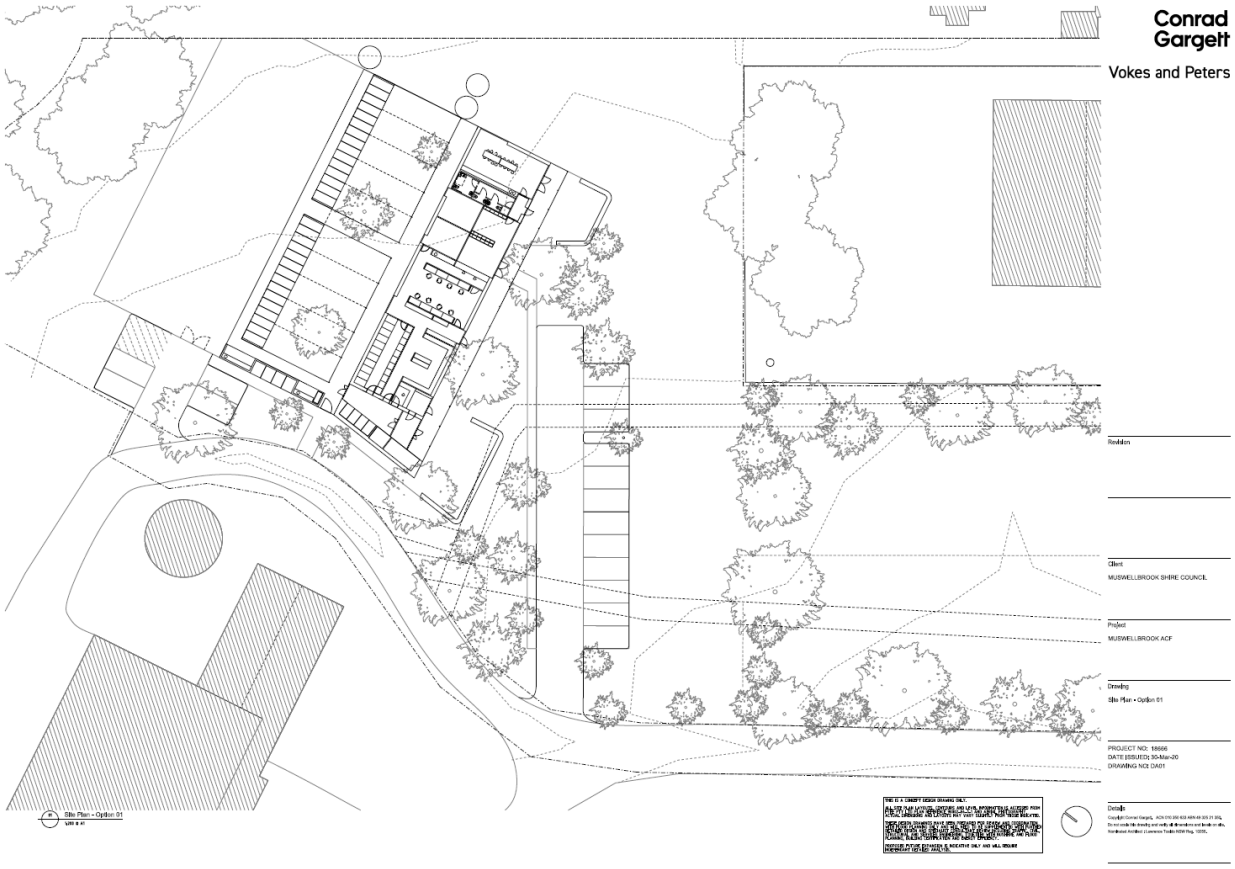

Figure 6: Proposed Site Plan

4.5 Model Results

4.5.1 5% AEP (with Proposed Development)

5% AEP flood levels and depths are presented in **Figure 7**. They show flood depths across the site are typically 0.5m deep, though the raised site is flood free.

