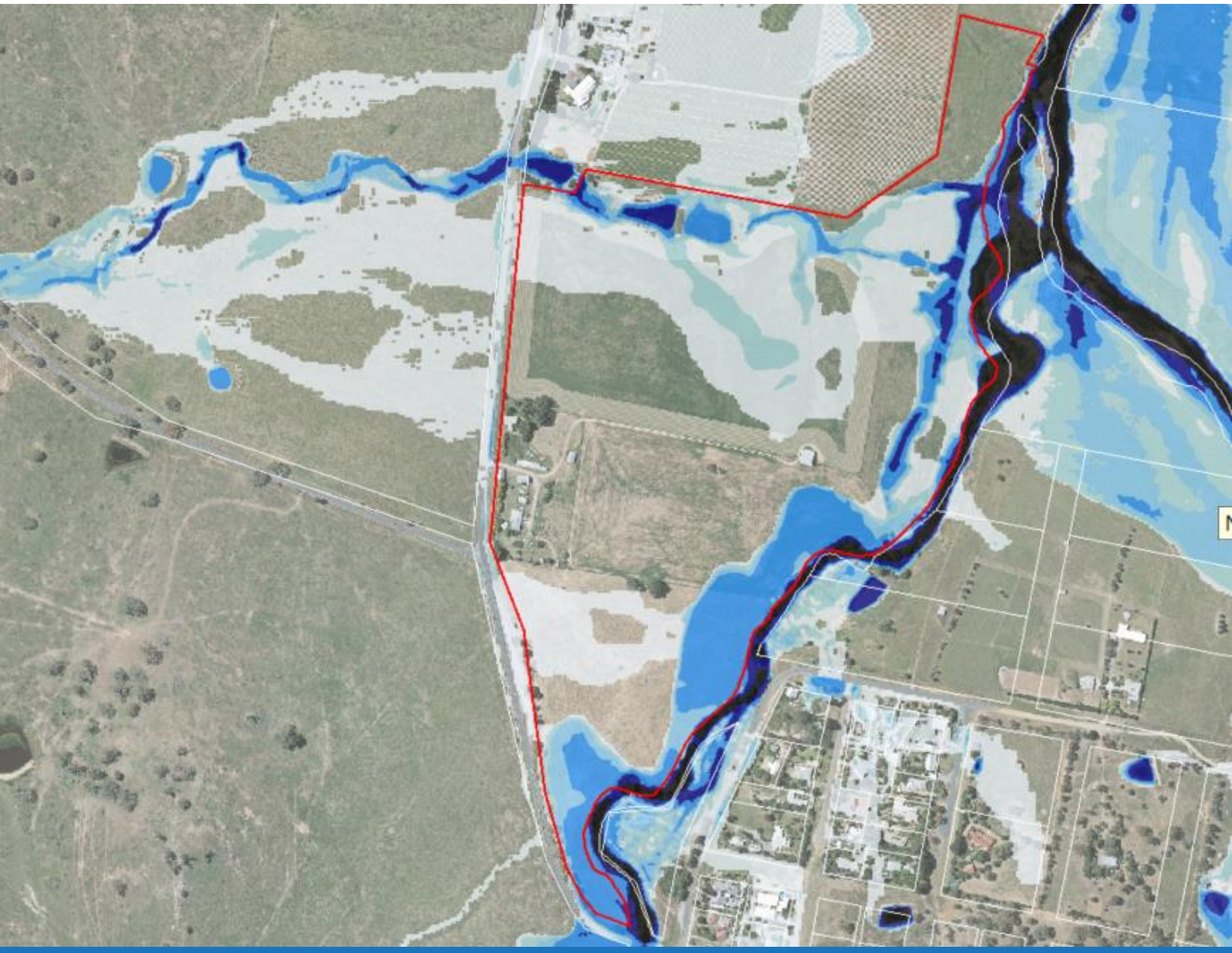
SUTTON LODGE

2402 SUTTON ROAD, SUTTON

PLANNING PROPOSAL - FLOOD INVESTIGATION



MAY 2021

2402 SUTTON ROAD, SUTTON – PLANNING PROPOSAL, FLOOD ASSESSMENT

Project Number:	200023
Client:	Sutton Lodge
Client Contact:	Neil Grubb
Report Author:	Zac Richards
Date:	31 May 2021

Date	Version	Description
25 May 2020	Draft	2402 Sutton Road, Sutton – Planning Proposal Flood Assessment - DRAFT
23 June 2020	Final	2402 Sutton Road, Sutton – Planning Proposal Flood Assessment - FINAL
31 May 2021	Revised Final	2402 Sutton Road, Sutton – Planning Proposal Flood Assessment – Revised FINAL

Filepath: J:\200023\Admin\Report\R230620_2402_Sutton_Road_Flood_Assessment.docx

GRC Hydro
Level 9, 233 Castlereagh Street
Sydney, NSW 2000
Tel: +61 432 477 036
Email: richards@grchydro.com.au

Contents

EXECUTIVE SUMMARY

This report has been prepared by GRC Hydro Pty Ltd on behalf of Sutton Lodge for submission of a planning proposal for 2402 Sutton Road, Sutton. The planning proposal aims to rezone currently zoned RU1 Primary Production land to R2 Low Density Residential and E3 Environmental Living to facilitate future development. The report addresses Section 9.1 Direction 4.3 Flood Prone Land requirements and has assessed the suitability of the site for rezoning and future development.

Flood modelling has been undertaken by GRC Hydro using the Sutton Flood Study (WMAwater, 2016) TUFLOW model as a basis for the modelling analysis. Council also engaged Lyall & Associates to undertake a cumulative impact assessment of the developed and two already approved developments (Keir and Cartwright).

A concept design which presents an indicative site configuration has been developed to show how future development of the site can occur in a manner consistent with the requirements of Section 9.1 Direction 4.3. Key findings of the assessment include:

- For Existing Conditions:
    - The majority of the site is not mainstream flood affected during the 1% AEP event. During this event, shallow flows breakout from a tributary to the north of the properties with depths up to 0.2 m experienced. With the exception of the creek channels, flow conditions are low hazard and classified as flood fringe;
    - A significant portion of the site (~60%) is mainstream flood affected during the PMF by high hazard flow conditions. The remaining areas of the site are not mainstream flood affected, however, do experience generally shallow overland flows which breakout from the above-mentioned northern tributary. There areas are typically affected by low hazard flow conditions.
- Implementation of the concept design resulted in:
    - Developable areas of the site to be flood free during the 1% AEP event;
    - All internal access roads to be situated outside of the PMF high hazard flood extent;
- Flood impact analysis found that negligible flood impacts are expected in the 1% AEP and PMF events due to the development. A cumulative impact assessment undertaken by Lyall & Associates confirmed these findings as well as confirming that "*future development within Sutton would have only a minor impact on flood behaviour*";
- A dam breach analysis study found that the risk to future development at the site due to dam failure is very low, with developable areas of the site being situated above a conservatively derived dam breach water level. The analysis found that a full dam breach assessment for the site is not warranted.
- The impact of climate change on peak flood levels affecting the site was found to minor, with projected increases in 1% AEP flood levels of ~0.2 m expected for the 2090 planning horizon. This is below the Flood Planning Level which is the 1% AEP flood level + 0.5 m freeboard;
- Flood evacuation has been considered with the following findings:
    - Implementation of the concept design results in all developable areas being situated outside the PMF high hazard extent and approximately 2 m above the 1% AEP flood

level. Evacuation during a Yass River/Mclaughlins Creek extreme flood event would be associated an extremely low probability of occurrence;
    - Internal access roads are situated above the 1% AEP flood level and outside of the PMF high hazard flood extent. These roads provide low hazard flood access to Sutton Road as well as areas of refuge outside of the mainstream PMF extent (see Figure 3 and 4);
    - Road design can be developed to ensure that Rising Road access is available for all future lots.
- The site's flood access has been reviewed with the following findings:
    - Access from the Site to Sutton and Canberra may be impacted due to flooding of the Sutton Road crossing of Mclaughlins Creek. Relatively frequent flood events inundate the crossing and cut-off road access at that location.
    - The crossing is identified as a flood risk area in the Sutton FRMS&P. Several flood risk management measures which aim to manage the risk of flooding of the crossing are identified in the Sutton Floodplain Risk Management Plan with 'High Priority' for implementation. These measures include replacement of the current crossing with a bridge as well as flood warning signage and automatic boom gates. Council has a responsibility to implement these measures as the Plan has been adopted.
    - Due to the 'High Priority' classification of these risk management measures in the Floodplain Management Plan, it is expected that the crossing or other mentioned risk management measures will be implemented in the short term (e.g. 2-5 years), prior to the site being occupied. Implementation of these measures will reduce the risk associated with flooding of this crossing.
    - Two alternate flood access routes have been identified at Mulligans Flat Road and Shingle Hill Way. New bridge crossings of major watercourses on these access routes will allow for 5% and 0.05% AEP flood access respectively. Use of these roads during times of flood can provide flood access to Canberra under most weather conditions. In addition to Canberra, Gundaroo can be accessed during an emergency, via Sutton Road.

The flood and risk characteristics described above have been considered when addressing Section 9.1 Direction 4.3 Flood Prone Land directives. The analysis has found that rezoning of the site is consistent with the requirements of directives if the following design requirements are adhered to during future development of the site:

- Land within the Flood Planning Area is rezoned as E3 Environmental Living, with areas outside of the Flood Planning Area zoned to R2 Low Density Residential. Sufficient space for development of all lots is required outside of the Flood Planning Area;
- Development of the site is to achieve, at a minimum, the flooding outcomes described in this report;
- Bulk earthworks should result in an approximately neutral cut/fill ratio within the FPA to minimise loss of flood storage.
- Internal roads are to be designed to allow for flood free Rising Road access in the 1% AEP event and outside of the PMF high hazard flood extent.

1. INTRODUCTION

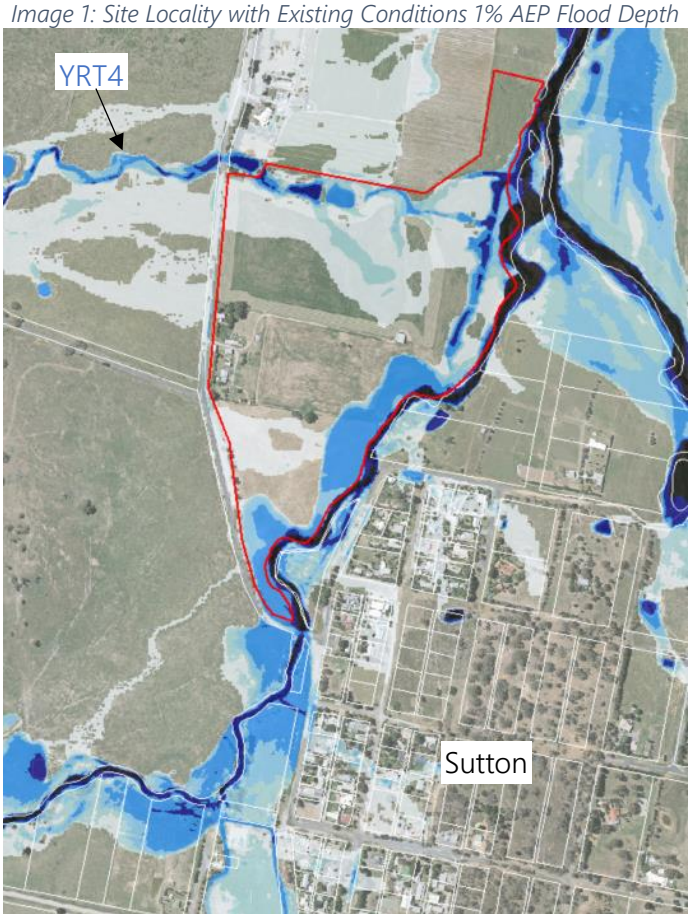
1.1 Project Overview

A Planning Proposal is being developed for 2402 Sutton Road, Sutton (the Site) situated in the Yass Valley Council (Council) Local Government Area.

GRC Hydro have been engaged by Sutton Lodge to investigate the Site's flood liability in relation to developable land potential. Section 9.1 Direction 4.3 has been considered to assess the suitability of the Site for rezoning and future development.

The Site is situated to the north of the Sutton Township and is currently zoned RU1 Primary Production. Rezoning to R2 Low Density Residential and E3 Environmental Living is proposed to facilitate development.

Image 1: Site Locality with Existing Conditions 1% AEP Flood Depth



Two watercourses affect the Site, with an unnamed tributary (named 'Yass River Tributary #4' in the Sutton Flood Study) flowing along the Site's northern boundary and Mclaughlins Creek along the eastern boundary. Flooding of the low-lying areas of the Site may occur due to either of these watercourses and/or backwater from the Yass River, however the majority of the site is not flood affected by mainstream flooding. Overland flow flooding and breakouts from YRT4 are responsible the majority of the Site's flood liability, with this mechanism resulting in shallow low hazard flood conditions.

1.2 Indicative Site Configuration

The objective of this planning proposal is the rezoning of RU1 land to R2 and E3 zones to facilitate future development. A concept design which presents an indicative site configuration has been developed to show how future development of the site can occur in a manner consistent with the requirements of Section 9.1 Direction 4.3. It must be reiterated that this is an indicative concept only, which aims to show how the site could potentially be developed, not how the site will be developed. However, any future development of the site shall include provision for the design requirements detailed in Section 6.

The concept aims to maximise lot yield whilst managing flood risk. Key aspects of the concept are presented in the maps detailed below:

- Land Zoning Area map (Image 2) and concept lot sizes (Table 1);
- Lot configuration with approximate building envelope and effluent treatment areas (Image 3);
- High-level bulk earthworks modelling (Image 4).

Image 2: Land Zoning Area Map

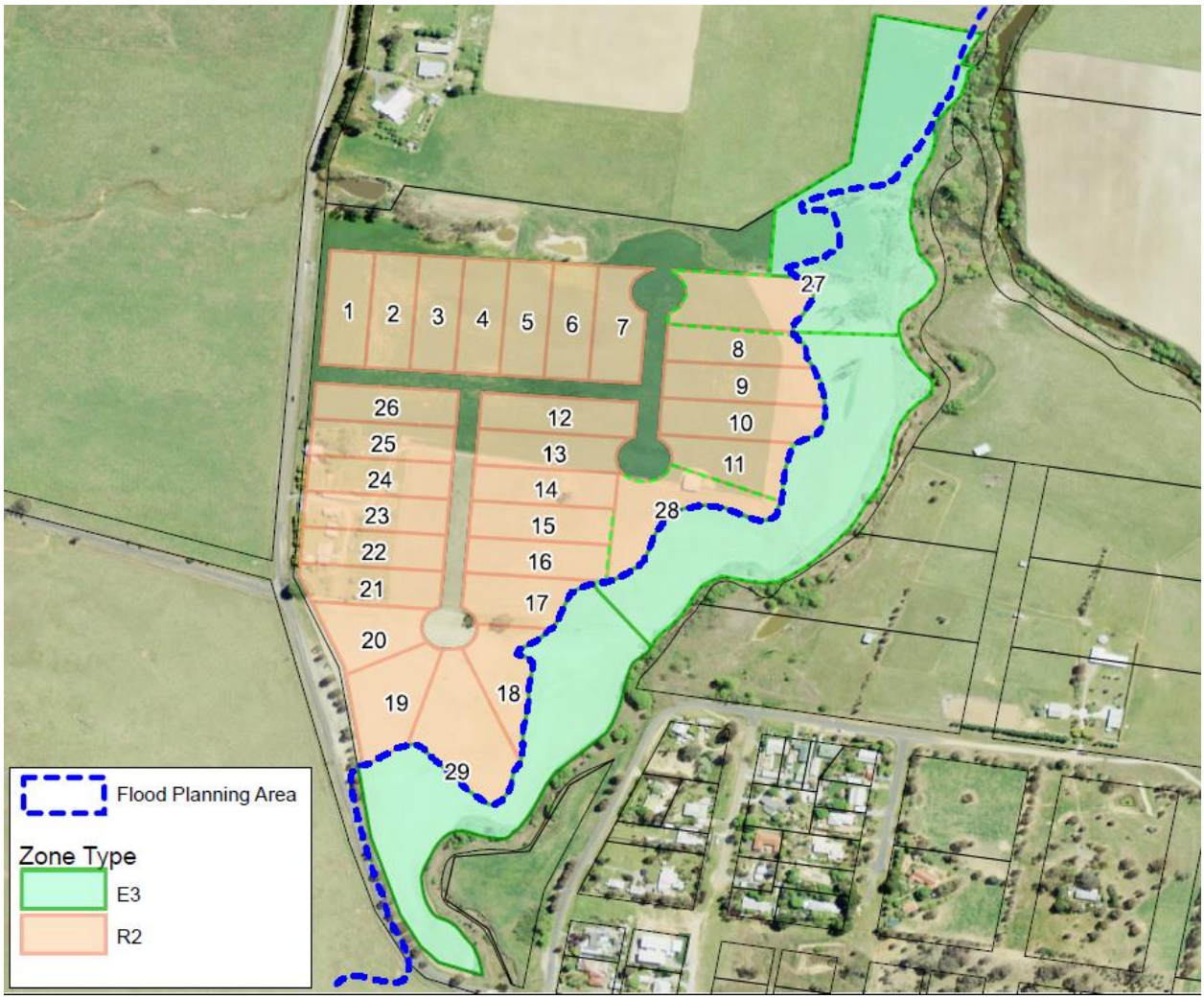


Table 1: Concept Lot Sizes and Zonings

Lot Number	Area (m^2)	Zone	Lot Number	Area (m^2)	Zone
1	5,000	R2	16	5,100	R2
2	5,000	R2	17	5,000	R2
3	5,000	R2	18	5,300	R2
4	5,000	R2	19	6,600	R2
5	5,000	R2	20	5,100	R2
6	5,000	R2	21	5,100	R2
7	5,220	R2	22	5,000	R2
8	5,000	R2	23	5,000	R2
9	5,700	R2	24	5,000	R2
10	5,800	R2	25	5,000	R2
11	5,100	R2	26	5,000	R2
12	5,500	R2	27	40,000	E3, R2
13	5,000	R2	28	40,000	E3, R2
14	5,000	R2	29	40,000	E3, R2
15	5,000	R2			

It should be noted that the concept is high-level/indicative only and further refinement/adjustment of the concept is expected during the DA and design phases of the project. The concept configuration achieves the following lot yields and flood management outcomes for the site:

- R2 zoning outside of FPA (5000 m^2) – 26 lots;
- E3 zoning within FPA (4 ha) – 4 lots (combined R2 and E3 with minimum size = 4 ha);
- R2 zoned land is situated outside of the FPA (Image 2)
- All lots are flood free in the 1% AEP event;
- All lots have 1000 m^2 building envelopes situated outside of high hazard PMF extent (Image 3);
- All internal roads are flood free in the 1% AEP event and situated outside of high hazard PMF extent (Image 3);
- All lots have space for effluent treatment areas outside of riparian buffers (Image 3);
- Approximately neutral cut and fill (800 m^3 fill surplus which can be re-examined during design);
- An increase in flood storage below the FPL (i.e. cut is focused in areas below the FPL with fill being moved to areas in the outer floodplain). See Image 4.

