Flood Study

Forresters Beach Planning

80519020

Prepared for
TGL Pty Ltd

27 July 2021

Cardno
Shaping the Future

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10	27/07/21	Revised Issue incorporating information within Cardno letters dated 24/5/21, 1/7/21 and 16/7/21.	SJB	BCP

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1 Introduction

1.1 Background

Cardno was engaged by Terrigal Grosvenor Lodge Pty Ltd in September 2018 to undertake a flood study for No 957 and Nos 987-991 The Central Coast Highway (CCH) and Nos 137,139, 143 and 145 Bakali Road, Forresters Beach (Lots 1-4 DP1000694, Lot 51 DP 1028301 and Lot 522 DP 1077907).

This report has been prepared in support of a planning proposal to be submitted to Central Coast Council seeking rezoning of the subject land. The rezoning application seeks to rezone the flood free and non-environmentally sensitive parts of the site to R2 to support low density residential development. An indicative lot layout has been prepared by Bannister and Hunter as shown in **Figure 5-1**.

The site is currently subject to overland flows from the upstream catchment. This report includes an assessment of the 100 year Average Recurrence Interval (ARI) flood and Probable Maximum Flood (PMF) under existing conditions (pre-development) and proposed future conditions (post-development) based on an indicative lot layout to assess any flood impacts if the rezoning is approved and residential development proceeds.

1.2 Scope of Study

The scope of works of this flood study was to identify any flood-prone land within the site, and to formulate recommendations for development of the site which respond to the assessed flood risks. Specifically, the scope included:

> Development of a hydrological model to estimate peak flows for the critical duration 100 year ARI design storm and the PMP event;

> Development of a detailed two dimensional (2D) hydraulic model to estimate flooding of the existing site;

> Incorporation of the results of the Wamberal Lagoon Flood Study (WMA, 2001) and upstream catchments to account for any backwater effects;

> Estimating flood extents, depths and flood velocities under existing conditions;

> Estimating flood extents, depths and flood velocities under proposed developed conditions to identify any impacts on flooding.

> Formulating recommendations which optimise the proposed development while minimising impacts and complying with relevant floodplain management development controls;

> Preparing flood maps of flood extents, depths and hazards in the 100 year ARI and PMF events under conditions of both 50% and 100% culvert blockage.

The following considerations were not included in the scope of this study:

> Impacts of the proposed development on water quantity. It is assumed that the increase in runoff due to the future development will be controlled by including appropriately sized on-site detention within the development.

> Impacts of the proposed development on water quality. It is assumed that the impacts of the future development on runoff quality will be controlled by including appropriately sized WSUD measures within the development.

1.3 Existing Conditions

The land to be rezoned covers an area of 9.855 ha and is located between the Central Coast Highway (CCH) (The Entrance Road) and Bakali Road (see **Figure 1-1**). The site is bound to the north by Lot 5 DP 1082979, to the east and south-east by existing residential properties which front on to the Central Coast Highway , to the west by Bakali Road (formed and unformed sections). The existing site falls from the Central Coast Highway to the western boundary at an approximate grade of 3%.

Figure 1-1 Site Boundary

Figure 1-2 Area of Proposed Rezoning

Figure 1-2 shows the site location and existing level of development.

The existing development on the site consists of open rural grassed paddocks with four residences and a large cluster of trees present towards the top north-eastern corner of the site.

An existing open channel runs through the site which starts directly behind the existing residential allotments fronting the Central Coast Highway and is situated opposite Maas Parade on the western side of the Central Coast Highway (see **Figure 1-1**).

A stormwater drainage easement is located on No. 971 Central Coast Highway, which drains the upstream catchment to the east of the Central Coast Highway.

A 900mm diameter reinforced concrete pipe is laid within the easement and discharges into the existing open channel. The majority of this catchment flow extends to the urban area to the east of the Central Coast Highway.

Appendix A includes a catchment plan showing the extent of the upstream catchment area.

2 Available Data

2.1 Topography

LiDAR data was purchased from NSW Land and Property Information (LPI). This data is supplied as a digital terrain model (DEM) with tree canopy and buildings filtered out to reveal the ground surface only. Ground data points are at maximum 1.0 m separation.

Additional detailed survey for the site was undertaken in support of the proposed development. The extent of detailed site survey is presented as pink hatching in **Figure 2-1**.

Figure 2-1 Detailed Survey Extent

Typical differences between the detailed survey and LiDAR DEM terrain profile across the site are plotted in **Figure 2-2** below. These differences are typical of LiDAR in vegetated landscapes where lush vegetation can mask the underlying ground levels.

The LiDAR data and the detailed survey were combined to produce a digital elevation model (DEM) for the regular 2 m grid cells for 2D floodplain model.

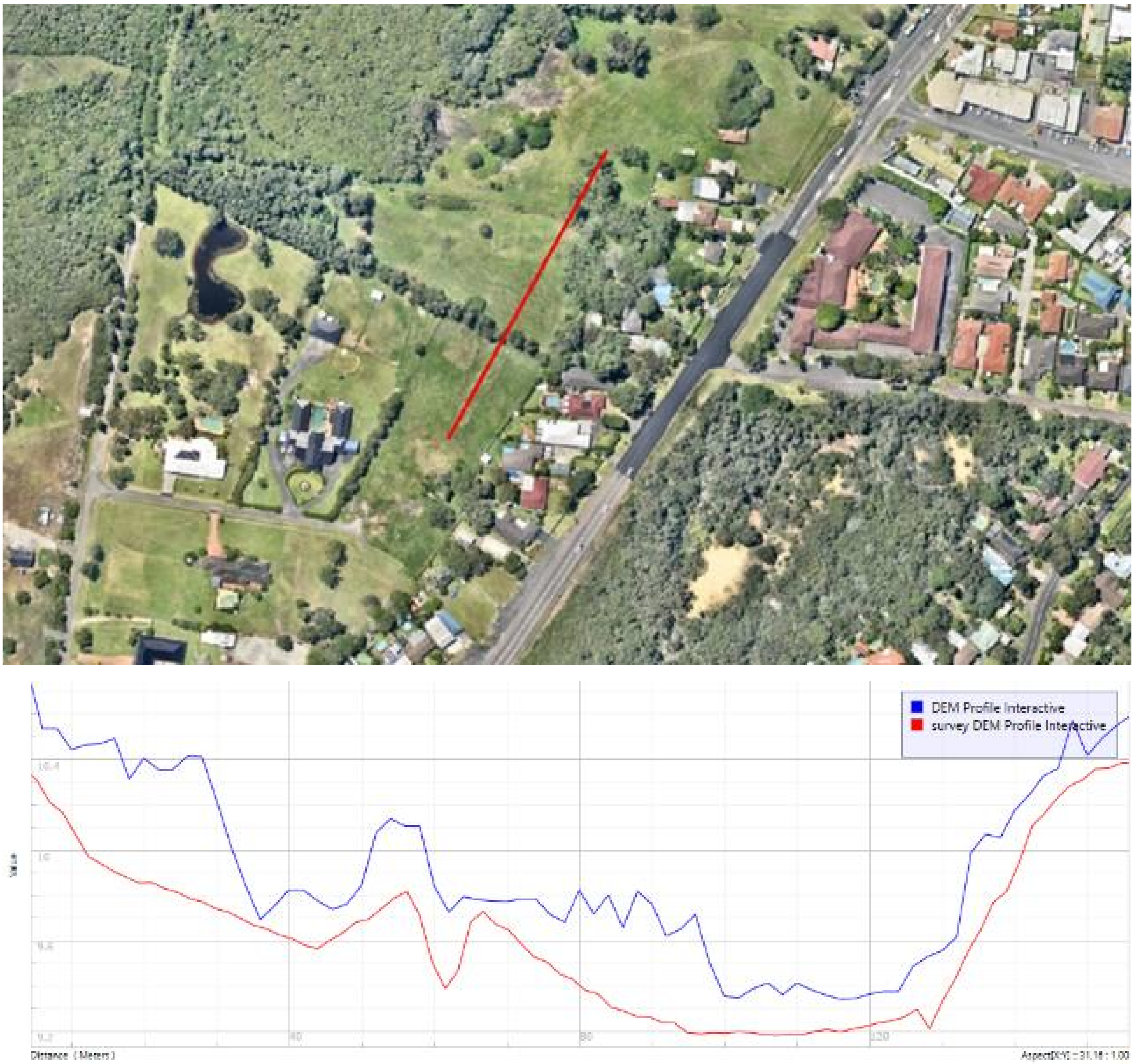


Figure 2-2 Comparison of Detailed Survey vs LiDAR DEM

2.2 Aerial Photography

Aerial photography was extracted from Nearmap and georeferenced to MGA coordinates. This aided in the establishment of the 2D model to determine land uses and approximate existing overland drainage paths.

2.3 2001 Wamberal Lagoon Flood Study

The Wamberal Lagoon Flood Study was completed by Webb, McKeown & Associates Pty Ltd (WMA) in 2001. It is a flood study of the Wamberal Lagoon (and its upstream catchment) which is located approximately 1.5 km downstream of the proposed development.

This study provides results including water heights, flow rates and velocity depth products across its study area. Hydrological modelling was undertaken using a WBNM model. One dimensional hydraulic modelling was undertaken using the RUBICON software. The study calibrated the hydraulic model to historical flood records at Wamberal Lagoon.

The proposed development site is located within the catchment of Wamberal Lagoon. **1.1.1** is an extract from the Wamberal Lagoon Flood Study which delineates the catchment area.

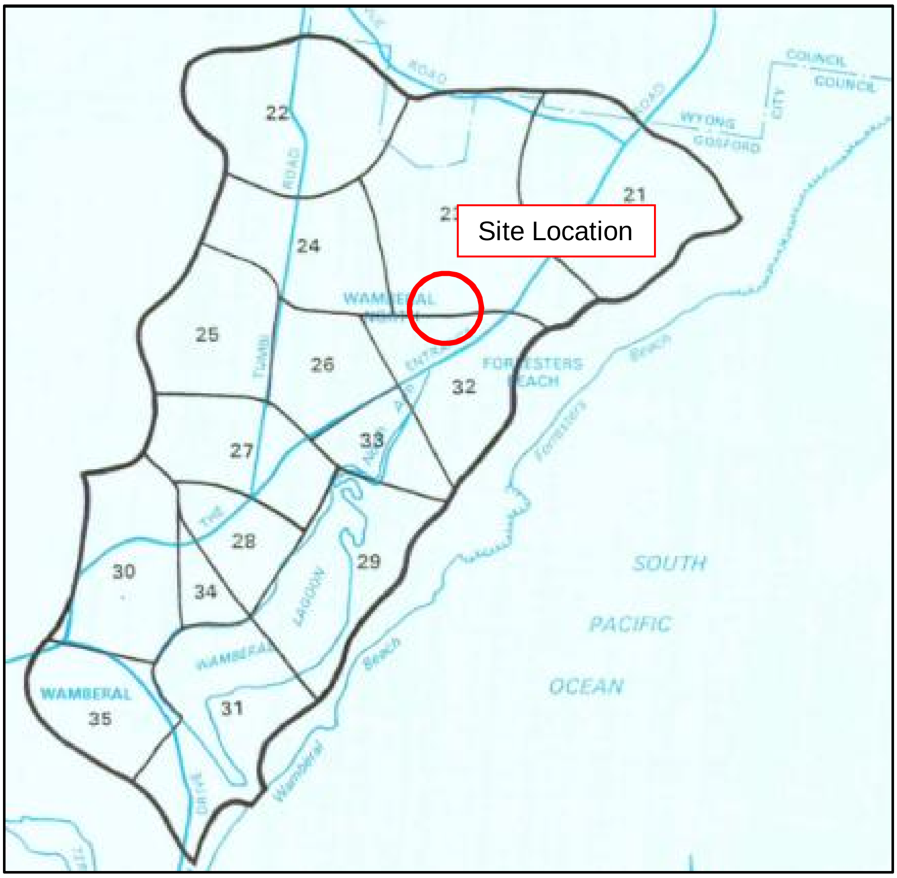


Figure 2-3 Wamberal Lagoon Flood Study Subcatchment Layout (after, WMA, 2001**)**

One dimensional (1D) hydraulic modelling was undertaken using RUBICON software based on the cross sections shown in **1.1.1**.

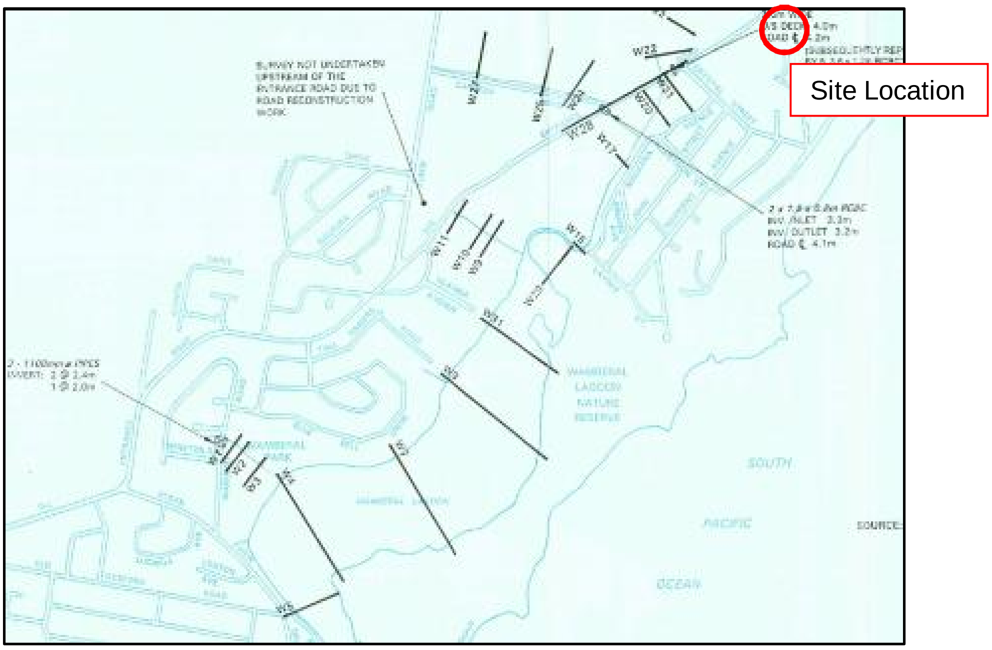


Figure 2-4 Wamberal Lagoon Flood Study Cross Sections (after, WMA, 2001)

3 Catchment Hydrology

Hydrological modelling was undertaken to estimate flood flows through the site from the upstream catchment and to estimate the runoff generated within the site.

Hydrological modelling of the upstream catchment and the receiving waters downstream of the site was undertaken using XP-SWMM's hydrological model.

3.1 Rainfall

The storms that were assessed were the 100 year ARI and the PMP (Probable Maximum Precipitation) events. The 100 year ARI IFD was determined in accordance with Council's standards. Adopted IFD values are presented in **Figure 3-1**. The PMP was determined in accordance with The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method (Bureau of Meteorology, 2003). Parameters are shown in **Figure 3-2** below.

LOCATION 33 450 S 151.450 E NEAR TERRIGAL ISSUED 26 SEPTEMBER 1986 REF FN1821

LIST OF COEFFICIENTS TO EQUATIONS OF THE FORM

ENSURE THE COORDINATES ARE THOSE REQUIRED SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME.

ln(I)=a+b*(ln(T))+c*(ln(T))**2+d*(ln(T))**3+e*(ln(T))**4+f*(ln(T))**5+g*(ln(T))**6

I = INTENSITY IN MILLIMETRES PER HOUR

T= TIME IN HOURS

RETURN PERIOD (YEARS)	a	b	c	d	e	f	g
1	3.5127	-0.6054	-0.0505	0.00769	0.002350	-0.0002202	-0.0000660
2	3.7639	-0.6015	-0.0524	0.00795	0.002546	-0.0002617	-0.0000647
5	4.0088	-0.5888	-0.0559	0.00744	0.002928	-0.0002310	-0.0000776
10	4.1266	-0.5828	-0.0579	0.00752	0.003132	-0.0002519	-0.0000796
20	4.2646	-0.5779	-0.0597	0.00752	0.003322	-0.0002645	-0.0000824
50	4.4193	-0.5720	-0.0617	0.00744	0.003555	-0.0002691	-0.0000877
100	4.5230	-0.5682	-0.0629	0.00742	0.003678	-0.0002757	-0.0000900

RAINFALL INTENSITY IN MM/HR FOR VARIOUS DURATIONS AND RETURN PERIODS

DURATION (HOURS)	RETURN PERIOD 1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
0.083	108.	137.	169.	186.	210.	241.	265.
0.100	101.	128.	158.	175.	197.	226.	248.
0.167	82.9	105.	131.	145.	164.	189.	208.
0.333	61.0	77.9	97.8	109.	124.	144.	159.
0.500	49.7	63.7	80.5	90.1	103.	120.	132.
1.000	33.5	43.1	55.1	62.0	71.1	83.0	92.1
2.000	21.6	27.8	35.8	40.4	46.5	54.4	60.5
3.000	16.4	21.2	27.3	30.9	35.6	41.7	46.4
6.000	10.3	13.2	17.1	19.4	22.4	26.3	29.2
12.000	6.47	8.37	10.9	12.3	14.3	16.8	18.7
24.000	4.16	5.40	7.07	8.06	9.35	11.0	12.3
48.000	2.65	3.45	4.57	5.23	6.10	7.25	8.12
72.000	1.95	2.55	3.40	3.91	4.57	5.44	6.10

Figure 3-1 Central Coast Council IFD Values

Lat. (deg,min)	-33	24	Long. (deg,min)	151	28
Smooth (S)			0.4		
ELEVATION ADJUSTMENT FACTOR					
Mean Elev. (m)		10	EAF	1.0	Compute
MOISTURE ADJUSTMENT FACTOR					
MAF			0.73		
PMP Values (mm)					
Duration (hours)	Initial Depth Smooth (Ds)	Initial Depth Rough(Dr)	PMP Estimate=(Ds X S+ Dr X R) X MAF X EAF		Rounded PMP Estimate nearest 10 mm
0.25	578.794	385.862	169.008		170
0.50	838.492	558.995	244.840		240
0.75	1060.691	707.127	309.722		310
1.00	1230.604	820.403	359.336		360
1.50	1405.346	1058.248	442.252		440
2.00	1567.717	1237.932	508.438		510
2.50	1670.044	1366.064	554.063		550
3.00	1759.786	1499.053	599.494		600

Figure 3-2 PMP Estimation Parameters and Values

3.2 Catchment Layout

3.2.1 Upstream of the Site

The existing channel commences at the eastern boundary of the site, and receives piped and overland flows from catchments to the east of the Central Coast Highway.

A detailed site survey by Bannister and Hunter provided plan details the location of the existing headwall on the Eastern side of the Central Coast Highway (near the intersection with Maas Parade). This headwall captures runoff to the east of the Central Coast Highway with the remainder of runoff discharging as surface runoff which flows across the Central Coast Highway. The headwall directs stormwater into an 825 mm diameter RCP which convey flows west under the Central Coast Highway . The piped drainage connects to a stormwater pit located on the western side of the Central Coast Highway with a 900 mm diameter RCP outlet which conveys flows downstream within the drainage easement.

A site inspection and 1:2,000 contour maps of the Forresters Beach area were used to determine the catchment area and the likely overland flow paths for catchment runoff. The catchments upstream of the Central Coast Highway are mapped in **Appendix A**.

The levels of the piped system (surface / invert levels), the bed and banks of the existing channel and adjacent over bank areas were determined from the survey information compiled by Bannister and Hunter Pty Ltd.

3.2.2 Downstream of the Site

As portions of the site are flood prone, it is important to consider both backwater flooding from downstream of the site and the impact development could have on downstream flood levels.

3.3 Hydrology

Flow estimation was undertaken using the Laurenson method (i.e. XP-RAFTS hydrology) within XP-SWMM. In order to achieve a closer match to the wetland flows reported in the Wamberal Lagoons Flood Study, a storage non-linearity exponent of -0.001 was adopted in the XP-SWMM hydrology model for the 100 year ARI and PMF events rather than the default value of -0.285.

3.3.1 Subcatchments

The subcatchment areas were delineated by utilising contours created from LIDAR data. **Figure 3-3** shows the resulting subcatchment boundaries. **1.1.1** summaries the area of each subcatchment and estimated imperviousness based on the most recent aerial photography.

Table 3-1 Subcatchment Areas and Imperviousness

Subcatchment	Area (ha)	Percentage Impervious (%)
1	59.36	10%
2	41.86	10%
3	84.99	40%
4	32.93	10%
5	15.15	10%
6	62.55	15%
7	32.42	5%
8	12.32	50%
Total	**341.59**	

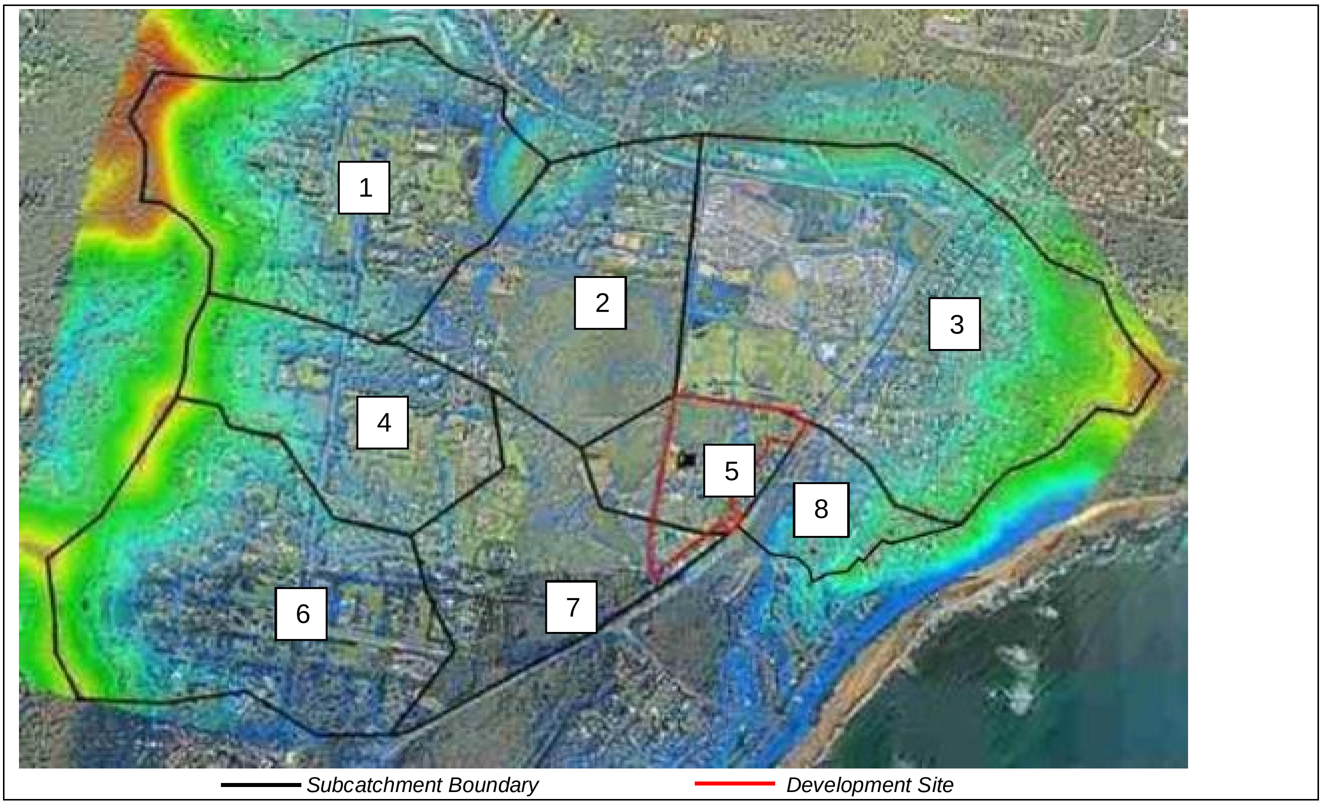


Figure 3-3 Subcatchment Boundaries

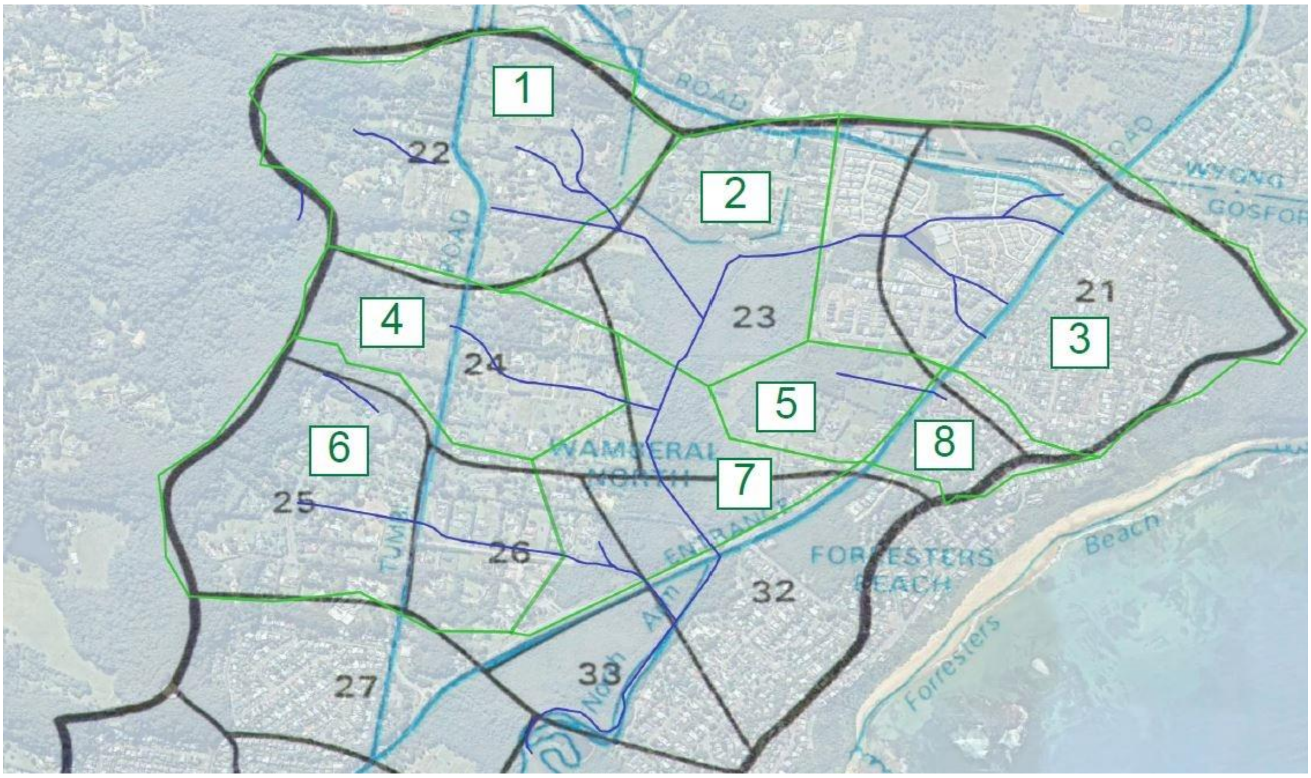


Figure 3-4 Comparison of Subcatchment Boundaries

(——— Cardno, 2021 ——— Webb, McKeown & Associates, 2001)

Figure 3-4 compares the subcatchment boundaries adopted by Cardno, 2021 with the subcatchment boundaries adopted in the 2001 Wamberal Lagoon Flood Study[2].

3.3.2 Rainfall Losses

The following loss values were adopted for the hydrological analysis of pervious areas:

> Pervious Area Initial Loss = 5 mm

> Pervious Area Continuing Loss = 2.5 mm/hr

The adopted rainfall losses for impervious areas were:

> Impervious Area Initial Loss = 1 mm

> Impervious Area Continuing Loss = 0 mm/hr

3.3.3 Results

Table 3-2 summaries the peak flows for the local subcatchments .

In the case of the 100 yr ARI storm the 90 minute storm burst was critical while in the PMP event the 60 minute storm was critical.

The hydrographs for the critical storm bursts were then input into the 2D hydraulic model.

[2] Webb, McKeown & Associates (2001) "Wamberal Lagoon Flood Study", Final Report, prepared for Gosford City Council, November, 37 pp + Apps

Table 3-2 100 yr ARI and PMF Peak Flows

Subcatchment	100 **yr** ARI Peak Flow (m^3/s)	PMF Peak Flow (m^3/s)
1	18.4	74.4
2	7.9	43.1
3	33.6	102.8
4	11.1	42.5
5	2.8	15.2
6	19.1	75.9
7	3.5	21.1
8	7.3	17.0

3.3.4 Cumulative Flows

3.3.4.1 100 yr ARI

Given that the hydraulic modelling was based on the input of local hydrographs at discrete locations from the Hydrology layer in XP-SWMM, these subcatchment were not linked to assess cumulative flows because this was undertaken in the Hydraulic 1D/2D layer in XP-SWMM. To estimate the cumulative peak flows the following steps were undertaken:

(i) links were created in the Hydrology layer based on the watercourses identified in **Figure 3-4**;

(ii) the length of the watercourse for each link was determined;

(iii) based on an assumed representative velocity of 1 m/s the lags were calculated for each link;

(iv) the Hydrology layer was updated and re-run to estimate peak flows.

The estimated 100yr ARI local and cumulative peak flows are given in **Table 3-3.**

Table 3-3 100 yr ARI Peak Flows

XP-SWMM Subcatchment ID	**Local** (m^3/s)	**Total** (m^3/s)
1	18.4	18.4
2	7.9	50.2
3	33.6	33.6
4	11.1	11.1
5	2.8	10.3
6	19.1	19.1
7	3.5	89.5
8	7.9	7.9

3.3.4.2 Probable Maximum Flood

The estimated PMF local and cumulative peak flows (based on a 60 minute PMP) are given in **Table 3-4.**

Table 3-4 PMF Peak Flows (60 mins)

XP-SWMM Subcatchment ID	Local (m^3/s)	Total (m^3/s)
1	75.8	75.8
2	43.9	219.8
3	104.8	104.8
4	43.2	43.2
5	15.6	31.8
6	77.6	77.6
7	21.7	377.7
8	17.8	17.8

3.3.5 Ratio of PMF Peak Flow to 100yr ARI Peak Flow

These ratios were calculated from the local and total peak flows from **Tables 3-3** and **3-4** as well as for the estimated peak flow estimates for Aspect Industrial Estate (AIE) which is located in the South Creek catchment north of Elizabeth Drive in Western Sydney. The ratios are plotted in **Figure 3-5**.

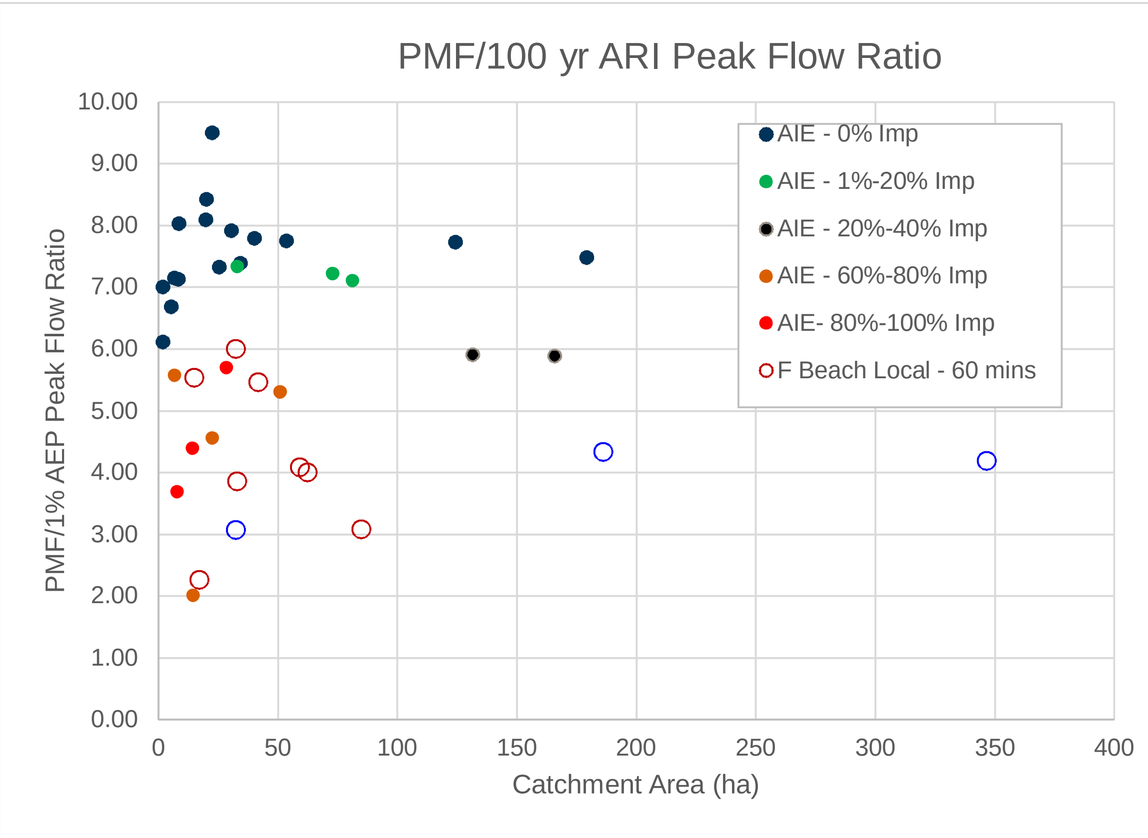


Figure 3-5 PMF/100 yr ARI Peak Flow Ratios

It was noted that the ratio for Subcatchment 8 was 2.25 which is at the lower limit of the plotted ratios and lower than expected.

This prompted an additional assessment of the PMF peak flows for 15 mins, 30 mins, 45 mins and 90 mins PMPs. It was found that the PMP critical duration for the Forresters Beach subcatchments vary from subcatchment to subcatchment.

The estimated local and total PMF peak flows are given in **Table 3-5** while the differences between the PMF peak flow for the critical duration and the PMF peak flow for the 60 mins PMP are given in **Table 3-6**.

The ratios were re-calculated from the local and total peak flows from **Tables 3-3** and **3-5** and are plotted in **Figure 3-6**.

It was noted that:

(i) the PMP critical duration for Subcatchment 5 is 60 mins which aligns with the adoption of 60 mins PMP in Cardno, 2021; and

(ii) the ratio for Subcatchment 8 increased to 3.79.

Table 3-5 PMF Peak Flows (15 mins, 30 mins, 45 mins, 60 mins, 90 mins)

XP-SWMM	PMF 90min		PMF 60min		PMF 45min		PMF 30min		PMF 15min	
Catchment	Local	Total	Local	Total	Local	Total	Local	Total	Local	Total
	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
1	65.0	65.0	74.9	74.9	79.1	79.1	80.7	80.7	64.8	64.8
2	40.5	196.6	43.4	217.4	41.9	222.9	35.3	209.2	23.9	154.0
3	93.3	93.3	103.5	103.5	105.1	105.1	103.9	103.9	100.6	100.6
4	36.6	36.6	42.7	42.7	45.2	45.2	47.0	47.0	39.6	39.6
5	14.5	29.2	15.3	31.5	14.6	33.1	12.2	34.5	8.3	37.1
6	68.4	68.4	76.4	76.4	80.1	80.1	80.4	80.4	61.4	61.4
7	23.8	342.2	21.3	373.8	18.2	385.5	13.5	352.7	9.0	286.8
8	15.2	15.2	17.8	17.8	20.0	20.0	23.3	23.3	29.9	29.9
	-	342.2	-	373.8	-	385.5	-	352.7	-	286.8

Table 3-6 PMF Peak Flow Differences

XP-SWMM Catchment	PMP Duration	PMF Local (m^3/s)	PMP Duration	Local (m^3/s)	Difference	PMP Duration	PMF Max Total (m^3/s)	PMP Duration		Difference
1	30min	80.7	60min	74.9	-7.3%	30min	80.7	60min	74.9	-7.3%
2	60min	43.4	60min	43.4	0.0%	45min	222.9	60min	217.4	-2.4%
3	45min	105.1	60min	103.5	-1.5%	45min	105.1	60min	103.5	-1.5%
4	30min	47.0	60min	42.7	-9.1%	30min	47.0	60min	42.7	-9.1%
5	60min	15.3	60min	15.3	0.0%	15min	37.1	60min	31.5	-15.0%
6	30min	80.4	60min	76.4	-4.9%	30min	80.4	60min	76.4	-4.9%
7	90min	23.8	60min	21.3	-10.6%	45min	385.5	60min	373.8	-3.0%
8	15min	29.9	60min	17.8	-40.5%	15min	29.9	60min	17.8	-40.5%
						45min	385.5	60min	373.8	-3.0%

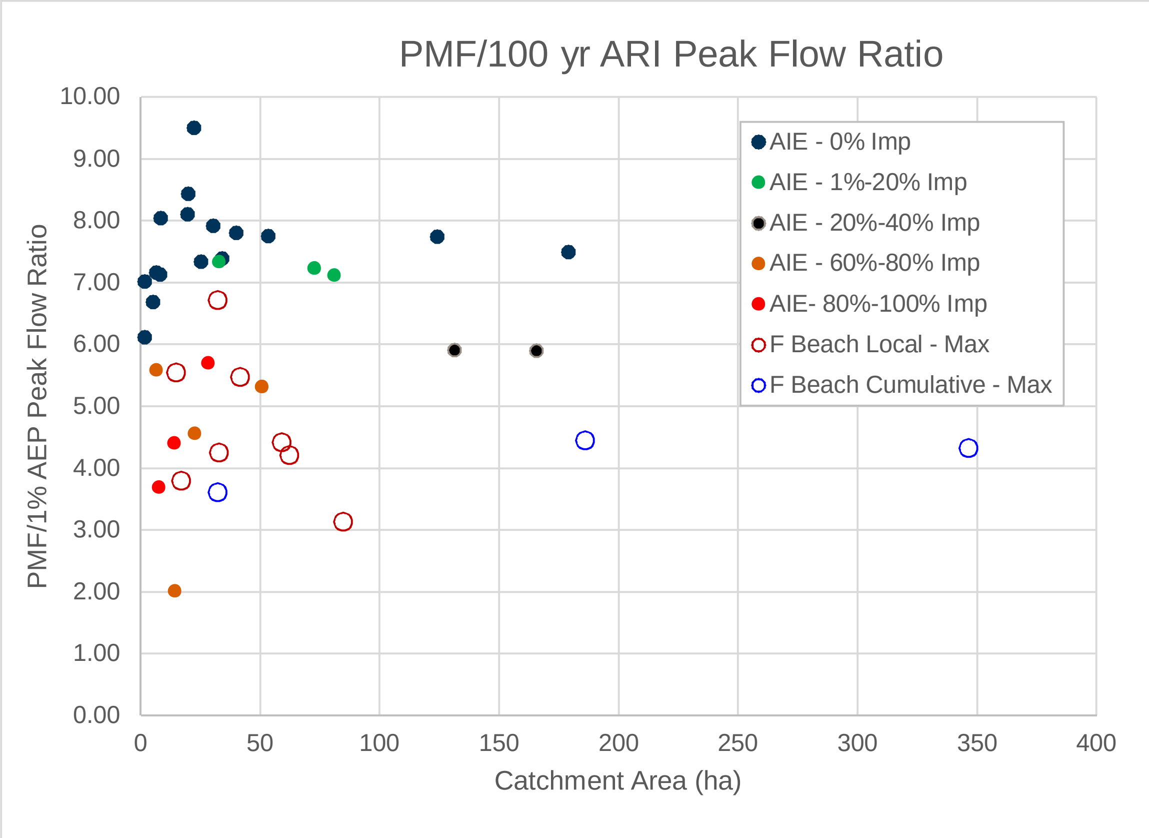


Figure 3-6 Revised PMF/100 yr ARI Peak Flow Ratios

4 Existing Conditions

Modelling of the floodplain was undertaken using an XP-SWMM2D floodplain model which uses the TUFLOW 2D modelling engine.