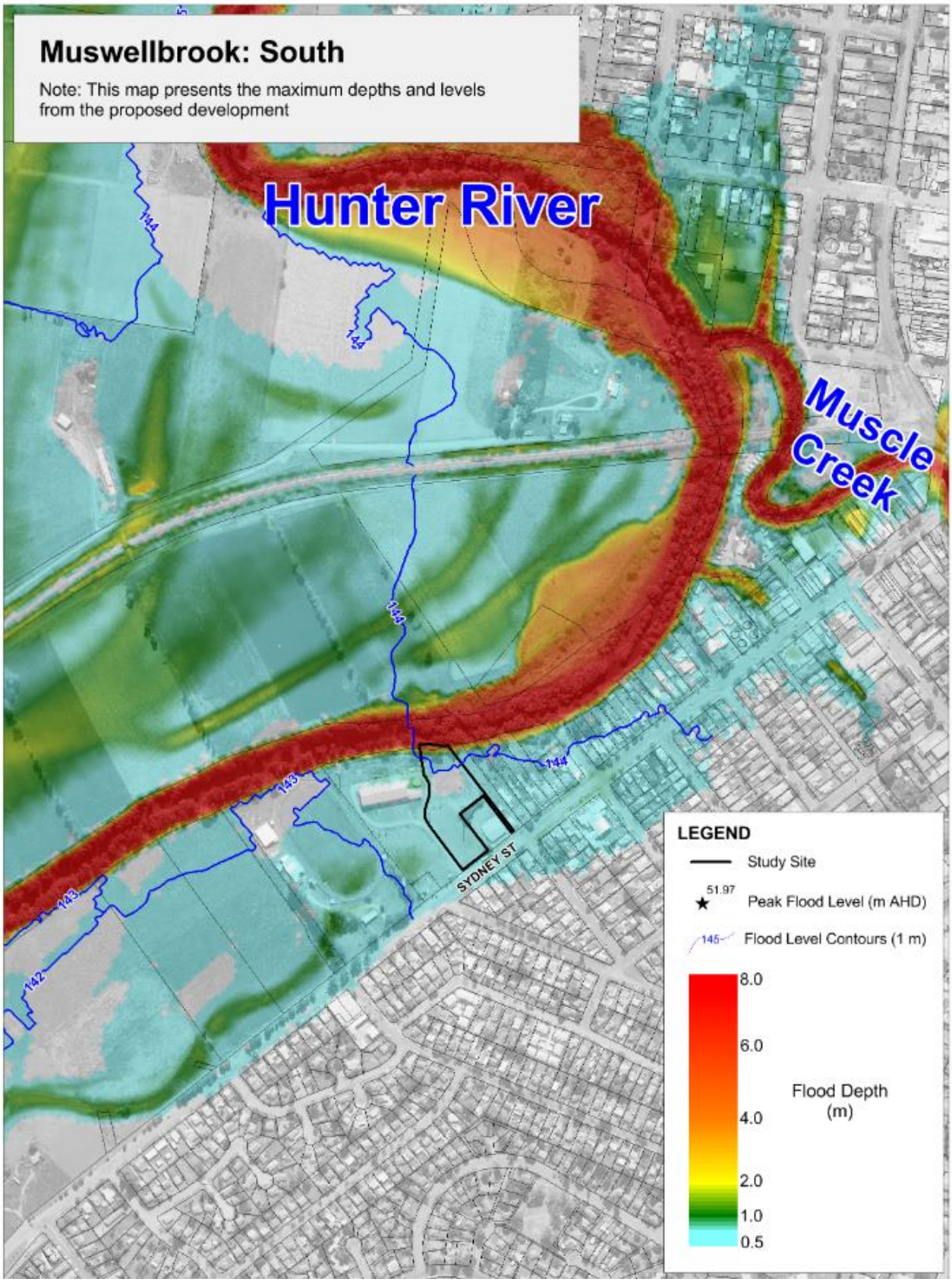

Figure 7: 5% AEP peak flood depths – proposed scenario

4.5.2 1% AEP (with Proposed Development)

Figure 8 presents the 1% AEP flood extents and flood contours adjacent to the site. The 1% AEP (100yr ARI) flood levels for the area to be raised are 144.3 m AHD indicating an FPL of 144.8 m AHD is required.

The results of the proposed scenario flood modelling are presented in the following figures below:

- **Figure 8** – 1% AEP peak flood depths and levels
- **Figure 9** – 1% AEP flood hazard

A comparison of **Figure 8** (proposed development) to the (existing / pre barn) shows that flood depths are largely unchanged and that the location of the 144m AHD flood level contour is in a similar position.