Image 3: Concept Lot Configuration with Building Envelopes and Effluent Areas

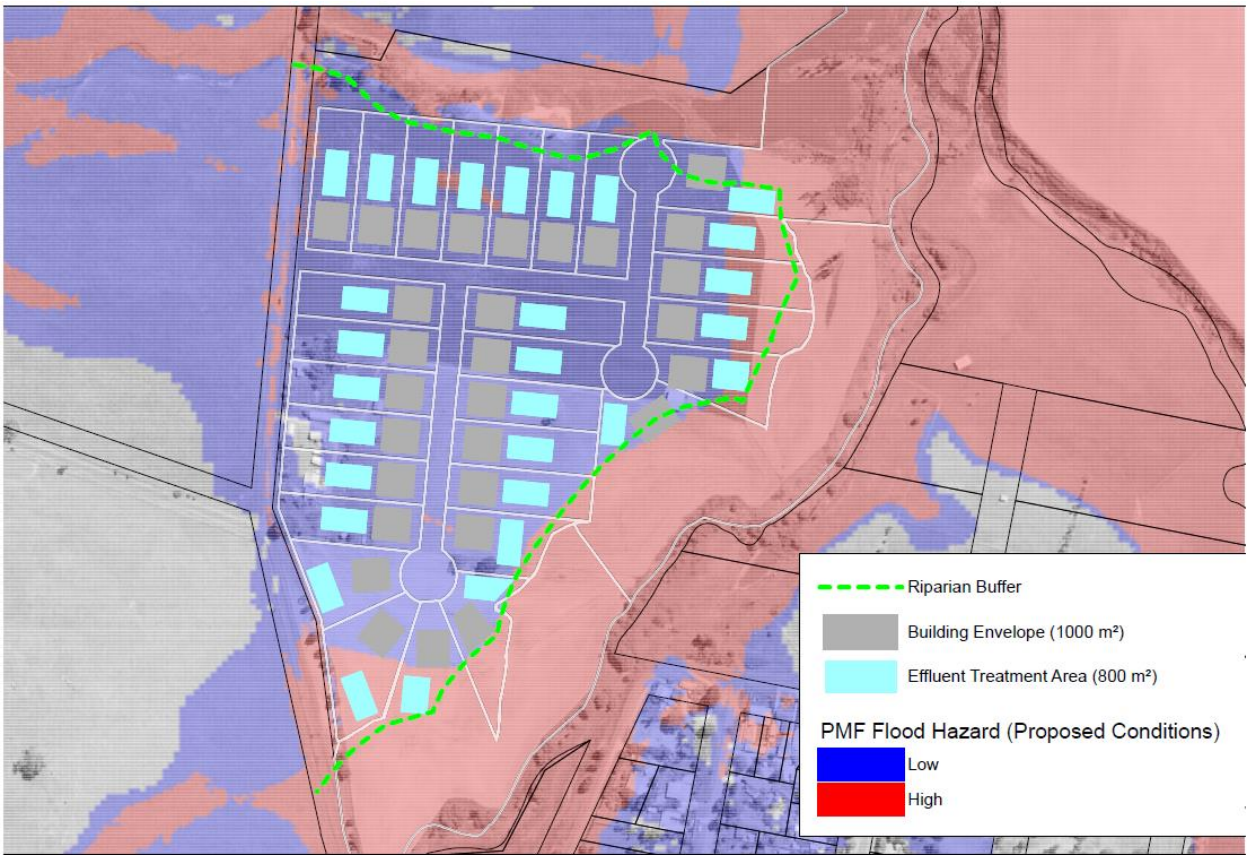
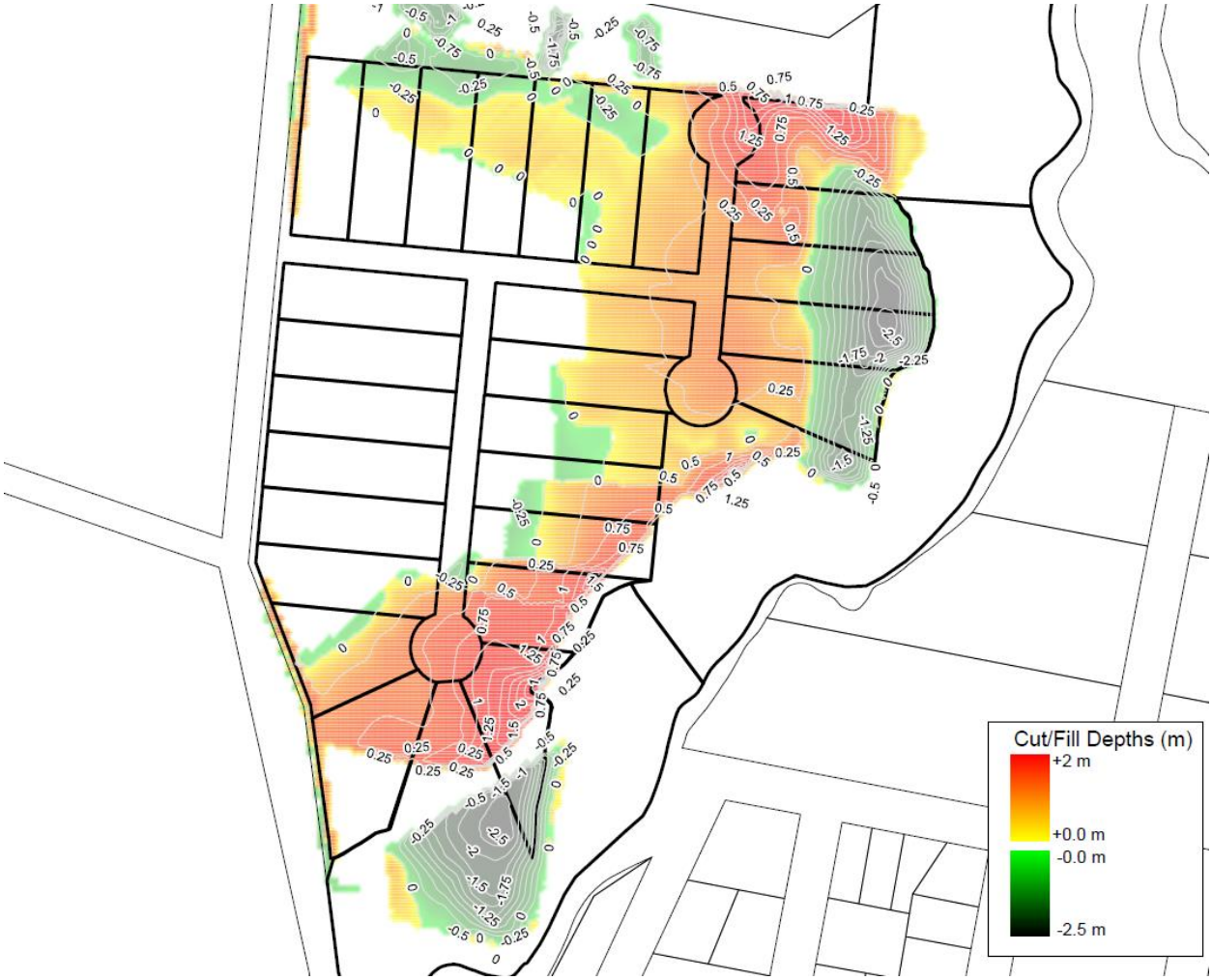


Image 4: Concept Bulk Earthworks Model



1.3 Previous Studies

Three pertinent studies exist for the Site, namely the:

- Sutton Flood Study (the Flood Study) - WMAwater, 2016;
- Sutton Floodplain Management Study and Plan (the FRMS&P) - WMAwater, 2016; and a
- Cumulative Impact Assessment – Lyall & Associates (April 2021).

The Flood Study produced a WBNM/DRAINS/TUFLOW hydrologic/hydraulic modelling system to model design flood behaviour for events ranging from the 0.2 EY to PMF. The modelling system was calibrated and verified to historic events and Flood Frequency Analysis. Council's Flood Study TUFLOW model has been used as the basis for flood investigatory works as part of this assessment.

The Sutton FRMS&P undertook to identify flood risk and develop amelioration strategies for the management of risk at Sutton. An outcome of the Management Study was the development of a Draft Flood Policy for inclusion into Council's DCP. Council use the Draft Flood Policy, in conjunction with the Yass Valley LEP (2013), as a guiding principle to assess the development of flood prone land.

The Draft Flood Policy and the Yass Valley Local Environment Plan (2013) have been considered in the context of potential future development.

Lyall & Associates were engaged by Council at the direction of DPIE to undertake a cumulative flood impact assessment for the Site and two other already approved planning proposals (Kier and Cartwright) near Sutton. The impact assessment incorporated the concept design presented herein into the Council Flood Study TUFLOW model and assessed the impacts of the three developments. The findings of this analysis found that "future development within Sutton would have only a minor impact on flood behaviour". This is an unsurprising result given the limited increase in impervious surface (<1%) relative to upstream catchment areas, and the fact that the concept design presented herein increases flood storage on the lower floodplain. The Lyall & Associates document is presented in Attachment A.

1.4 Terminology

1.4.1 Acronyms and Terminology

Table 2 presents a list of acronyms and terminology used in the report.

Table 2: List of Acronyms and Terminology

Abbreviation	Description
AEP	Annual Exceedance Probability (see Section 1.4.2)
AHD	Australian Height Datum – national surface level datum corresponding to mean sea level
ARI	Average Recurrence Interval (see Section 1.4.2)
ARR87	Australian Rainfall and Runoff 1987 Edition - is a national guideline document that is used for the estimation of design flood characteristics in Australia.
ARR2016	The latest revision of Australian Rainfall and Runoff.
Design Event	The current study has defined the 1% AEP event + 10% rainfall as the 'Design Event'.
Freeboard	Freeboard is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Typically set at 0.5 m for floor levels.
Hydraulic	Term given to the study of water flow; in particular, the evaluation of flow parameters such as water level and velocity.
Hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs.
Model	Computer model - The mathematical representation of the physical processes involved in runoff generation and flow. These models are run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
PMF	Probable Maximum Flood - The PMF is the largest flood that could conceivably occur at a particular location. The PMF defines the extent of flood prone land, that is, the floodplain. Generally, it is not physically or economically possible to provide complete protection against this event.
Probability	A statistical measure of the expected chance of flooding (see AEP).

1.4.2 Adopted Probability Terminology

Event probability is often described in terms of:

- *Annual Exceedance Probability (AEP) - the probability of an event being equalled or exceeded within a year; or*
- *Average Recurrence Interval (ARI) - the average time period between occurrences equalling or exceeding a given value.*

The current study has adopted the 'AEP' terminology when describing event probability as is recommended in the latest revision of Australian Rainfall and Runoff 2019 (ARR2019). The relationship between 'AEP' and 'ARI' is presented in Table 3.

Table 3: Relationship between AEP and ARI

AEP (%)	ARI (years)
10	10
5	20
2	50
1	100

2. FLOOD MODELLING

2.1 Introduction

Flood modelling as part of the planning proposal assessment has been undertaken by both GRC Hydro and Lyall & Associates. GRC Hydro updated the Sutton Flood Study TUFLOW model and modelled existing flood behaviour at the site for a range of design flood events. A 'proposed conditions' scenario was also modelled based on an indicative site layout/concept design presented in Section 1.2. Existing and Proposed Conditions flood behaviour and impacts are discussed in Sections 2.2 to 2.5. Separate to this work, Lyall & Associates were engaged by Council to undertake a cumulative impact assessment (Section 2.6). Dam breach and climate change assessments are presented in Sections 2.7 and 2.8.

2.2 Existing Conditions - Model Amendments

The Sutton Flood Study TUFLOW model has been used as the basis for flood investigatory works as part of this assessment. The following amendments to the model have been implemented to define a revised Existing Conditions scenario to better assess flood behaviour for the Site:

- Ground Level Survey – for the Site has been incorporated into the model where available. The survey was obtained by Diverse Project Solutions.
- Model Grid Resolution – has been increased from 5 m to 2.5 m to better define channel capacity and such that mitigation measures for the 'Proposed Conditions' scenario (see Section 2.3) could be better assessed.
- TUFLOW Version – has been updated from TUFLOW.2012-12-AD to TUFLOW.2020-01-AA to use the latest version of the TUFLOW as recommended by the software provider.
- Breaklines –for dams, drains, roads etc. were revised at the property and surrounding areas were updated based on available survey.
- Materials Layers – were refined based on the provided survey information to enhance definitions of vegetation.

Revised Existing Conditions results were compared to the Sutton Flood Study results and were noted to have not changed significantly (typically < 0.1 m change in flood level for the 1% AEP event).

A Proposed Conditions scenario was developed by modifying the Existing Conditions model to incorporate the concept design and flood mitigation works described in Sections 1.2 and 2.3.

2.3 Proposed Conditions - Concept Bulk Earthworks and Flood Mitigation

To reduce the extent of flooding affecting the Site, flood mitigation works were developed in conjunction with the concept design discussed in Section 1.2. These changes were incorporated into flood model to produce a Proposed Conditions scenario. These works/model changes are outlined below:

- Removal of farm dams- the removal of the dams on Yass River Tributary #4 was implemented to increase the capacity of this flow path and minimise flow breakouts;

- Swale and bund #1 – were implemented along Sutton Road to the north of the Site and used to divert flow north towards Yass River Tributary #4. The swale is required to have a capacity of ~0.7 m^3/s to convey the 1% AEP flow (approximate dimensions of 4m wide by 0.5m deep) and the bund of ~0.5m above existing ground;
- Swale and bund #2 - were implemented along Sutton Road to the south of the Site and used to divert flow south towards Mclaughlins Creek. The swale is required to have a capacity of ~0.8 m^3/s to convey the 1% AEP flow (approximate dimensions of 4m wide by 0.5m deep) and the bund of ~0.5m above existing ground;
- Bulk Earthworks – The concept bulk earthworks design (see Section 1.2) was developed to enhance conveyance/storage on the lower floodplain and raise areas of the outer floodplain. The concept design was developed from a flood management perspective and civil design is required during the DA and design phases of the project. The objective of the bulk earthworks was to ensure that both internal and external access roads for the site are situated outside of the PMF high hazard flood extent. The concept design was approximate cut/fill neutral (800 m^3 of fill surplus required on the outer floodplain).

The location of the proposed mitigation works is presented in Figures 3 to 6 and can be implemented to reduce the flood liability of the Site. Note that the provided dimensions are approximate only and required further design development/optimisation which will be undertaken at the development application stage.

The concept design on which the Proposed Conditions scenario is based, aims to maximise the lot yield whilst achieving the following flood management outcomes for the site:

- R2 zoning outside of FPA (5000 m^2) – 25 lots;
- E3 zoning within FPA (4 ha) – 4 lots (combined R2 and E3 with minimum size = 4 ha);
- R2 zoned land is situated outside of the FPA (Image 2)
- All lots are flood free in the 1% AEP event;
- All lots have 1000 m^2 building envelopes situated outside of high hazard PMF extent (Image 3);
- All internal roads are flood free in the 1% AEP event and situated outside of high hazard PMF extent (Image 3);
- All lots have space for effluent treatment areas outside of riparian buffers (Image 3);
- Approximately neutral cut and fill (800 m^3 fill surplus which can be re-examined during design);
- An increase in flood storage below the FPL (i.e. cut is focused in areas below the FPL with fill being moved to areas in the outer floodplain). See Image 4.

2.4 Flood Model Results

2.4.1 Existing Conditions Flood Characteristics

Existing Conditions flood depths, levels and hazard for the 1% event is presented in Figure 1. During the 1% AEP event, shallow flows breakout from the Yass River Tributary #4 affect the north of the property with depths up to 0.2 m for a 1% AEP event. The flow characteristics of these breakouts are classified as low hazard flood fringe based on the criteria outlined in the Sutton FRMSP. All areas of high hazard, flood storage or floodway occurs in the low lying areas of the Mclaughlins Creek floodplain and Yass River Tributary #4 channel. Pre and post development hydraulic categories are presented in Figure A01.

Figure 2 presents the PMF flood depths, levels and hazard. Much of the Site is affected by low hazard flooding, with high hazard flooding predominately affecting the Mclaughlins Creek floodplain and the Yass River Tributary #4 channel. The shallow flow breakouts from the Yass River Tributary #4 seen in the 1% AEP event increase in depth up to ~0.6 m and result in a band of high hazard flooding to the north of the property.

2.4.2 Proposed Conditions Flood Characteristics

The Proposed Conditions scenario results are presented in Figures 3 and 4 for the 1% AEP and PMF events respectively. The figures show that with implementation of the proposed works, the shallow overland flow breakouts from Yass River Tributary #4 are removed for events up to the 1% AEP and the majority of the Site is flood free during this event. Flooding still occurs in the low lying areas of the Mclaughlins Creek floodplain and Yass River Tributary #4 channel to the same extent as per Existing Conditions. Pre and post development hydraulic categories are presented in Figure A01.

Figure 4 shows the PMF flood depths and hazard for Proposed Conditions. With implementation of the concept bulk-earth works, the extent of high hazard flooding during the PMF is reduced. This allows internal access roads as well as all developable areas to be situated outside of the PMF high hazard flood extent.

2.5 Flood Impacts

The impact of the proposed mitigation works on peak flood levels is presented in Figure 5 for the 1% AEP events and Figure 6 for the PMF event. The maps show the change in peak flood level expected with implementation of the concept design and mitigation works.

The mapping shows that for the large areas of land that are no longer flood affected for events up to the 1% AEP event as well as a decrease in flood level in the Yass River Tributary #4, due to the removal of the farm dams. Slight increases in flood level are expected towards the downstream of the Yass River Tributary #4, however these increases are within the site and do not affect surrounding properties (see Figure 5). In the PMF event (see Figure 6), impacts are again noted along Yass River Tributary #4, with localised impacts (< 0.1 m) noted on Sutton Road to the west of the site, which could be further investigated at the DA stage.

2.6 Cumulative Impact Assessment (Lyall & Associates)

Lyall & Associates have undertaken a cumulative impact assessment of potential development at the site combined with two other already approved planning proposals (Kier and Cartwright) near Sutton. The assessment is presented in Attachment A. The assessment aimed to determine if future development could have a significant cumulative impact on flooding, for example by significantly increasing runoff rates due to an increase of impervious surfaces.

The Lyall & Associates assessment compared existing flood behaviour with a cumulative development model scenario of increased impervious areas across Sutton. The comparison found that "*future development within Sutton would have only a minor impact on flood behaviour*", and that "*areas where peak flood levels are shown to be increased are limited to areas which are presently undeveloped*" (Lyall & Associates email dated 21/4/21).

2.7 Dam Failure Assessment

The risk associated with failure of dams upstream of the site has been assessed. The analysis presented herein is not intended to be a complete dam breach assessment and instead aims to determine if more detailed analysis is warranted. The assessment is based on the procedures set out in "Predicting Peak Outflow from Breached Embankment Dams" (Pierce et. al., 2010) which presents an approach to estimating the geometric and temporal parameters of a dam breach. The method is based on case-study data which was used to develop empirical-regression relationships relating the peak discharge of the failed dam to the dam height and/or the reservoir-storage volume.