Hydraulic modelling has been carried out in accordance with the guidance given in the 2019 edition of Australian Rainfall and Runoff (AR&R), as well as AR&R Project 15: Two Dimensional Modelling in Urban and Rural Floodplains.

The model DEM was created using LiDAR data and ground survey.

For this study, a grid cell size of 2 m x 2 m was selected and run with a time step of one second. This provides adequate resolution and accuracy of results while keeping model run times to approximately a duration of one hour.

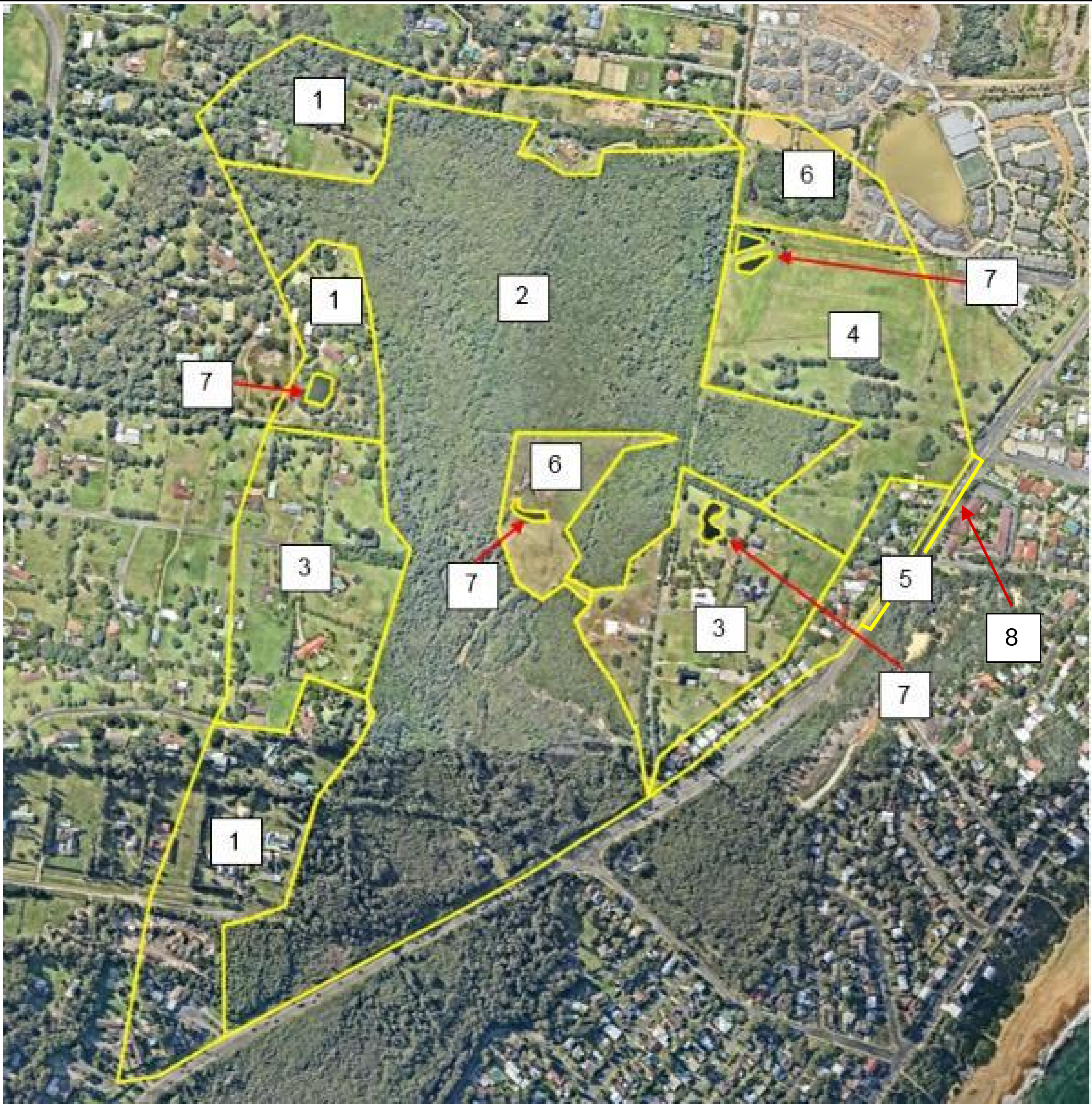
The 2D modelling domain for this study is shown in **Figure 4-1**.

Figure 4-1 2D Model Domain

4.1 Model Parameters

4.1.1 Surface Roughness

Surface roughness zones were based on aerial photography of the current conditions. The adopted values were primarily based on vegetation density. It is noted that existing houses were removed from the 2D model domain to accurately model flowpaths around buildings. **Figure 4-2** shows the spatial distribution of different surface roughness zones in the study area. The adopted Manning roughness values were based on Table 6.2.2. Valid Manning 'n' Ranges for Different Land Use Types from Australian Rainfall and Runoff. **Table 4-1** lists the roughness values adopted for each roughness zone.



1 – Moderate vegetation with residential *2 – Thick vegetation and trees* *3 – Open grass with residential*
4 – Open grass *5 – Medium density residential* *6 – Vegetated wetland*
7 – Open water *8 – Road*

Figure 4-2 Surface Roughness Zones

Table 4-1 Surface Roughness Values

Roughness Zone	Manning 'n' Value
Moderate vegetation with residential	0.080
Thick vegetation and trees	0.120
Open grass with residential	0.04
Open grass	0.04
Medium density residential	0.035
Vegetated wetland	0.065
Open water	0.020
Road	0.020

4.1.2 Boundary Conditions

The downstream boundary conditions adopted in the XP-SWMM model were based on the flood water levels reported in the Wamberal Lagoon Flood Study at the Central Coast Highway.

The WBNM/RUBICON model did not assess flooding in a PMF. Rather, the 2001 flood study assessed flooding in an Extreme event based on doubling the 100 yr ARI flows. The report states that "*the true Probable Maximum Flood levels are likely to be higher.*" The downstream boundary condition selected is the best available estimate and is located far enough downstream that any significant increase will not have an effect on the model results at the development site

Table 4-2 lists the adopted downstream boundary water levels.

Table 4-2 Downstream Boundary Water Levels

Location	Maximum 100 yr ARI Water Level (m AHD)	Maximum PMF/Extreme* Water Level (m AHD)
Central Coast Highway	4.25	4.90

The upstream boundary was located on the eastern side of the Central Coast Highway to model the spread of flows across the highway. Velocity maps show water slowing down as it approaches the Central Coast Highway and accelerating as it spills across the road surface, suggesting the boundary is located a sufficient distance upstream of the highway to accurately model the flow behaviour at this location.

4.2 Validation

To ensure relative consistency with the 2001 flood modelling, the estimated flows at the approximate location of section W23 in the RUBICON model (refer **1.1.1**) were extracted from the XP-SWMM model results. **Table 4-3** compares the peak flows reported in the 2001 WMA study and this study.

Table 4-3 Comparison of Peak Flows at Section W23

	100 yr ARI Peak Flow (m^3/s)	PMF/Extreme* Peak Flow (m^3/s)
2001 Study	54	111
This Study	51 *(-5.5%)*	247 *(+122.5%)*

As noted, the 2001 Flood Study assessed an Extreme Flood only. It is not surprising that the PMF flow estimated in this study is far greater than the peak flow for an Extreme event reported in 2001.

Additionally, the critical storm durations (and subsequent reported flood heights and flow discharges) were determined based on the maximum height of the Wamberal Lagoon and not the maximum flows at any point within the catchment.

It is concluded that:

(i) The estimated 100 yr ARI peak flow is in good agreement with the 100 yr ARI peak flow reported in the 2001 flood study; and

(ii) The PMF peak flow is considerably higher than the peak flow for the Extreme flood reported in the 2001 flood Study

(iii) The PMF peak flow estimated in this study is a more accurate estimate of a PMF flow from this small catchment than adopted in the 2001 flood study.

4.3 Results

Flood depths, flood levels, velocities and hazards (as represented by velocity x depth) under Existing Conditions were assessed within the study area two blockage scenarios.

The following Existing Conditions results are presented in **Appendix B**:

> Catchment wide water depths for the 100 year ARI, 50% culvert blockage

> Site water depths for the 100 year ARI and PMF events, 50% and 100% culvert blockage

> Site water flood levels for the 100 year ARI and PMF events, 50% and 100% culvert blockage

> Site water velocities for the 100 year ARI and PMF events, 50% and 100% culvert blockage

> Site flood hazard for the 100 year ARI and PMF events, 50% culvert blockage

5 Proposed Conditions

Bannister and Hunter prepared an indicative subdivision layout which is shown in **Figure 5-**1.

The details added to this layout for the flood modelling included batters, a catch drain and building pad locations. This layout includes an overland flow path to convey overland flows from the east of the site to the vegetated area on the north via six (6) x 600mm high x 2100mm wide reinforced concrete box culverts (RCBCs) under the proposed road. The overland flow path has been shaped to allow a short retaining wall (600 mm) at the property boundary, and 1V:4H batter at the base of the wall to the invert of the overland flow path. At the road crossing, a 1V:6H batter is proposed for egress and maintenance access. The longitudinal grade of the overland flow path is 0.5%.

It is noted that upgrades to the Central Coast Highway upstream of the site are scheduled to commence in the near future. It is assumed that 1% AEP flows from the catchment upstream of the Central Coast Highway will be managed as part of the highway drainage upgrade works and thus there is potential for a narrowing/realignment of the site overland flow path once the CCH works have been completed.

Investigations regarding the narrowing/realignment of the overland flow path would form part of a separate site flood study following the CCH upgrade.

An open 4 m wide catch drain was also modelled along the eastern boundary of the subdivision, behind the existing properties along the Central Coast Highway, to capture and convey runoff to the proposed overland flow path. The catch drain has assumed vertical sides and a 1:10 base grade to invert. Both the overland flow path and catch drain will be fully fenced to prevent entry and for safety.

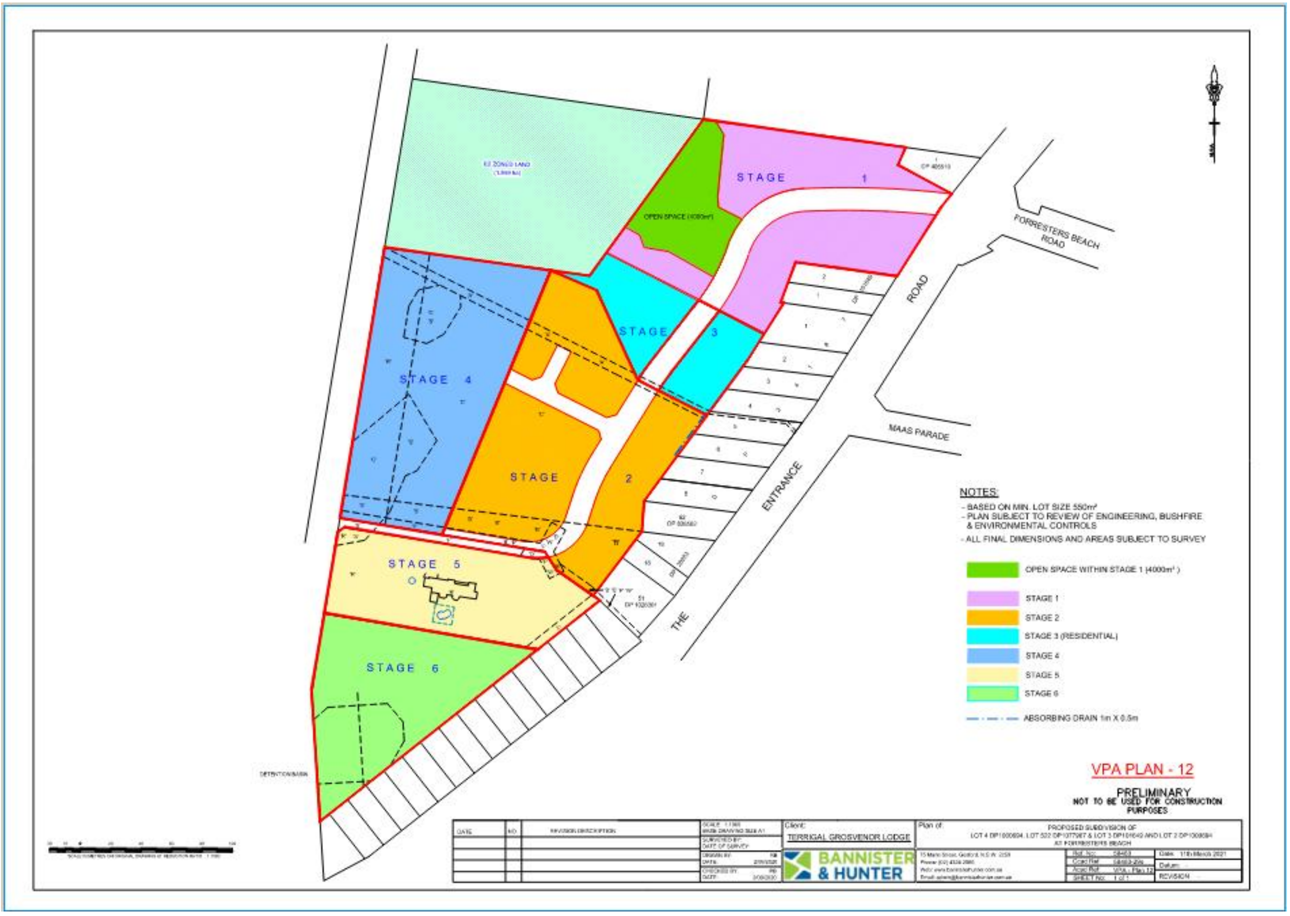


Figure 5-1 Indicative Subdivision Layout (after Bannister and Hunter)

5.2 Model Adjustments

5.2.1 Roughness Values

Due to the proposed development, the surface roughness associated with the development area was adjusted to a Manning roughness value of 0.035 due to the increased density of the residential area compared to existing conditions. The Manning roughness value for the proposed road reserve was set at 0.02. Approximate dwelling footprints for the subdivision have been estimated and blocked out in the model.

Figure 5-2 shows the area of changed roughness under the proposed conditions.

Figure 5-2 Area of Change of Surface Roughness

5.2.2 Stormwater Flows

An overland flow path has been provided to convey overland flows from the Central Coast Highway through the development directly to the vegetated area to the north of the site. Flows conveyed by the existing 900 mm RCP crossing of the Central Coast highway will discharge into this overland flow path.

The proposed residential lots have been raised to a minimum finished floor level equal to the 100 year ARI event plus 0.5 m freeboard ie. the Flood Planning Level.

Blockage factors of 50% and 100% were applied to all headwalls and inlet pits and the resulting flooding was assessed under both existing and proposed conditions.

The following energy loss coefficients have been adopted in accordance with HEC22 – Urban Drainage Design Manual. All losses and proposed pipe/culvert sizes will be confirmed as part of detailed drainage modelling to be undertaken during concept design.

- Entry loss (headwall inlet or first pit) = 0.5
- Entry loss (pit to downstream pipe) = 0.2
- Exit loss (pipe to downstream pit) = 0.4
- Exit loss (outlet) = 1

Figure 5-3 depicts the existing drainage line, proposed overland flow path, proposed catch drain (as a drainage easement) and the overall development layout.

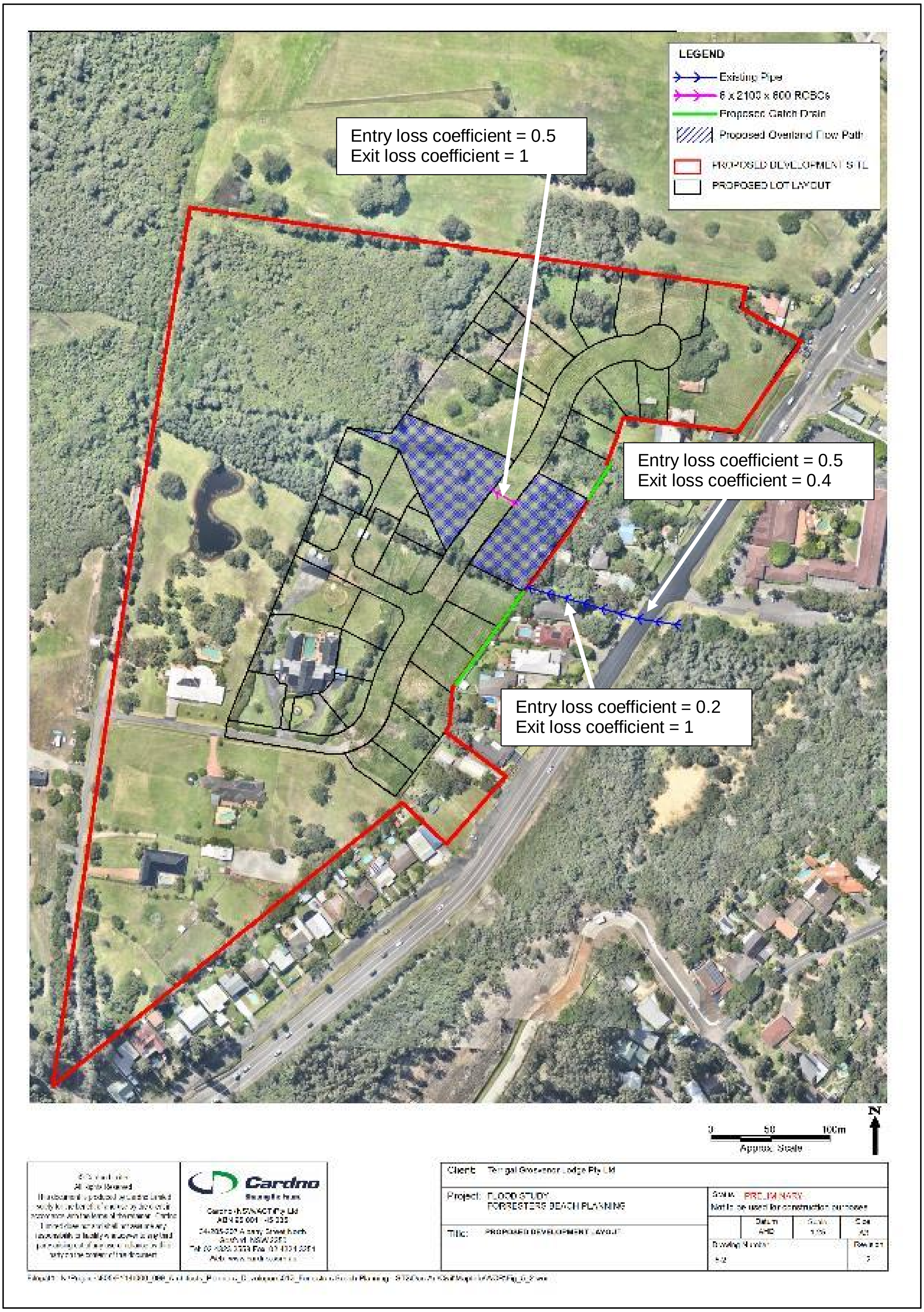


Figure 5-3 Proposed Development Layout

5.2.3 Flows to the Existing Wetland

The intent of the proposed overland flow path is to maintain flows to the wetland, given the current location of the low point.

Under existing conditions and in smaller events, flows to the wetland from the catchment upstream of the Central Coast Highway occur at the end of the open channel system within Bakali Road.

Under proposed conditions and in smaller events, flows to the wetland will occur directly to the E4 vegetation located within the subject site, as the trunk drainage has been diverted to the proposed overland flow path. Ultimately, these flows will reach the same location in the wetland downstream of the site.

Figure D9 indicates that a small area of the E4 area is wet and was previously dry in a 100 yr flood under 50% blockage, but that this area is a small fraction of the E4 area. In smaller storms this area would be further reduced. A larger area is impacted under the 100% blockage case and in PMF events. These impacts are contained within the proposed development site, and as the frequency of these events is likely to be rare, the adverse impacts are considered minimal.

5.3 Results

Flood depths, flood levels, velocities and hazards (as represented by velocity x depth) under Proposed Conditions were assessed within the study area two blockage scenarios.

The following Existing Conditions results are presented in **Appendix B**:

Refer to **Appendix C** for mapping of the following proposed condition results:

> Developed site flood depths and flood level contours for the 100 yr ARI and PMF events under 50% and 100% culvert/inlet blockage.

> Developed site flood hazard (product of velocity and depth) for the 100 yr ARI and PMF events under 50% and 100% culvert/inlet blockage.

> Difference in flood levels between the existing conditions and the proposed conditions for the 100 yr ARI and PMF events under 50% and 100% culvert/inlet blockage.

It is noted that the 100% blockage scenario includes complete blockage of the 6 x 600mm high, 2100mm wide RCBCs crossing the proposed internal road. This results in considerable impacts on the 100 yr ARI and PMF events as water ponds at the proposed road. Given the size of these culverts compared to likely size of entrained debris, a blockage of 50% is far more reasonable and thus the 50% blockage scenario should be adopted for the purpose of the impact assessment.

5.3.1 Hazard Categories

Hazard Category mapping has been included for the 100 year ARI and PMF events, for the 50% blockage cases (Refer Figures D14, D15 and D16). Hazard mapping had been undertaken in accordance with the general flood hazard classification in *Australian Disaster Resilience Handbook Collection – Flood Hazard, Guideline 7-3, 2017*.

In summary, the relevant hazard categories are as follows for the proposed conditions:

- 100 year ARI with 50% blockage– Hazard categories H1 to H4 occur within the overland flow path and drainage catch drain. As these areas are fully fenced, there is no access for pedestrians and vehicles.
- PMF with 50% blockage– Hazard categories H1 to H4 occur within the overland flow path and drainage catch drain. As these areas are fully fenced, there is no access for pedestrians and vehicles. Hazard categories H1 to H3 occur within the road reserve, adjacent to the road low point over the proposed culverts. Category H3 is localised to the culvert crossing location. The extent of this category could be refined during Development Application design of the road levels in this area.

5.3.2 PMF Extents Downstream of the Central Coast Highway

In review of previous versions of this report Council requested further information on the apparent linear mapped extent of the PMF within the subject property. Council was concerned that the linear extent of the PMF was due to the flood extent reaching the boundary of the floodplain model.

A comparison of the model grid and the 60 mins PMF depths and velocity vectors under Proposed Conditions is plotted in **Figure 5-4.** The flood depths are based on a depth filter = 0.0 m

The same comparison is plotted in **Figure 5-5** except a depth filter = 0.01 m was applied.

It was concluded from a comparison of **Figures 5-4** and **5-5** that:

(i) Downstream of the Central Coast Highway the floodplain model extent clearly extends well beyond the PMF extents is not influencing the PMF extents;

(ii) The linear extent of the PMF is due to extremely shallow PMF depths (< 1 cm) on the edges of the PMF;

(iii) The application of a 1 cm depth filter creates a variation in the PMF extent which aligns with Council's expected non-linear flood extents.

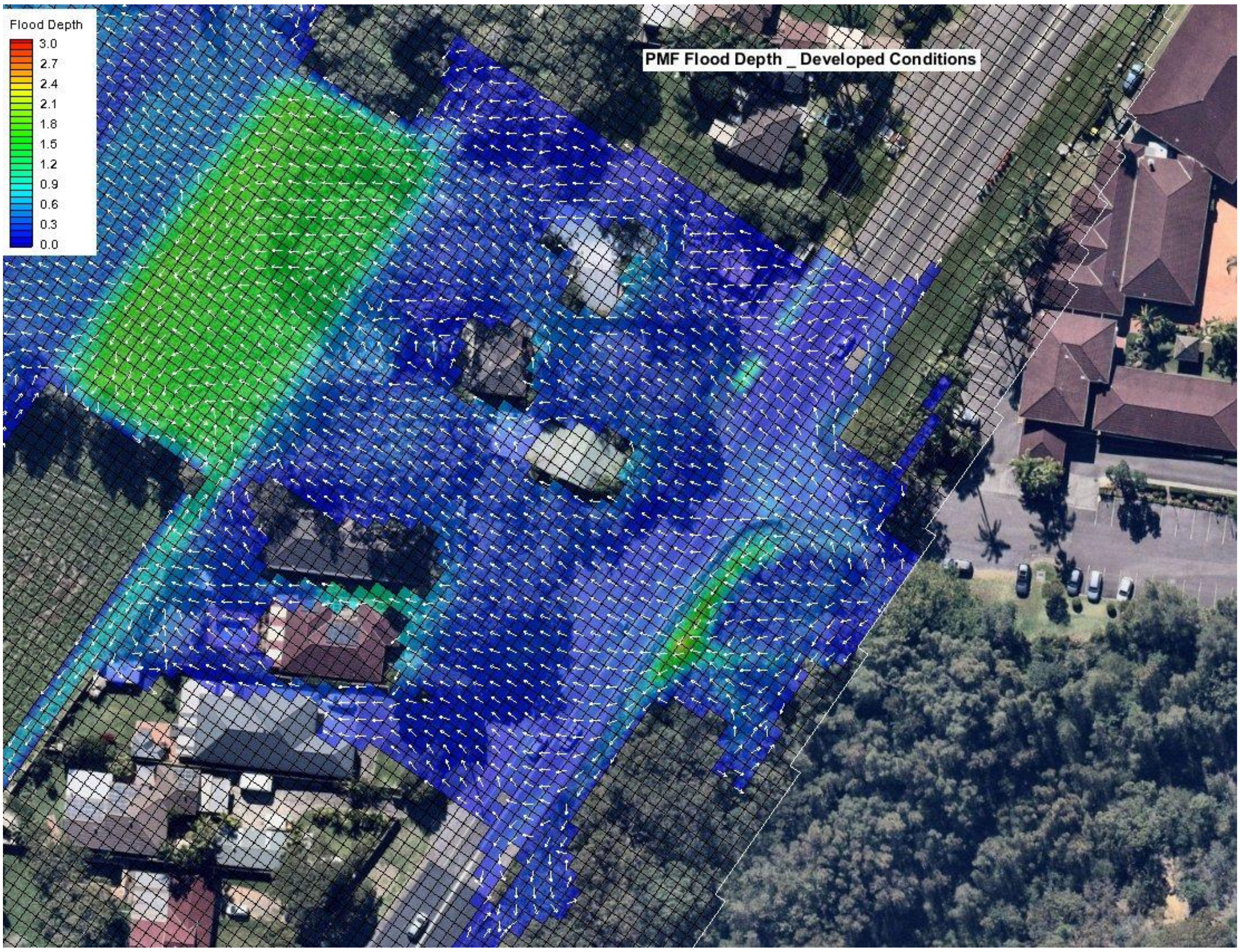


Figure 5-4 PMF Depths under Proposed Conditions (Depth filter = 0.0 m)

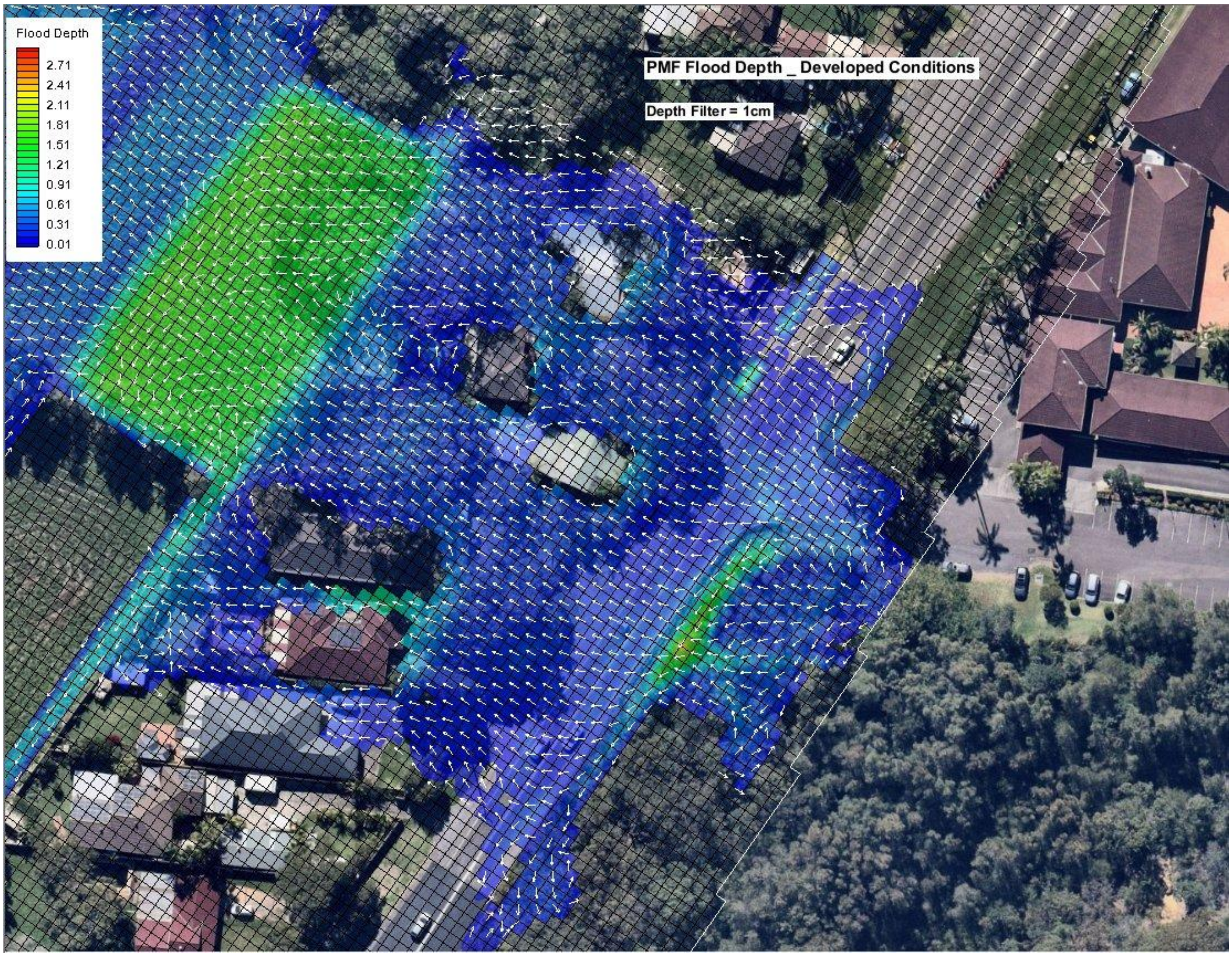


Figure 5-5 PMF Depths under Proposed Conditions (Depth filter = 0.01 m)

5.3.3 Impact of PMF Critical Duration

In view of the marked difference in the critical duration of the PMP in Subcatchment 8 and Subcatchment 5 the floodplain model was re-run for the 15 mins PMP under Existing Conditions and Proposed Conditions for both 50% and 100% blockage.

The estimated 15 mins PMF depths and flood differences between the 15 mins PMF and the 60 mins PMF are included in **Appendix D.** These include the following figures:

Figure E1 PMF Depths (15 mins) – Existing Conditions – 50% Blockage
Figure E2 PMF Flood Level Difference (15 mins – 60 mins) – Existing Conditions – 50% Blockage
Figure E3 PMF Depths (15 mins) – Existing Conditions – 100% Blockage
Figure E4 PMF Flood Level Difference (15 mins – 60 mins) – Existing Conditions – 100% Blockag

Figure P1 PMF Depths (15 mins) – Proposed Conditions – 50% Blockage
Figure P2 PMF Flood Level Difference (15 mins – 60 mins) – Proposed Conditions – 50% Blockage
Figure P3 PMF Depths (15 mins) – Proposed Conditions – 100% Blockage
Figure P4 PMF Flood Level Difference (15 mins – 60 mins) – Proposed Conditions – 100% Blockage

It was concluded that:

(i) Under Existing Conditions

- the difference in peak runoff crossing the Central Coast Highway leads to small increases in the PMF level immediately downstream of the highway under both 50% and 100 % blockage in comparison to the 60 mins PMF levels;
- there are limited minor differences within the subject property; and
- there are reductions in the PMF levels downstream of the subject property due to the reduced volume of runoff in a 15 mins PMP (around 46% of the volume of runoff in a 60 mins PMP).

(ii) Under Proposed Conditions

- the difference in peak runoff crossing the Central Coast Highway leads to small increases in the PMF level immediately downstream of the highway under both 50% and 100 % blockage in comparison to the 60 mins PMF levels;
- there are limited minor differences within the subject property;
- the lateral extent of the shallow PMF depths increases in the upstream area of the subject property; and
- there are reductions in the PMF levels downstream of the subject property due to the reduced volume of runoff in a 15 mins PMP.

In its “Flooding Review of Forresters Beach Bakali Rd” dated 18 June, 2021 Council requested, in part:

> *Finally, the 2D modelling flows must be confirmed by extracting the flow hydrograph from the 2D model to confirm the model reflects the increase in flow (when it is established what that flow will be {with regard to PMF})*

In response to Council’s request, the flow hydrographs were extracted at three locations from the 2D model. These locations are identified in **Figure 5-6.**

The 1D/2D model includes the conduit crossing located under the Central Coast Highway and a second conduit downstream of the Highway. The location and length of these conduits is disclosed in **Figure 5-7**.

Under 100% blockage conditions there is no flow through these conduits. Under 50% blockage there is flow through the conduits in a PMF.

The flows through both these conduits in a 60 mins PMF under 50% blockage and Existing Conditions and proposed Future Conditions are plotted in **Appendix E.** It will be noted there the differences in peak flows under Existing and Future Conditions is <3%. Very similar flows in the conduits occur in the 15 mins PMF.

The flow hydrographs under Existing Conditions and 50% blockage were extracted at the three locations identified in **Figure 5-6** as well from Link 13 under the Central Coast Highway (see **Figure 5-7**) for the 15 mins PMF and the 60 mins PMF.

In the case of Line 1, the total flow was calculated by summing the flow in Link 13 with the flow over the Central Coast Highway at each time step. In the cases of Line 2 and Line 3, these were located downstream of the conduits and are therefore total flows.