Parts of the site adjacent to Sydney St are H5 (Unsafe for people and buildings. Building require special engineering design and consideration). This means that evacuation would need to be carefully considered and the location of other infrastructure would need appropriate design.

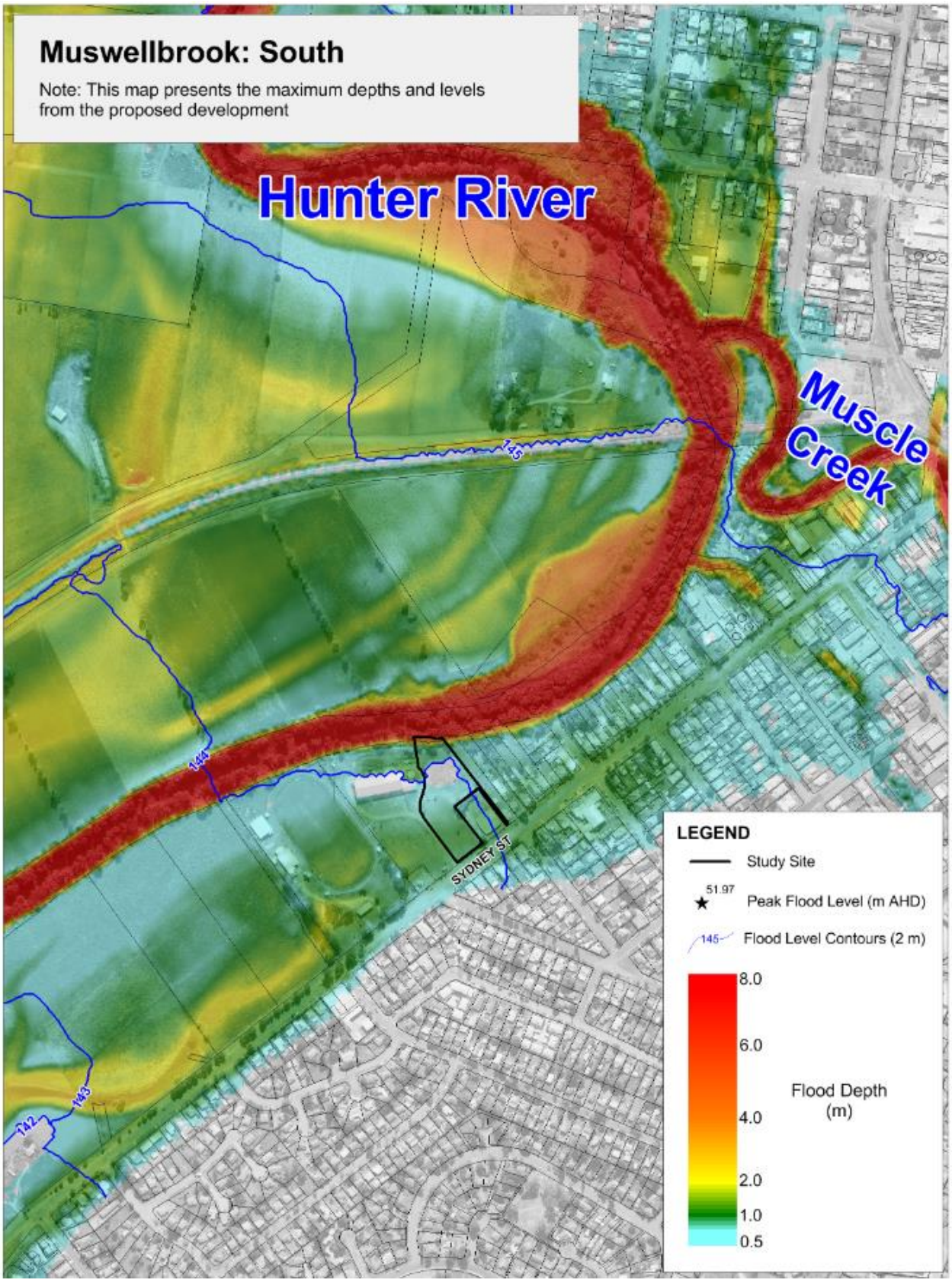

