Great Lakes Coastal Hazard Study

Appendix D – Coastal Hazard Analysis

For: Great Lakes Council

Project Name:	Great Lakes Coastal Hazard Study
Project Number:	3001829
Report for:	Great Lakes Council

PREPARATION, REVIEW AND AUTHORISATION

Revision #	Date	Prepared by	Reviewed by	Approved for Issue by
1	22/08/12	M. Glatz; A. Xiao	C. Adamantidis	D. Messiter
2	23/10/13	M. Glatz; A. Xiao	E. Watterson	D. Messiter

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SMEC Australia Pty Ltd

PO Box 1346, Newcastle NSW 2300

Tel: **02 4925 9621**

Fax: **02 4925 3888**

Email: **Dan.Messiter@smec.com**

www.smec.com

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1 INTRODUCTION

The principal hazards induced by the coastal processes that are relevant for a coastal hazard risk assessment of the beaches along the Great Lakes coastline include:

- short-term coastal erosion including that resulting from severe storms, the behaviour of river entrances and slope instability
- long term coastline recession including that resulting from Aeolian sand transport and sea level rise
- oceanic inundation of low lying areas

Short-term beach erosion and long term coastline recession along the Great Lakes coastline has been determined in accordance with the stability criteria in Nielsen *et al.* (1992), as described in Appendix B and illustrated in Figure D.1. Foreshore recession resulting from projected sea level rise has been assessed using the Bruun Rule and Hallermeier method in Appendix C.

In this Appendix, coastal hazard induced by beach erosion and shoreline recession are synthesised and applied for the present day, 2050, 2060 and 2100 planning periods, schematised in Figure D.2. A zone of reduced foundation capacity (ZRFC) for planning purposes exists landward of the hazard lines, as illustrated in Figure D.1. A sensitivity analysis is carried out to examine the relative impact of sea level rise on the locations of the coastal hazard zones. The coastal hazard risk assessment is carried out with reference to the hazard mapping done for each of the three planning periods.

The hazard of coastal inundation was assessed in the areas considered most at risk, which separately deals with additional areas potentially impacted by processes of wave runup and foredune overtopping.

2 OCEAN INUNDATION HAZARD

2.1 Introduction

Coastal inundation at the beaches would occur if the frontal dune is low enough to allow overtopping during a major storm. Wave runup levels can vary at different locations along the beach, due to varying beach slopes. Wave runup levels on the beaches of the Great Lakes were estimated using parameters from long term wave statistics at the Crowdy Head Waverider buoy.

2.2 Ocean Inundation

Design incident wave conditions for the assessment of wave runup were determined for a maximum deepwater offshore wave height corresponding to the 0.1% AEP (Annual Exceedance Probability). From long term wave statistics as measured at the Crowdy Head Waverider buoy (which is representative of the study region), this corresponds to an offshore deepwater significant wave height of around 10.2 m. Wave refraction modelling using SWAN was applied to transfer offshore wave climate to the beaches of difference orientations for nearshore modelling using SBEACH and estimation of the wave runup on the beaches. For open coast beaches exposed to swell waves, it can be assumed that the peak wave height reached offshore at the different beaches of the Great Lakes coastline would be similar to what could be expected at Crowdy Head.

Wave runup levels along the Great Lakes coastline were estimated using the Automated Coastal Engineering Software (ACES) using the value of the nearshore significant wave height calculated with SBEACH software. The wave runup module of ACES was used to determine the levels, which assumes a smooth slope, linear beach.

SBEACH (Storm-induced BEAch CHange 32) is an empirically based, two-dimensional, morphological, numerical model. The model is founded on extensive large wave tank and field data measurements and analysis (Larson *et al.*, 1990; Rosati *et al.*, 1993). The model accepts as data:

- surveyed beach profiles
- time-varying water levels
- regular or irregular wave heights and periods
- wave angles
- wind speeds and wind directions
- an arbitrary grain size in the fine-to-medium sand range

Nearshore boundary conditions for ACES adopted for various locations along the beach are shown in Table D.1. The assumed nearshore beach profile was measured from approximately 2 m below AHD to the top of the dune, to obtain a beach slope for use in the wave runup calculation. Runup was added to the nearshore water level, which included an allowance for wave setup and wind setup. The maximum expected wave runup and 2% wave runup (runup exceeded by 2% of waves) is given in Table D.1. Runup levels have been calculated by adding the runup calculated by ACES to the nearshore water level and the maximum recorded ocean water level at Sydney of 1.48 m on AHD (Kulmar and Nalty, 1997).

