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FLOW VELOCITY MODELLING

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ARRAWARRA CARAVAN PARK COASTAL PROTECTION WORKS

Flow Velocity Modelling

January 2017

Astoria Group

ARRAWARRA CARAVAN PARK COASTAL PROTECTION WORKS

Flow Velocity Modelling

Prepared by
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on behalf of
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Report No. 3530/R02/FINAL
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Tables

1.0 Introduction

Astoria Group Pty Ltd (Astoria) is seeking approval to subdivide Arrawarra Beach Caravan Park. The township of Arrawarra is located on the east coast of New South Wales approximately 30 kilometres north of Coffs Harbour.

A Flooding and Stormwater Assessment (Umwelt, June 2016) was submitted with the development application.

NSW Coastal Assessment Plan, who is considering the development application engaged Royal HaskoningDHV (RHDHV) to undertake an assessment of the impacts of the proposed revetment or seawall that forms part of the proposed development.

RHDHV's concluded that:

> *'based on the key engineering elements as presented by the proponent: saddle bed level affecting wave penetration into the creek (Item 16), toe scour (Item 22), armour size (Item 19) and wave overtopping (Items 4, 24 and 25), and given that no assessment has been made to quantify off-site erosion impacts (Item 8 and Section 4), inadequate information is currently before the NSW Coastal Panel in order for it to consider approval of the proposed revetment.'*

This supplementary report explores changes in channel velocity and the potential for toe scour and off-site erosion impacts as a result of the proposed development.

2.0 Previous Flood Modelling

In June 2016 Umwelt prepared a Flood and Stormwater Assessment report for the site. Flooding assessment was undertaken Using XP-Storm which is a one dimensional hydrodynamic model. The extent of the XP-Storm model and node and link locations for the model are shown on **Figure 1**.

This modelling explored flooding conditions under seven scenarios. Model attributes and modelled flood levels for each of the scenarios for the existing and developed conditions are set out in **Table 1**.

Table 1 Modelled Scenarios and Flood Levels for Existing Conditions

Scenario ID	1 Existing_ 1_1_5%AEP	2 Existing_1_ 5_1%AEP	3 Existing_2 %AEP	4 Existing_5 %AEP	5 Existing_1 0%AEP	6 Existing_2 0%AEP	7 Existing_5 0%AEP
Storm Event (years ARI)	100	100	50	20	10	5	2
Critical Duration (Hrs) at Outlet	72	72	72	2	2	2	2
Storm Event (% AEP)	1%	1%	2%	5%	10%	20%	50%
Catchment Flood (% AEP)	1%	5%	2%	5%	10%	20%	50%
Ocean Tide (% AEP) or Water Level Boundary Scenario	5%	1%	5%	HHWS(SS)	HHWS(SS)	HHWS(SS)	HHWS(SS)
Tide Peak Level (mAHD)	2.45	2.65	2.45	1.25	1.25	1.25	1.25
Modelled Tidal Cycle	Dynamic Hydrograph	Dynamic Hydrograph	Dynamic Hydrograph	Fixed Elevation	Fixed Elevation	Fixed Elevation	Fixed Elevation
Existing Water Elevation at junction Arrawarra Creek and Unnamed Tributary (mAHD)	2.452	2.651	2.452	2.136	2.015	1.92	1.743
Developed Water Elevation at junction Arrawarra Creek and Unnamed Tributary (mAHD)	2.452	2.652	2.452	2.141	2.017	1.924	1.741

As set out in **Table 1** modelling indicated that the combination of the 5% AEP storm event in the creek system combined with a 1% AEP ocean tide level (Scenario 2 in **Table 1**) resulted in the maximum modelled flood elevation at the site of 2.65 mAHD. This reflects the dominance of the ocean tide condition in dictating flood levels at the site.

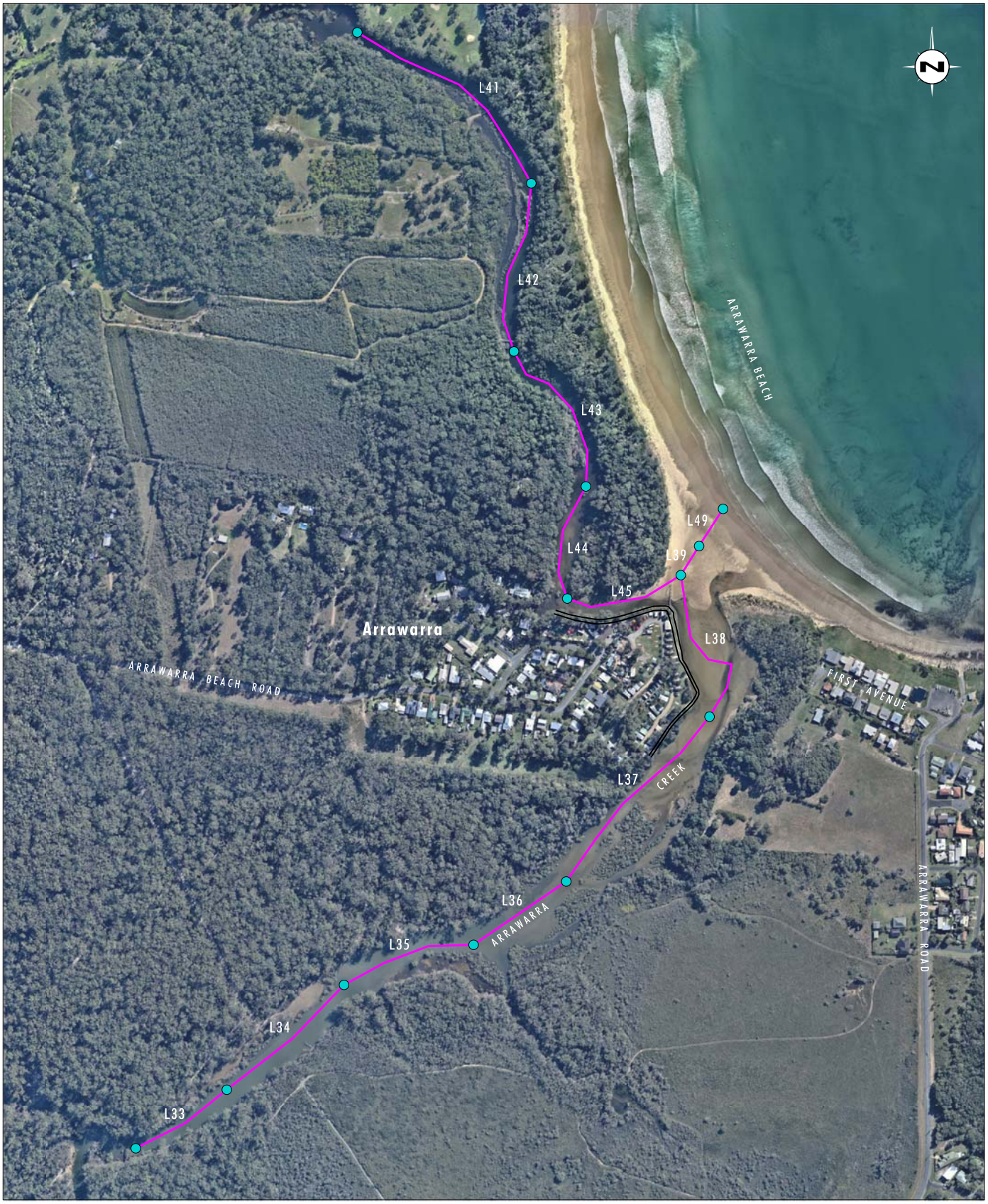


Image Source: Google Earth, CNES/Astrium (2015)

0 100 200 400m
1:7500

Legend

- Proposed Revetment of Arrawarra Caravan Park
- XP Strom Link
- XP Storm Node

FIGURE 1

XP Storm Hydrodynamic Model Links

3.0 Flood Velocities

3.1 One Dimensional Modelling Results

As part of the one dimensional hydrodynamic modelling undertaken for the proposed development, maximum in-channel velocities were also determined for each of the modelled scenarios at each of the modelled links between nodes as shown on **Figure 1**. The results of this analysis for the existing creek system and developed with seawall constructed are summarised **Tables 2** and **3** respectively.