The total flow hydrographs under Existing Conditions and 50% blockage at the three lines are compared with the XP-RAFTS inflow hydrograph under the 15 mins PMF and 60 mins PMF in **Figure 5-7** and **5-8** respectively

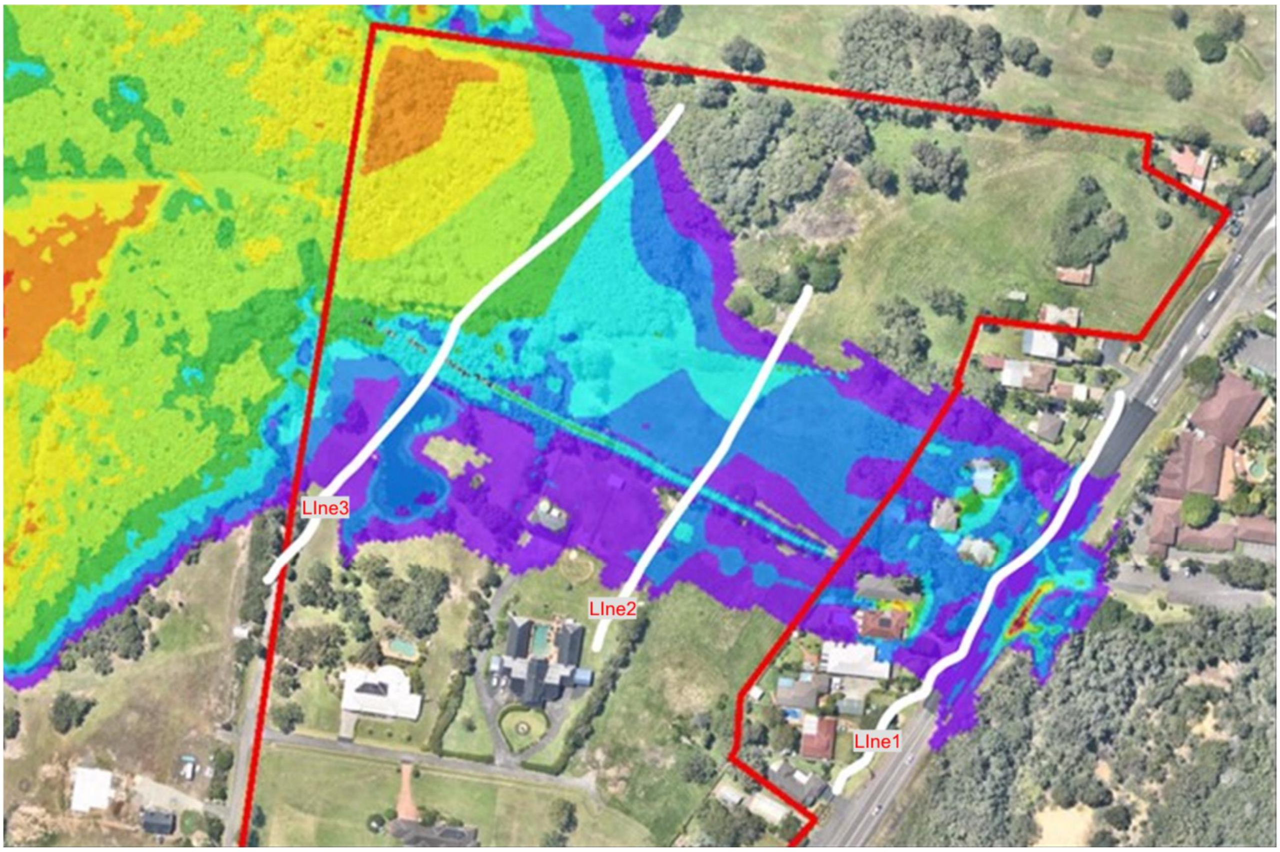


Figure 5-6 Alignment of Lines 1, 2 and 3 for Flow Hydrographs

Figure 5-7 Location of Conduits in the vicinity of the Central Coast Highway

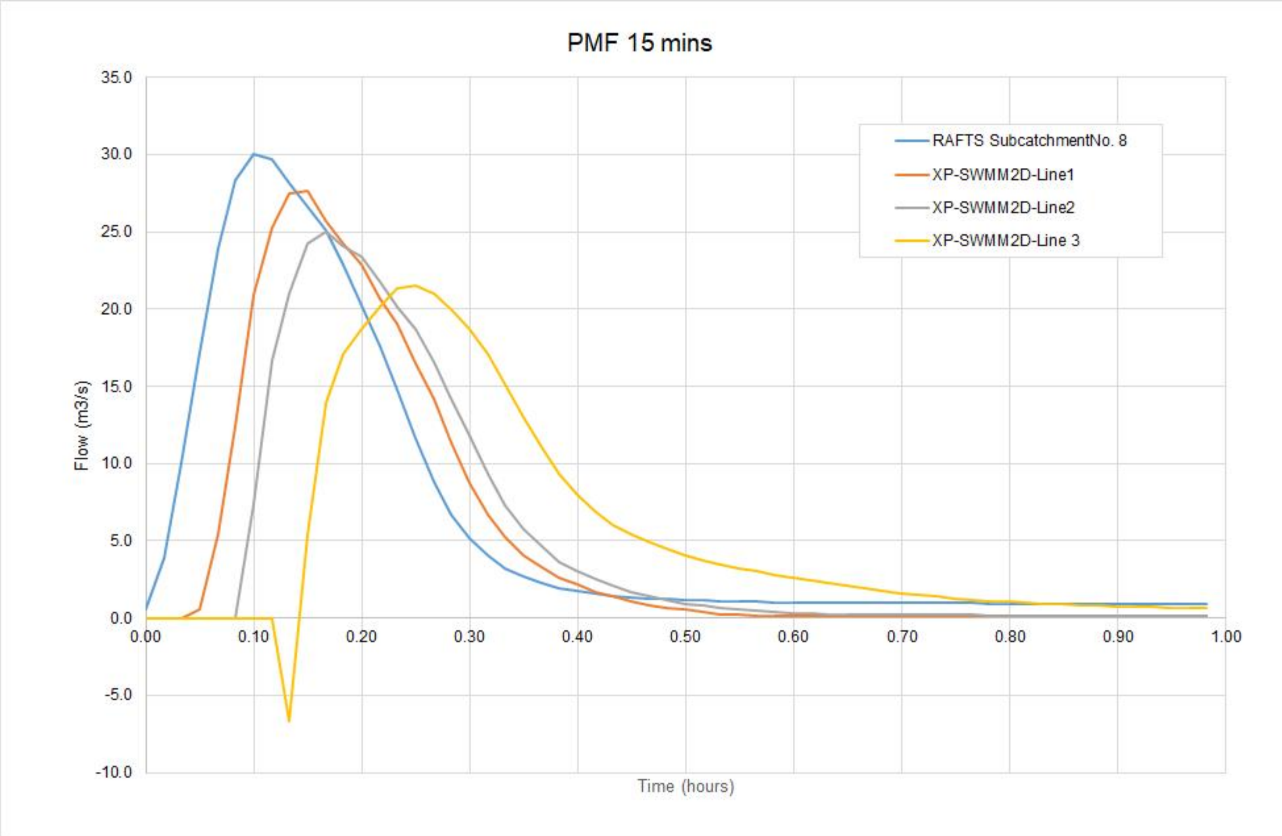


Figure 5-8 Comparison of Hydrographs - PMF 15 mins

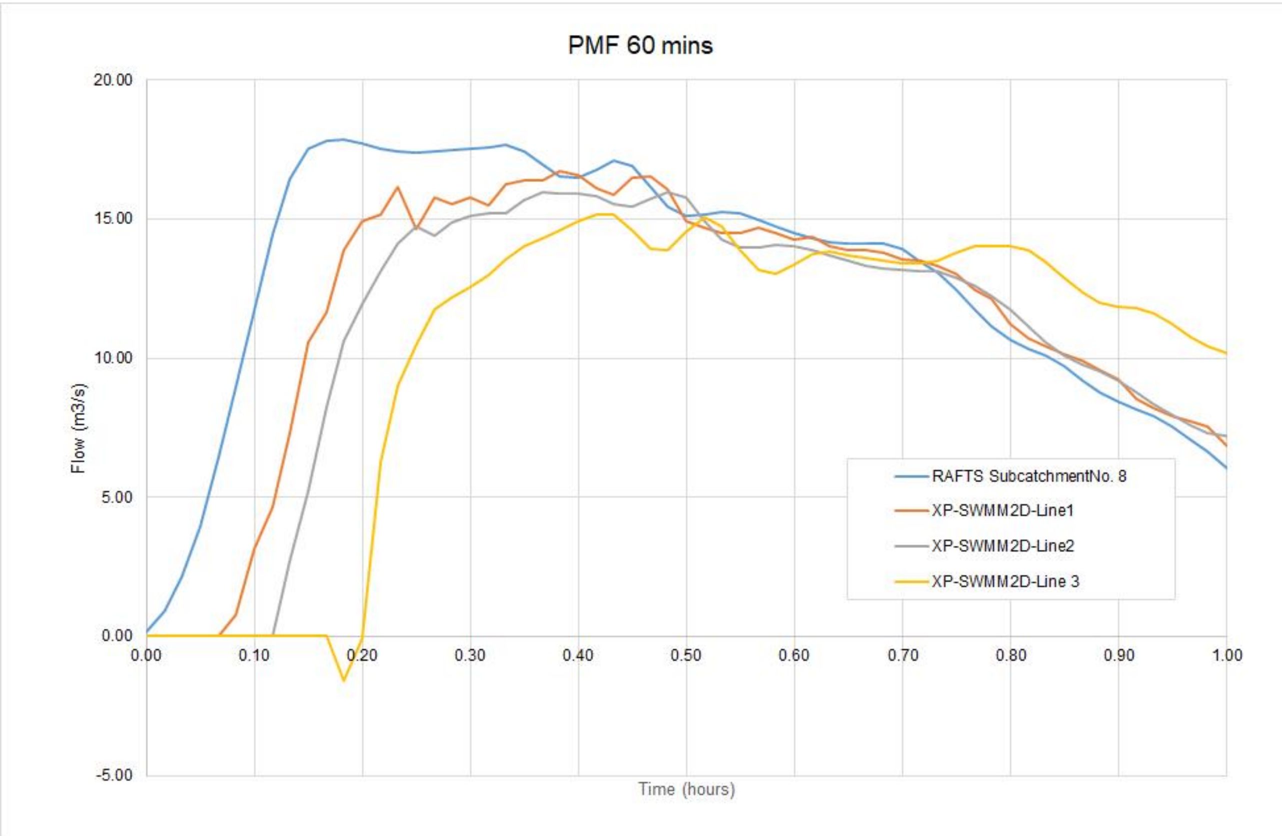


Figure 5-9 Comparison of Hydrographs - PMF 60 mins

It is noted from **Figures 5-8** and **5-9** that:

- There is minor attenuation of the 15 mins PMF and 60 mins PMF flows cross the Central Coast Highway with greater attenuation of flows as they are conveyed through the subject property,
- The degree of attenuation is greater in the 15 mins PMF due to the reduced volume of runoff in comparison to the dynamic floodplain storage;
- In both the 15 mins PMF and 60 mins PMF there is backflow from downstream of the subject site back into the site early in events which manifests as "negative" flow.

It is further noted that the attenuation in PMF flows that is noted in **Figures 5-8** and **5-9** also reflects the subcatchment discretisation adopted in **Figure 3-4** where local inflow hydrographs are input at the downstream "outlet" of each subcatchment.

It is concluded that **Figures 5-8** and **5-9** confirm that the hydraulic modelling of the PMF reflects the PMF peak flows for Subcatchment 8 summarised in **Table 3-5** and that the degree of attenuation of PMF flow through the subject site reflects the relative volume of runoff in comparison to the dynamic floodplain storage.

6 2020 Coastal Lagoon Catchments Overland Flood Study

The final report of the Coastal Lagoon Catchments Overland Flood Study was released on 5 November 2020[3]. As described by MHL, 2020, in part:

> *The Coastal Lagoons Catchments Overland Flood Study has been completed to provide a detailed flooding assessment of Avoca Lagoon, Cockrone Lagoon, Terrigal Lagoon and Wamberal Lagoon. The objective of this study is to improve understanding of flood behaviour and impacts, and better inform management of flood risk in the study area. The study also provides a sound technical basis for any further flood risk management investigation in the area. The previous studies while providing relevant information that relates to the lagoon levels do not provide hazard information in the upper catchments. The lagoons levels are largely dependent upon the berm beach levels and are a key consideration in this project. …..*
>
> *The flood maps appended to this report are presenting the flood levels, depths and velocities for the critical duration and rainfall pattern of a full set of events including the 50%, 20%, 10%, 5%, 2%, 1%, 1 in 200, 1 in 500 AEP and PMF events and represent an envelope of the critical duration/pattern of a selected representative upstream catchment and the critical duration/pattern at the lagoon. The upper catchments are very flashy with very short critical durations of less than 2h to reach the peak level while the downstream catchments (lagoons), have typical critical durations ranging between 2h and 9h. …..*
>
> *Sensitivity analysis highlighted the following points:*
>
> - *The lower catchments of the four lagoons are highly sensitive to the berm level at the time of the flood and maintaining the berm at a set level would minimise the risk of the lagoon reaching very high levels should mechanical opening of the berm not be possible during a storm.*
> - *Tailwater conditions (including sea level rise) typically have minimal impact on most lagoons flooding given the managed berm elevations. Only very large increases in tailwater levels such as the 0.74m sea level rise scenario would influence the lagoon level. The exception is Terrigal Lagoon that has a relatively low managed berm level and changes in tailwater level would have significant impact on the lagoon level as elevated ocean levels would flow into the lagoon. This identifies a significant potential issue with flooding becoming more common in Terrigal with rising sea level.*
> - *Increase in rainfall intensity due to climate change may exacerbate the overland flooding but would typically have a relatively low impact on the lagoon level.*
> - *Changes in roughness or antecedent conditions of the catchment (wet/dry catchment leading to varying losses) could have minor to moderate impacts on the overland flooding.*
> - *Blockages of structures can have severe impact in areas with no gravity flow that only relies on the drainage network (e.g. ponding area) and maintaining the pits and pipes network is essential to avoid exacerbating the flooding in such location.*
> - *Intermittently Closed and Open Lakes and Lagoons (ICOLLs) entrance conditions are sensitive to ocean inundation. These processes need to be carefully considered in conjunction with this study.*

[3] MHL (2020) "Coastal Lagoon Catchments Overland Flood Study", Final Report, prepared for Central Coast Council, November, 133 pp + Apps

6.1 Hydrology

As described by MHL, 2020, in part:

The direct rainfall method was employed in this study. This method applies rainfall directly to the 2D hydraulic model cells which then determine the quantity, direction and velocity of flow on a highly local scale based on detailed surface material and topographic information. Therefore, development of a traditional hydrologic model was not required to complete the study.

Although the direct rainfall method negates the need for hydrological models, hydrological models were still developed to:

- *Provide verification of the direct-rainfall method;*
- *Identify critical design duration/pattern hyetographs from the ensemble of events specified by AR&R 2019; and*
- *Potentially be utilised at a later stage in the floodplain management process, such as flood warning systems or flood information tools (e.g. MHLFIT).*

The hydrological model selected for this study is WBNM (version 2017). …..

The design events modelled in this study include:

- *Frequent events - 50% AEP, 20% AEP and 10% AEP;*
- *Rare events - 5% AEP, 2% AEP and 1% AEP;*
- *Very rare events - 1 in 200 AEP and 1 in 500 AEP; and*
- *Extreme event - Probable Maximum Flood (PMF).*

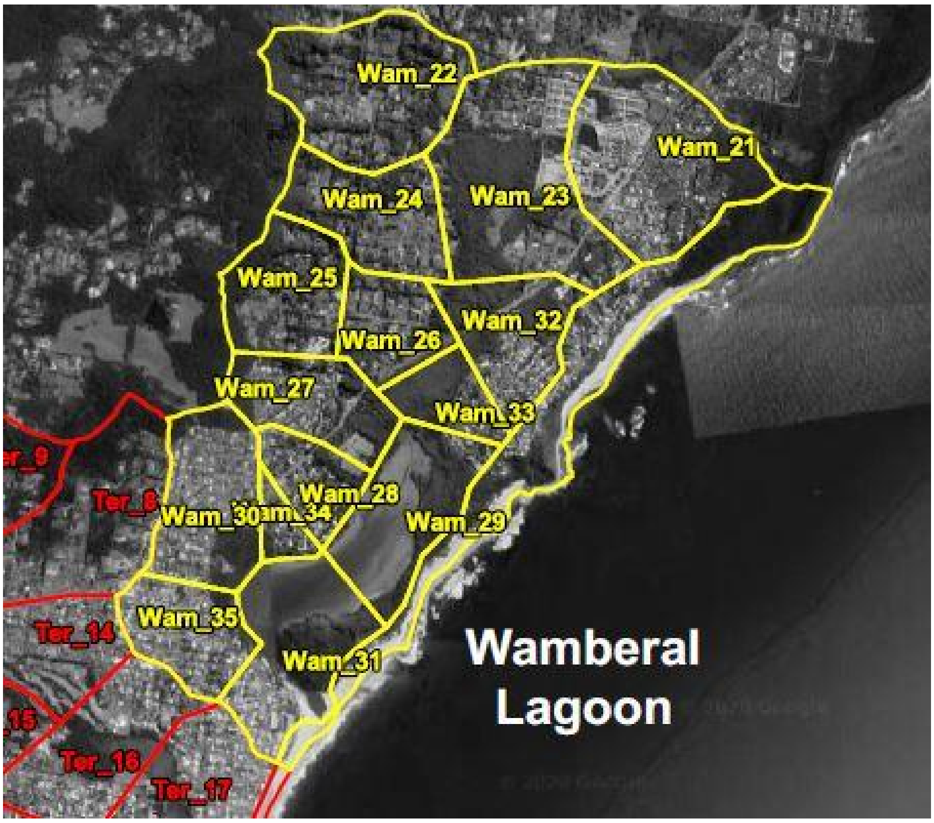


Figure 6-1 Wamberal Lagoon Subcatchments (after Figure 5.1, MHL, 2020)

The adopted WBNM subcatchment layout for the Wamberal Lagoon catchment is plotted in **Figure 6-1**. These boundaries align with the subcatchment boundaries adopted in the 2001 Wamberal Lagoon Flood Study.

6.2 Estimated Peak Design Flows up to 1 in 500 AEP

As described by MHL, 2020, in part:

The results of the WBNM model were processed using the Storm Injector software that allows a quick determination of the critical duration and critical patterns for each design storm event for both the upper and lower catchments.

The selection of the critical duration for the lower catchment was based on the peak flow out of the lagoon rather than the peak inflow into the lagoon. This approach was adopted to consider the significant effect of the storage on attenuating flows through the lagoon. This would be equivalent to considering the peak water level into the lagoon (since the outflow of the lagoon is directly dependent on the water level).

Each design event was modelled for 24 different duration ranging from 10 minutes to 168 hours (except for the PMF that was modelled for eight durations from 15 minutes to 6 hours). Each duration was run for 10 patterns as recommended by AR&R 2019.

….. Critical durations are presented in Table 5-3.

Table 5-3 Critical durations for each event

<table>
<tr><th>Lagoon</th><th>Catchment</th><th>Event</th><th>Adopted Critical Duration</th><th>Event Rainfall Depth (mm)</th></tr>
<tr><td rowspan="18">Wamberal</td><td rowspan="9">Upper</td><td>50% AEP</td><td>2 hr</td><td>40</td></tr>
<tr><td>20% AEP</td><td>45 min</td><td>38</td></tr>
<tr><td>10% AEP</td><td>45 min</td><td>47</td></tr>
<tr><td>5% AEP</td><td>20 min</td><td>38</td></tr>
<tr><td>2% AEP</td><td>20 min</td><td>47</td></tr>
<tr><td>1% AEP</td><td>20 min</td><td>55</td></tr>
<tr><td>1 in 200 AEP</td><td>20 min</td><td>60</td></tr>
<tr><td>1 in 500 AEP</td><td>20 min</td><td>69</td></tr>
<tr><td>PMF</td><td>30 min</td><td>230</td></tr>
<tr><td rowspan="9">Lower</td><td>50% AEP</td><td>4.5 hr</td><td>55</td></tr>
<tr><td>20% AEP</td><td>4.5 hr</td><td>77</td></tr>
<tr><td>10% AEP</td><td>4.5 hr</td><td>94</td></tr>
<tr><td>5% AEP</td><td>3 hr</td><td>95</td></tr>
<tr><td>2% AEP</td><td>2 hr</td><td>100</td></tr>
<tr><td>1% AEP</td><td>2 hr</td><td>116</td></tr>
<tr><td>1 in 200 AEP</td><td>2 hr</td><td>129</td></tr>
<tr><td>1 in 500 AEP</td><td>1.5 hr</td><td>133</td></tr>
<tr><td>PMF</td><td>2 hr</td><td>510</td></tr>
</table>

It is noted that the adopted 1% AEP critical storm burst duration for the upper subcatchments under ARR2019 was 20 mins which is considerably shorter than the 90 mins critical storm burst duration adopted under ARR1987 by Cardno, 2021.

The mapped 1% AEP flood depths in the vicinity of the site are given in **Figure 6-2**.

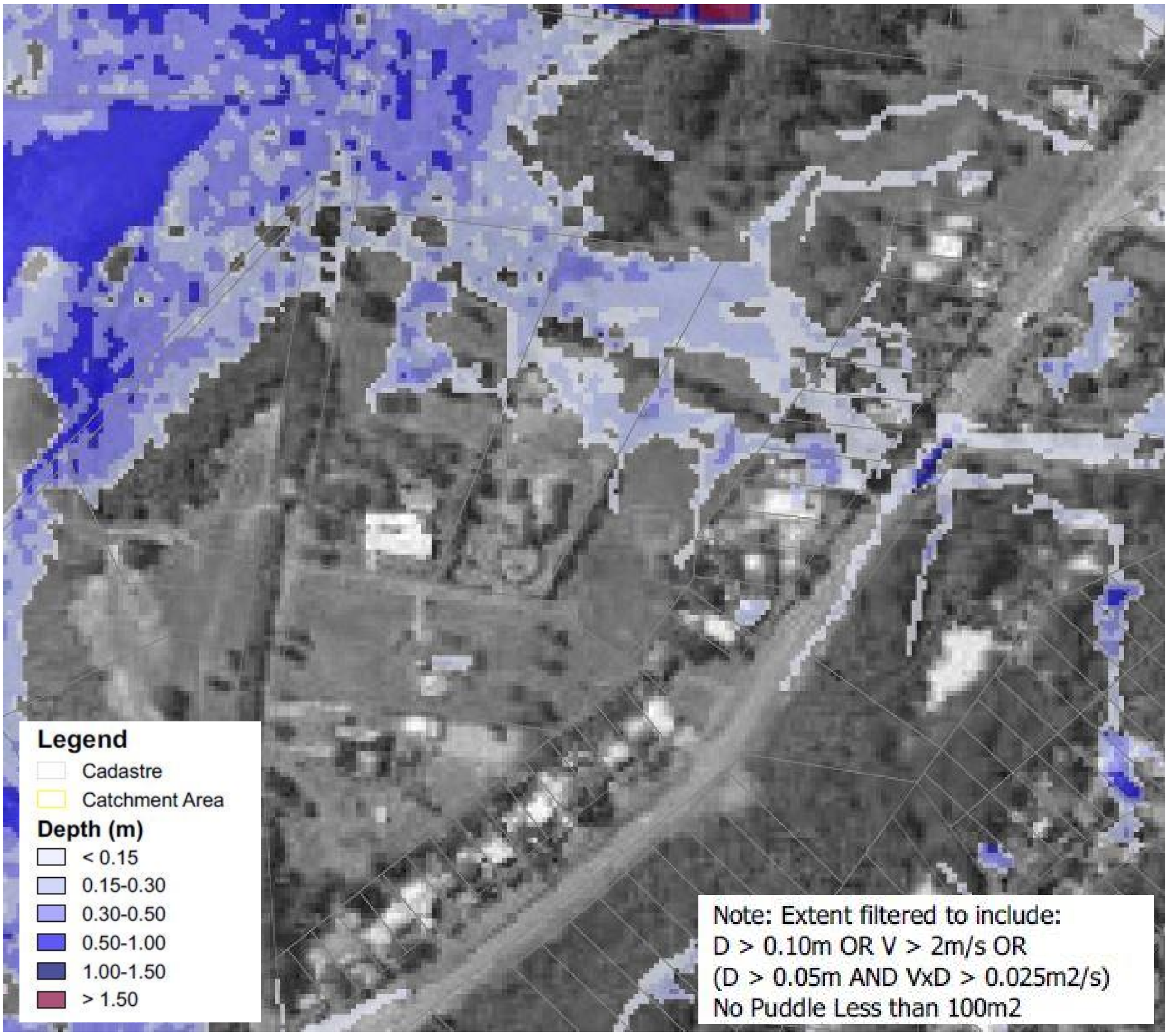


Figure 6-2 1% AEP Flood Depths (after Figure K.14, MHL, 20210)

A direct comparison of F**igure 6-2** and the 100 yr ARI flood extents presented in Cardno, 2021 is difficult because of the difference in modelling approach (rainfall on grid versus discrete inflows) and difference in filtering of results (V and D or VxD filters versus no depth filter).

It was concluded that, within the subject property, the extent of inundation in a 1% AEP flood mapped in **Figure 6-2** is less than mapped by Cardno, 2021. It is expected that the application of the filters adopted in the 2020 study to the Cardno, 2021 results would bring the Cardno, 2021 flood extents into closer agreement with **Figure 6-2.**

6.3 PMF

As described by MHL, 2020, in part:

> *The PMP rainfall depth has been estimated using the Generalised Short Duration Method (GSDM) derived by the Bureau of Meteorology. Durations of up to 6-hours have been considered for the PMP in accordance with the GSDM.*
>
> *The temporal patterns used to derive the probable maximum flood (PMF) should be selected from an ensemble of patterns appropriate for use with the Generalised Probable Maximum Precipitation (PMP). Similarly, to the other design event, an envelope of two critical durations has been applied for the PMF calculation, one shorter duration to consider flashy sub- catchments and a longer duration for the lagoon.*
>
> *At present, the best source of ensemble temporal patterns for use with short duration Very Rare to Extreme events are those derived by Jordan et al. (2005); these patterns were derived specifically from storms associated with thunderstorm or deeply convective events.*
>
> *These ten patterns were therefore adopted in this study and applied to the calculated PMP rainfall depth. The critical pattern was determined as per the typical AR&R 2019 guidelines applied to the other design events.*

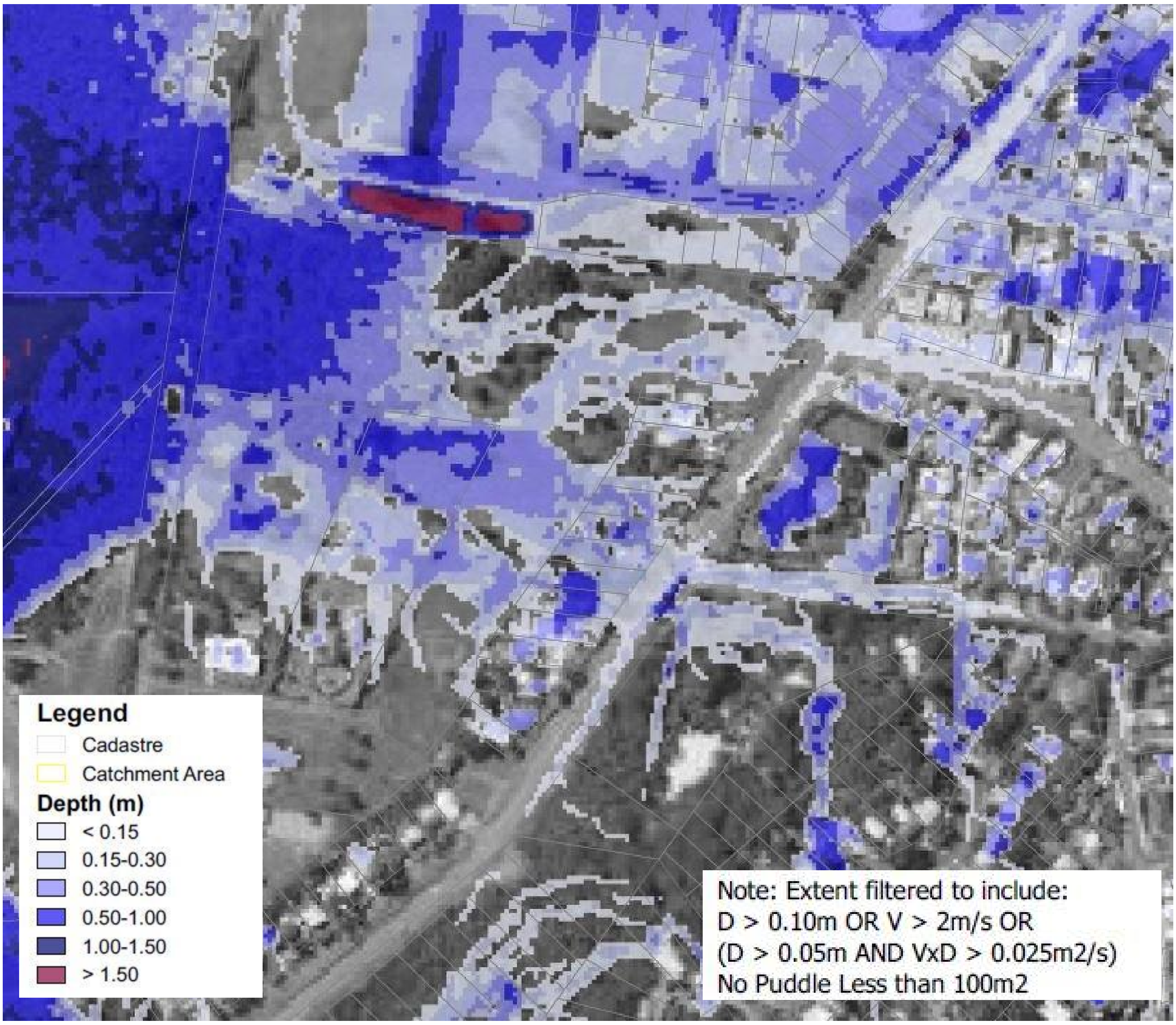


Figure 6-3 PMF Depths (after Figure K.10, MHL, 20210

The approach adopted by Cardno, 2021 to the PMP temporal pattern was to adopt the single PMP temporal pattern given in The Estimation of Probable Precipitation in Australia: Generalised Short-Duration Method[4] (BoM, 2003).

It is noted that temporal patterns adopted by MHL, 2020 are described in *Growth curves and temporal patterns of short duration design storms for extreme events,)*[5]. It was also noted that Jordan et al, 2005, in part, concluded from a benchmarking analysis that "*In this case adoption of a sample of temporal patterns and the antecedent rainfalls had negligible effect on the peak inflow distribution*" in comparison to peak flow estimated using the single PMP temporal pattern given by BOM, 2003.

The mapped PMF depths in the vicinity of the site are given in **Figure 6-3**.

A direct comparison of F**igure 6-3** and the 100 yr ARI flood extents presented in Cardno, 2021 is difficult because of the difference in modelling approach (rainfall on grid versus discrete inflows) and difference in filtering of results (V and D or VxD filters versus no depth filter).

It was noted that Figure 8 disclosed that under Existing Conditions that overland flows from Forresters Beach Road are expected to traverse the northeast part of the subject property. This was not identified in the Cardno, 2021 maps due to the adopted approach of inputting PMF hydrographs at discrete locations.

Figure 6-3 also identified within the southern flood extents some shallow lateral "fingers" of overland flow which were also not identified in the Cardno, 2021 maps due to the adopted approach of inputting PMF hydrographs at discrete locations

It was concluded that, within the subject property, the extent of inundation in a PMF mapped in Cardno, 2021 and MHL, 2020 are broadly similar noting the MHL, 2020 "rainfall on grid" modelling approach did identify some additional PMF overland flowpaths through the subject property under Existing Conditions.

[4] BOM (2003) "The Estimation of Probable Precipitation in Australia: Generalised Short-Duration Method", Hydrometeorological Advisory Service, June. 34 pp.

[5] Jordan, P. N., Nathan, R., Mittiga, L. and Taylor, B. (2005). "Growth Curves and Temporal Patterns for Application to Short Duration Extreme Events", *Australian Journal of Water Resources*, 9(1), 69-80.

7 Conclusions and Recommendations

This report has been prepared in support of a planning proposal to be submitted to Central Coast Council seeking rezoning of the subject land. The rezoning application seeks to rezone the flood free and non-environmentally sensitive parts of the site to R2 to support low density residential development. An indicative lot layout has been prepared by Bannister and Hunter as shown in **Figure 5-1**.

The site is currently subject to overland flows from the upstream catchment. This report includes an assessment of the 100 yr ARI flood and Probable Maximum Flood (PMF) under Existing Conditions (pre-development) and proposed Future Conditions (post-development) based on an indicative lot layout to assess any flood impacts if the rezoning is approved and residential development proceeds.

It was concluded from the hydrological and hydraulic modelling of Existing Conditions that:

(i) The estimated 100 yr ARI peak flow is in good agreement with the 100 yr ARI peak flow reported in the 2001 flood study;

(ii) The PMF peak flow is considerably higher than the peak flow for the Extreme flood reported in the 2001 flood Study; and

(iii) The PMF peak flow estimated in this study is a more accurate estimate of a PMF flow from this small catchment than adopted in the 2001 flood study.

The following was also concluded from the modelling of the Existing Conditions (refer **Appendix B**):

> The existing site receives upstream runoff from an existing 900 mm RCP west of the Central Coast Highway and overland flow over the highway in both the 100 yr ARI and PMF events.

> Flows from the Wamberal Lagoon catchment affect the western side of the proposed development;

> Existing 100 yr ARI flows with 50% blockage through the site where residential development is proposed and outside of the existing open channel, reach an approximate maximum depth of 0.4 (Refer Figure A02). This overland flow originates from east of the Central Coast Highway. Maximum velocities are approximately 1.4 m/s.

> Existing PMF flows through the site where residential development is proposed and outside of the existing open channel, reach an approximate maximum depth of 0.4 m (Refer Figure A11). This overland flow originates from east of the Central Coast Highway. Maximum velocities are approximately 1.8 m/s.

The following was concluded from the modelling of the proposed Future Conditions (refer **Appendix C**)**:**

> The proposed development conveys the existing overland flow through the proposed wider road network directly to the vegetated area;

> During a 100 yr ARI flood under 50% blockage a peak flood depth of 0.75 m occurs in the overland flow path;

> During a PMF under 50% blockage the peak flood depth of 1.6 m occurs in the overland flow path;

> During a 100 yr ARI flood under 50% blockage the peak flood hazard reaches a maximum of 0.85 m^2/s in the rear swale and 0.75 m^2/s in the overland flow path;

> During a PMF under 50% blockage the peak flood hazard is up to 1.4 m^2/s in the rear swale and 1.3 m^2/s in the overland flow path;

> None of the proposed residential lots are inundated by floodwaters during a 100 yr ARI flood under conditions of 50% blockage;

> During a PMF under 50% blockage, none of the lots are impacted by floodwaters deeper than 200 mm. Refer to Figure D02 for the extent of the 0.2 m inundation (adjacent to the culvert crossing).;

> During a 100 yr ARI flood under 50% blockage the proposed development results in an increase in flood levels of up to 0.75 m which is confined to the overland flow path;
> During a PMF under 50% blockage the proposed development results in an increase in flood levels of up to 1.4 m in the overland flow path and 1.4 m in the roadway It should be noted that the surface levels have changed under the development conditions, and therefore the change in flood level reflects an amended ground elevation. The flood depths within the roadway under the proposed conditions are between 0.2 m and 0.4 m directly over the culverts and low point;
> There is no significant off-site impact on flood hazard in the 100 yr ARI flood or PMF under 50% blockage; and
> Proposed roadways are flood free in the 100 yr ARI flood under 50% blockage and slightly flooded in the PMF under 50% blockage.

It is recommended that:

> The proposed overland flow path be carefully designed to avoid any water ponding for extended periods; and
> Fencing and/or signage be installed to alert residents and others to the flood hazard and to restrict access to the overland flow path and to the proposed open catch drain (drainage easement) along the eastern boundary.

8 References

BOM (2003) “The Estimation of Probable Precipitation in Australia: Generalised Short-Duration Method”, Hydrometeorological Advisory Service, June. 34 pp.

Jordan, P. N., Nathan, R., Mittiga, L. and Taylor, B. (2005). “Growth Curves and Temporal Patterns for Application to Short Duration Extreme Events”, Australian Journal of Water Resources, 9(1), 69-80.

MHL (2020) “Coastal Lagoon Catchments Overland Flood Study”, Final Report, prepared for Central Coast Council, November, 133 pp + Apps

Webb, McKeown & Associates (2001) “Wamberal Lagoon Flood Study”, Final Report, prepared for Gosford City Council, November, 37 pp + Apps.

Forresters Beach Planning

APPENDIX

A

SUBCATCHMENTS EAST OF HIGHWAY

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DATE PLOTTED: 02 March, 2015 - 11:02am

PLAN
SCALE 1:200

40 20 0 40 80 120 160 200m
A1 1:2000 (A3 1:4000)

REV	DATE	REVISIONS	DRN	CHK
1	20/05/08	PRELIMINARY - FOR INFORMATION ONLY	M.K.	V.C.