Six farm dams upstream of the site were identified, with all dams being located Mclaughlins Creek Tributary #2 (as defined in the Sutton Flood Study), between 1.1 to 2.3 km south of the site. The locations of the dams are presented in Image 5.

The current study analysis was undertaken for 'wet day' conditions which assumed that cascading dam failure for all six dams coincided with the 1% AEP flood peak. The dam heights and volumes were estimated from LiDAR. Estimation of the dam volume was problematic due to the LiDAR not penetrating the water surface level in the dam and survey was not available for a more detailed assessment. To account for the approximate nature of the assessment, two methods of estimating the dam volume were applied:

- Best Estimate – Volume = (1% AEP flood surface area x embankment height) / 4. This assumes that the dam geometry is approximately prismatic. The embankment height was taken at the downstream toe of the dam wall.
- Conservative Estimate – Volume = (1% AEP flood surface area x embankment height), Design Flow = 2.5 x the Pierce calculated flow. This estimate is highly conservative as it assumes that the internal dam walls are vertical thus greatly increasing the volume of the dam, and the flow estimate determined by the analysis was then multiplied by 2.5 which is the upper confidence estimate of the expected order of accuracy as defined by Pierce (2010).

The estimated characteristics of the dams are presented in Table 4, with the dam locations presented in Image 5.

Table 4: Dam and Breach Characteristics

#	Embankment Heigh (m)	Best Estimate Volume (m^3)	Best Estimate Peak Flow (m^3/s)	Conservative Estimate Volume (m^3)	Conservative Estimate Peak Flow (m^3/s)
1	2.7	5765	7	23060	33
2	2.8	5758	7	23032	34
3	4.4	13354	17	53416	84
4	1.1	2390	2	9560	8
5	1.8	3767	4	15067	17
6	2.1	3143	4	12570	19

Image 5: Mclaughlins Creek Tributary Dams

Using the dam volume and peak flow estimates for both scenarios, flow hydrographs which matched these characteristics were determined for application to the TUFLOW model. The flow hydrographs were applied to the TUFLOW model to coincide with the 1% AEP flood peak.

The results of the assessment are shown in Figure 7, which presents the increase in flood level and flow under both approaches. The increase is relative to the existing 1% AEP flood level which is assumed to coincide with the dam failure. As shown on the figure, the creek at the subject site will experience an increase of around 0.1-0.2 m under a dam failure scenario, using the Best Estimate approach, and this increases to around 0.4-0.6 m in the Conservative Estimate approach. The results show that the increase is relatively small and that proposed developable areas are unaffected by a dam failure upstream.

Based on the findings of this analysis, risk to the proposed development site due to dam failure is very low, and a full dam breach assessment is not warranted.

2.8 Climate Change Assessment

The impact of climate change on design flood behaviour has been assessed. Climate change may potentially result in increased rainfall intensity which can in turn increase the frequency and magnitude of flooding. Three climate change scenarios were modelled in the Sutton Flood Study (WMAwater, 2016), which were 1% AEP event with rainfall increases of 10%, 20% and 30%. The assessment found that the climate change scenarios caused negligible increases in peak flood level for areas of overland flow, and a minor increase in the Mclaughlins Creek level, at around 0.1-0.3 m. The sensitivity results from the Sutton Flood Study have been extracted at two locations near the subject site:

- 100 m upstream of Mclaughlins Creek causeway:
    - 0.07 m increase under 10% rainfall increase;
    - 0.13 m increase under 20% rainfall increase;
    - 0.20 m increase under 30% rainfall increase.
- Yass River upstream of Mclaughlins Creek confluence:
    - 0.13 m increase under 10% rainfall increase;
    - 0.24 m increase under 20% rainfall increase;
    - 0.33 m increase under 30% rainfall increase.

Subsequent to the flood study analysis, ARR2019 provides the estimated rainfall percentage increase under different emissions scenarios and planning horizons. In the long term (the year 2090), a moderate emissions scenario (RCP4.5 emissions scenario) is expected to increase rainfall intensity by 12%, and a high emissions scenario (RCP8.5) will increase it by 22%. This means that the 20% increase modelled by the flood study is considered conservative.

The results show that climate change is expected to cause a minor increase in flood level at the site. The increase is within the applied freeboard and will not change the flood risk for future development. Under a conservative rainfall increase, the flood level increase is still below the Flood Planning Level which includes 0.5 m freeboard.

3. FLOOD EVACUATION, ACCESS AND EGRESS

The planning proposal has been assessed in regard to evacuation and access during times of flood. Two potential risks have been identified:

- Flood Evacuation - during extreme events, areas of the development site may require evacuation. The concept design has placed all developable areas outside the PMF high hazard extent and approximately 2 m above the 1% AEP flood level. Evacuation of properties during a Yass River/Mclaughlins Creek extreme flood event would be associated an extremely low probability event approaching the magnitude of the PMF.
- Flood Access - The Sutton Road crossing of Mclaughlins Creek was noted in the Sutton FRMSP to be frequently flooded with the potential for risk for vehicles attempting to use the crossing during times of flood.

These two potential risks have been examined in the following sections.

3.1 Flood Evacuation

The concept design has been developed to ensure that all developable areas are situated above the Flood Planning Level and outside of the high hazard areas of the PMF (see Section 1.2). This significantly reduces the risk to residents and the impact on emergency services requirements. Notwithstanding, a residual risk remains during extreme events which has been considered through analysis of internal and external site access.

A requirement of future development of the site is that internal roads are flood free for events up to and including 1% AEP flood event, and situated outside of the PMF high hazard flood extent. This has been achieved by the concept design as presented in Figures 3 and 4. During the PMF event some areas of the Mclaughlins Creek floodplain are subject to high hazard flood conditions, however, significant areas of the Site are not mainstream flood affected.

Areas outside of the Mclaughlins Creek floodplain are affected by shallow overland flows during the PMF, which originate from the YRT4 breakout. The concept design was developed to ensure that the internal access roads provide access to flood free areas or areas of low flood hazard. The duration of these overland flows is short (typically less than 1 hour) due to the small upstream catchment area and refuge can be sought in these areas if required (see Figure 4). Appropriate design of access roads and a lot configuration which is sympathetic to the flood risk, can be implemented to allow Rising Road/Overland Escape access for future lots. The concept lot configuration achieves these objectives.

In summary, the concept design manages flood risk though an internal site access design which results in:

- All developable areas are outside the PMF high hazard extent and approximately 2 m above the 1% AEP flood level. Evacuation during a Yass River/Mclaughlins Creek extreme flood event would be associated an extremely low probability event;

- Internal access roads are situated above the 1% AEP flood level and outside of the PMF high hazard flood extent. These roads provide low hazard flood access to Sutton Road as well as areas of refuge outside of the mainstream PMF extent (see Figure 3 and 4);
- Road design can be developed to ensure that Rising Road access is available for all future lots.

Implementation of the above-described outcomes of the concept design manage the residual flood risk associated with extreme flooding of the site.

3.2 Flood Access

The site will be linked to the existing road network via Sutton Road. From Sutton Road, the township of Sutton is around 300 m to the south-east. Continuing on Sutton Road through Sutton leads to the Federal Highway and Canberra, around 20 km away. In the other direction, Sutton Road leads to the town of Gundaroo, around 15 km to the north.

Access from the Site to Sutton and Canberra may be impacted due to flooding of the Sutton Road crossing of Mclaughlins Creek. The road crosses the creek with a low crossing just prior to entering the town. Relatively frequent flood events inundate the crossing and cut-off road access at that location. Flooding of this crossing is also noted to impact on access for Gundaroo residents. The crossing is identified as a flood risk area in the Sutton FRMS&P due to frequent overtopping and as such a bridge crossing at Mclaughlins Creek was recommended, with 'High Priority' for implementation. Other risk management measures are also recommended to manage flood risk at the crossing including flood warning signage and automatic boom gates.

Due to the 'High Priority' classification of these risk management measures in the Floodplain Management Plan, it is expected that the crossing or other mentioned risk management measures will be implemented in the near future. High priority measures are typically implemented in the short term (e.g. 2-5 years) and council has a responsibility to implement these measures after a Plan is adopted. Implementation of these measures will reduce the risk associated with flooding of this crossing.

In comparison, the planning proposal for the subject site is only for re-zoning of the site and a subsequent development application, and then construction of houses and sale of the land, will occur before the site is occupied. Given the typical timeframes associated with this process, it is reasonable to assume the Sutton Road crossing of Mclaughlins Creek will be upgraded, or other risk management measures detailed in the Plan implemented, before the site is occupied. In the unlikely scenario that this does not happen, there are alternative access routes to the site (see Section 3.2.1). It is also re-iterated that in the vast majority of flood events, the site will not need to evacuate or require any other particular assistance, and areas of refuge outside of the high hazard areas of the PMF are available if evacuation is required.

3.2.1 Alternate Access Routes

Canberra is the main population centre in the area and is relied on for provision of services such as health care. There are three possible access routes to Canberra from the subject site:

1. North on Sutton Road then east on Shingle Hill Way and then west on the Federal Highway that enters Canberra;
2. North on Sutton Road then west on Mulligans Flat Road which enters Canberra in its northern suburb of Bonner; and
3. South on Sutton Road then west on the Federal Highway that enters Canberra.

The location of these three routes is shown on Image 6. As described, Route 3 is the preferred route which is used in non-flood conditions. The other routes can be used during times of flood and have recently completed or will be imminently undertaking bridge crossing works to improve flood access:

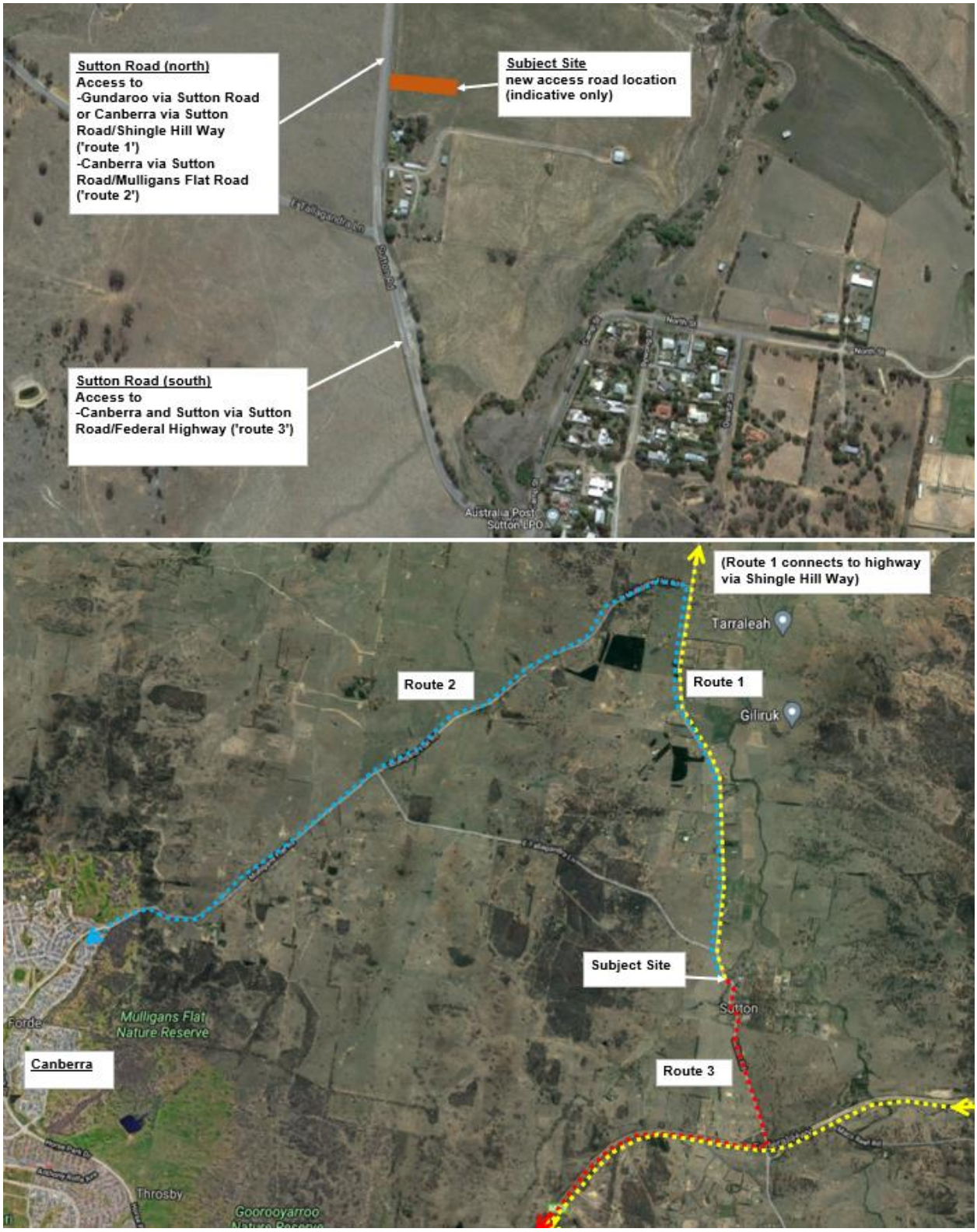
1. Mulligans Flat Road - Council have upgraded the road and creek crossing of Back Creek to provide flood protection up to the 5% AEP (Flood Study Investigation for the Mulligans Flat Road Bridge Over Back Creek, Jones Nicholson Consulting Engineering on behalf of Yass Valley Council, October 2018);
2. Shingle Hill Way - Council are in the process of upgrading the road with the new design providing flood protection up the 0.05% AEP (Shingle Hill Way Bridge Design Report, SMEC, 2021).

Use of these roads during times of flood can provide flood access to Canberra under most weather conditions. In addition to Canberra, Gundaroo can be accessed during an emergency, via Sutton Road.

Whilst flooding of the Sutton Road crossing of Mclaughlins Creek can temporarily result in reduced flood access, overall the site does not have significant access issues during times of flood. A summary risks associated with the site's flood access is outlined below:

- Implementation of the concept design (Section 1.2) results in an extremely low probability that evacuation of dwellings would be required.
- The site's internal access roads can be designed to ensure they have rising road access and are situated outside of the PMF high hazard flood extent to manage the residual flood risk.
- Three routes are available between the site and Canberra, with two of the routes providing flood access.
- Various risk management measures are recommended in the Sutton Floodplain Risk Management Plan with 'High Priority' to manage the risk of the Sutton Road crossing of Mclaughlins Creek. Council is required to implement these measures and it is likely that they will be implanted prior to the site being occupied.
- In considering re-zoning of the site, it was also noted that multiple new approved developments currently underway in Gundaroo face similar access constraints in extreme flood events.

Image 6: Access Routes to Canberra



4. STATE PLANNING POLICY

4.1 Overview of Relevant Planning Policy

The Section 9.1 Direction 4.3 Flood Prone Land directive *'applies when a relevant planning authority prepares a planning proposal that creates, removes or alters a zone or a provision that affects flood prone land'*. The Direction aims to ensure that '*the development of flood prone land is consistent with NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005'* (FDM, 2005), including the principles of Planning Circular PS 07-003, '*Guideline on development controls on low risk flood areas'*.

The FDM (2005) *'promotes the use of a merit approach which balances social, economic, environmental and flood risk parameters to determine whether particular development or use of the floodplain is appropriate and sustainable'* and aims to *'avoid the unnecessary sterilisation of flood prone land'*.

Direction 4.3 states that *'a planning proposal must not impose flood related development controls above the residential flood planning level for residential development on land, unless a relevant planning authority provides adequate justification for those controls to the satisfaction of the Director-General'* and that a *'planning authority must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005'*.

Direction 4.3 states that, *'a planning proposal may be inconsistent with this direction only if the relevant planning authority can satisfy the Director-General (or an officer of the Department nominated by the Director-General) that'*, *'the planning proposal is in accordance with a floodplain risk management plan prepared in accordance with the principles and guidelines of the Floodplain Development Manual 2005*'.

Planning Circular PS 07-003, 'Guideline on development controls on low risk flood areas' outlines a set of guidelines for *'flood-related development controls on residential development on land above the 1-in-100 year flood and up to the Probable Maximum Flood (PMF)'*. The Guideline confirms that:

- *'unless there are exceptional circumstances, councils should adopt the 100-year flood as the FPL for residential development; and*
- *unless there are exceptional circumstances, councils should not impose flood related development controls on residential development on land above the residential FPL.'*

The site is within the Sutton Floodplain Management Study and Plan (the FRMS&P) study area. The FRMSP was reviewed and found to have a recommendation for applying for exceptional circumstances. The recommendation was to implement a Flood Risk Management clause into the LEP so that controls for sensitive and critical uses can be applied for areas above the FPL up to the PMF. The FRMSP does not suggest that additional exceptional circumstances are applied for residential development and as such the proposal is consistent with the recommendations presented in Council's floodplain risk management study.

Further to this, Section 6.2 'Flood Planning', of the Yass Valley Local Environmental Plan 2013 (YVLEP), *'applies to land at or below the flood planning level'* with *'the flood planning level'* classified as the *'1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard'*.

Accordingly, assessment of the 2402 Sutton Road Planning Proposal must necessarily have consideration for the nominated flood planning level of the '*1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard'* as per Council's LEP and the requirements of the Section 9.1 of Direction 4.3.

4.2 Recent Policy Updates

In June 2020, the Department of Planning, Infrastructure & Environment (DPIE) exhibited a draft Flood Prone Land Package which includes a draft Local Planning Direction and a draft Planning Guideline for the consideration of flooding in land use.

The draft Local Planning Direction prescribes, inter alia, that land should not be rezoned to permit development in a floodway, or development that will result in significant flood impacts to other properties or which permits a significant increase in the dwelling density in a high hazard areas. Further, the Direction requires that a council's Flood Planning Level(s) must be consistent with the Floodplain Development Manual 2005 (or its update) or as otherwise determined by an adopted Floodplain Risk Management Study.

It is noted that the site experiences limited flood liability in the 1% AEP and development is not proposed within a floodway or high hazard area during Council's nominated design flood event.

The draft Planning Guideline reinforces the purpose and usefulness of a flood risk management (FRM) process to understand the implication of flood events, up to and including the PMF, in considering the development of flood-prone land. The Guideline nominates the 1% AEP flood event (plus freeboard) as the appropriate flood planning level and the area of land beneath this level as the Flood Planning Area (FPA), where the majority of flood-related development controls apply. The Guideline allows Councils to set a different FPL where the merit of such an approach is demonstrated and documented.

The Guideline also identifies other categories of flood management – a Regional Evacuation Consideration Area (RECA) and a Special Flood Considerations (SFC) category – these allow for areas of land to be identified for special evacuation consideration and/or for specific controls to be developed for flood events between the FPL and the PMF. These typically relate to the identification and prohibition of sensitive, vulnerable or critical land uses. The Guideline suggests that circumstances defined through an FRM process where development controls might be needed to address risk to life may include areas where development is isolated by floodwaters and terrain for an extended period, areas where development may have evacuation capacity limitations and areas impacted by high hazard in the PMF and are unable to safely evacuate. The duration of flooding affecting the site is short (hours rather than days) and the intent of the concept design is that all internal access roads and developable areas are situated outside of the PMF high hazard flood extent. A such, the planning proposal is consistent with these objectives.