Table 2 Modelled Maximum Velocities by Scenario for Existing Conditions

Link ID/ Scenario Number	1	2	3	4	5	6	7
L33	0.789	0.706	0.773	1.335	1.283	1.244	1.136
L34	0.434	0.379	0.422	0.769	0.689	0.634	0.529
L35	0.662	0.598	0.653	0.969	0.939	0.896	0.759
L36	0.25	0.214	0.243	0.349	0.321	0.298	0.26
L37	0.686	0.588	0.67	0.885	0.828	0.784	0.699
L38	0.486	0.388	0.471	0.669	0.604	0.557	0.483
L41	0.467	0.421	0.46	0.671	0.65	0.624	0.54
L42	0.518	0.443	0.502	0.751	0.689	0.631	0.535
L43	0.665	0.571	0.647	0.871	0.813	0.761	0.662
L44	0.414	0.343	0.402	0.529	0.5	0.469	0.402
L45	0.584	0.464	0.564	0.702	0.673	0.641	0.565

Table 3 Modelled Maximum Velocities by Scenario for Developed Conditions

Link ID/ Scenario Number	1	2	3	4	5	6	7
L33	0.775	0.669	0.734	1.336	1.284	1.253	1.145
L34	0.429	0.359	0.402	0.762	0.684	0.632	0.536
L35	0.646	0.567	0.62	0.956	0.927	0.879	0.739
L36	0.245	0.202	0.228	0.343	0.316	0.295	0.251
L37	0.718	0.601	0.676	0.921	0.871	0.823	0.725
L38	0.48	0.362	0.44	0.666	0.6	0.553	0.472
L41	0.469	0.412	0.449	0.67	0.649	0.623	0.54
L42	0.52	0.426	0.484	0.752	0.691	0.633	0.543
L43	0.669	0.552	0.629	0.875	0.817	0.768	0.678
L44	0.418	0.329	0.39	0.547	0.514	0.477	0.408
L45	0.624	0.456	0.57	0.832	0.774	0.718	0.604

As can be seen from **Table 2**, maximum modelled velocity within the each of the links used to represent the existing creek system ranges from 0.214 m/s at Link L36 (approximately 400 m upstream of the site) under Scenario 2 to 1.335 m/s at the upstream boundary of the model on Arrawarra Creek (Link L33) under Scenario 4.

As can be seen from **Table 3**, maximum modelled velocity within the developed creek system (i.e. with proposed seawall constructed) ranges from 0.202 m/s at Link L36 under Scenario 2 to 1.336 m/s at Link L33.

As can be seen from this analysis, the range of modelled velocities for the existing and developed systems are similar.

Modelling indicates that within the scenarios modelled, lowest maximum velocity typically occur when ocean tide level is high (Scenario 2) with highest velocities occurring when ocean tide level is at High High Water Springs (Solstice Spring) (HHWS(SS)) with a 5% AEP flood in the creek system (Scenario 4).

The change in velocity at each of the model links for each of the scenarios modelled has been determined from **Tables 2** and **3** and is summarised in **Table 4**.

Table 4 Modelled Changes in Velocity for each of the Modelled Scenarios

Link ID/ Scenario Number	1	2	3	4	5	6	7
L33	-0.01	-0.04	-0.04	0.00	0.00	0.01	0.01
L34	-0.01	-0.02	-0.02	-0.01	0.00	0.00	0.01
L35	-0.02	-0.03	-0.03	-0.01	-0.01	-0.02	-0.02
L36	-0.01	-0.01	-0.02	-0.01	-0.01	0.00	-0.01
L37	0.03	0.01	0.01	0.04	0.04	0.04	0.03
L38	-0.01	-0.03	-0.03	0.00	0.00	0.00	-0.01
L41	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00
L42	0.00	-0.02	-0.02	0.00	0.00	0.00	0.01
L43	0.00	-0.02	-0.02	0.00	0.00	0.01	0.02
L44	0.00	-0.01	-0.01	0.02	0.01	0.01	0.01
L45	0.04	-0.01	0.01	0.13	0.10	0.08	0.04

As shown on **Figure 1,** the one dimensional model developed for the Arrawarra Creek system extends from approximately 1 km upstream of the site on both Arrawarra and Yarrawarra Creeks to the outlet at Arrawarra Beach.

As shown in **Table 4**, modelled changes in velocity based on the one dimensional modelling that has been undertaken, range from a decrease of 0.04 m/s from existing to developed at the upstream boundary on Arrawarra Creek (Link L33) for Scenarios 2 and 3 to an increase of 0.13 m/s adjacent the site on Yarrawarra Creek (Link L45) under Scenario 4.

Based on the results of the one dimensional modelling that was undertaken (Umwelt, June 2016), predicted changes in velocity in the Arrawarra Creek system are negligible with the greatest increase predicted adjacent to the site at Link L45 under Scenario 4.

This modelling indicates that the potential for increased erosion at locations away from or off-site as a result of the proposed development are negligible.

3.2 Two Dimensional Modelling Results

One dimensional flood modelling as discussed in **Section 3.1** calculates the average velocity across a cross-section that is representative of each of the sections of creek represented by a link in the model. Modelled links for the creek system are shown on **Figure 1**.

In reality, velocity within the creek system varies across the creek and within each of the sections represented by a link in the model. To explore further, potential changes in velocity as a result of the

proposed development, a two dimensional hydrodynamic model of the creek system surrounding the site was developed using RMA. The extent of the area modelled and finite element meshes used for the existing and developed scenarios are shown on **Figure 2**.

As shown on **Figure 2**, the model extent covers the same extent of the creek system as shown on **Figure 1**.

The two dimensional finite element model, the extent of which is shown on **Figure 2**, was developed using available survey information for the existing and developed sites. Creek inflows, hydraulic roughness characteristics and downstream/tailwater conditions are the same as was adopted for the one-dimensional model.

As discussed in **Section 3.1**, one dimensional modelling indicated that maximum predicted increase in velocity as a result of the proposed development occurred adjacent the proposed site (Link L45) under Scenario 4 (ocean tide level is at High High Water Springs (Solstice Spring) (HHWS(SS)) with a 5% AEP flood in the creek system).

To explore potential impacts in terms of erosion and scouring, flood and ocean tide level conditions of Scenario 4 were modelled using the two dimensional model shown on **Figure 2**.

Modelled flood extents using the one dimensional model for existing and developed sites (Umwelt, June 2016) are shown on **Figures 3.1** and **3.2** respectively.

