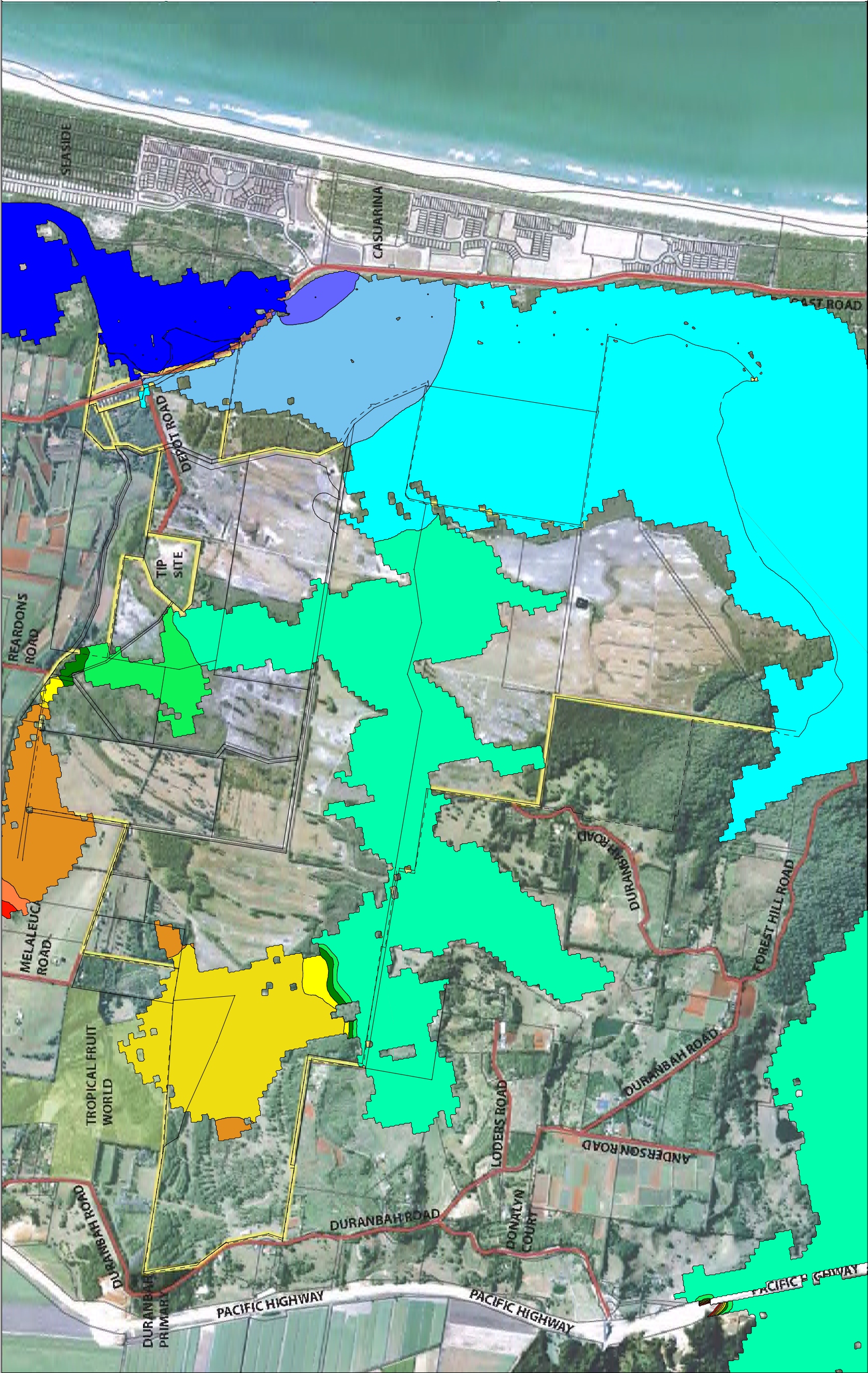


Water Surface Levels
(mAHd)

- 2.00 to 2.25
- 2.25 to 2.50
- 2.50 to 2.75
- 2.75 to 3.00
- 3.00 to 3.25
- 3.25 to 3.50
- 3.50 to 3.75
- 3.75 to 4.00
- 4.00 to 4.25
- 4.25 to 4.50
- 4.50 to 4.75
- 4.75 to 5.00



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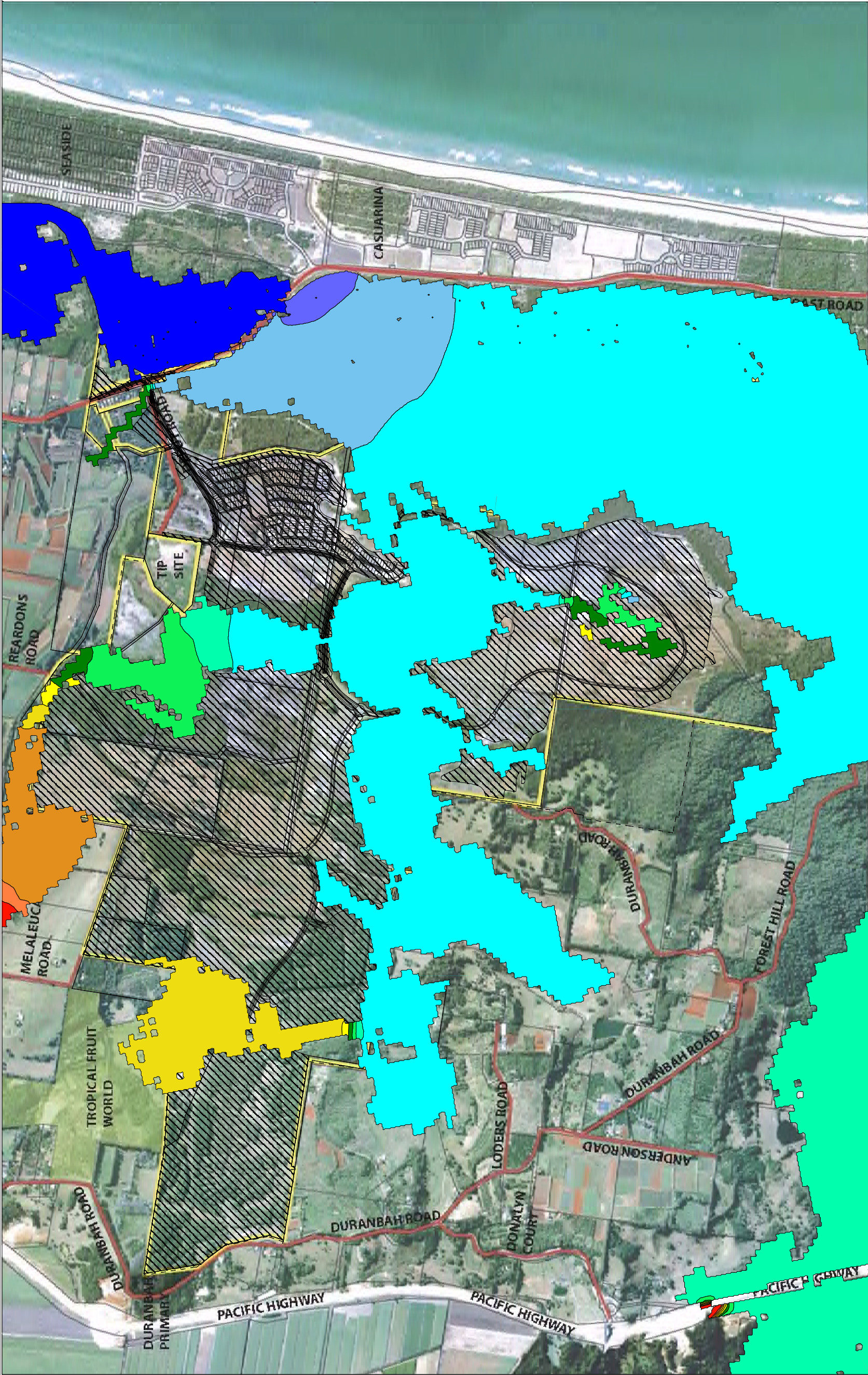
PROJECT

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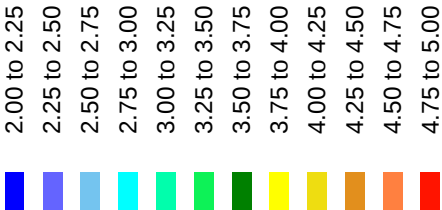
PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

EXISTING ARI 100 YEAR WATER LEVELS



Water Surface Levels
(mAHd)



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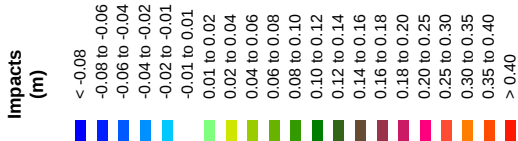
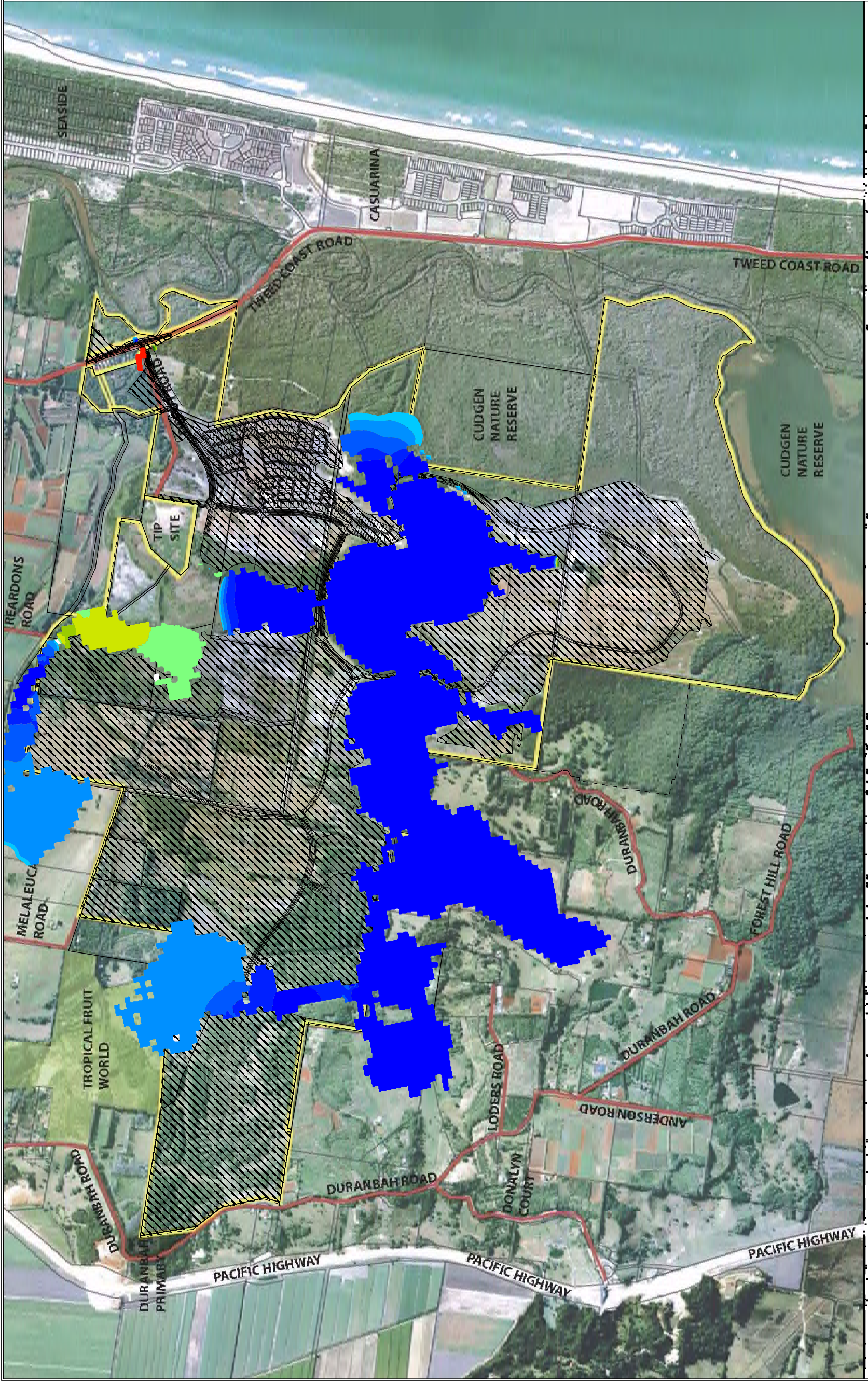
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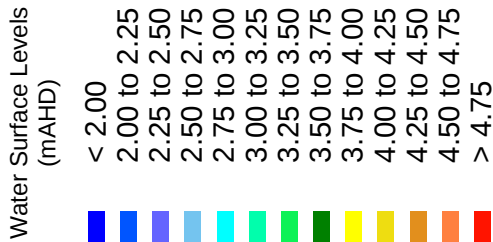
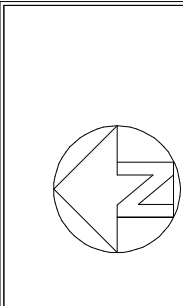
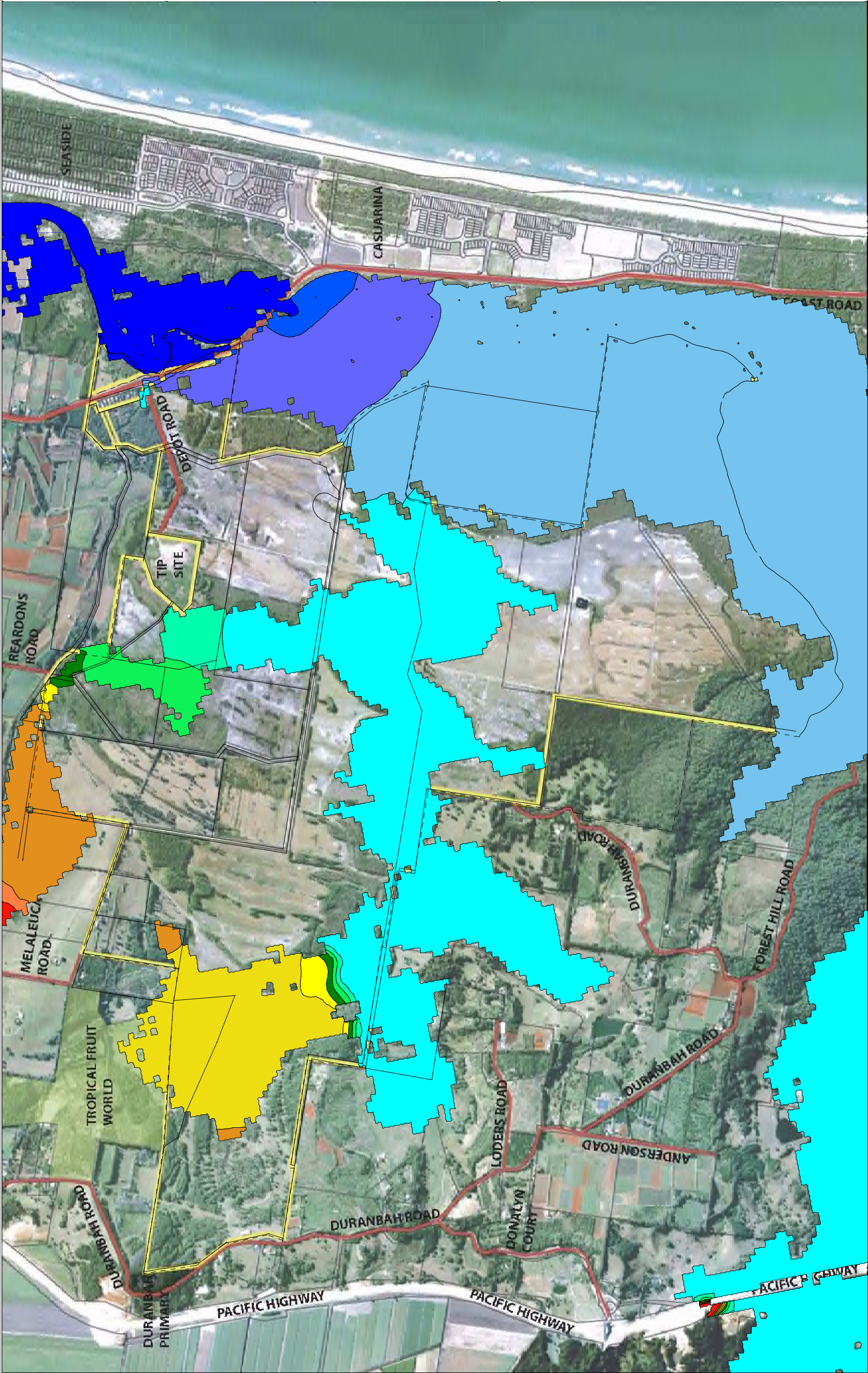
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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