Figure 8: 1% AEP peak flood depths – proposed scenario

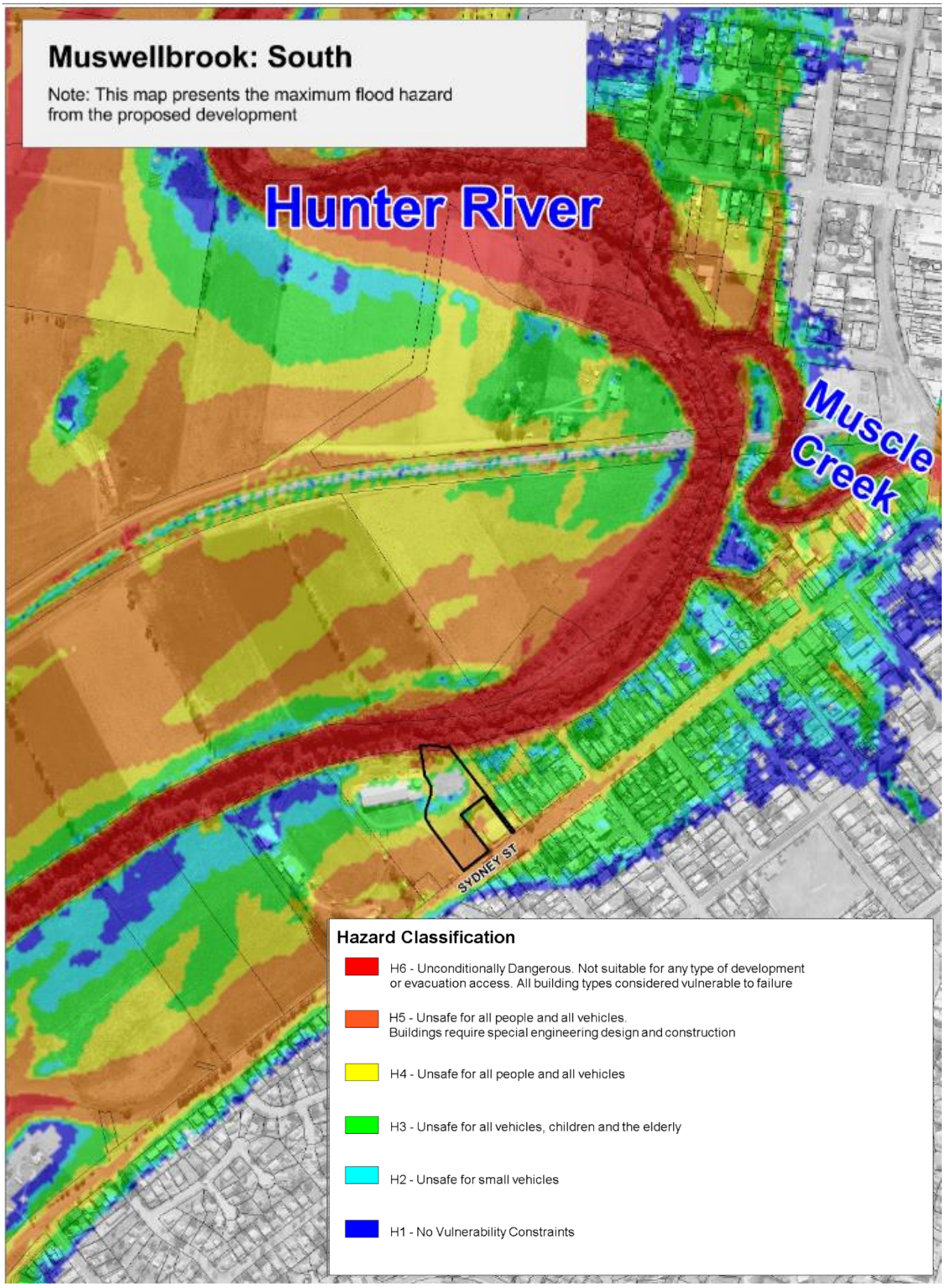

Figure 9: 1% AEP flood hazard – proposed scenario

4.5.3 Probable Maximum Flood

Probable Maximum Flood (PMF) levels and depth for the proposed development are presented in **Figure 10**.