CLIENT:

DESIGNED: C.B.
DRAWN: M.K.
CHECKED: V.C.
RECOMMENDED: PROJECT MANAGER DATE

DATUM: AHD
A1
COORDINATE SYSTEM:
APPROVED: PROJECT DIRECTOR DATE

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CATCHMENT PLAN
PROPOSED DWELLING AND ASSOCIATED WORKS
LOT 522 DP 10779077, 987-991 CENTRAL COAST HIGHWAY
FORRESTERS BEACH
For : TAMAZA PTY LTD

DRAWING STATUS: PRELIMINARY
DRAWING NUMBER: 89023660-CAT
REV 1

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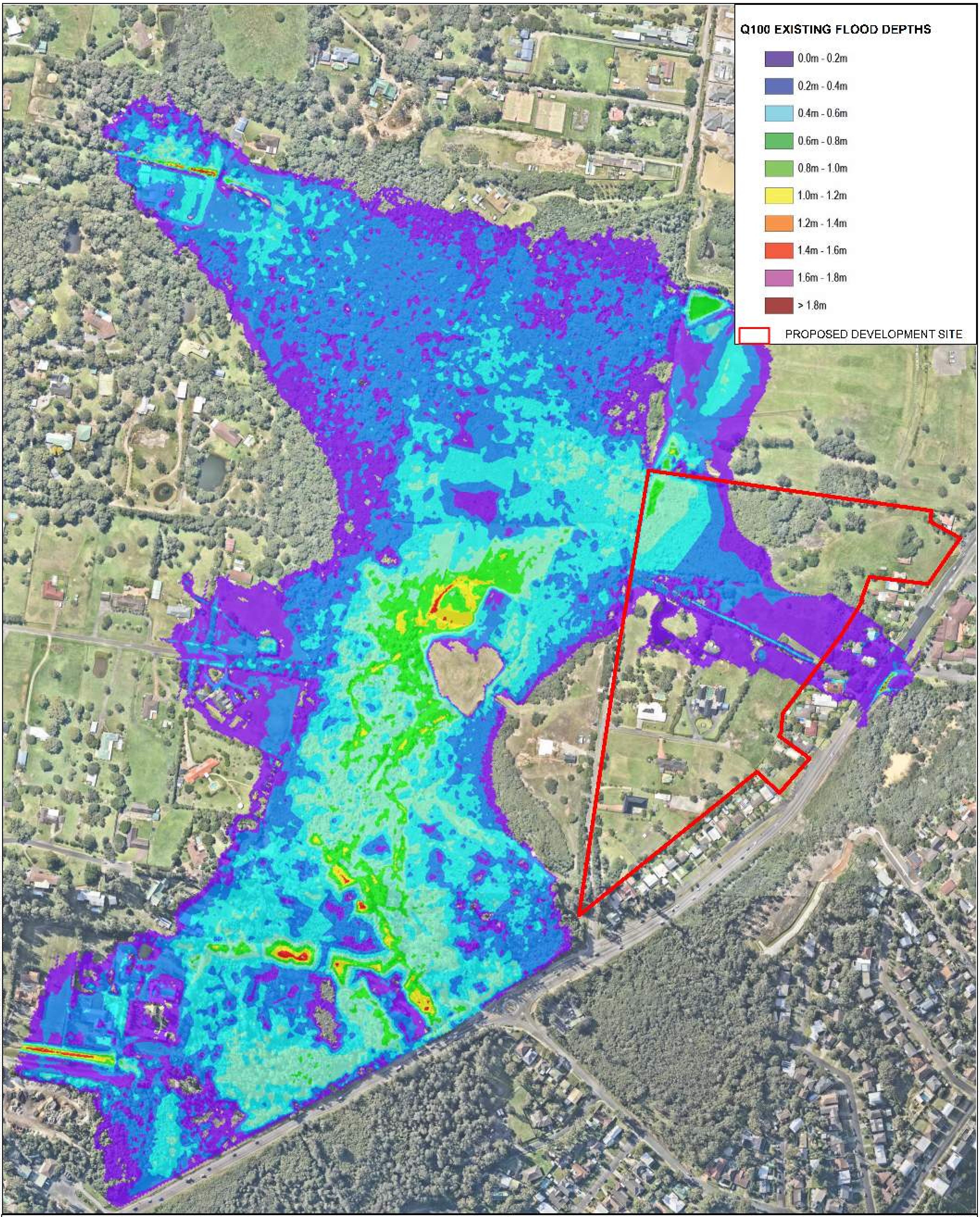
CAD FILE: P:\8902_36_Misc\89023660_987_991_Entrance_Rd_Forresters_Beach\Acad\Civil\89023660-CAT.dwg
XREF's: x89023660-Cat; x89023660-Title

Forresters Beach Planning

APPENDIX

B

EXISTING CONDITIONS FLOOD MAPS



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Approx. Scale
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Drawn SN	Date 10/10/2016
Checked SJB	Date 10/10/2016
Designed SN	Date 10/10/2016
Verified SJB	Date 10/10/2016
Approved SJB	Date 10/10/2016

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **100 YEAR ARI MAXIMUM FLOOD DEPTHS**
MODEL EXTENT - EXISTING CONDITIONS
50% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

	Datum	Scale	Size
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Drawing Number	Revision
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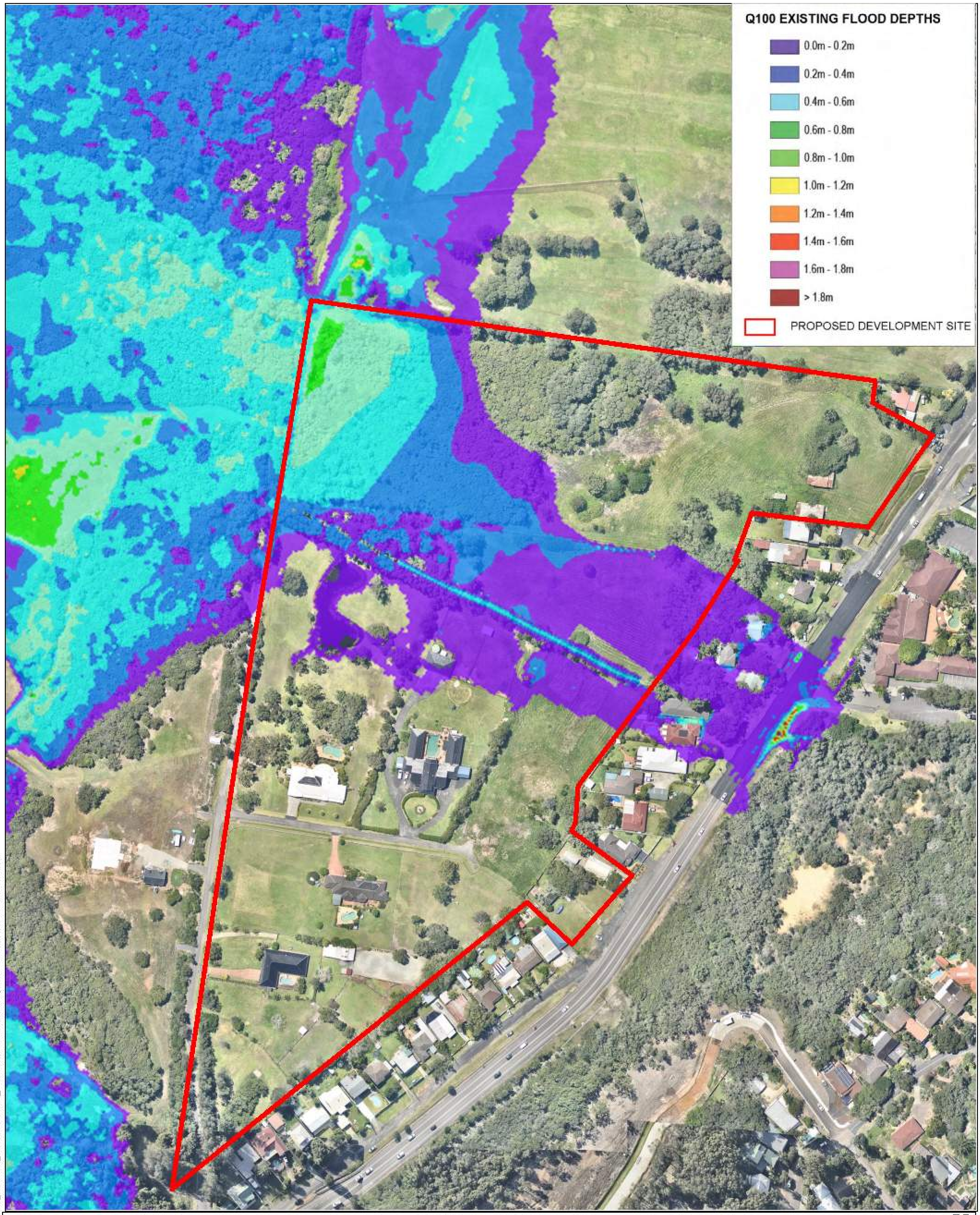

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Checked SY	Date 13/04/2021
Designed JY/SY	Date 13/04/2021
Verified SJB	Date 13/04/2021
Approved SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **100 ARI MAXIMUM FLOOD DEPTH**
EXISTING CONDITIONS
50% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number A2
Revision D

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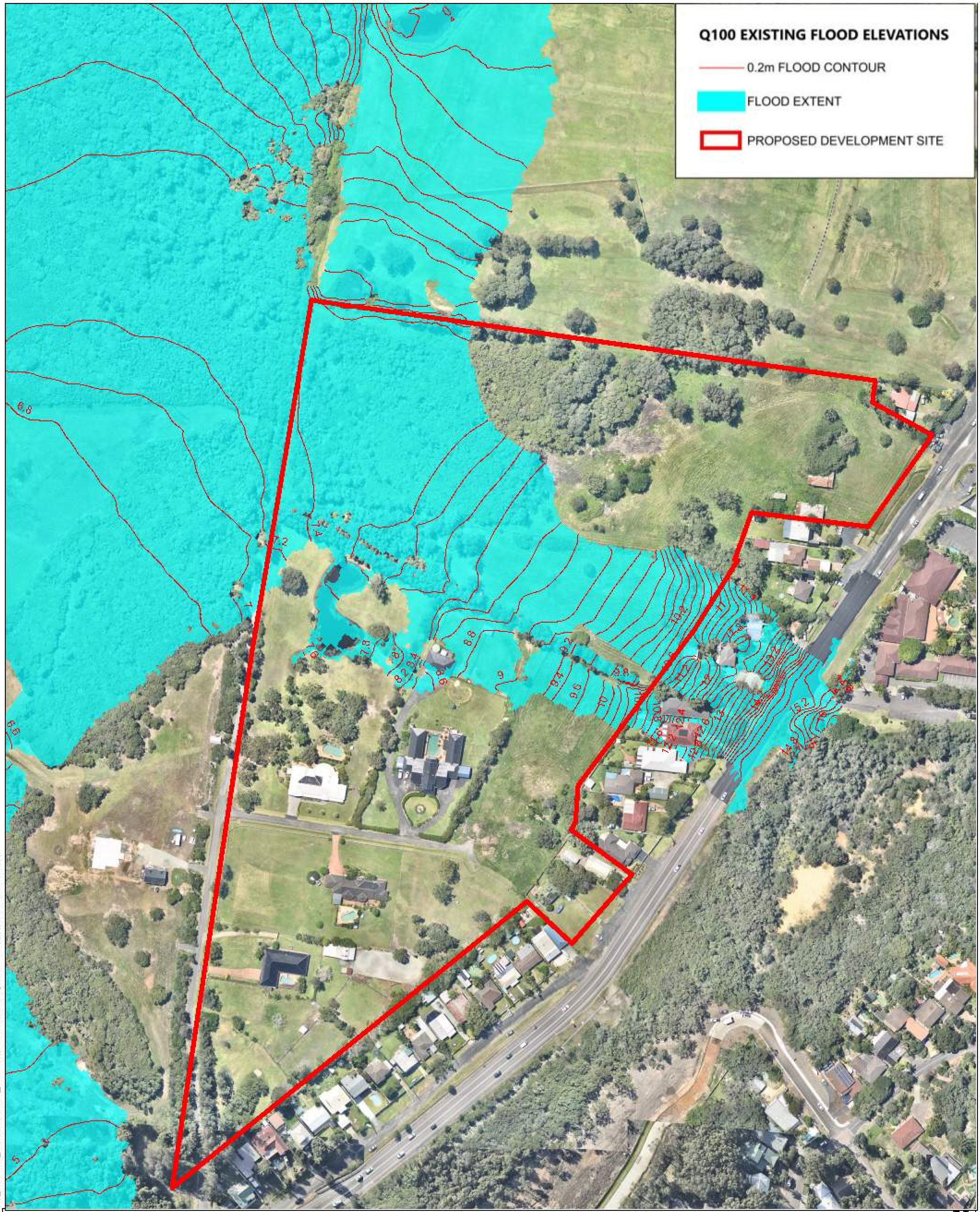

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Checked	SY	13/04/2021
Designed	JY/SY	13/04/2021
Verified	SJB	13/04/2021
Approved	SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **100 ARI MAXIMUM FLOOD ELEVATION**
EXISTING CONDITIONS
50% BLOCKAGE

Status: PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
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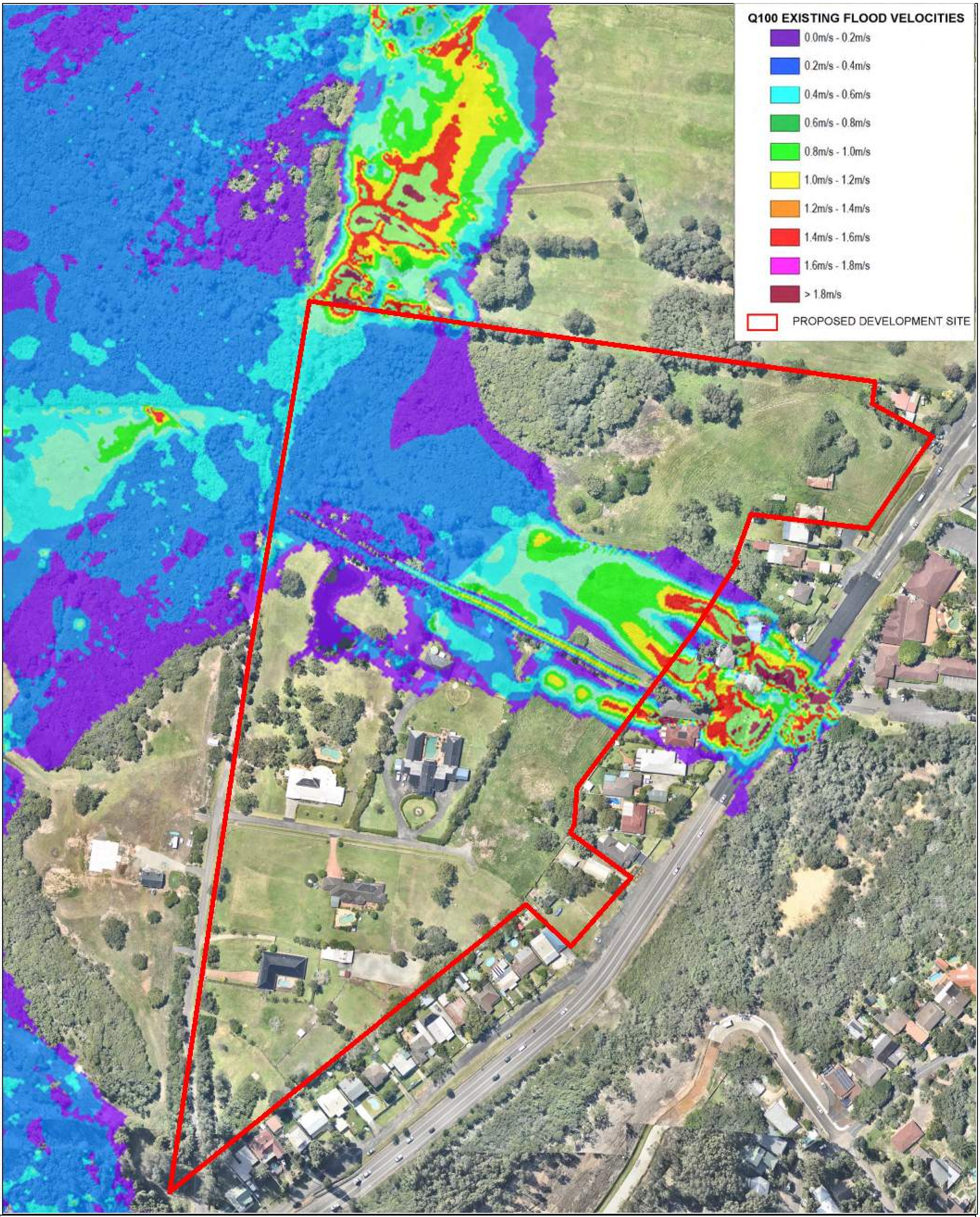

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Drawn YL	Date 13/04/2021	Client:	Terrigal Grosvenor Lodge Pty Ltd
Checked SY	Date 13/04/2021	Project:	FLOOD STUDY FORRESTERS BEACH PLANNING
Designed JY/SY	Date 13/04/2021	Status	PRELIMINARY Not to be used for construction purposes
Verified SJB	Date 13/04/2021	Title:	100 ARI MAXIMUM FLOOD VELOCITIES EXISTING CONDITIONS 50% BLOCKAGE
Approved SJB	Date 13/04/2021		

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
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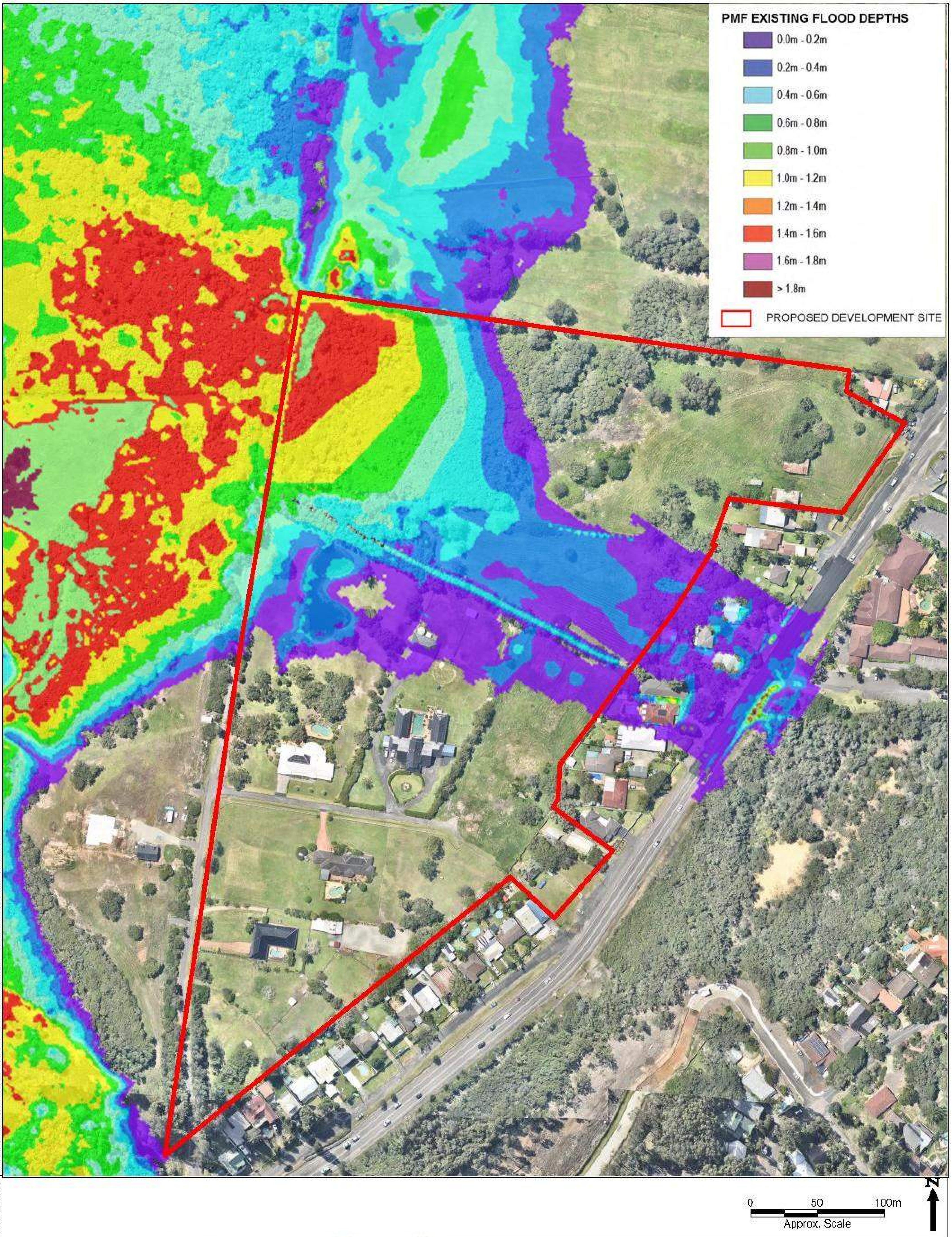

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Designed: JY/SY	Date: 13/04/2021
Verified: SJB	Date: 13/04/2021
Approved: SJB	Date: 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF MAXIMUM FLOOD DEPTH**
EXISTING CONDITIONS
50% BLOCKAGE

Status: PRELIMINARY
Not to be used for construction purposes

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Drawing Number	Revision
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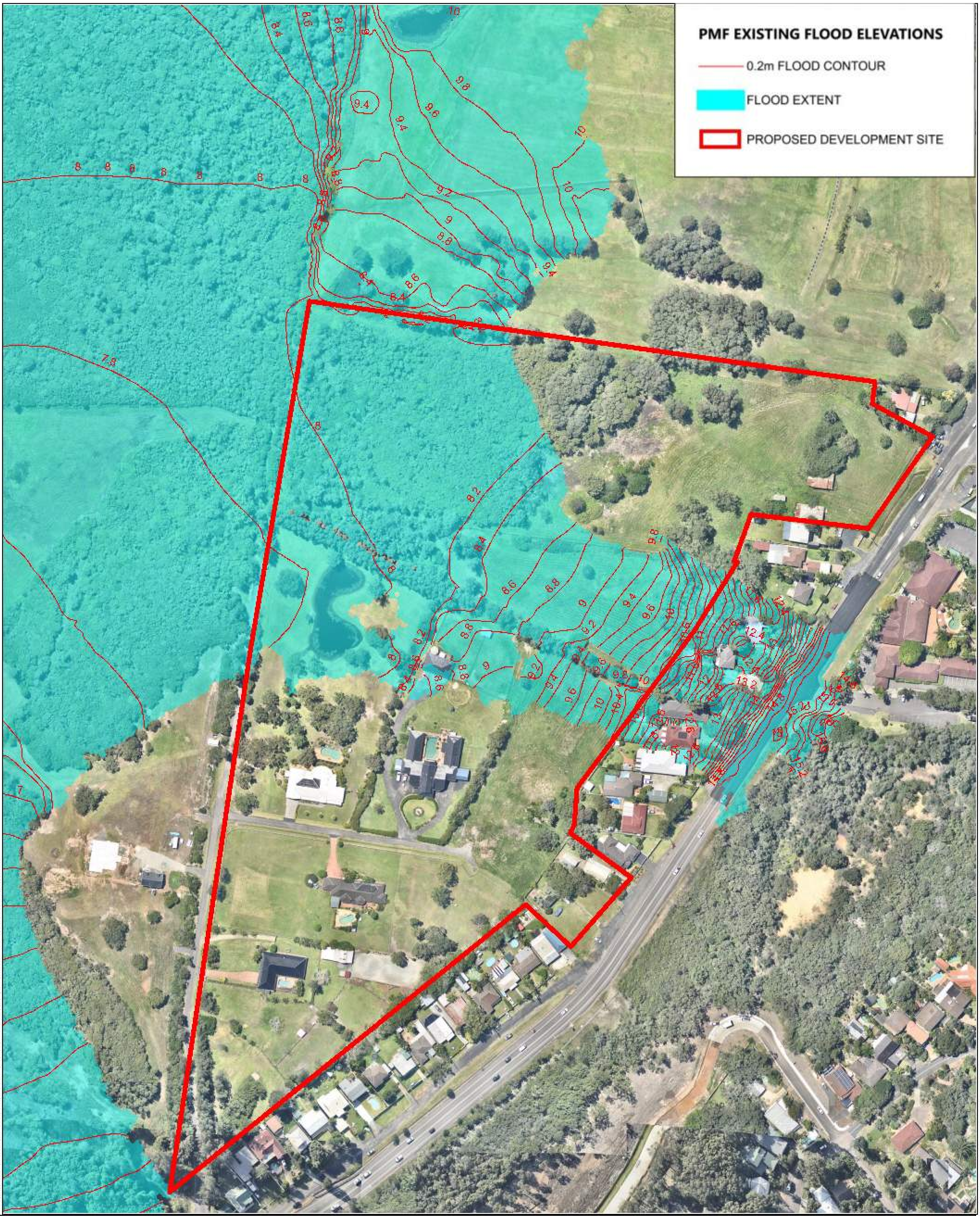

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Designed JY/SY	Date 13/04/2021
Verified SJB	Date 13/04/2021
Approved SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF MAXIMUM FLOOD ELEVATION EXISTING CONDITIONS 50% BLOCKAGE**

Status PRELIMINARY
Not to be used for construction purposes

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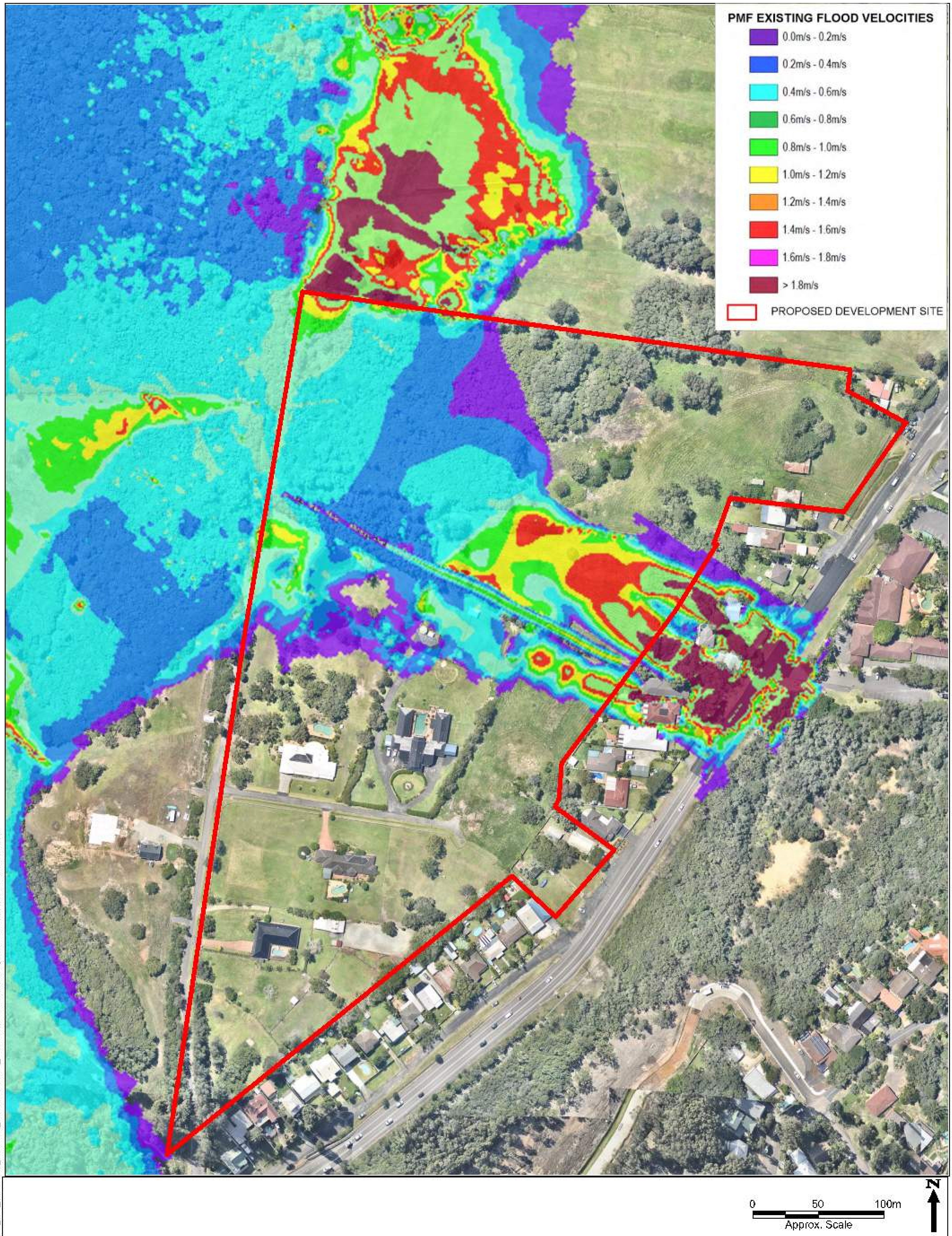
Drawing Number A06
Revision D



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Verified SJB	Date 13/04/2021
Approved SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF MAXIMUM FLOOD VELOCITIES**
EXISTING CONDITIONS
50% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
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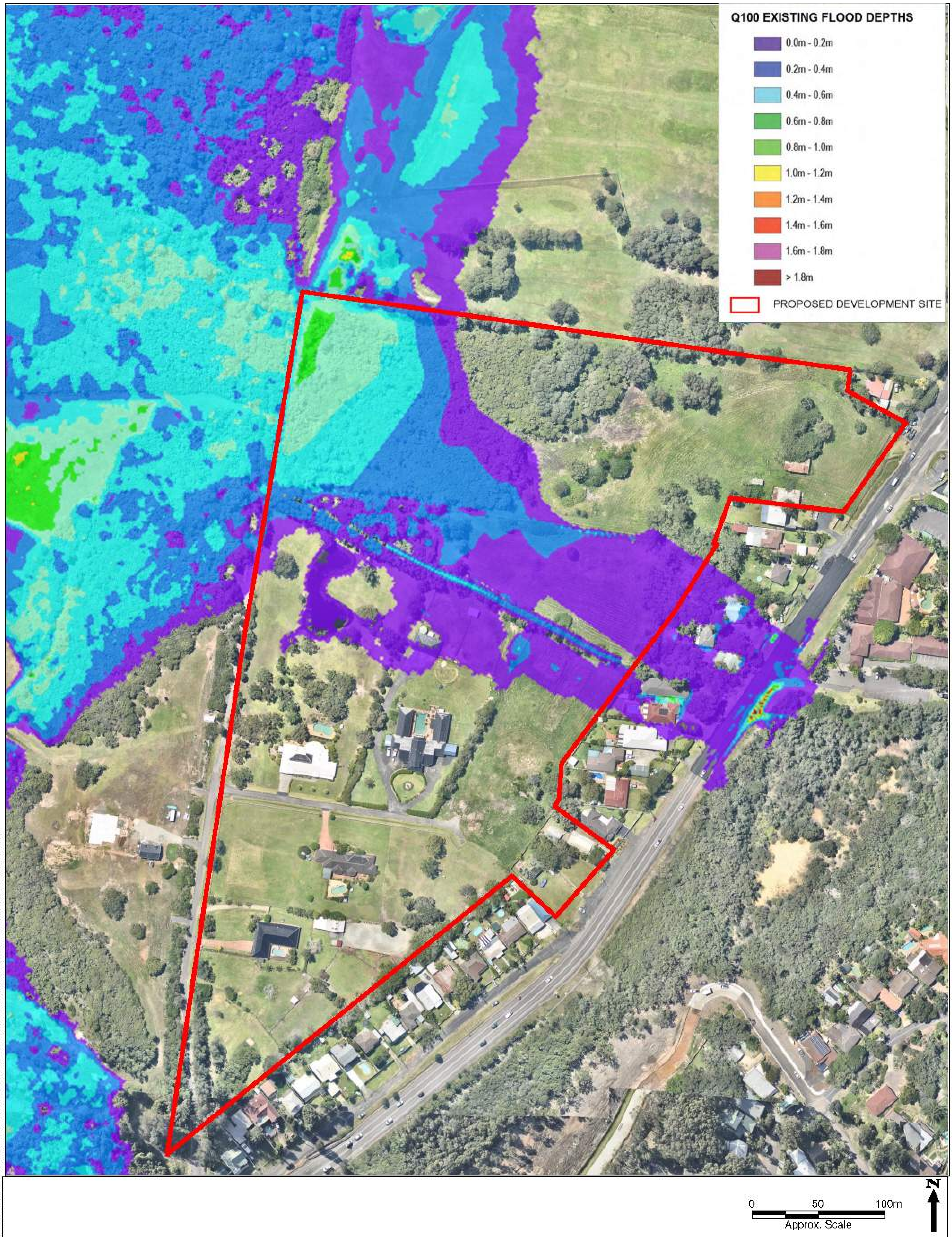

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Verified	SJB	Date 13/04/2021
Approved	SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **100 ARI MAXIMUM FLOOD DEPTHS**
EXISTING CONDITIONS
100% BLOCKAGE

Status: PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
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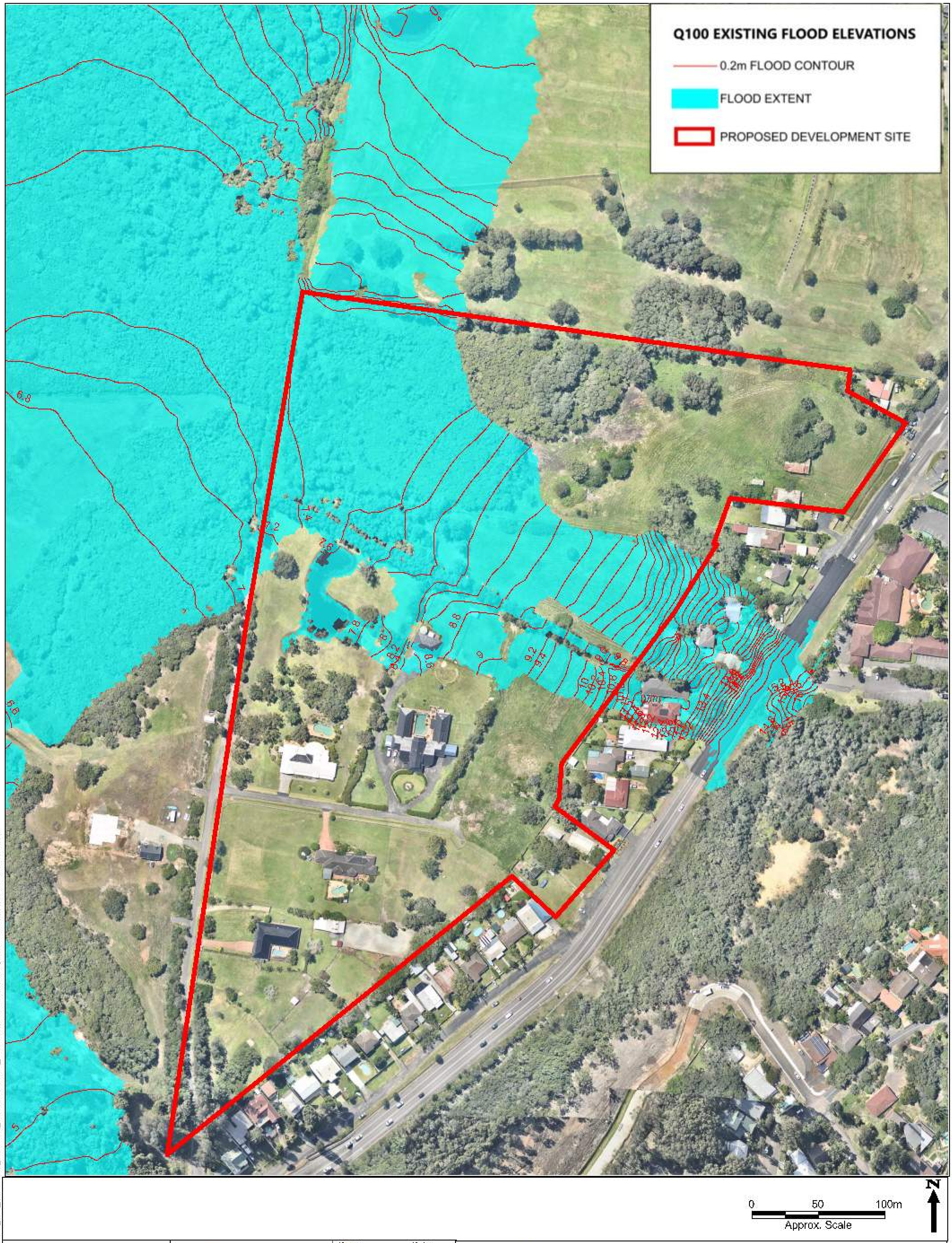
Drawing Number	Revision
A08	D



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Verified SJB	Date 13/04/2021
Approved SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **100 ARI MAXIMUM FLOOD ELEVATION**
EXISTING CONDITIONS
100% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number A09

Revision D

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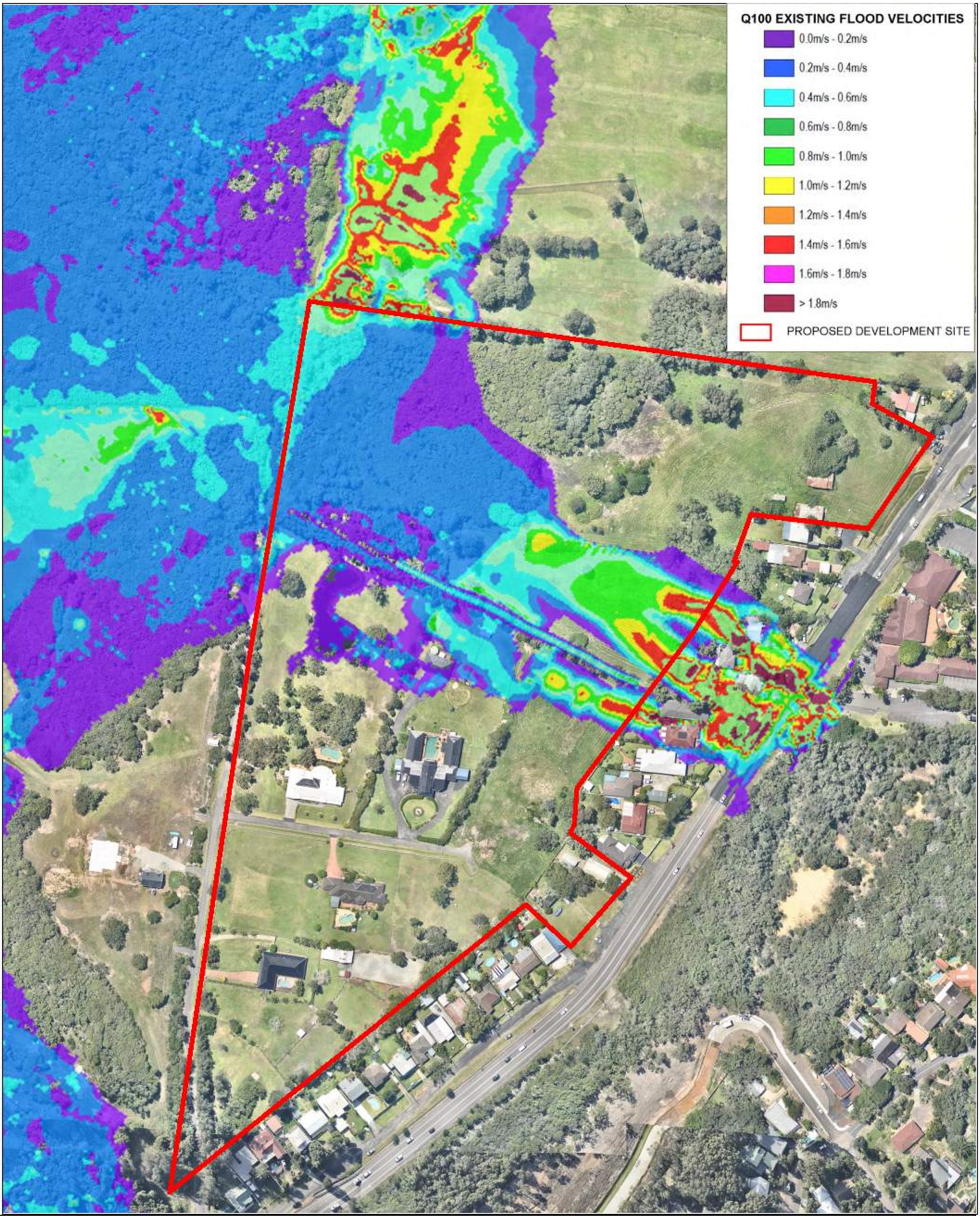