ARI 100 YEAR IMPACTS



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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

EXISTING ARI 50 YEAR WATER LEVELS

SCALE AS SHOWN

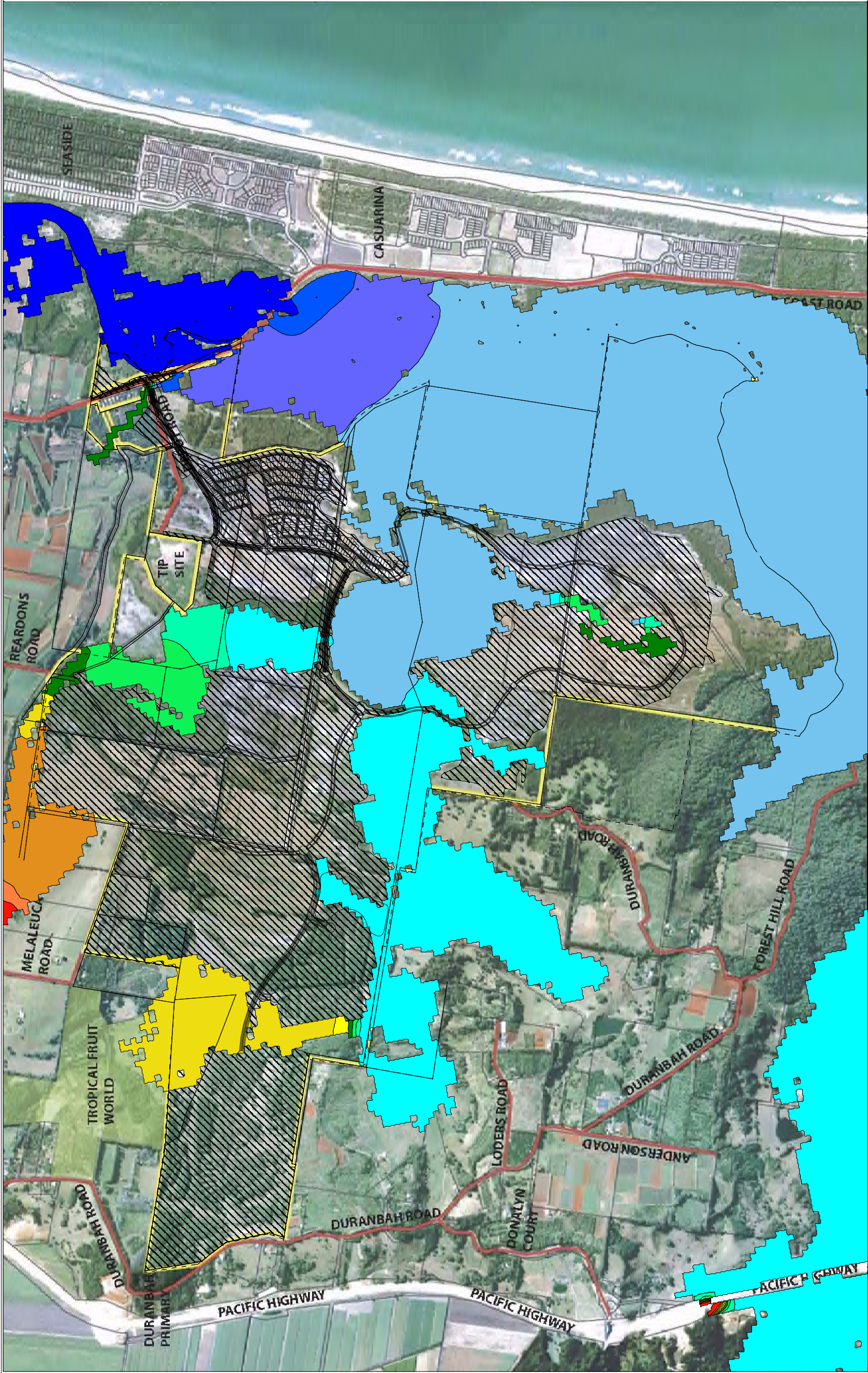
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Water Surface Levels
(mAHd)

< 2.00
2.00 to 2.25
2.25 to 2.50
2.50 to 2.75
2.75 to 3.00
3.00 to 3.25
3.25 to 3.50
3.50 to 3.75
3.75 to 4.00
4.00 to 4.25
4.25 to 4.50
4.50 to 4.75
> 4.75

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PROPOSED KINGS FOREST DEVELOPMENT
KINGSCLIFF, NSW

DEVELOPED ARI 50 YEAR WATER LEVELS

SCALE AS SHOWN

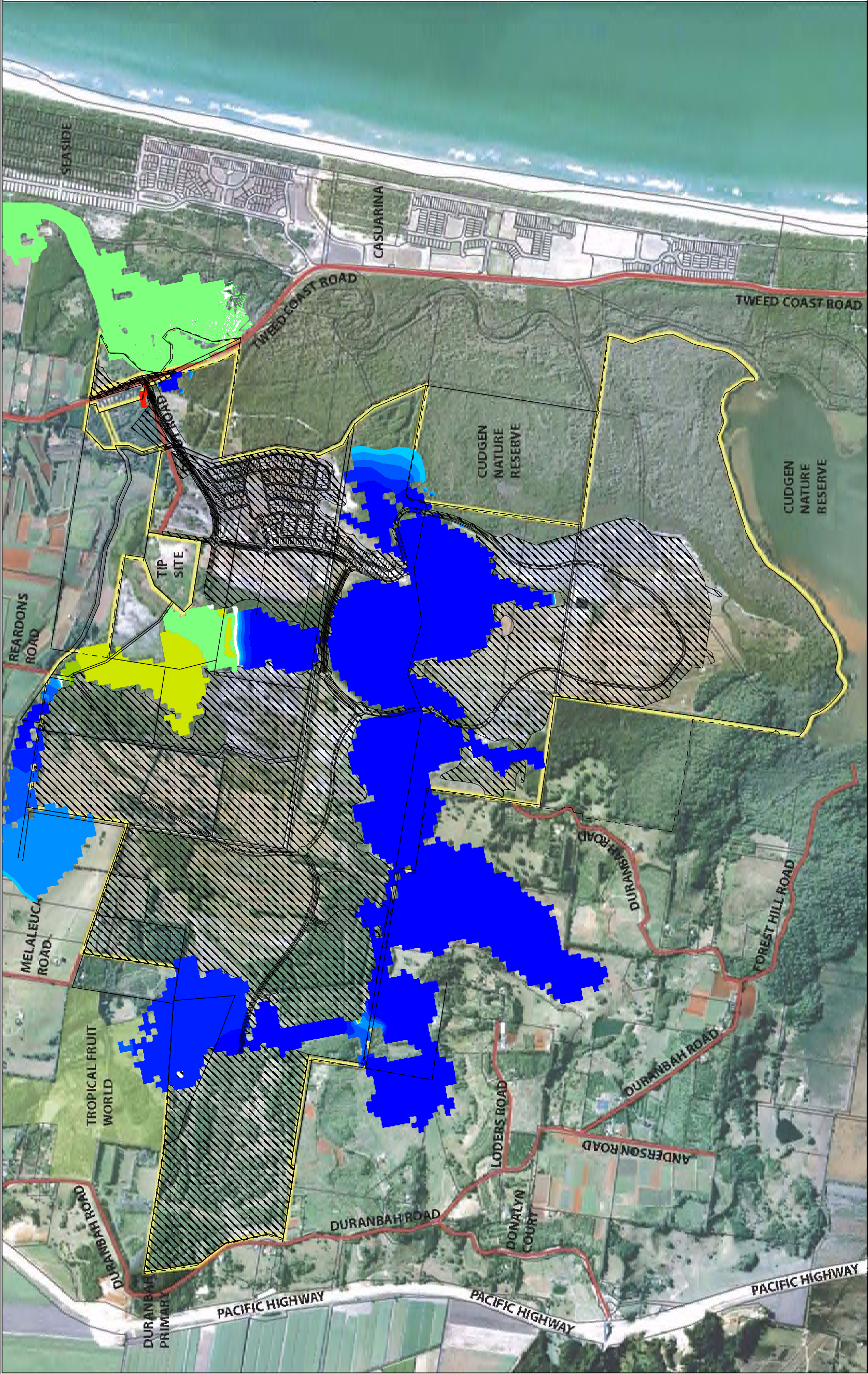
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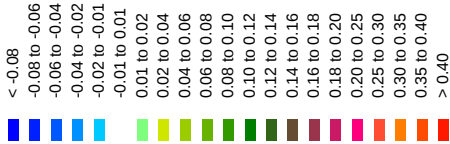
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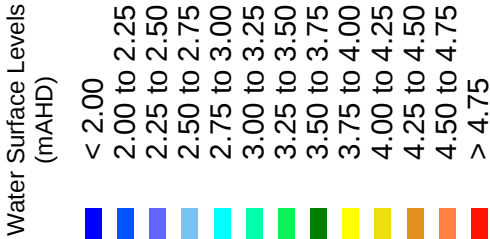
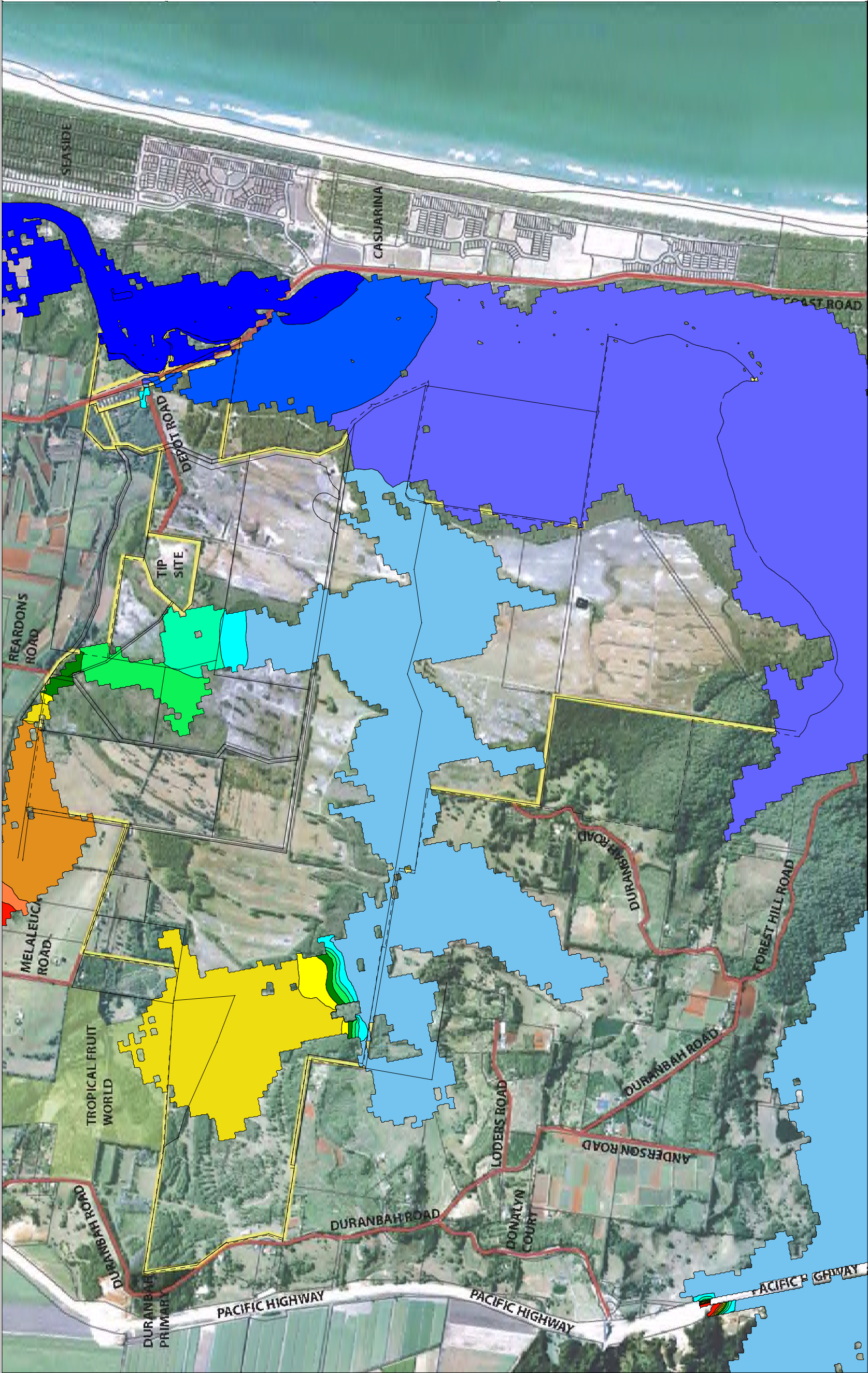
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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

DEVELOPED ARI 50 YEAR IMPACTS



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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