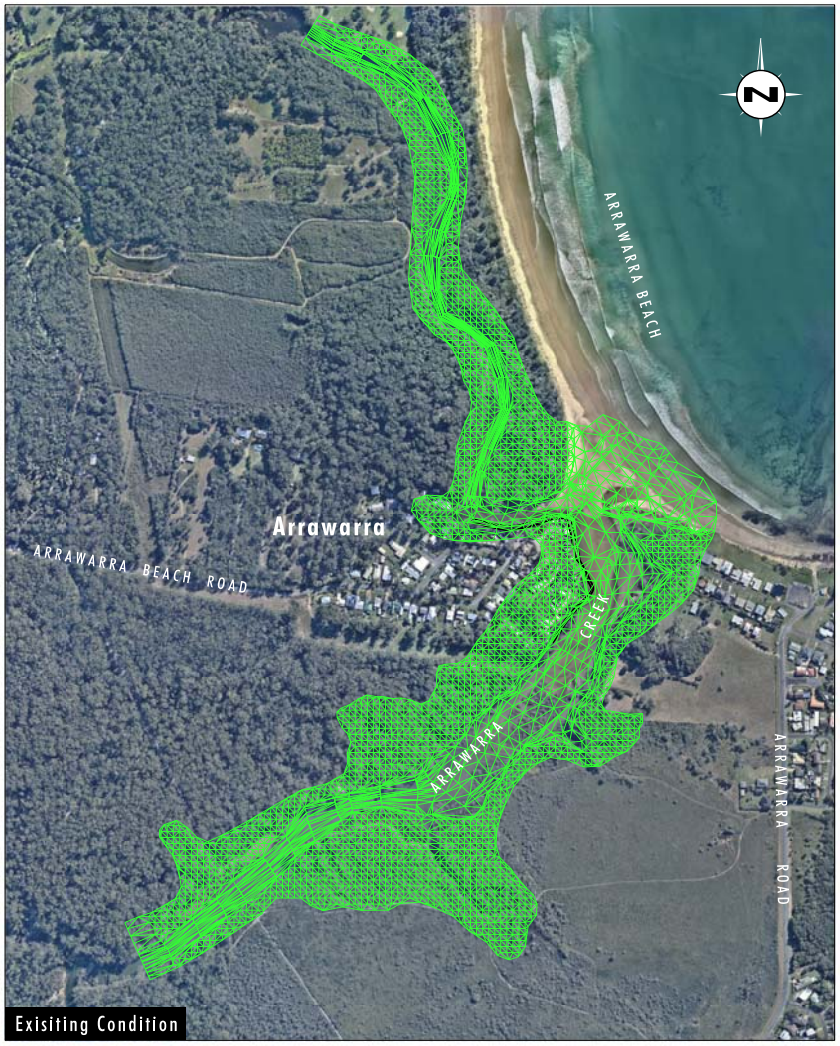
Modelled flood depths for Scenario 4 using the two dimensional model for existing and developed sites are shown on **Figures 3.3** and **3.4** respectively.

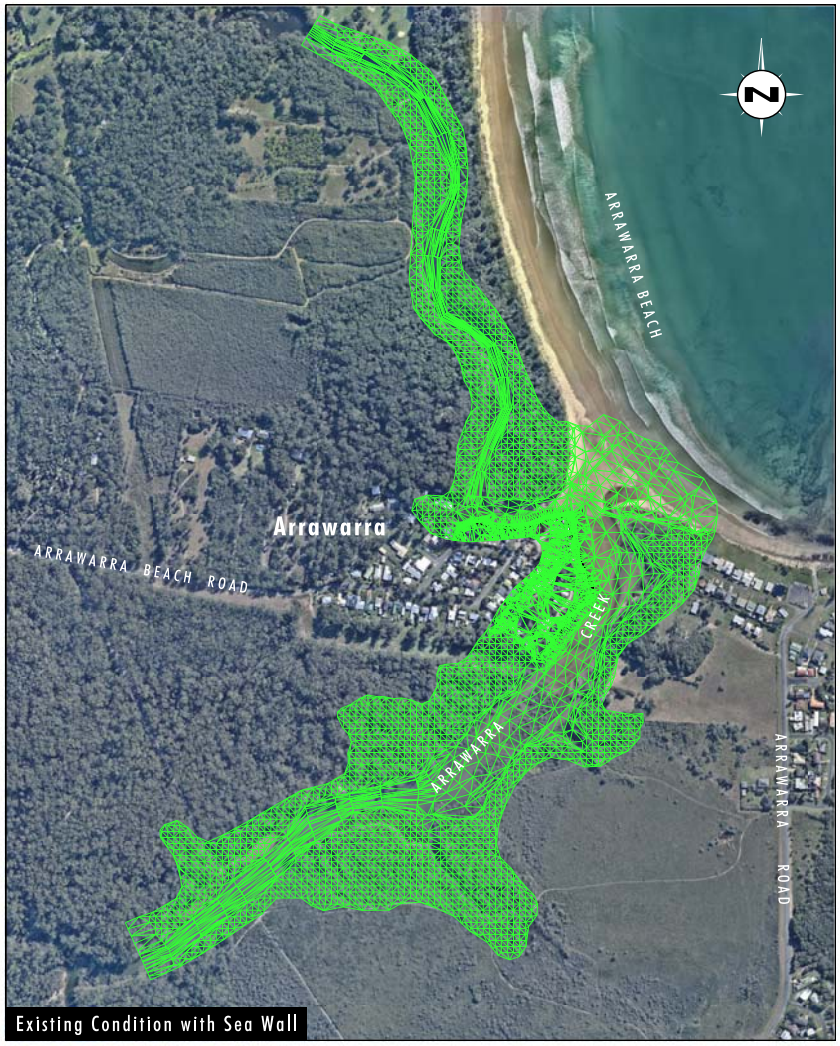
Modelled flood velocities for Scenario 4 using the two dimensional model for existing and developed sites are shown on **Figures 3.5** and **3.6** respectively.

The results of two dimensional modelling for the modelled difference in velocity between existing and developed landform for Scenario 4 are shown on **Figure 3.7** and in more detail on **Figures 3.7A, 3.7B** and **3.7C**.

As can be seen on **Figure 3.7A**, two dimensional modelling indicates that velocities adjacent to the site in Yarrawarra Creek are predicted to increase by up to 0.2 m/s with velocities upstream and on the northern bank of Yarrawarra Creek adjacent the site either not changing or decreasing.

As can be seen on **Figures 3.7B** and **3.7C**, two dimensional modelling indicates that velocities adjacent to the eastern side of the site in Arrawarra Creek are predicted to increase by up to 0.2 m/s with velocities upstream and on the eastern bank of Arrawarra Creek adjacent the site either not changing or decreasing.





Legend

Proposed Revetment of Arrawarra Caravan Park

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Image Source: Google Earth, CNES/Astrium (2015)

File Name (A4): R02/3530_021.dgn
20140214 9.05

FIGURE 2

RMA 2D Flood Models
Exisiting Condition and
Existing Condition with Sea Wall

Image Source: Google Earth, CNES/Astrium (2015)

0 100 200 400m
1:7500

Legend

- Proposed Revetment of Arrawarra Caravan Park
- 1% AEP Flood Extent (1% AEP Catchment Flood and 5% AEP Ocean Water Level)
- 1% AEP Flood Extent (5% AEP Catchment Flood and 1% AEP Ocean Water Level)
- 2% AEP Flood Extent
- 5% AEP Flood Extent
- 10% AEP Flood Extent
- 20% AEP Flood Extent
- 50% AEP Flood Extent

FIGURE 3.1

1, 5, 10, 20 and 100% AEP Flood Extents, Existing Landform

File Name (A4): R02/3530_022.dgn
20160518 9.14

Image Source: Google Earth, CNES/Astrium (2015)

0 100 200 400m
1:7500

Legend

- Proposed Revetment of Arrawarra Caravan Park
- 1% AEP Flood Extent (1% AEP Catchment Flood and 5% AEP Ocean Water Level)
- 1% AEP Flood Extent (5% AEP Catchment Flood and 1% AEP Ocean Water Level)
- 2% AEP Flood Extent
- 5% AEP Flood Extent
- 10% AEP Flood Extent
- 20% AEP Flood Extent
- 50% AEP Flood Extent

FIGURE 3.2

1, 5, 10, 20 and 100% AEP Flood Extents, Existing Landform with Sea Wall Designed