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Drawn YL	Date 13/04/2021
Checked SY	Date 13/04/2021
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Verified SJB	Date 13/04/2021
Approved SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **100 ARI MAXIMUM FLOOD VELOCITIES**
EXISTING CONDITIONS
100% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
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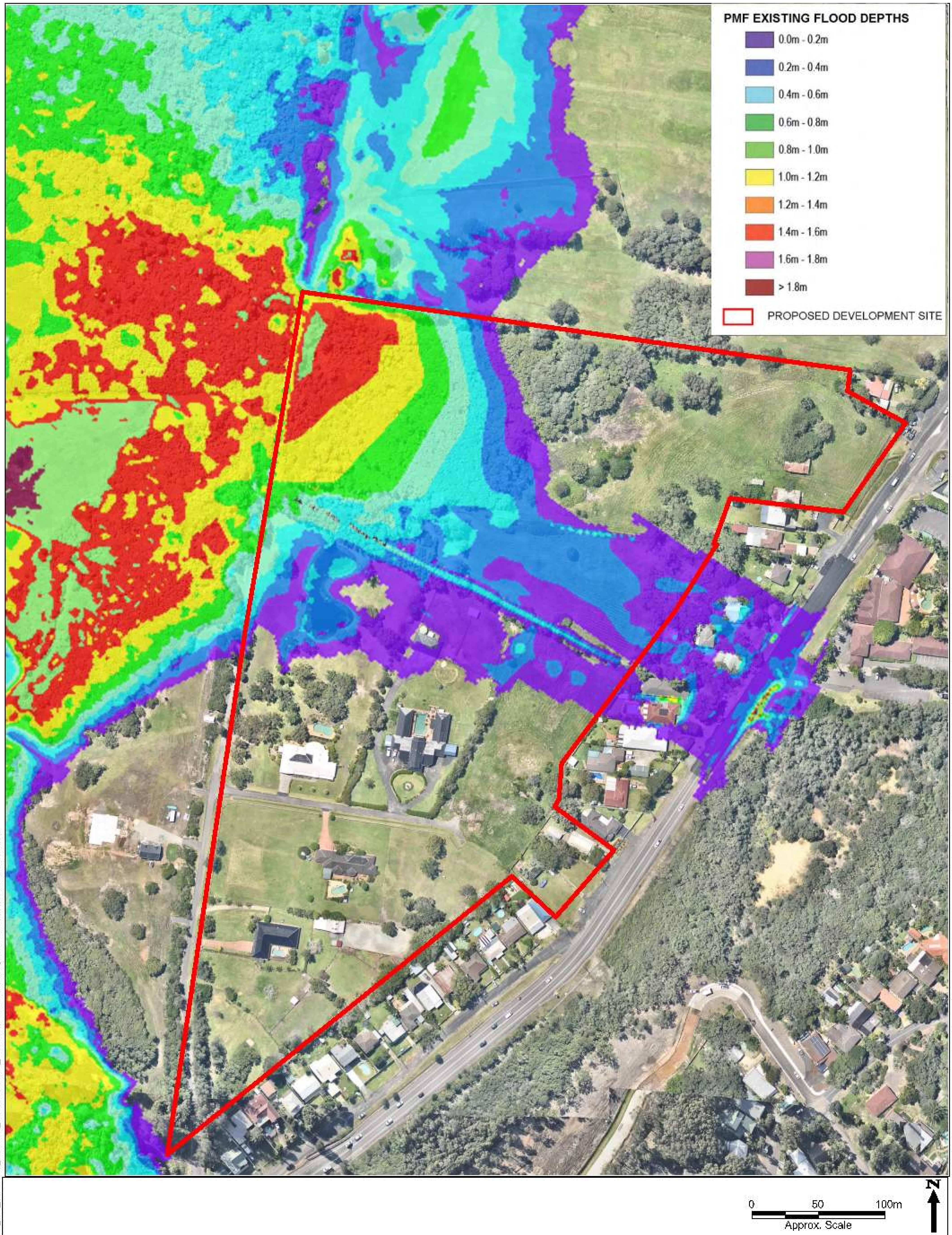

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Drawn	YL	Date 13/04/2021
Checked	SY	Date 13/04/2021
Designed	JY/SY	Date 13/04/2021
Verified	SJB	Date 13/04/2021
Approved	SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF MAXIMUM FLOOD DEPTHS**
EXISTING CONDITIONS
100% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number: A11
Revision: D

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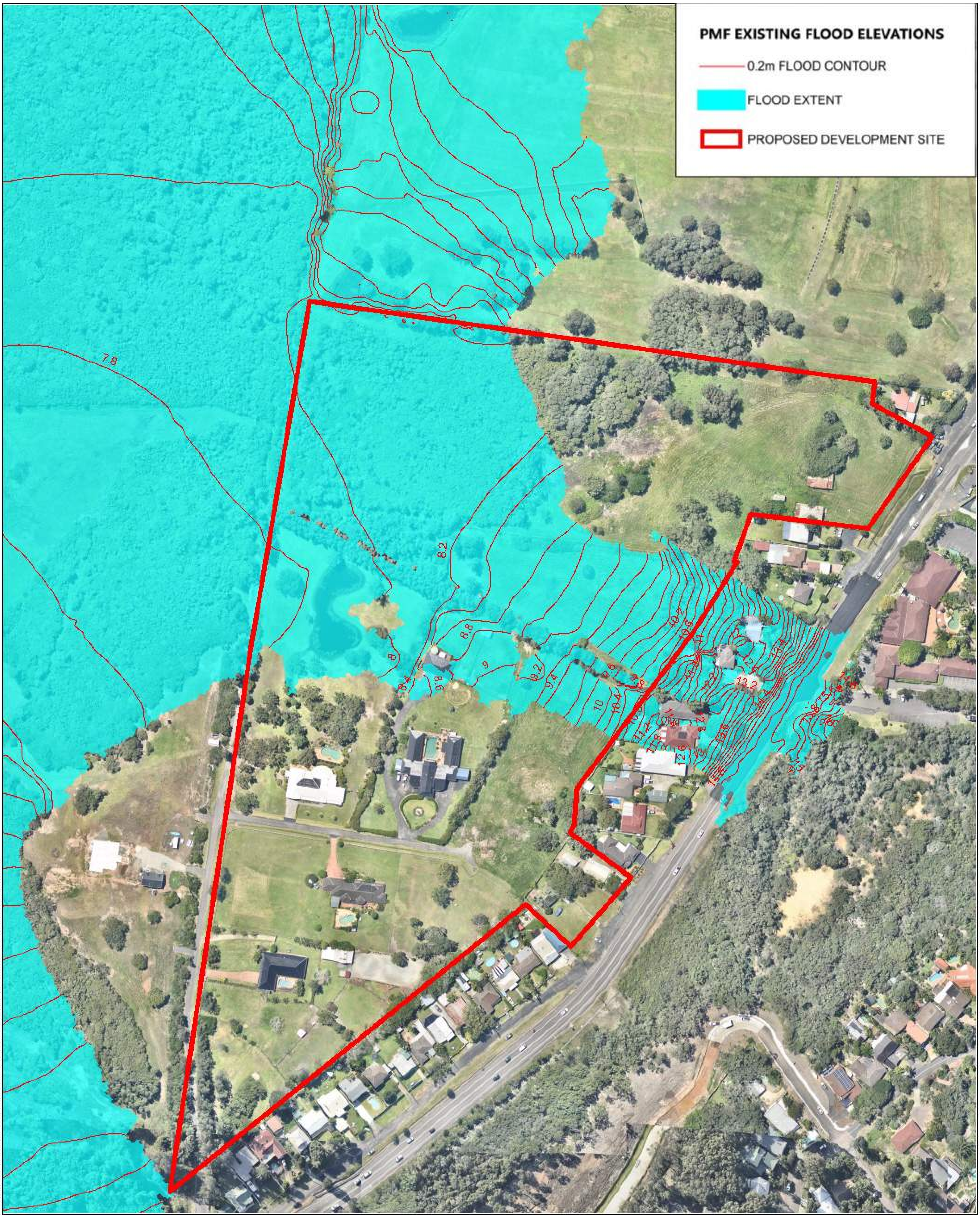

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		Date
Drawn	YL	13/04/2021
Checked	SY	13/04/2021
Designed	JY/SY	13/04/2021
Verified	SJB	13/04/2021
Approved	SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF MAXIMUM FLOOD ELEVATION**
EXISTING CONDITIONS
100% BLOCKAGE

Status: PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
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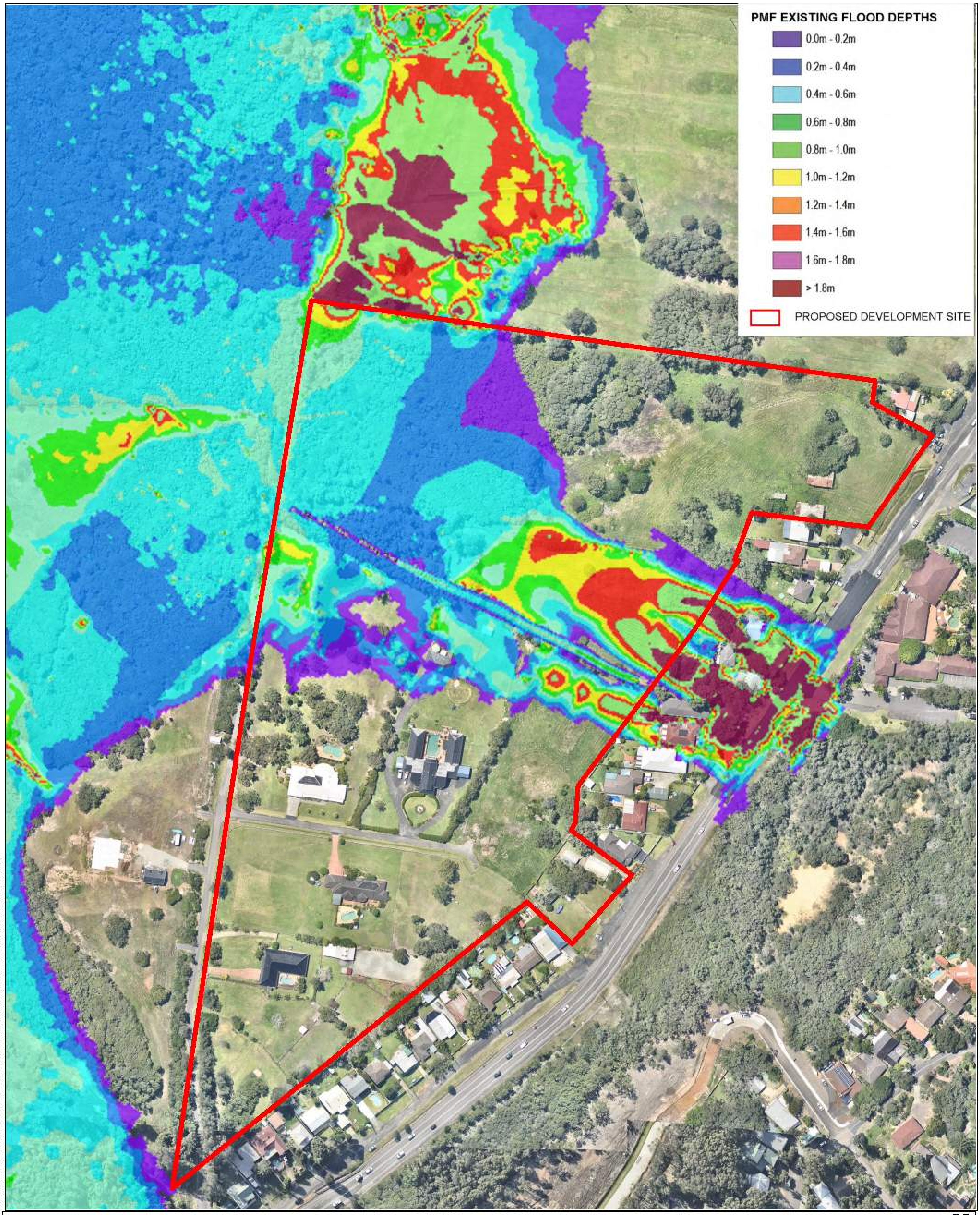

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Verified: SJB	Date: 13/04/2021
Approved: SJB	Date: 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF MAXIMUM FLOOD VELOCITIES
EXISTING CONDITIONS
100% BLOCKAGE**

Status: PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
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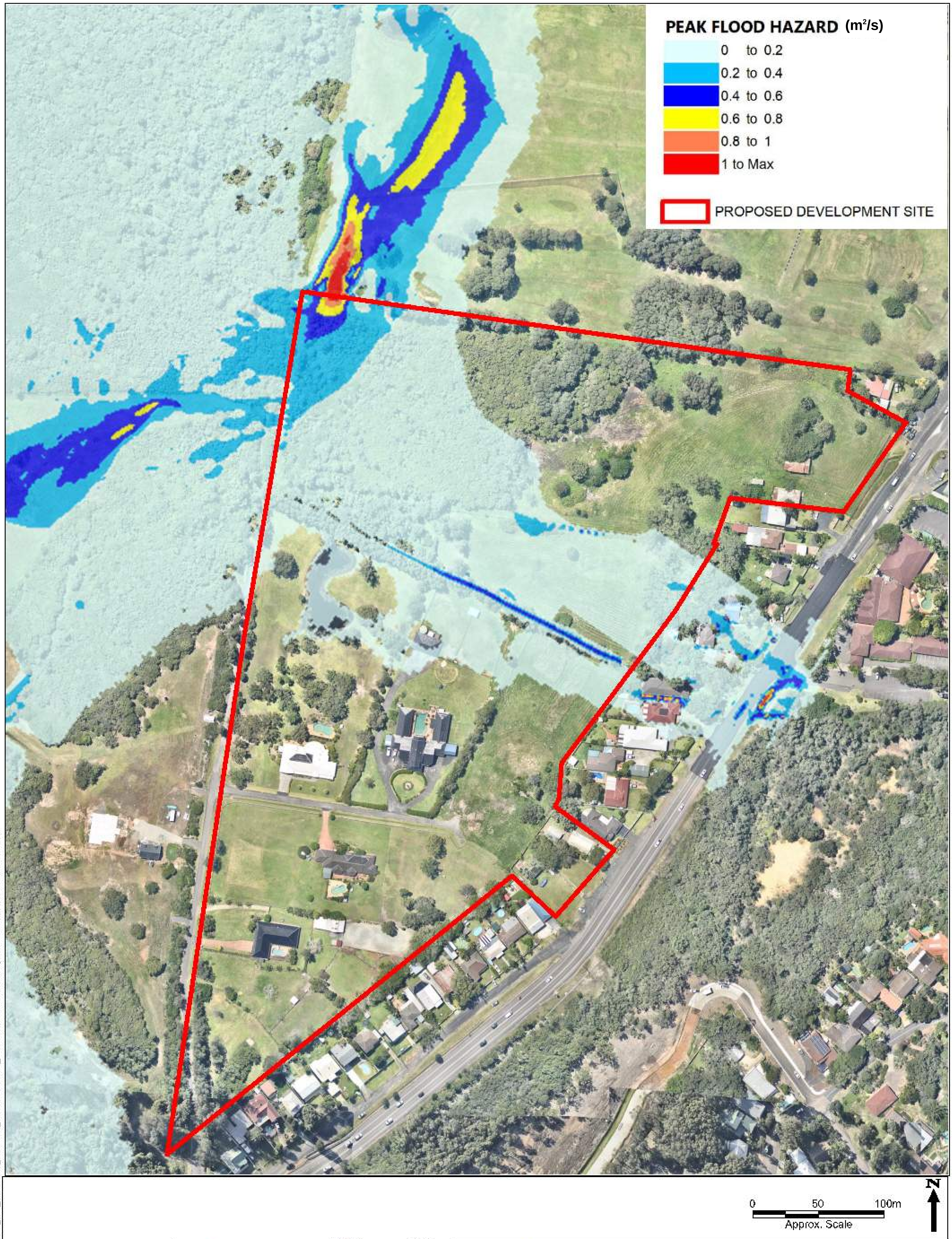

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Verified SJB	Date 13/04/2021
Approved SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

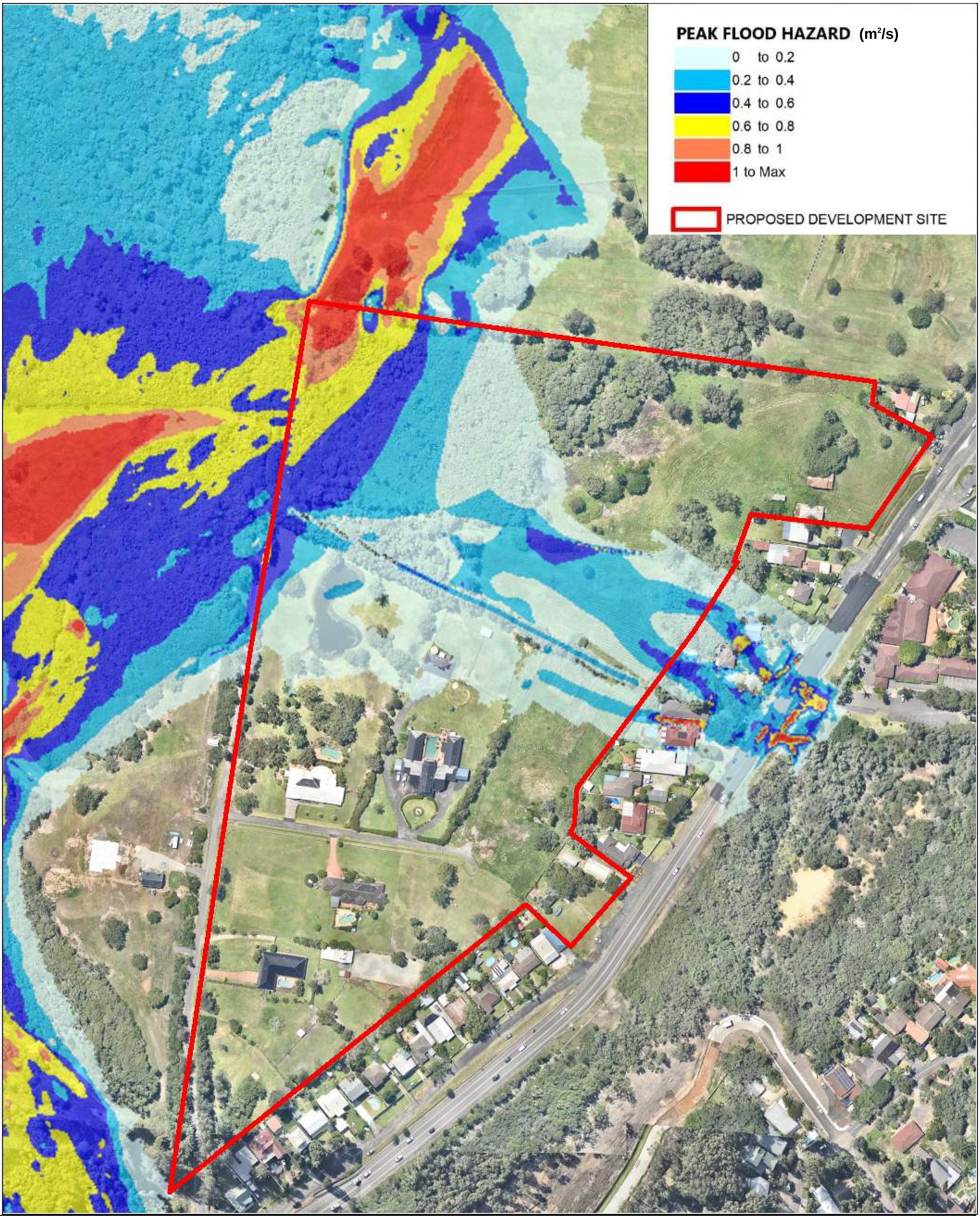
Title: **100 ARI MAXIMUM FLOOD HAZARD (VXD)**
EXISTING CONDITIONS
50% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
A14	D

Filepath: N:\Projects\806\FY14000_090_Architects_Planners_Developers\C3_Forresters Beach Planning - ST2\Des-An\Civil\MapInfo\WOR



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	Date
Drawn YL	13/04/2021
Checked SY	13/04/2021
Designed JY/SY	13/04/2021
Verified SJB	13/04/2021
Approved SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF MAXIMUM FLOOD HAZARD (V X D)**
EXISTING CONDITIONS
100% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
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Drawing Number A15
Revision D

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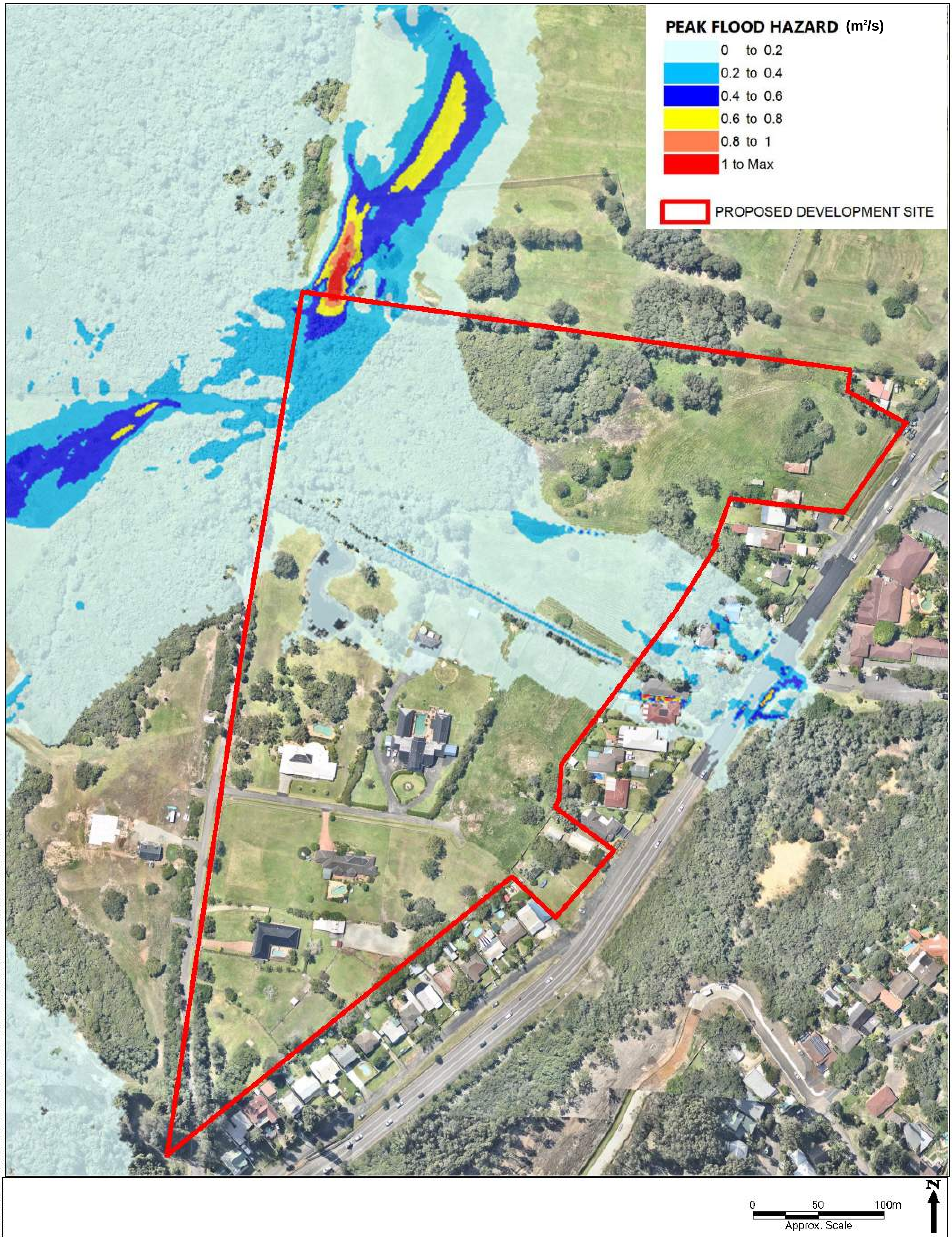

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Verified SJB	Date 13/04/2021
Approved SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Status PRELIMINARY
Not to be used for construction purposes

Title: **100 ARI MAXIMUM FLOOD HAZARD (VXD)**
EXISTING CONDITIONS
100% BLOCKAGE

Datum	Scale	Size
AHD	1 25	A3

Drawing Number	Revision
A16	D

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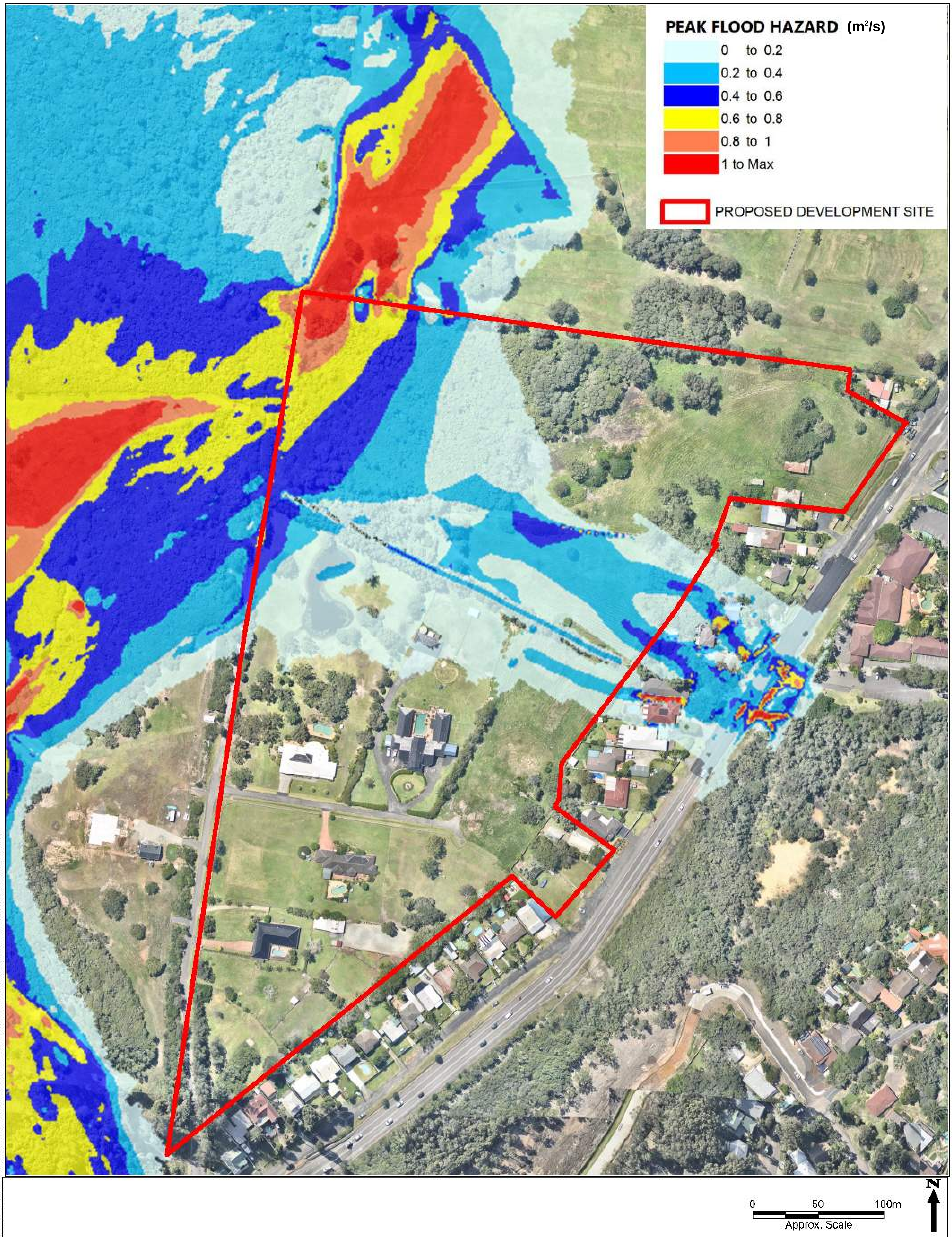

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	Date
Drawn YL	13/04/2021
Checked SY	13/04/2021
Designed JY/SY	13/04/2021
Verified SJB	13/04/2021
Approved SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF MAXIMUM FLOOD HAZARD (VXD)**
EXISTING CONDITIONS
100% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

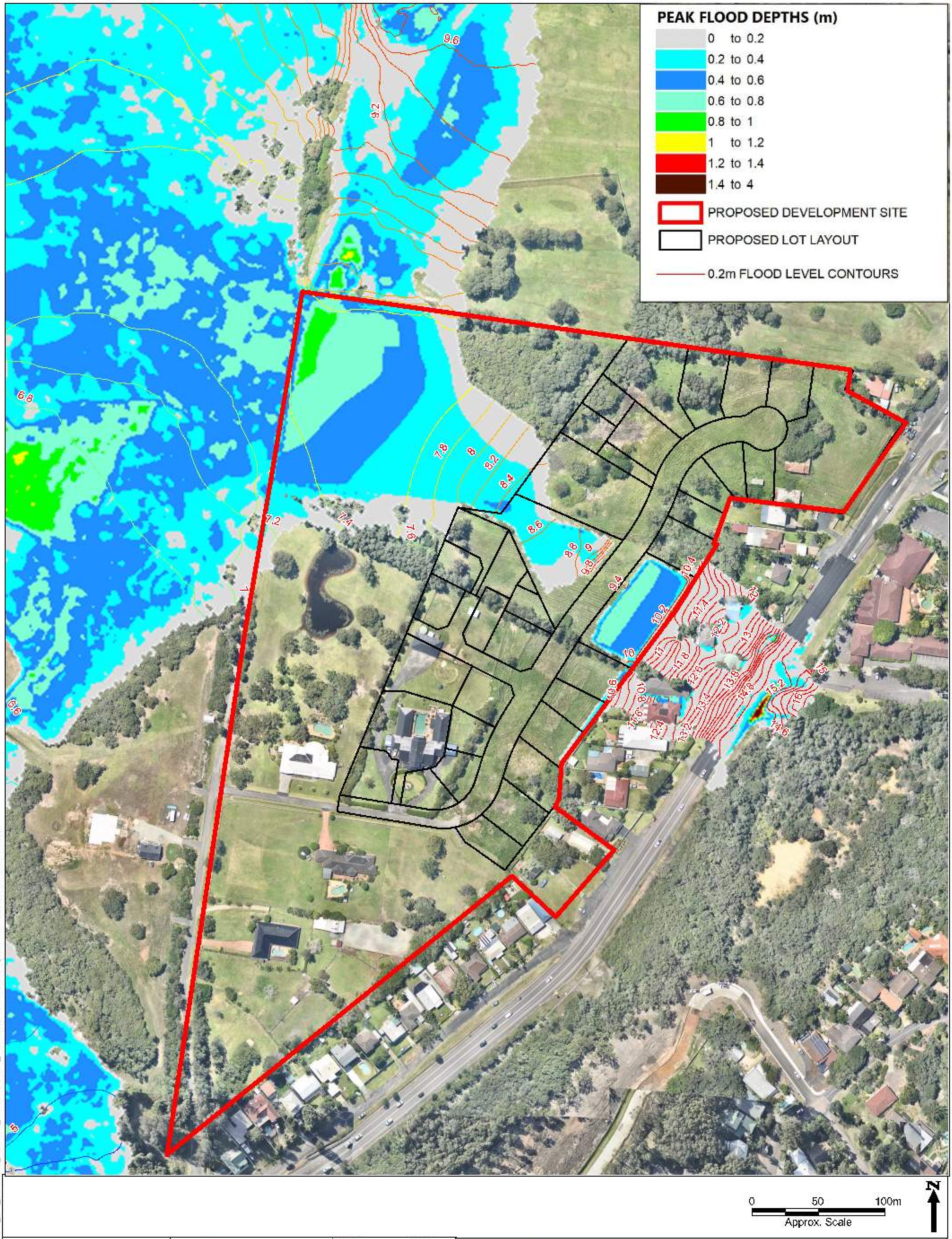
Drawing Number	Revision
A17	D

Filepath: N:\Projects\806\FY14000_090_Architects_Planners_Developers\C3_Forresters Beach Planning - ST2\Des-An\Civil\MapInfo\WOR

APPENDIX

C

PROPOSED DEVELOPMENT FLOOD MAPS



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Drawn: YL	Date: 13/04/2021
Checked: SY	Date: 13/04/2021
Designed: JY/SY	Date: 13/04/2021
Verified: SJB	Date: 13/04/2021
Approved: SJB	Date: 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **100 YEAR ARI MAXIMUM FLOOD DEPTHS**
PROPOSED CONDITIONS
50% BLOCKAGE

Status: PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
D01	D

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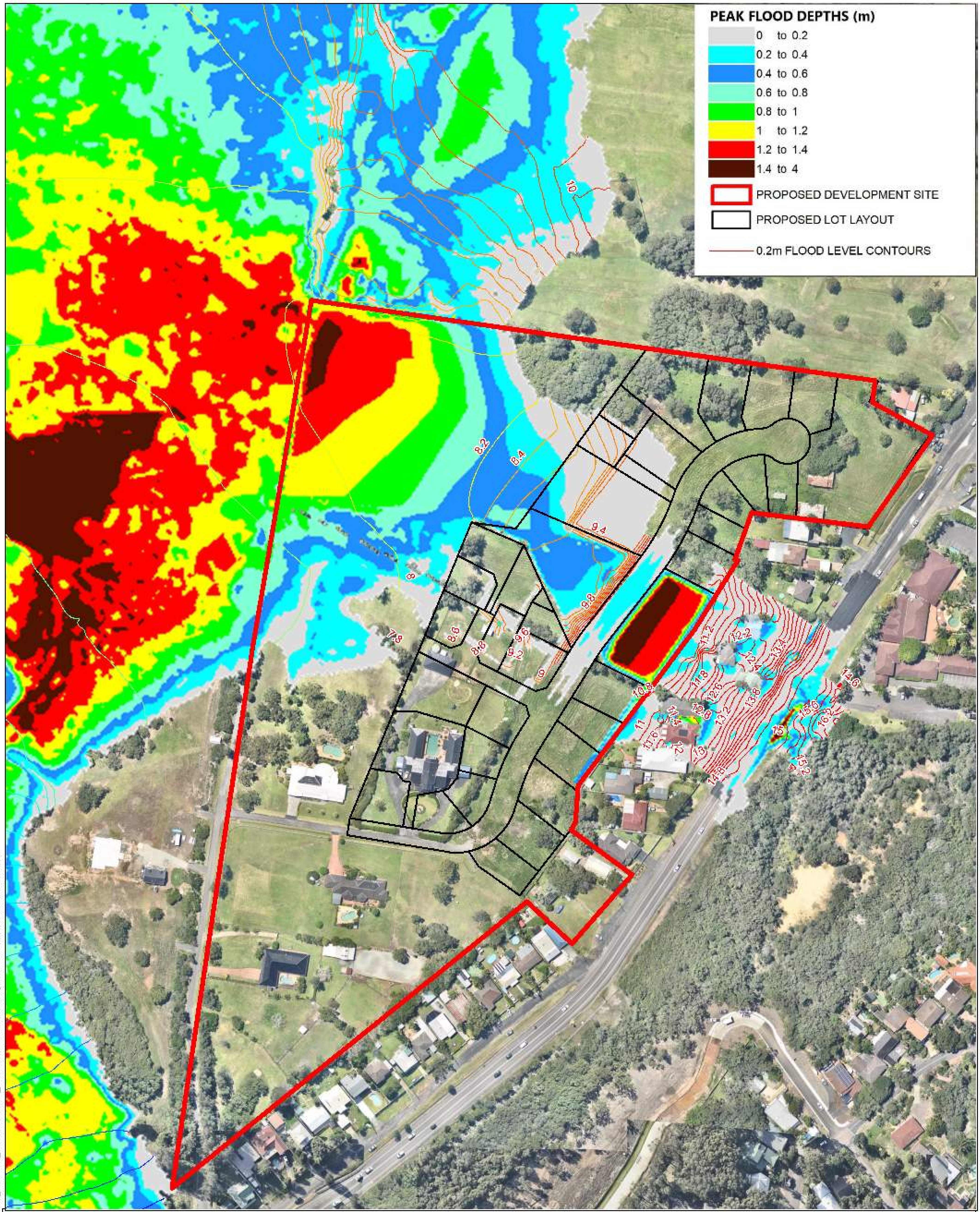

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Checked SY	Date 13/04/2021	Project: FLOOD STUDY FORRESTERS BEACH PLANNING	Status PRELIMINARY Not to be used for construction purposes
Designed JY/SY	Date 13/04/2021	Title: PMF MAXIMUM FLOOD DEPTHS PROPOSED CONDITIONS 50% BLOCKAGE	Datum AHD · Scale 1:25 · Size A3
Verified SJB	Date 13/04/2021		Drawing Number D02 · Revision D
Approved SJB	Date 13/04/2021		

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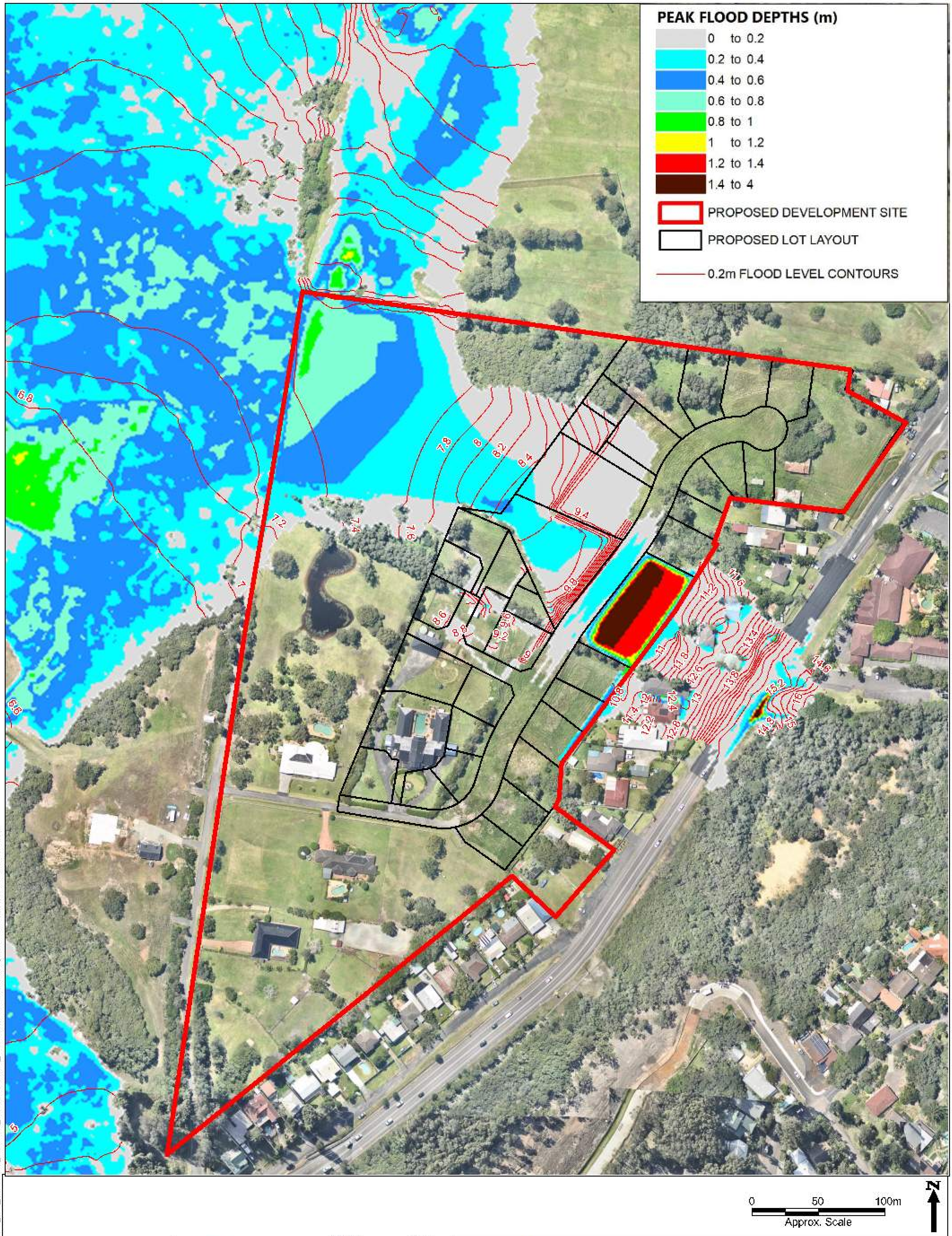