In the subject case Council's FPL remains at the 1% AEP + 500mm freeboard level and no action has been taken thus far, or suggested to be taken, to nominate the Sutton Road site as a Regional Evacuation Consideration Area (RECA). Similarly, there is no policy direction from Council that requires special consideration of events rarer than the FPA.

Notwithstanding, for the subject site and for the purpose of advancing agency consideration of the 2402 Sutton Road Planning Proposal, additional consideration of flood risk due to flood events exceeding the flood planning level is prudent given the magnitude of Mclaughlins Creek flooding for areas of the site during extreme events.

4.3 Consideration of Section 9.1 Direction 4.3

The pertinent aspects of Section 9.1 Direction 4.3 are reproduced below and addressed in blue.

The direction requires that:

- *A planning proposal must include provisions that give effect to and are consistent with the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas).*

Response:

Consideration of flood events up to the PMF, including flood hazard and flood function classification, has been undertaken. Further, site access and the potential for isolation and emergency vehicle access issues are considered. The analysis and findings are consistent with the objectives of the Floodplain Development Manual 2005.

- *A planning proposal must not rezone land within the flood planning areas from Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zones to a Residential, Business, Industrial, Special Use or Special Purpose Zone.*

Response:

The Planning Proposal is for a site that has minimal flooding but does contain areas of significant flood risk, below the Flood Planning Level. The re-zoning seeks to have R2 zoning outside of the Flood Planning Area (5000 m^2) and E3 zoning within the FPA (2.5 ha). The planning proposal is this consistent with these objectives.

- *A planning proposal must not contain provisions that apply to the flood planning areas which:*
  - *i. permit development in floodway areas,*
  - *ii. permit development that will result in significant flood impacts to other properties,*
  - *iii. permit a significant increase in the development of that land,*
  - *iv. are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services, or*
  - *v. permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, buildings or structures in floodways or high hazard areas), roads or exempt development.*

Response:

The indicative lot layout produced for the site shows that all lots have sufficient space outside of floodway areas for development. Flood impact analysis and the cumulative impact assessment shows that the development will not result in significant flood impacts to other properties. Limited flood liability of

developable areas will mean the design can incorporate the flood risk at the site and not require government spending on mitigation measures. The site will have low hazard flow and rising road access to a main road (Sutton Road) in events up and including the PMF. Road upgrade works in the LGA (which are not a result of the proposed development) are expected in the short to medium term, to provide flood access from the site to Sutton and Canberra. This is expected to occur prior to development of the site. This will ensure there is not increased requirement for emergency services.

- *A planning proposal must not impose flood related development controls above the residential flood planning level for residential development on land, unless a relevant planning authority provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).*
- *For the purposes of a planning proposal, a relevant planning authority must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas) unless a relevant planning authority provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).*

Response:

The Planning Proposal has consideration for the nominated flood planning level of the '1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard' as per Council's LEP. Land below this level is not proposed to be developed. This flood planning level is consistent with the FDM (2005).

5. COUNCIL PLANNING POLICY

5.1 Policy Overview

The Flood Study indicates that the proposed Site is situated within the interim Sutton Flood Planning Area (FPA). Accordingly, the Site is tagged as a flood control lot and is subject to flood related development controls. Flood related development controls are implemented through various flood controls described in the:

- Yass Valley Local Environmental Plan (YVLEP, 2013); and the
- Draft flood policy as presented in Appendix C of the Sutton FRSM&P.

The Draft Flood Policy provides detailed planning and design guidelines to support the planning controls in the YVLEP (2013). Compliance with the Draft Flood Policy indicates compliance with the relevant portions of the YVLEP (2013).

5.2 Yass Valley Draft Flood Policy

The Draft Flood Policy presented in the Sutton FRMS&P holds statutory weight and follows the Flood Risk Precinct approach to flood planning. The Flood Risk Precinct method identifies and utilised the idea that the floodplain is subject to different degrees of hazard, or flood risk.

Proposed conditions Flood Risk Precincts for the Site can be interpreted by review of the 1% AEP flood hazard and PMF extent. The Flood Risk Precincts for both pre and post development are presented in Figure A02. The majority of the Site is noted to be classified as Low Flood Risk, however areas of Medium and High Flood Risk are expected within the Mclaughlins Creek lower floodplain

and Yass River Tributary #4 channel. The various risk exposure types have been considered for pertinent affected areas. Examination of the matrix presented in Appendix C of the FRMS&P (reproduced below as Table 3) indicates which planning controls to future development.

Table 5: Flood Risk Matrix (Appendix C, Schedule 2 of the FRMS&P)

Flood Risk Category	Land Use Risk Category	Planning Controls						
		Floor Level	Building Components	Structural Soundness	Flood Effects	Evacuation / Access	Management & Design	Parking & Driveway Access
Low Flood Risk	Critical Uses & Facilities							
	Sensitive Uses & Facilities	3	2	2	1,2	1,2,3	4,5	1,3,5,6,7
	Subdivision				3			
	Residential	2			3	1,2		9
	Commercial & Industrial	5			3	1,2		9
	Recreation & Non-urban	1			3	2,3		9
	Alterations and additions	4			3	2		9
Medium Flood Risk	Critical Uses & Facilities							
	Sensitive Uses & Facilities							
	Subdivision				1,2		1	1,3,5,6,7
	Residential	2	1	1	1,2	2		1,3,5,6,7
	Commercial or Industrial	5	1	1	1,2	1,2	2,3,5	1,3,5,6,7
	Recreation or Non-urban	1	1	1	1,2	2,3	2,3,5	2,4,6,7
	Alterations and additions	4	1	1	1,2	3	2,3,5	6,7,8
High Flood Risk	Critical Uses & Facilities							
	Sensitive Uses & Facilities							
	Subdivision							
	Residential							
	Commercial or Industrial							
	Recreation or Non-urban	1	1	1	1,2	2,3	2,3,5	2,4,6,7
	Alterations and additions	4	1	1	1,2	2	2,3,5	6,7,8

Potentially Unsuitable Land Use Not Relevant

Application of the applicable planning controls for a future subdivision can manage the flood risk of the Site. Note that the Site is largely situated outside of High and Medium Flood Risk areas, with appropriate lot configuration and zoning it is possible to allow for development outside of the Medium and High Hazard areas. The following lot configuration is proposed:

- R2 Low Density Residential - zoned lots are situated in the Low Flood Risk areas only (see Figure A02). This will position them outside of the 1% AEP flood extent. However, application of flood planning controls is recommended for properties situated within the Existing Conditions 1% AEP flood extent to manage residual flood risk and/or failure of proposed flood mitigation works discussed in Section 2.3.
- E4 Environmental Living- zoned lots can be situated within the Medium and High Flood Risk precincts, however each lot is required to have sufficient room outside of these areas for future development and wastewater treatment.

Configuration of the lot layout to adhere to the above criteria would result in all proposed development being located in the Low Flood Risk Precinct, which is suitable for residential development types.

6. CONCLUSIONS AND RECOMMENDATIONS

This report has been prepared by GRC Hydro Pty Ltd on behalf of Sutton Lodge for submission of a planning proposal for 2402 Sutton Road, Sutton. The planning proposal aims to rezone currently zoned RU1 Primary Production land to R2 Low Density Residential and E3 Environmental Living to facilitate future development. The report addresses Section 9.1 Direction 4.3 Flood Prone Land requirements and has assessed the suitability of the site for rezoning and future development.

Flood modelling has been undertaken by GRC Hydro using the Sutton Flood Study (WMAwater, 2016) TUFLOW model as a basis for the modelling analysis. Council also engaged Lyall & Associates to undertake a cumulative impact assessment of the developed and two already approved developments (Keir and Cartwright).

A concept design which presents an indicative site configuration has been developed to show how future development of the site can occur in a manner consistent with the requirements of Section 9.1 Direction 4.3. Key findings of the assessment include:

- For Existing Conditions:
    - The majority of the site is not mainstream flood affected during the 1% AEP event. During this event, shallow flows breakout from a tributary to the north of the properties with depths up to 0.2 m experienced. With the exception of the creek channels, flow conditions are low hazard and classified as flood fringe;
    - A significant portion of the site (~60%) is mainstream flood affected during the PMF by high hazard flow conditions. The remaining areas of the site are not mainstream flood affected, however, do experience generally shallow overland flows which breakout from the above-mentioned northern tributary. There areas are typically affected by low hazard flow conditions.
- Implementation of the concept design resulted in:
    - Developable areas of the site to be flood free during the 1% AEP event;
    - All internal access roads to be situated outside of the PMF high hazard flood extent;
- Flood impact analysis found that negligible flood impacts are expected in the 1% AEP and PMF events due to the development. A cumulative impact assessment undertaken by Lyall & Associates confirmed these findings as well as confirming that "*future development within Sutton would have only a minor impact on flood behaviour*";
- A dam breach analysis study found that the risk to future development at the site due to dam failure is very low, with developable areas of the site being situated above a conservatively derived dam breach water level. The analysis found that a full dam breach assessment for the site is not warranted.
- The impact of climate change on peak flood levels affecting the site was found to minor, with projected increases in 1% AEP flood levels of ~0.2 m expected for the 2090 planning horizon. This is below the Flood Planning Level which is the 1% AEP flood level + 0.5 m freeboard;
- Flood evacuation has been considered with the following findings:
    - Implementation of the concept design results in all developable areas being situated outside the PMF high hazard extent and approximately 2 m above the 1% AEP flood

level. Evacuation during a Yass River/Mclaughlins Creek extreme flood event would be associated an extremely low probability of occurrence;
    - Internal access roads are situated above the 1% AEP flood level and outside of the PMF high hazard flood extent. These roads provide low hazard flood access to Sutton Road as well as areas of refuge outside of the mainstream PMF extent (see Figure 3 and 4);
    - Road design can be developed to ensure that Rising Road access is available for all future lots.
- The site's flood access has been reviewed with the following findings:
    - Access from the Site to Sutton and Canberra may be impacted due to flooding of the Sutton Road crossing of Mclaughlins Creek. Relatively frequent flood events inundate the crossing and cut-off road access at that location.
    - The crossing is identified as a flood risk area in the Sutton FRMS&P. Several flood risk management measures which aim to manage the risk of flooding of the crossing are identified in the Sutton Floodplain Risk Management Plan with 'High Priority' for implementation. These measures include replacement of the current crossing with a bridge as well as flood warning signage and automatic boom gates. Council has a responsibility to implement these measures as the Plan has been adopted.
    - Due to the 'High Priority' classification of these risk management measures in the Floodplain Management Plan, it is expected that the crossing or other mentioned risk management measures will be implemented in the short term (e.g. 2-5 years), prior to the site being occupied. Implementation of these measures will reduce the risk associated with flooding of this crossing.
    - Two alternate flood access routes have been identified at Mulligans Flat Road and Shingle Hill Way. New bridge crossings of major watercourses on these access routes will allow for 5% and 0.05% AEP flood access respectively. Use of these roads during times of flood can provide flood access to Canberra under most weather conditions. In addition to Canberra, Gundaroo can be accessed during an emergency, via Sutton Road.

The flood and risk characteristics described above have been considered when addressing Section 9.1 Direction 4.3 Flood Prone Land directives. The analysis has found that rezoning of the site is consistent with the requirements of directives if the following design requirements are adhered to during future development of the site:

- Land within the Flood Planning Area is rezoned as E3 Environmental Living, with areas outside of the Flood Planning Area zoned to R2 Low Density Residential. Sufficient space for development of all lots is required outside of the Flood Planning Area;
- Development of the site is to achieve, at a minimum, the flooding outcomes described in this report;
- Bulk earthworks should result in an approximately neutral cut/fill ratio within the FPA to minimise loss of flood storage.
- Internal roads are to be designed to allow for flood free Rising Road access in the 1% AEP event and situated outside of the PMF high hazard flood extent.

7. REFERENCES

WMAwater
1. Sutton Flood Study
Yass Valley Council, 2016

WMAwater
2. Sutton Floodplain Risk Management Study and Plan
Yass Valley Council, 2016

BMT WBM
3. TUFLOW User Manual - Build 2016-03-AA
TUFLOW, 2016

FIGURES

Cadastral Boundaries

Flood Level (mAHD) - Major Contour (Spacing = 1.0 m)

Flood Level (mAHD) - Minor Contour (Spacing = 0.2 m)

0 500

metres

Flood Depth (m)

0.0 to 0.15	0.5 to 1.0
0.15 to 0.3	1.0 to 2.0
0.3 to 0.5	> 2.0

Hazard Category

- High Hazard
- Low Hazard

N W E S

grc HYDRO

TITLE :	PROJECT	PROJECT No.	DATE:	SCALE:	FIGURE NUMBER:
Existing Conditions - 1% AEP event flood depths and levels (left pane) and hazard maps (right pane)	**2402 Sutton Road Planning Proposal**	**200023**	**December 2020**	**1:5,000**	**01**

Cadastral Boundaries

Flood Level (mAHD) - Major Contour (Spacing = 1.0 m)

Flood Level (mAHD) - Minor Contour (Spacing = 0.2 m)

0 500

meters

Flood Depth (m)

0.0 to 0.15

0.15 to 0.3

0.3 to 0.5

0.5 to 1.0

1.0 to 2.0

> 2.0

Hazard Category

High Hazard

Low Hazard

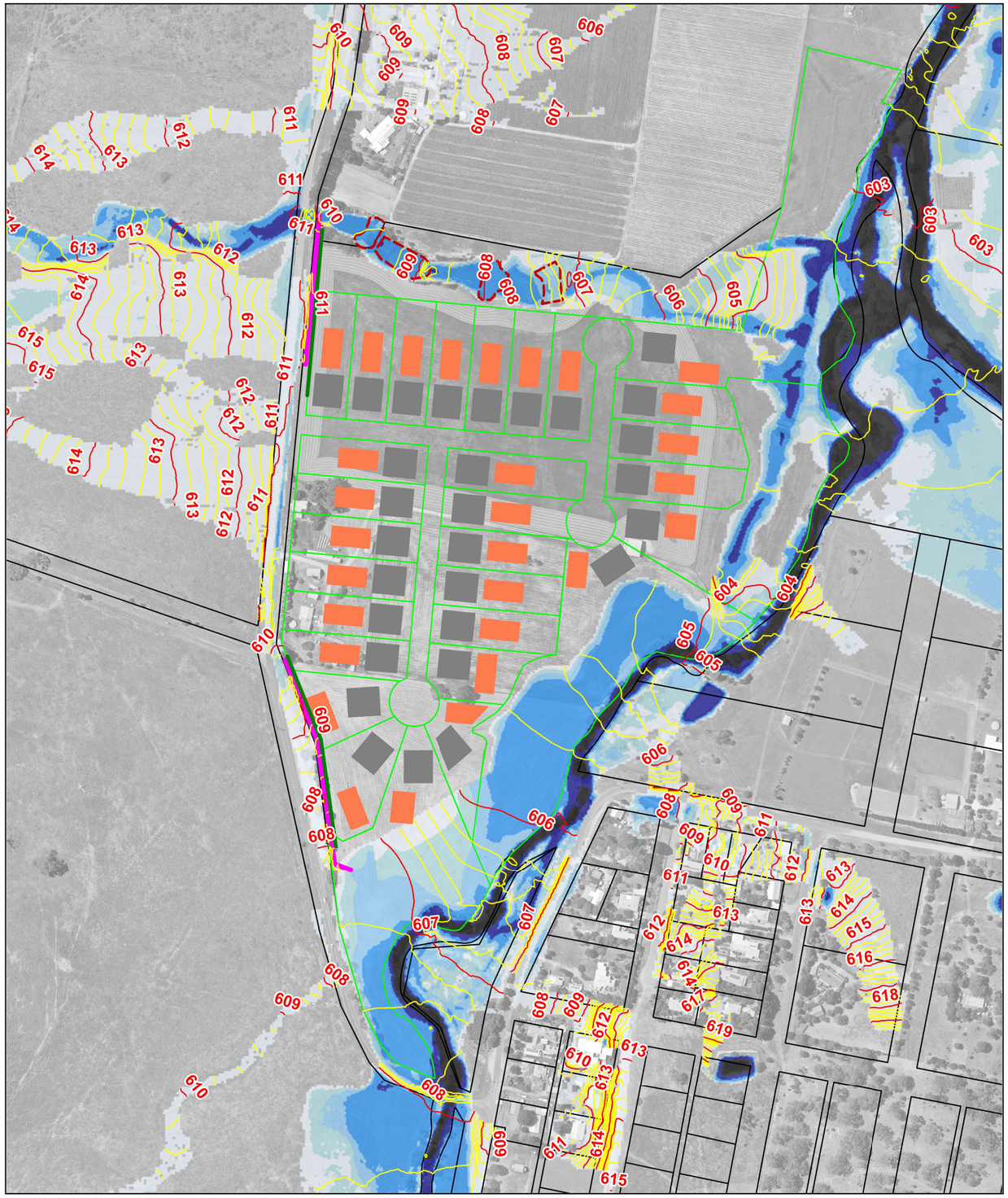
N

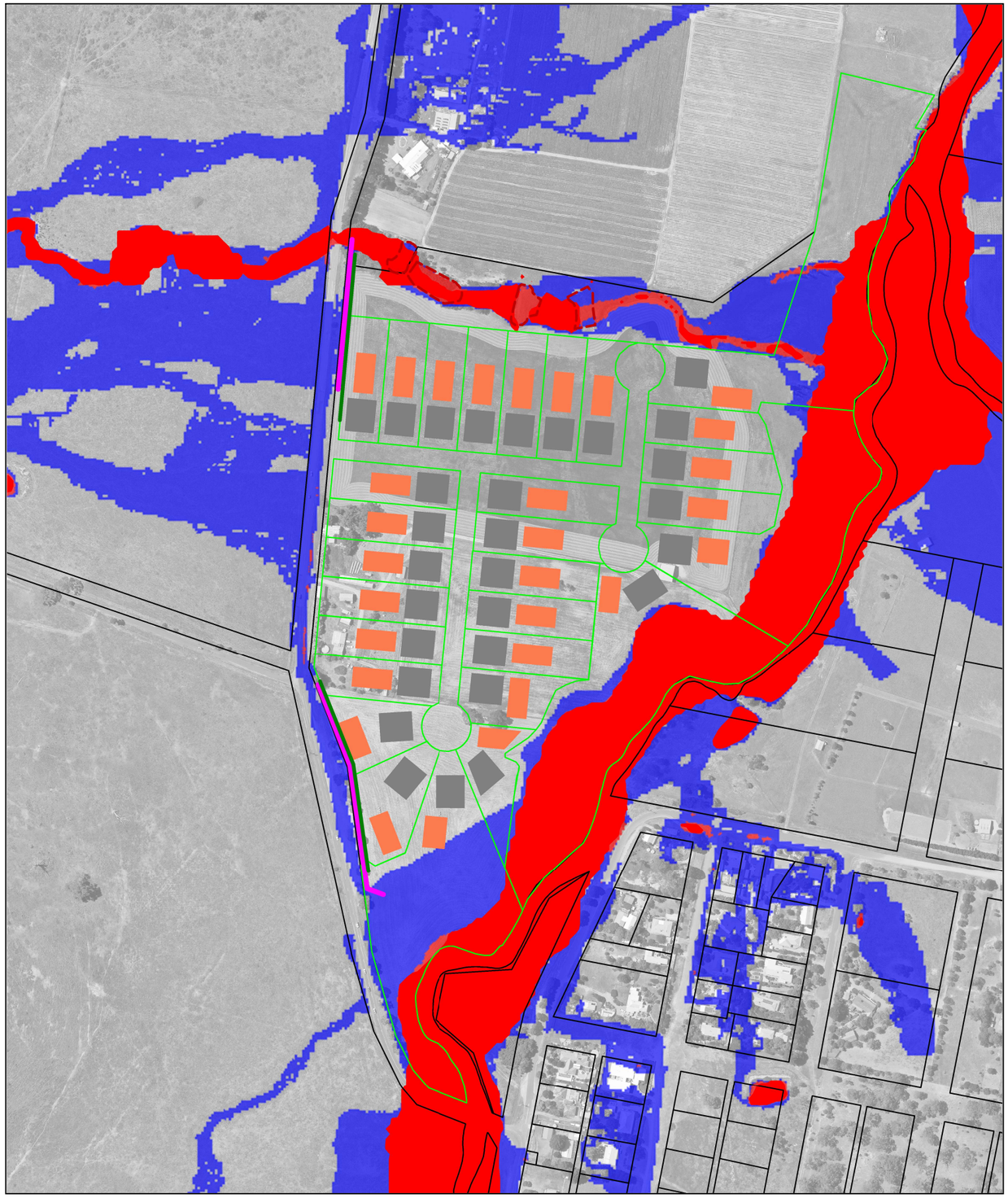
W E

S

grc HYDRO

TITLE : **Existing Conditions - PMF event flood depths and levels (left pane) and hazard maps (right pane)**	PROJECT: **2402 Sutton Road Planning Proposal**	PROJECT No. **200023**	DATE: **December 2020**	SCALE: **1:5,000**	FIGURE NUMBER: **02**





