60 Macleay Street, Narrawallee

Flood Assessment Report

Project No. 2135
Date: 14 November 2021

Prepared for:
Planning Law Solutions

Footprint (NSW) Pty Ltd
15 Meehan Drive
Kiama Downs, NSW 2533, Australia
ACN 131 571 929   ABN 44 131 571 929
Phone: 02 4237 6770
Mobile: 0430 421 661
Email: ashley@footprinteng.com.au

Document and Distribution Status

Author(s)	Reviewer(s)	Signatures
Ashley Bond		

Revision No.	Status	Release Date	Document Distribution					
			Planning Law Solutions					
1	DRAFT	11/11/2021	PDF					
2	FINAL	14/11/2021	PDF					

Distribution Types: F = Fax, H = Hard Copy, P = PDF, E = Other Electronic Document. Digits indicate number of copies.

TABLE OF CONTENTS

APPENDICES

APPENDIX A

Proposed Development Plans

APPENDIX B

Catchment Plan

APPENDIX C

ARR Hub Data

APPENDIX D

Design Rainfall Intensities

APPENDIX E

PMP Calculations

APPENDIX F

Hydrographs

APPENDIX G

RFFE Method Results

APPENDIX H

Hydraulic Model Plan

APPENDIX I

Flood Mapping

1.0 INTRODUCTION

Footprint (NSW) Pty. Ltd. (*Footprint*) has been engaged to undertake a hydrological and hydraulic analysis in support of a proposed two-storey residential dwelling, carport and swimming pools at 60 Macleay Street, Narrawallee, New South Wales.

A development application (DA20/2061) for the proposed development was refused by Shoalhaven Council and the proponent subsequently commenced proceedings in the Land and Environment Court appealing Council's decision. Amongst other items of contention, the Statement of Facts and Contentions (SOFAC) prepared by Council includes the lack of a flood assessment report.

The purpose of the analysis is to define the flood behaviour, including depth of inundation, flood velocity and flood hazard within the Narrawallee Inlet adjacent to the subject site and prepare a flood assessment report assessing the proposed development against Clause 5.21 of the Shoalhaven LEP 2014 and Chapter G9 (Development on Flood Prone Land) of the Shoalhaven DCP 2014.

2.0 FLOODING CONTENTIONS

Flooding contentions stated in the Statement of Facts and Contentions (SOFAC) dated 11 October 2021 are noted below for reference.

The development application should be refused because a Flood Assessment Report has not been submitted to enable a proposer assessment of the proposed development in accordance with the requirements of clause 5.21 of SLEP 2014 and Chapter G9 of SDCP2014.

Particulars

a) *The subject site is located within close proximity to Narrawallee Creek. The Respondent does not have any flood mapping in relation to the site as a flood study has not been completed for Narrawallee Creek.*
b) *The majority of the proposed development has a ground level lower than 2m AHD, with a small area located at the end of the existing driveway handle off MacLeay Street with a level above RL3m AHD.*
c) *Based on the site's proximity to Narrawallee Creek and the ground elevations it is considered to comprise flood prone land. Parts of the site are likely to be lower than the flood planning level and therefore the proposed development would be subject to flood specific development controls in Chapter G9of SDCP 2014.*
d) *Section 2 in Chapter G of SDCP 2014 relevantly states:*

> *"Advisory Note:*
>
> *There are a number of catchment within the Shoalhaven that have not been subject of a detailed flood stud. Any works proposed within such an area may therefore need to be accompanied by a flood assessment report – refer to Supporting Document 1: Chapter G9 – Guidelines for Development on Flood Prone Land for more information. It is noted that if a flood assessment report identified land to be at or below the Flood Planning Level (FPL) then Clause 7.3 of Shoalhaven LEP 2014 will also apply to development on that land. FPL is defined in the DCP Dictionary and Shoalhaven LEP Dictionary."*

e) *Supporting Document 1: Chapter G9 – Guidelines for Development on Flood Prone Land relevantly states:*

> *"3.1 Flood Compliance Report*
>
> *To enable Council to assess a development proposal, a flood DCP compliance report is to be provided for every development proposal on flood prone land. A flood DCP compliance report checklist if provided in Schedule 1 of these Guidelines.*

The flood DCP compliance report must include the following compulsory information.

The information can be provided as either:

1. A current Flood Certificate

Where available, an up to date Flood Certificate must be submitted with your development application (refer Schedule 2 of these Guidelines for information on how to obtain this document and whether you need a basic or detailed certificate).

OR

2. A Flood Assessment Report

A flood assessment report is needed in the following two instances:

a) Where flood data is not available but the site:

- *is within 40 meters of a creek;*
- *is within 10 metres of a major drainage system, local overland flood path or drainage easement; or*
- *has a history of flooding; or*
- *is considered to be flood prone by Council's Floodplain Engineer*

OR

b) Where flood data is available but may require interpolation, extrapolation or refinement to greater detail."

f) *A compliance certificate cannot be issued for the site in circumstances where a flood study has not been completed for Narrawallee Creek, as such a flood assessment report is required to be submitted in order to enable a proper assessment of the proposed development to be undertaken against the requirements of Chapter G9 of SDCP 2014 and clause 5.21 'Flood Planning' of SLEP 2014.*

g) *Notwithstanding that the Respondent does not have flood information for the site, it is considered possible that the site is below the flood planning level. In that regard the 2050 scenario 1% AEP flood level at the downstream extent of Lake Conjola and Burrill Lake is 2.9m. If there is a similar level at Narrawallee Creek, this would result in a 2050 Flood Planning Level of 3.4m AHD for the site.*

3.0 SUBJECT SITE

3.1. Site Description

The subject site is described as Lot 145 DP718994, 60 Macleay Street, Narrawallee and comprises an area of 3.18 hectares.

The site is located at the end of an existing driveway handle off Macleay Street which currently services 62 and 64 Macleay Street, Narrawallee. The site abuts Narrawallee Creek on its' northern boundary.

The site is currently vacant and consists predominately of vegetated land, with an area of cleared land located adjacent to the access handle.

The location of the subject site and its proximity to Narrawalle Creek is shown in Figure 1.

Analysis of available LiDAR data from the site indicates that the site varies in elevation for approximately RL3.5m AHD at Macleay Street to RL0.5m AHD at the northern boundary adjacent to Narrawallee Creek as shown in Figure 2. Elevations over much of the site are lower than 1.5m AHD except for a small platform at the end of the existing driveway handle which is above RL3.0m AHD.

Figure 1: Site Location (Shaded Yellow) – source Six Maps

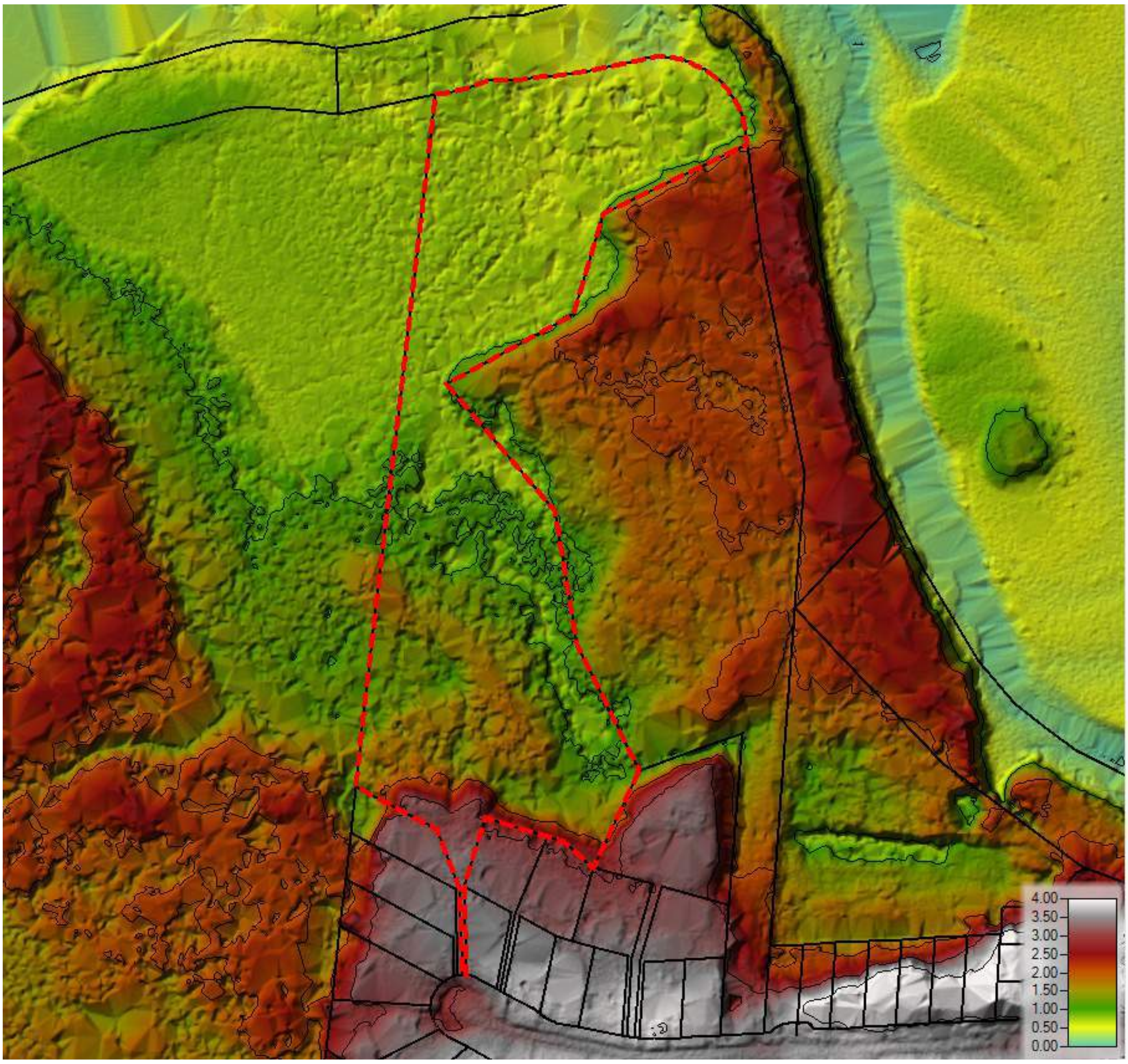


Figure 2: Terrain Analysis over Subject Site

3.2. Proposed Development

The proposed development seeks consent for the construction of a two-storey dwelling containing nine bedrooms each with their own ensuite, a carport, sauna, swimming pool, and 5 plunge pools.

Proposed development plans are included in Appendix A.

4.0 HYDROLOGICAL MODELLING

4.1. Purpose

Hydrological modelling was conducted to enable the extraction of hydrographs for the critical storm duration and median storm within the ensemble to import into the two-dimensional hydraulic model.

4.2. Model Adoption

Hydrological modelling was conducted in DRAINS using a RAFTS storage routing model.

Storage routing models can model larger catchments using a lumped approach by assuming heterogeneity within the sub-catchment to account for the storage and retardence of flows that occurs within the sub-catchment. Such models account for slope and roughness and use a loss model to produce a hydrograph at the sub-catchment outlet.

The RAFTS hydrological model was chosen because it is widely used and accepted across Australia within the industry and has been shown to be insensitive to initial conditions.

4.3. Catchment Areas

The total catchment area draining to Narrawallee Creek at its outlet to the South Pacific Ocean (Tasman Sea) was estimated to be approximately 8,404 hectares (84.04km^2) and was determined using 5m Digital Elevation Models (DEM) obtained through the Australian Foundation Spatial Data web portal.

The overall catchment was dissected into 11 sub-catchments using hydrologic analysis software package Catchment SIM and ranged in size from 403 to 1284 hectares, with an average size of approximately 760 hectares. Sub-catchment slopes were derived by CatchmentSIM using the above terrain data.

A catchment plan and summary of the sub-catchments is shown in Figure 1.1 in Appendix B.

4.4. Modelling Input Parameters

The parameters adopted for hydrological modelling are shown in Table 1.

Table 1: Hydrological Parameters Adopted

Parameter	**Value Adopted**	**Justification/Source**
Impervious Area Initial Loss (mm)	1	Typical value for urban areas. Only applicable to existing urban area.
Impervious Area Continuing Loss (mm/hr)	0	Typical value for urban areas.
Pervious Area Initial Loss (mm)	26	Recommended value from ARR 2019 data hub (refer Appendix C).
Impervious Area Initial Loss (mm)	2.24	40% of the recommended value from ARR 2019 data hub (refer Appendix C) in accordance with NSW loss hierarchy (level 5)
BX	1	RAFTS Default and consistent with the value adopted in the Lake Conjola Flood Study (2007).
Sub-catchment Area (ha)	Varies	As per Figure 1.1 in Appendix B
Impervious Area (%)	Varies (Typically 0%)	As per Figure 1.1 in Appendix B. Based on aerial photography. It is acknowledged that some catchments may contain some small impervious areas (i.e. roads and roofs) these areas would not generally be directly connected to the receiving waters, but would rather be dispersed over pervious areas prior to receiving waters and therefore the effective impervious area would be zero, or very close to it.
Sub-catchment Slope (%)	Varies	Varies based on site topography. Refer to Figure 1.1 in Appendix B
Manning's n	Varies 0.050 – 0.10	Based on aerial photography and consistent with values adopted in the Lake Conjola Flood Study (2007). Refer to Figure 1.1 in Appendix B

4.5. Rainfall Data

4.5.1. Design Rainfall

IFD design rainfall depth data and temporal patterns were derived in accordance with Australian Rainfall and Runoff (2019) using the Bureau of Meteorology's 2019 Rainfall IFD on-line Data System.

The temporal patterns for the South East Coast region was used as these cover the subject site (latitude -35.292, longitude 150.399).

A copy of the rainfall depths for the range of storm durations used can be found in Appendix D.

Due to the relatively small size of the catchment areal reduction of rainfall intensities was not undertaken.

4.5.2. Pre-Burst Rainfall

NSW transformation pre-burst rainfall depths derived from ARR 2019 data hub (refer Appendix D) were adopted in the model.

4.5.3. Probable Maximum Precipitation

The PMF is the response of the catchment to the probable maximum precipitation (PMP) and is the largest flood event that can reasonably be expected to occur at a location.

Estimates of PMP were made using the Generalised Short Duration Method (GSDM) presented in Bureau of Meteorology (2003) and are provided in Appendix E.

This method is appropriate for estimating extreme rainfall depths for catchments up to 1,000km^2 in area and storm durations up to 6 hours and is therefore considered appropriate for the subject catchment.

Due to the inability of DRAINS to model spatially variable rainfall no adjustment to the point values above where made.

4.6. Flow Routing

The routing of flows through the catchment was undertaken by adopting an average link velocity of 0.5m/s in the lower, flatter areas of the catchment (i.e. estuaries) and 1m/s in the upper steeper reaches of the catchment, which is considered a typical value for watercourses in similar topography. These values were checked against the hydraulic model and found to be reasonable.

4.7. Results

The DRAINS model was run in lite hydraulic (standard) mode for storm durations ranging from 1 hour to 24 hours for the 5% AEP and 1% AEP events and 15 minutes to 6 hours for the PMF event.

The critical duration and median storm from the ensemble, where applicable, for the range of events modelled are shown in Table 2 whilst hydrographs are provided in Appendix F.

Table 2: Summary of Critical Durations and Storms

Event	Critical Duration	Median Storm from Ensemble	Peak Flow at Outlet (m^3/s)
5% AEP	9 hours	Storm 5	297
1% AEP	12 hours	Storm 9	474
PMF	5 hours	N/A	2,086

4.7.1. Comparison to Regional Flood Frequency Method

Peak flows for the 5% and 1% AEP events were compared to the peak flows obtained through the Regional Flood Frequency Estimation (RFFE) Method and the results are shown in Table 3 and Figure 3, with a copy of the RFFE Method report contained in Appendix G.

The comparison shows good correlation between the calculated and RFFE method values with calculated flows within 30% and 10% for the 5% AEP and 1% AEP events respectively and well within the RFFE model confidence limits. The results are therefore considered reasonable for the purposes of this assessment.