EXISTING ARI 20 YEAR WATER LEVELS

SCALE AS SHOWN

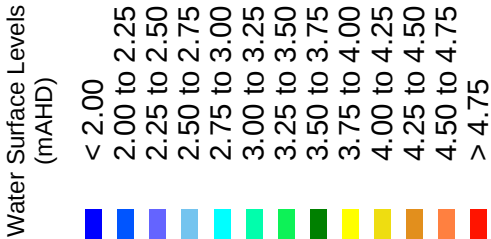
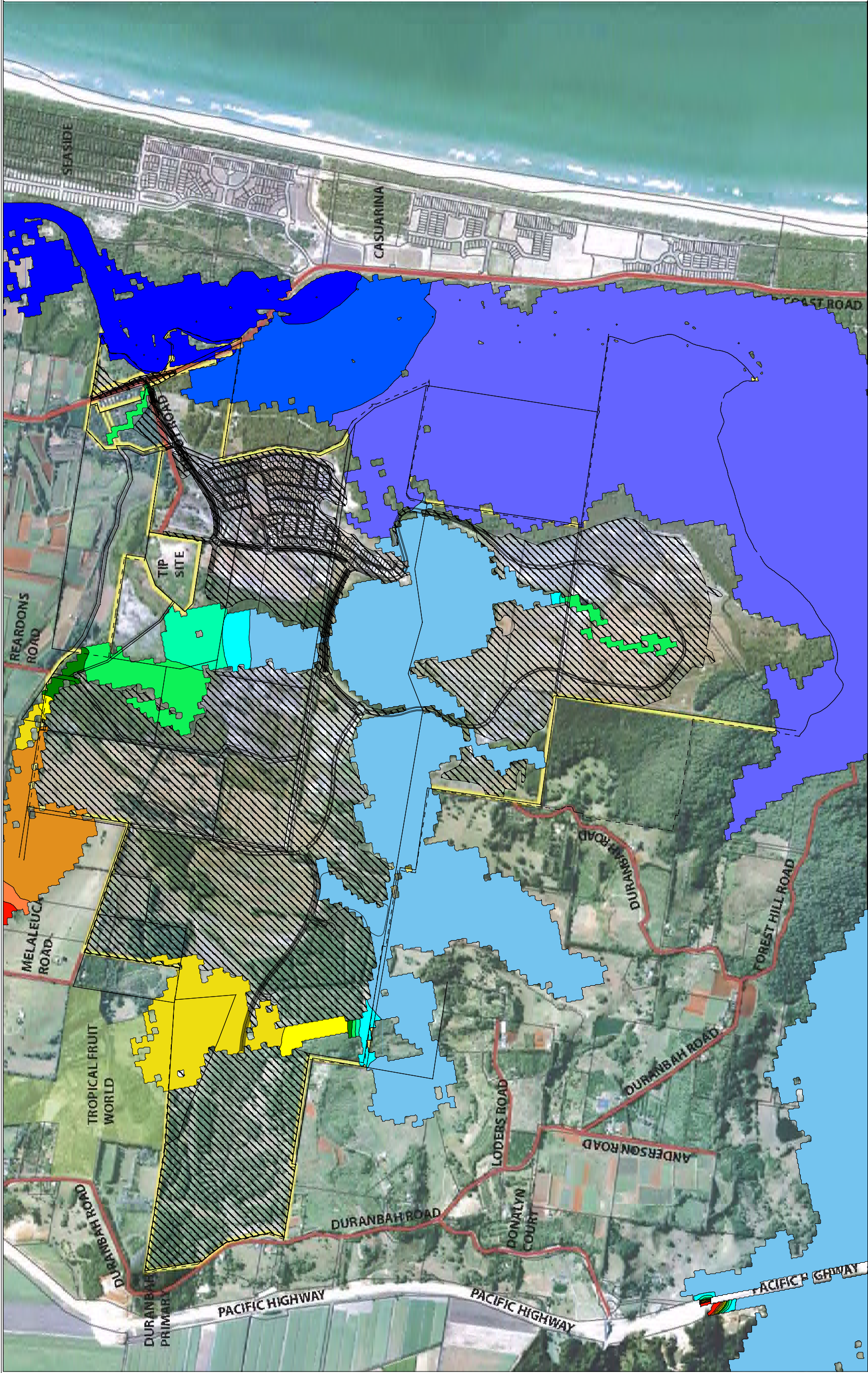
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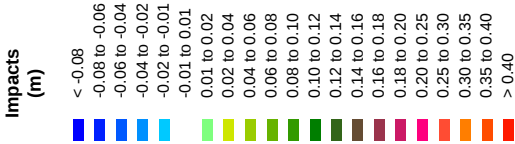
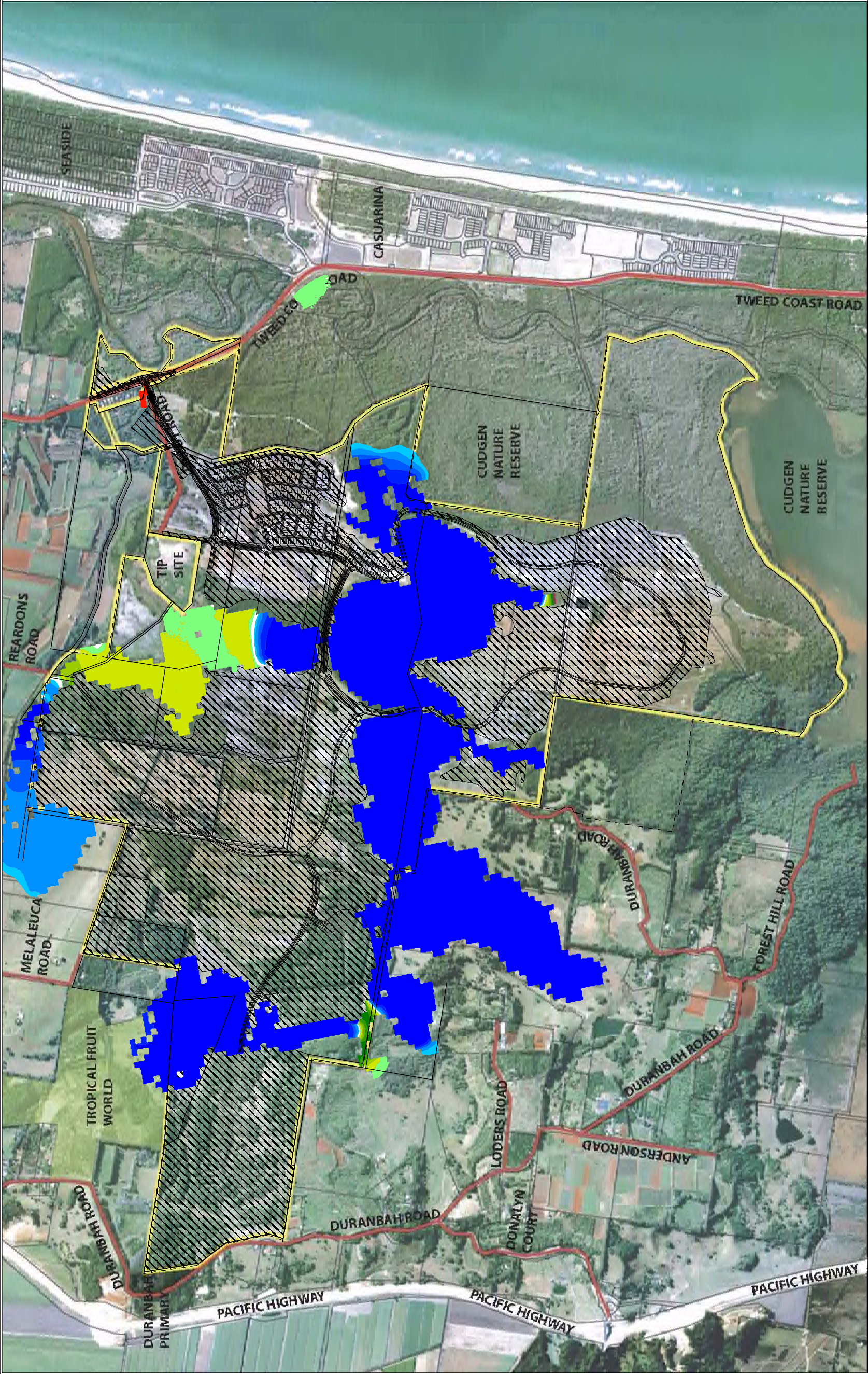
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PROJECT

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PROPOSED KINGS FOREST DEVELOPMENT
KINGSCLIFF, NSW
DEVELOPED ARI 20 YEAR WATER LEVELS



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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

DEVELOPED ARI 20 YEAR IMPACTS

SCALE AS SHOWN

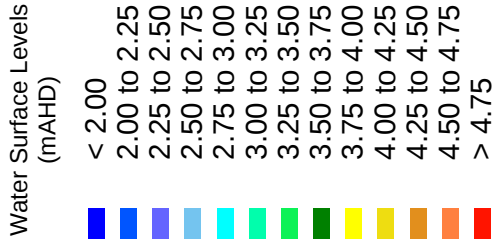
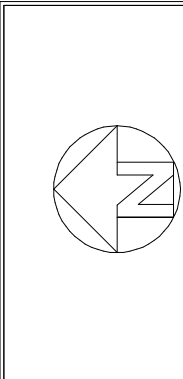
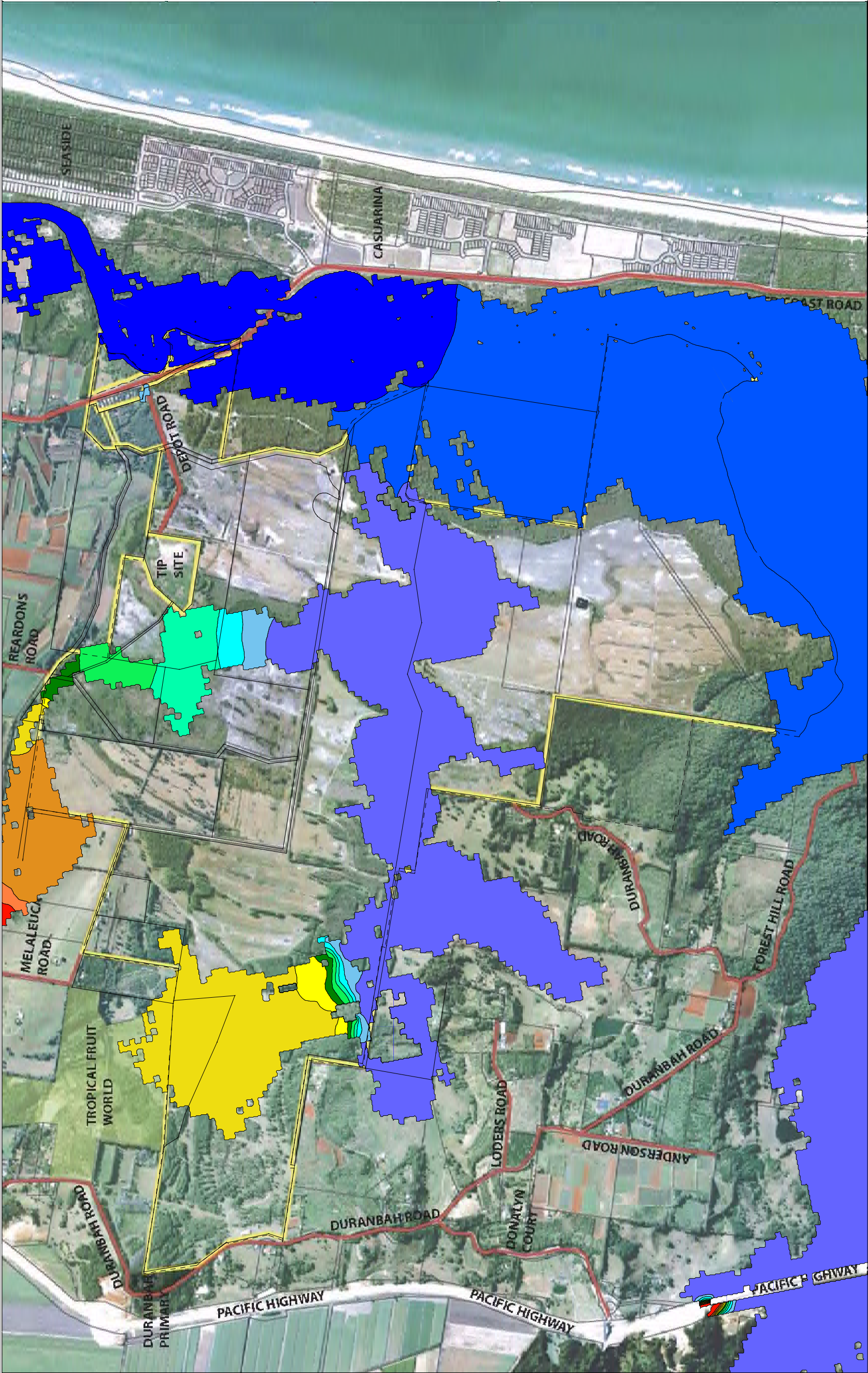
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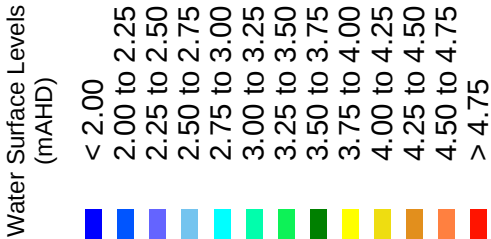
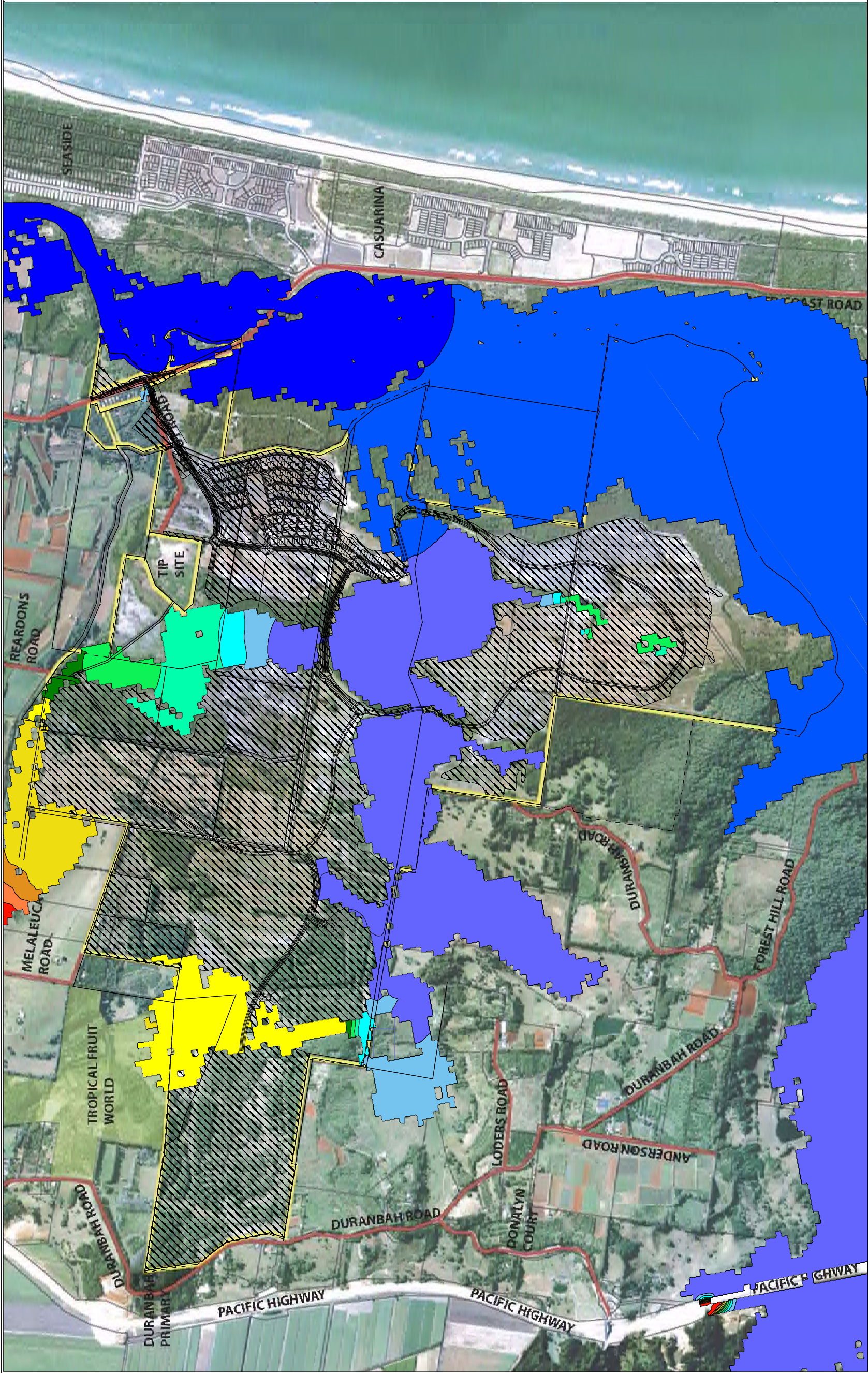
PROJECT