Cadastral Boundaries

Removed Dams

Bund

Flood Level (mAHD) - Major Contour (Spacing = 1.0m)

Flood Level (mAHD) - Minor Contour (Spacing = 0.2m)

Swale

Line

Proposed Lot Layout Building Envelope

Effluent Area

Flood Depth (m)

0.0 to 0.15

0.15 to 0.3

0.3 to 0.5

0.5 to 1.0

1.0 to 2.0

> 2.0

Hazard Category

High Hazard

Low Hazard

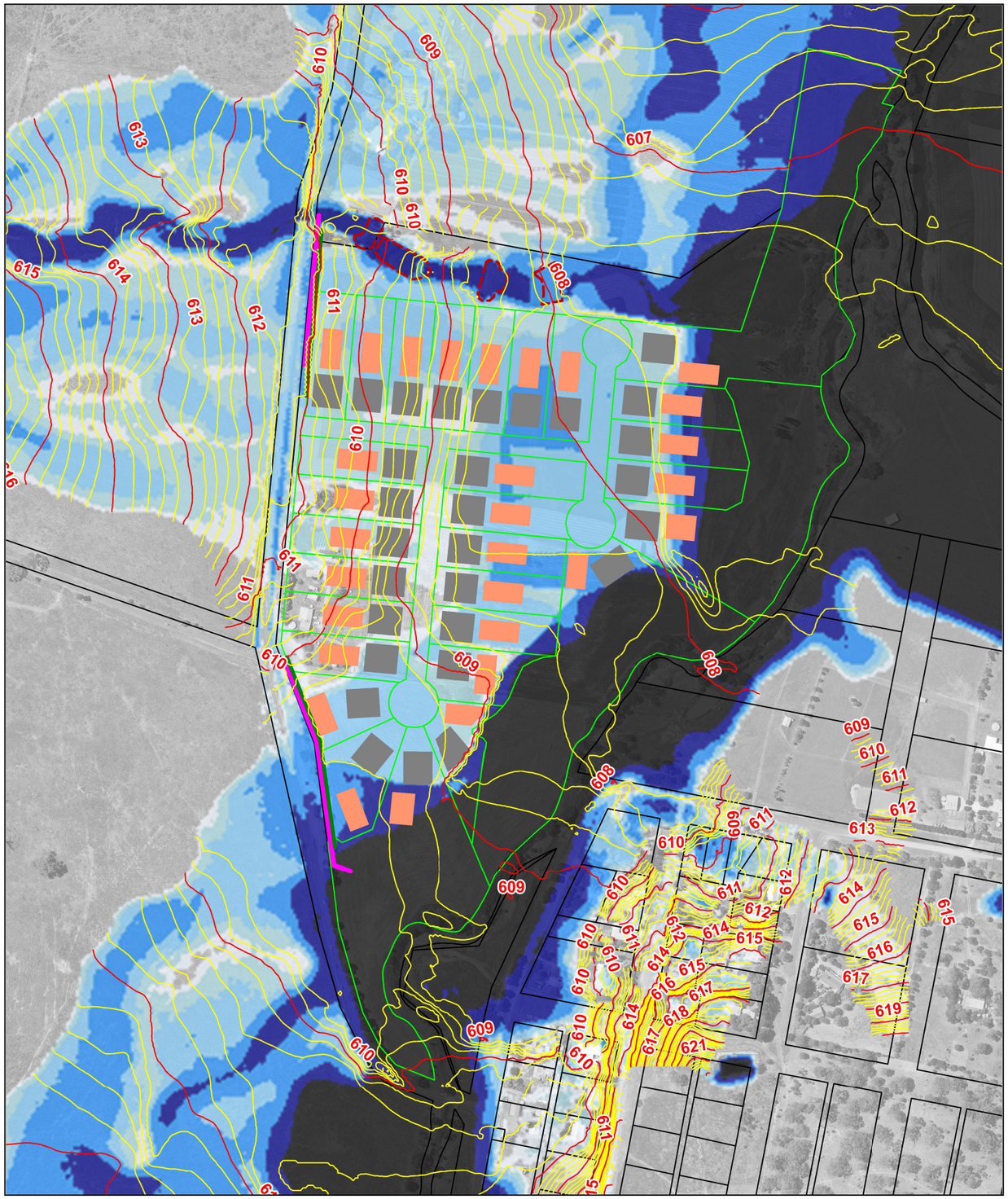
N

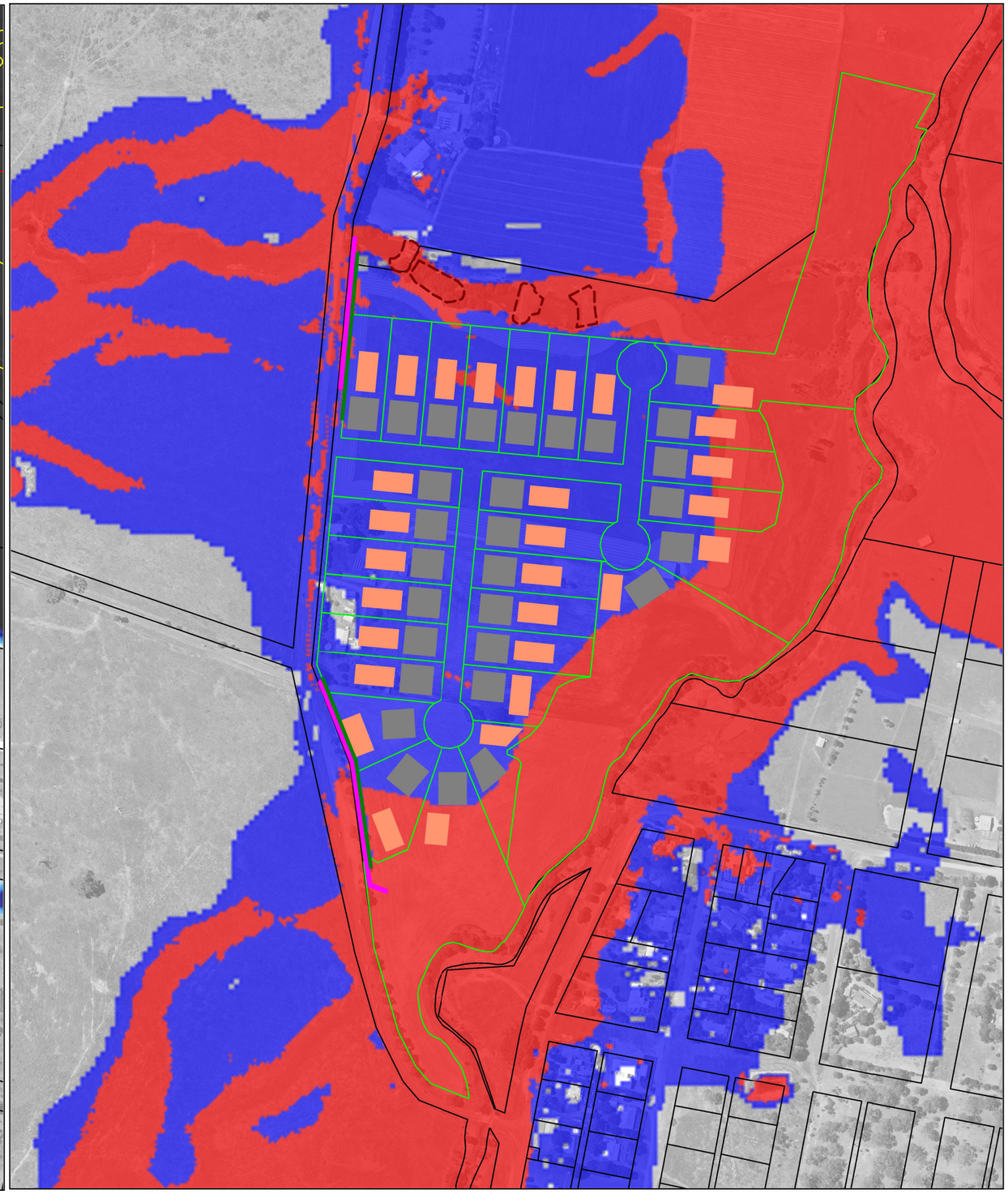
W E

S

grc HYDRO

TITLE :	PROJECT	PROJECT No.	DATE:	SCALE:	FIGURE NUMBER:
1% AEP Peak Flood Depths, Levels, and Hazard Proposed Conditions	**2402 Sutton Road Planning Proposal**	**200023**	**December 2020**	**1:5,000**	**03**





Cadastral Boundaries

Removed Dams

Bund

Flood Level (mAHD) - Major Contour (Spacing = 1.0m)

Flood Level (mAHD) - Minor Contour (Spacing = 0.2m)

Swale

Proposed Lot Layout

Building envelope

Effluent Area

0 500

metres

Flood Depth (m)

0.0 to 0.15		0.5 to 1.0	
0.15 to 0.3		1.0 to 2.0	
0.3 to 0.5		> 2.0	

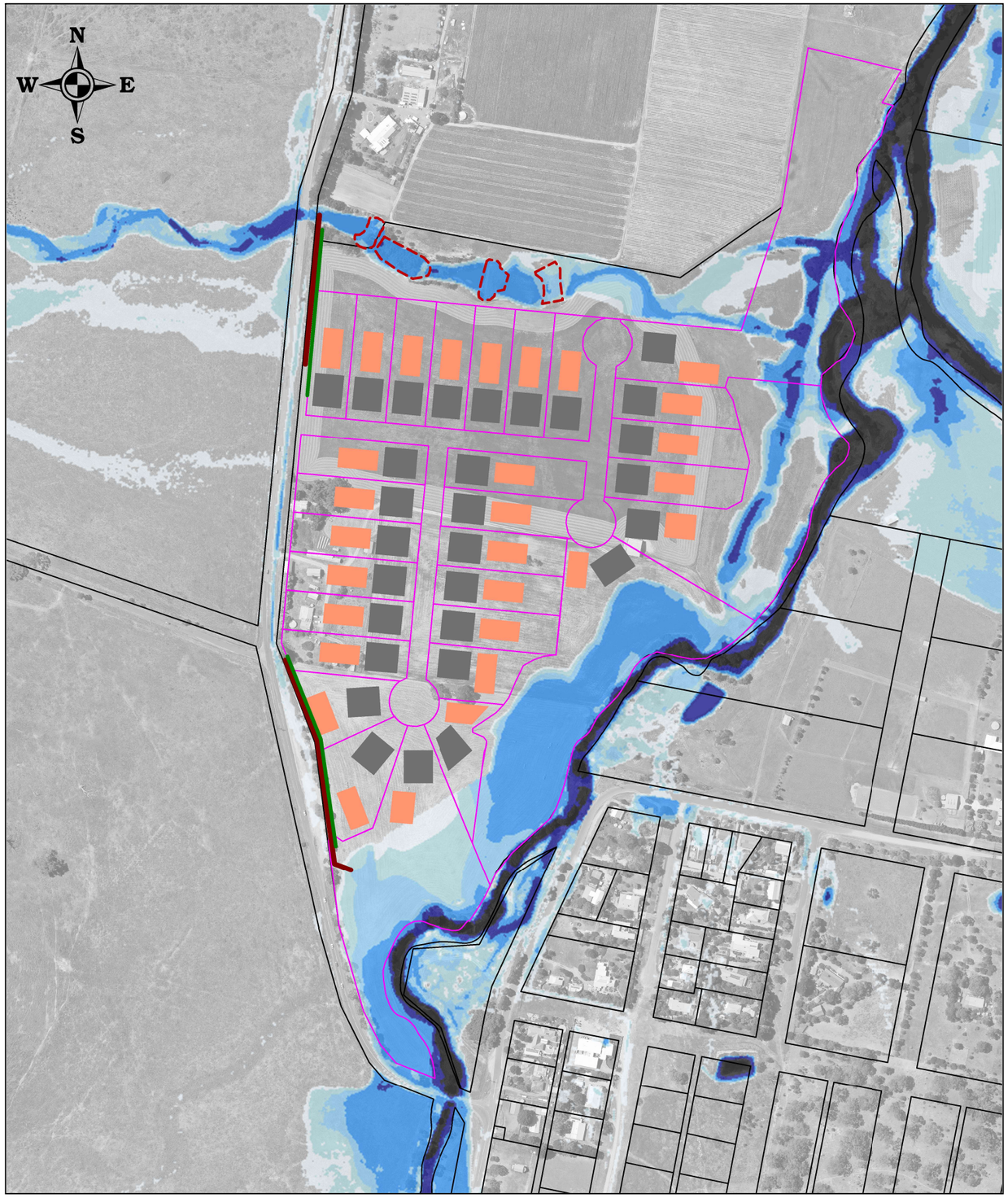
Hazard Category

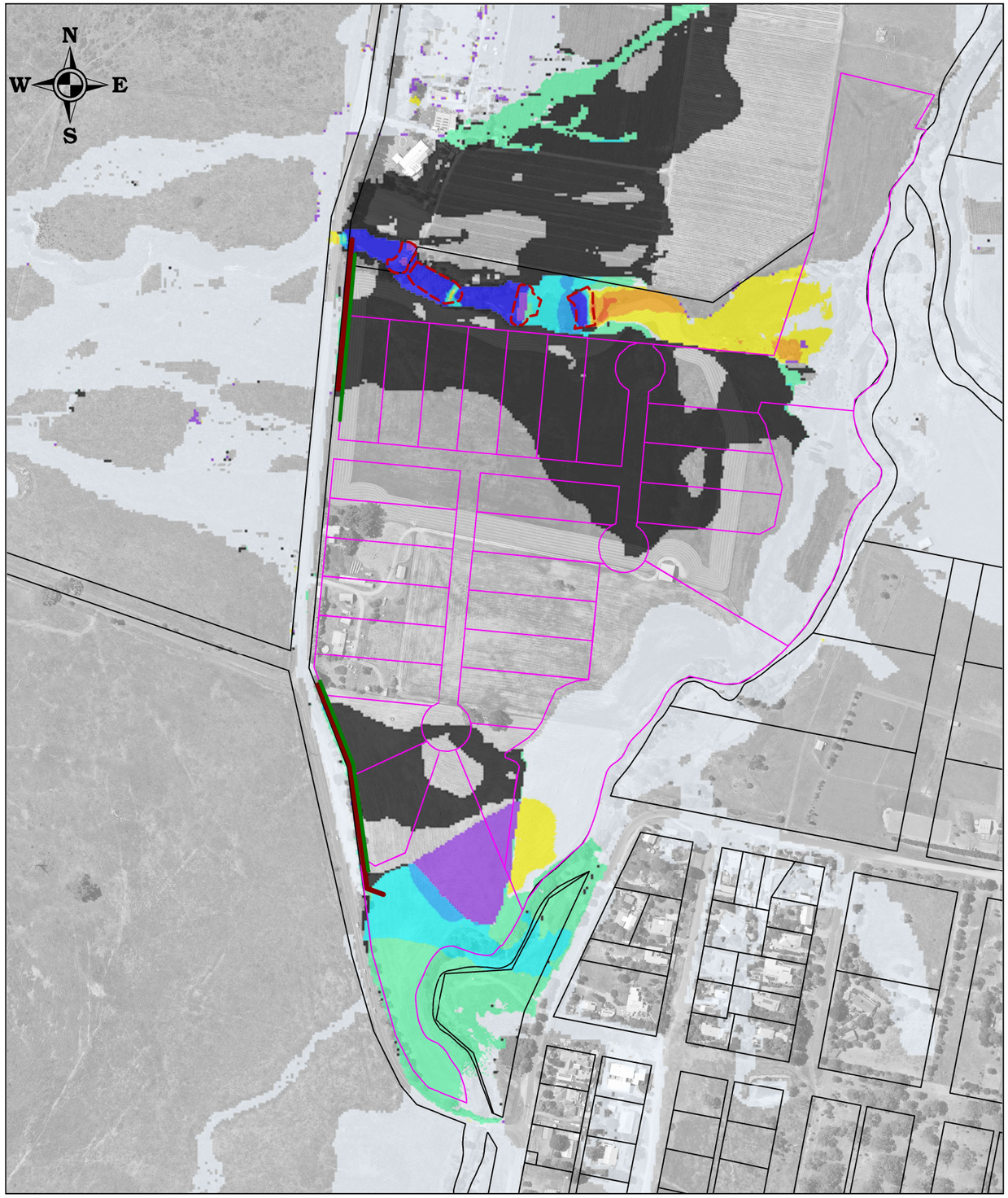
- High Hazard
- Low Hazard

N W E S

grc HYDRO

TITLE :	PROJECT	PROJECT No.	DATE:	SCALE:	FIGURE NUMBER:
PMF Peak Flood Depths, Levels, and Hazard Proposed Conditions	**2402 Sutton Road Planning Proposal**	**200023**	**December 2020**	**1:5,000**	**04**





Cadastral Boundaries

Removed Dams

Bund

Flood Level (mAHD) - Major Contour (Spacing = 1.0m)

Flood Level (mAHD) - Minor Contour (Spacing = 0.2m)

Swale

Proposed Lot Layout

Building Envelope

Effluent Area

Flood Depth (m)