File Name (A4): R02/3530_023.dgn
20160518 9.15

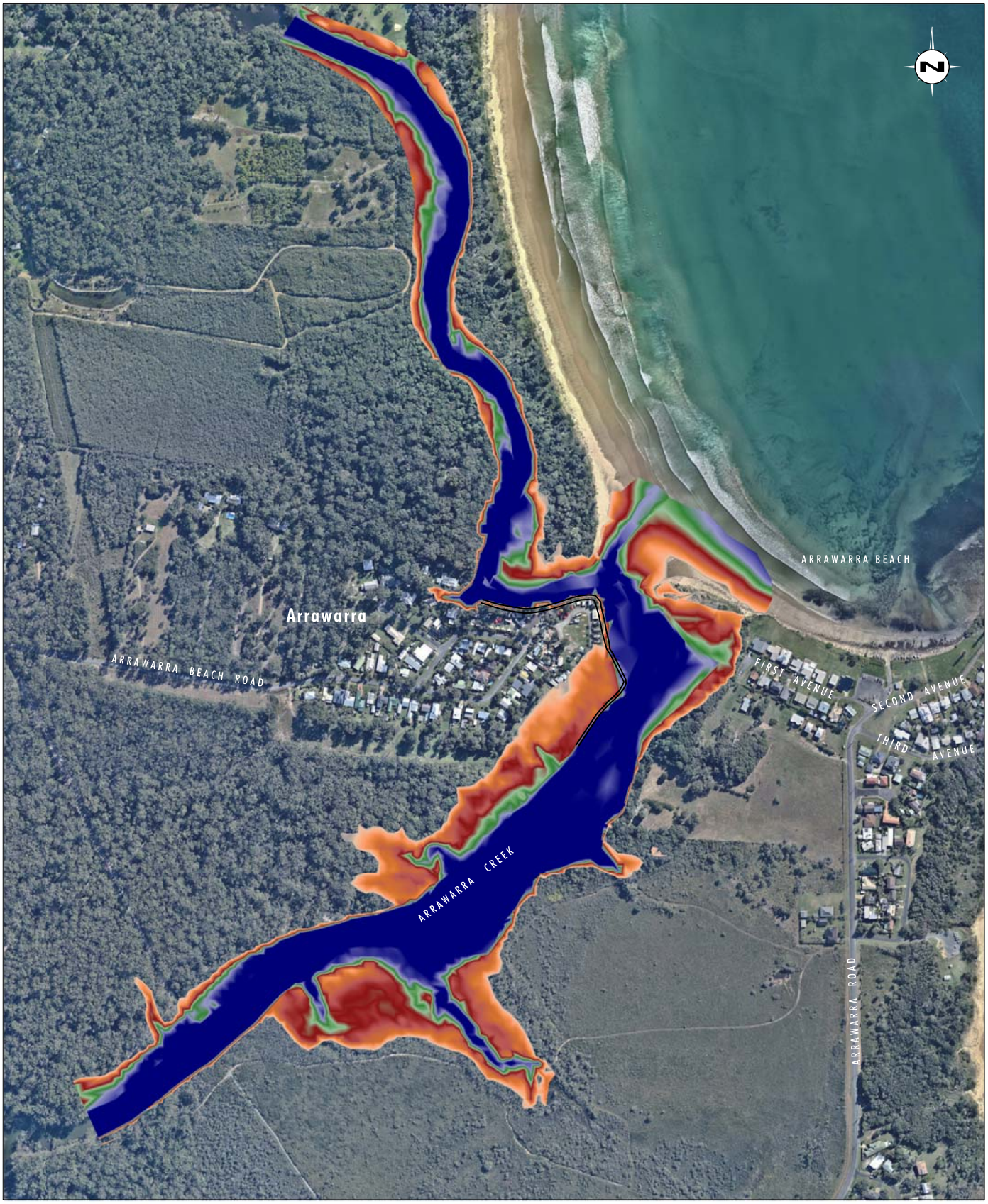

Image Source: Nearmap (May 2016)

0 100 200 400m

1:7500

Legend

Proposed Revetment of Arrawarra Caravan Park

Water Depth (m)

- Range [0.001 : 0.100]
- Range [0.100 : 0.300]
- Range [0.300 : 0.500]
- Range [0.500 : 0.700]
- Range [0.700 : 0.900]
- Range [0.900 : 1.100]
- Range [1.100 : 1.300]
- Range [1.300 : 1.500]
- Range [1.500 : 1.700]
- Range [1.700 : 1.900]
- Range [>1.900]

FIGURE 3.3

5% AEP Flood Event, Maximum Depth, Existing Landform

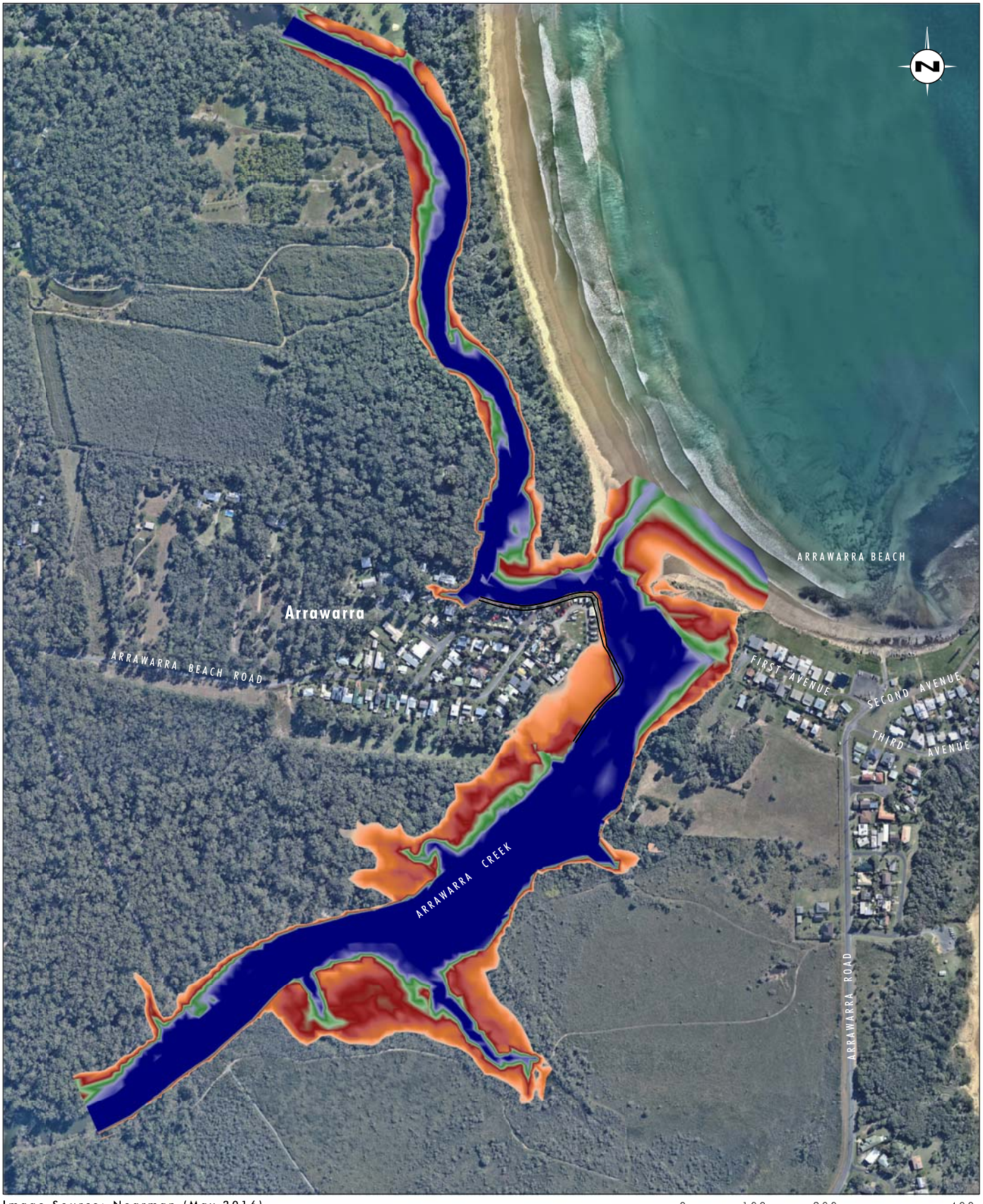

Image Source: Nearmap (May 2016)

0 100 200 400m

1:7500

Legend

Proposed Revetment of Arrawarra Caravan Park

Water Depth (m)