Table 3: Comparison to RFFE Method

AEP	Peak Flow Rate (cumecs)			
	DRAINS	Regional Flood Frequency Estimation Method		
		Discharge	Lower (5%)	Upper (95%)
5%	297	225	84.6	613
1%	474	430	153	1,240

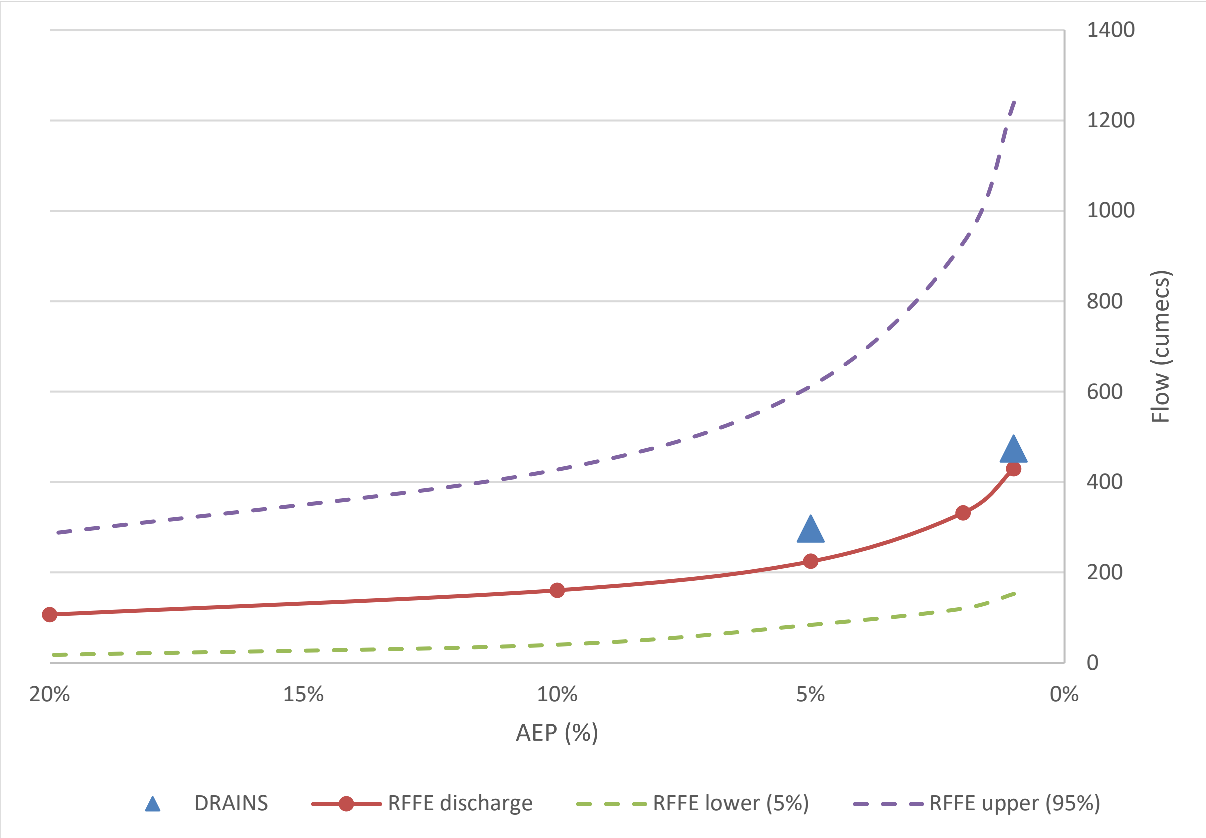


Figure 3: Comparison to RFFE Method

5.0 HYDRAULIC MODELLING

Hydraulic modelling was conducted using an unsteady direct rainfall two-dimensional HEC-RAS model (Version 6.0.1) over the lower reaches of the catchment with hydrographs extracted from the DRAINS hydrological model representing internal and external flows to and within the two-dimensional domain.

5.1. Two-Dimensional Domain

A digital elevation model (DEM) over the lower reaches of the catchment covering the study area was developed using a combination of the following elevation datasets:

i. NSW DPIE 5 metre Topo-Bathy DEM derived from NSW Marine LiDAR Project 2018 raster data. This date was used to define depths primarily within the ocean and estuary.
ii. Geosciences Australia 5 metre DEM
iii. NSW Government 2 metre DEM (Ulladulla 210804) for areas west of the available 5m DEM which were resample of a 5m grid to enable the dataset to be merged.

The 5m DEM grid was imported into HEC-RAS and used as the basis for development of a 20m x 20m terrain model. The DEM grid was further refined where required by applying breaklines to enforce critical changes in geometry, such as at the Princes Highway.

A two-dimensional flow area (i.e. active cells) was defined over the lower reaches of the catchment as shown in Figure 2.1 in Appendix H.

5.2. Manning's Roughness

The two-dimensional domain was assigned a default Manning's n value of 0.035 which is considered representative of rural agricultural areas present in the catchment.

The default value was modified in the areas shown in Figure 2.1 in Appendix H to represent areas of higher and lower values.

The values adopted in the model are consistent with those values adopted in Section 5.4.1 of the adjacent Lake Conjola Flood Study (2007).

5.3. Design Event Modelling

5.3.1. Methodology

Design event modelling was undertaken in accordance with NSW OEH Floodplain Risk Management Guide – Modelling the Interaction of Catchment Flooding and Oceanic Inundation in Coastal Waterways (2015).

Narrawallee Inlet is described as a wave dominated barrier estuary in accordance with the NSW DPIE Estuaries of NSW website. The Narrawallee Inlet Natural Resources Management Plan (2002) describes Narrawallee Inlet as a mature estuarine complex open to the sea with an apparently very stable entrance. It is described as having a large sand shoal located on the southern shore, with a permanent channel along the northern side and a shallow channel extending along the southern side. The Management Plan further states that the entrance has not been known to close, nor is it artificially opened through intervention under the management plan.

NSW OEH (2015) defines wave dominated estuaries as Group 3 estuaries and due to its untrained nature would be classified as a Type C estuary for the purposes of assessment.

NSW OEH (2015) guideline outlines three modelling approaches: a simplistic approach, a general approach, and a detailed approach. The first two approaches comprise components related to elevated ocean water levels, tidal anomalies and wave setup and can be considered conservative in some situations, particularly where these factors are reduced or negated by entrance conditions. This degree of conservatism is in lieu of a more sophisticated analysis outlined in the detailed approach. The decision on the approach used needs to be weigh up the degree of investigation required (i.e. costs) against the implications in determining an approach that is fit for purpose.

The 'simplistic' modelling approach was adopted on the basis that the assessment aims to derive design flood levels as a basis for determining planning controls, such as the flood planning level for an individual house where no flood information is available from Council in accordance with NSW OEH (2015).

In accordance with Table 1c of NSW OEH (2015) for a simplistic approach for a Type C Waterway Entrance the methodology summarised in Table 4 can be adopted.

Table 4: Design Event Modelling Methodology

Parameter	Methodology
Modelling Ocean Water Level Boundary	Steady state ocean boundary for Waterway Entrance Type C based on level obtained from Figure 5.1 (adjusting for whether site is north or south of Crowdy Head, see Figure 5.2) Consideration of maximum height of berm and/or recorded water levels in the estuary.
Relative Timing of Catchment Flooding and Oceanic Inundation	Peak Catchment flood level with static ocean boundary
Determining design flood levels	Only 1% and extreme
Sensitivity testing	0.3m increase in both ocean water level boundary condition and berm level.

5.3.2. Downstream Boundary Condition

Table 5.2 of NSW OEH (2015) defines peak design ocean water levels of RL2.35m AHD and 2.55m AHD for the 5% AEP and 1% AEP events respectively for the area south of Crowdy Head.

Climate change increases of 0.23m for both the 5% AEP and 1% AEP events were added to these values in accordance with the Shoalhaven Climate Change Policy (2015) to enable assessment of the 2050 flood behaviour.

The final ocean boundary levels adopted are shown in Table 5.

Table 5: Adopted Ocean Boundary Levels

Design Storm Event	Ocean Boundary Level	
	Current	2050
5% AEP (2050)	2.35m AHD	2.58m AHD
1% AEP (2050)	2.55m AHD	2.78m AHD

As detailed above Narrawallee Inlet is described as a stable entrance with permanently open channel and therefore the bathymetry DEM data used to define the entrance and estuary condition is considered to reliably reflect the condition of the entrance. On this basis there is no need to further consider maximum entrance berm conditions.

5.3.3. Inflow Boundaries

Inflow hydrographs for the critical duration storms were extracted from the DRAINS hydrological model and input into the hydraulic model in the locations shown in Figure 2.1 in Appendix H. Table 6 provides a summary of the application of the hydrographs to the hydraulic model.

Table 6: Design Event Modelling Methodology

Inflow Boundary	**Catchments**
BC01	Downstream of 1 (i.e. Catchments 1 & 9)
BC02	Downstream of 8 (i.e. Catchments 8, 10 & 11)
BC03	Downstream of 3 (i.e. Catchments 3, 4, 5, 6 & 7)
BC04	Catchment 2

The inflow boundaries were extended along the upstream face of the two-dimensional domain across watercourses over enough length to enable the model to appropriately distribute the flow to the cells that are wet. At any given timestep, only a portion of the boundary condition line may be wet, thus only the cells in which the water surface elevation is higher than their outer boundary face terrain will receive water.

5.3.4. Design Event Modelling

NSW OEH (2015) recommends that flood planning areas in tidal waterways consider the interaction of catchment and coastal flooding from the selection of peak flood levels from an envelope of scenarios such as:

- 1% AEP ocean flooding with 5% AEP catchment flooding with coincident peaks
- 5% AEP ocean flooding with 1% AEP catchment flooding with coincident peaks

On the above basis design event modelling was undertaken for the suite of events shown in Table 7.

Table 7: Design Model Runs

Design AEP for Peak Flood Levels	Catchment Flood Scenario	Ocean Water Boundary Scenario
Design Model Runs		
1% AEP Envelope	5% AEP	1%AEP (2050)
	1% AEP	5% AEP (2050)
PMF Catchment	PMF	1% AEP (2050)

5.4. Results

The HEC-RAS model was run in unsteady mode with variable timestep controlled by Courant condition using the diffusion wave computational method.

Model results for the individual 1% AEP model runs were analysed and the maximum values from each data set extracted to provide an envelop of maximum results. Due to the proximity of the site to the ocean flood levels were dominated by the 5% AEP catchment and 1% AEP ocean boundary scenario.

A summary of applicable flood levels at the subject site is provided in Table 8 whilst flood mapping is provided in Appendix I and includes the mapping figures in

Table *9*.

The results include the mapping of flood hazard vulnerability in accordance with Book 6, Chapter 7 of Australian Rainfall and Runoff (2019).

Table 8: Summary of Flood Levels

Design Event	Flood Level
1% AEP	2.80m AHD
PMF	3.43m AHD

Table 9: Summary of Mapping Results

Figure	Description
Figure 3.1	Envelop of Maximum Flood Levels and Depths – 1% AEP, 2050 Sea Level Rise
Figure 3.2	Envelop of Maximum Flood Velocity – 1% AEP, 2050 Sea Level Rise
Figure 3.3	Envelop of Maximum Flood Hazard (ARR 2019) – 1% AEP, 2050 Sea Level Rise
Figure 4.1	Maximum Flood Levels and Depths – PMF
Figure 4.2	Maximum Flood Velocity – PMF
Figure 4.3	Maximum Flood Hazard (ARR 2019) – PMF

5.5. Results Discussion

The mapping shows that except for the small higher elevated portion of the site towards Macleay Street which remains flood free, most of the site is inundated to depths of more than 1m in the 1% AEP event. In the PMF event the entire site except for a small portion of the access handle is inundated.

Due to low flood velocities in the estuarine floodplain flood risk within the subject site is dictated by flood depth with most of the site being classified as either H4 or H5 in the 1% AEP event except for the proposed building location which is relatively flood free or of lesser hazard category. As expected, flood hazard increases in the PMF event in reflection of increase flood depths over the floodplain.

6.0 ASSESSMENT AGAINST PLANNING PROVISIONS

6.1. Shoalhaven LEP 2014

The proposed development has assessed against clause 5.21 of the Shoalhaven LEP 2014 and a response to each planning objective or control is provided in Table 10.

Table 10: Assessment Against SLEP 2014

Planning objective/control	**Response**
(1) The objectives of this clause are as follows:	
(a) to minimise the flood risk to life and property associated with use of the land,	The proposed development is appropriately located and confined to those areas of the site which are either flood free or low flood hazard in the 1% AEP event. Furthermore, the development is sited such that flood free access to Macleay Street is available in the 1% AEP event. The proposed development therefore minimises the risk to life and property.
(b) to allow development on the land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change'	The proposed development is located on that part of the land least impacted by flooding. The maximum flood hazard within the proposed development footprint is H4 in the 1% AEP when assessed under ARR 2019 and the development is compatible with this risk. In accordance with Table 6.7.3 of ARR 2019 buildings are not vulnerable to structural damage until a H5 hazard.

	The impact of sea level rise in accordance with SCC Climate Change Policy has been included in the assessment and the year 2050 sea level rise scenario used as the basis for determining the FPL in accordance with the SDCP 2014.
(c) to avoid adverse or cumulative impacts on flood behaviour and the environment,	The proposed development will largely occupy land which is flood free in the 1% AEP event. Some minor encroachment into the 1% AEP flood extent is proposed however given floodplain in this location functions as flood storage any minor loss in floodplain storage volume will be inconsequential to existing flood behaviour and will not cause any adverse flood impacts on adjacent properties.
(d) to enable the safe occupation and efficient evacuation of people in the event of a flood.	Reliable flood free access from the proposed dwelling to Macleay Street is available for both vehicular and pedestrians during a 1% AEP flood event.
(2) Development consent must not be granted to development on the land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development-	
(a) is compatible with the flood function and behaviour on the land, and	The proposed development site is classified as Low Hazard Flood Storage/Fringe (refer to Section 6.2) and the development is compatible with this classification. Development in Low Flood Hazard land is permitted under the SDCP 2014.

(b) will not adversely affect flood behaviour in a way that results in determinantal increases in the potential flood affectation of other development or properties, and	The proposed development will largely occupy land which is flood free in the 1% AEP event. Some minor encroachment into the 1% AEP flood extent is proposed however given floodplain in this location functions as flood storage any minor loss in floodplain storage volume will be inconsequential to existing flood behaviour and will not cause any adverse flood impacts on adjacent properties.
(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and	Reliable flood free access from the proposed dwelling to Macleay Street is available for both vehicular and pedestrians during a 1% AEP flood event. Further afield flood free access routes through to Mollymook and Ulladulla would be available from Macleay Street.
(d) incorporates appropriate measures to manage risk to life in the event of a flood, and	The proposed development incorporates a ground floor finished floor level above the flood planning level and flood free access from the site. Furthermore, the proposed development includes a first storey which could be used as a flood refuge in the event of more extreme flooding events.
(e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction the stability or river banks or watercourses	Construction of the proposed development would include appropriate sediment controls to minimise the likelihood of siltation. The proposed development would have an inconsequential impact on existing flood behaviour and as a result would not cause erosion or reduce the stability of river banks or watercourses.

(3) In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters-	
(a) the impact of the development on projected changes in flood behaviour as a result of climate change,	The impact of sea level rise in accordance with SCC Climate Change Policy has been included in the assessment and the year 2050 sea level rise scenario used as the basis for determining the FPL in accordance with the SDCP 2014.
(b) the intended design and scale of building resulting from the development,	The proposed development is appropriately located and confined to those areas of the site which are either flood free or low flood hazard in the 1% AEP event and are therefore of a scale that is compatible with the flood hazard of the site.
(c) whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,	The proposed development incorporates a ground floor finished floor level above the flood planning level and flood free access from the site. Furthermore, the proposed development includes a first storey which could be used as a flood refuge in the event of more extreme flooding events.
(d) the potential to modify, relocate or remove buildings resulting from the development if the surrounding area is impacted by flooding or coastal erosion.	The proposed development is appropriately located and confined to those areas of the site which are either flood free or low flood hazard in the 1% AEP event and are therefore of a scale that is compatible with the flood hazard of the site. Flood hazard over the remainder of the site would preclude development.

6.2. Shoalhaven DCP 2014

The proposed development has assessed against Schedule 2 of Chapter G9 of the Shoalhaven DCP 2014 and a response to each development control is provided in Table 11.

In accordance with Schedule 1 of the SDCP 2014 the proposed development is classified as a Type A(I) development as it comprises a single residential dwelling.

Further, based on the modelling undertaken, that part of the land on which the proposed development is to be located is deemed to be categorised as a Low Hazard Flood Storage and Low Hazard Flood Fringe. Flood depths over the development footprint are less than 1m and velocities are near zero placing the hazard in the intermediate zone in accordance with Figure L2 of the NSW Floodplain Development Manual (refer to Figure 4).