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YL	13/04/2021
Checked	Date
SY	13/04/2021
Designed	Date
JY/SY	13/04/2021
Verified	Date
SJB	13/04/2021
Approved	Date
SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **100 YEAR ARI MAXIMUM FLOOD DEPTHS**
PROPOSED CONDITIONS
100% BLOCKAGE

Status: PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
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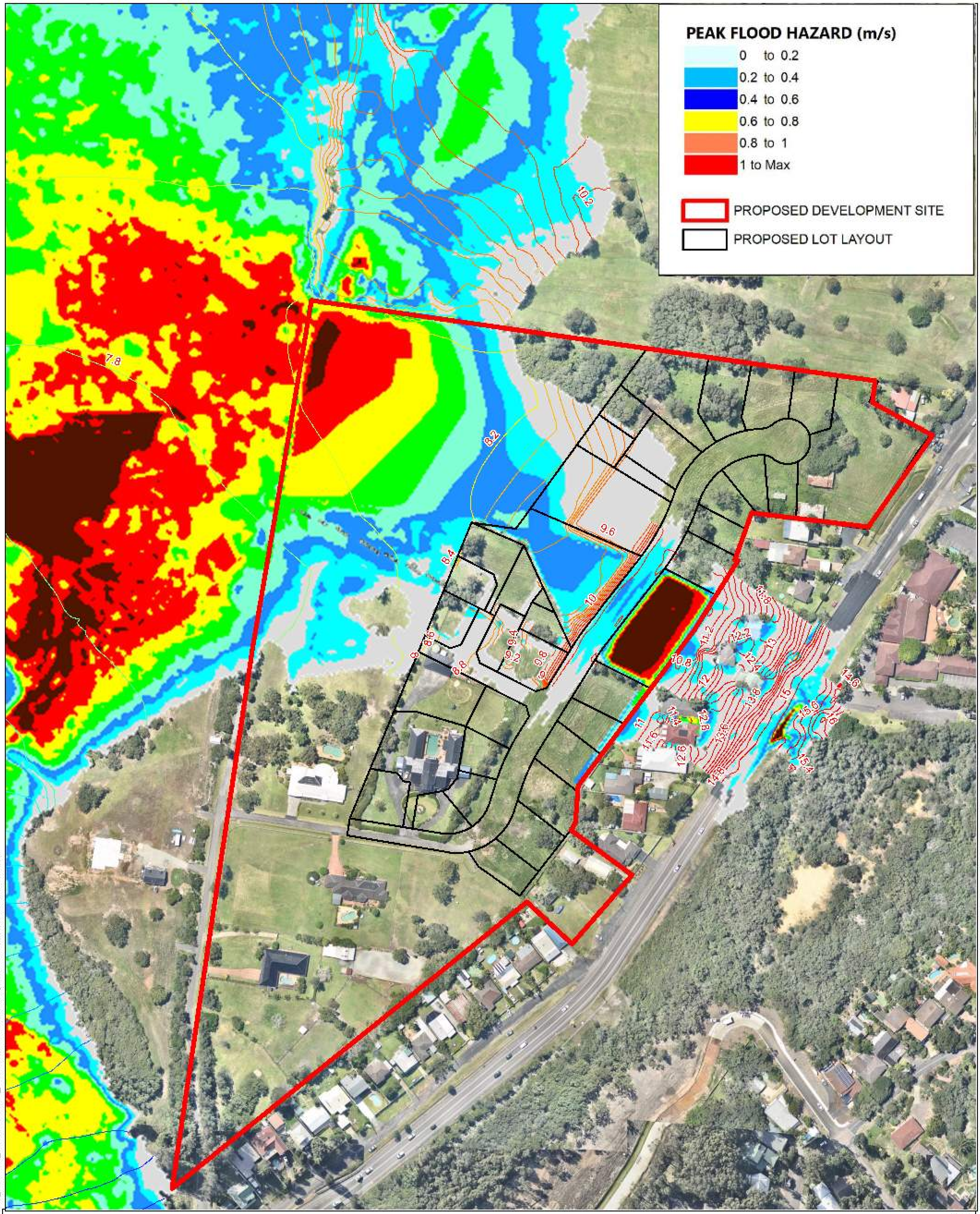

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Approx. Scale
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Drawn: YL	Date: 13/04/2021
Checked: SY	Date: 13/04/2021
Designed: JY/SY	Date: 13/04/2021
Verified: SJB	Date: 13/04/2021
Approved: SJB	Date: 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: PMF MAXIMUM FLOOD DEPTHS
PROPOSED CONDITIONS
100% BLOCKAGE

Status: PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
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Drawing Number	Revision
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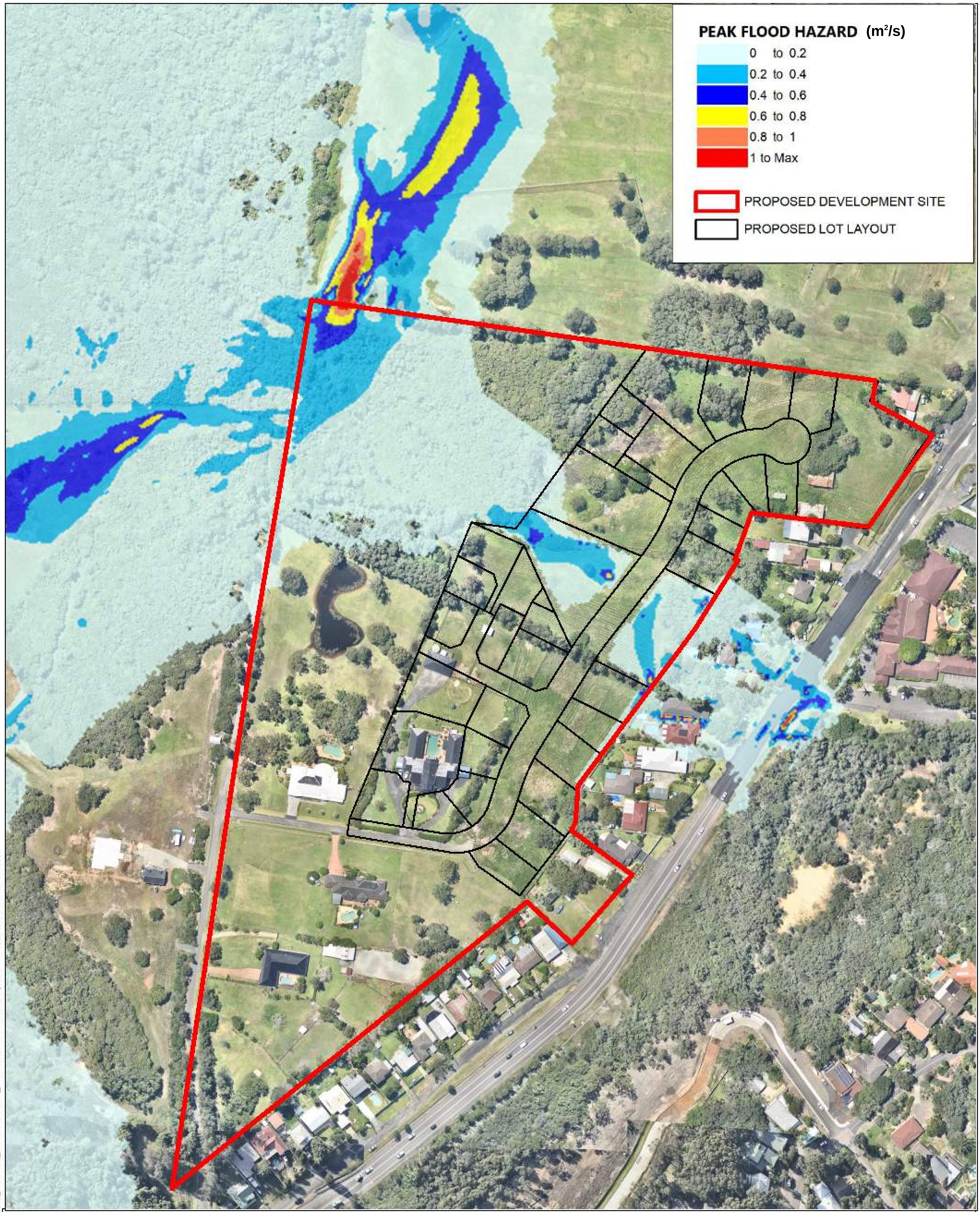

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Drawn YL	Date 13/04/2021
Checked SY	Date 13/04/2021
Designed JY/SY	Date 13/04/2021
Verified SJB	Date 13/04/2021
Approved SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **100 YEAR ARI MAXIMUM FLOOD HAZARD**
PROPOSED CONDITIONS
50% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
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Drawing Number D05 | Revision D

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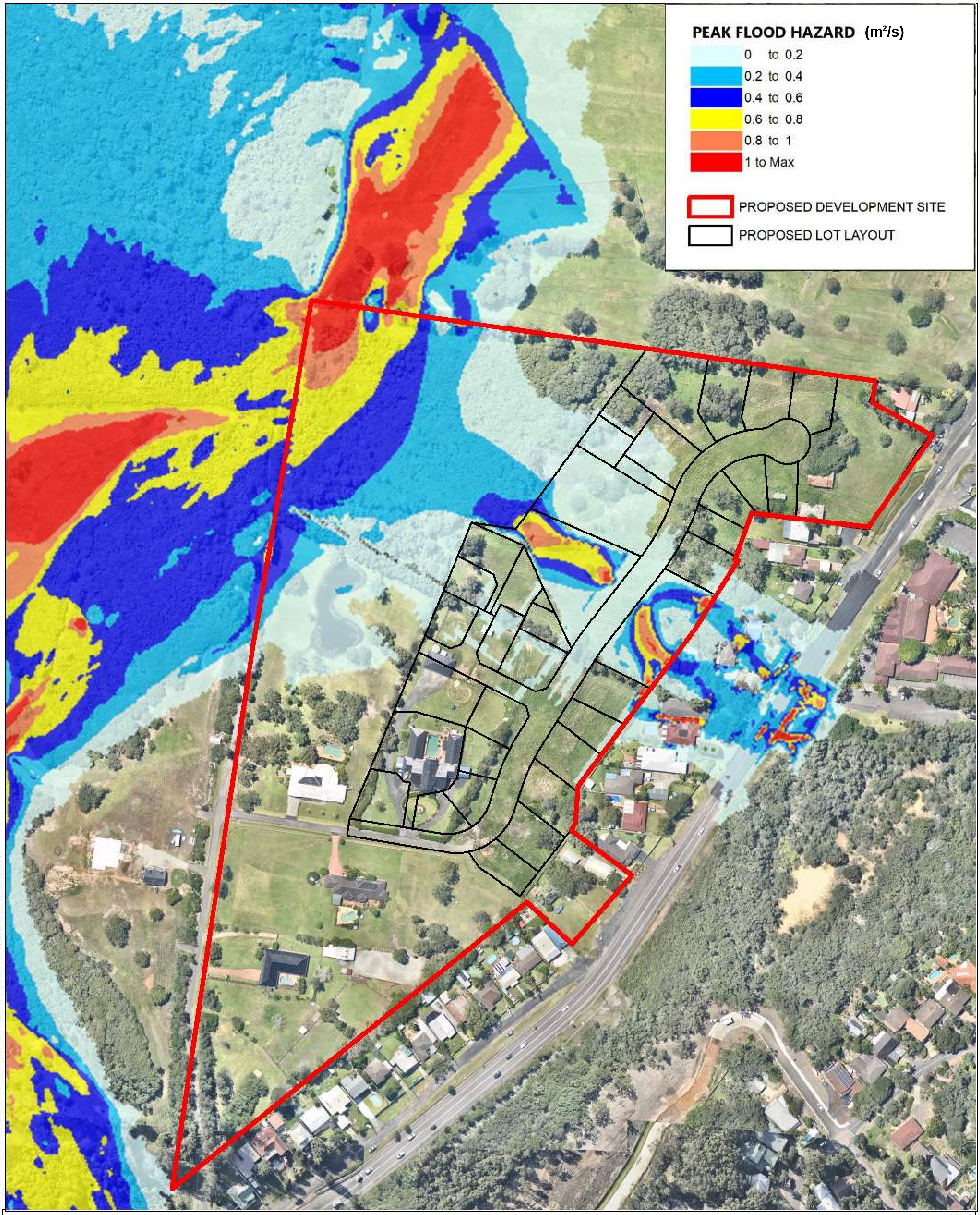

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Drawn YL	13/04/2021
Checked SY	13/04/2021
Designed JY/SY	13/04/2021
Verified SJB	13/04/2021
Approved SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF MAXIMUM FLOOD HAZARD (V X D)**
PROPOSED CONDITIONS
50% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number D06
Revision D

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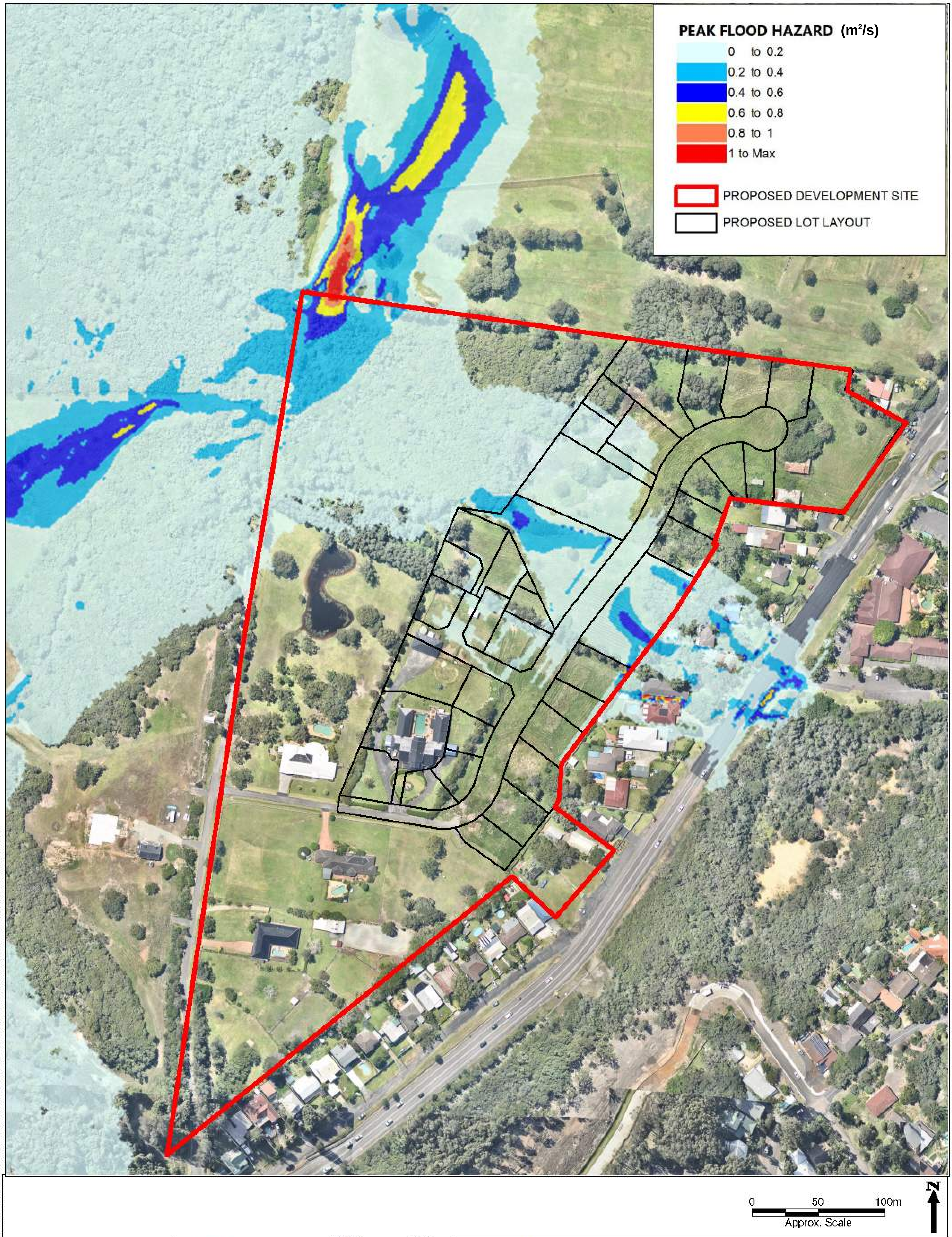

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Drawn	Date
YL	13/04/2021
Checked	Date
SY	13/04/2021
Designed	Date
JY/SY	13/04/2021
Verified	Date
SJB	13/04/2021
Approved	Date
SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: 100 YEAR ARI MAXIMUM FLOOD HAZARD
PROPOSED CONDITIONS
100% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
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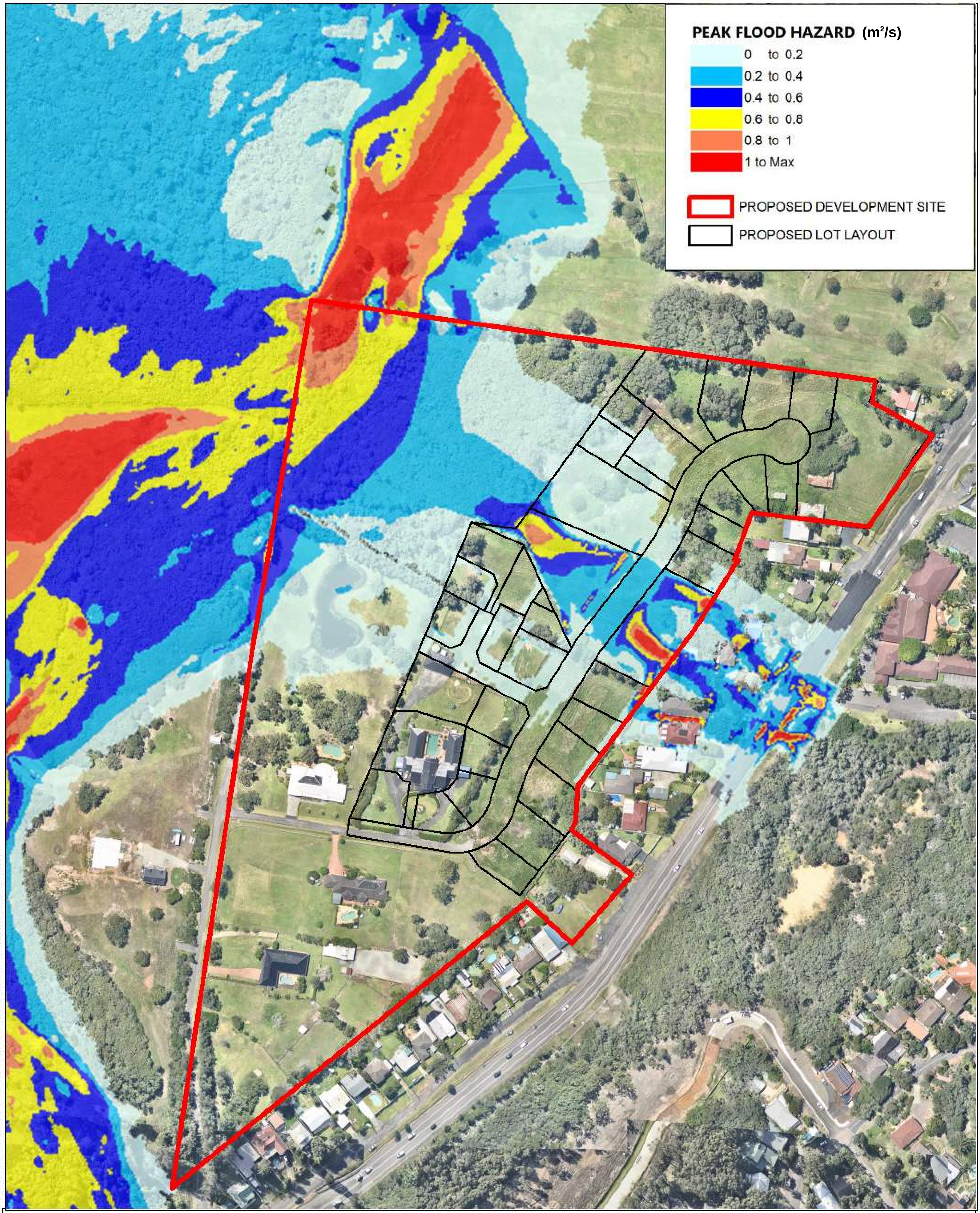

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Drawn	YL	13/04/2021
Checked	SY	13/04/2021
Designed	JY/SY	13/04/2021
Verified	SJB	13/04/2021
Approved	SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: PMF MAXIMUM FLOOD HAZARD (V X D)
PROPOSED CONDITIONS
100% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number: D08
Revision: D

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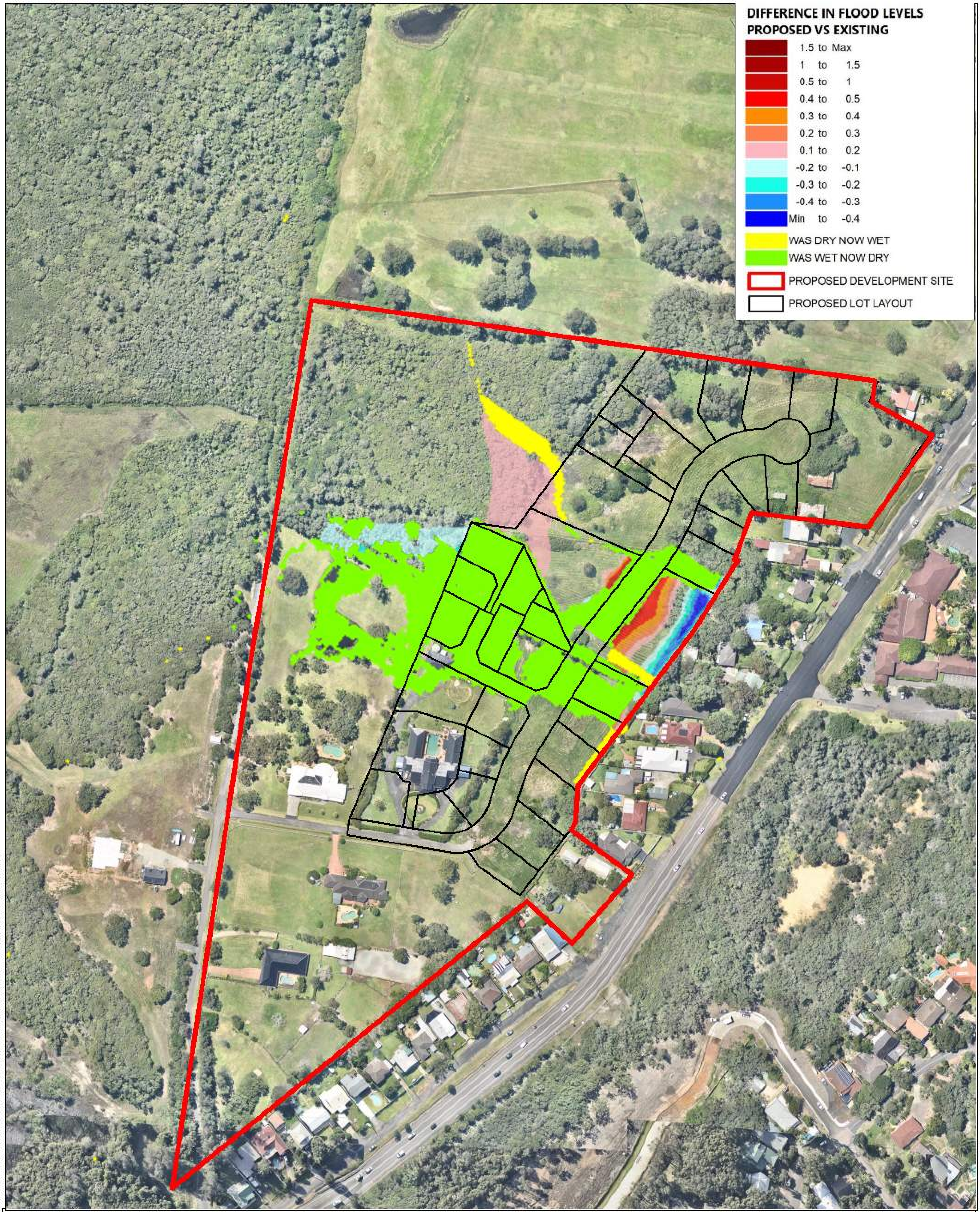

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		Date
Drawn	YL	13/04/2021
Checked	SY	13/04/2021
Designed	JY/SY	13/04/2021
Verified	SJB	13/04/2021
Approved	SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: 100 YEAR ARI DIFFERENCE IN FLOOD LEVELS
PROPOSED VS EXISTING
50% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number: D09
Revision: D

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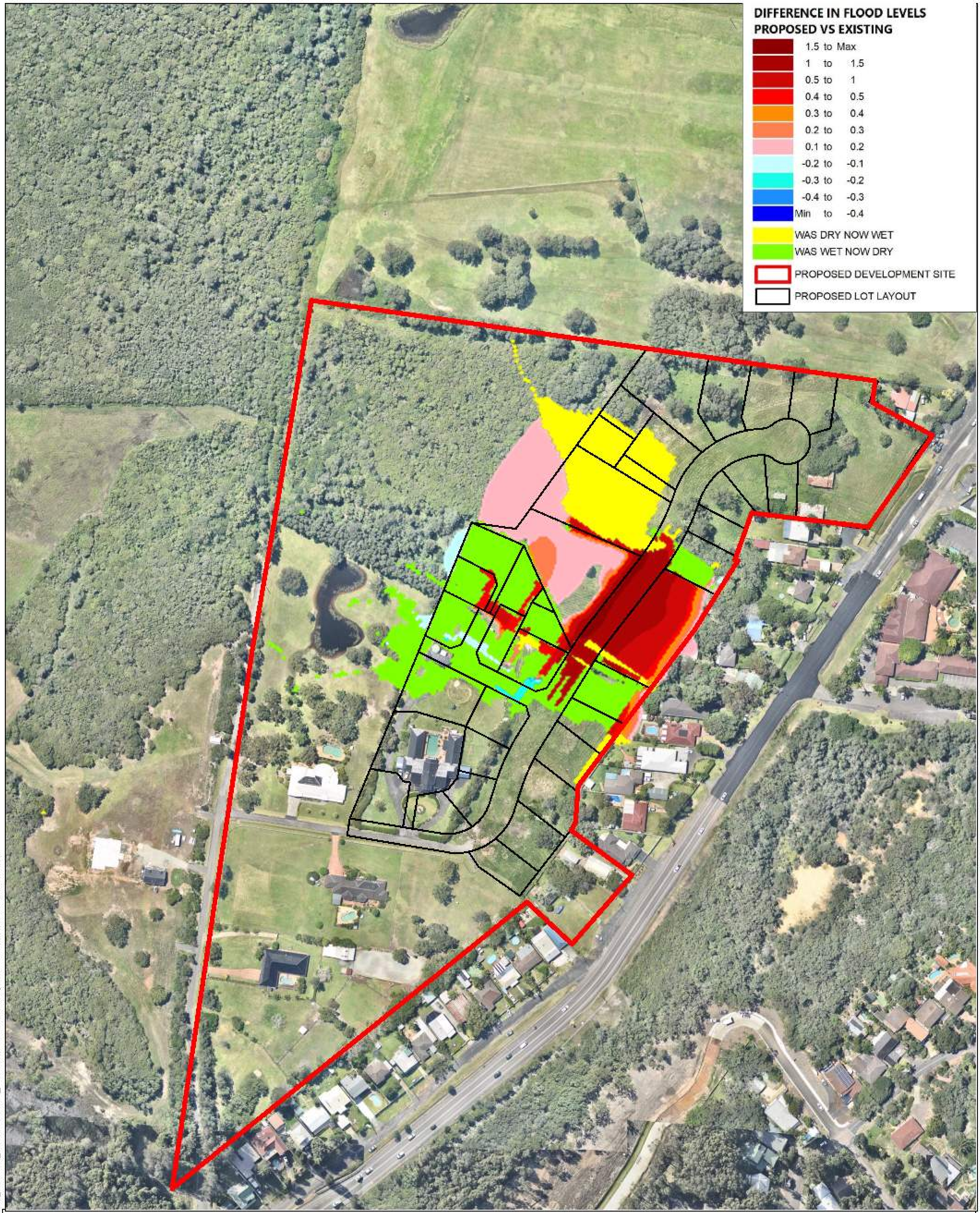

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Drawn YL	Date 13/04/2021
Checked SY	Date 13/04/2021
Designed JY/SY	Date 13/04/2021
Verified SJB	Date 13/04/2021
Approved SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF DIFFERENCE IN FLOOD LEVELS PROPOSED VS EXISTING 50% BLOCKAGE**

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
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Drawing Number	Revision
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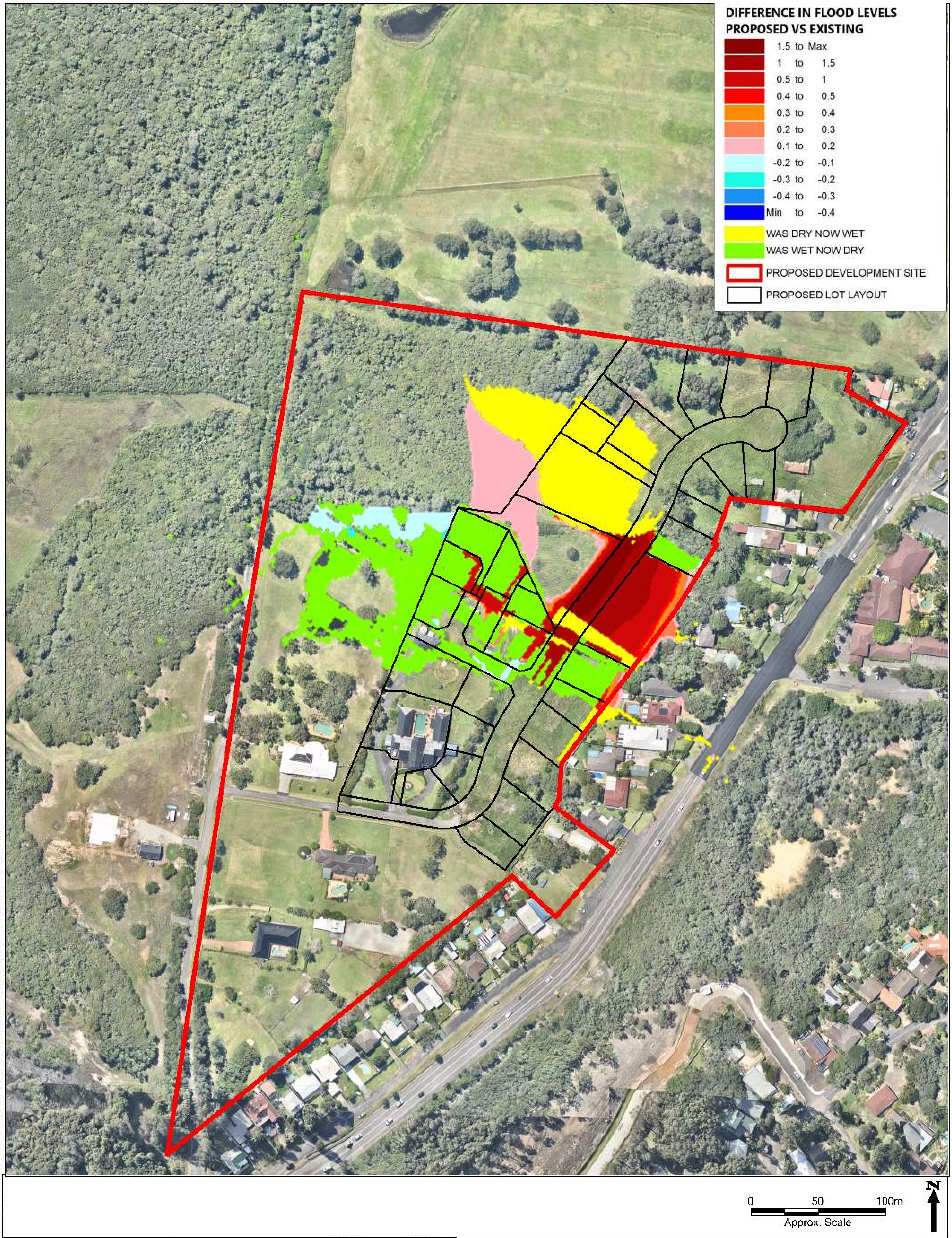

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Drawn YL	Date 13/04/2021
Checked SY	Date 13/04/2021
Designed JY/SY	Date 13/04/2021
Verified SJB	Date 13/04/2021
Approved SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

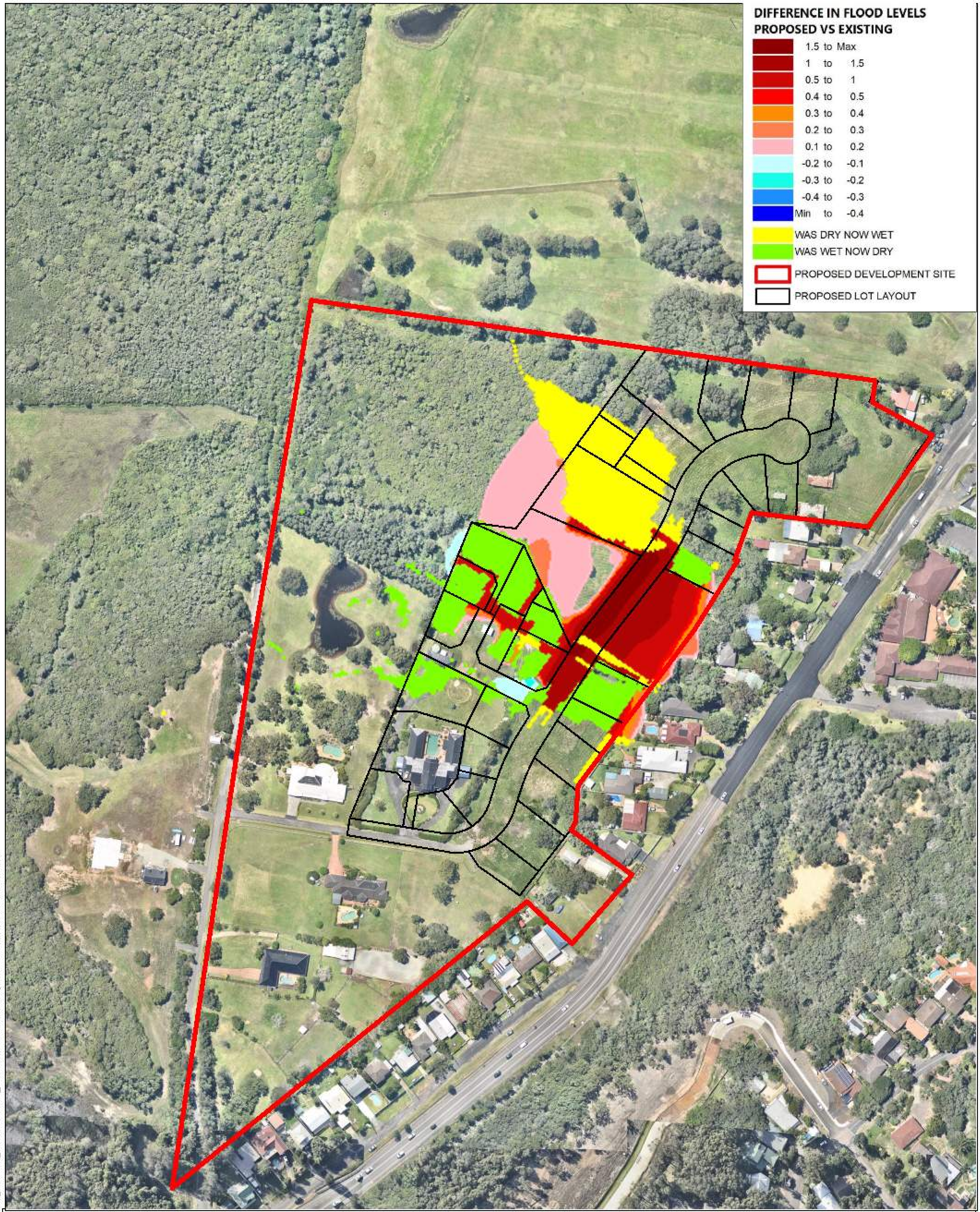
Title: 100 YEAR ARI DIFFERENCE IN FLOOD LEVELS
PROPOSED VS EXISTING
100% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number D11
Revision D

Filepath: N:\Projects\806\FY14\000_089_Architects_Planners_Developers\C13_Forresters Beach Planning - ST2\Des-An\Civil\MapInfo\WOR