0.05 to 0.15
0.15 to 0.3
0.3 to 0.5
0.5 to 1.0
1.0 to 2.0
> 2.0

Impact (m)

< -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to -0.01
No Impact
0.01 to 0.1
0.1 to 0.2
0.2 to 0.3
> 0.3
newly flooded
no longer flooded

grc HYDRO

TITLE : **1% AEP Peak Flood Depths, Levels, and Impacts Proposed Conditions**	PROJECT **2402 Sutton Road Planning Proposal**	PROJECT No. **200023**	DATE: **December 2020**	SCALE: **1:5,000**	FIGURE NUMBER: **05**

N
W E
S

N
W E
S

Cadastral Boundaries
Removed Dams
Bund
Flood Level (mAHD) - Major Contour (Spacing = 1.0m)
Flood Level (mAHD) - Minor Contour (Spacing = 0.2m)
Swale
Proposed Lot Layout
Building Envelope
Effluent Area

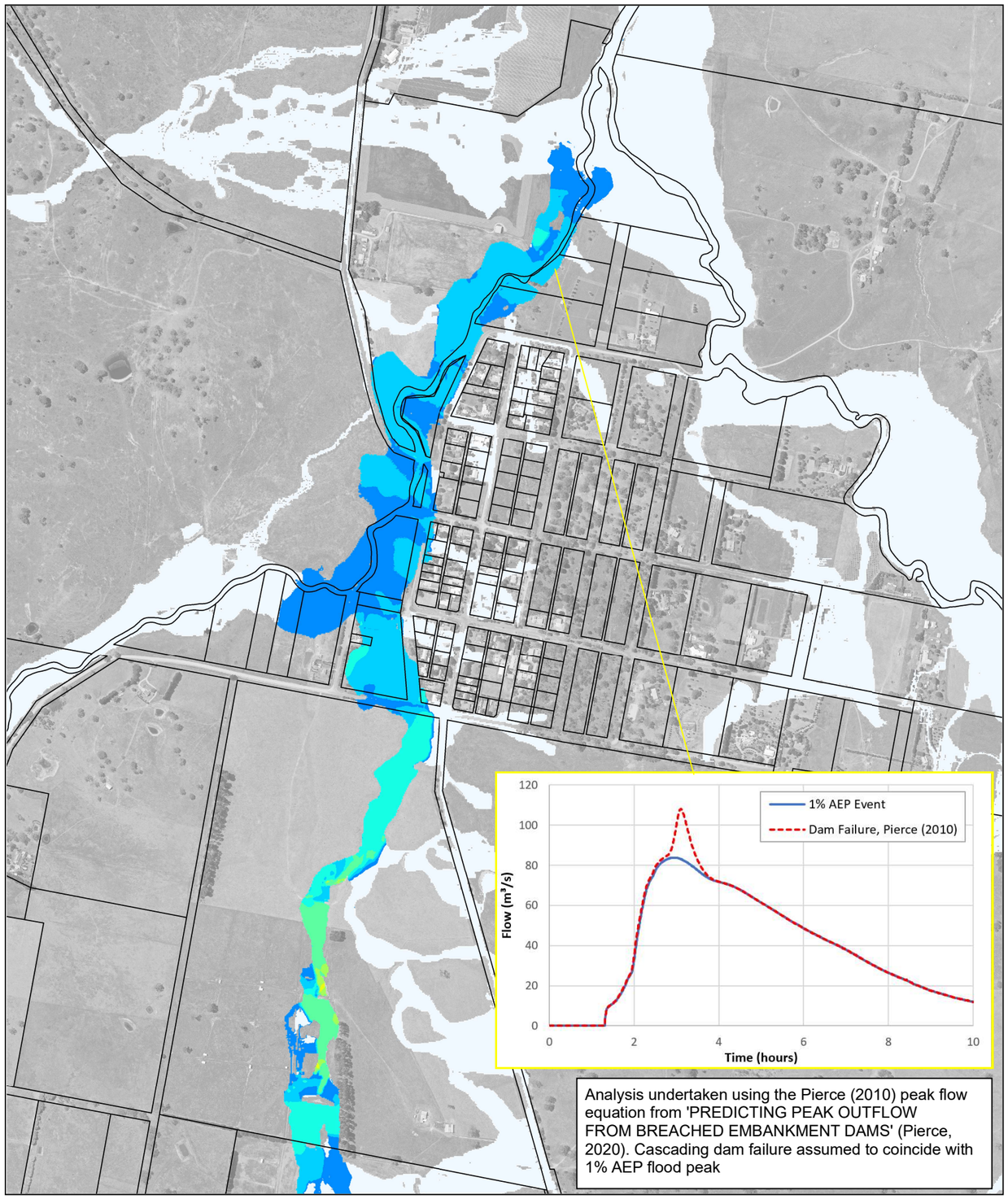
0 500
metres

Flood Depth (m)
0.0 to 0.15
0.15 to 0.3
0.3 to 0.5
0.5 to 1.0
1.0 to 2.0
> 2.0

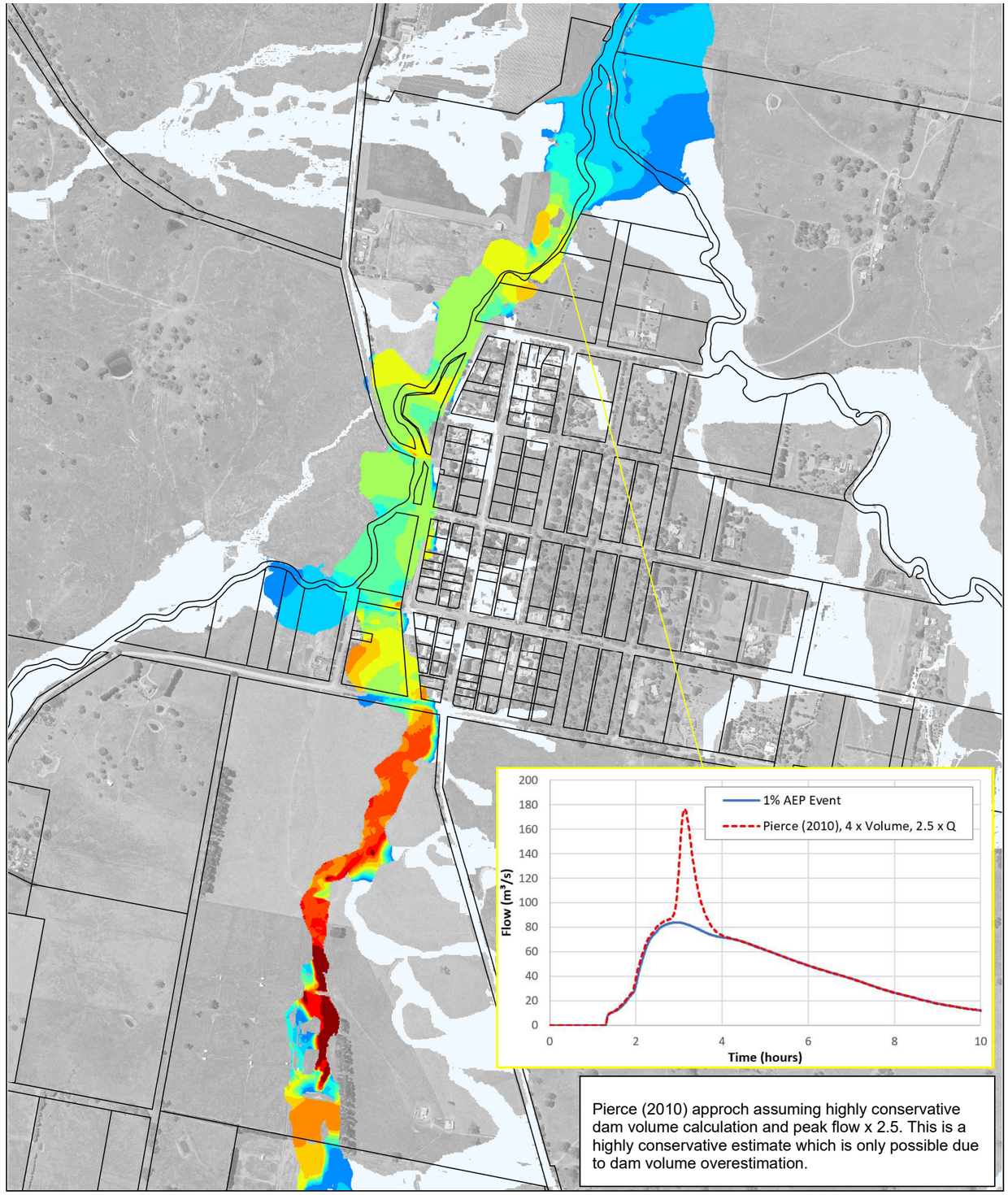
Impact (m)
< -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to -0.01
No Impact
0.01 to 0.1
0.1 to 0.2
0.2 to 0.3
> 0.3
newly flooded
no longer flooded

grc HYDRO

TITLE : **PMF Peak Flood Depths, Levels, and Impacts Proposed Conditions**	PROJECT **2402 Sutton Road Planning Proposal**	PROJECT No. **200023**	DATE: **December 2020**	SCALE: **1:5,000**	FIGURE NUMBER: **06**



Analysis undertaken using the Pierce (2010) peak flow equation from 'PREDICTING PEAK OUTFLOW FROM BREACHED EMBANKMENT DAMS' (Pierce, 2020). Cascading dam failure assumed to coincide with 1% AEP flood peak



Pierce (2010) approch assuming highly conservative dam volume calculation and peak flow x 2.5. This is a highly conservative estimate which is only possible due to dam volume overestimation.

Cadastral Boundaries

0 1,000
meters

Increase in Flood Level (m)

No Change	0.3 to 0.4	0.7 to 0.8
0.01 to 0.1	0.4 to 0.5	0.8 to 0.9
0.1 to 0.2	0.5 to 0.6	0.9 to 1.0
0.2 to 0.3	0.6 to 0.7	> 1.0

N
W E
S

grc HYDRO

TITLE :	PROJECT:	PROJECT No.	DATE:	SCALE:	FIGURE NUMBER:
Dam Breach Analysis - Pierce (2010) Expedient Approximation - Wet Day, failure at 1% AEP event peak	**2402 Sutton Road Planning Proposal**	**200023**	**June 2020**	**1:5,000**	**07**

Hydraulic Categories

- Flood Fringe
- Flood Storage
- Floodway

Cadastral Boundaries

0 500

meters

N W E S

TITLE :	PROJECT:	PROJECT No.	DATE:	SCALE:	FIGURE NUMBER:
1% AEP Hydraulic Categories - Existing (left pane) and Proposed Conditions (right pane)	**2402 Sutton Road Planning Proposal**	**200023**	**December 2020**	**1:5,000**	**A01**

grc HYDRO

Flood Risk Precinct

Low Risk

Medium Risk

High Risk

Cadastral Boundaries

0 500

meters

N

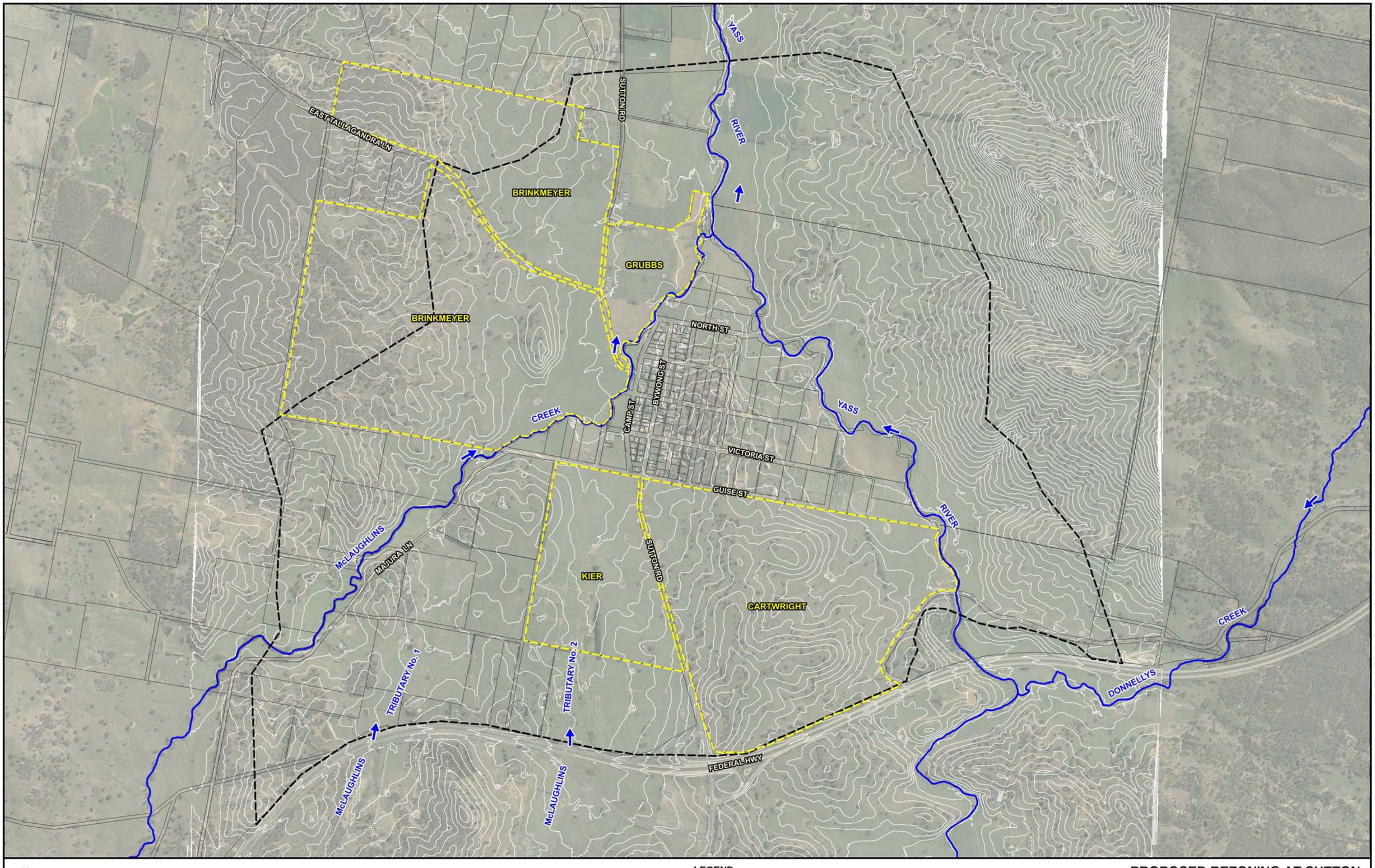
W E

S

TITLE :	PROJECT:	PROJECT No.	DATE:	SCALE:	FIGURE NUMBER:
Flood Risk Precincts - Existing Conditions (left pane) and Proposed Conditions (right pane)	**2402 Sutton Road Planning Proposal**	**200023**	**December 2020**	**1:5,000**	**A02**

grc HYDRO

ATTACHMENT A

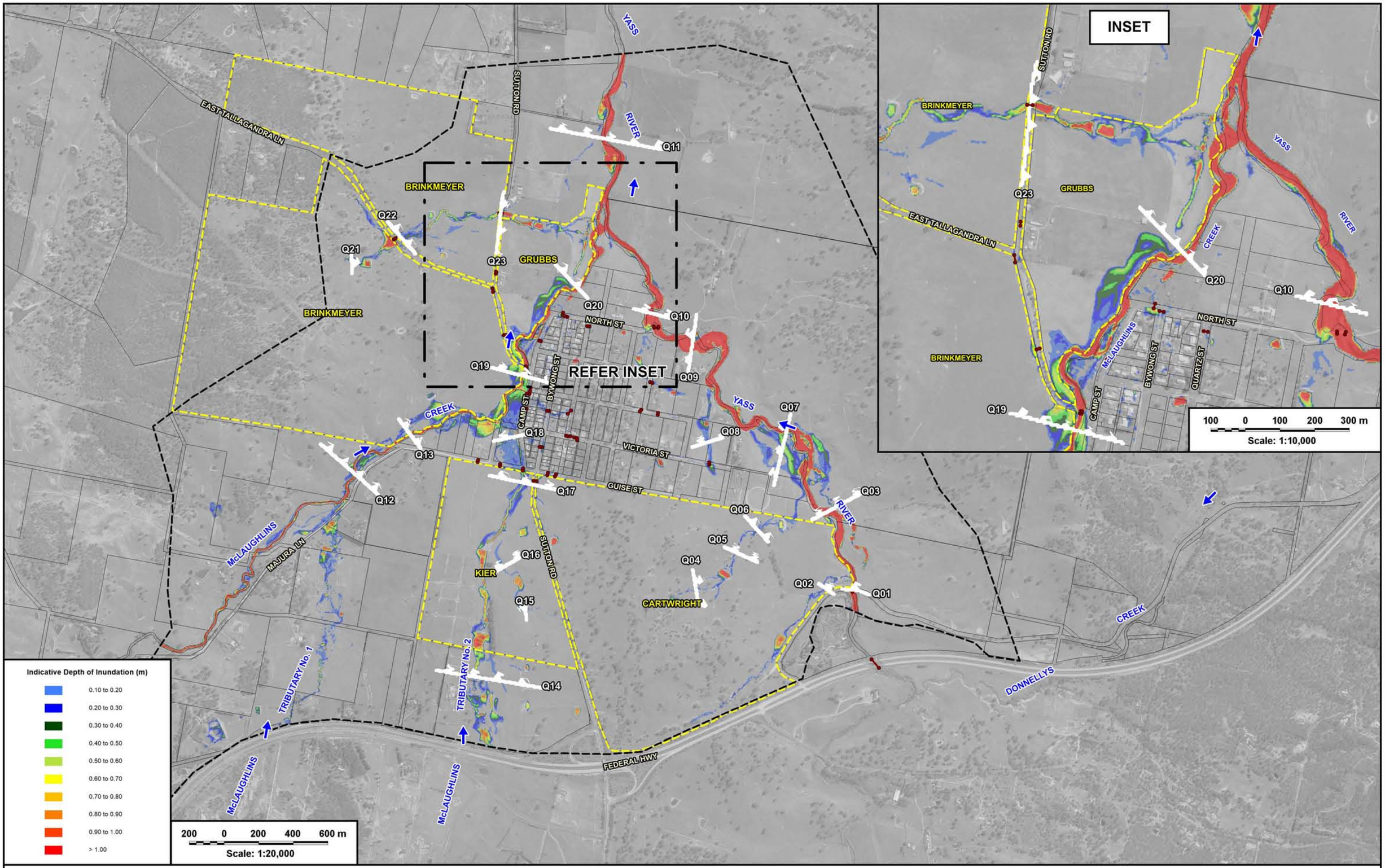


Lyall & Associates

PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT

Figure 1

LOCATION PLAN



N

Lyall & Associates

NOTE:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5 m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