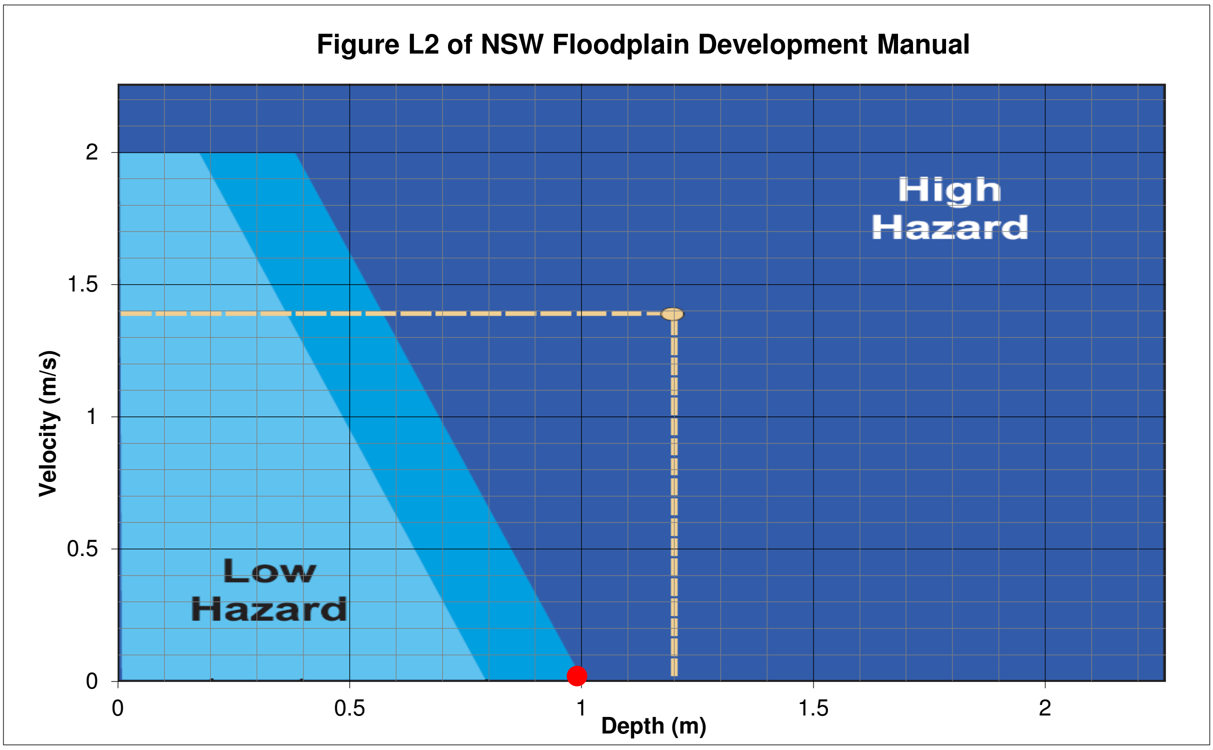


Figure 4: Figure L2 of the NSW Floodplain Development Manual

Table 11: Assessment Against SDCP 2014

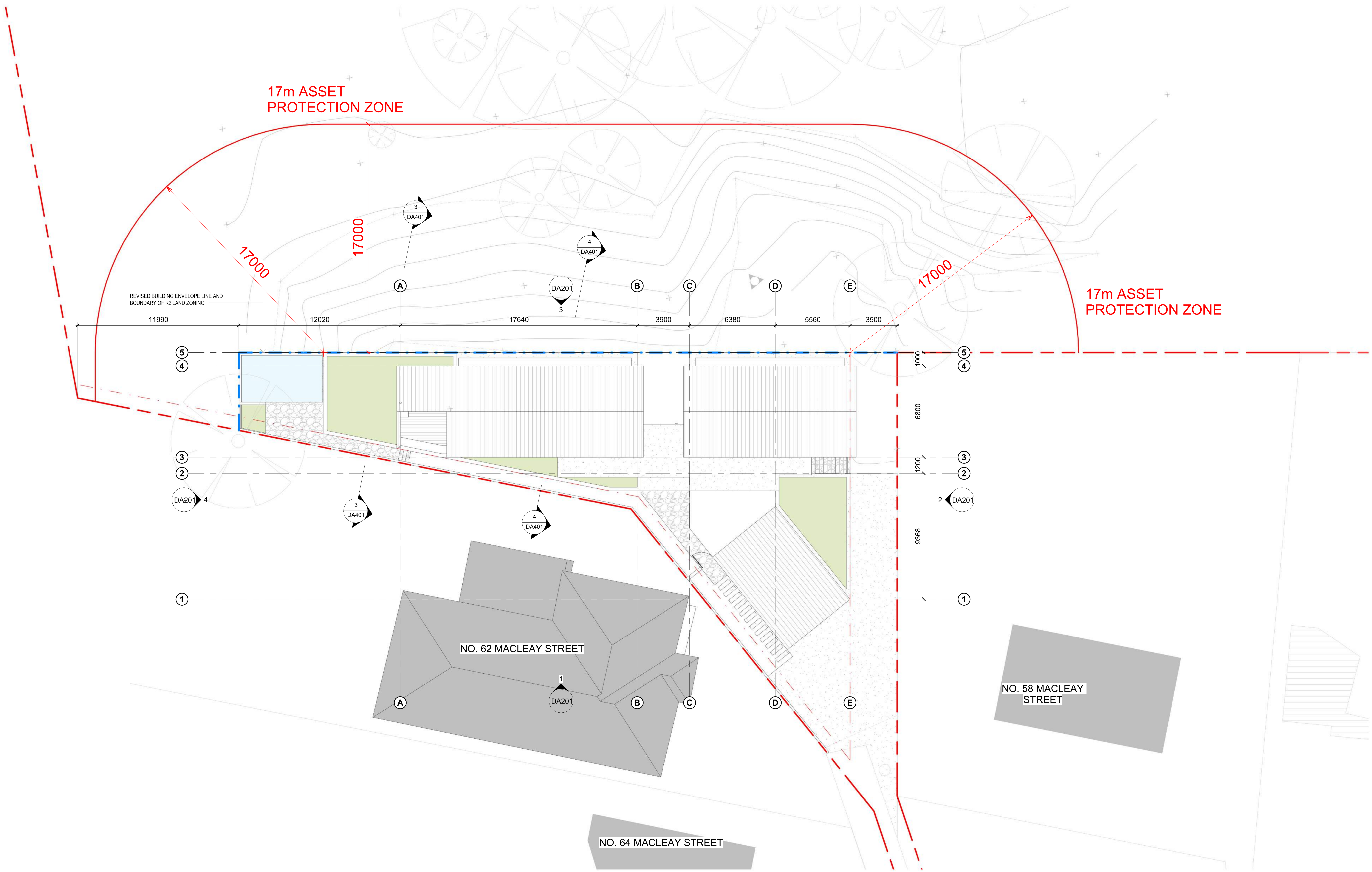
Development Control	**Response**
Floor Level (1) 1% AEP flood level + 0.5m freeboard	In accordance with SDCP 2014 new building applications flood levels for the year 2050 are to be used. The 1% AEP 2050 flood level at the location of the proposed dwelling is RL2.80m AHD and therefore the flood planning level (FPL) is RL3.30m AHD The finished floor level (FFL) of the proposed dwelling is RL3.30m AHD and therefore satisfies the minimum requirement.
Building Components (1) Any portion of the building or structure below the FPL to be built from flood compatible materials (being those materials using in building that are resistant to damage when inundated) (2) All electrical installations to be above the FPL	Below the FPL or RL 3.30m AHD the proposed dwelling will largely consist of concrete slab on ground and masonry walls both of which are flood compatible. All electrical installations would be contained in the walls and ceilings of the proposed dwelling and therefore above the FPL. Care should be taken with respect to the location of the proposed pool pumps and if the cannot be located above the FPL should be capable of disconnection by a single plug and socket assembly.
Structural Soundness (4) Appropriate consulting engineers report – the structure will not become floating debris during a 1% AEP flooding scenario	

	Flood velocities in the location of the proposed dwelling are ear zero and this would equate to an equivalent AS4005 wind classification of N1 in accordance with Table C.2A of Reducing Vulnerability of Building to Flood Damage, Guidance on Building in Flood Prone Areas (2007) and therefore flood loading would be less than that required for wind loading. Additional details can be provided at construction certificate stage as required.
Hydraulic Impact Not applicable for Type A(I) development	Not applicable
Access (1) Reliable emergency vehicle access is required for ambulance, SES, fire brigade, police and other emergency services during a 1% AEP flood event (2) Reliable access for pedestrians is required during a 1% AEP flood event	Reliable flood free access from the proposed dwelling to Macleay Street is available for both vehicular and pedestrians during a 1% AEP flood event.
Flood Evacuation Plan Not applicable for Type A(I) development	Not Applicable
Management and Design Not applicable for Type A(I) development	Not Applicable

footprint.
sustainable engineering.

APPENDIX A

Proposed Development Plans



NOTE:
CHECK ALL DIMENSIONS ON SITE BEFORE COMMENCING FABRICATION. USE FIGURED DIMENSIONS AND DO NOT SCALE OFF THE DRAWINGS.

REV	DATE	DETAILS
A	22.10.2021	LEC REVISION DRAFT
B	10.11.2021	APZ ADJUSTED
C	12.11.2021	COUNCIL CONTENTION AMENDMENTS

Smyth & Smyth ARCHITECTURE | INTERIORS
306/77 dunning avenue
rosebery nsw 2018
t 9662 2720
www.smythandsmyth.com.au
NOMINATED ARCHITECT - DAVID SMYTH - REGISTRATION NO. 10044 NSW

NEW DWELLING AT
60 MACLEAY STREET,
NARRAWALLEE
FOR D & T HARTWIG
project description:

SITE PLAN
this sheet:

north

date: 22.10.2021	scale: 1 : 150
drawn: JY	checked: DS

933	DA100	C
project no.	sheet no.	revision

NOTE:
CHECK ALL DIMENSIONS ON SITE BEFORE COMMENCING FABRICATION.
USE FIGURED DIMENSIONS AND DO NOT SCALE OFF THE DRAWINGS.
COPYRIGHT: THIS DESIGN & DRAWING ARE NOT PERMITTED TO BE REPRODUCED WITHOUT THE PERMISSION OF THE OFFICE OF SMYTH & SMYTH PTY LTD.

REV	DATE	DETAILS
A	22.10.2021	LEC REVISION DRAFT
B	12.11.2021	COUNCIL CONTENTION AMENDMENTS

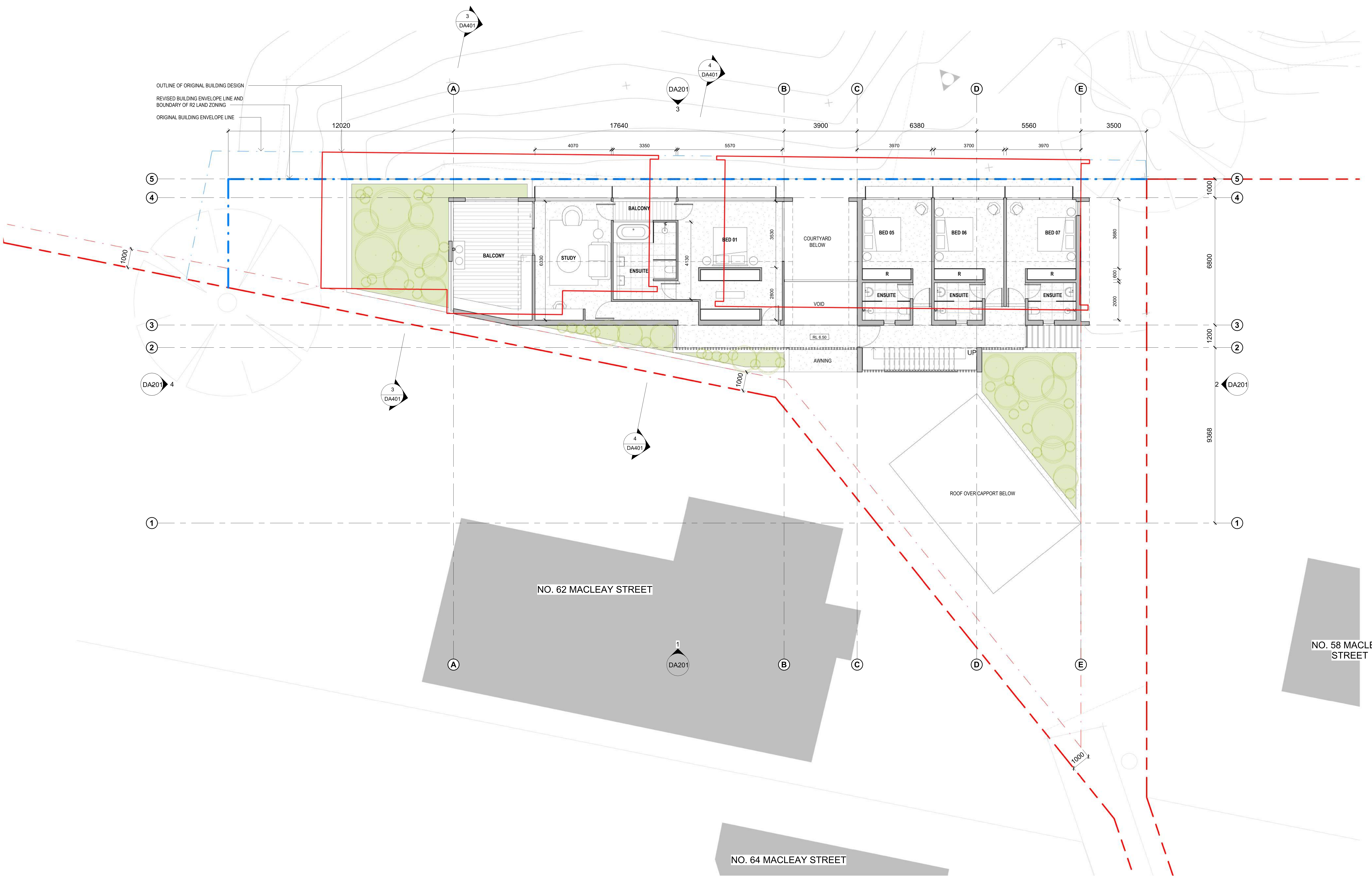
Smyth & Smyth ARCHITECTURE | INTERIORS
306/77 dunning avenue
rosebery nsw 2018
t 9662 2720
www.smythandsmyth.com.au
NOMINATED ARCHITECT - DAVID SMYTH - REGISTRATION NO. 10044 NSW

NEW DWELLING AT
60 MACLEAY STREET,
NARRAWALLEE
FOR D & T HARTWIG
project description:

GROUND FLOOR PLAN
this sheet:

north

date: 22.10.2021	scale: 1 : 100	
drawn: JY	checked: DS	
933 project no.	DA101 sheet no.	B revision



NOTE:
CHECK ALL DIMENSIONS ON SITE BEFORE COMMENCING FABRICATION. USE FIGURED DIMENSIONS AND DO NOT SCALE OFF THE DRAWINGS.

REV	DATE	DETAILS
A	22.10.2021	LEC REVISION DRAFT
B	12.11.2021	COUNCIL CONTENTION AMENDMENTS

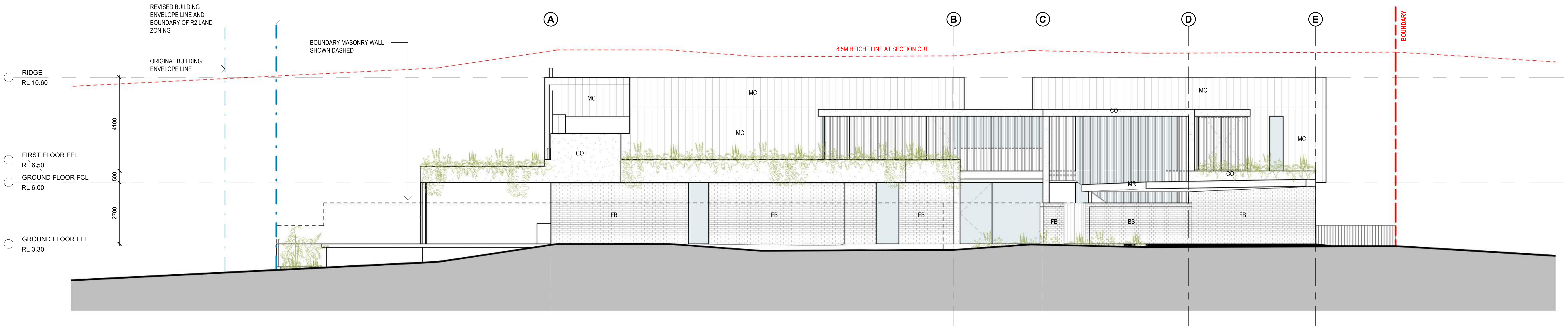
Smyth & Smyth ARCHITECTURE I INTERIORS
306/77 dunning avenue
rosebery nsw 2018
t 9662 2720
www.smythandsmyth.com.au
NOMINATED ARCHITECT - DAVID SMYTH - REGISTRATION NO. 10044 NSW

NEW DWELLING AT
60 MACLEAY STREET,
NARRAWALLEE
FOR D & T HARTWIG
project description:

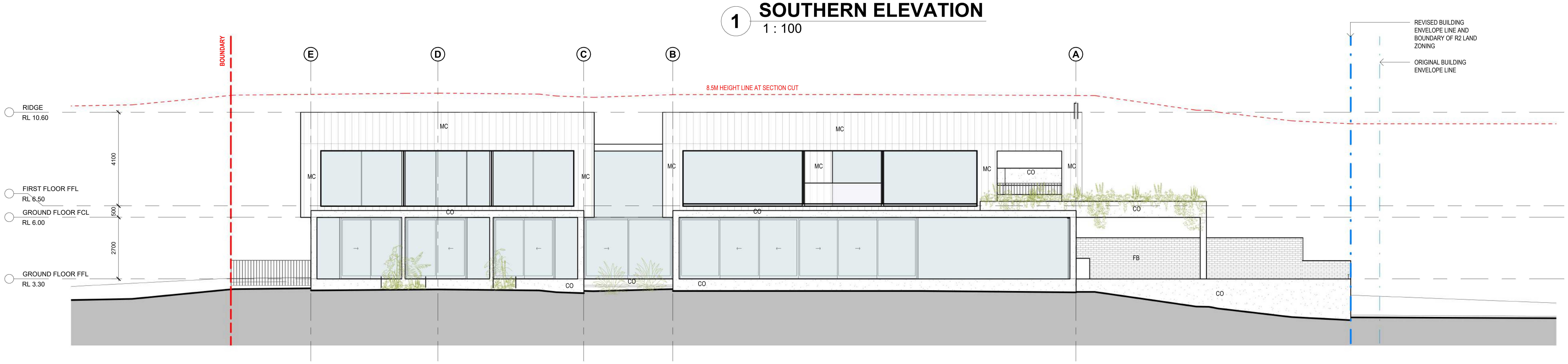
FIRST FLOOR PLAN
this sheet:

north

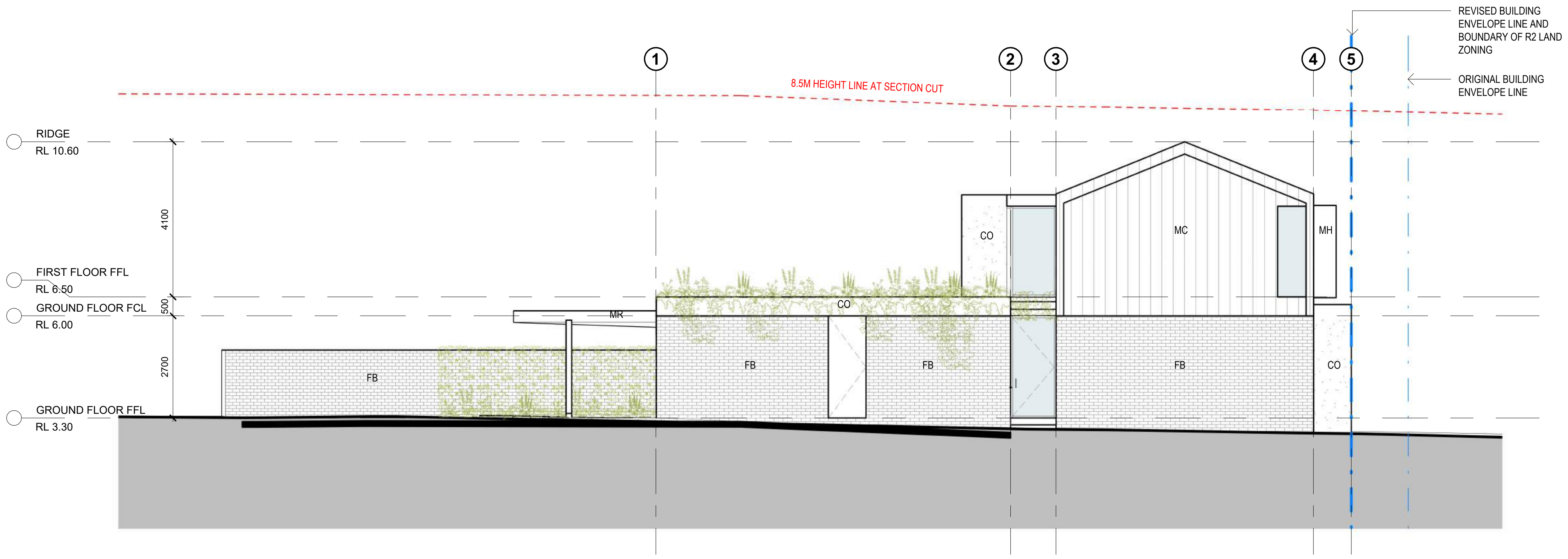
date: 22.10.2021	scale: 1 : 100
drawn: JY	checked: DS
933 project no.	DA102 sheet no.
B revision	