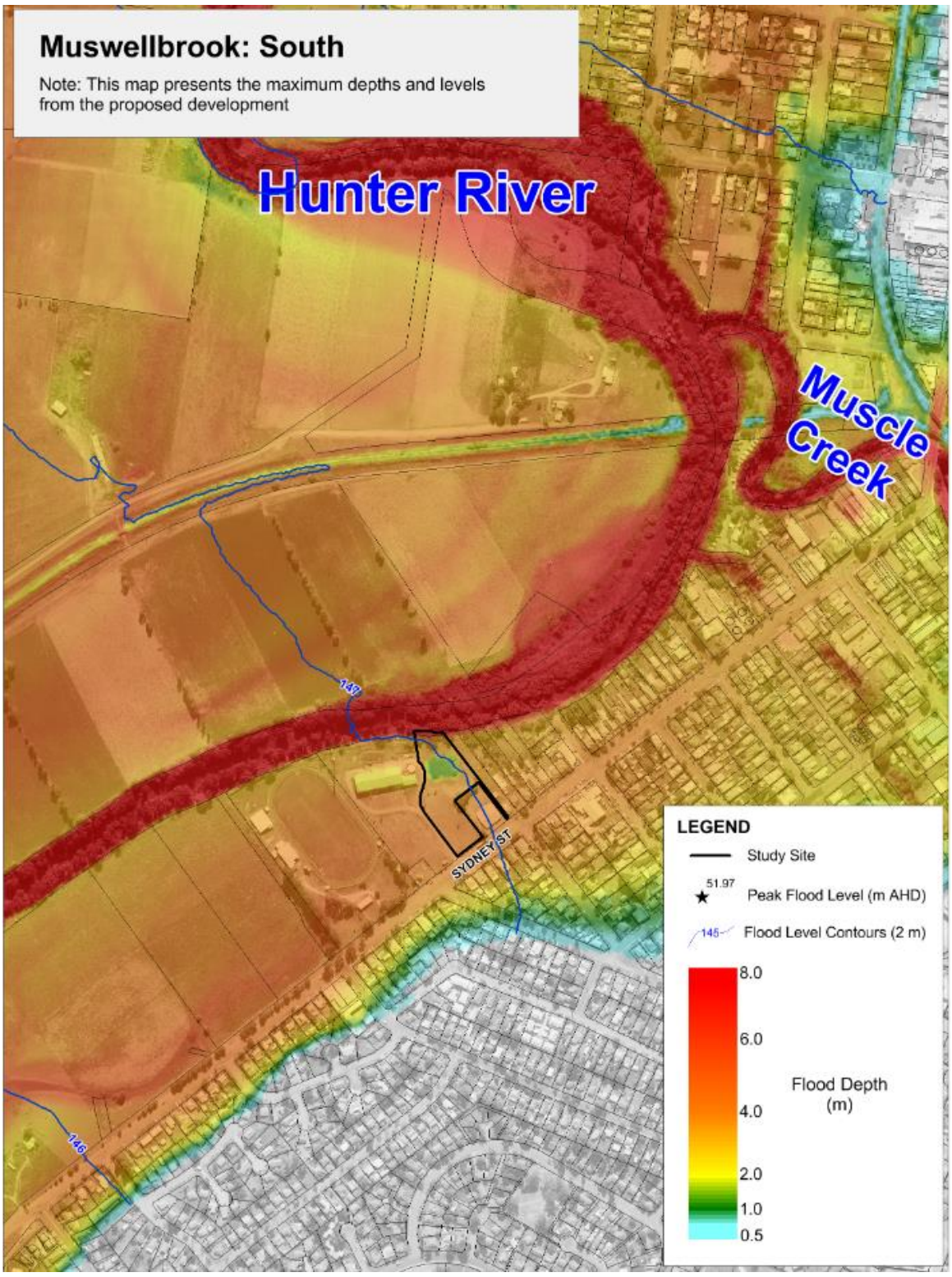

Figure 10: PMF peak flood depths – proposed scenario

5 Flood Evacuation Considerations

5.1 Requirement

Section 13 of the Muswellbrook DCP (Flood Prone Land) requires that 'an evacuation plan for users of the development is prepared (to the satisfaction of Council) and maintained throughout the life of the development.' Whilst not explicitly stated in the Muswellbrook DCP, flood evacuation typically takes into consideration the extent and depth of flooding in all events up to the Probable Maximum Flood (PMF).

5.2 Available Options

A range of flood management/evacuation options should be considered to determine the appropriate option for a given site. Typical options include:

- Vertical evacuation (i.e. shelter in place)
- Evacuation to a flood free location

The timing, triggers and method of evacuation to a flood free site needs to be considered.