- Range [0.001 : 0.100]
- Range [0.100 : 0.300]
- Range [0.300 : 0.500]
- Range [0.500 : 0.700]
- Range [0.700 : 0.900]
- Range [0.900 : 1.100]
- Range [1.100 : 1.300]
- Range [1.300 : 1.500]
- Range [1.500 : 1.700]
- Range [1.700 : 1.900]
- Range [>1.900]

FIGURE 3.4

5% AEP Flood Event, Maximum Depth, Existing Landform with Sea Wall Designed

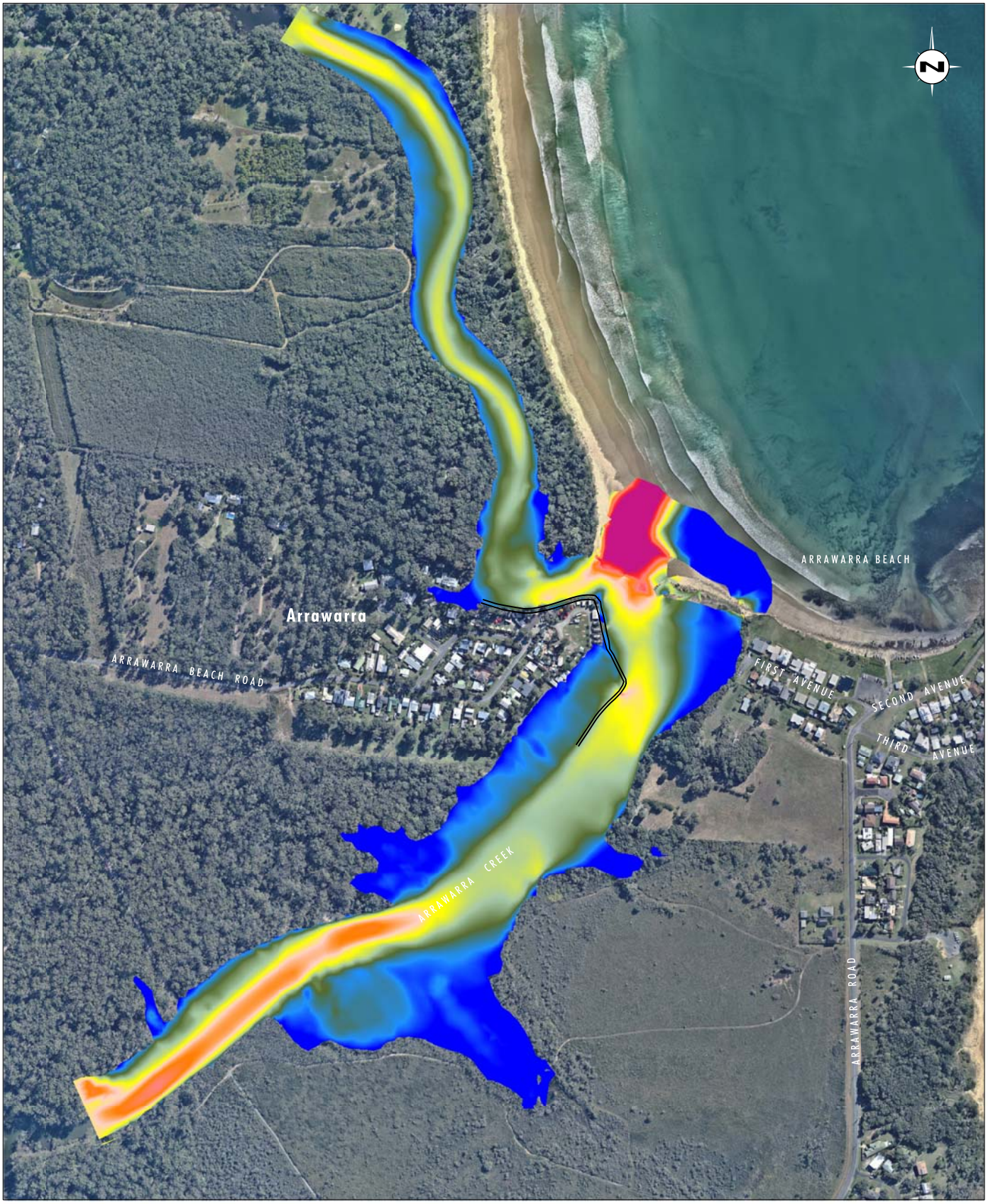

Image Source: Nearmap (May 2016)

0 100 200 400m

1:7500

Legend

Proposed Revetment of Arrawarra Caravan Park

Water Velocity (m/s)

- Range [0.100 : 0.250]
- Range [0.250 : 0.500]
- Range [0.500 : 0.750]
- Range [0.750 : 1.000]
- Range [1.000 : 1.250]
- Range [0.750 : 1.000]
- Range [1.000 : 1.250]
- Range [1.250 : 1.500]
- Range [2.000 : 2.250]
- Range [2.250 : 3.000]

FIGURE 3.5

5% AEP Flood Event, Maximum Velocity, Existing Landform

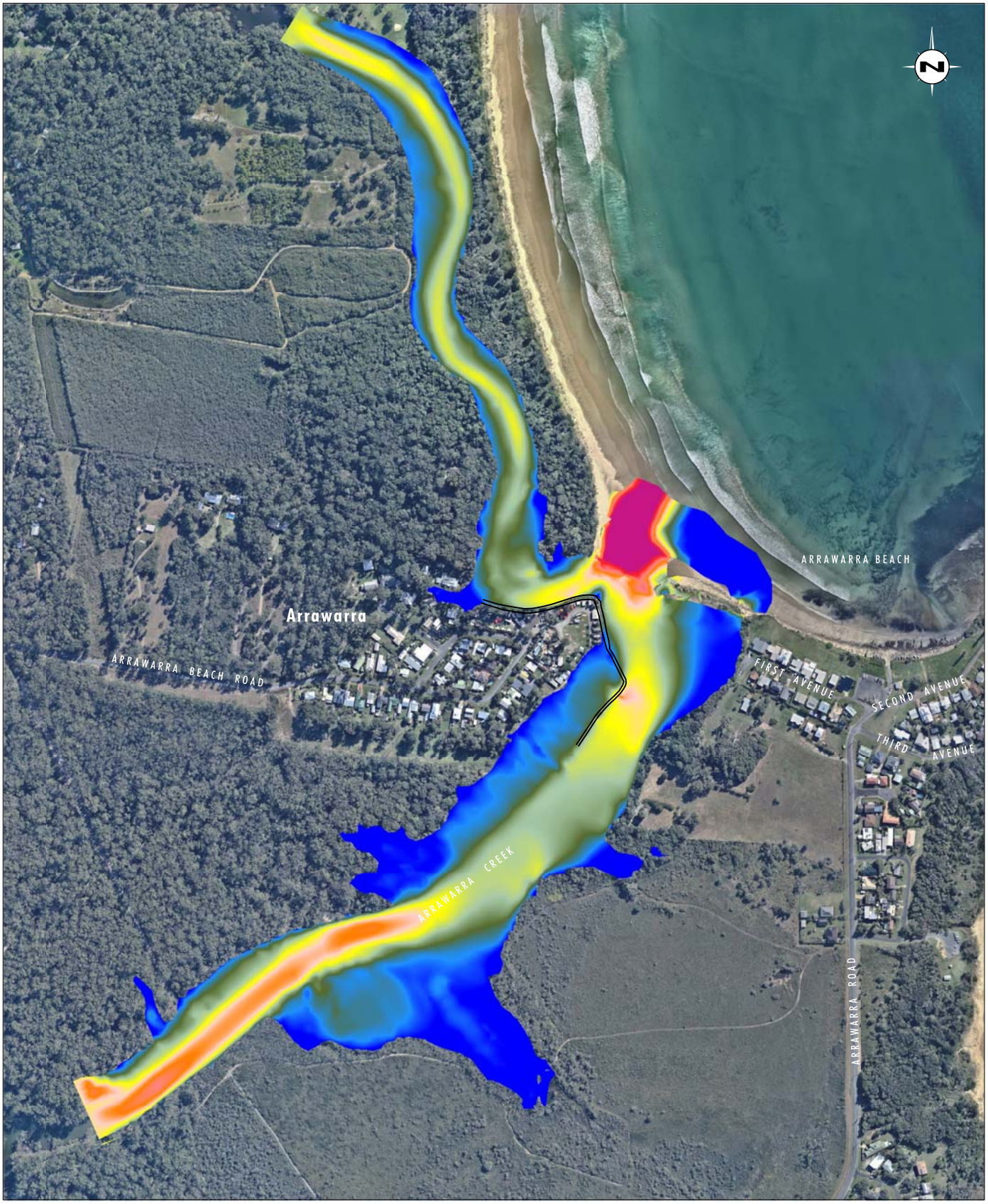

Image Source: Nearmap (May 2016)