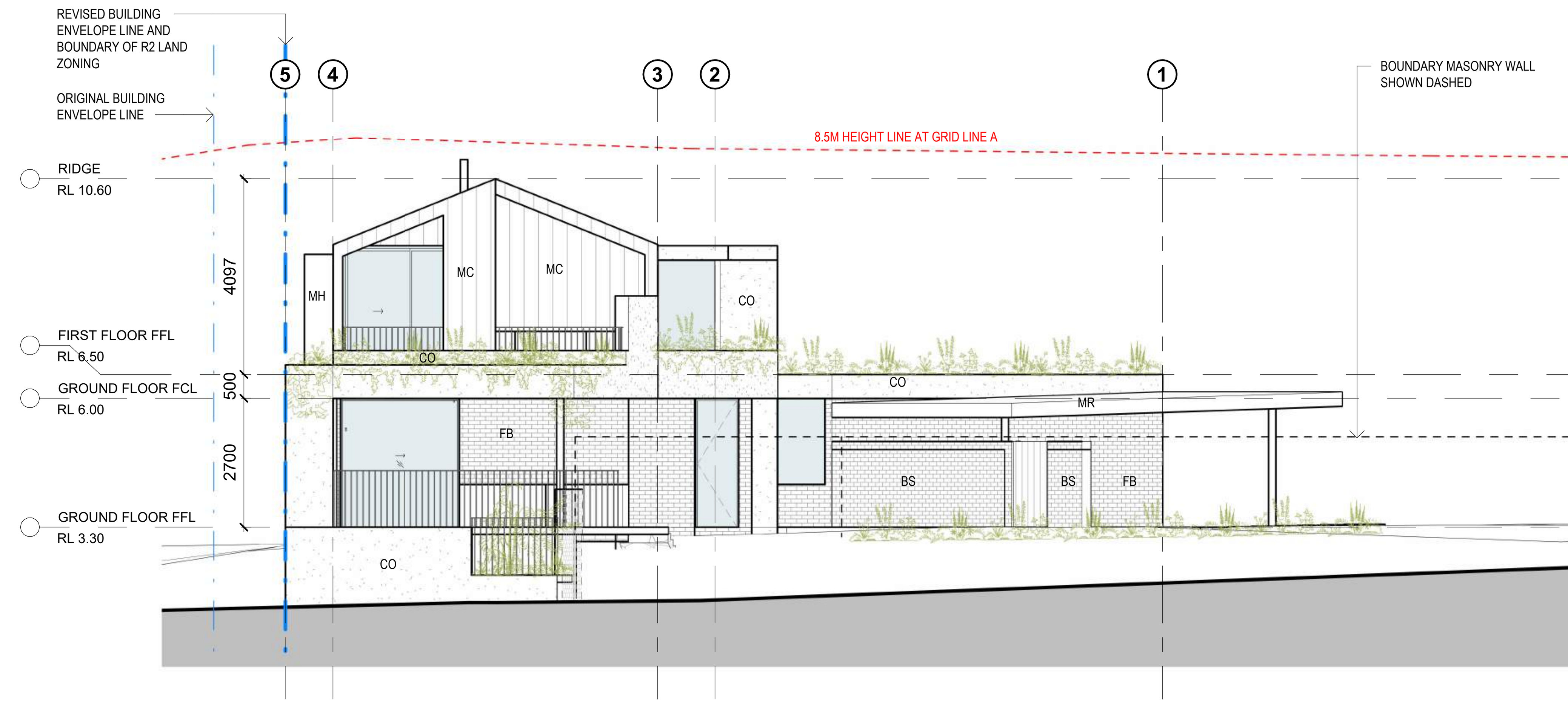
1 **SOUTHERN ELEVATION**
1 : 100



3 **NORTHERN ELEVATION**
1 : 100



2 **EASTERN ELEVATION**
1 : 100



4 **WESTERN ELEVATION**
1 : 100

REV	DATE	DETAILS
A	22.10.2021	LEC REVISION DRAFT
B	12.11.2021	COUNCIL CONTENTION AMENDMENTS

Smyth & Smyth ARCHITECTURE | INTERIORS
306/77 dunning avenue
rosebery nsw 2018
t 9662 2720
www.smythandsmyth.com.au
NOMINATED ARCHITECT - DAVID SMYTH - REGISTRATION NO. 10044 NSW

NEW DWELLING AT
60 MACLEAY STREET,
NARRAWALLEE
FOR D & T HARTWIG
project description:

ELEVATIONS
this sheet:

north

date: 22.10.2021
scale: 1 : 100
drawn: JY
checked: DS

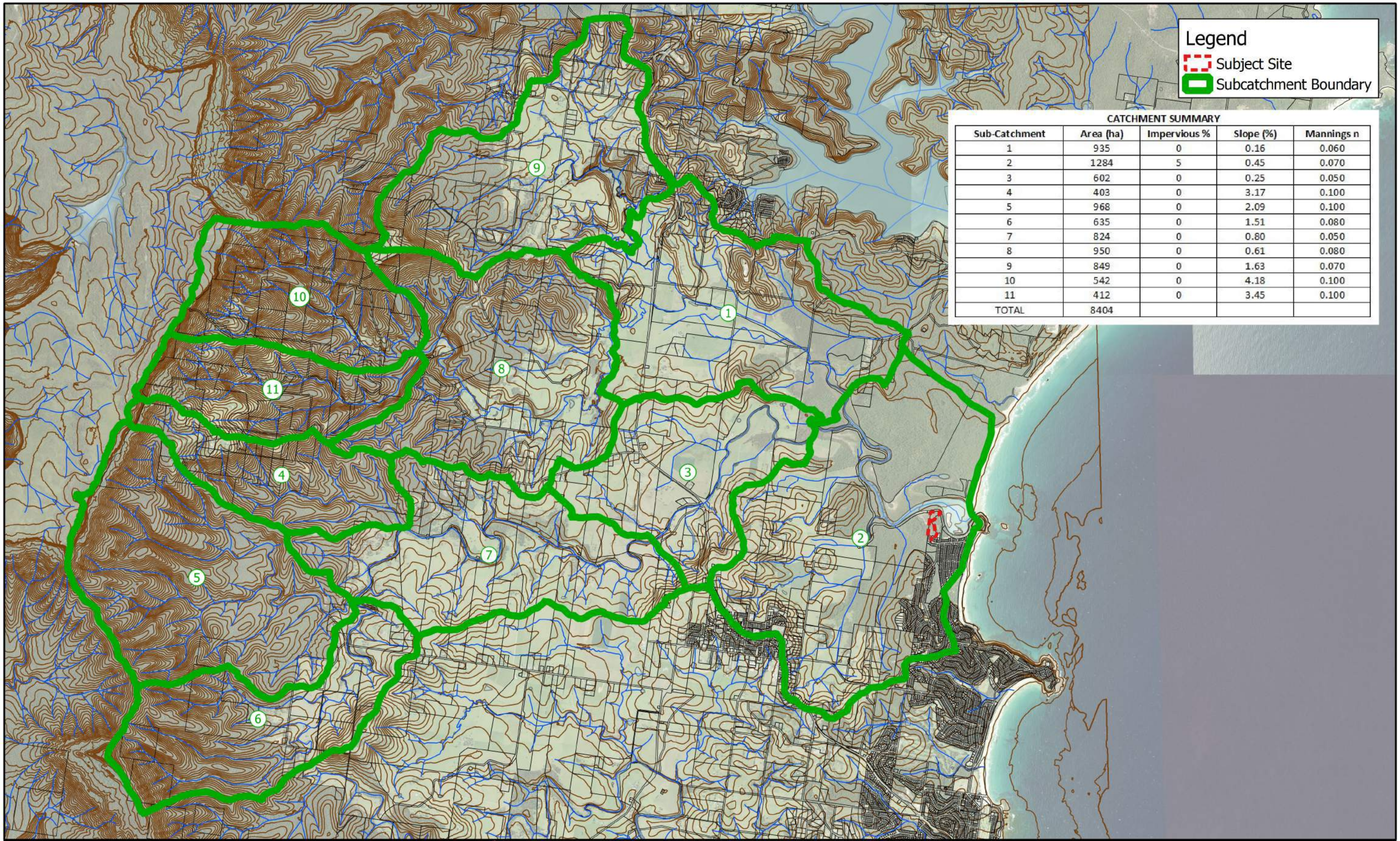
933
project no.

DA201
sheet no.

B
revision

APPENDIX B

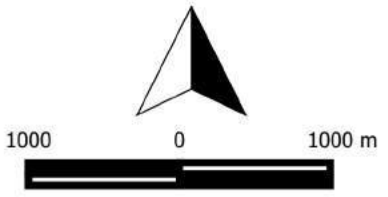
Catchment Plan



CATCHMENT SUMMARY

Sub-Catchment	Area (ha)	Impervious %	Slope (%)	Mannings n
1	935	0	0.16	0.060
2	1284	5	0.45	0.070
3	602	0	0.25	0.050
4	403	0	3.17	0.100
5	968	0	2.09	0.100
6	635	0	1.51	0.080
7	824	0	0.80	0.050
8	950	0	0.61	0.080
9	849	0	1.63	0.070
10	542	0	4.18	0.100
11	412	0	3.45	0.100
TOTAL	8404			

footprint.
sustainable engineering.
15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770



60 MACLEAY STREET, NARRAWALLEE

FIGURE 1.1
CATCHMENT PLAN

Rev 1 - 11 NOVEMBER 2021

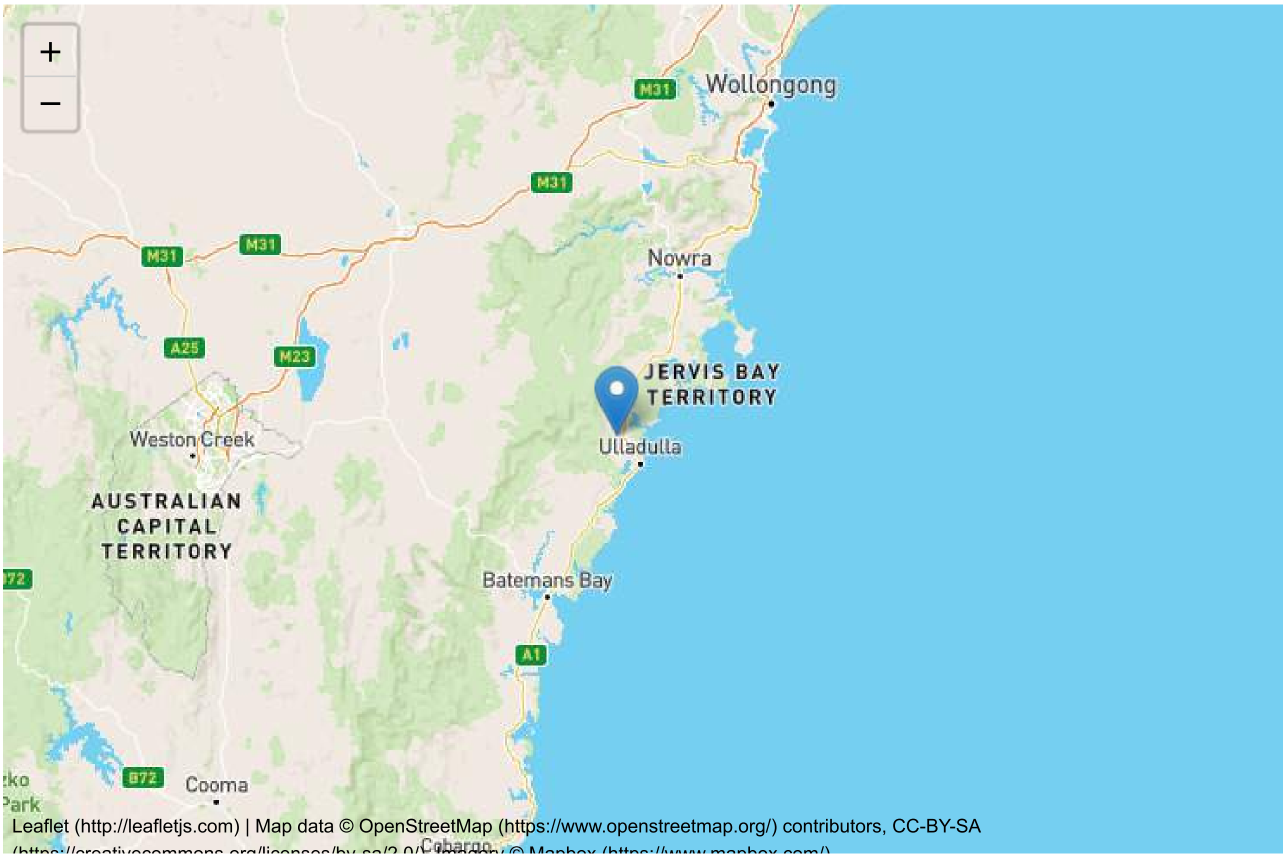
APPENDIX C

ARR Hub Data

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	150.399
Latitude	-35.292
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Interim Climate Change Factors	show
Probability Neutral Burst Initial Loss (./nsw_specific)	show



Data

River Region

Division	South East Coast (NSW)
River Number	16
River Name	Clyde River-Jervis Bay

Layer Info

Time Accessed	09 November 2021 12:48PM
Version	2016_v1

ARF Parameters

$$ARF = Min\left\{1, \left[1 - a\left(Area^{b} - c\log_{10}Duration\right)Duration^{-d} + eArea^{f}Duration^{g}\left(0.3 + \log_{10}AEP\right) + h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\right]\right\}$$

Zone	a	b	c	d	e	f	g	h	i
SE Coast	0.06	0.361	0.0	0.317	8.11e-05	0.651	0.0	0.0	0.0

Short Duration ARF

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} + 2.26 \text{ x } 10^{-3} \text{ x } Area^{0.226}.Duration^{0.125}\left(0.3 + \log_{10}(AEP)\right) + 0.0141 \text{ x } Area^{0.213} \text{ x } 10^{-0.021\frac{(Duration-180)^{2}}{1440}}\left(0.3 + \log_{10}(AEP)\right)\right]$$

Layer Info

Time Accessed	09 November 2021 12:48PM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

Note: As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. The continuing storm loss information from the ARR Datahub provided below should only be used where relevant under the loss hierarchy (level 5) and where used is to be multiplied by the factor of 0.4.