5.2.1 Vertical Evacuation

Vertical evacuation (i.e. shelter in place) can be an effective flood management option which is beneficial in that a significant movement / transportation of animals would not be required. However, vertical evacuation would require:

a) An area of the site that is above the PMF level;
b) The ability to reach the site to provide care if necessary.

Given that the PMF level is approximately 147 m AHD and the FPL of the site is 144.8 m AHD, vertical evacuation to a 2nd storey may be possible. However, the following would need to be considered:

i) the structural stability of such a proposed structure against the extreme hydraulic forces that are likely to be present during the PMF would be expensive;
ii) provision of an access ramp to the 2nd storey would be required;
iii) due to the potential duration of isolation (likely greater than 24hrs) means of re-supply to the 2nd storey would be necessary and difficult;

Due to the above issues and the nature of flooding at the site, **vertical evacuation is not recommended.**

5.2.2 Evacuation to a Flood Free Location

As shelter in place (or vertical evacuation) is not considered appropriate/safe for the site, evacuation to a flood free location is required. There are a number of factors to be considered for this option including:

a) selection of a suitable refuge location;
b) transportation of the animals;
c) provision of care at refuge location;
d) setting of triggers to initiate evacuation;
e) setting of triggers for when it is safe to return.

This report is primarily concerned with factors: a, d and e. Factors b and c will be covered by the facility operators.

5.2.3 Selection of a Suitable Refuge Location

The selection of a suitable refuge site needs to:

i) be in a flood free location;
ii) be accessible without crossing flooded roads and be close by, to reduce transport time;
iii) have suitable facilities available to receive the animals;
iv) be accessible/open in the event a flood.

While the final selection of a site may take some negotiation with the facility operators and owners/managing of the refuge location, a **suitable location is the existing pavilion, barns and stables associated with the Muswellbrook Showground** location on the corner of Maitland Street & Rutherford Roads. This site is only 3.3 km away and according to the FRMS&P is flood free (refer **Figure 11**).

An **alternative site could be the location of the current Council Animal Care facility** located on the Skellatar Stoke Route and is also shown on **Figure 11.** Access would need to be via Osbourn Avenue (requiring a 2.6 km journey) as Sydney Street may be flooded.

Figure 11: Suggested Evacuation Route along Forbes Street to Muswellbrook Showground

5.2.4 Setting of Triggers to Initiate Evacuation

The setting of an appropriate trigger to initiate site evacuation requires a consideration of:

a) The availability data to base a decision on;
b) The reliability of the evacuation trigger;
c) The amount of lead time between a warning being given and the trigger being reached;
d) The amount of time between the trigger being reached and the site becoming isolated or flooded;
e) The likely frequency of evacuation triggers.

The Bureau of Meteorology (BoM) uses a water level gauge located at the Kayuga Road Bridge crossing of the Hunter River to provide flood warnings for Muswellbrook. The gauge is located only 2 km to the north of the study site so provides an excellent source of trigger warnings for the proposed Animal Care facility.

Observed water levels are published on the below website which is also accessible using the BoM Rainfall and River Condition website (http://www.bom.gov.au/nsw/flood/midnorth.shtml).

Kayuga Road Water Levels - http://www.bom.gov.au/fwo/IDN60232/IDN60232.561005.plt.shtml

The Bureau of Meteorology (BoM) currently provides a formal flood warning service for the Hunter River and provides an estimate of peak flood levels. The warning are considered reliable and are considered accurate to within +/- 0.3m. An example of a BoM flood warning for the Williams River (at tributary of the Hunter River) is presented in **Figure 12**.

Flood classifications in the form of locally defined flood levels are used in flood warnings to give an indication of the severity of flooding (minor, moderate or major) expected. These levels are used by the NSW State Emergency Service (SES) and the Bureau of Meteorology (BoM) in flood bulletins and flood warnings.

The BoM/SES classifies minor, moderate and major (as defined by BoM below) flooding at the Kayuga Road gauge on the Hunter River (Muswellbrook) as detailed in **Table 2**. At the Muswellbrook gauge, BoM provides a target warning lead time of 4 hours for a Minor flood event and a 12 hours warning lead time for a Major flood event.