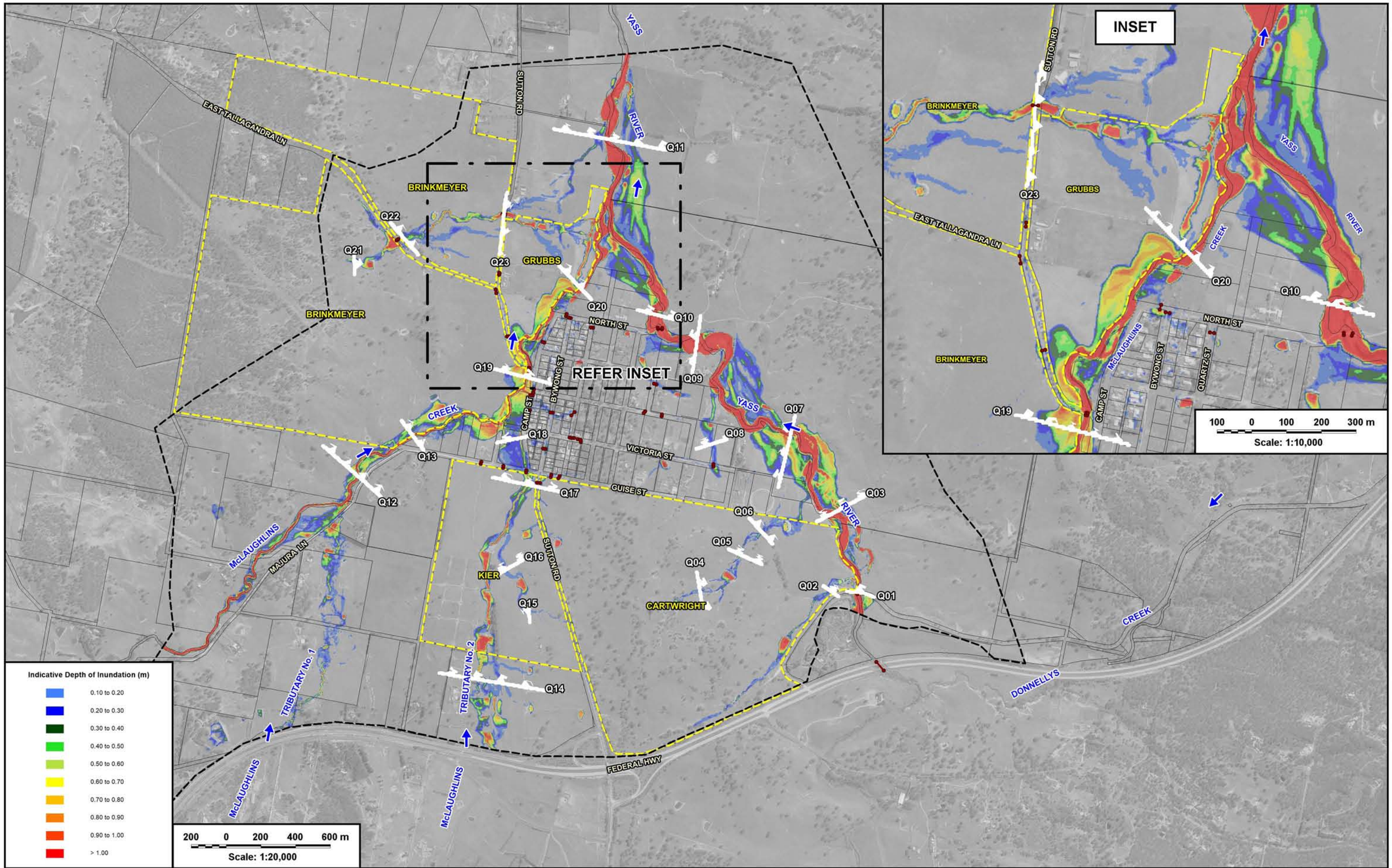
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

LEGEND
- Proposed Development Sites
- Two-Dimensional Model Boundary
- Modelled Stormwater Drainage Network
- Q01 Peak Flow Location and Identifier

PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT

Figure 2

INDICATIVE EXTENT AND DEPTHS OF INUNDATION
PRESENT DAY CONDITIONS - 5% AEP



N

Lyall & Associates

NOTE:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5 m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

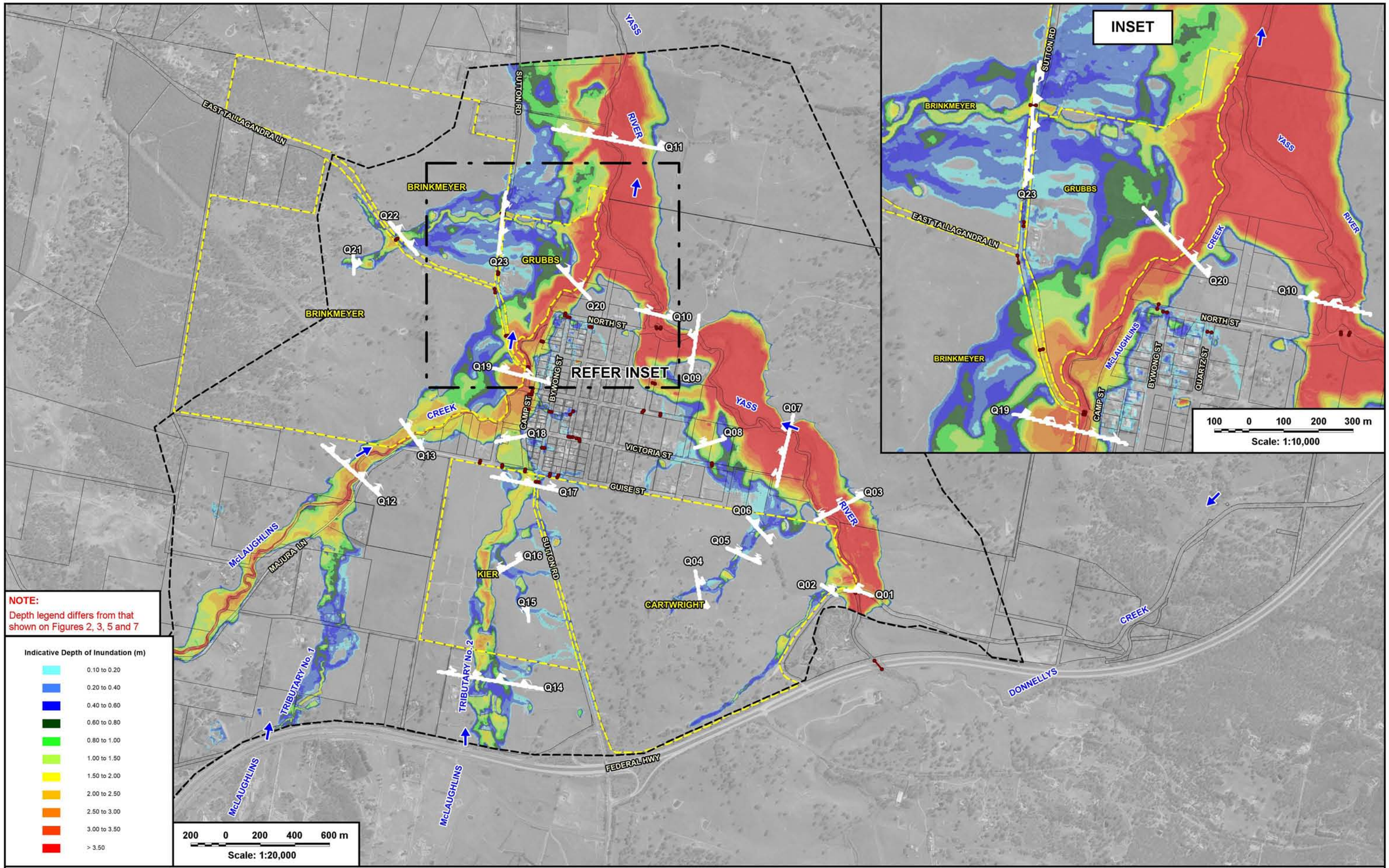
LEGEND

- Proposed Development Sites
- Two-Dimensional Model Boundary
- Modelled Stormwater Drainage Network
- Q01 Peak Flow Location and Identifier

PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT

Figure 3

INDICATIVE EXTENT AND DEPTHS OF INUNDATION
PRESENT DAY CONDITIONS - 1% AEP



NOTE:
Depth legend differs from that shown on Figures 2, 3, 5 and 7

Indicative Depth of Inundation (m)

0.10 to 0.20
0.20 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 2.50
2.50 to 3.00
3.00 to 3.50
> 3.50

N

Lyall & Associates

NOTE:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5 m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

LEGEND

- Proposed Development Sites
- Two-Dimensional Model Boundary
- Modelled Stormwater Drainage Network
- Q01 Peak Flow Location and Identifier

PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT

Figure 4

INDICATIVE EXTENT AND DEPTHS OF INUNDATION
PRESENT DAY CONDITIONS - PMF

INSET

REFER INSET

BRINKMEYER
GRUBBS
KIER
CARTWRIGHT
EAST TALLAGANDRA LN
SUTTON RD
YASS RIVER
CREEK
NORTH ST
CAMP ST
BYWONG ST
McLAUGHLINS
QUARTZ ST
VICTORIA ST
GUISE ST
MAJURA LN
TRIBUTARY No. 1
TRIBUTARY No. 2
FEDERAL HWY
DONNELLYS

100 0 100 200 300 m
Scale: 1:10,000

200 0 200 400 600 m
Scale: 1:20,000

N

LEGEND

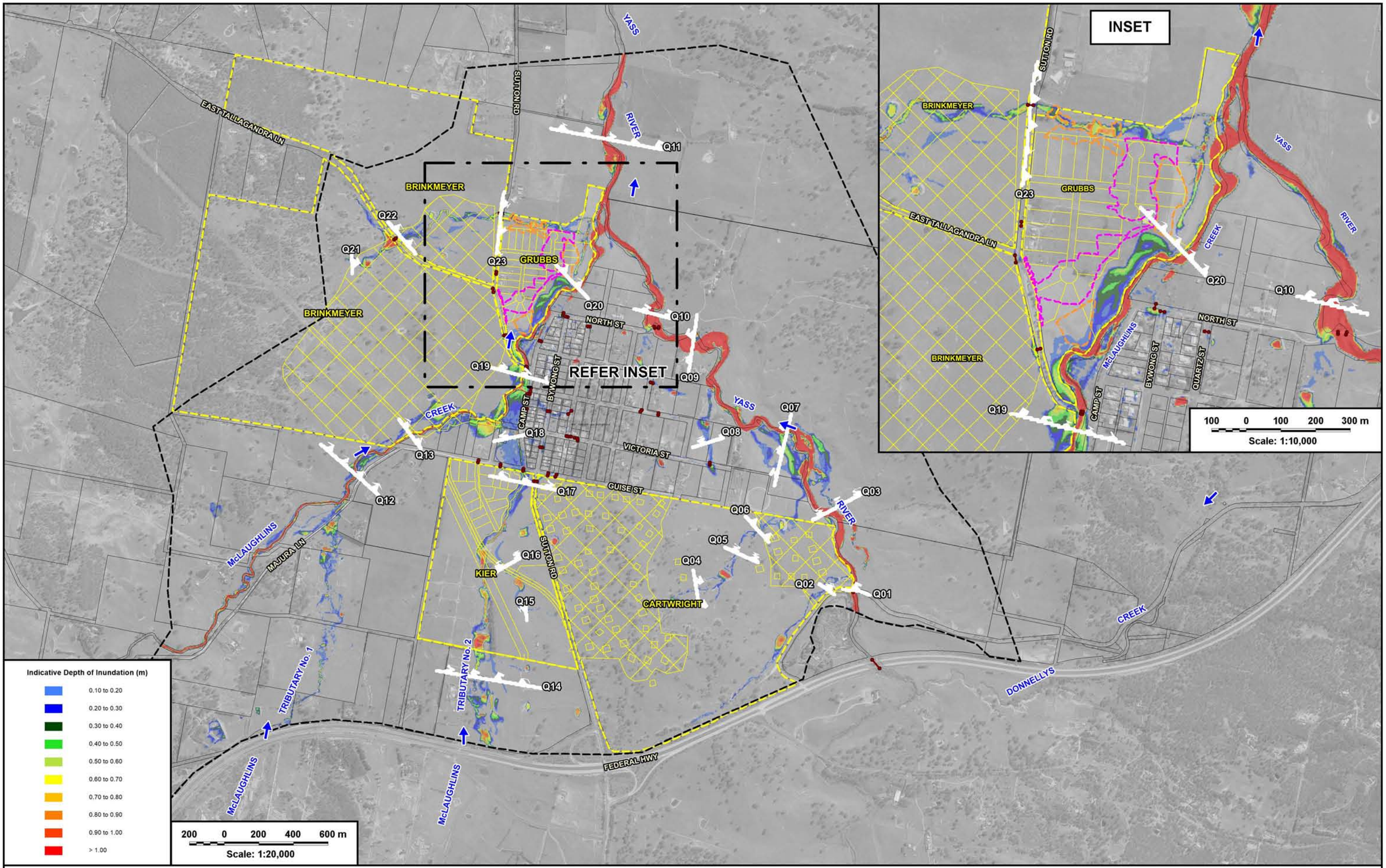
- Sub-Catchment Boundary and Identifier
- TUFLOW Inflow Boundary and Identifier
- Proposed Development Sites
- Indicative Allotment Layout (Grubbs and Kier)
- Extent of Proposed Subdivision (Brinkmeyer and Cartwright)
- Two-Dimensional Model Boundary
- Modelled Stormwater Drainage Network

Lyall & Associates

PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT

Figure 5

LOCATION OF CATCHMENT INFLOWS



N

Lyall & Associates

NOTE:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5 m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

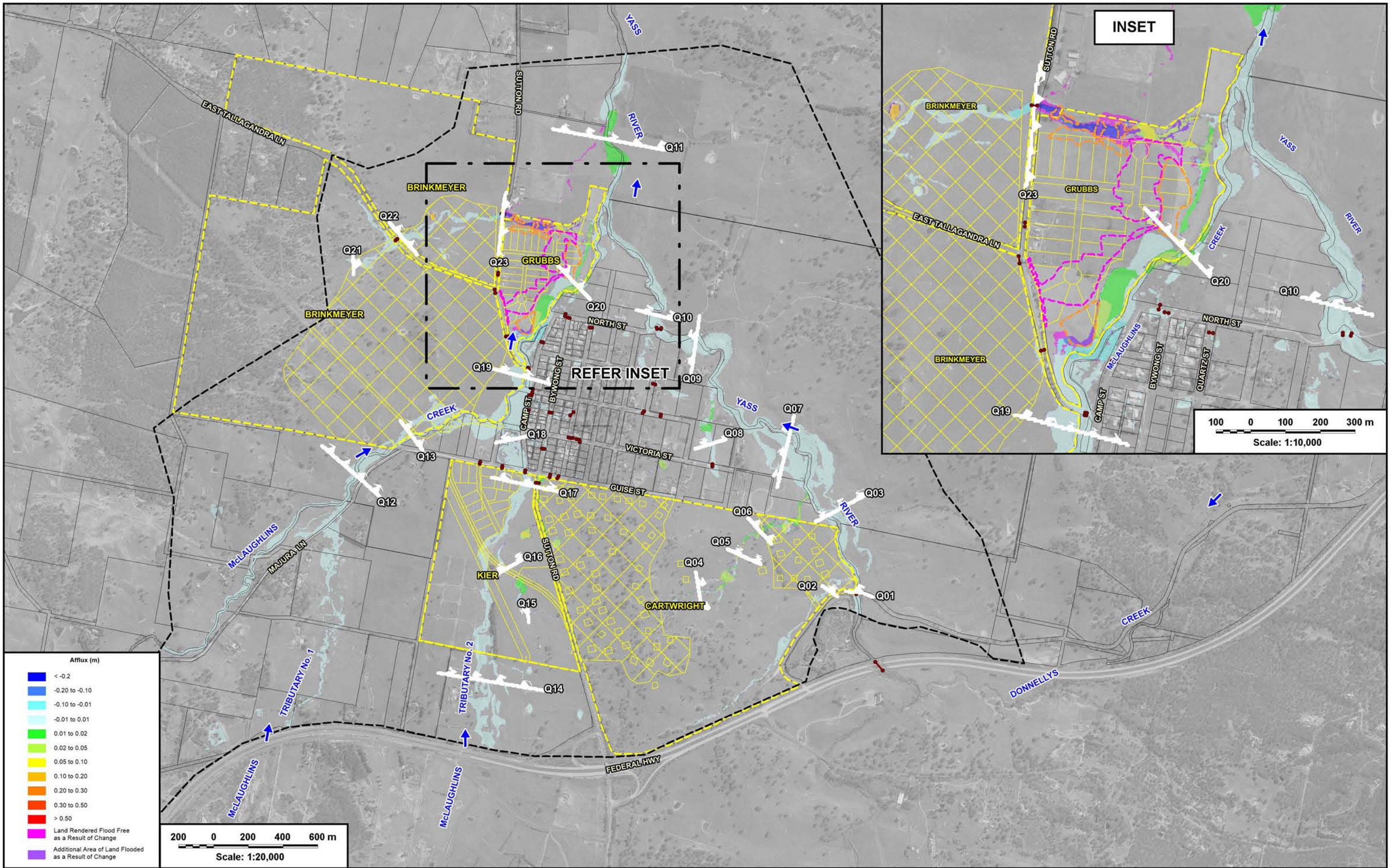
LEGEND

- Extent of Cut
- Extent of Fill
- Q01 Peak Flow Location and Identifier
- Proposed Development Sites
- Indicative Allotment Layout (Grubbs and Kier)
- Extent of Proposed Subdivision (Brinkmeyer and Cartwright)
- Two-Dimensional Model Boundary
- Modelled Stormwater Drainage Network

PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT

Figure 6

INDICATIVE EXTENT AND DEPTHS OF INUNDATION
POST-DEVELOPMENT CONDITIONS - 5% AEP



NOTE:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5 m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

LEGEND

- Extent of Cut
- Extent of Fill
- Q01 Peak Flow Location and Identifier
- Proposed Development Sites
- Indicative Allotment Layout (Grubbs and Kier)
- Extent of Proposed Subdivision (Brinkmeyer and Cartwright)
- Two-Dimensional Model Boundary
- Modelled Stormwater Drainage Network

Lyall & Associates

PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT

Figure 7

IMPACT OF PROPOSED DEVELOPMENT ON FLOOD BEHAVIOUR
5% AEP

INSET

REFER INSET

BRINKMEYER
GRUBBS
EAST TALLAGANDRA LN
SUTTON RD
YASS RIVER
CREEK
NORTH ST
VICTORIA ST
GUISE ST
CAMP ST
BYWONG ST
McLAUGHLINS
MAJURA LN
TRIBUTARY No. 1
TRIBUTARY No. 2
KIER
CARTWRIGHT
QUARTZ ST
FEDERAL HWY
DONNELLYS

Q01 Q02 Q03 Q04 Q05 Q06 Q07 Q08 Q09 Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19 Q20 Q21 Q22 Q23

100 0 100 200 300 m
Scale: 1:10,000

200 0 200 400 600 m
Scale: 1:20,000

Indicative Depth of Inundation (m)

- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.40
- 0.40 to 0.50
- 0.50 to 0.60
- 0.60 to 0.70
- 0.70 to 0.80
- 0.80 to 0.90
- 0.90 to 1.00
- > 1.00

N

Lyall & Associates

NOTE:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5 m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