ID	28225.0
Storm Initial Losses (mm)	26.0
Storm Continuing Losses (mm/h)	5.6

Layer Info

Time Accessed	09 November 2021 12:48PM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/SSmainland.zip)

code	SSmainland
Label	Southern Slopes (Vic/NSW)

Layer Info

Time Accessed	09 November 2021 12:48PM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_SSmainland.zip)

code	SSmainland
arealabel	Southern Slopes (Vic/NSW)

Layer Info

Time Accessed	09 November 2021 12:48PM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-35.292082975&longitude=150.3993&sdmin=true&sdhr=true&sdday=true&user_label=) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	09 November 2021 12:48PM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	2.1 (0.080)	2.7 (0.070)	3.1 (0.065)	3.5 (0.061)	2.0 (0.029)	0.9 (0.011)
90 (1.5)	1.7 (0.056)	4.5 (0.099)	6.3 (0.113)	8.1 (0.121)	4.8 (0.059)	2.4 (0.026)
120 (2.0)	4.5 (0.128)	9.2 (0.180)	12.4 (0.196)	15.4 (0.205)	8.0 (0.087)	2.5 (0.023)
180 (3.0)	10.3 (0.245)	11.6 (0.188)	12.5 (0.165)	13.3 (0.148)	10.1 (0.093)	7.7 (0.062)
360 (6.0)	9.7 (0.163)	19.3 (0.222)	25.6 (0.242)	31.7 (0.253)	21.3 (0.141)	13.5 (0.079)
720 (12.0)	5.8 (0.068)	11.9 (0.096)	16.0 (0.106)	19.9 (0.112)	32.0 (0.150)	41.2 (0.170)
1080 (18.0)	7.3 (0.070)	11.9 (0.079)	15.0 (0.081)	18.0 (0.083)	29.2 (0.112)	37.7 (0.127)
1440 (24.0)	1.2 (0.010)	6.4 (0.037)	9.9 (0.047)	13.2 (0.053)	18.3 (0.061)	22.1 (0.065)
2160 (36.0)	0.4 (0.003)	2.4 (0.012)	3.8 (0.015)	5.1 (0.017)	8.0 (0.022)	10.1 (0.025)
2880 (48.0)	0.0 (0.000)	0.2 (0.001)	0.3 (0.001)	0.4 (0.001)	2.5 (0.006)	4.0 (0.009)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.7 (0.002)	1.3 (0.003)

Layer Info

Time Accessed	09 November 2021 12:48PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

10% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	09 November 2021 12:48PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

25% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.6 (0.012)	1.0 (0.016)	1.4 (0.019)	0.6 (0.006)	0.0 (0.000)
180 (3.0)	0.5 (0.011)	0.3 (0.004)	0.1 (0.002)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.6 (0.011)	0.4 (0.005)	0.3 (0.003)	0.1 (0.001)	0.1 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.1 (0.001)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	1.8 (0.007)	3.1 (0.011)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	09 November 2021 12:48PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

75% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	18.6 (0.712)	25.5 (0.663)	30.1 (0.633)	34.5 (0.605)	35.2 (0.501)	35.7 (0.440)
90 (1.5)	16.3 (0.529)	28.2 (0.622)	36.1 (0.646)	43.7 (0.654)	44.1 (0.537)	44.4 (0.470)
120 (2.0)	42.4 (1.212)	52.1 (1.015)	58.6 (0.928)	64.8 (0.862)	63.4 (0.689)	62.4 (0.591)
180 (3.0)	53.4 (1.266)	58.6 (0.949)	62.1 (0.821)	65.4 (0.729)	74.0 (0.677)	80.4 (0.644)
360 (6.0)	41.2 (0.689)	66.9 (0.770)	84.0 (0.792)	100.3 (0.802)	98.0 (0.649)	96.3 (0.562)
720 (12.0)	28.9 (0.338)	45.1 (0.363)	55.8 (0.369)	66.1 (0.371)	86.8 (0.406)	102.3 (0.423)
1080 (18.0)	31.2 (0.299)	40.7 (0.269)	47.0 (0.255)	53.0 (0.244)	76.3 (0.291)	93.7 (0.317)
1440 (24.0)	18.7 (0.157)	29.5 (0.171)	36.6 (0.174)	43.4 (0.174)	59.8 (0.199)	72.1 (0.212)
2160 (36.0)	7.1 (0.051)	19.6 (0.097)	27.9 (0.112)	35.9 (0.121)	49.8 (0.139)	60.2 (0.148)
2880 (48.0)	4.7 (0.031)	9.2 (0.041)	12.2 (0.044)	15.0 (0.046)	24.9 (0.062)	32.3 (0.071)
4320 (72.0)	0.0 (0.000)	0.9 (0.003)	1.4 (0.005)	2.0 (0.005)	23.2 (0.051)	39.1 (0.075)

Layer Info

Time Accessed	09 November 2021 12:48PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

90% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	86.8 (3.329)	91.7 (2.385)	95.0 (1.999)	98.1 (1.724)	112.5 (1.602)	123.3 (1.519)
90 (1.5)	77.8 (2.522)	113.0 (2.490)	136.3 (2.437)	158.7 (2.376)	148.0 (1.804)	139.9 (1.482)
120 (2.0)	118.8 (3.400)	147.5 (2.871)	166.4 (2.635)	184.6 (2.455)	171.1 (1.859)	161.0 (1.525)
180 (3.0)	111.4 (2.641)	148.0 (2.396)	172.3 (2.276)	195.5 (2.177)	194.5 (1.780)	193.8 (1.552)
360 (6.0)	79.9 (1.336)	111.6 (1.283)	132.6 (1.251)	152.7 (1.221)	176.0 (1.166)	193.5 (1.129)
720 (12.0)	76.2 (0.890)	97.1 (0.782)	110.9 (0.734)	124.1 (0.698)	147.6 (0.690)	165.2 (0.683)
1080 (18.0)	69.1 (0.662)	91.4 (0.604)	106.2 (0.576)	120.3 (0.553)	152.8 (0.584)	177.2 (0.599)
1440 (24.0)	67.9 (0.572)	76.9 (0.446)	82.9 (0.394)	88.6 (0.356)	114.7 (0.382)	134.2 (0.395)
2160 (36.0)	51.6 (0.372)	63.5 (0.313)	71.3 (0.287)	78.9 (0.267)	102.6 (0.287)	120.3 (0.296)
2880 (48.0)	22.0 (0.144)	36.1 (0.161)	45.5 (0.165)	54.4 (0.166)	73.3 (0.184)	87.4 (0.192)
4320 (72.0)	9.7 (0.057)	18.3 (0.074)	24.1 (0.078)	29.6 (0.080)	82.7 (0.182)	122.4 (0.236)

Layer Info

Time Accessed	09 November 2021 12:48PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

	RCP 4.5	RCP6	RCP 8.5
2030	**0.648 (3.2%)**	0.687 (3.4%)	**0.811 (4.0%)**
2040	**0.878 (4.4%)**	0.827 (4.1%)	**1.084 (5.4%)**
2050	**1.081 (5.4%)**	1.013 (5.1%)	**1.446 (7.3%)**
2060	**1.251 (6.3%)**	1.229 (6.2%)	**1.862 (9.5%)**
2070	**1.381 (7.0%)**	1.460 (7.4%)	**2.298 (11.9%)**
2080	**1.465 (7.4%)**	1.691 (8.6%)	**2.719 (14.2%)**
2090	**1.496 (7.6%)**	1.906 (9.7%)	**3.090 (16.3%)**

Layer Info

Time Accessed	09 November 2021 12:48PM
Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Probability Neutral Burst Initial Loss

min (h)\AEP(%)	50.0	20.0	10.0	5.0	2.0	1.0
60 (1.0)	14.2	10.7	10.2	10.0	10.1	6.6
90 (1.5)	14.6	10.9	10.3	9.2	9.6	5.7
120 (2.0)	11.8	9.3	9.0	8.2	9.4	5.5
180 (3.0)	11.2	9.6	9.4	8.6	9.0	4.6
360 (6.0)	12.7	9.0	9.4	8.3	10.2	2.8
720 (12.0)	16.1	11.8	12.5	9.4	11.1	3.5
1080 (18.0)	16.8	12.9	13.3	10.9	10.3	4.3
1440 (24.0)	19.7	15.6	15.8	13.3	14.3	5.0
2160 (36.0)	22.7	16.9	17.1	14.8	15.6	6.2
2880 (48.0)	25.2	21.3	20.8	21.0	21.4	7.1
4320 (72.0)	27.9	25.1	25.7	25.6	22.8	8.3

Layer Info

Time Accessed	09 November 2021 12:48PM
Version	2018_v1

Note	As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. Probability neutral burst initial loss values for NSW are to be used in place of the standard initial loss and pre-burst as per the losses hierarchy.

Download TXT (downloads/698207e1-a0a3-4ed7-8ad7-10c90ea4b796.txt)

Download JSON (downloads/50a09630-3ec3-4e72-9985-0c54902eb247.json)

Generating PDF... (downloads/bb708abd-7d2b-42a5-9baf-bb2c52c047a9.pdf)

APPENDIX D

Design Rainfall Intensities

Location

Label: Not provided

Latitude: -35.2921 [Nearest grid cell: 35.2875 (S)]

Longitude:150.3993 [Nearest grid cell: 150.3875 (E)]

IFD Design Rainfall Depth (mm)

Issued: 09 November 2021

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	1.96	2.29	3.37	4.17	5.00	6.19	7.17
2 min	3.26	3.81	5.62	6.94	8.30	10.2	11.8
3 min	4.51	5.27	7.77	9.59	11.5	14.1	16.3
4 min	5.63	6.56	9.67	11.9	14.3	17.6	20.3
5 min	6.61	7.70	11.3	14.0	16.8	20.7	24.0
10 min	10.2	11.9	17.5	21.6	26.0	32.2	37.4
15 min	12.6	14.6	21.5	26.7	32.1	39.8	46.2
20 min	14.3	16.7	24.6	30.5	36.6	45.5	52.8
25 min	15.7	18.3	27.1	33.5	40.3	50.0	58.1
30 min	17.0	19.8	29.2	36.1	43.4	53.9	62.5
45 min	19.9	23.2	34.3	42.4	50.9	63.0	73.0
1 hour	22.3	26.1	38.5	47.5	56.9	70.2	81.1
1.5 hour	26.4	30.8	45.4	55.9	66.8	82.0	94.4
2 hour	30.0	35.0	51.4	63.1	75.2	92.0	106
3 hour	36.2	42.2	61.8	75.7	89.8	109	125
4.5 hour	44.2	51.6	75.2	91.9	109	131	150
6 hour	51.3	59.8	87.0	106	125	151	171
9 hour	63.5	73.9	107	130	154	185	209
12 hour	73.6	85.6	124	151	178	214	242
18 hour	89.8	104	151	184	218	262	296
24 hour	102	119	173	211	249	300	340
30 hour	112	130	189	232	275	331	376
36 hour	119	139	203	249	296	358	406
48 hour	131	152	224	275	329	399	455
72 hour	144	168	249	309	371	453	519
96 hour	152	177	264	329	397	487	558
120 hour	157	183	274	342	414	508	584

144 hour	161	188	281	351	426	523	601
168 hour	165	192	287	358	436	535	614

Note:
The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

This page was created at **12:50 on Tuesday 9 November 2021 (AEDT)**

APPENDIX E

PMP Calculations

GSDM Calculation Sheet

Location Information				
Catchment	Narrawallee Inlet	Area (km2)	84.04	
State	NSW	Duration Limit (hrs)	6	
Latitude	-35.29208	Longitude	150.3993	
Proportion of Area Considered:				
Smooth S= (0.0 - 1.0)	0	Rough R= (0.0-1.0)	1	
Elevation Adjustment Factor (EAF)				
Mean Elevation (m AHD)			96	
Adjustment for Eelvation (-0.05 per 300m above 1500m)			0	
EAF = (0.85-1.00)			1	
Moisture Adjustment Factor (MAF)				
MAF = (0.40 - 1.00)			0.65	
PMP Values				
Duarion (hrs)	Initial Depth - Smooth	Initial Depth - Rough	PMP Estimate	Rounded PMP Estimate (nearest 10mm)
0.25		170	111	110
0.50		255	166	170
0.75		320	208	210
1.0		390	254	250
1.5		500	325	330
2.0		575	374	370
2.5		650	423	420
3.0		700	455	460
4.0		790	514	510
5.0		870	566	570
6.0		930	605	600

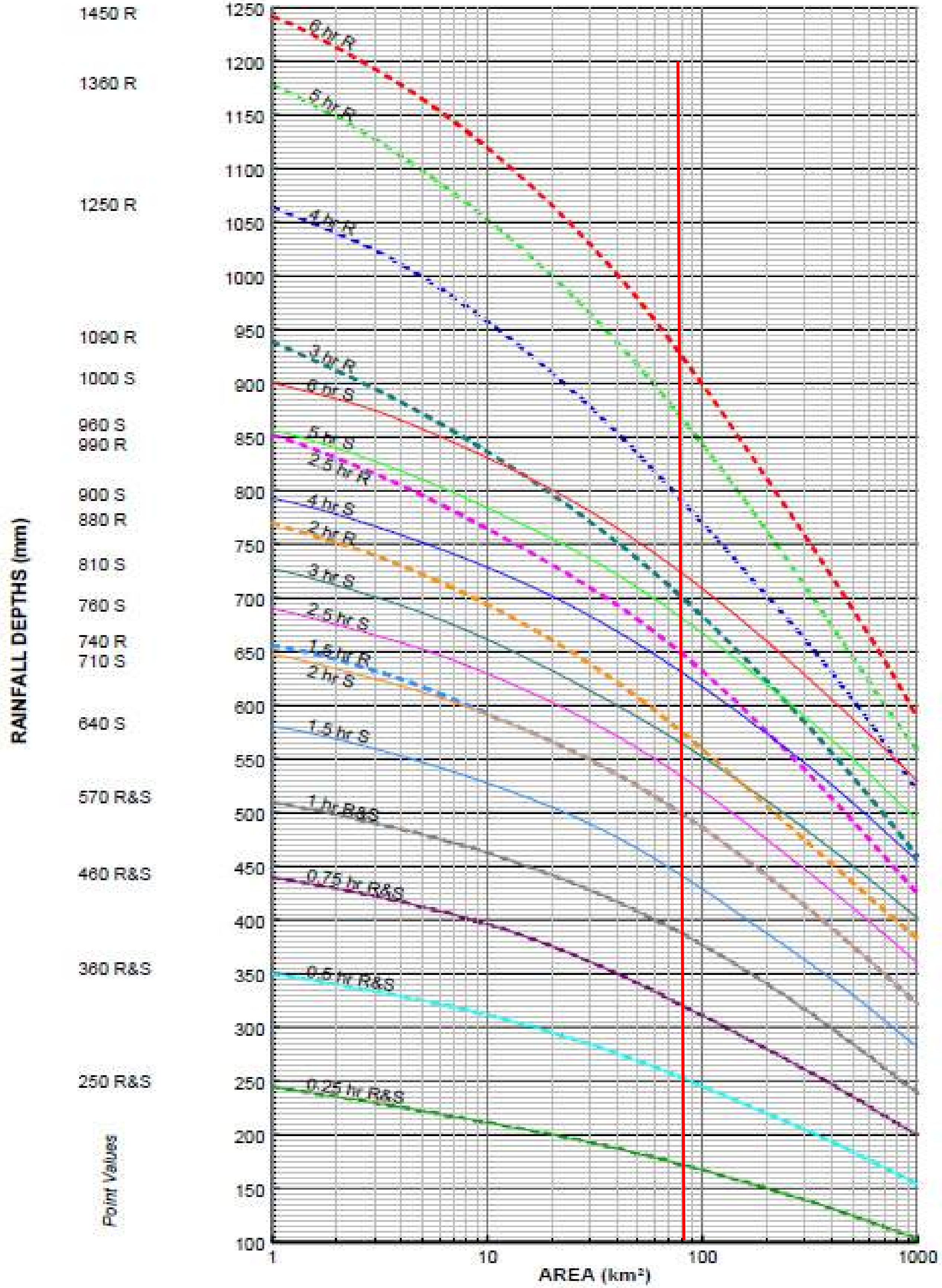
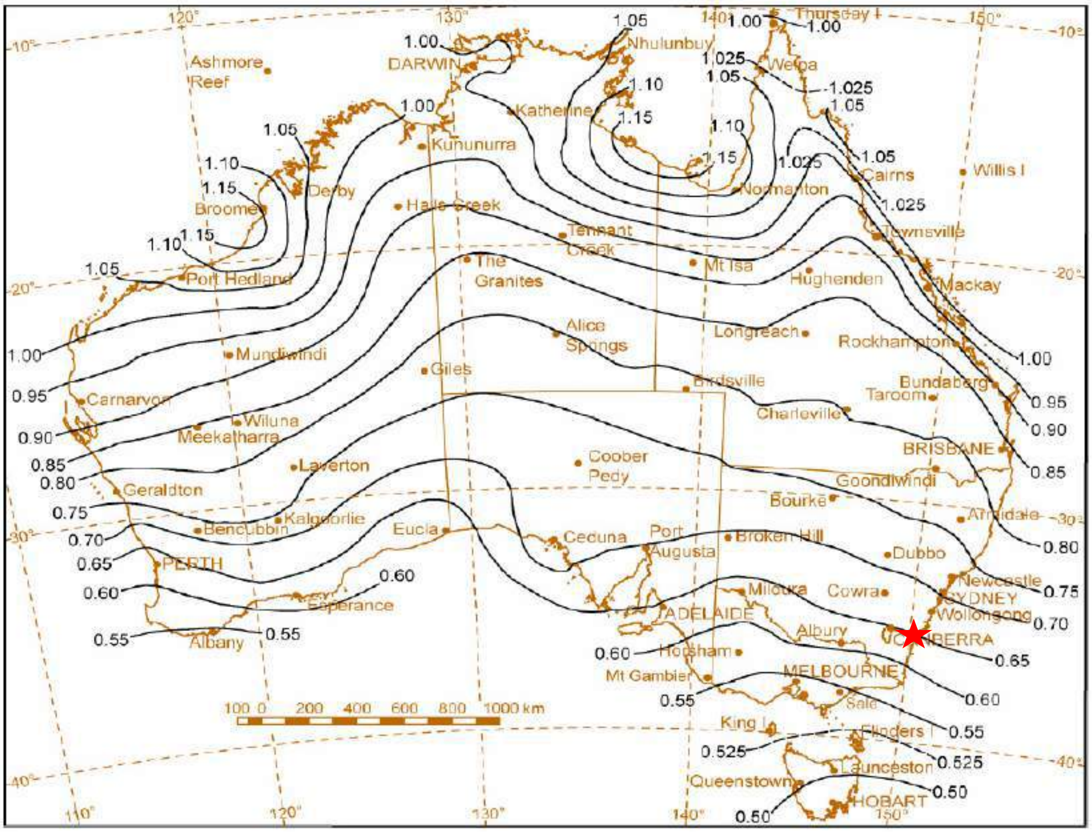
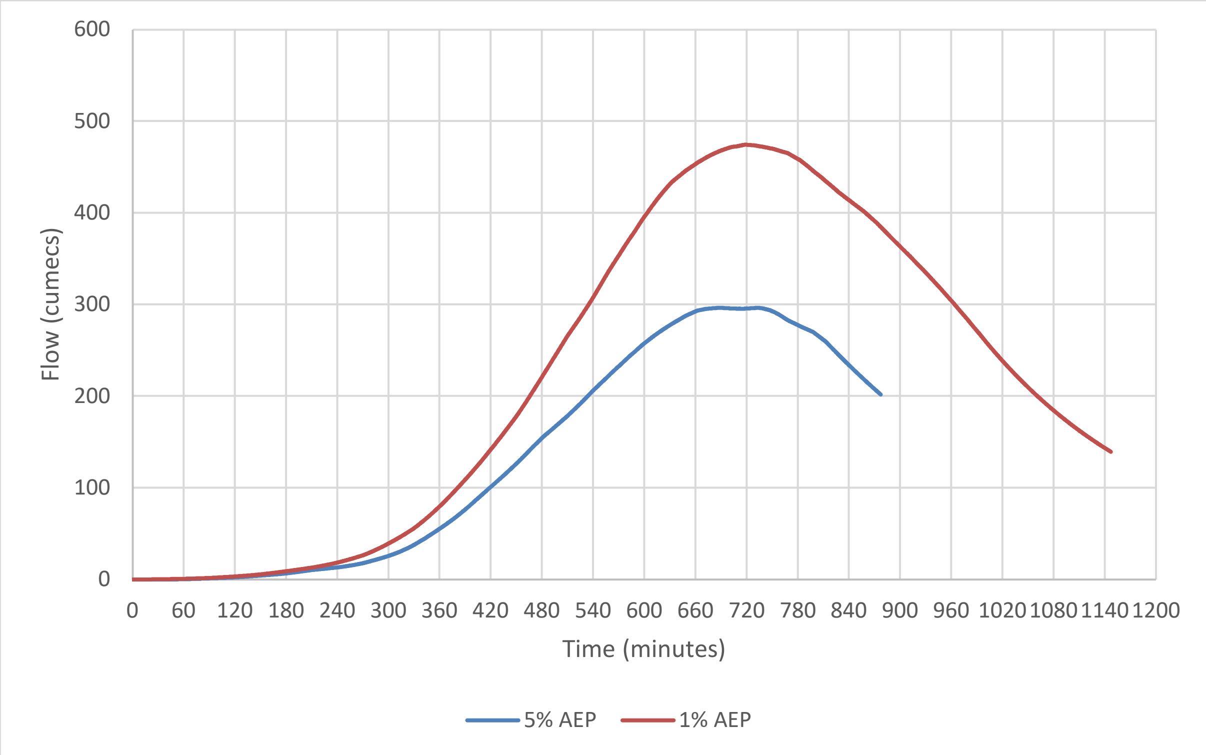