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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

EXISTING ARI 10 YEAR WATER LEVELS



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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

DEVELOPED ARI 10 YEAR WATER LEVELS

SCALE AS SHOWN

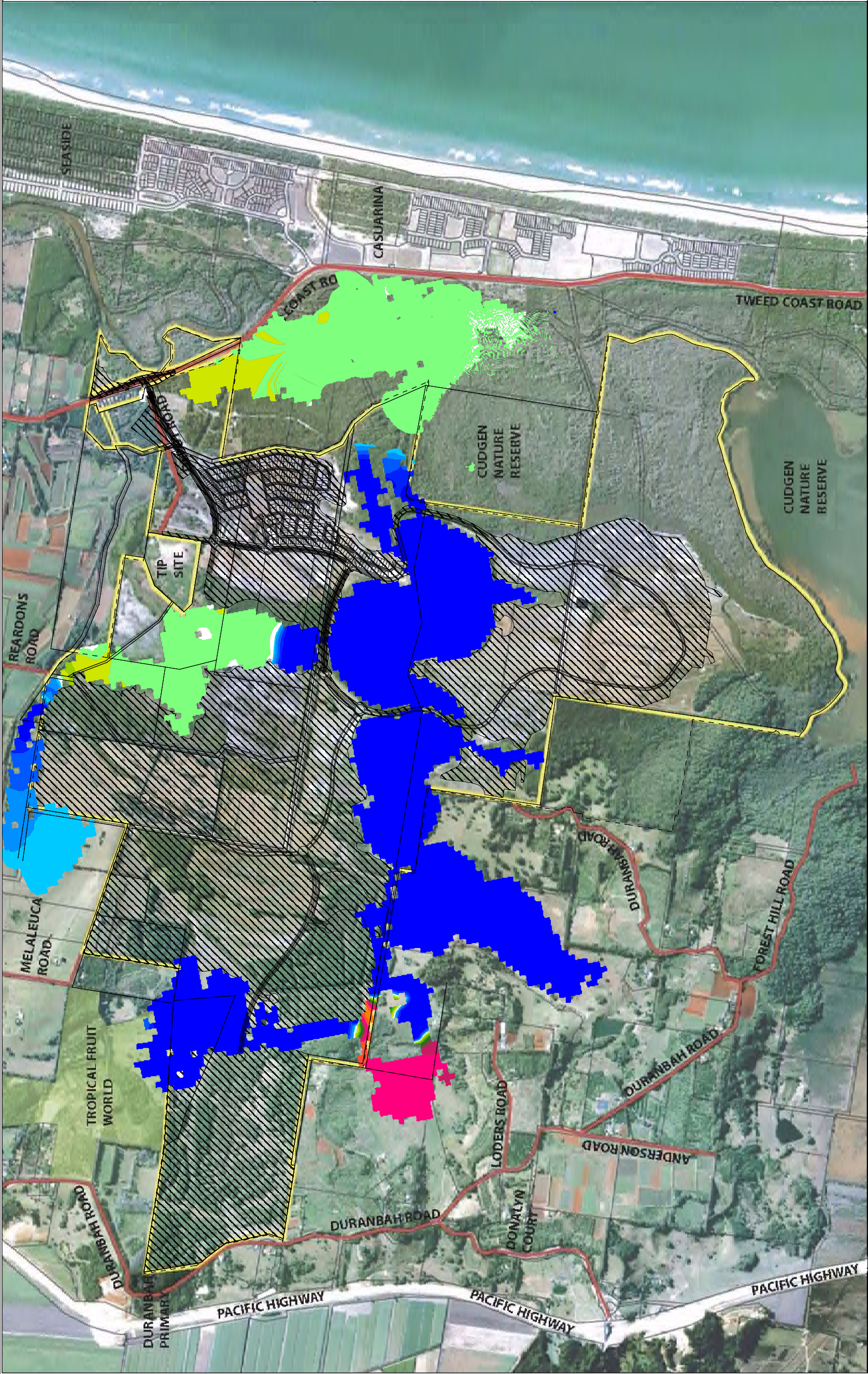
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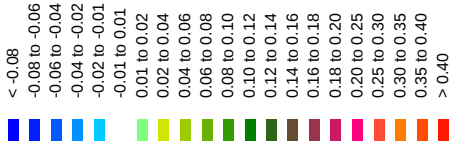
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PROPOSED KINGS FOREST DEVELOPMENT
KINGSLIFF, NSW
ARI 10 YEAR IMPACTS

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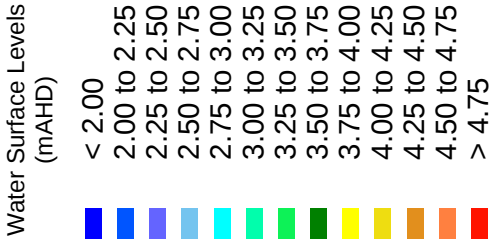
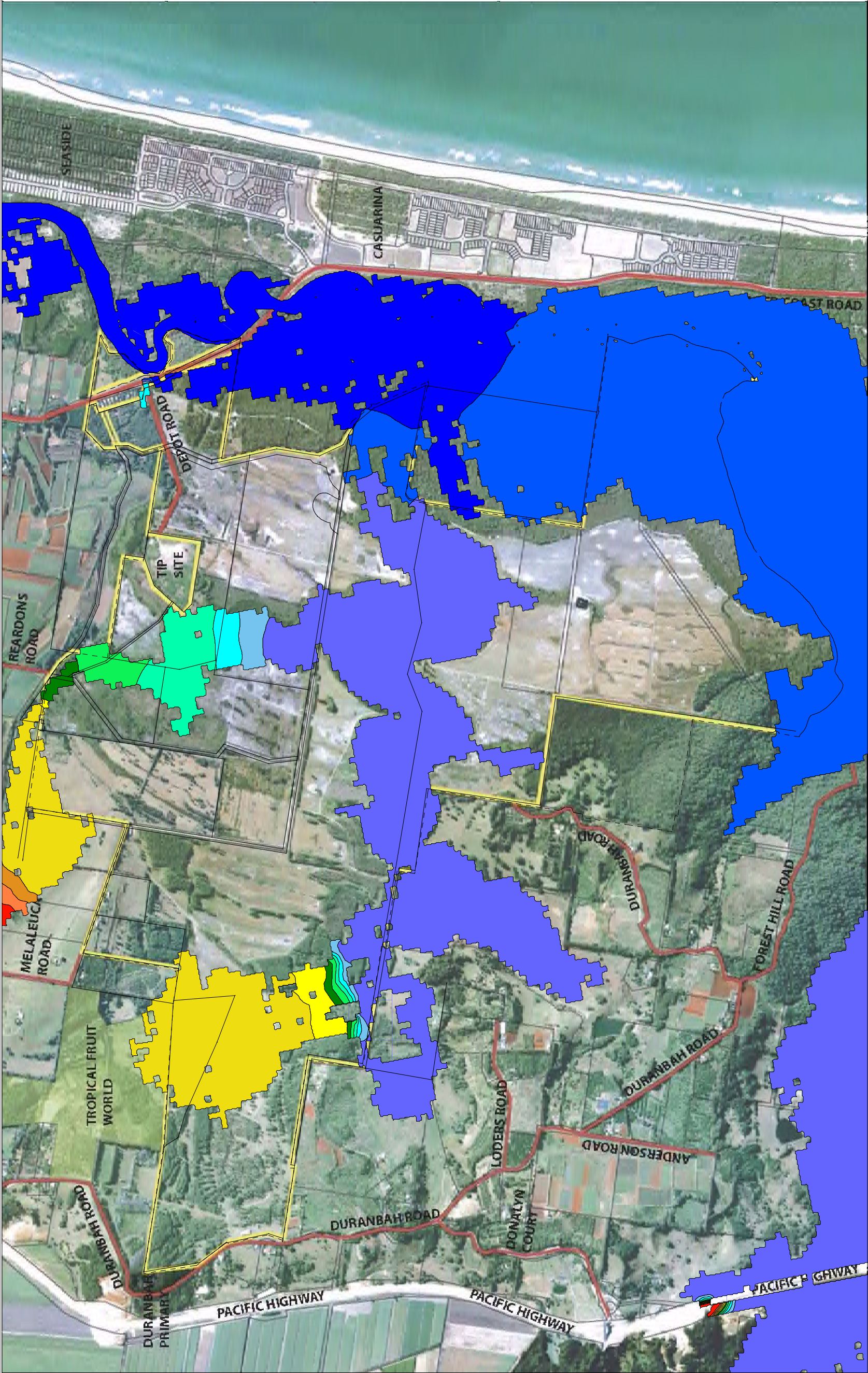
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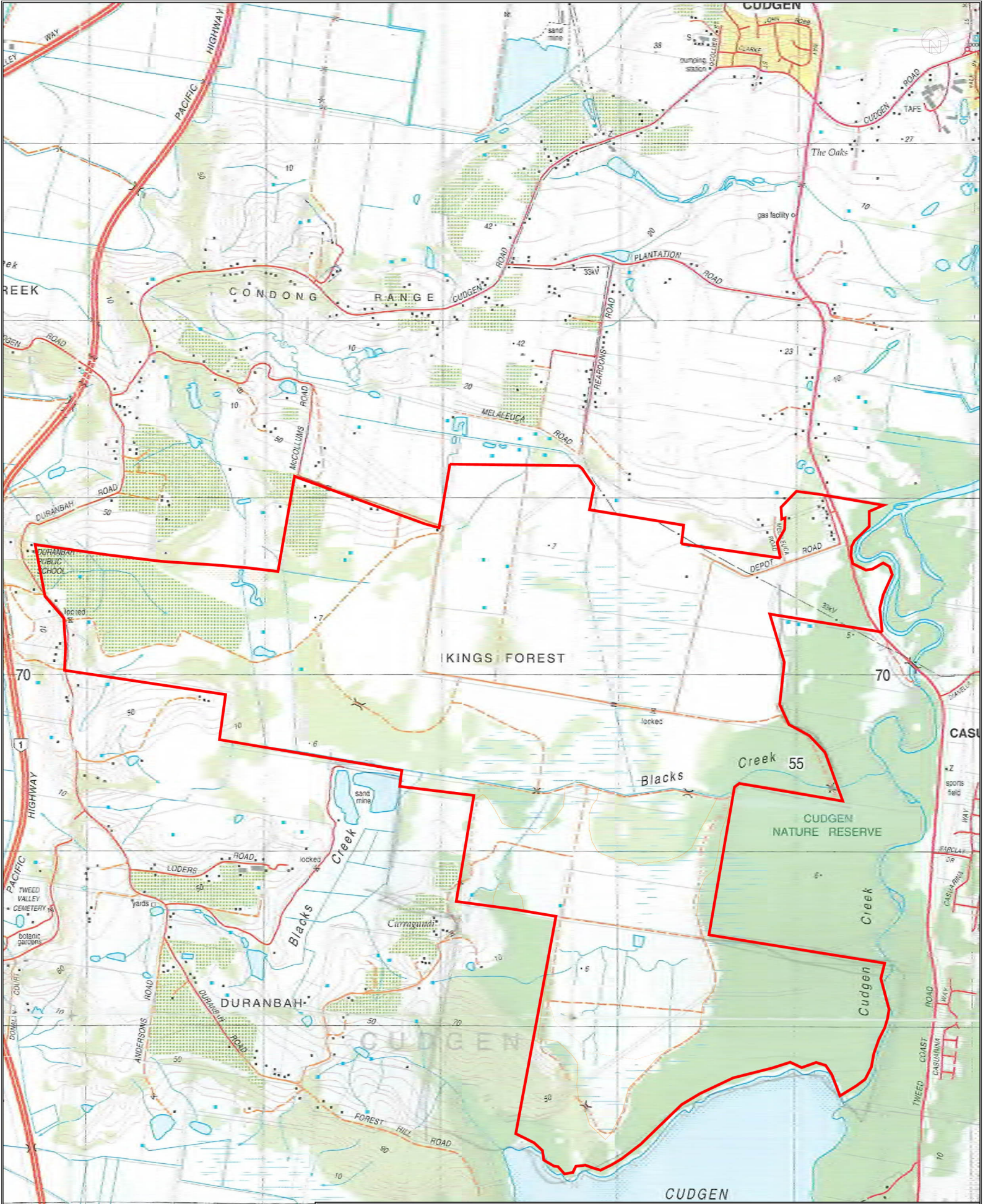
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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

EXISTING ARI 5 YEAR WATER LEVELS



NOTES:
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TOPOGRAPHIC AND ORTHOGRAPHIC MAP

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Eastside
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KINGS FOREST PROJECT APPLICATION