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Approx. Scale

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	Date
Drawn YL	13/04/2021
Checked SY	13/04/2021
Designed JY/SY	13/04/2021
Verified SJB	13/04/2021
Approved SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

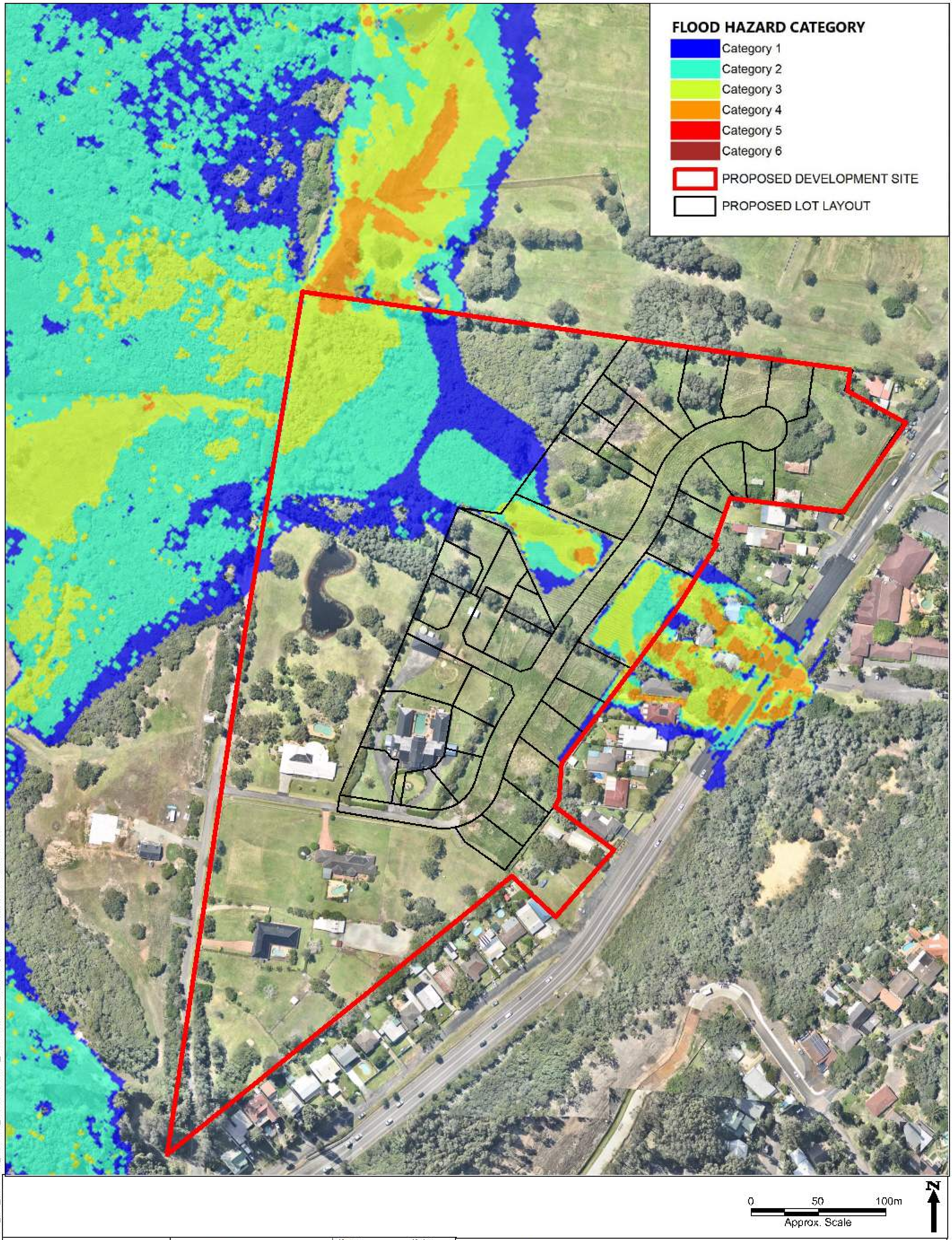
Title: **PMF DIFFERENCE IN FLOOD LEVELS
PROPOSED VS EXISTING
100% BLOCKAGE**

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number D12
Revision D

Filepath: N:\Projects\806\FY14\000_030_Architects_Planners_Developers\C3_Forresters Beach Planning - ST2\Des-An\Civil\MapInfo\WOR



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	Date
Drawn YL	13/04/2021
Checked SY	13/04/2021
Designed JY/SY	13/04/2021
Verified SJB	13/04/2021
Approved SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **100 YEAR ARI FLOOD HAZARD CATEGORIES
PROPOSED CONDITIONS
50% BLOCKAGE**

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
D13	D

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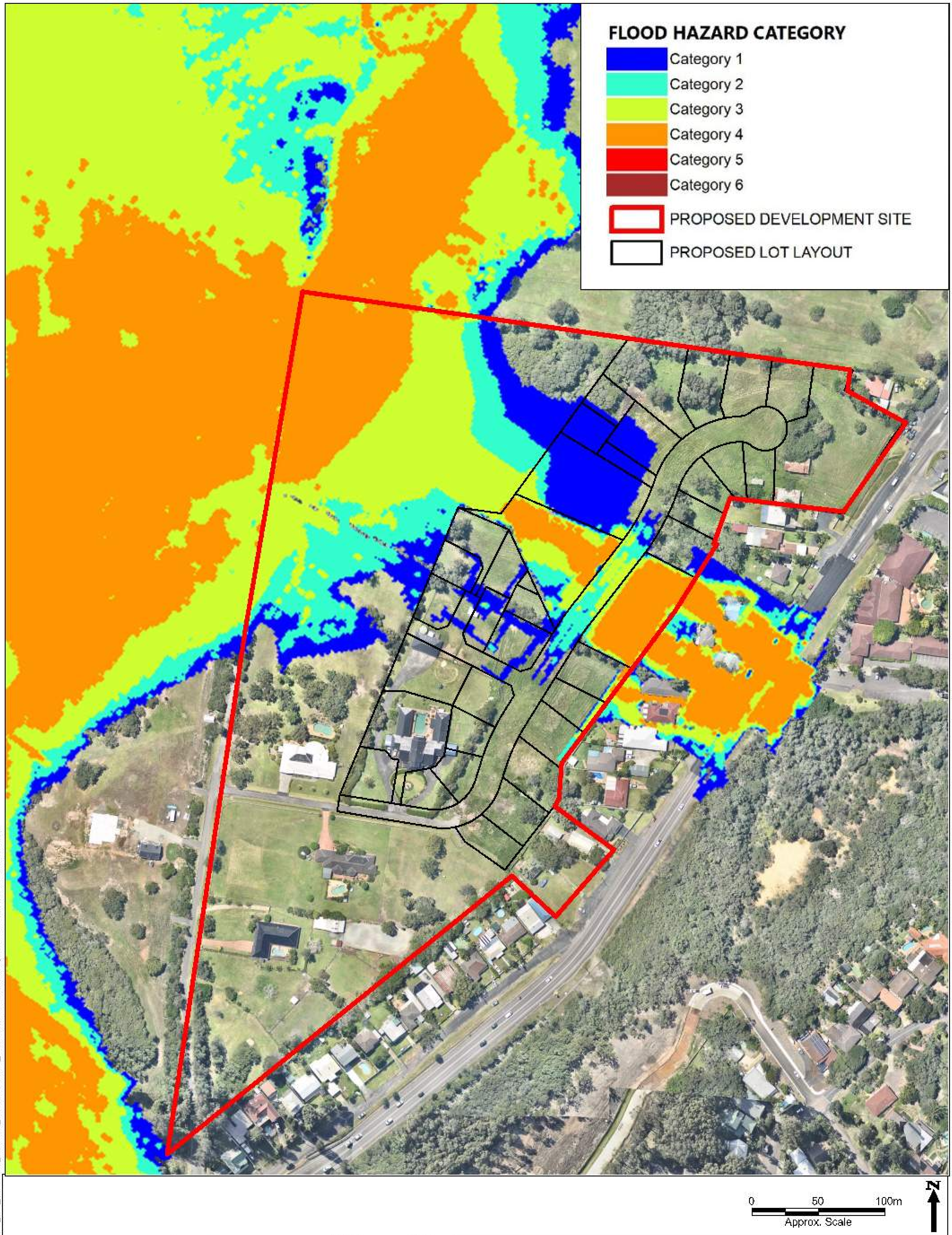

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Checked: SY	Date: 13/04/2021
Designed: JY/SY	Date: 13/04/2021
Verified: SJB	Date: 13/04/2021
Approved: SJB	Date: 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF FLOOD HAZARD CATEGORIES**
PROPOSED CONDITIONS
50% BLOCKAGE

Status: PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
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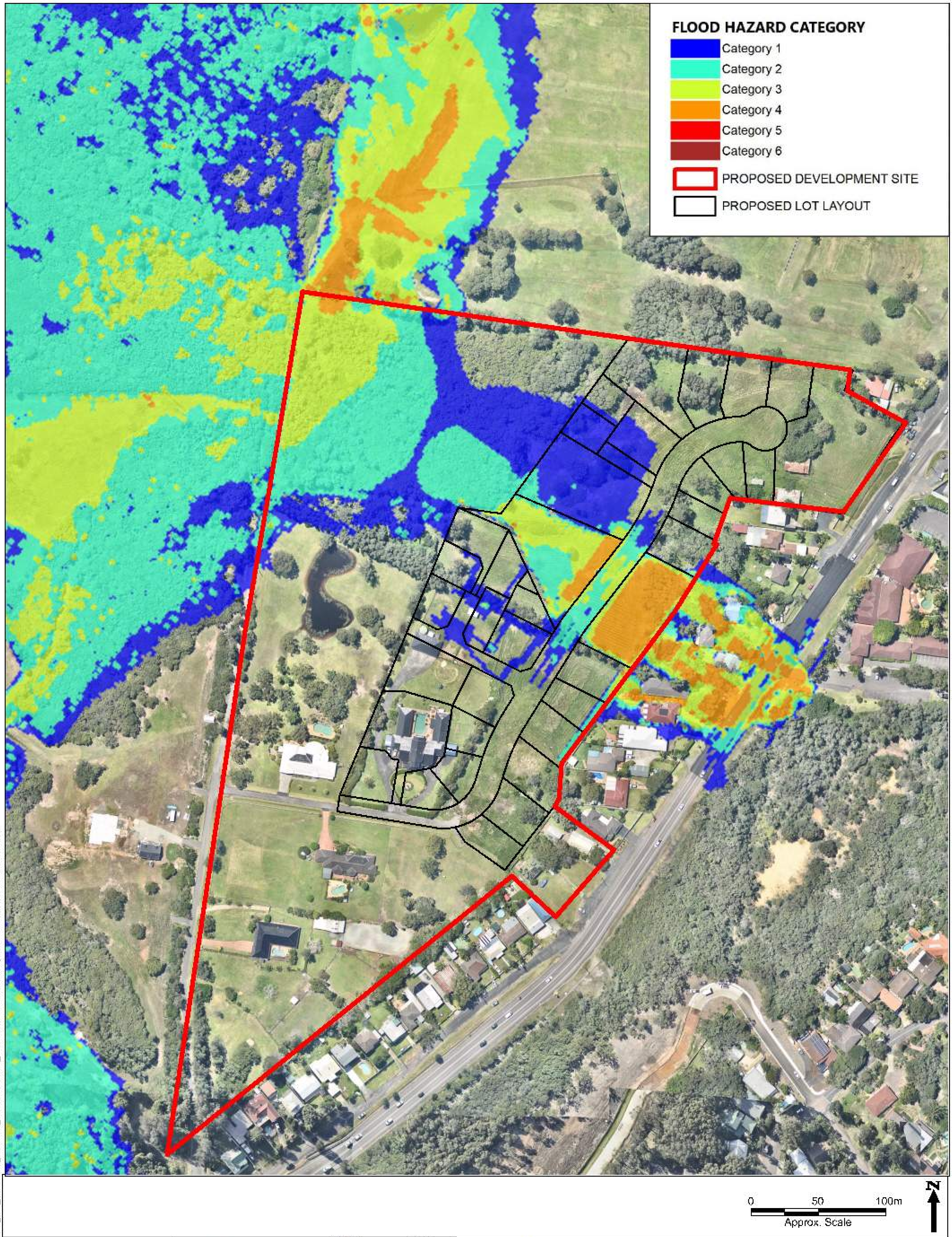

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Checked SY	Date 13/04/2021	Project: FLOOD STUDY FORRESTERS BEACH PLANNING
Designed JY/SY	Date 13/04/2021	Status PRELIMINARY Not to be used for construction purposes
Verified SJB	Date 13/04/2021	Datum AHD · Scale 1:25 · Size A3
Approved SJB	Date 13/04/2021	Title: 100 YEAR ARI FLOOD HAZARD CATEGORIES PROPOSED CONDITIONS 100% BLOCKAGE
		Drawing Number D15 · Revision D

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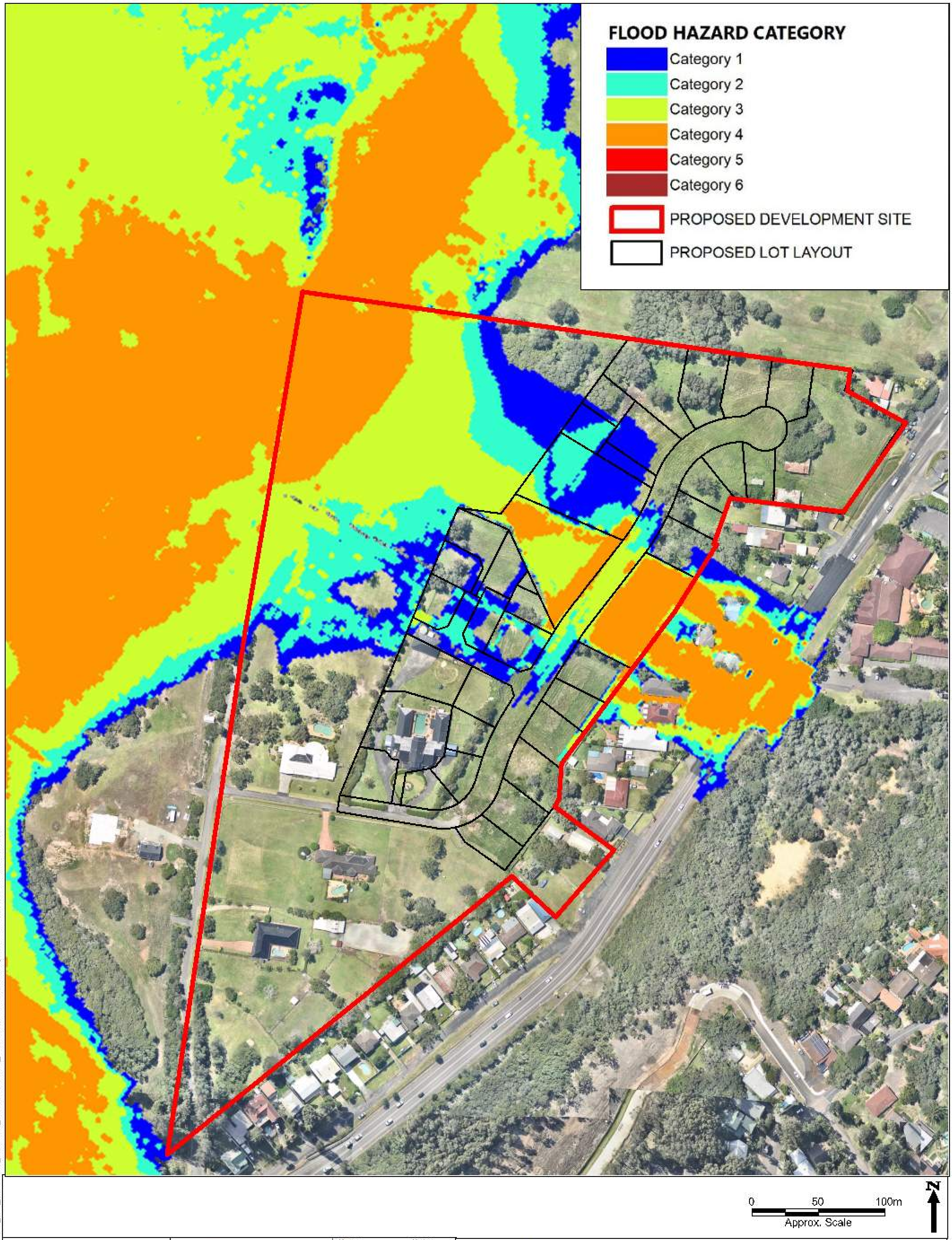

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Drawn	YL	13/04/2021
Checked	SY	13/04/2021
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Verified	SJB	13/04/2021
Approved	SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

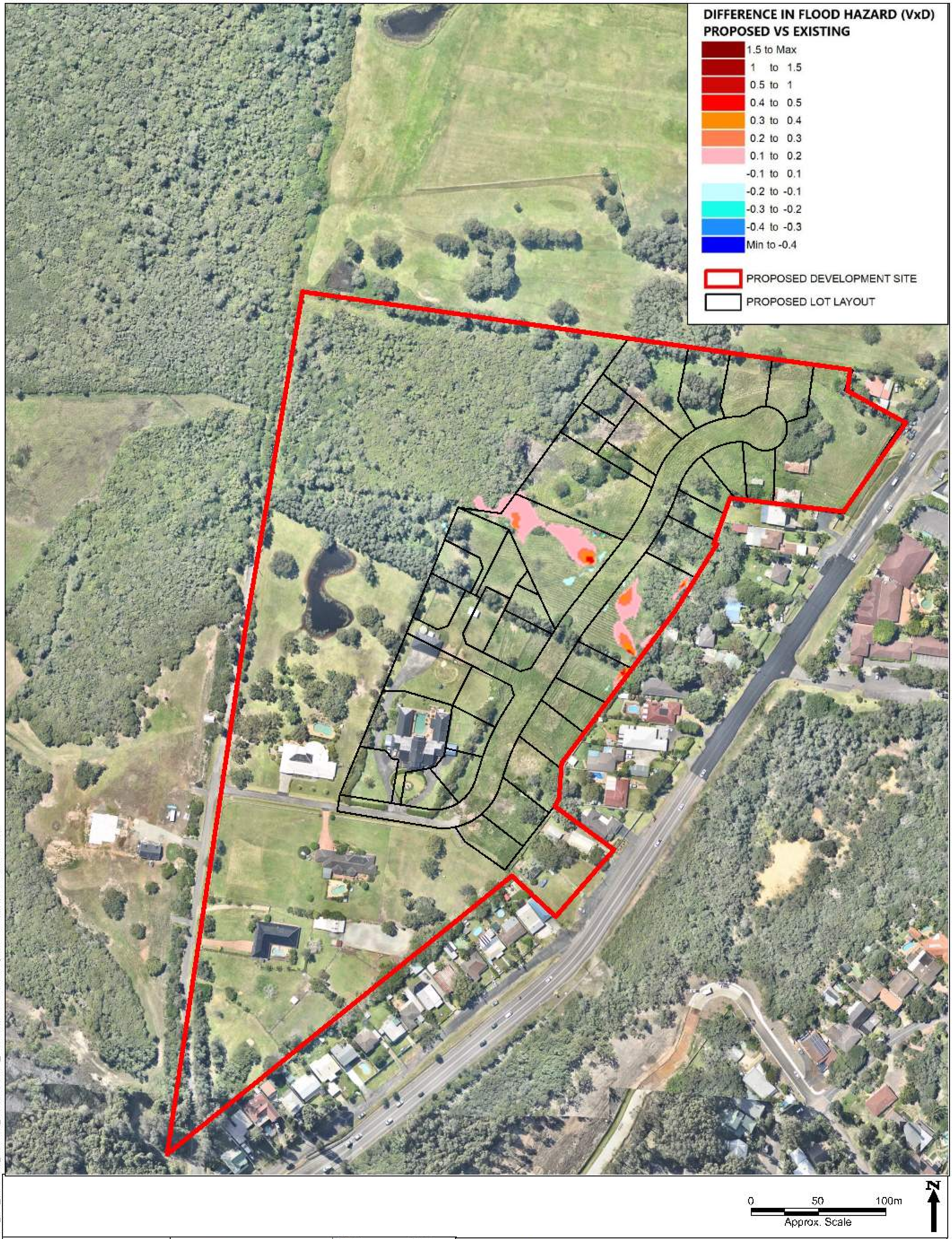
Title: **PMF FLOOD HAZARD CATEGORIES**
PROPOSED CONDITIONS
100% BLOCKAGE

Status: PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
D16	D

Filepath: N:\Projects\806\FY14000_090_Architects_Planners_Developers\C3_Forresters Beach Planning - ST2\Des-An\Civil\Mac\nfewWOR



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Verified	SJB	13/04/2021
Approved	SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

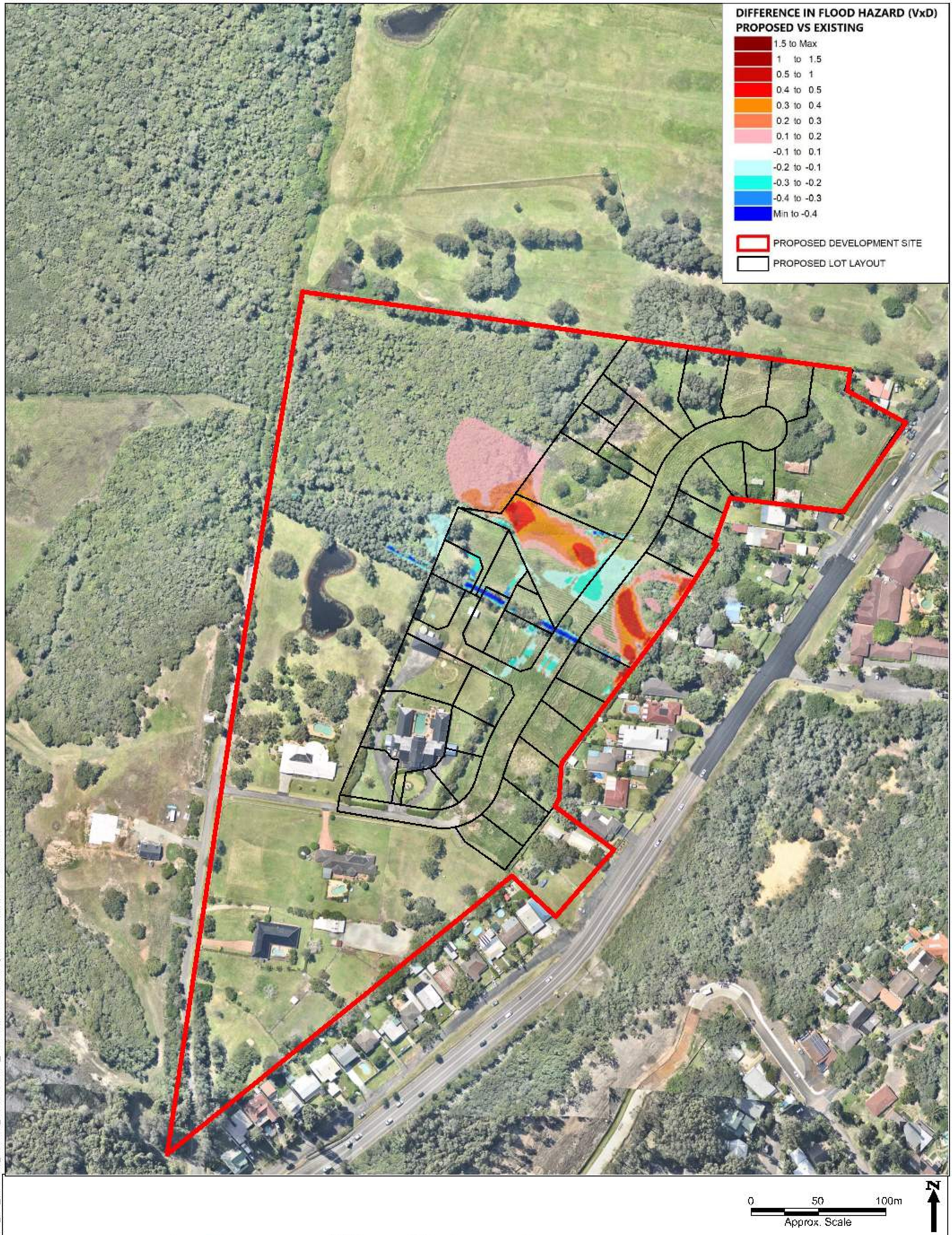
Title: **100 YEAR ARI DIFFERENCE IN FLOOD HAZARD (V X D)**
PROPOSED VS EXISTING
50% BLOCKAGE

Status: PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number: D17
Revision: D

Filepath: N:\Projects\8605\FY14000_030_Architects_Planners_Developers\03_Forresters Beach Planning - ST2\Des-An\Civil\MapInfo\WOR



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Approved SJB	Date 13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: PMF DIFFERENCE IN FLOOD HAZARD (V X D)
PROPOSED VS EXISTING
50% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

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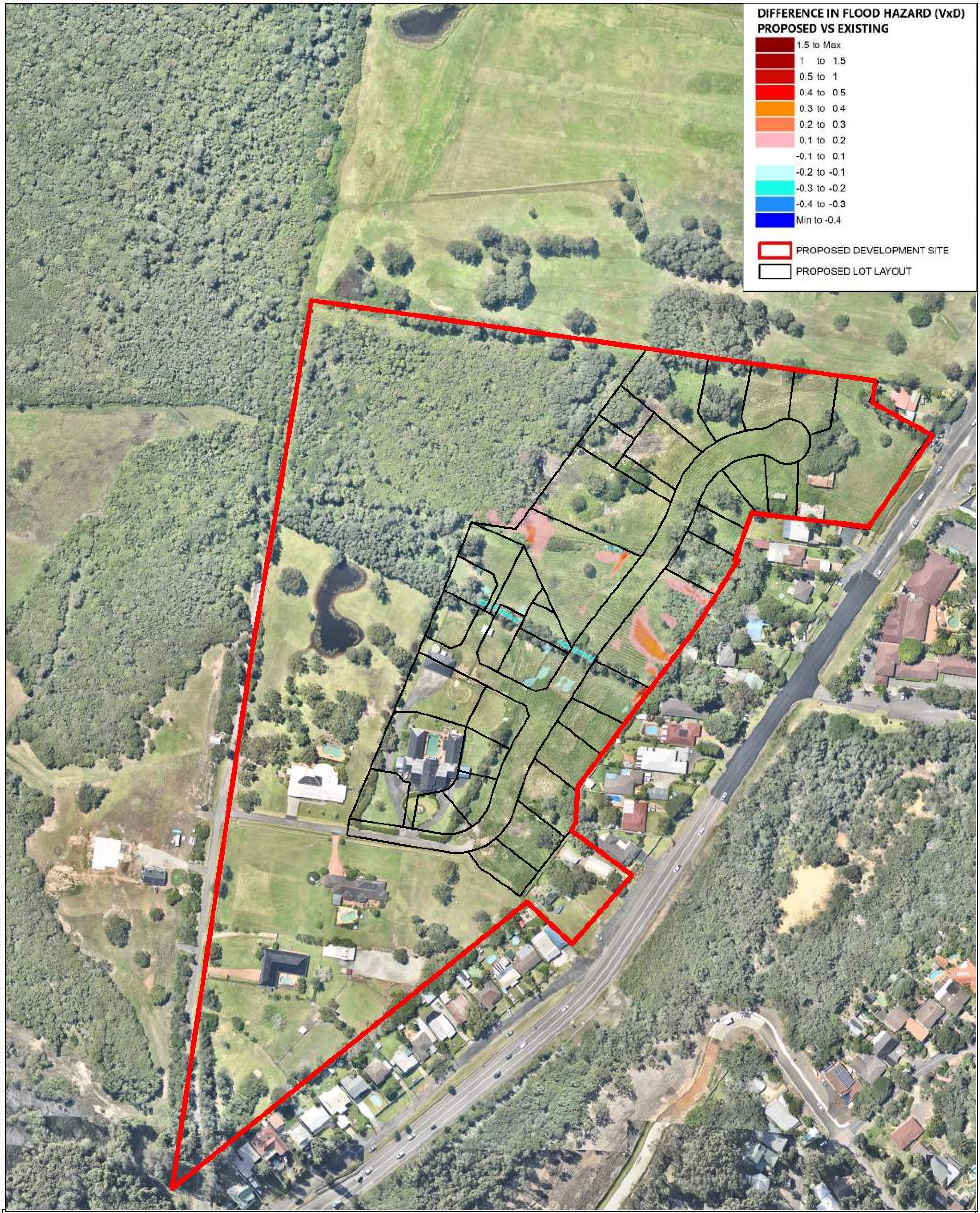

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Drawn YL	Date 13/04/2021	
Checked SY	Date 13/04/2021	
Designed JY/SY	Date 13/04/2021	
Verified SJB	Date 13/04/2021	
Approved SJB	Date 13/04/2021	

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

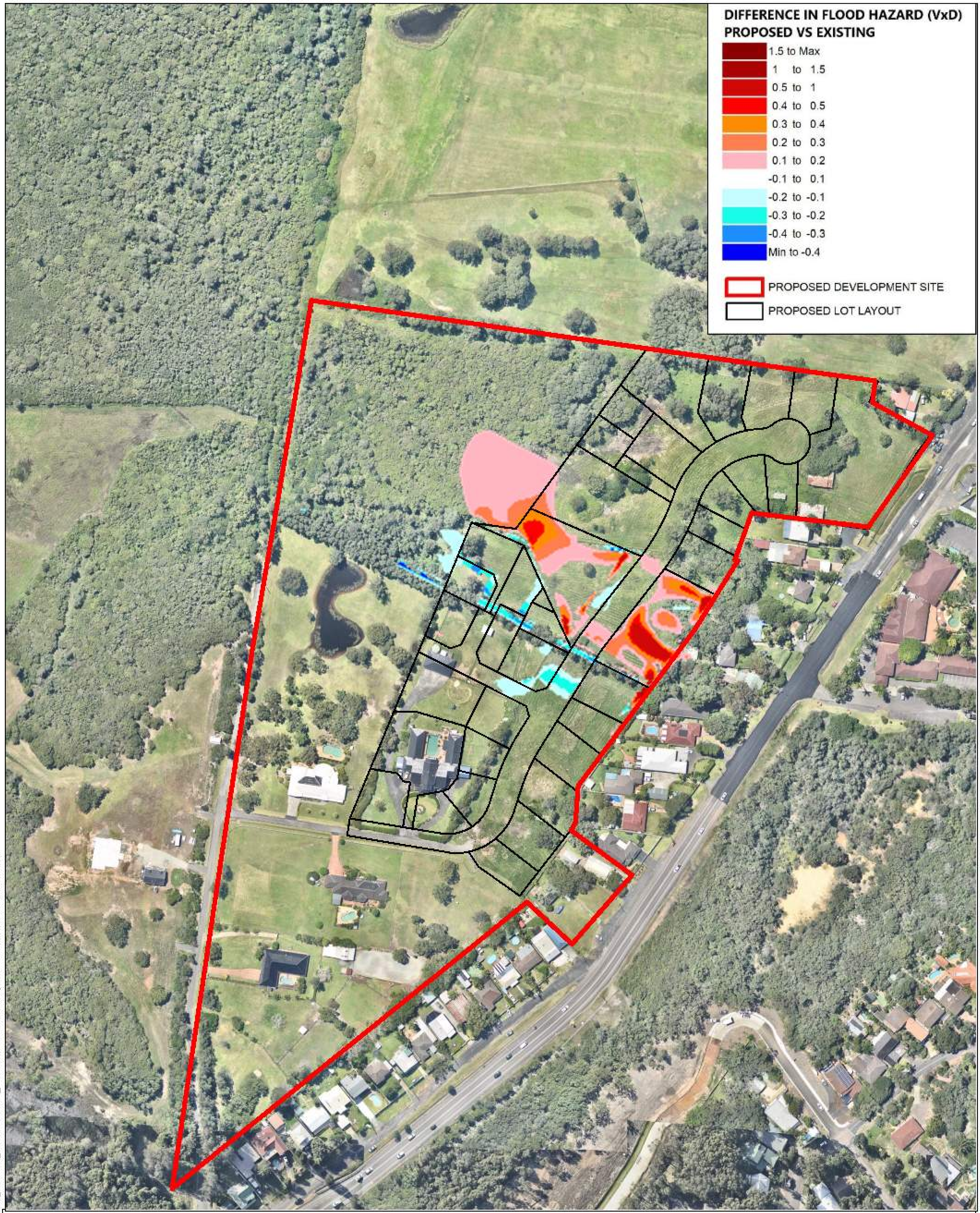
Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Title: 100 YEAR ARI DIFFERENCE IN FLOOD HAZARD (V X D)
PROPOSED VS EXISTING
100% BLOCKAGE

Drawing Number D19

Revision D



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Checked	SY	13/04/2021
Designed	JY/SY	13/04/2021
Verified	SJB	13/04/2021
Approved	SJB	13/04/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: PMF DIFFERENCE IN FLOOD HAZARD (V X D)
PROPOSED VS EXISTING
100% BLOCKAGE

Status: PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
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Drawing Number	Revision
D20	D

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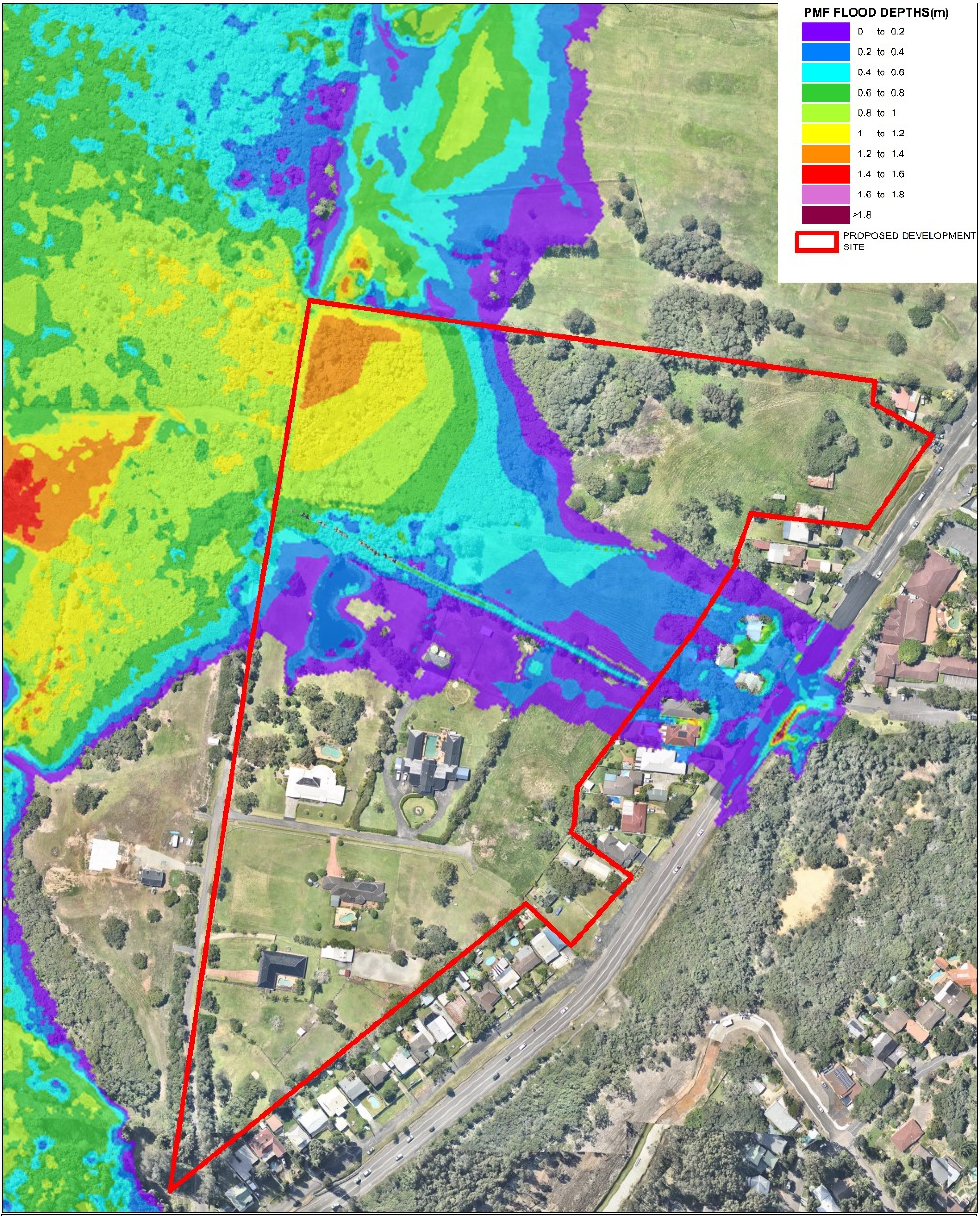
APPENDIX D

PMF DEPTH COMPARISONS



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Checked SY	Date 24/05/2021	Project: FLOOD STUDY FORRESTERS BEACH PLANNING	Status PRELIMINARY Not to be used for construction purposes	
Designed JY/SY	Date 24/05/2021		Datum AHD	Scale 1:25	Size A3
Verified SJB	Date 24/05/2021	Title: PMF DEPTH EXISTING CONDITIONS 50% BLOCKAGE	Drawing Number E1	Revision B
Approved SJB	Date 24/05/2021			