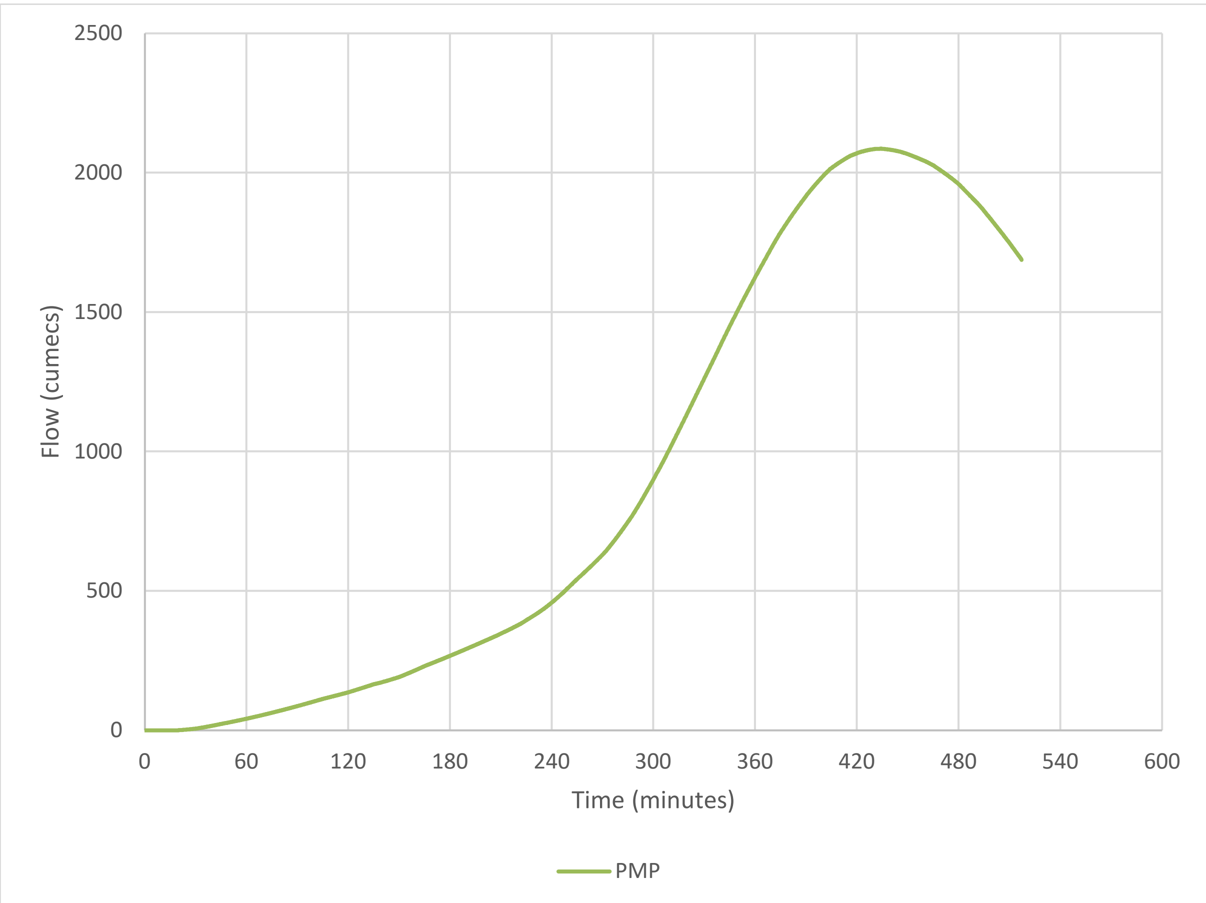
Figure 4: **Depth-Duration-Area Curves of Short Duration Rainfall**


Ashmore Reef
DARWIN
Katherine
Nhulunbuy
Thursday I
Weipa
Kununurra
Derby
Broome
Halls Creek
Port Hedland
Tennant Creek
Mt Isa
Normanton
Cairns
Willis I
Townsville
Hughenden
Mackay
The Granites
Alice Springs
Longreach
Rockhampton
Mundiwindi
Giles
Birdsville
Bundaberg
Taroom
Carnarvon
Wiluna
Meekatharra
Charleville
BRISBANE
Laverton
Coober Pedy
Goondiwindi
Geraldton
Bourke
Armidale
Bencubbin
Kalgoorlie
Eucla
Ceduna
Port Augusta
Broken Hill
Dubbo
PERTH
Newcastle
SYDNEY
Wollongong
Esperance
Mildura
Cowra
ADELAIDE
Albury
Albany
Horsham
Mt Gambier
MELBOURNE
Sale
King I
Flinders I
Launceston
Queenstown
HOBART
100 0 200 400 600 800 1000 km
1.00
1.05
1.10
1.15
1.025
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.525
0.50
10°
20°
30°
40°
110°
120°
130°
140°
150°

APPENDIX F

Hydrographs

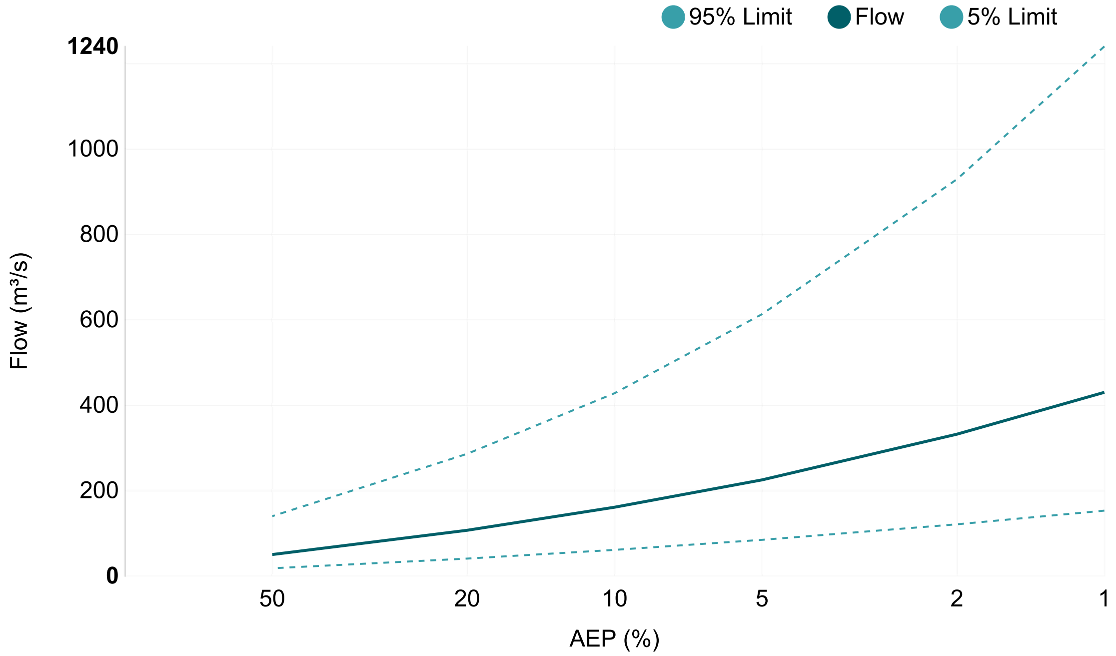

600
500
400
300
200
100
0
Flow (cumecs)
0 60 120 180 240 300 360 420 480 540 600 660 720 780 840 900 960 1020 1080 1140 1200
Time (minutes)
5% AEP
1% AEP


2500
2000
1500
1000
500
0
Flow (cumecs)
0 60 120 180 240 300 360 420 480 540 600
Time (minutes)
PMP

APPENDIX G

RFFE Method Results

Results | Regional Flood Frequency Estimation Model



AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	50.2	18.0	140
20	107	40.7	286
10	161	61.1	428
5	225	84.6	613
2	332	121	929
1	430	153	1240

Statistics

Variable	Value	Standard Dev
Mean	4.117	0.655
Standard Dev	0.881	0.193
Skew	0.093	0.027

Note: These statistics come from the nearest gauged catchment. Details.

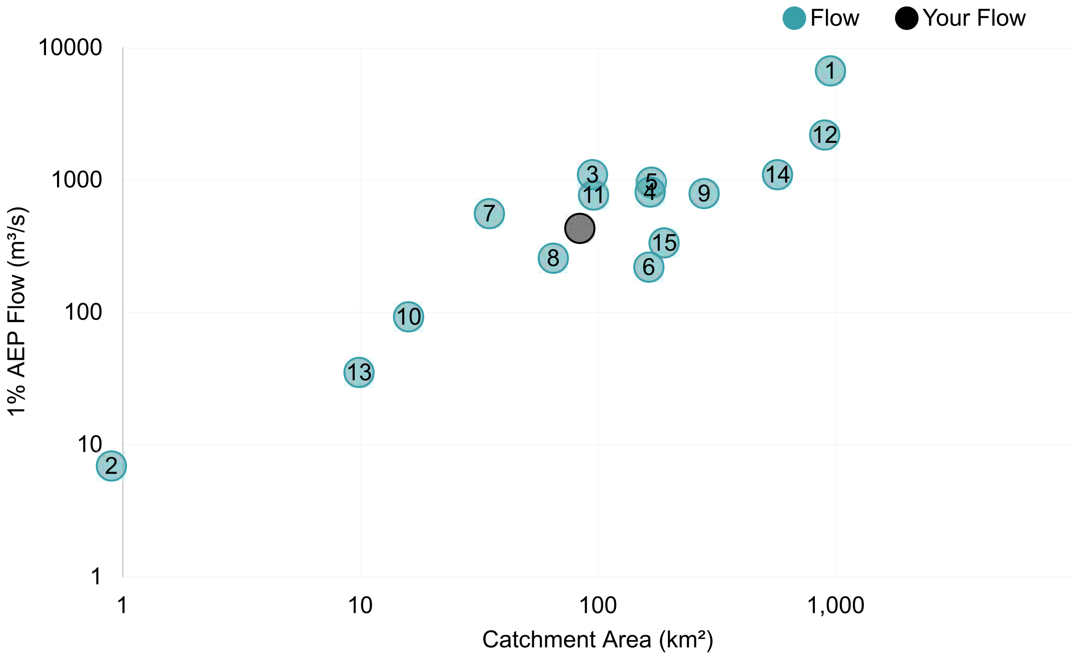
Correlation

Correlation

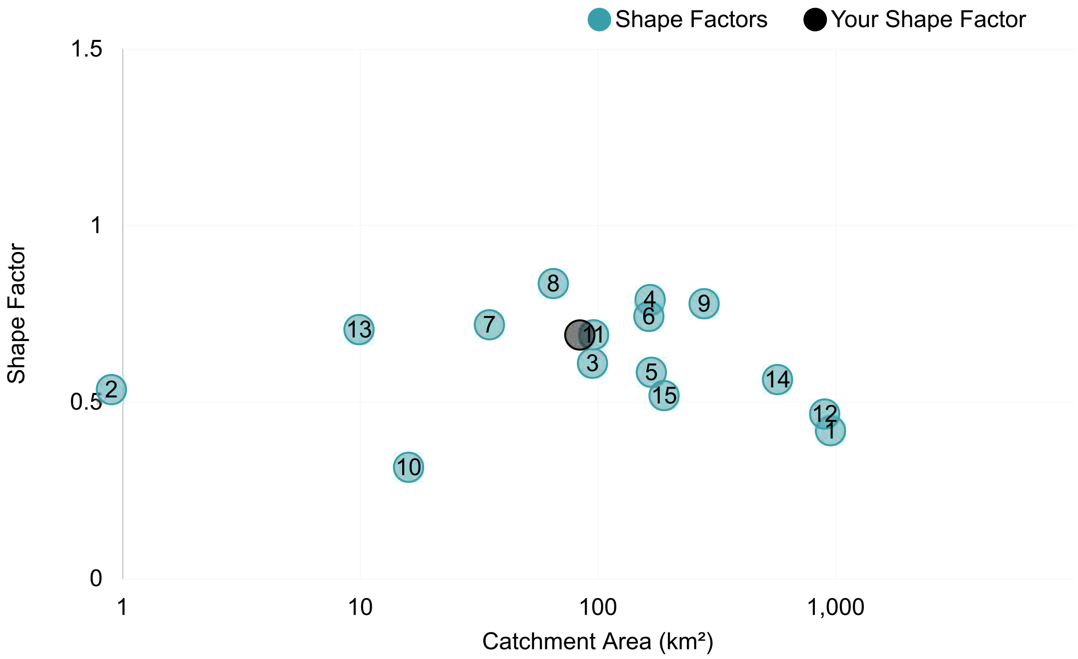
1.000		
-0.330	1.000	
0.170	-0.280	1.000

Note: These statistics are common to each region. Details.