LOCAL HYDROLOGICAL ASSESSMENT

SITE LOCATION

SCALE AS SHOWN

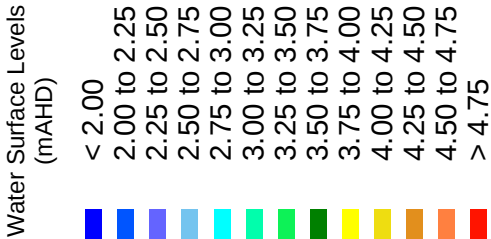
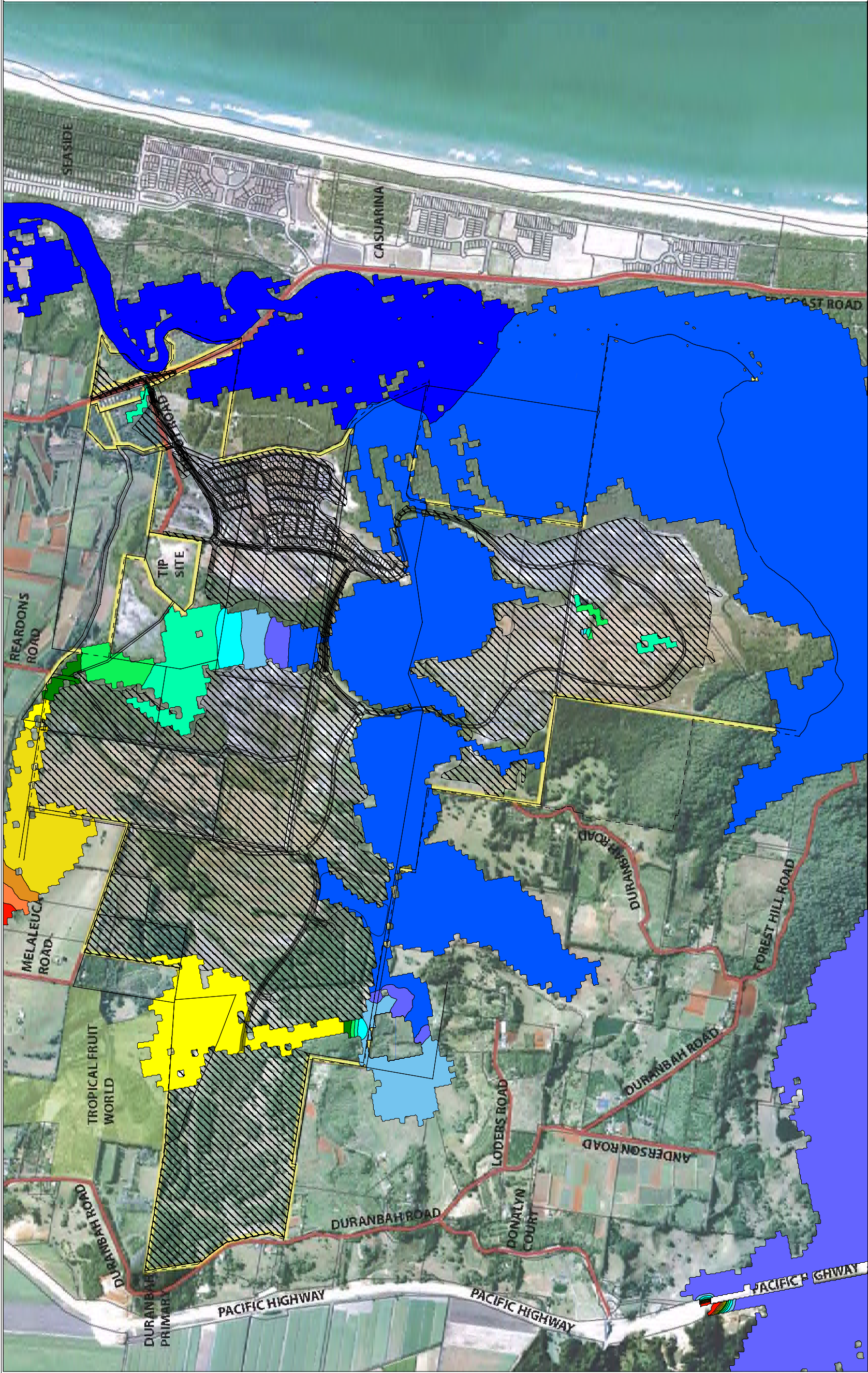
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PROPOSED KINGS FOREST DEVELOPMENT
KINGSCLIFF, NSW

DEVELOPED ARI 5 YEAR WATER LEVELS

SCALE AS SHOWN

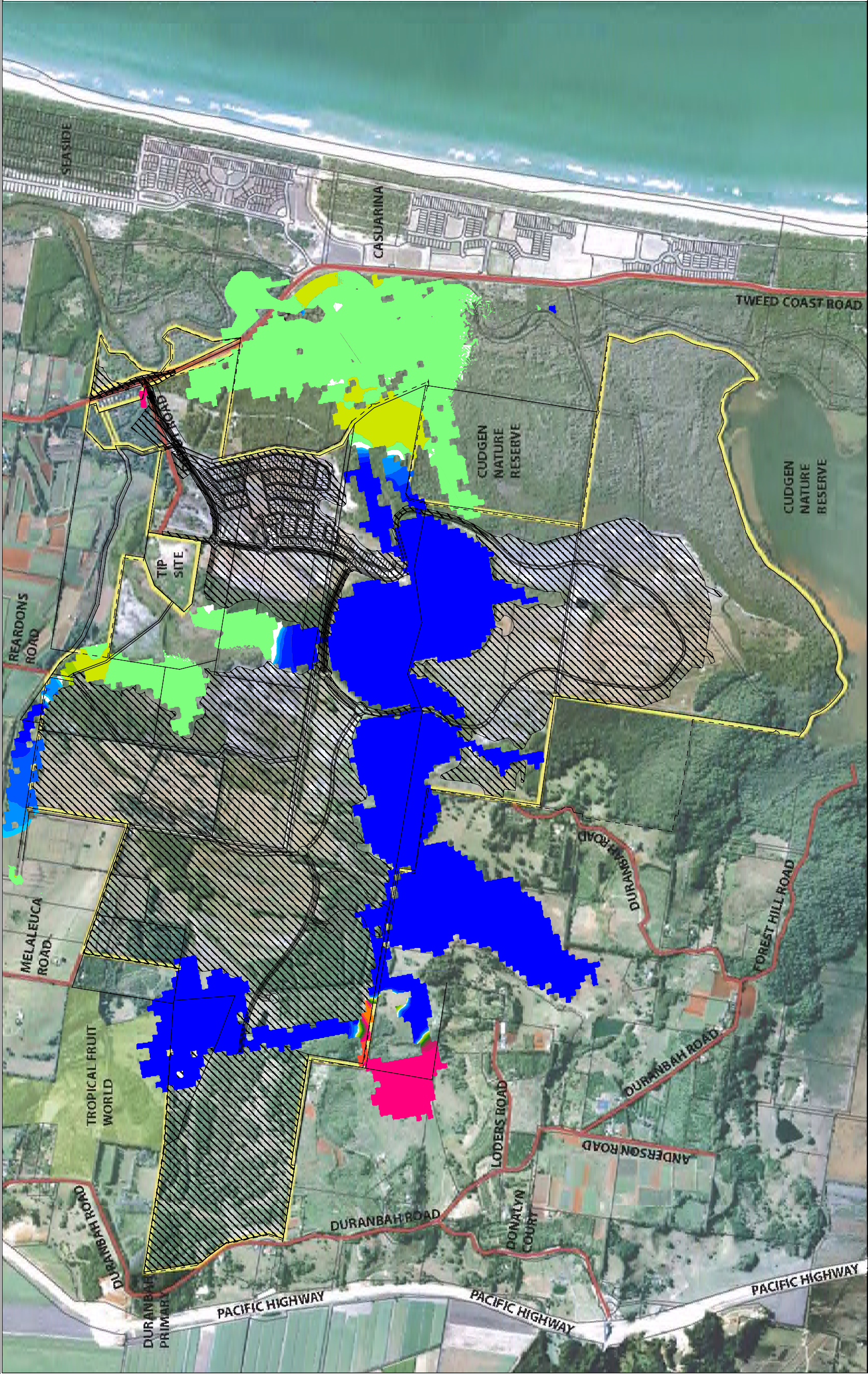
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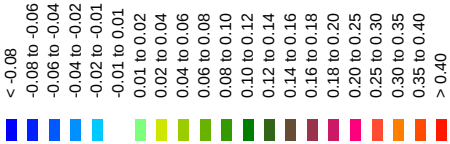
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KINGSCLIFF, NSW

ARI 5 YEAR WATER LEVEL IMPACTS

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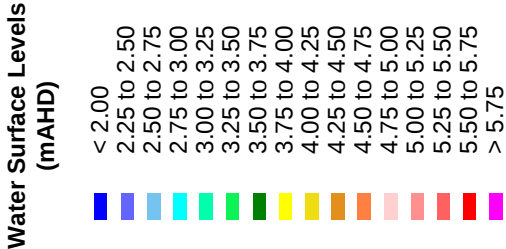
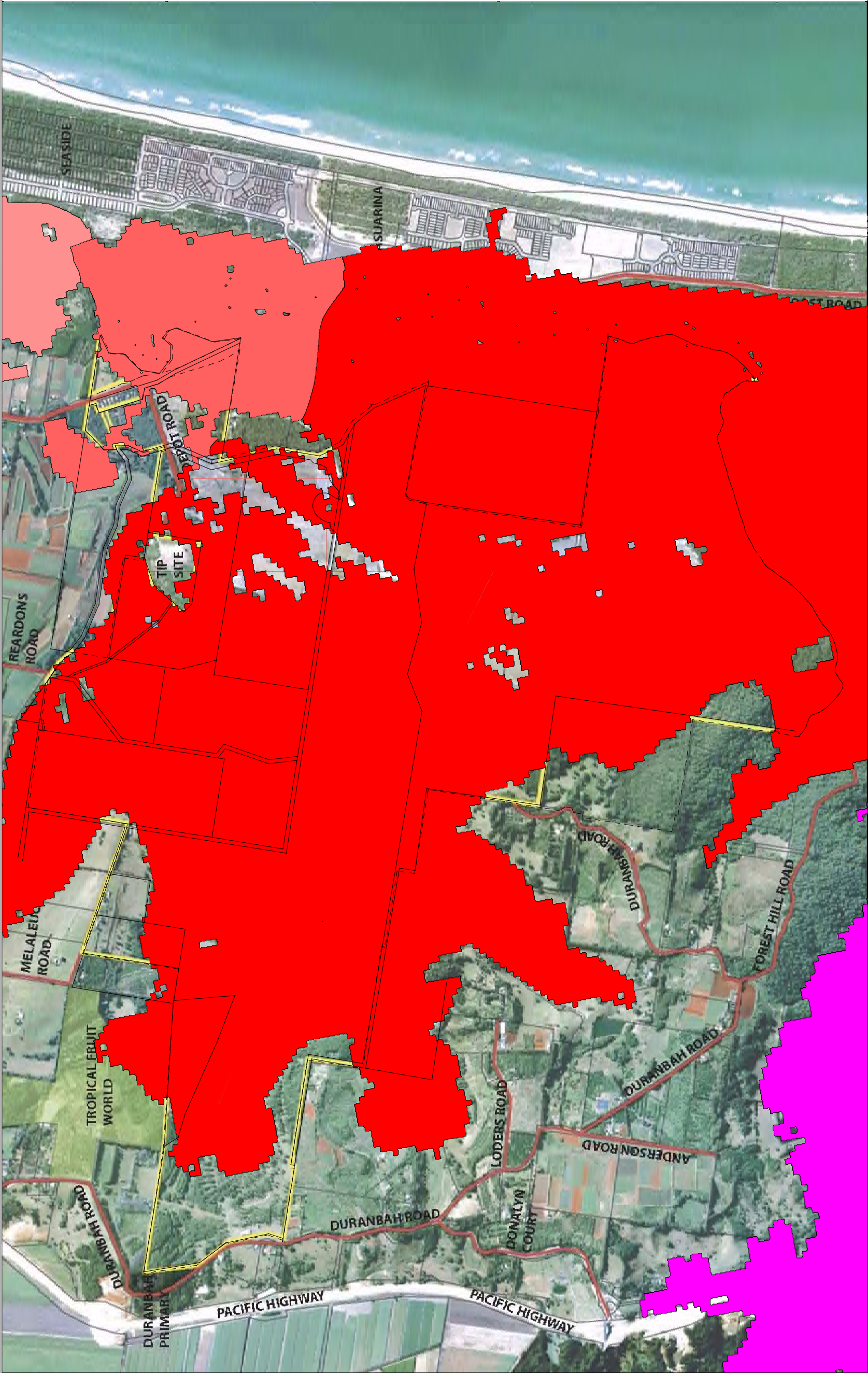
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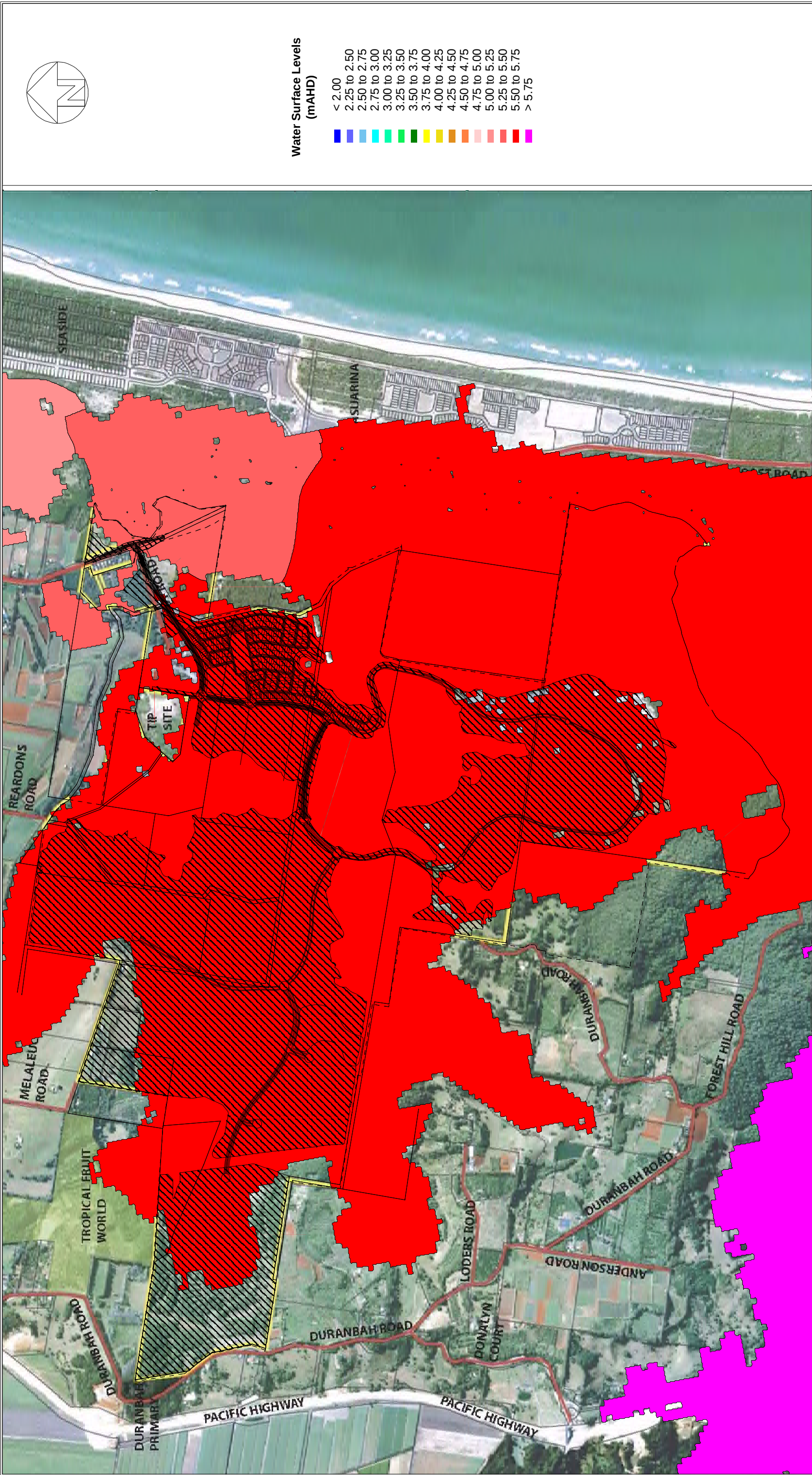
PROJECT

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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

EXISTING PMF WATER LEVELS



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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