0 100 200 400m

1:7500

Legend

Proposed Revetment of Arrawarra Caravan Park

Water Velocity (m/s)

- Range [0.100 : 0.250]
- Range [0.250 : 0.500]
- Range [0.500 : 0.750]
- Range [0.750 : 1.000]
- Range [1.000 : 1.250]
- Range [0.750 : 1.000]
- Range [1.000 : 1.250]
- Range [1.250 : 1.500]
- Range [2.000 : 2.250]
- Range [2.250 : 3.000]

FIGURE 3.6

5% AEP Flood Event, Maximum Velocity, Existing Landform with Sea Wall Designed

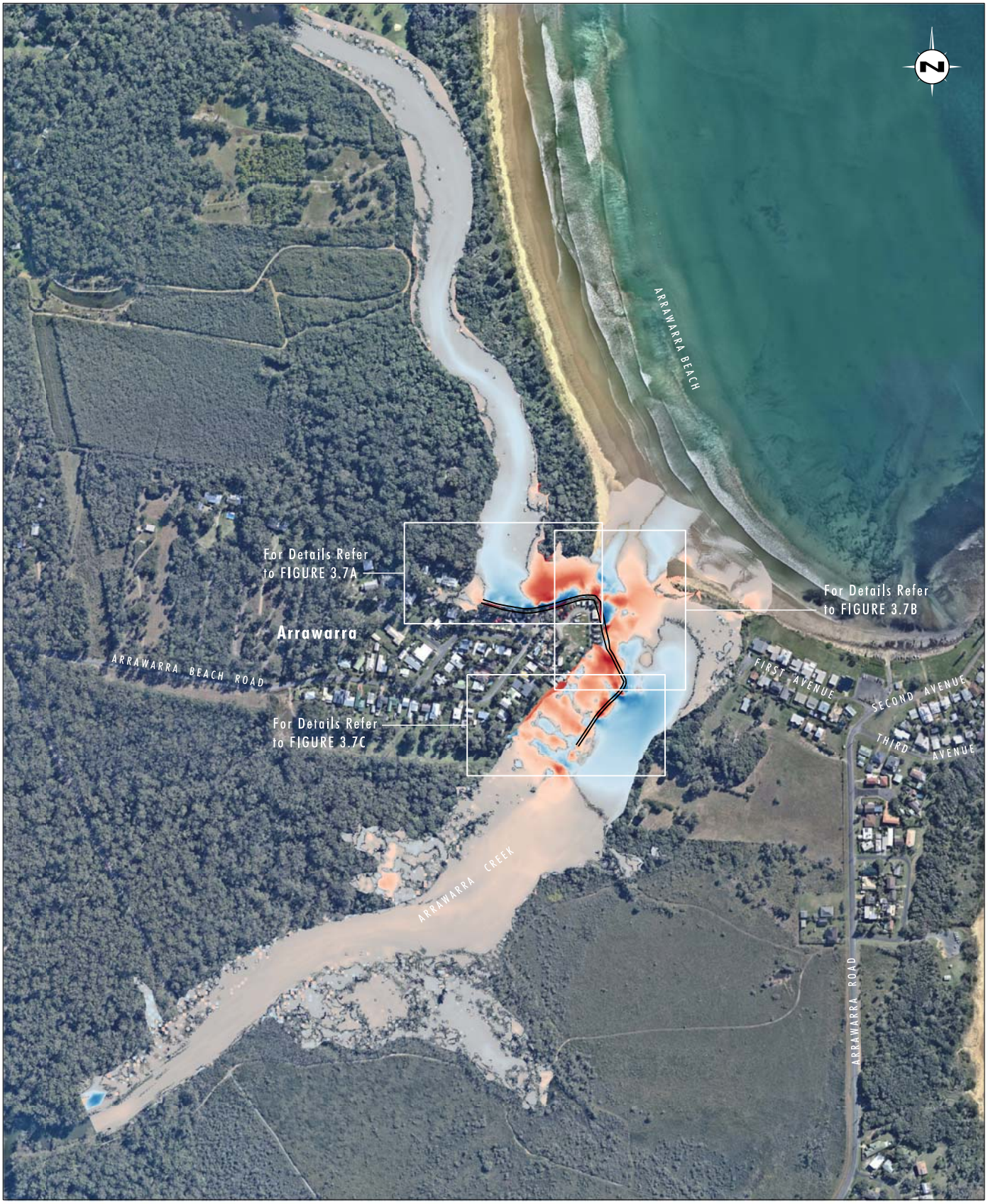

Image Source: Google Earth, CNES/Astrium (2015)

0 100 200 400m
1:7500

Legend

Proposed Revetment of Arrawarra Caravan Park

Delta Velocity (m/s)

- Range [0.000 : 0.010]
- Range [0.010 : 0.050]
- Range [0.050 : 0.100]
- Range [0.100 : 0.200]
- Range [0.200 : 0.500]
- Range [-0.500 : -0.200]
- Range [-0.200 : -0.100]
- Range [-0.100 : -0.050]
- Range [-0.050 : -0.010]
- Range [-0.010 : -0.000]

FIGURE 3.7

5% AEP Flood Event, Delta Maximum Velocity, Existing Landform with Sea Wall Designed versus Existing Landform