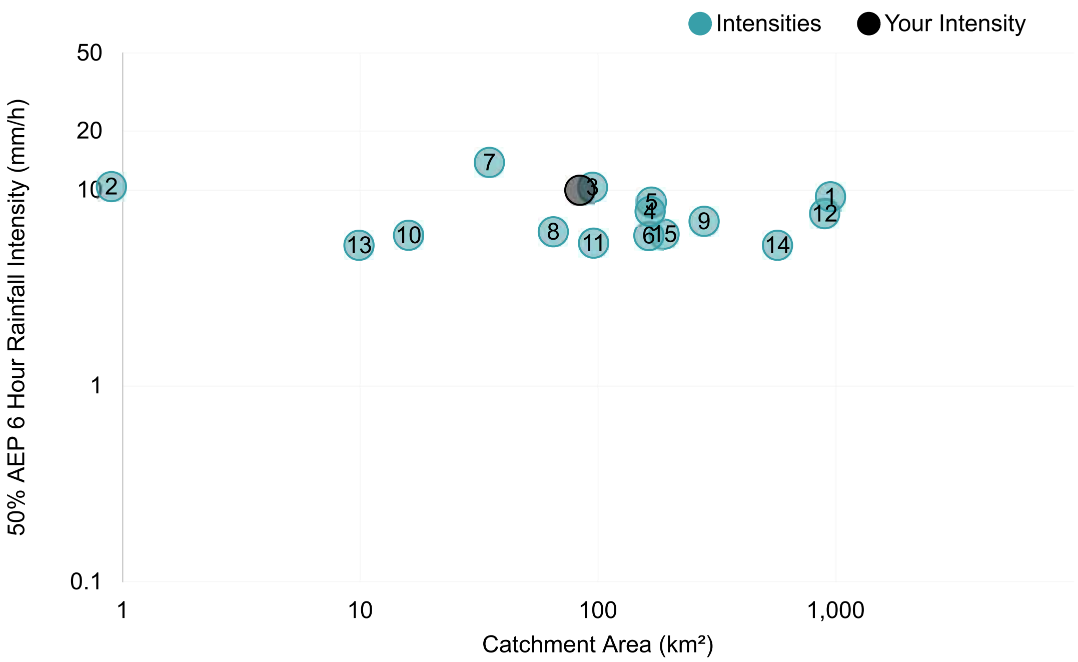
1% AEP Flow vs Catchment Area



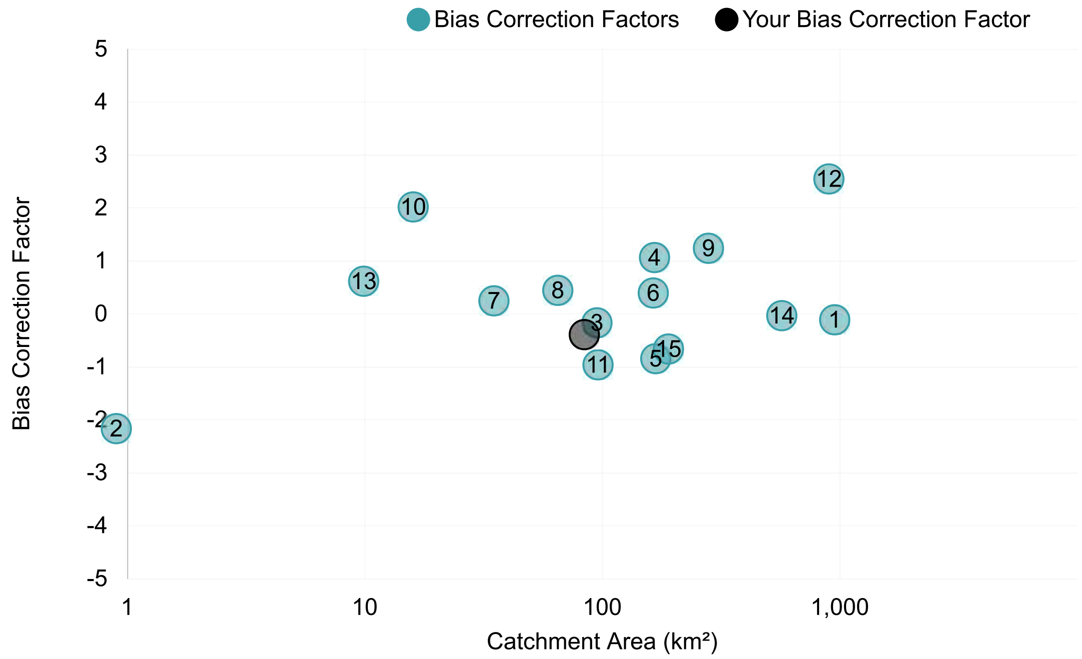
Shape Factor vs Catchment Area



Intensity vs Catchment Area



Bias Correction Factor vs Catchment Area



Download

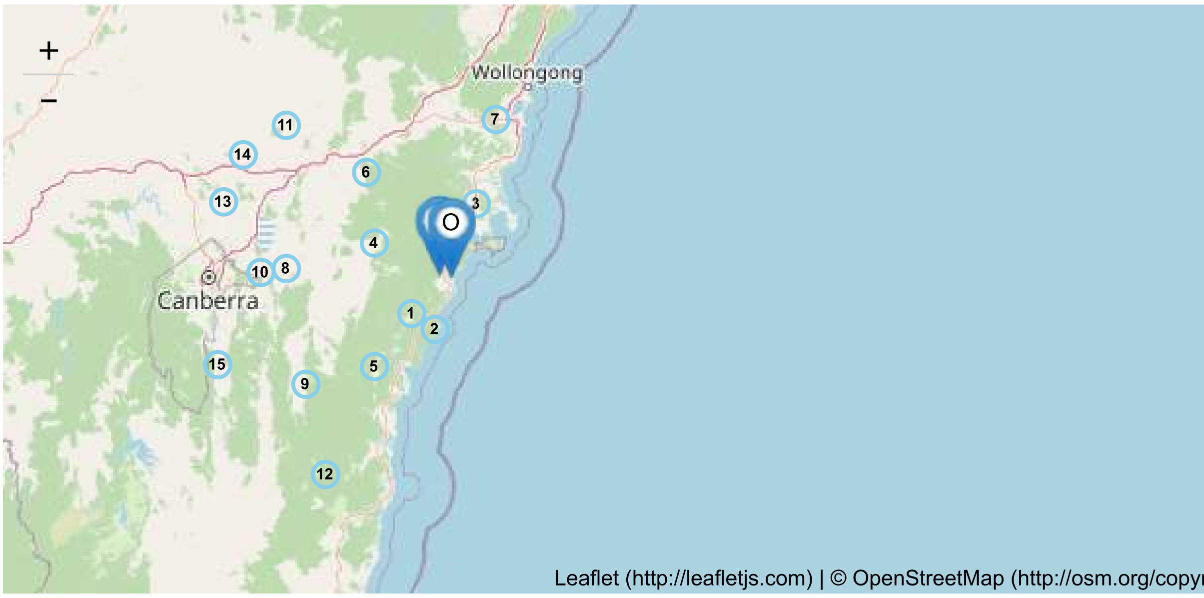
TXT Nearby JSON

Input Data

Date/Time	2021-11-10 17:44
Catchment Name	Narrawallee
Latitude (Outlet)	-35.300904696
Longitude (Outlet)	150.468365894
Latitude (Centroid)	-35.292082975
Longitude (Centroid)	150.3993
Catchment Area (km^2)	84.04
Distance to Nearest Gauged Catchment (km)	28.08
50% AEP 6 Hour Rainfall Intensity (mm/h)	9.96569
2% AEP 6 Hour Rainfall Intensity (mm/h)	25.18471
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast

Input Data

Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.69
Interpolation Method	Natural Neighbour
Bias Correction Value	-0.393



Leaflet (http://leafletjs.com) | © OpenStreetMap (http://osm.org/copyright) contributors

Method by Dr Ataur Rahman and Dr Khaled Haddad from Western Sydney University for the Australian Rainfall and Runoff Project. Full description of the project can be found at the project page (http://arr.ga.gov.au/revision-projects/project-list/projects/project-5) on the ARR website. Send any questions regarding the method or project here (mailto:admin@arr-software.org).

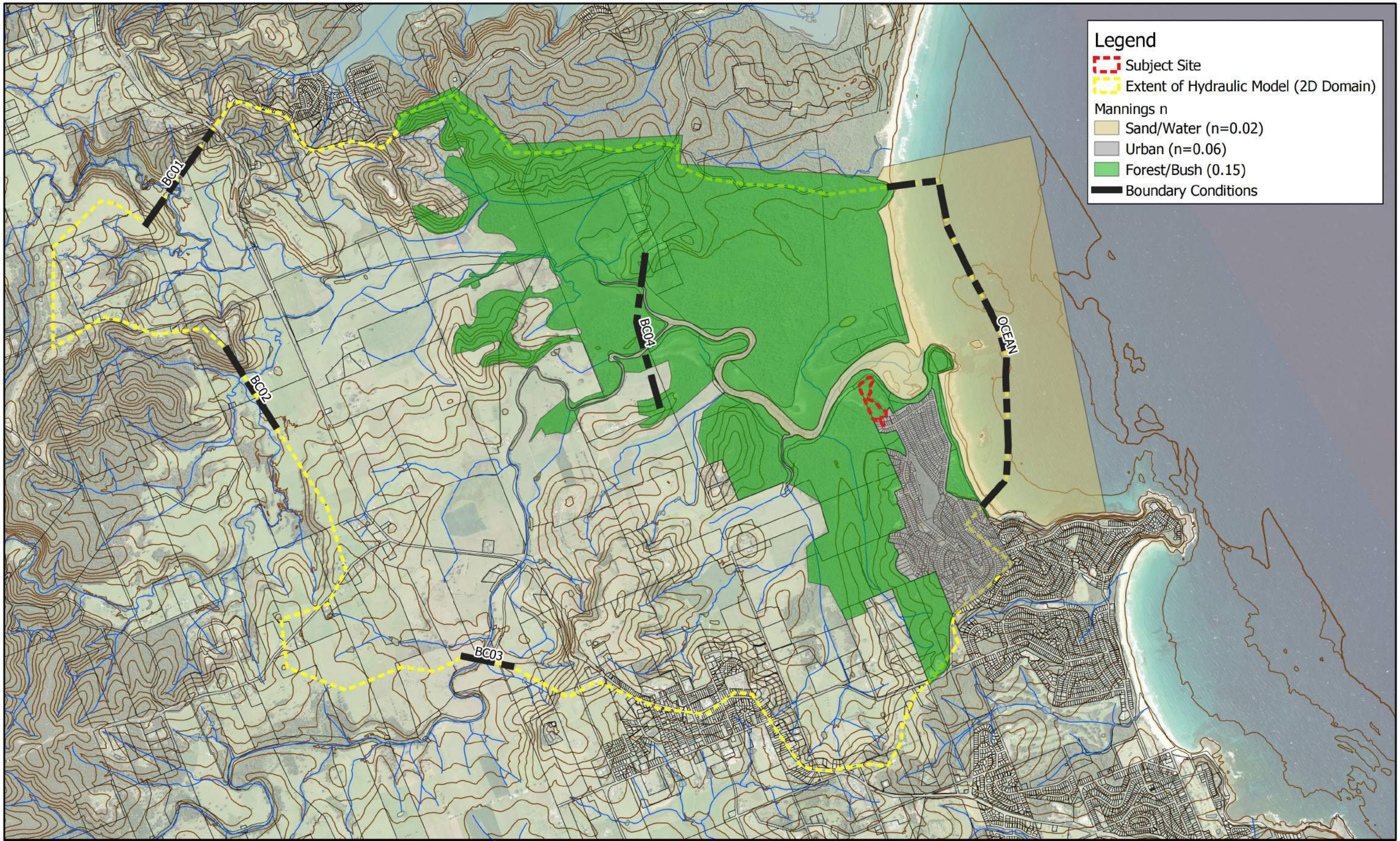
ENGINEERS AUSTRALIA (http://www.engineersaustralia.org.au)

WESTERN SYDNEY UNIVERSITY (http://www.uws.edu.au)

footprint.
sustainable engineering.

APPENDIX H

Hydraulic Model Plan



footprint.
sustainable engineering.
15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

500 0 500 1000 m
Scale 1:30,000 at A3

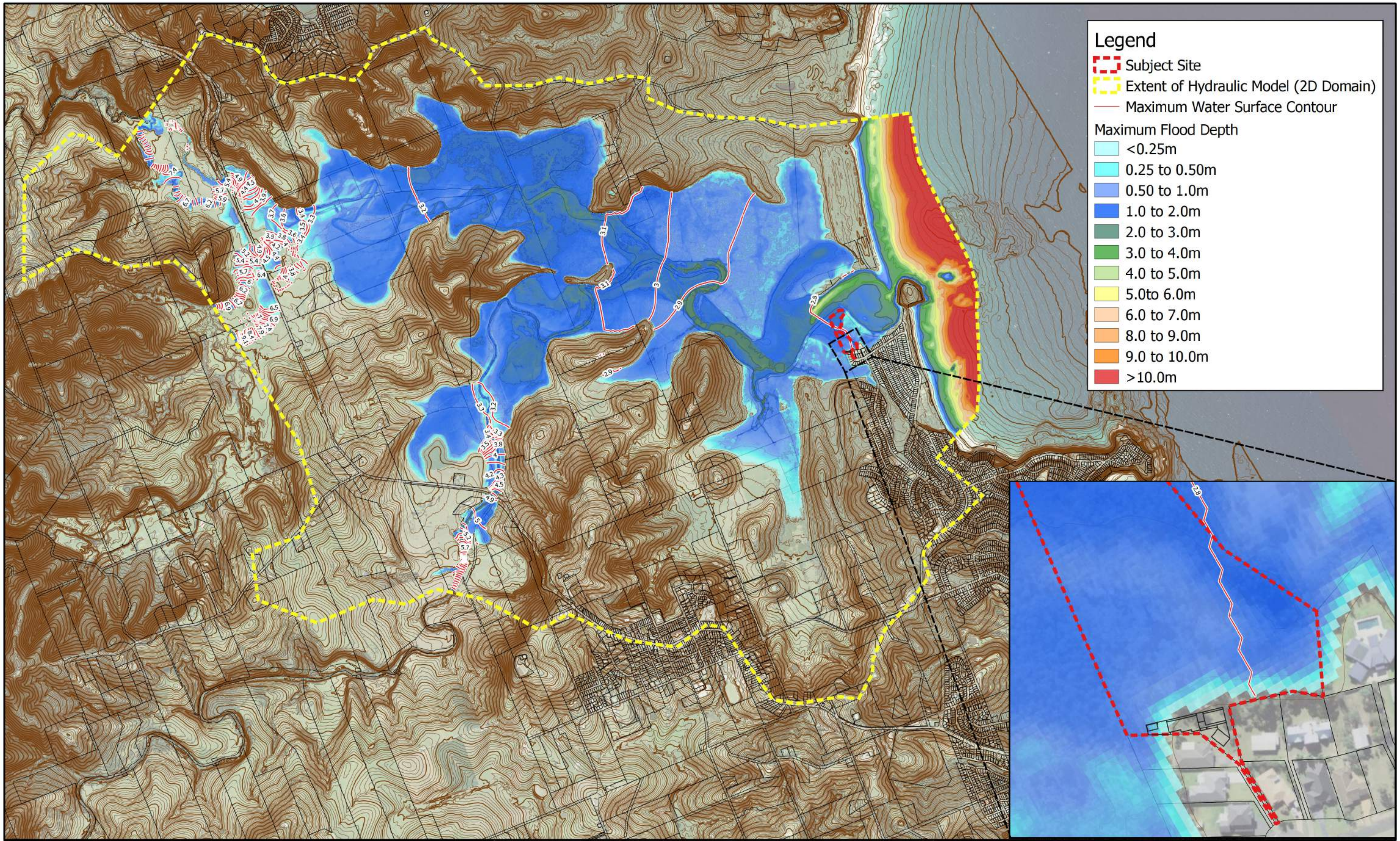
60 MACLEAY STREET, NARRAWALLEE

FIGURE 2.1
HYDRAULIC MODEL PLAN

Rev 1 - 11 NOVEMBER 2021

APPENDIX I

Flood Mapping



footprint.
sustainable engineering.
15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

500 0 500 1000 m

Scale 1:30,000 at A3

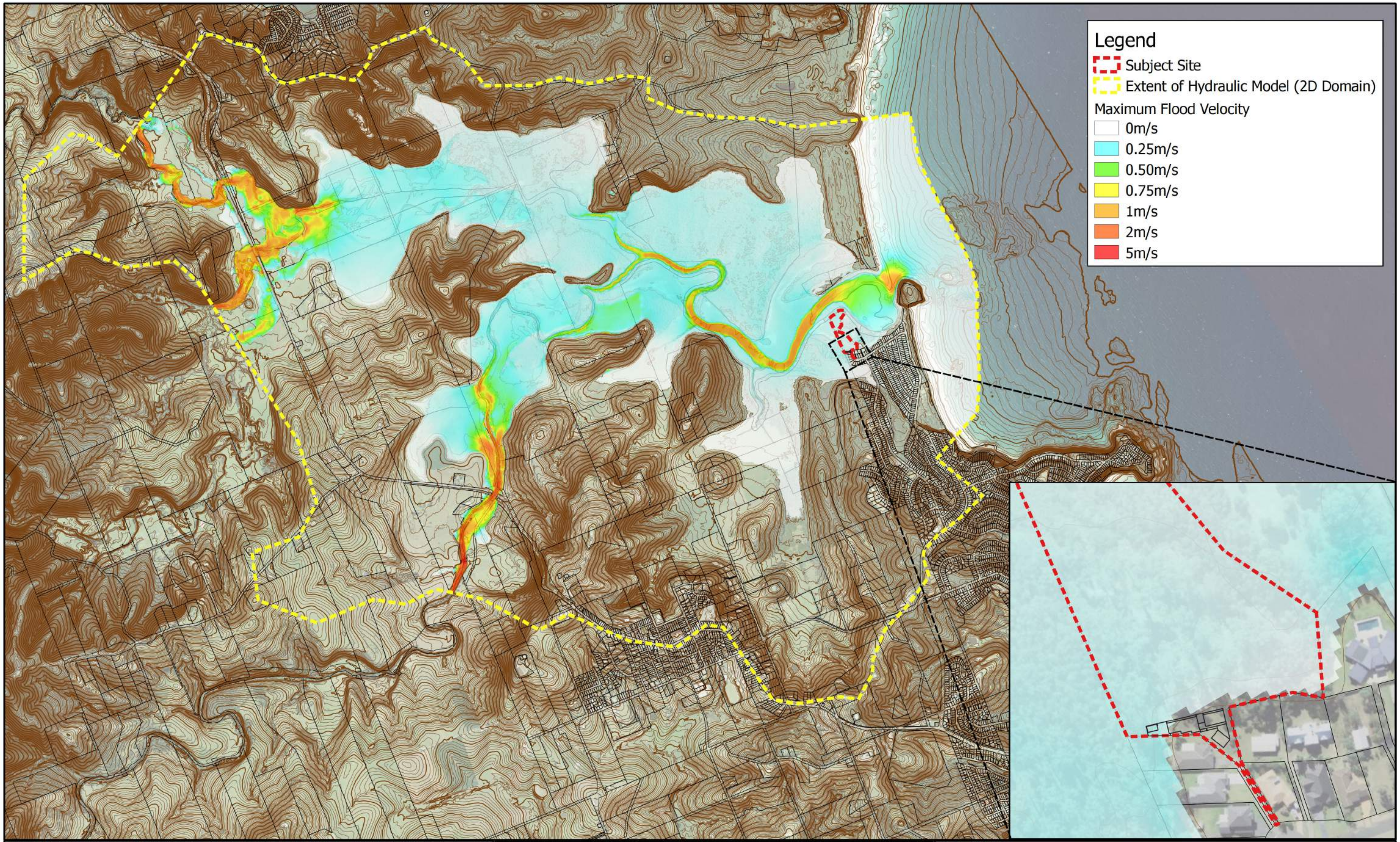
60 MACLEAY STREET, NARRAWALLEE

FIGURE 3.1

ENVELOPE OF MAXIMUM FLOOD LEVELS AND DEPTHS

1% AEP, 2050 SEA LEVEL RISE

Rev 2 - 13 NOVEMBER 2021



footprint.
sustainable engineering.
15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