Table 2: Details of Relevant Flood Warning Gauges
Source: http://www.bom.gov.au/nsw/NSW_SLS_Current.pdf

Gauge Name (Location)	Station Number BoM (DPI)	Minor (m)	Moderate (m)	Major (m)	Gauge Zero (mAHD)
Muswellbrook (under Kayuga Road Bridge)	561005 (210002)	7.2*	8.0	10.0	136.25

A comparison of the Major flood level classification to the flood model results is presented in **Table 1** and Major flood level would have a design magnitude (frequency) of between a 5yr ARI (20% AEP) and 10yr ARI (10% AEP) event at the Muswellbrook gauge.

An examination of the ground levels and design flood levels presented in **Figure 5** shows that this 10m, major flood level warning provides a suitable evacuation warning as the site is only inundated in a 20 yr ARI event (i.e. gauge level between 10.3 and 11.1m).

Because this trigger warning is for an event more severe than a 1 in 10 year ARI, it is unlikely that the event would require frequent evacuation. It is more likely that the site would only need to be evacuated at

say between a 5 and 20 year frequency. While the low frequency of evacuation is considered fortunate from an operational perspective, long intervals between events may mean that the evacuation procedure becomes forgotten. Therefore, it is recommended that flood evacuation drills are carried out every 1 to 2 years to ensure staff are suitability trained to understand the requirements for evacuation.

An examination of water levels at the Muswellbrook Bridge Kayuga Road Gauge indicates that in the 75 years of available data between 1913 and 2020 (note: no data from 1928 to 1960) there have only been 5 events (1971, 1976, 1992, 1913 and 2000) with a peak water level near or above 10m. The 1998 event peaked at 9.66m.

Australian Government Bureau of Meteorology, New South Wales

Final Flood Warning for the Williams River

At Dungog

Issued at 1:55 pm EDT on Saturday 18 March 2017
Flood Warning Number: 3

Rainfall has eased since 11:00 am Saturday morning over the Williams river valley, however further rainfall is forecast for the next 24 hours.
The Williams River at Dungog is expected to peak below the minor flood level.
The situation is being closely monitored and warnings and predictions will be issued if necessary.

Williams River:
The Williams River at Dungog is approaching a peak below the minor flood level

Flood Safety Advice:
FloodSafe advice is available at www.ses.nsw.gov.au

For emergency assistance call the SES on telephone number 132 500.
For life threatening emergencies, call 000 immediately.

Next issue:
This is a final warning, no further warnings will be issued for this event.

Latest River Heights:
Williams River at Dungog, 3.77, Steady, 12:45 PM SAT 18/03/17
Williams River at Mill Dam Falls, 1.48, Rising, 01:00 PM SAT 18/03/17
Allyn River at Halton, 2.01, Rising, 01:00 PM SAT 18/03/17
Paterson River at Gostwyck Bridge, 1.65, Rising, 01:00 PM SAT 18/03/17

This advice is also available by dialling 1300 659 218. Warning, rainfall and river information are available at www.bom.gov.au/nsw/flood. The latest weather forecast is available at www.bom.gov.au/nsw/forecasts.

Figure 12: Example BoM Flood Warning for the Williams River

From http://weather.news.com.au/warning/?id=IDN36639

In the 20yr ARI event (refer **Figure 7**), flood depths above 0.5m may make evacuation difficult. An evacuation to higher ground that is flood free in the PMF is available by heading east along Forbes Street as presented in **Figure 13**. As discussed in Section 4.3, it is recommended to commence evacuation of the site if a major flood is predicted at the Muswellbrook (Kayuga Road) Gauge. Given that animals are likely to be held on the site overnight, special attention to a suitable and practical evacuation plan will be required.

If animals were allowed to stay onsite during a flood that exceeded the major flood level, even though the site is raised to 0.5 m above the 1 in 100yr ARI flood level, the exact magnitude of a flood event is difficult to predict, so if a larger than predicted flood event did occur, the animals may drown or be harmed. While evacuation of the site via boat may be possible, given the high velocity of the floodwaters between Sydney Street and the site (refer **Figure 2** which shows the site is classified a floodway and **Figure 9** which shows an H5 Hazard (i.e. unsafe for people and vehicles)) it would put emergency workers at risk, so early evacuation is recommended.