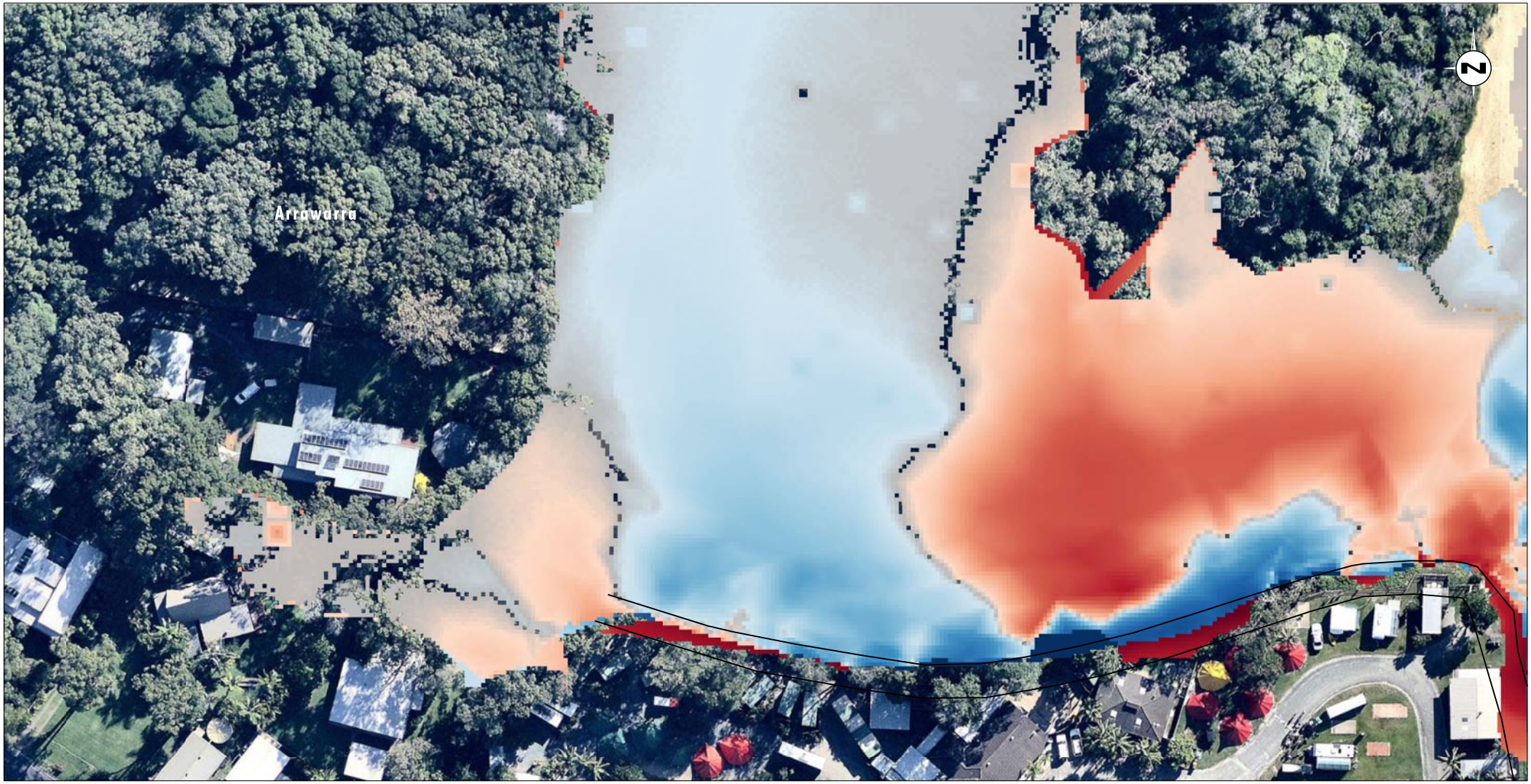

Image Source: Nearmap (May 2016)

0 10 25 50 m
1:1 000

Legend

Proposed Revetment of Arrawarra Caravan Park

Delta Velocity (m/s)

- Range [0.000 : 0.010]
- Range [0.010 : 0.050]
- Range [0.050 : 0.100]
- Range [0.100 : 0.200]
- Range [0.200 : 0.500]
- Range [-0.500 : -0.200]
- Range [-0.200 : -0.100]
- Range [-0.100 : -0.050]
- Range [-0.050 : -0.010]
- Range [-0.010 : -0.000]

FIGURE 3.7A

5% AEP Flood Event, Delta Maximum Velocity,
Existing Landform with Sea Wall Designed versus Existing Landform

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20140214 9.05

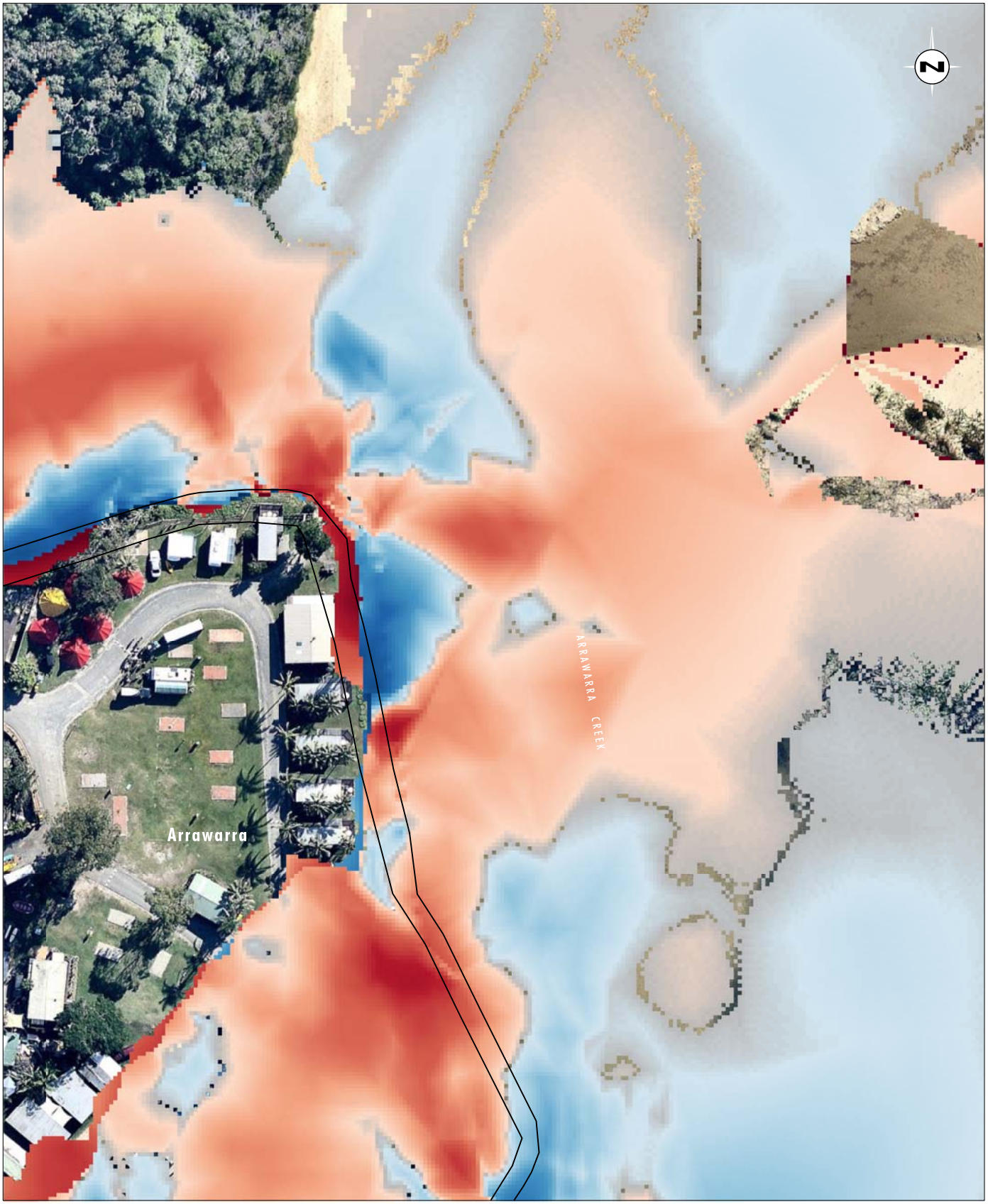

Image Source: Nearmap (May 2016)

0 10 25 50m
1:1 000

Legend

Proposed Revetment of Arrawarra Caravan Park

Delta Velocity (m/s)

- Range [0.000 : 0.010]
- Range [0.010 : 0.050]
- Range [0.050 : 0.100]
- Range [0.100 : 0.200]
- Range [0.200 : 0.500]
- Range [-0.500 : -0.200]
- Range [-0.200 : -0.100]
- Range [-0.100 : -0.050]
- Range [-0.050 : -0.010]
- Range [-0.010 : -0.000]

FIGURE 3.7B

5% AEP Flood Event, Delta Maximum Velocity,
Existing Landform with Sea Wall Designed versus Existing Landform