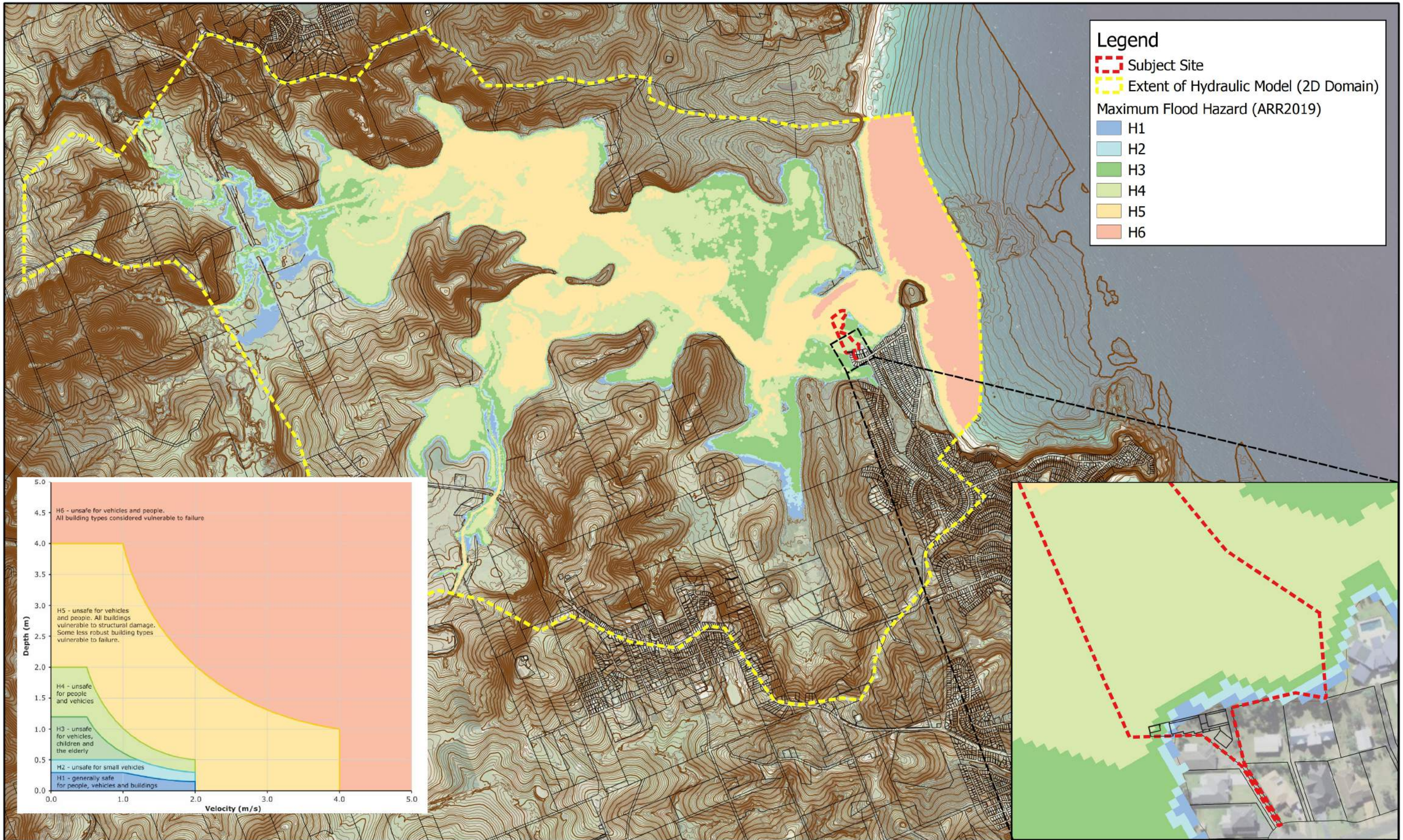
60 MACLEAY STREET, NARRAWALLEE

FIGURE 3.2

ENVELOPE OF MAXIMUM FLOOD VELOCITY

1% AEP, 2050 SEA LEVEL RISE

Rev 2 - 13 NOVEMBER 2021



footprint.
sustainable engineering.

15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

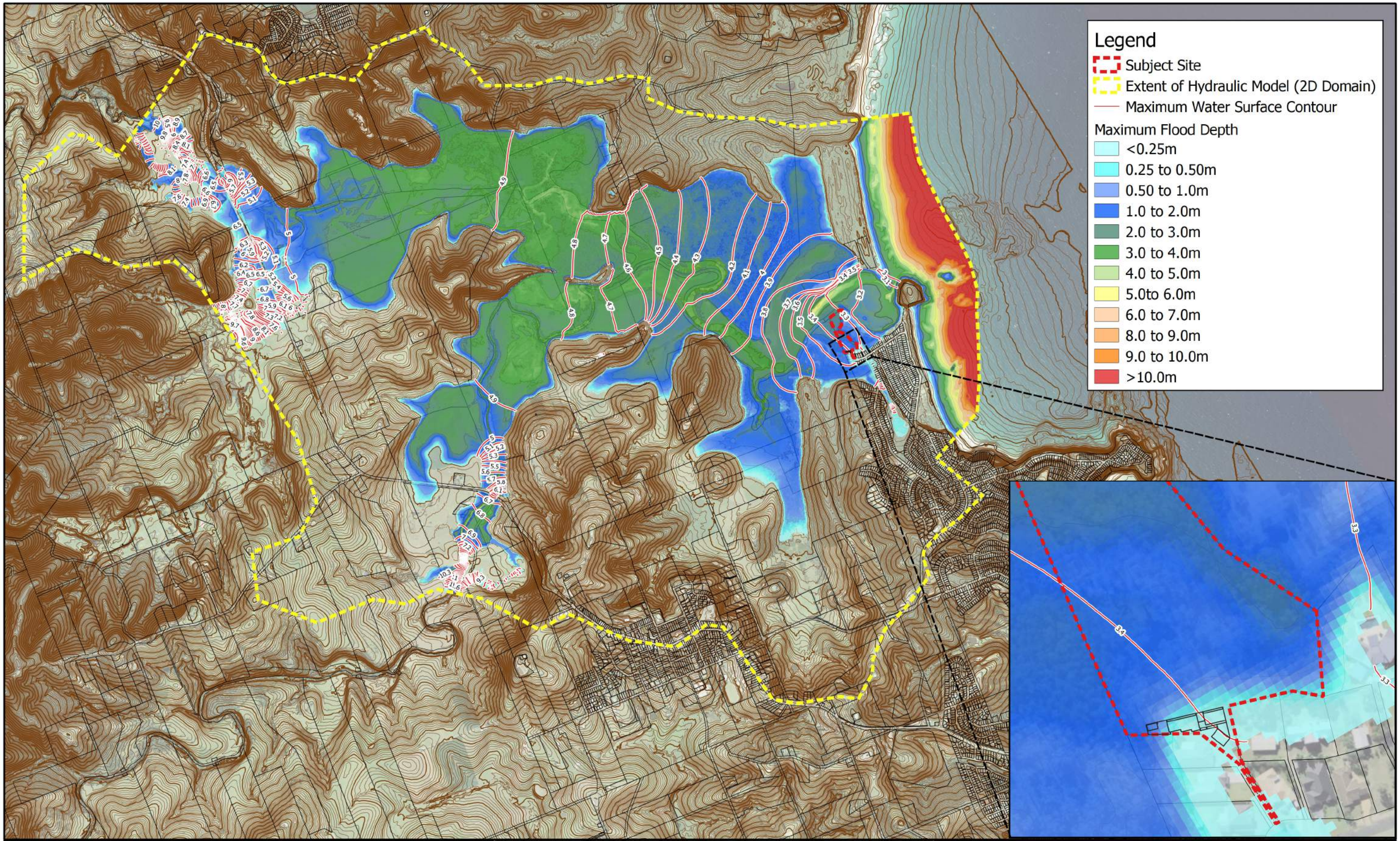
500 0 500 1000 m

Scale 1:30,000 at A3

60 MACLEAY STREET, NARRAWALLEE

FIGURE 3.3
ENVELOPE OF MAXIMUM FLOOD HAZARD (ARR2019)
1% AEP, 2050 SEA LEVEL RISE

Rev 2 - 13 NOVEMBER 2021

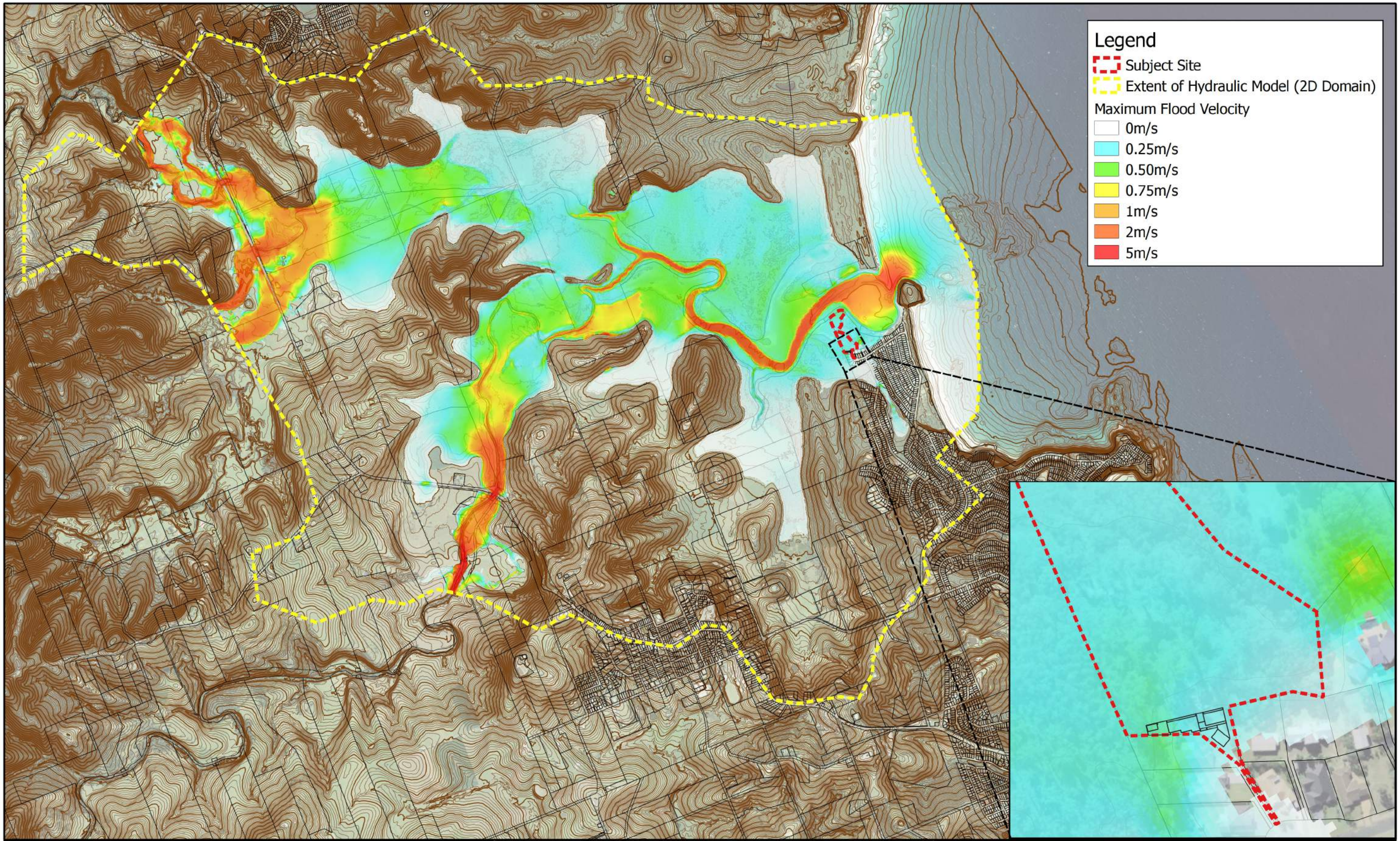


footprint.
sustainable engineering.
15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

60 MACLEAY STREET, NARRAWALLEE

FIGURE 4.1
MAXIMUM FLOOD LEVELS AND DEPTHS
PMF, 2050 SEA LEVEL RISE

Rev 2 - 13 NOVEMBER 2021



footprint.
sustainable engineering.

15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

500 0 500 1000 m

Scale 1:30,000 at A3

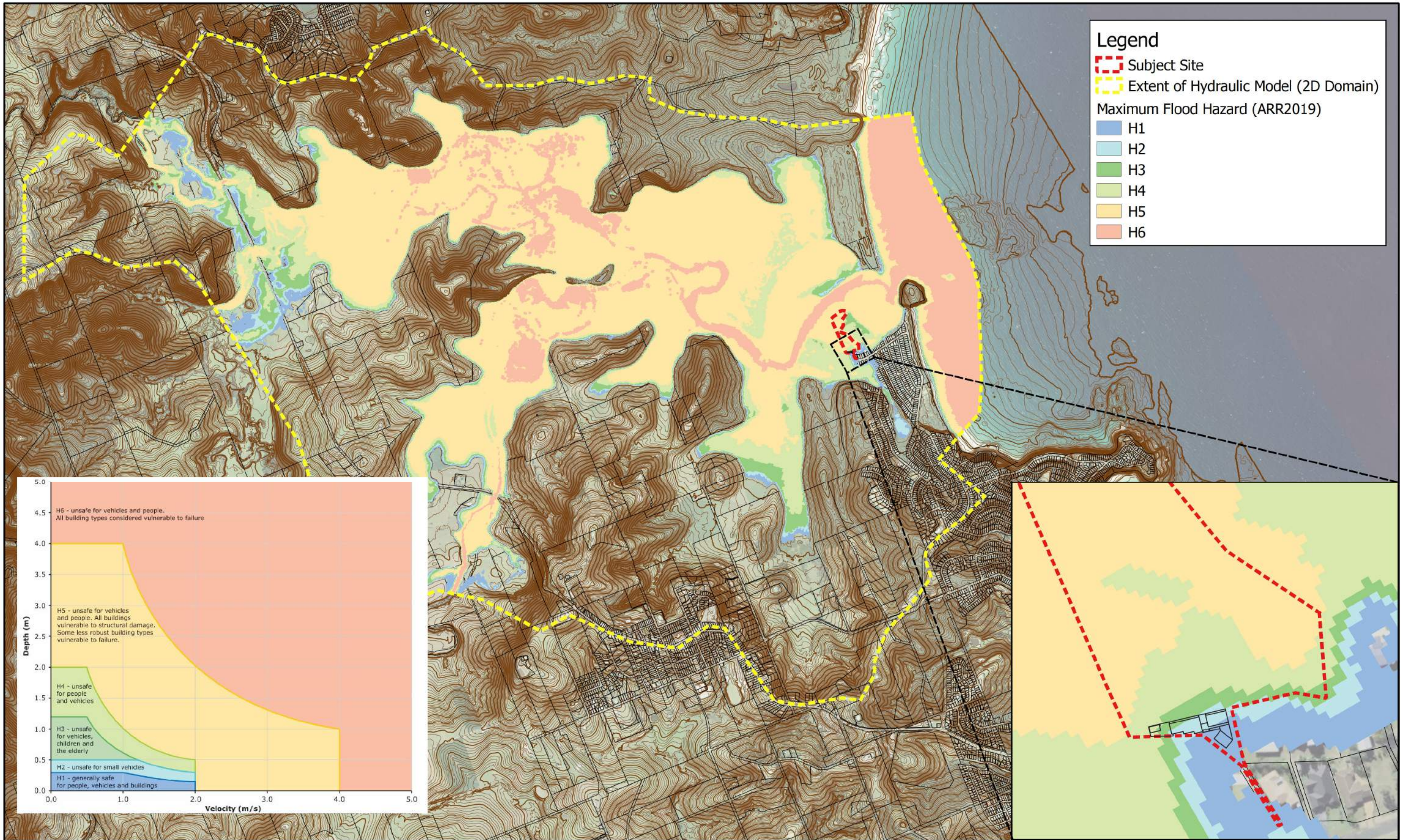
60 MACLEAY STREET, NARRAWALLEE

FIGURE 4.2

MAXIMUM FLOOD VELOCITY

PMF, 2050 SEA LEVEL RISE

Rev 2 - 13 NOVEMBER 2021



footprint.
sustainable engineering.

15 meehan drive, kiama downs,
nsw 2533 p: (02) 4237 6770

500 0 500 1000 m

Scale 1:30,000 at A3

60 MACLEAY STREET, NARRAWALLEE

FIGURE 4.3
MAXIMUM FLOOD HAZARD (ARR2019)
PMF, 2050 SEA LEVEL RISE

Rev 2 - 13 NOVEMBER 2021