In terms of flood warning times, at the Muswellbrook gauge, BoM provides a target warning lead time of 4 hours for a Minor flood event and a 12 hour warning lead time for a Major flood event. This should be sufficient time to plan and allow for safe evacuation of the facility.

Figure 13: PMF Flood Extent and Suggested Evacuation Route along Forbes Street

5.2.5 Duration of Flooding and Triggers for Safe Return

An analysis of the design flood events which are for the critical 24 hour rain show that for the 100yr ARI event, the Kayuga Gauge would remain above 144.0 m AHD for 24 hours. However, it is important to remember that longer, but slightly lower (i.e. “non-critical”) events are possible. Therefore, the potential for flood durations between 12 and 72 hours should be considered possible. The BoM should be able to provide the information on the timing of the water level fall for future events.

Return to the site should be considered once the water level has fallen below the minor flood warning and no significant further rainfall is predicted. Before returning to site, a site inspection to ensure that no significant damage to the site has occurred should be conducted.

5.2.6 Consideration of Raised Causeway to Increase Evacuation Lead Time

The provision of a raised causeway that sat above the existing ground level would make evacuation safer and potentially reduce the frequency of flood evacuations. The construction of a causeway at the 100 yr ARI level of 144.3 m AHD, would not be feasible because:

a) Sydney Road is only at 143.0 m AHD so would also require raising to ensure a safe evacuation route. This is not considered feasible.

b) Any causeway raising (even with the provision of culverts) would constrain a major floodway and would therefore result in significant upstream flood impacts which would not be permitted.

6 Conclusions

This report provides advice on a suitable flood management / evacuation plan for the proposed development of an Animal Care Facility located at 125 Sydney Street Muswellbrook, NSW.

The assessment found that because the PMF is likely to inundate the site for potentially more than 24 hours and produce hazard conditions that would require specialised engineering, **shelter in place / vertical evacuation is not recommended.**

As shelter in place (or vertical evacuation) is not considered appropriate/safe for the site, evacuation to a flood free location is required. While the final selection of a site may take some negotiation with the facility operators and owners/managing of the refuge location, a **suitable location is the existing pavilion, barns and stables associated with the Muswellbrook Showground** location on the corner of Maitland Street & Rutherford Roads. This site is only 3.3 km away and according to the FRMS&P is flood free

An **alternative site could be the location of the current Council Animal Care facility** located on the Skellatar Stoke Route. Access would need to be via Osbourn Avenue (requiring a 2.6 km journey) as Sydney Street may be flooded.

While the site is flood free in the 10yr ARI event access is no longer possible in the 20yr ARI event (refer **Figure 7**). This means that despite the facility being constructed 0.5 m above the 100yr ARI level, earlier evacuation will be required.

It is suggested that the major (i.e. 10m) flood warning for Muswellbrook (i.e. at the Muswellbrook Bridge BoM Warning Gauge) is adopted as the trigger for evacuation. An event of this magnitude has only occurred on 5 occasions in the 75 years of available records and is likely to only occur with a typical 5 to 20 year frequency. However, it is recommended that flood evacuation drills are carried out every 1 to 2 years to ensure staff are suitability trained to understand the requirements for evacuation.

In terms of flood warning times, at the Muswellbrook gauge, BoM provides a target warning lead time of 4 hours for a Minor flood event and a 12 hour warning lead time for a Major flood event. This should be sufficient time to plan and allow for safe evacuation of the facility.

The potential for flood durations between 12 and 72 hours should be considered possible, such that offsite flood refuge may be required for up to 3 days.

Return to the site should be considered once the water level has fallen below the minor flood warning and no significant further rainfall is predicted. Before returning to site, a site inspection to ensure that no significant damage to the site has occurred should be conducted.

7 References

1) *Royal HaskoningDHV (2019), **Muswellbrook FRMS&P**, Prepared by Royal HaskoningDHV on behalf Muswellbrook Shire Council, 8th April 2019.*

2) *Royal HaskoningDHV (2020), **Flood Impact Assessment - Muswellbrook Animal Care Facility - DA**, Prepared by Royal HaskoningDHV on behalf Muswellbrook Shire Council, 5th May 2020.*

3) *Worley Parson (2014) "**Hunter River Flood Study (Muswellbrook to Denman)**" Rev C 8/9/2014, Report prepared for Muswellbrook Shire and the NSW Office of Environment and Heritage.*