DEVELOPED PMF WATER LEVELS

SCALE AS SHOWN

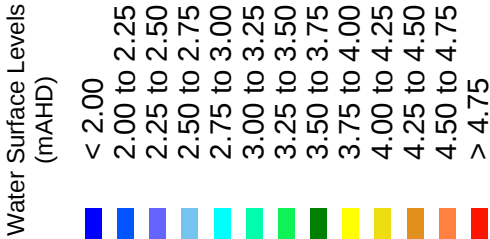
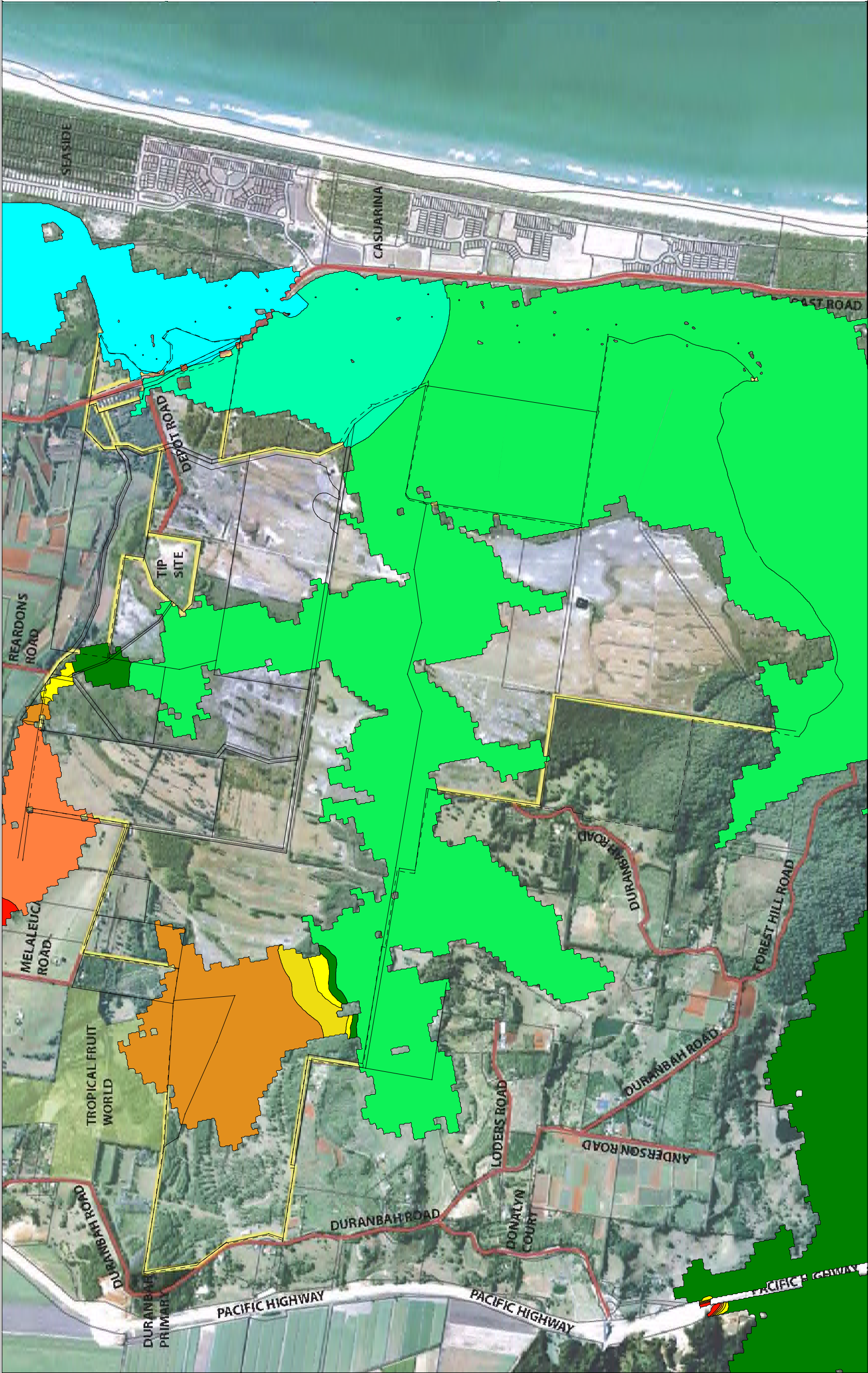
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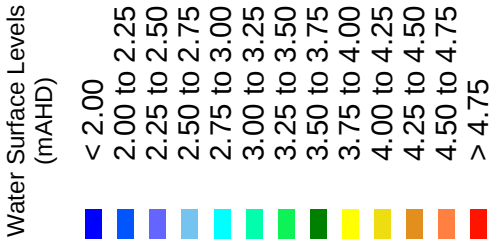
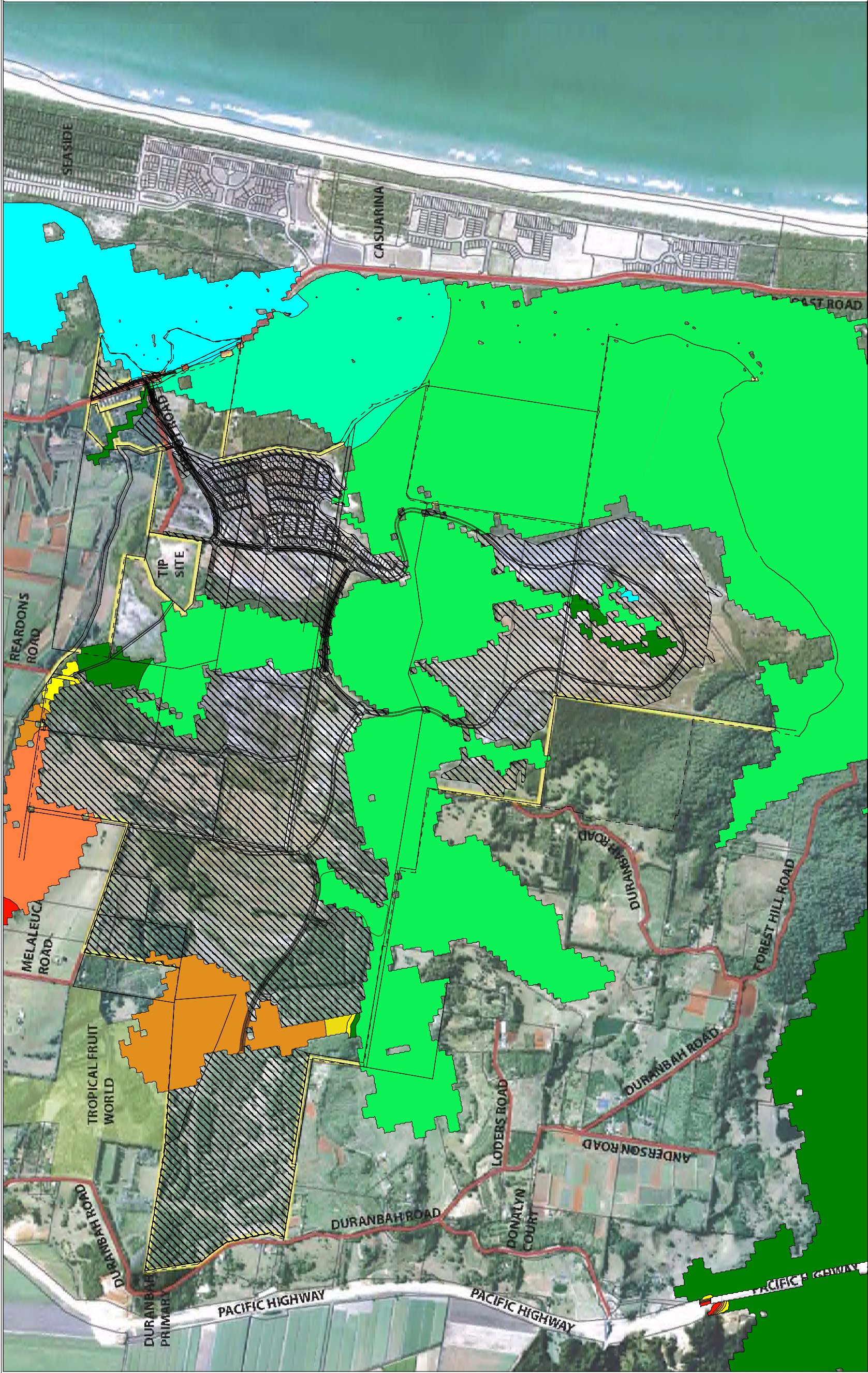
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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

EXISTING ARI 100 YEAR HIGHCC WATER LEVELS



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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

DEVELOPED ARI 100 YEAR HIGHCC WATER LEVELS

11 Appendix 2 – ‘Local Hydrological Assessment, Kings Forest, Kingscliff, NSW’ (Gilbert & Sutherland, December 2009)

Local Hydrological Assessment
Kings Forest
Kingscliff, NSW

Prepared for:
Project 28 Pty Ltd

November 2009

Document control

Document: KJ0224-1_HYD_RAF1F.doc	Gilbert and Sutherland P/L ABN 56 077 310 840 Originating Office: Robina Eastside 5/232 Robina Town Centre Drive, Q4226 PO Box 4115, Robina Q4230 Telephone 07 5578 9944 Facsimile 07 5578 9945 gsrobina@groupgs.com Also at Kawana and Brisbane
Title: Local Hydrological Assessment, Kings Forest, Kingscliff, NSW	
Project Manager: Neil Collins	
Author: Alison Fullagar	
Client: Project 28 Pty Ltd	
Client Contact: Reg van Rij	
Client Reference:	
Synopsis: This report describes assessments of local hydrologic conditions within the Kings Forest catchment under existing and proposed developed conditions.	

Revision History

Revision #	Date	Edition By		Approved By	
1	29/11/09	AJF		AWH	

Distribution

	Revision Number									
Distribution	1	2	3	4	5	6	7	8	9	10
Project 28 Pty Ltd	1									
G&S library and file	1									

Summary

Gilbert & Sutherland Pty Ltd (G&S) was commissioned by Project 28 Pty Ltd, a subsidiary of Leda Developments (LEDA), to undertake specialist studies and assessments in support of a Part 3A Project Application. These studies have been undertaken to provide responses to the Director General's Environmental Assessment Requirements for Project Application No. 08_0194, dated October 14, 2008.

This report describes assessments of local hydrology within the site catchment under existing and proposed developed conditions. A separate report detailing impacts of local site and regional flooding has also been prepared.

A hydrologic assessment has been undertaken using the Rational Method and the Watershed Bounded Network Model (WBNM) to estimate peak flows within the site (upstream of Cudgen Creek) under existing conditions and the impact which the proposed development will have on these flows.

An assessment of the potential climate change impacts on the local catchment hydrology has also been carried out. The sensitivity assessments were based on those outlined in the NSW Department of Environment, Climate Change and water (DECC) publication, 'Practical Consideration of Climate Change', 2007. The scenario used for the sensitivity analysis included a 30% increase in rainfall intensity over the entire catchment.

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List of drawings

Drawing No.	Description
KJ0224.2.1	Site location
KJ0224.2.2	Catchment Plan

1) Introduction

Gilbert & Sutherland Pty Ltd (G&S) was commissioned by Project 28 Pty Ltd, a subsidiary of Leda Developments (LEDA) to undertake specialist studies and assessments in support of a Part 3A Project Application. These studies have been undertaken to provide responses to the Director General's Environmental Assessment Requirements (DGRs) for Project Application No. 08_0194, dated October 14, 2008 and to support the associated project

application in relation to the management of local flooding.

This report describes assessments of the local catchment hydrology and the impact which the proposed Kings Forest development will have on these flows.

This assessment has been based on existing survey data and preliminary civil design details for the proposed works provided by Mortons Urban Solutions.

2) Site description and proposal

2.1 Location

The site for the proposed development occupies approximately 870ha and is located in Kingscliff, on the NSW far North Coast. The site is bounded by Depot Road to the east and Duranbah Road to the west.

The site location is shown on Drawing No. KJ0224.2.1.

2.2 Receiving environment

The land ranges in elevation from approximately RL0m Australian Height Datum (AHD) to RL55m AHD.

Runoff from this development generally flows in an easterly direction via a number of unnamed ephemeral gullies and SEPP14 wetlands into Cudgen Creek. Cudgen Creek flows from Cudgen Lake which lies to the south-east of the site to its mouth at Kingscliff approximately 4.5km to the north-east of the site.

2.3 Existing development

The site has been selectively cleared. A large portion of the site was used as a pine plantation which has recently been harvested and removed.

There are a number of dwellings and farm sheds on the subject land.

2.4 Proposed development

The Kings Forest Concept Plan proposes the creation of a residential community inclusive of associated educational, social, commercial, sporting and recreational amenities. The proposed development would be completed in stages and includes substantial areas of open space which would provide substantial riparian buffer areas to the SEPP14 wetlands Cudgen Creek and Cudgen Lake.

Given that the present application is for approval of a concept plan, detailed road and allotment layouts have not been completed for the whole of the project, however preliminary bulk earthworks design, site grading and drainage design has been prepared. The proposed concept plan, prepared by MPS Architects is included in Appendix 1 of this report.

The ultimate proposed development includes the construction and/or installation of the following components:

- site earthworks
- roads / trafficable areas
- stormwater drains
- sewer reticulation mains
- water reticulation mains
- underground electricity distribution cables
- telecommunications cables
- other ancillary services
- construction/building works
- landscaping.

3) Hydrologic assessment method

A hydrological assessment was undertaken to develop hydrographs for flows within the Kings Forest catchment under a range of rainfall events using the Rational Method and the Watershed Bounded Network Model (WBNM) computer modelling software.

3.1 Rational Method

The Rational Method (Section 4.03 QUDM 2007) is flexible in its data requirements and is able to produce satisfactory estimates of peak discharges from a site with the following data input:

- local intensity frequency duration data
- catchment areas
- runoff coefficients.

Discharge using the Rational Method is calculated by:

$$Q = \frac{F_Y C_{10} I A}{360}$$

where: Q = Peak flow (m^3/s)
 F_Y = Frequency factor
 C_{10} = Runoff coefficient (10yr)
 I = Rainfall intensity (mm/hr)
 A = Catchment area (ha)

Peak discharges were estimated for the pre-developed and post-developed cases, at the main discharge point on the eastern site boundary. Estimations were carried out for events with average recurrence intervals (ARI) between 1 and 100 years.

3.1.1 Time of concentration

The time of concentration for the pre-developed catchment was calculated using the method for Eastern New South Wales described in Section 1.4.1 in Book 4 of AR&R (1987):

$$t_c = 0.76A^{0.38}$$

where: t_c = Time of concentration (hours)
 A = Area (km^2)

A catchment plan for the existing site is provided in Drawing No. KJ0224.2.2.

The catchment area draining to the discharge point on the eastern site boundary is 1242.6ha, yielding a time of concentration of 125 minutes.

3.1.2 Local intensity frequency

Rainfall intensities for the simulation of design rainfall events at the site were calculated in accordance with ARR for the Kings Forest catchment ($28^{\circ}18'00''S$, $153^{\circ}33'00''E$) using the IFD tool on the Bureau of Meteorology website to generate IFD coefficients. A copy of the IFD table generated for Kings Forest is provided in Appendix 2.

3.1.3 Runoff coefficients

The runoff coefficient for the 10 year (C_{10}) average recurrence interval (ARI) was adopted based on the recommendations in QUDM (2007).

Using Table 4.05.3(b) from QUDM, an average value of 0.70 was calculated for the catchment under existing conditions.

3.2 WBNM Modelling

The Watershed Bounded Network Model (WBNM) is an event-based hydrologic model which calculates flood hydrographs from storm rainfall hyetographs. It can be used for modelling natural, partially developed and fully developed catchments.

For developed catchments, it calculates runoff from pervious and impervious surfaces and routes it through the major system of open water courses. WBNM does not model the details of piped drainage systems. It can be used to generate hydrographs from an actual storm event and or a design storm utilising Intensity – Frequency – Duration data together with dimensionless storm temporal patterns.