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20150309 9.47

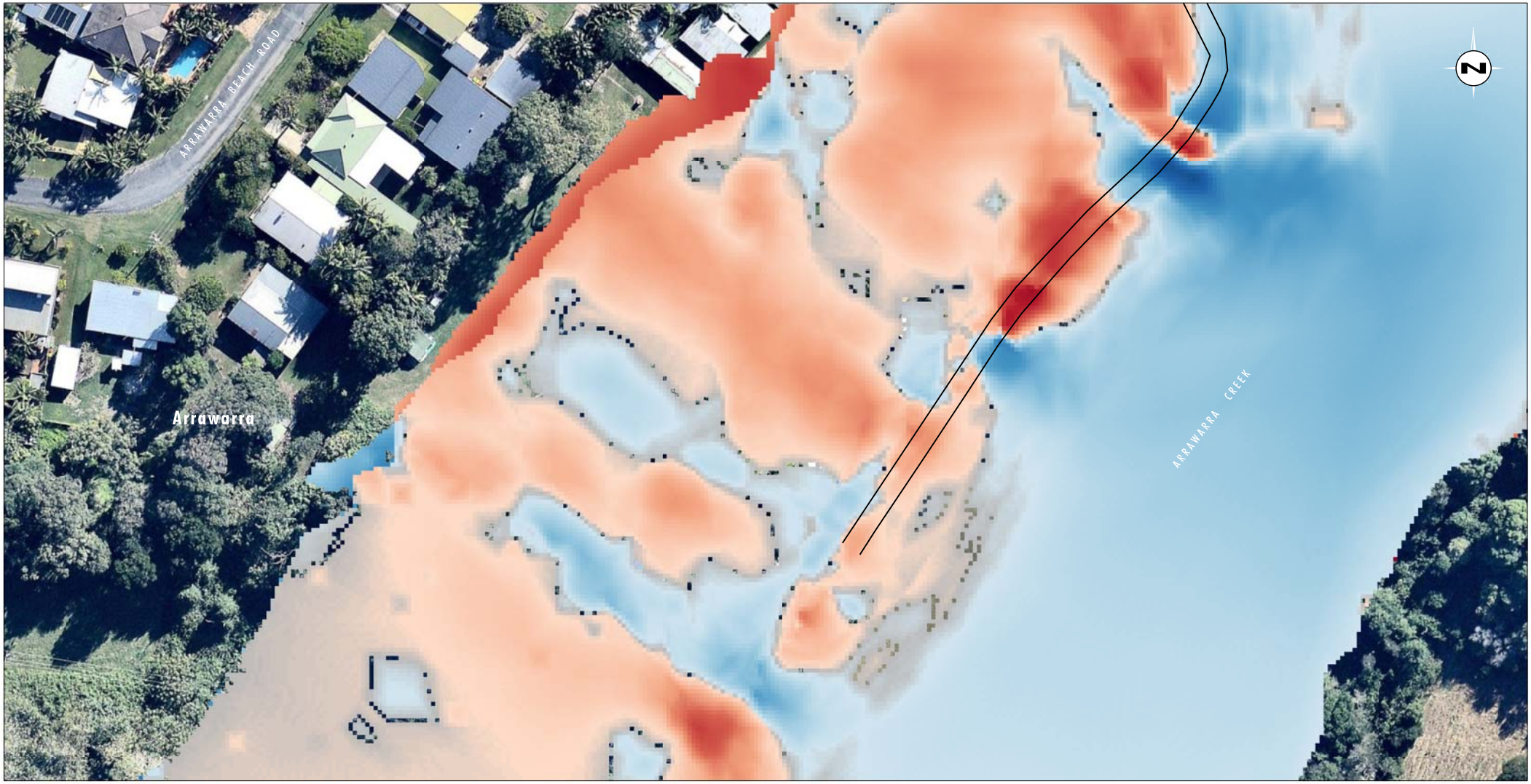

Image Source: Nearmap (May 2016)

0 10 25 50 m
1:1 000

Legend

Proposed Revetment of Arrawarra Caravan Park

Delta Velocity (m/s)

- Range [0.000 : 0.010]
- Range [0.010 : 0.050]
- Range [0.050 : 0.100]
- Range [0.100 : 0.200]
- Range [0.200 : 0.500]
- Range [-0.500 : -0.200]
- Range [-0.200 : -0.100]
- Range [-0.100 : -0.050]
- Range [-0.050 : -0.010]
- Range [-0.010 : -0.000]

FIGURE 3.7C

5% AEP Flood Event, Delta Maximum Velocity,
Existing Landform with Sea Wall Designed versus Existing Landform

File Name (A4): R02/3530_031.dgn
20140214 9.05

4.0 Conclusions

Results of the one dimensional modelling (Umwelt, June 2016) and two dimensional modelling undertaken as part of this report indicate that the proposed development will have a negligible impact on off-site erosion and limited potential for scour to occur at the toe of the seawall with predicted increases being localised and typically less than 0.1 m/s to 0.2 m/s.

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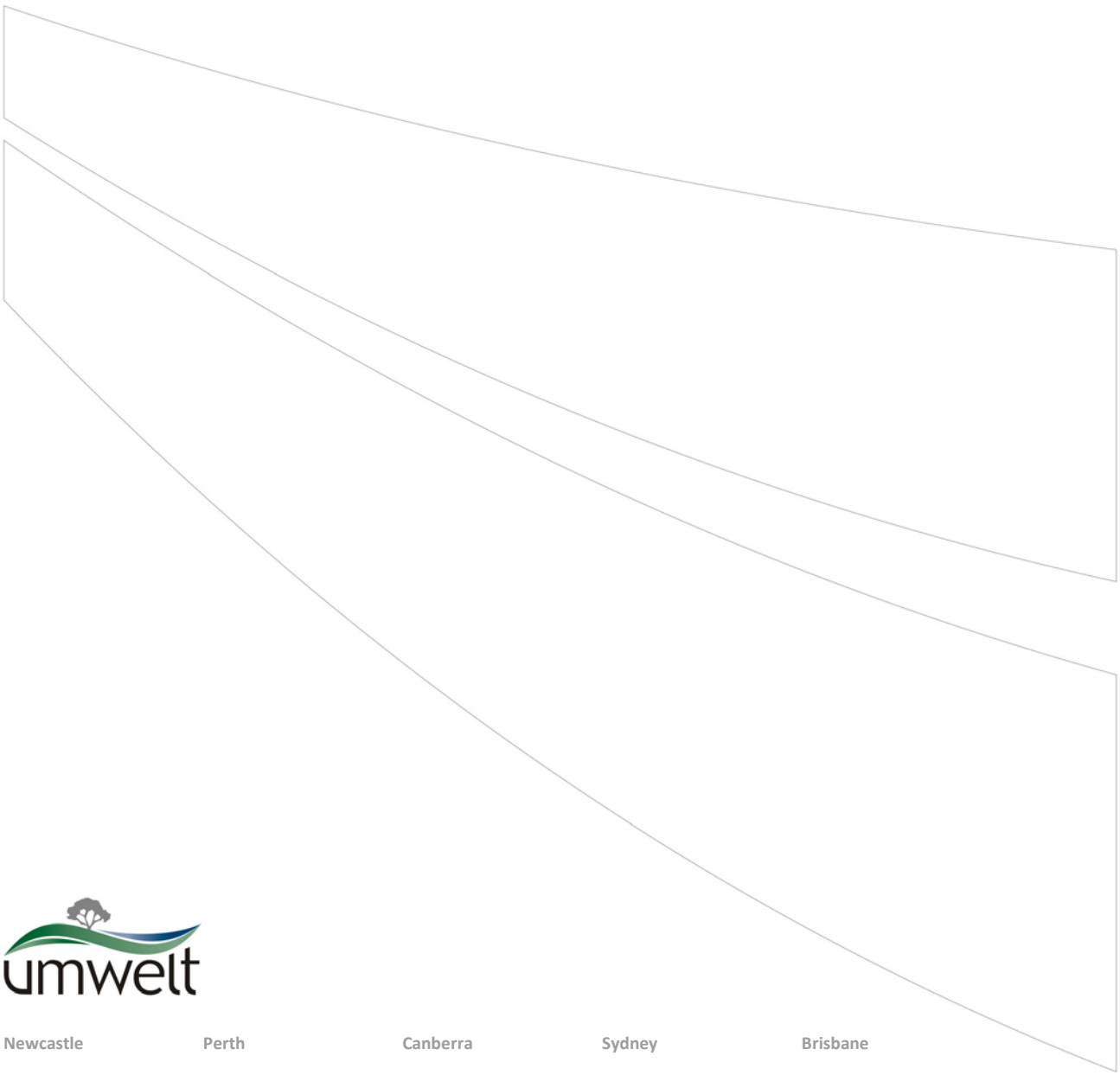

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