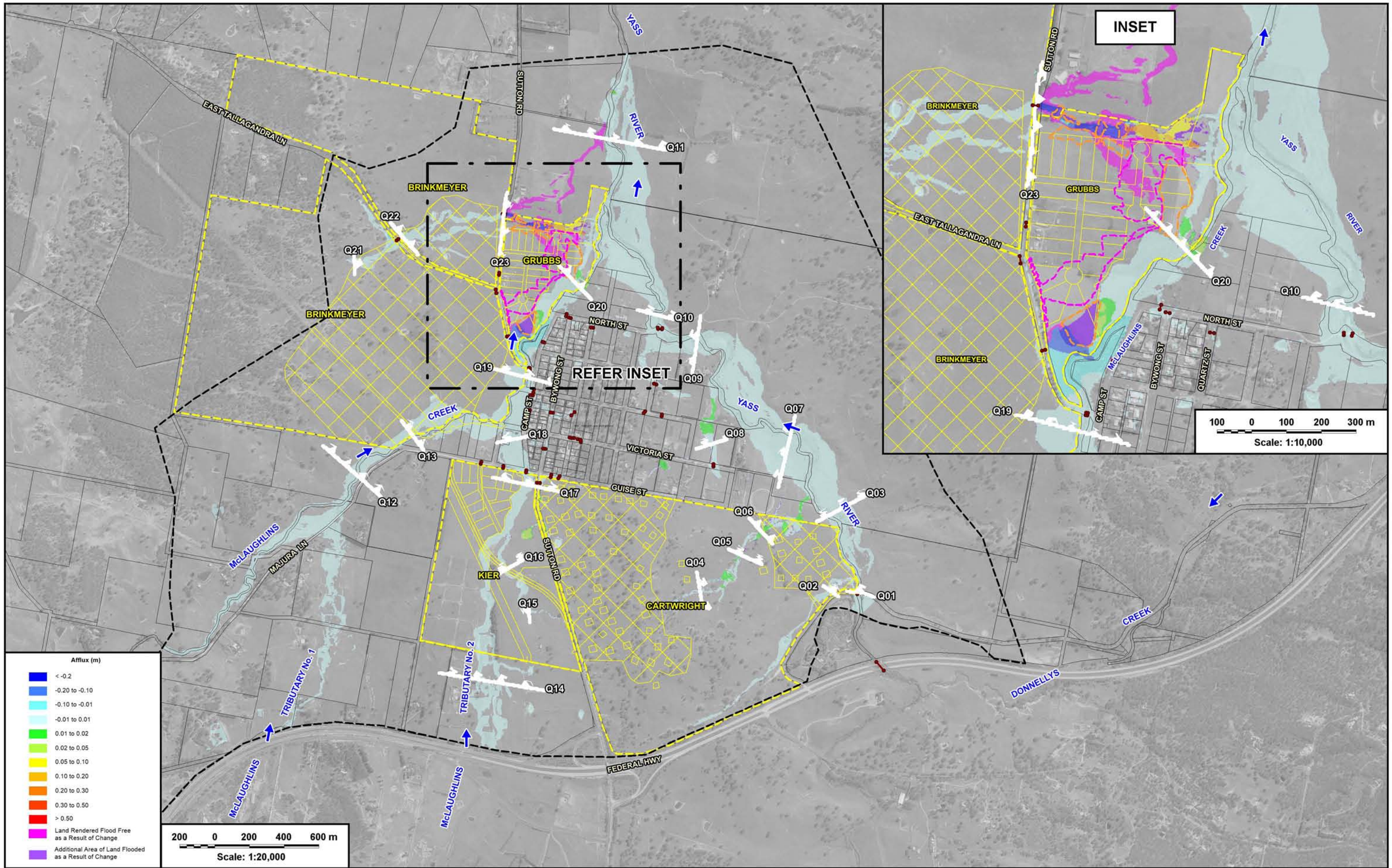
LEGEND

- Extent of Cut
- Extent of Fill
- Q01 Peak Flow Location and Identifier
- Proposed Development Sites
- Indicative Allotment Layout (Grubbs and Kier)
- Extent of Proposed Subdivision (Brinkmeyer and Cartwright)
- Two-Dimensional Model Boundary
- Modelled Stormwater Drainage Network

PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT

Figure 8

INDICATIVE EXTENT AND DEPTHS OF INUNDATION
POST-DEVELOPMENT CONDITIONS - 1% AEP


INSET
REFER INSET
BRINKMEYER
GRUBBS
CARTWRIGHT
KIER
EAST TALLAGANDRA LN
SUTTON RD
YASS
RIVER
CREEK
NORTH ST
VICTORIA ST
GUISE ST
CAMP ST
BYWONG ST
McLAUGHLINS
MAJURA LN
TRIBUTARY No. 1
TRIBUTARY No. 2
FEDERAL HWY
DONNELLYS
QUARTZ ST
Q01
Q02
Q03
Q04
Q05
Q06
Q07
Q08
Q09
Q10
Q11
Q12
Q13
Q14
Q15
Q16
Q17
Q18
Q19
Q20
Q21
Q22
Q23
Afflux (m)
< -0.2
-0.20 to -0.10
-0.10 to -0.01
-0.01 to 0.01
0.01 to 0.02
0.02 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.50
> 0.50
Land Rendered Flood Free as a Result of Change
Additional Area of Land Flooded as a Result of Change
200 0 200 400 600 m
Scale: 1:20,000
100 0 100 200 300 m
Scale: 1:10,000
N
NOTE:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5 m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.
Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.
LEGEND
Extent of Cut
Extent of Fill
Q01 Peak Flow Location and Identifier
Proposed Development Sites
Indicative Allotment Layout (Grubbs and Kier)
Extent of Proposed Subdivision (Brinkmeyer and Cartwright)
Two-Dimensional Model Boundary
Modelled Stormwater Drainage Network
Lyall & Associates
PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT
Figure 9
IMPACT OF PROPOSED DEVELOPMENT ON FLOOD BEHAVIOUR
1% AEP

INSET

REFER INSET

NOTE:
Depth legend differs from that shown on Figures 2, 3, 5 and 7

Indicative Depth of Inundation (m)

- 0.10 to 0.20
- 0.20 to 0.40
- 0.40 to 0.60
- 0.60 to 0.80
- 0.80 to 1.00
- 1.00 to 1.50
- 1.50 to 2.00
- 2.00 to 2.50
- 2.50 to 3.00
- 3.00 to 3.50
- > 3.50

200 0 200 400 600 m
Scale: 1:20,000

100 0 100 200 300 m
Scale: 1:10,000

N

Lyall & Associates

NOTE:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5 m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

LEGEND

- Extent of Cut
- Extent of Fill
- Q01 Peak Flow Location and Identifier
- Proposed Development Sites
- Indicative Allotment Layout (Grubbs and Kier)
- Extent of Proposed Subdivision (Brinkmeyer and Cartwright)
- Two-Dimensional Model Boundary
- Modelled Stormwater Drainage Network

PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT

Figure 10

INDICATIVE EXTENT AND DEPTHS OF INUNDATION
POST-DEVELOPMENT CONDITIONS - PMF

INSET

REFER INSET

Afflux (m)

- < -0.2
- -0.20 to -0.10
- -0.10 to -0.01
- -0.01 to 0.01
- 0.01 to 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.50
- > 0.50
- Land Rendered Flood Free as a Result of Change
- Additional Area of Land Flooded as a Result of Change

200 0 200 400 600 m
Scale: 1:20,000

100 0 100 200 300 m
Scale: 1:10,000

N

Lyall & Associates

NOTE:
The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5 m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

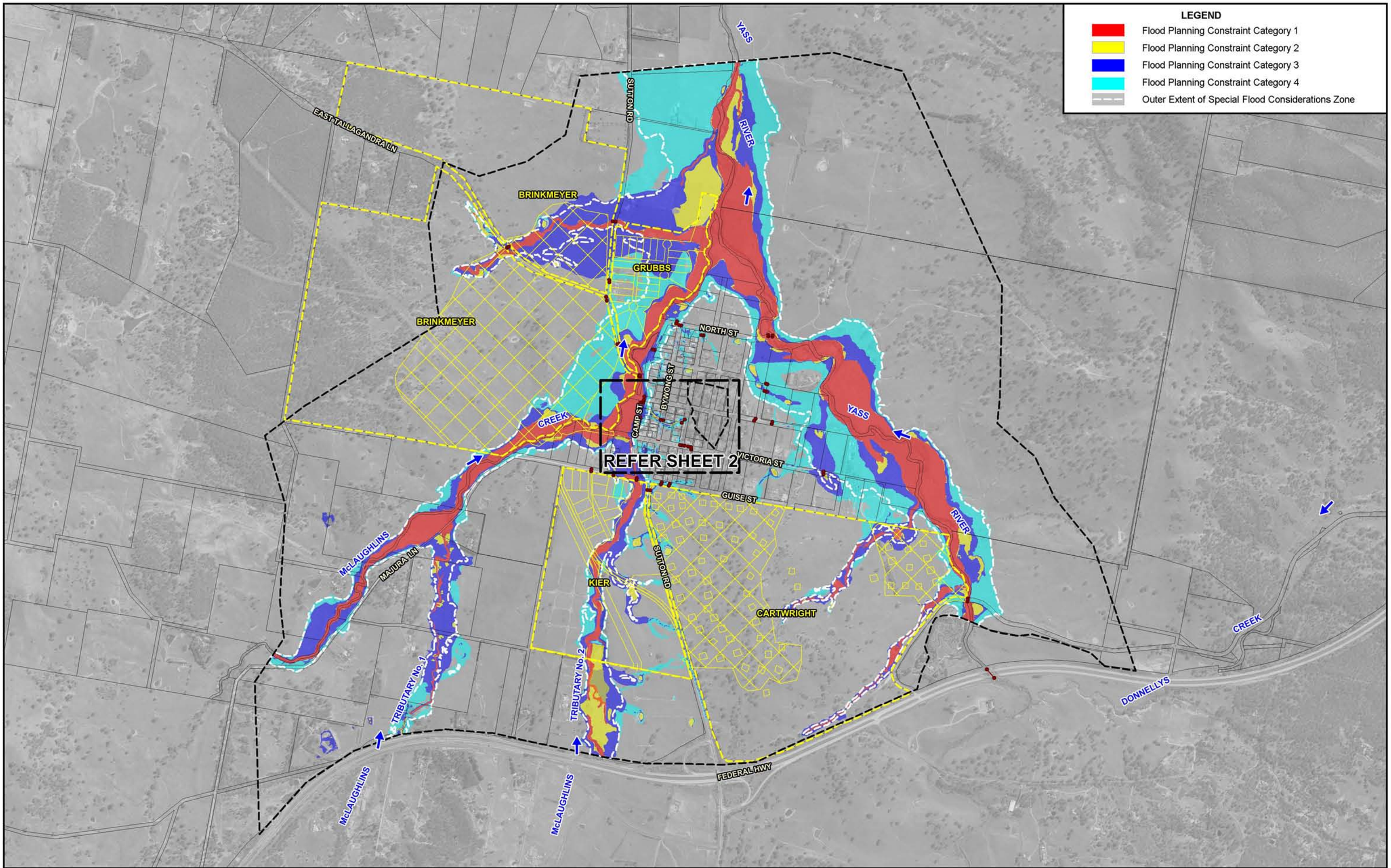
LEGEND

- Extent of Cut
- Extent of Fill
- Q01 Peak Flow Location and Identifier
- Proposed Development Sites
- Indicative Allotment Layout (Grubbs and Kier)
- Extent of Proposed Subdivision (Brinkmeyer and Cartwright)
- Two-Dimensional Model Boundary
- Modelled Stormwater Drainage Network

PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT

Figure 11

IMPACT OF PROPOSED DEVELOPMENT ON FLOOD BEHAVIOUR
PMF



N

200 0 200 400 600 m

Scale: 1:20,000

Lyall & Associates

NOTE:

The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5 m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

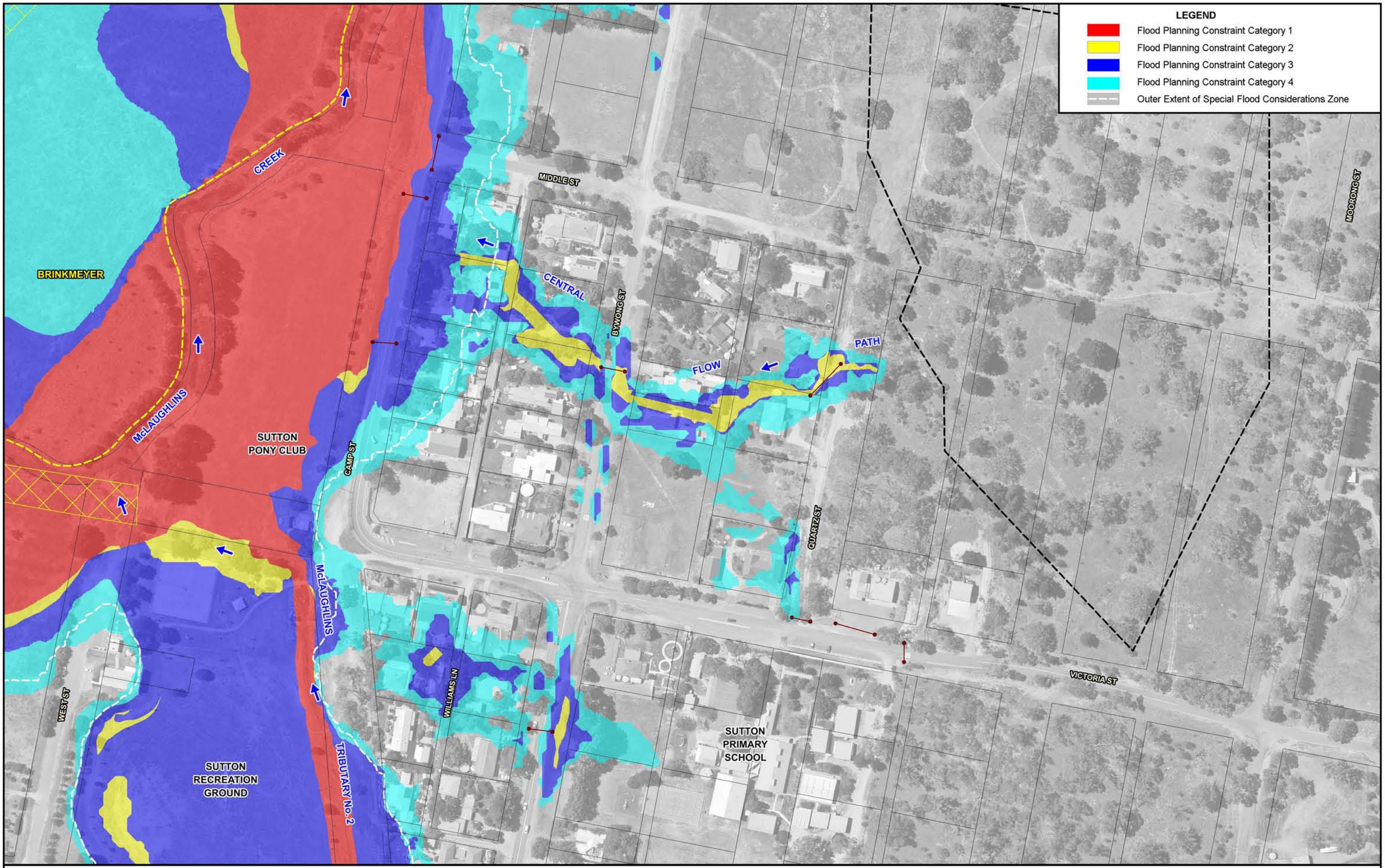
LEGEND

- Two-Dimensional Model Boundary
- Modelled Stormwater Drainage System
- Proposed Development Sites
- Indicative Allotment Layout (Grubbs and Kier)
- Extent of Proposed Subdivision (Brinkmeyer and Cartwright)

PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT

Figure 12
(Sheet 1 of 2)

EXTRACT OF YASS VALLEY FLOOD PLANNING CONSTRAINT CATEGORY MAP AT SUTTON



N

20 0 20 40 60 m

Scale: 1:2,000

Lyall & Associates

NOTE:

The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 5 m grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

LEGEND

Two-Dimensional Model Boundary

Modelled Stormwater Drainage System

Proposed Development Sites

Extent of Proposed Subdivision (Brinkmeyer)

PROPOSED REZONING AT SUTTON
FLOOD IMPACT ASSESSMENT

Figure 12
(Sheet 1 of 2)

EXTRACT OF YASS VALLEY FLOOD PLANNING CONSTRAINT CATEGORY MAP AT SUTTON

PROPOSED REZONING AT SUTTON FLOOD IMPACT ASSESSMENT
COMPARISON OF PEAK FLOWS

Flow Location Identifier	5% AEP			1% AEP			PMF		
	Present Day (m^3/s)	Post-Development (m^3/s)	Difference (m^3/s)	Present Day (m^3/s)	Post-Development (m^3/s)	Difference (m^3/s)	Present Day (m^3/s)	Post-Development (m^3/s)	Difference (m^3/s)
Q01	100.3	100.3	0	176.4	176.4	0	-	-	-
Q02	3.5	3.5	0	6.9	6.9	0	57.7	57.7	0
Q03	100.3	100.3	0	177.4	177.4	0	3046	3046	0
Q04	2.9	3.2	0.3	5.1	5.3	0.2	36.6	36.7	0.1
Q05	3.6	4.2	0.6	7.2	7.5	0.3	58.4	58.7	0.3
Q06	4	4.8	0.8	8.4	9.1	0.7	75.5	75.9	0.4
Q07	100.2	100.2	0	177.4	177.5	0.1	-	-	-
Q08	3	3.1	0.1	5.3	5.6	0.3	177	177	0
Q09	99.8	99.9	0.1	177.6	177.7	0.1	2814	2814	0
Q10	99.7	99.8	0.1	177.8	177.9	0.1	3141	3141	0
Q11	132.7	133	0.3	242.5	243	0.5	-	-	-
Q12	31.5	31.5	0	60.6	60.6	0	857	857	0
Q13	31.3	31.3	0	61.6	61.6	0	857.7	857.7	0
Q14	8.8	8.8	0	15.5	15.5	0	217	217	0
Q15	1.1	1.2	0.1	1.8	1.9	0.1	10	10.4	0.4
Q16	1.6	1.8	0.2	3.4	3.6	0.2	35.3	35.8	0.5
Q17	11.2	11.3	0.1	21.1	21.3	0.2	301.4	301.6	0.2
Q18	12	12.2	0.2	23.2	23.3	0.1	327.7	327.9	0.2
Q19	43.9	44.2	0.3	85.8	86.1	0.3	-	-	-
Q20	44.5	45	0.5	87.6	87.9	0.3	-	-	-
Q21	6.3	6.3	0	12	12	0	109.7	109.7	0
Q22	11.1	11.1	0	18.5	18.5	0	169.5	170.3	0.8
Q23	8.8	9.2	0.4	18	18.1	0.1	-	-	-

J:\454es002 - Proposed Sutton Rezoning Flood Impact Assessment\Calcs\Comparison of Peak Flows.xlsx