The WBNM model is flexible in its data requirements and is able to produce satisfactory results with the following data input:

- local intensity frequency duration data
- design temporal patterns
- subcatchment areas
- impervious areas.

The model was calibrated by adjusting the model losses and lag parameter (C) values

to closely replicate the runoff estimated by using the Rational Formula.

3.2.1 Storm data

The rainfall intensities for the simulation of the design rainfall events were calculated in accordance with Book 2 of Australian Rainfall and Runoff 1998 (AR&R) as described in Section 3.1.2. The temporal patterns used were those provided in Attachment 3.5D of the GCCC Land Development Guidelines, in accordance with the Tweed Shire Council's Development Design Specification D5.

Losses used in the modelling were estimated in order to replicate the flows calculated using the rational method.

Losses were also determined in conjunction with the recommendations contained in the XP-RAFTS reference manual and those published in Australian Rainfall and Runoff 1998, Book 2, Design Rainfall Considerations, Section 3.4.

The losses adopted for this catchment are shown in Table 3.2.1.

Table 3.2.1 Model losses

Storm ARI (years)	Pervious Initial loss (mm)	Pervious Continuing loss (mm)	Impervious Initial loss (mm)
1	20	2.5	0.5
2	15	2.5	0.5
5	14	2.5	0.5
10	8	2.5	0.5
20	5	2.5	0.5
50	5	2.5	0.5
100	0	1.0	0.5

3.3 Peak flow site characteristics

The physical characteristics of the catchment were described in Section 2 of this report. In its current state, the catchment may be described as rural, with a total area of 1242.6ha, including a site area of 871ha.

For the purpose of the modelling, this was divided into a number of sub-catchments representing flows along the main stream and its tributaries.



GILBERT+SUTHERLAND agriculture · water · environment Eastside 5/232 Robina Town Centre Drive, Robina, Qld. 4226 Phone 55789944 Mobile 0418 760919 Fax 55789945		PROJECT PROJECT 28 PTY LTD KINGS FOREST PROJECT APPLICATION LOCAL HYDROLOGICAL ASSESSMENT EXISTING CATCHMENT PLAN			
FIGURED DIMENSIONS TO BE READ IN PREFERENCE TO SCALING.	APPROVED	SCALE AS SHOWN	DRAWN A.J.F.	DRAWING No. KJ0224.2.2	
		DATE 22/12/2009	CHECKED		

4) Hydrologic assessment results

4.1 Rational Method peak flows

The assumptions adopted to determine the peak flow rates discharging from catchment in its present condition are listed below:

- Runoff coefficient C_{10} 0.70
- Time of concentration t_c 125.1min
- Catchment area A 1424.6ha

The resultant peak flow rates, calculated at the downstream site discharge point, over the standard range of ARI events are shown Table 4.1.1.

Table 4.1.1 Pre-developed peak flows by Rational method

ARI (yrs)	$C_y = F_y \cdot C_{10}$	I (mm/hr)	Q (m ³ /s)
1	0.47	26.3	48.8
2	0.57	33.6	75.3
5	0.64	42.1	107.4
10	0.70	47.0	130.1
20	0.75	53.5	158.6
50	0.82	62.0	201.0
100	0.90	68.4	242.6

4.2 WBNM modelling results

The inputs and assumptions detailed above were incorporated into the WBNM model to generate hydrographs for the subject site.

Peak catchment discharges were estimated for storms with durations ranging from 5 minutes to 2 days for each ARI.

The lag parameter (C) was adjusted and a value of 1.60 was found to produce results that most closely replicated the rational method flows at the downstream end of the catchment for storms with an ARI up to 20 years, with a value of 1.30 found to produce the best results for storms with an ARI greater than 20 years.

The peak flows to the downstream site discharge point of the central drain from the generated hydrographs for the catchment

in its present state under a range of rainfall events are shown in Table 4.2.1 for comparison with the peak flows previously determined by the rational method.

Table 4.2.1 Rational method and WBNM modelled peak flow comparison

ARI (years)	Rational method calculated flow (m ³ /s)	WBNM modelled flow (m ³ /s)
1	48.8	48.5
2	75.3	75.0
5	107.4	107.6
10	130.1	130.8
20	158.6	157.6
50	201.0	202.6
100	242.6	243.3

It is considered that a good correlation was achieved for the model for storm events up to and including the 100 year ARI storm.

The model was then modified to incorporate the proposed development to generate inflow hydrographs for use in the flood modelling.

Peak flows for the same catchment under developed conditions are shown in Table 4.2.2, below.

Table 4.2.2 WBNM modelled peak flows (developed case)

ARI (years)	Developed WBNM modelled flow (m ³ /s)
1	63.8
2	98.3
5	135.5
10	160.3
20	190.1
50	247.2
100	292.5

The increase in peak flows resulting from the development will be attenuated to pre-development levels to ensure no net increase in peak discharge rate at the site discharge point. Design for flow attenuation in being carried out separately by Mortons Urban Solutions.

4.3 Climate change impacts

To assess the predicted impacts of future climate change, modifications were made to the Existing Case model in accordance with the NSW Climate Change Policy, to include 30% increase in rainfall intensity.

This was achieved by increasing the values in the IFD table by 30% and re-running the WBNM model to generate new hydrographs for input into the flood model.

The modified IFD table for climate change is presented in Appendix 1.

Peak flows at the site discharge point for the climate change scenario are provided in Table 4.3.1.

Table 4.3.1 WBNM estimated peak flows under climate change adaption

ARI (years)	Predicted peak flow under climate change scenario (m³/s)
1	72.7
2	110.3
5	153.6
10	182.7
20	217.7
50	281.1
100	332.1

5) Conclusions

A hydrologic analysis of the site has been undertaken to estimate peak site discharge under a range of predicted storm events and to generate flow hydrographs for input into the hydraulic model.

Increased flows, arising from the proposed development will be attenuated locally within each catchment to ensure no worsening in peak flow at the downstream site discharge point.

6) Qualification

This report has been prepared by G&S specifically for Project 28 Pty Ltd, a subsidiary of LEDA Manorstead Pty Ltd, to provide advice on flooding in relation to the Project Application for the Kings Forest development, located in Kingscliff, NSW. As such its use is limited to this purpose and may not be applicable beyond this scope. Third parties should therefore seek advice from G&S on applicability for any other use.

In preparing this report, we have relied on information by others including:

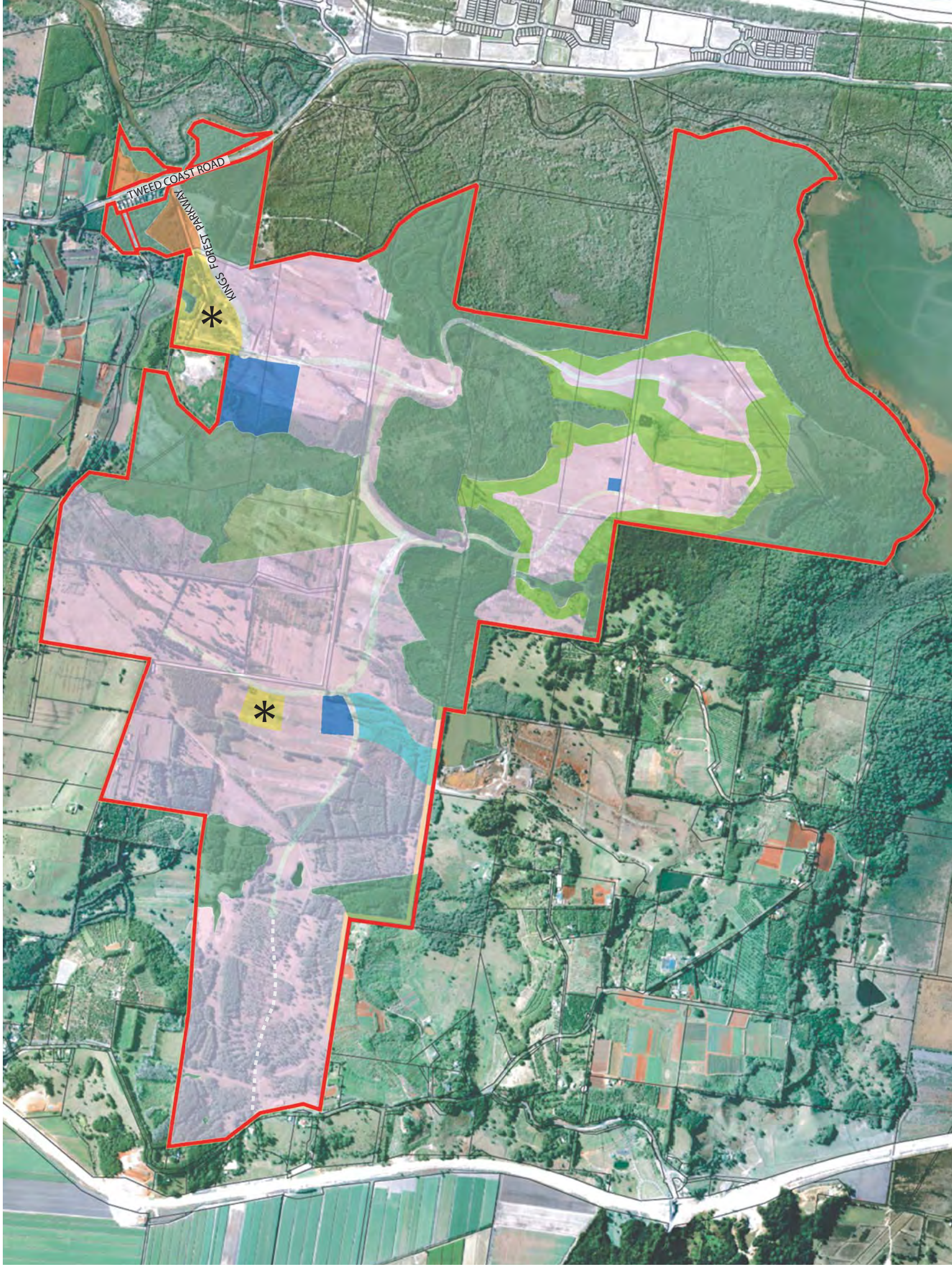
- Site survey supplied by Mortons Urban Solutions
- Concept Plan provided by MPS architects

- Preliminary civil design carried out by Mortons Urban Solutions

The accuracy of this report is limited to the accuracy of this information. While G&S's report accurately assesses flooding from design storms, future observed flood levels may vary from the predicted, depending on the accuracy of rainfall/runoff.

Our analysis and overall approach has been specifically to cater for the particular requirements of LEDA and may not be applicable beyond this scope. For this reason any third parties are not authorised to utilise the report without further input and advice from G&S.

7) Appendix 1 – Kings Forest Concept Plan



- TOWN CENTRE / NEIGHBOURHOOD CENTRE
- RESIDENTIAL SMALL LOT INTEGRATED / ATTACHED
- COMMUNITY FACILITIES / EDUCATION
- EMPLOYMENT LAND
- GOLF COURSE
- STRUCTURED OPEN SPACE (ACTIVE) 17Ha
- ENVIRONMENTAL PROTECTION AREA
- LAKE
- INDICATIVE STATE SCHOOL SITE



0 100 200 400 600 800 1000 m

SCALE 1:20000@A3

PROJECT 28 PTY LTD

CONCEPT PLAN

KINGS FOREST

MPS Architects

1300 368090
OCTOBER 2009
MPS 2142 SK-102g
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8) Appendix 2 – IFD tables for Kings Forest

Rainfall IFD for Kings Forest, Kingscliff

Geographic Location: 28°18'00.00"S 153°33'00.00"E

Generated from BOM online IFD coefficients

16/07/2009

Duration (mins)	1 Year ARI (mm/hour)	2 Year ARI (mm/hour)	5 Year ARI (mm/hour)	10 Year ARI (mm/hour)	20 Year ARI (mm/hour)	50 Year ARI (mm/hour)	100 Year ARI (mm/hour)
5	131.55	165.45	199.82	218.42	244.67	278.33	303.20
5.5	127.18	159.98	193.36	211.46	236.94	269.64	293.82
6	123.21	155.03	187.51	205.15	229.93	261.77	285.33
6.5	119.60	150.51	182.19	199.39	223.55	254.59	277.57
7	116.28	146.38	177.30	194.11	217.70	248.01	270.46
7.5	113.23	142.57	172.80	189.24	212.30	241.94	263.90
8	110.41	139.04	168.63	184.73	207.30	236.31	257.82
8.5	107.78	135.77	164.76	180.54	202.66	231.08	252.16
9	105.33	132.71	161.14	176.62	198.31	226.19	246.87
9.5	103.03	129.85	157.75	172.95	194.25	221.60	241.92
10	100.88	127.16	154.57	169.50	190.42	217.29	237.25
11	96.93	122.24	148.73	163.18	183.41	209.38	228.70
12	93.39	117.83	143.50	157.51	177.11	202.28	221.01
13	90.20	113.84	138.76	152.37	171.41	195.85	214.04
14	87.29	110.21	134.45	147.69	166.21	189.98	207.69
15	84.63	106.89	130.49	143.40	161.44	184.59	201.85
16	82.18	103.82	126.84	139.44	157.04	179.62	196.46
17	79.91	100.99	123.46	135.77	152.96	175.01	191.46
18	77.80	98.35	120.32	132.35	149.16	170.72	186.80
19	75.84	95.89	117.38	129.17	145.61	166.70	182.45
20	73.99	93.59	114.63	126.18	142.28	162.94	178.37
21	72.27	91.43	112.05	123.37	139.15	159.40	174.53
22	70.64	89.39	109.61	120.72	136.20	156.06	170.90
23	69.11	87.47	107.31	118.22	133.41	152.91	167.47
24	67.66	85.65	105.14	115.85	130.77	149.91	164.23
25	66.28	83.93	103.07	113.60	128.26	147.08	161.14
26	64.97	82.29	101.11	111.47	125.88	144.37	158.21
27	63.73	80.73	99.24	109.43	123.61	141.80	155.41
28	62.54	79.24	97.45	107.49	121.44	139.34	152.74
29	61.41	77.83	95.75	105.64	119.36	136.99	150.19
30	60.33	76.47	94.12	103.86	117.38	134.75	147.75
32	58.31	73.92	91.06	100.53	113.66	130.52	143.15
34	56.44	71.58	88.24	97.46	110.22	126.63	138.91
36	54.72	69.41	85.63	94.61	107.04	123.01	134.98
38	53.11	67.40	83.21	91.97	104.08	119.65	131.33
40	51.62	65.53	80.95	89.50	101.31	116.51	127.91
45	48.30	61.35	75.90	83.99	95.14	109.50	120.27
50	45.45	57.76	71.56	79.26	89.83	103.46	113.69
55	42.98	54.64	67.79	75.12	85.19	98.18	107.94
60	40.80	51.89	64.46	71.48	81.10	93.52	102.86
75	35.59	45.31	56.46	62.72	71.25	82.29	90.60
90	31.72	40.42	50.50	56.18	63.88	73.88	81.41
105	28.71	36.62	45.85	51.07	58.14	67.31	74.22
120	26.31	33.58	42.12	46.97	53.51	62.00	68.42
135	24.33	31.07	39.05	43.58	49.69	57.63	63.63
150	22.68	28.97	36.47	40.74	46.47	53.94	59.59
165	21.27	27.19	34.27	38.31	43.73	50.80	56.14
180	20.06	25.65	32.38	36.22	41.36	48.07	53.15
195	19.00	24.31	30.72	34.38	39.29	45.69	50.53
210	18.07	23.12	29.26	32.76	37.46	43.58	48.22
225	17.24	22.07	27.96	31.33	35.83	41.71	46.16
240	16.50	21.13	26.79	30.04	34.37	40.03	44.32
270	15.23	19.52	24.80	27.82	31.86	37.13	41.14
300	14.19	18.19	23.14	25.99	29.78	34.73	38.50
360	12.55	16.11	20.55	23.11	26.51	30.96	34.34
420	11.33	14.55	18.60	20.95	24.05	28.12	31.22
480	10.38	13.34	17.09	19.26	22.13	25.90	28.77
540	9.62	12.37	15.87	17.90	20.59	24.11	26.79
600	8.99	11.57	14.86	16.78	19.31	22.63	25.15
660	8.47	10.90	14.02	15.84	18.24	21.38	23.78
720	8.02	10.33	13.30	15.03	17.32	20.31	22.60
840	7.29	9.40	12.13	13.72	15.83	18.58	20.69
960	6.73	8.68	11.22	12.70	14.66	17.22	19.18
1080	6.28	8.10	10.48	11.87	13.71	16.12	17.97
1200	5.90	7.62	9.87	11.19	12.93	15.21	16.96
1320	5.58	7.21	9.35	10.61	12.26	14.44	16.10
1440	5.31	6.86	8.90	10.10	11.69	13.77	15.36
1800	4.67	6.04	7.85	8.93	10.34	12.19	13.61
2160	4.20	5.44	7.08	8.06	9.34	11.03	12.32
2520	3.83	4.96	6.48	7.38	8.56	10.11	11.31
2880	3.53	4.58	5.98	6.81	7.91	9.35	10.47
3240	3.27	4.25	5.55	6.33	7.36	8.71	9.75
3600	3.05	3.96	5.18	5.92	6.88	8.14	9.12
3960	2.85	3.71	4.86	5.54	6.45	7.64	8.57
4320	2.68	3.48	4.56	5.21	6.06	7.19	8.06