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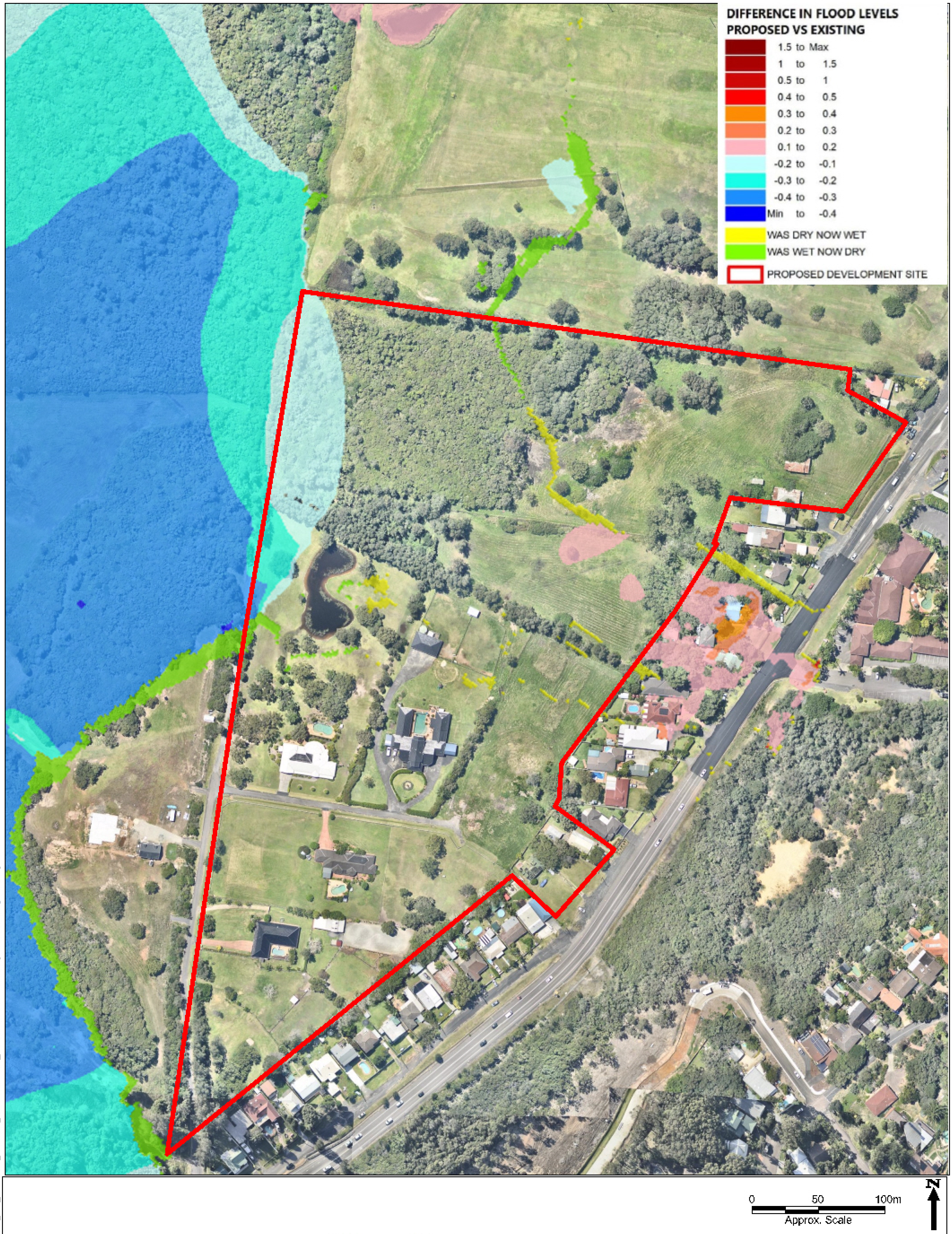

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SY	24/05/2021
Designed	Date
JY/SY	24/05/2021
Verified	Date
SJB	24/05/2021
Approved	Date
SJB	24/05/2021

Client: Tarrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF FLOOD LEVEL DIFFERENCE (15MINS-60MINS)**
EXISTING CONDITIONS
50% BLOCKAGE

Status PRELIMINARY
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	Datum	Scale	Size
	AHD	1:25	A3

Drawing Number	Revision
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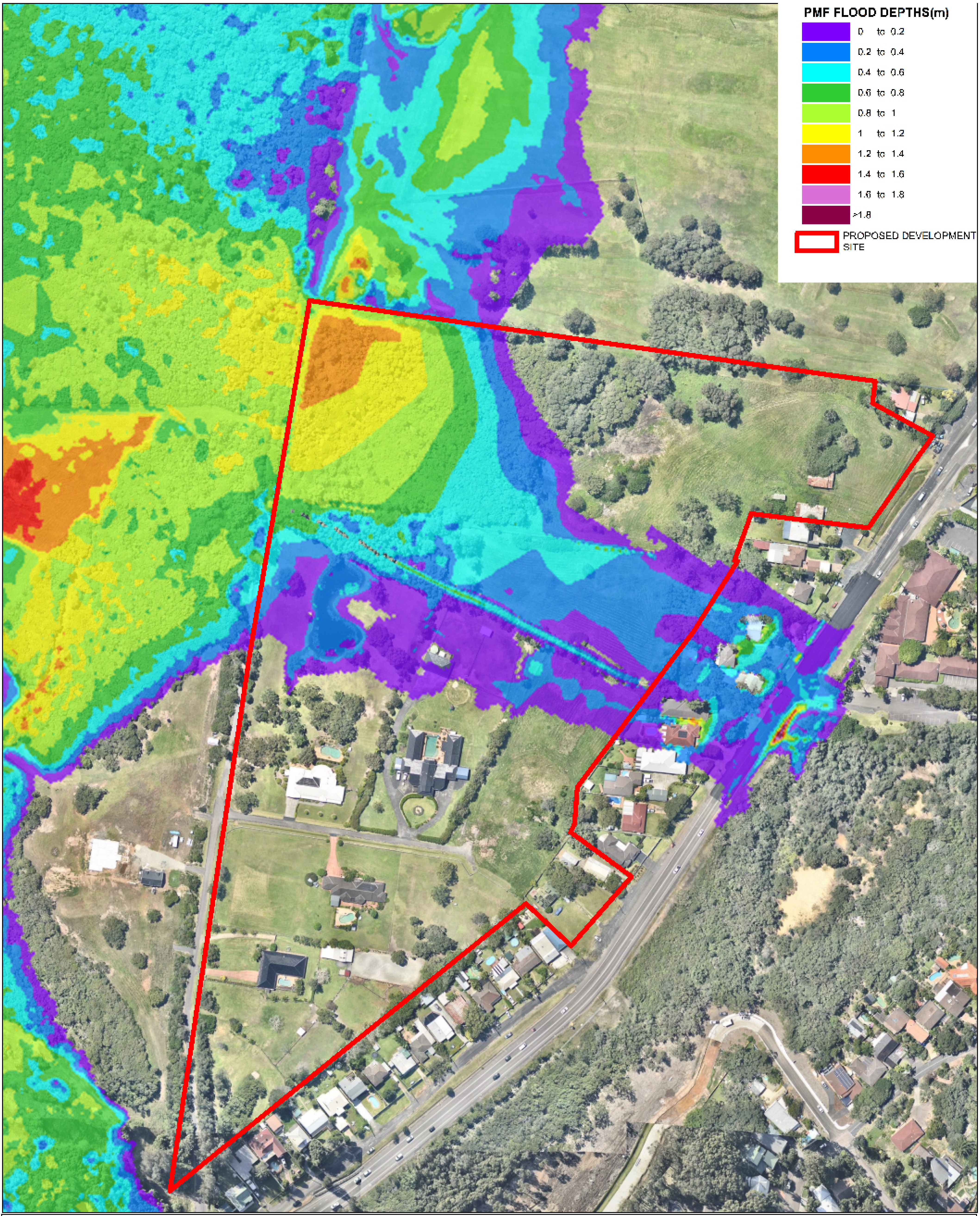

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Verified SJB	Date 24/05/2021
Approved SJB	Date 24/05/2021

Client: Tarrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF DEPTH**
EXISTING CONDITIONS
100% BLOCKAGE

Status PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
E3	B

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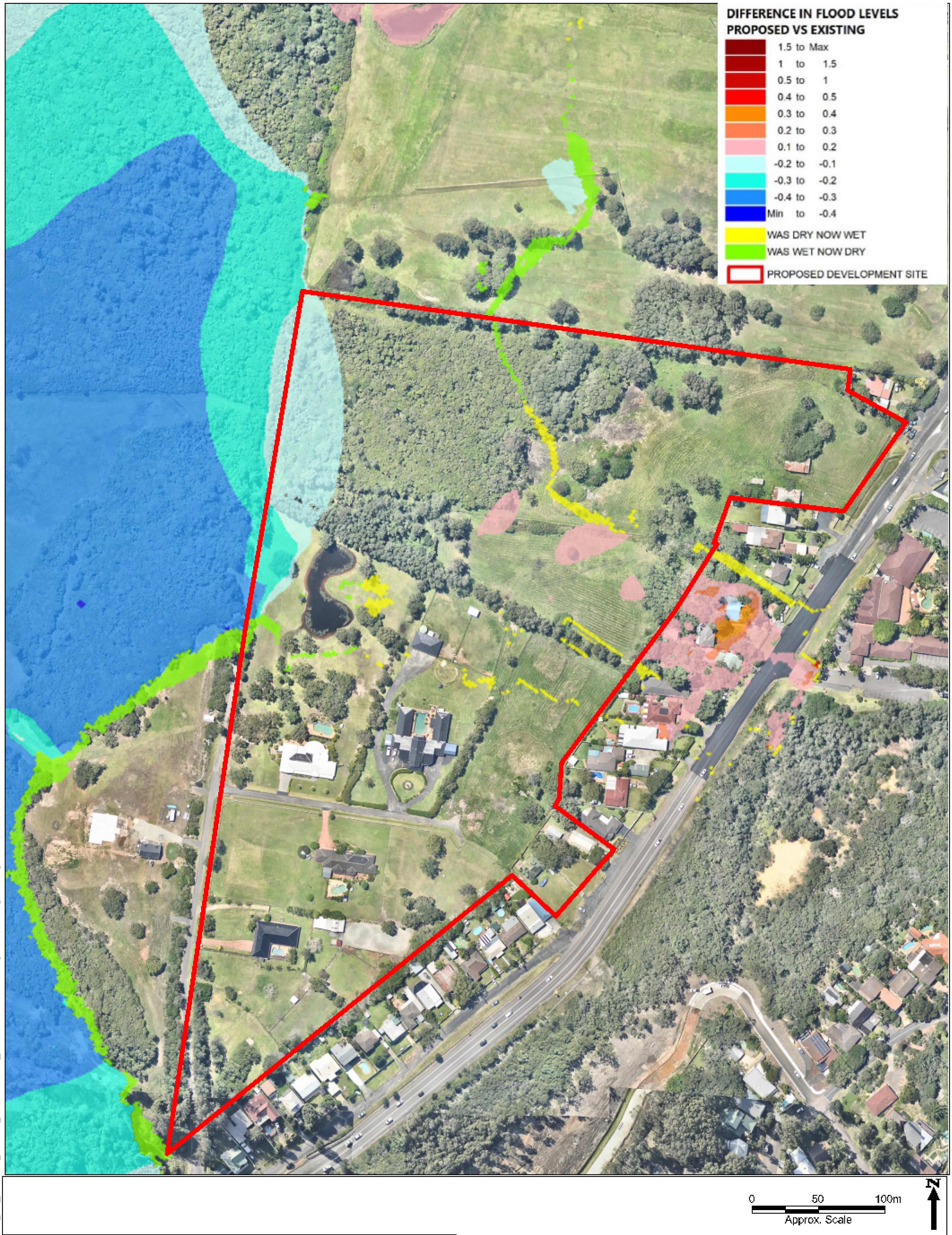

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Verified SJB	Date 24/05/2021
Approved SJB	Date 24/05/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF FLOOD LEVEL DIFFERENCE (15MINS-60MINS)
EXISTING CONDITIONS
100% BLOCKAGE**

Status PRELIMINARY
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Datum	Scale	Size
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Drawing Number	Revision
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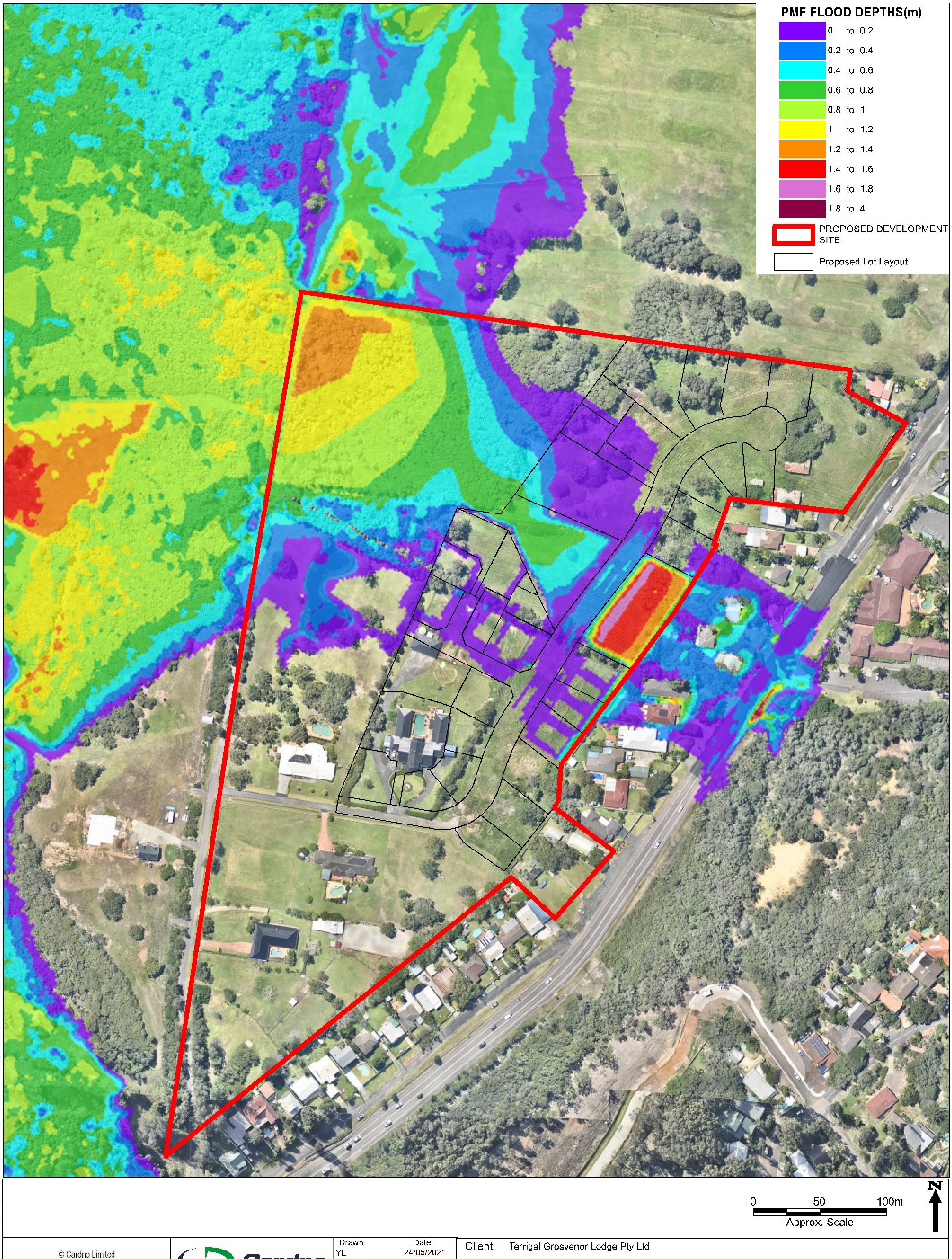

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Approved	SJB	Date 24/05/2021

Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF DEPTH**
PROPOSED CONDITIONS
50% BLOCKAGE

Status PRELIMINARY
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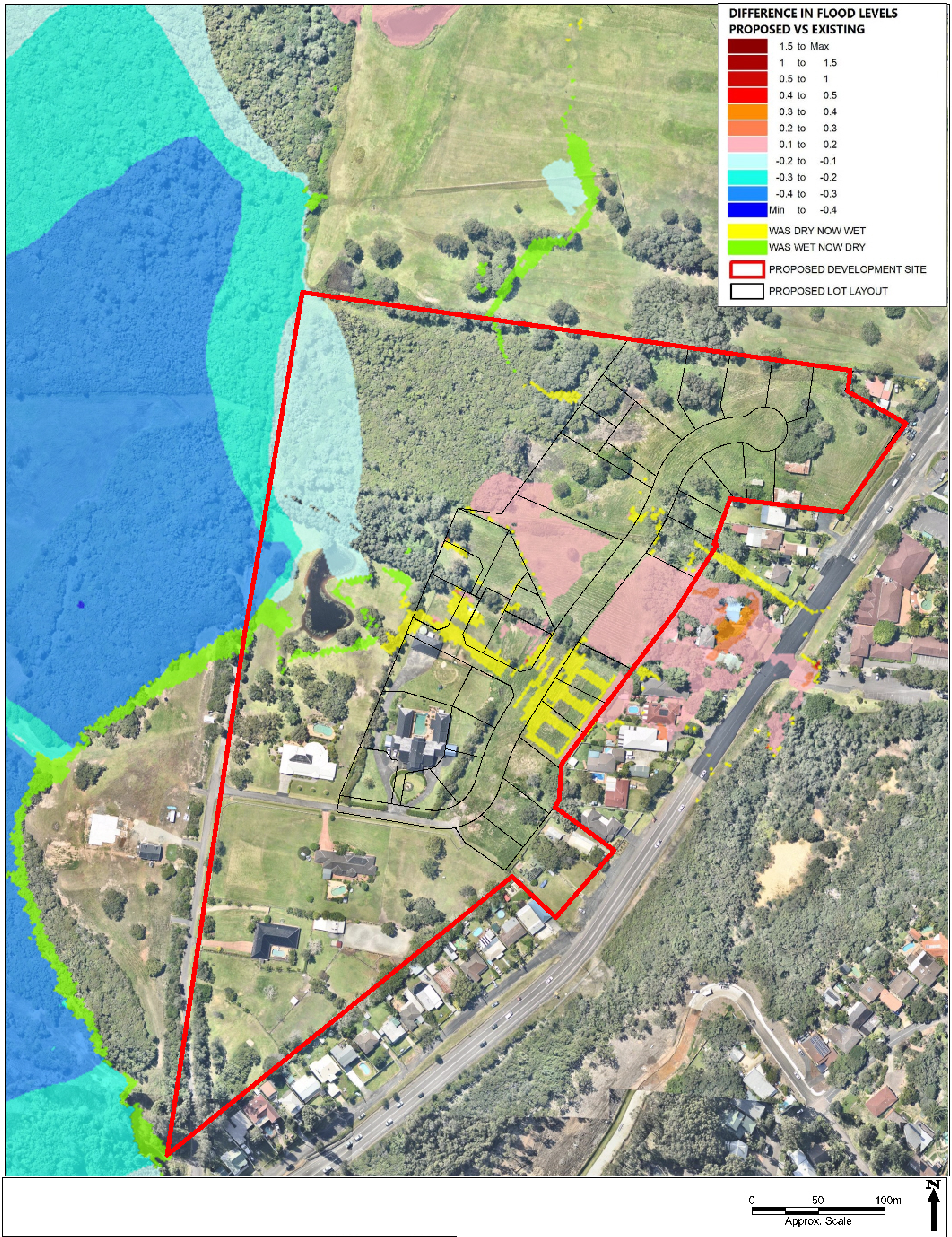
Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
P1	B

Filepath: N:\Projects\906\FY14\000_039_Architects_Planners_Developers\C13_Foresters Beach Planning - ST2\Drawings\GIS\Figures



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Client: Terrigal Grosvenor Lodge Pty Ltd

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FORRESTERS BEACH PLANNING

Title: **PMF FLOOD LEVEL DIFFERENCE (15MINS-60MINS)
PROPOSED CONDITIONS
50% BLOCKAGE**

Status: PRELIMINARY
Not to be used for construction purposes

Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
P2	B

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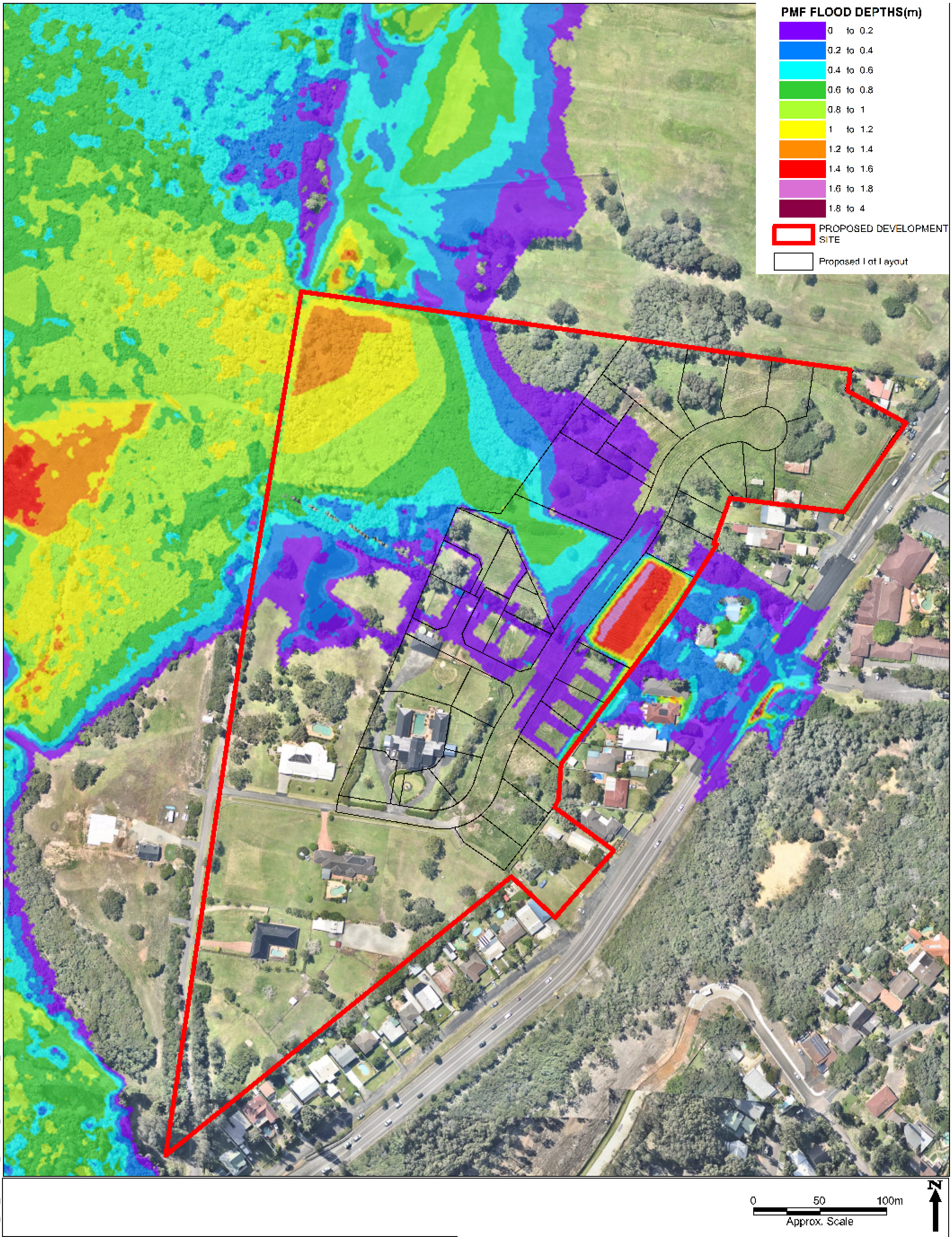

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Client: Terrigal Grosvenor Lodge Pty Ltd

Project: FLOOD STUDY
FORRESTERS BEACH PLANNING

Title: **PMF DEPTH**
PROPOSED CONDITIONS
100% BLOCKAGE

Status PRELIMINARY
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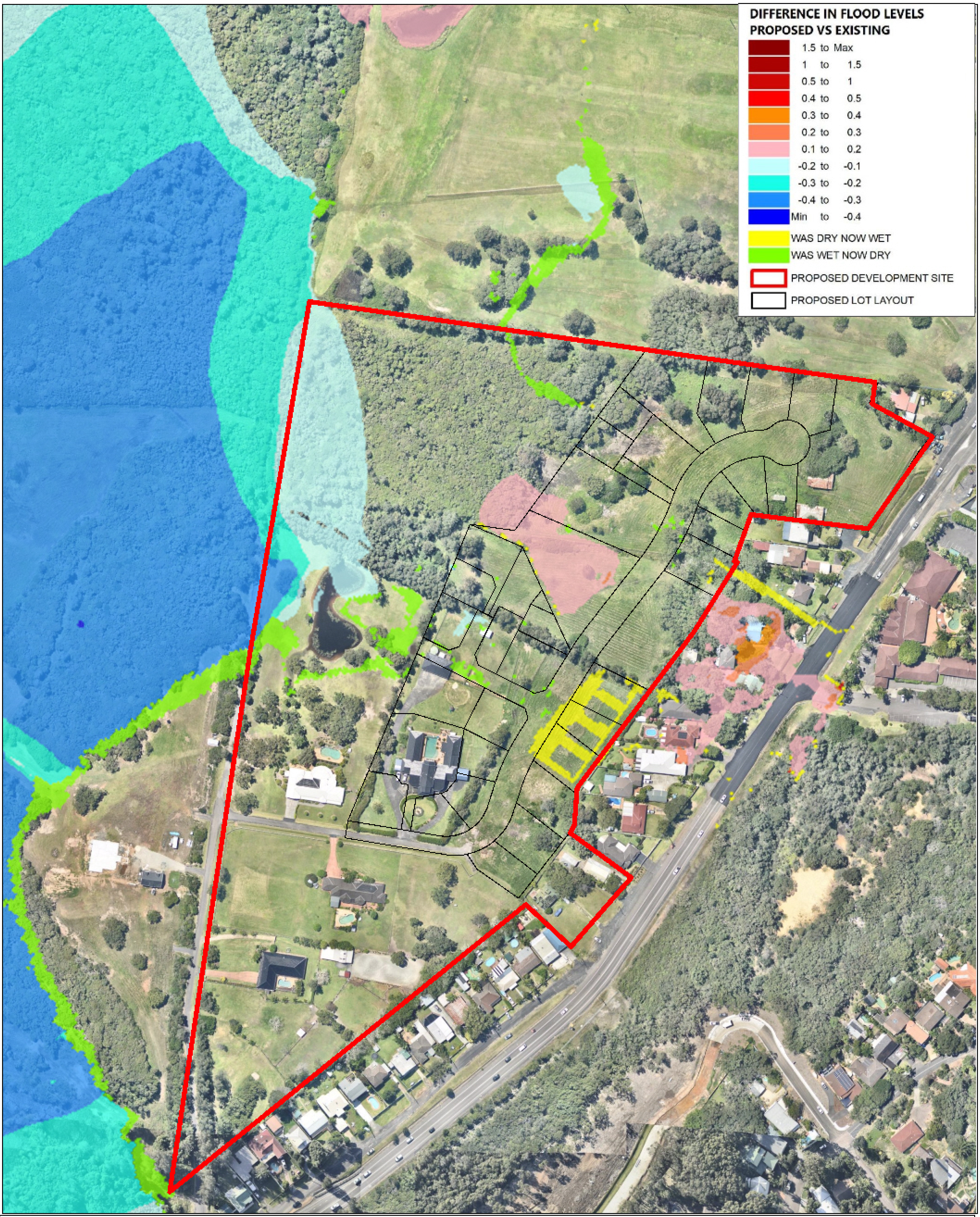

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Approx. Scale

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FORRESTERS BEACH PLANNING

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PROPOSED CONDITIONS
100% BLOCKAGE

Status: PRELIMINARY
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Datum	Scale	Size
AHD	1:25	A3

Drawing Number	Revision
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Forresters Beach Planning

APPENDIX

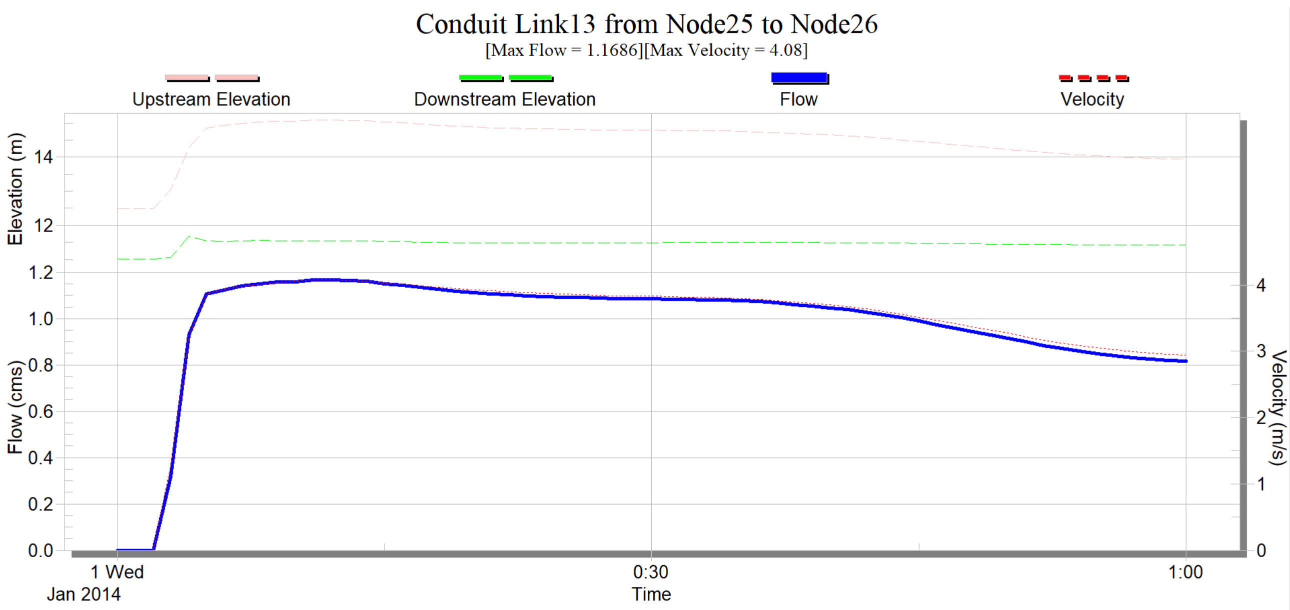
E

PMF CONDUIT FLOWS UNDER EXISTING AND FUTURE CONDITIONS

Attachment A

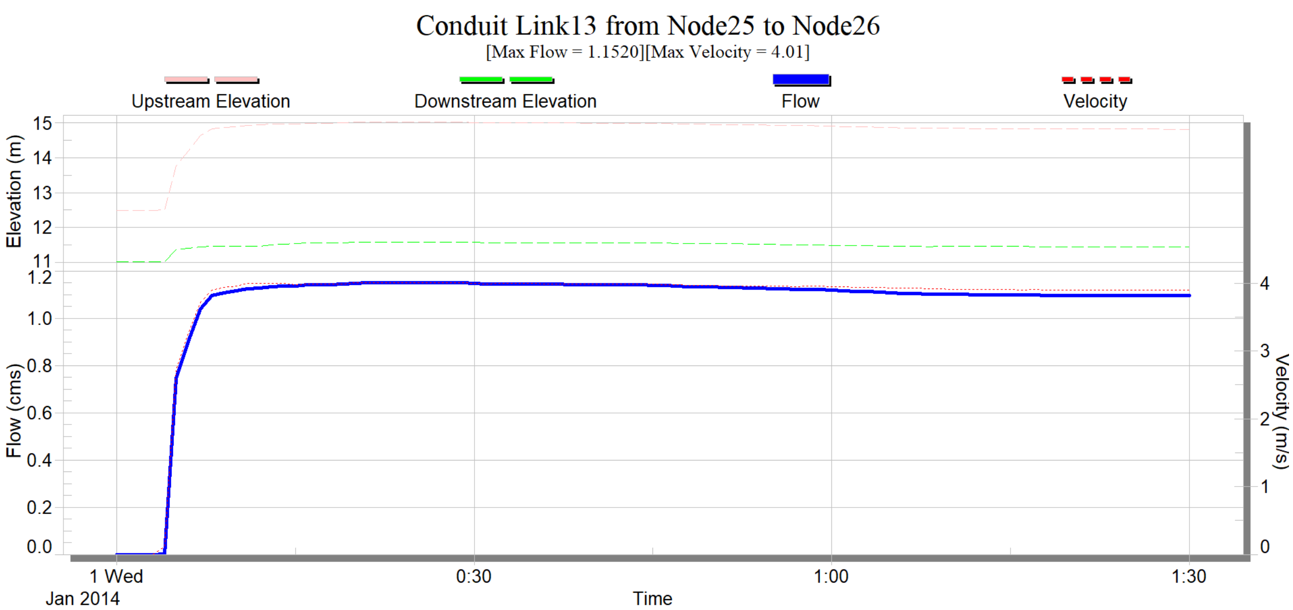
Representative PMF Conduit Flows under Existing and Future Conditions

Figure A.1 Pipe Locations (Existing and Future Conditions)



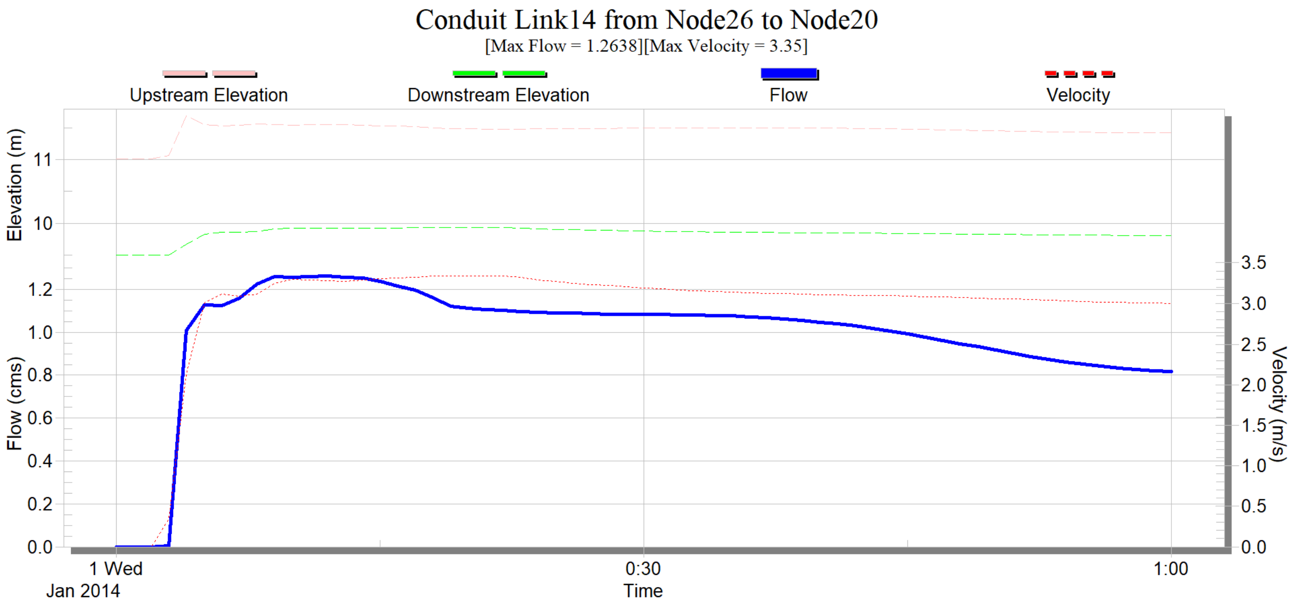
Link 13 is 1 x 0.6 m diameter RCP crossing under the Central Coast Highway

Figure A.2 PMF flows (60 mins) – Link 13 - Existing Conditions (50% blocked)



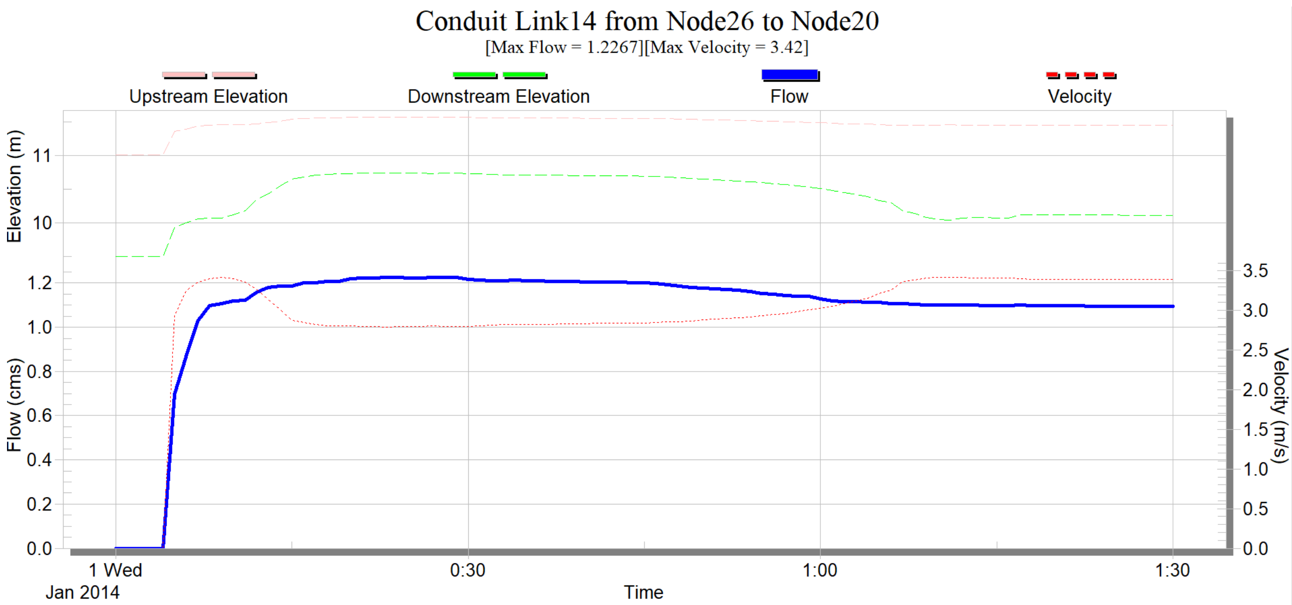
Link 13 is 1 x 0.6 m diameter RCP crossing under the Central Coast Highway

Figure A.3 PMF flows (60 mins)– Link 13 - Developed Conditions (50% blocked)



Link 14 is 1 x 0.9 m diameter RCP downstream of the Central Coast Highway

Figure A.4 PMF flows (60 mins) – Link 14 - Existing Conditions (50% blocked)



Link 14 is 1 x 0.9 m diameter RCP downstream of the Central Coast Highway

Figure A.5 PMF flows (60 mins) – Link 14 - Developed Conditions (50% blocked)