Rainfall IFD for Kings Forest, Kingscliff - Intensities increased by 30% to account for predicted climate change
Geographic Location: 28°18'00.00"S 153°33'00.00"E

Generated from BOM online IFD coefficients 16/07/2009

Duration (mins)	1 Year ARI (mm/hour)	2 Year ARI (mm/hour)	5 Year ARI (mm/hour)	10 Year ARI (mm/hour)	20 Year ARI (mm/hour)	50 Year ARI (mm/hour)	100 Year ARI (mm/hour)
5	171.01	215.09	259.77	283.95	318.08	361.83	394.16
5.5	165.33	207.97	251.37	274.89	308.02	350.53	381.97
6	160.18	201.53	243.77	266.69	298.91	340.30	370.92
6.5	155.48	195.67	236.84	259.21	290.61	330.97	360.84
7	151.17	190.29	230.49	252.34	283.00	322.41	351.60
7.5	147.20	185.34	224.64	246.01	275.99	314.52	343.07
8	143.53	180.76	219.22	240.15	269.49	307.20	335.16
8.5	140.11	176.50	214.18	234.70	263.45	300.40	327.81
9	136.93	172.53	209.48	229.61	257.81	294.04	320.93
9.5	133.94	168.81	205.08	224.84	252.52	288.08	314.49
10	131.14	165.31	200.94	220.36	247.55	282.48	308.43
11	126.01	158.91	193.35	212.13	238.43	272.20	297.31
12	121.41	153.18	186.54	204.76	230.25	262.97	287.31
13	117.26	148.00	180.39	198.08	222.84	254.61	278.26
14	113.48	143.28	174.78	192.00	216.08	246.98	269.99
15	110.02	138.95	169.63	186.42	209.88	239.97	262.40
16	106.83	134.97	164.89	181.27	204.15	233.51	255.40
17	103.88	131.29	160.50	176.50	198.85	227.51	248.90
18	101.14	127.86	156.41	172.06	193.91	221.93	242.84
19	98.59	124.66	152.60	167.92	189.29	216.71	237.19
20	96.19	121.67	149.02	164.03	184.97	211.82	231.88
21	93.95	118.86	145.66	160.38	180.90	207.22	226.88
22	91.83	116.21	142.50	156.94	177.06	202.88	222.17
23	89.84	113.71	139.51	153.69	173.44	198.78	217.72
24	87.95	111.35	136.68	150.61	170.00	194.89	213.50
25	86.16	109.11	133.99	147.69	166.74	191.20	209.49
26	84.46	106.98	131.44	144.91	163.64	187.69	205.67
27	82.85	104.95	129.01	142.26	160.69	184.34	202.04
28	81.31	103.02	126.69	139.74	157.87	181.15	198.56
29	79.84	101.17	124.47	137.33	155.17	178.09	195.25
30	78.43	99.41	122.36	135.02	152.60	175.17	192.07
32	75.80	96.10	118.38	130.69	147.75	169.68	186.10
34	73.37	93.05	114.72	126.70	143.29	164.61	180.59
36	71.13	90.24	111.32	123.00	139.15	159.92	175.48
38	69.05	87.62	108.17	119.56	135.30	155.55	170.72
40	67.11	85.18	105.23	116.35	131.71	151.47	166.29
45	62.79	79.75	98.67	109.19	123.68	142.35	156.36
50	59.09	75.09	93.03	103.03	116.78	134.49	147.80
55	55.87	71.03	88.12	97.66	110.75	127.63	140.32
60	53.04	67.46	83.80	92.93	105.43	121.58	133.72
75	46.26	58.91	73.40	81.53	92.62	106.98	117.78
90	41.23	52.55	65.65	73.03	83.05	96.04	105.83
105	37.33	47.61	59.61	66.39	75.58	87.50	96.49
120	34.20	43.65	54.76	61.06	69.56	80.61	88.95
135	31.63	40.39	50.77	56.66	64.59	74.92	82.71
150	29.48	37.67	47.42	52.96	60.42	70.13	77.47
165	27.65	35.35	44.56	49.81	56.85	66.03	72.98
180	26.07	33.34	42.09	47.08	53.77	62.49	69.10
195	24.70	31.60	39.93	44.70	51.07	59.39	65.69
210	23.49	30.06	38.03	42.59	48.69	56.66	62.69
225	22.41	28.70	36.34	40.72	46.58	54.22	60.01
240	21.45	27.47	34.83	39.05	44.68	52.03	57.61
270	19.81	25.38	32.23	36.17	41.42	48.28	53.48
300	18.44	23.65	30.08	33.78	38.71	45.15	50.05
360	16.32	20.94	26.71	30.04	34.46	40.25	44.65
420	14.73	18.92	24.19	27.23	31.27	36.56	40.58
480	13.50	17.35	22.22	25.04	28.77	33.67	37.39
540	12.50	16.08	20.63	23.27	26.76	31.34	34.82
600	11.69	15.04	19.32	21.81	25.10	29.41	32.70
660	11.01	14.17	18.23	20.59	23.71	27.79	30.91
720	10.43	13.43	17.29	19.54	22.51	26.41	29.38
840	9.48	12.22	15.77	17.84	20.57	24.16	26.89
960	8.75	11.28	14.58	16.51	19.06	22.39	24.94
1080	8.16	10.53	13.62	15.44	17.83	20.96	23.36
1200	7.67	9.90	12.83	14.54	16.81	19.77	22.04
1320	7.26	9.37	12.15	13.79	15.94	18.77	20.93
1440	6.90	8.92	11.57	13.14	15.19	17.90	19.96
1800	6.07	7.85	10.21	11.60	13.44	15.85	17.69
2160	5.46	7.07	9.21	10.48	12.15	14.34	16.02
2520	4.98	6.45	8.42	9.59	11.13	13.15	14.70
2880	4.59	5.95	7.77	8.86	10.28	12.16	13.61
3240	4.26	5.52	7.22	8.23	9.57	11.32	12.67
3600	3.97	5.15	6.74	7.69	8.94	10.59	11.86
3960	3.71	4.82	6.31	7.21	8.39	9.93	11.14
4320	3.48	4.52	5.93	6.77	7.88	9.35	10.48

12 Appendix 3 – ‘Revised Local Hydrological Assessment Results, Kings Forest, Kingscliff, NSW’ (Gilbert & Sutherland, July 2010)

Table 11.1.1 shows the peak flows discharging from the site under a Climate Change scenario adopting a 10% increase in rainfall intensity when compared to the existing situation, as estimated by our revised WBNM computer modelling. This table replaces the data displayed in Table 4.3.1 of the Local Hydrological Assessment (Appendix 2 to this report).

Table 11.1.1 WBNM estimated peak flows under climate change adaption for 10% increase in rainfall intensity

ARI (years)	Predicted peak flow under climate change scenario (m ³ /s)
1	56.4
2	86.6
5	122.8
10	147.8
20	177.6
50	228.6
100	272.3

Rainfall IFD for Kings Forest, Kingscliff - Intensities increased by 10% to account for predicted climate change
 Geographic Location: 28°18'00.00"S 153°33'00.00"E

Generated from BOM online IFD coefficients 16/07/2009

Duration (mins)	1 Year ARI (mm/hour)	2 Year ARI (mm/hour)	5 Year ARI (mm/hour)	10 Year ARI (mm/hour)	20 Year ARI (mm/hour)	50 Year ARI (mm/hour)	100 Year ARI (mm/hour)
5	144.70	182.00	219.80	240.26	269.14	306.16	333.52
5.5	139.89	175.98	212.70	232.60	260.63	296.60	323.21
6	135.53	170.53	206.27	225.66	252.93	287.95	313.86
6.5	131.56	165.56	200.40	219.33	245.90	280.05	305.33
7	127.91	161.02	195.03	213.52	239.47	272.81	297.51
7.5	124.56	156.83	190.08	208.17	233.53	266.13	290.29
8	121.45	152.95	185.50	203.21	228.03	259.94	283.60
8.5	118.56	149.34	181.23	198.59	222.92	254.18	277.38
9	115.86	145.98	177.25	194.28	218.15	248.80	271.56
9.5	113.34	142.84	173.53	190.25	213.67	243.76	266.11
10	110.96	139.88	170.02	186.45	209.46	239.02	260.98
11	106.62	134.46	163.60	179.50	201.75	230.32	251.57
12	102.73	129.61	157.85	173.26	194.82	222.51	243.11
13	99.22	125.23	152.64	167.61	188.55	215.44	235.45
14	96.02	121.23	147.89	162.46	182.83	208.98	228.45
15	93.09	117.58	143.54	157.74	177.59	203.05	222.03
16	90.40	114.21	139.52	153.38	172.74	197.58	216.11
17	87.90	111.09	135.81	149.34	168.26	192.51	210.61
18	85.58	108.19	132.35	145.59	164.08	187.79	205.48
19	83.42	105.48	129.12	142.08	160.17	183.37	200.70
20	81.39	102.95	126.10	138.80	156.51	179.23	196.20
21	79.49	100.57	123.25	135.71	153.07	175.34	191.98
22	77.71	98.33	120.57	132.79	149.82	171.67	187.99
23	76.02	96.22	118.04	130.04	146.75	168.20	184.22
24	74.42	94.22	115.65	127.44	143.85	164.91	180.65
25	72.91	92.32	113.38	124.97	141.09	161.78	177.26
26	71.47	90.52	111.22	122.62	138.47	158.81	174.03
27	70.10	88.80	109.16	120.38	135.97	155.98	170.95
28	68.80	87.17	107.20	118.24	133.58	153.28	168.02
29	67.55	85.61	105.32	116.20	131.30	150.69	165.21
30	66.37	84.12	103.53	114.25	129.12	148.22	162.52
32	64.14	81.32	100.17	110.58	125.02	143.58	157.47
34	62.08	78.74	97.07	107.20	121.24	139.29	152.81
36	60.19	76.35	94.20	104.08	117.74	135.31	148.48
38	58.43	74.14	91.53	101.17	114.48	131.62	144.46
40	56.79	72.08	89.04	98.45	111.45	128.17	140.70
45	53.13	67.48	83.49	92.39	104.66	120.45	132.30
50	50.00	63.53	78.72	87.18	98.81	113.80	125.06
55	47.28	60.10	74.57	82.64	93.71	108.00	118.73
60	44.88	57.08	70.90	78.63	89.21	102.88	113.15
75	39.15	49.84	62.11	68.99	78.37	90.52	99.66
90	34.89	44.46	55.55	61.79	70.27	81.27	89.55
105	31.59	40.28	50.44	56.18	63.95	74.04	81.64
120	28.94	36.93	46.34	51.66	58.86	68.21	75.26
135	26.77	34.18	42.96	47.94	54.65	63.39	69.99
150	24.95	31.87	40.12	44.81	51.12	59.34	65.55
165	23.40	29.91	37.70	42.14	48.11	55.88	61.75
180	22.06	28.21	35.61	39.84	45.50	52.88	58.47
195	20.90	26.74	33.79	37.82	43.22	50.26	55.59
210	19.87	25.44	32.18	36.04	41.20	47.94	53.05
225	18.96	24.28	30.75	34.46	39.41	45.88	50.78
240	18.15	23.25	29.47	33.04	37.81	44.03	48.75
270	16.76	21.48	27.28	30.61	35.05	40.85	45.25
300	15.61	20.01	25.45	28.59	32.76	38.21	42.35
360	13.81	17.72	22.60	25.42	29.16	34.05	37.78
420	12.46	16.01	20.47	23.04	26.46	30.93	34.34
480	11.42	14.68	18.80	21.18	24.35	28.49	31.64
540	10.58	13.61	17.46	19.69	22.65	26.52	29.47
600	9.89	12.73	16.35	18.46	21.24	24.89	27.67
660	9.31	11.99	15.42	17.42	20.06	23.52	26.16
720	8.82	11.36	14.63	16.53	19.05	22.35	24.86
840	8.02	10.34	13.34	15.10	17.41	20.44	22.75
960	7.40	9.55	12.34	13.97	16.12	18.95	21.10
1080	6.90	8.91	11.53	13.06	15.08	17.74	19.76
1200	6.49	8.38	10.85	12.31	14.22	16.73	18.65
1320	6.14	7.93	10.28	11.67	13.49	15.88	17.71
1440	5.84	7.54	9.79	11.11	12.86	15.14	16.89
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3240	3.60	4.67	6.11	6.97	8.10	9.58	10.72
3600	3.36	4.36	5.70	6.51	7.57	8.96	10.04
3960	3.14	4.08	5.34	6.10	7.10	8.41	9.42
4320	2.94	3.82	5.02	5.73	6.67	7.91	8.87

13 Appendix 4 – Letter from Neil Collins BMT WBM

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16 December 2010

Gilbert & Sutherland
20/115 Wickham Street
FORTITUDE VALLEY QLD 4006

Attention: Nathan Zurig

Dear Nathan

Re: Latest Layout – Kings Forest

With reference to your previous correspondence in relation to the above matter, I wish to advise that the design for the western precinct as referred to in your email of 13 December 2010 could be considered "generally in accordance with the modelled design" as reported in Gilbert and Sutherland's letter of 16 July 2010 (KJ0224-1_FLD4_CNC1F).

Whilst there are some minor changes in the offstream lake shape, the effects of these changes on flooding would not be significant.

If you require any further clarification on this matter, please do not hesitate to contact me.

Yours faithfully
BMT WBM Pty Ltd

A handwritten signature in black ink, appearing to read "N. Collins".

Neil Collins
Principal Hydraulic and Water Resources Engineer