Following future sea level rise, maximum runup levels would be expected to increase by at least the value of future sea level rise. As the shoreline alignment could be expected to change in the future along sandy shorelines, it is not possible to accurately estimate the

future limits of inundation due to wave runup. However, an indicative future runup level for 2050 and 2100 has been mapped, assuming that the nearshore beach slopes and wave climate are unchanged and using the existing Aerial Laser Scan data as the basis for the mapping. This provides an indication of infrastructure which may be at risk from future inundation due to wave runup.

The analysis indicates that overtopping could occur at Nine Mile Beach South, Main Beach, One Mile Beach, Elizabeth Beach, Sandbar Beach, Boat Beach and Bennetts Beach. Maximum wave runup levels are mapped in Figures D.3 to D.13. Where overtopping volumes would transverse large distances (>100 m) across the dune system, the maximum runup levels would not be reached due to infiltration process. Accordingly, in these areas no line has been mapped.

Table D.1 – Wave Runup levels for Great Lakes, 0.1% AEP storm event

Location	Nearshore Water Level	2% Wave RunUp from ACES	Max Wave RunUp from ACES	2% Wave RunUp Level	Max RunUp Level	2050 Max RunUp Level	2100 Max RunUp Level	Min Dune Height Along Frontage (Indicative only)[1]
	m AHD	m	m	m AHD	m AHD	m AHD	m AHD	m AHD
Nine Mile Beach Golf Course	2.0	2.5	3.0	4.6	5.0	5.4	5.9	4.8
Nine Mile Beach	2.3	3.3	4.0	5.6	6.3	6.7	7.2	4.9
Nine Mile Beach South	2.6	3.8	4.7	6.4	7.3	7.6	8.1	5.6
Main Beach North	2.4	4.0	5.0	6.5	7.4	7.8	8.3	6.0
Main Beach South	2.3	2.3	2.7	4.6	5.0	5.3	5.8	6.9
Pebbly Beach	1.7	3.1	3.7	4.8	5.4	5.8	6.3	>10
One Mile Beach North	2.5	3.3	4.0	5.8	6.5	6.8	7.3	8.6
One Mile Beach South	2.5	2.9	3.4	5.4	5.9	6.3	6.8	6.0
Burgess Beach	2.4	2.8	3.4	5.2	5.8	6.1	6.6	>10
Seven Mile Beach North	2.5	2.4	2.8	4.8	5.3	5.6	6.1	5.6
Seven Mile Beach Caravan Park	2.4	3.0	3.7	5.4	6.1	6.5	7.0	>10
Seven Mile Beach South	2.5	2.6	3.1	5.0	5.5	5.9	6.4	7.1
Elizabeth Beach SLSC	2.6	2.0	2.3	4.5	4.9	5.2	5.7	7.0
Sandbar Beach	2.5	2.4	2.9	4.8	5.3	5.6	6.1	8.5
Number One Beach North	2.38	4.78	5.98	7.16	8.36	8.8	9.2	>10
Number One Beach South	2.46	2.31	2.75	4.77	5.21	5.65	6.05	8.7
Boat Beach	3.20	2.75	3.39	5.95	6.59	7.03	7.43	7.4
Lighthouse Beach	2.61	3.01	3.65	5.62	6.26	6.7	7.1	8.4
Treachery Beach	2.37	2.04	2.35	4.41	4.72	5.16	5.56	9.0
Bennetts Beach Treatment Plant	2.44	3.90	4.80	6.34	7.24	7.68	8.08	>10
Bennetts Beach Golf Course	2.38	3.18	3.87	5.56	6.25	6.69	7.09	6.8
Bennetts Beach SLSC	2.38	3.36	4.10	5.74	6.48	6.92	7.32	7.3
Bennetts Beach South	2.49	2.54	3.04	5.03	5.53	5.97	6.37	5.6
Jimmys Beach East	1.45	2.33	2.77	3.78	4.22	4.66	5.06	4.7
Jimmys Beach Centre-East	1.55	3.72	4.54	5.27	6.09	6.53	6.93	5.4
Jimmys Beach Centre-West	1.57	3.10	3.74	4.67	5.31	5.75	6.15	6.1
Jimmys Beach West	1.58	1.83	2.10	3.41	3.68	4.12	4.52	7.4

[1] Minimum dune heights are based on preliminary analysis of LiDAR, small local depressions in the frontal dunes may not be picked up (e.g. beach access ways)

3 CALCULATION OF HAZARD LIMITS

The limits of the *Zone of Wave Impact and Slope Adjustment* and the *Zone of Reduced Foundation Capacity* have been calculated using values for design storm erosion demand, with reference to Appendix B, for the present day, 2050, 2060 and 2100 planning periods, adding estimated recession as a result of upper range sea level rise projections as advocated by the NSW Sea Level Rise Policy and measured long term recession.

To obtain the location of the various zones, average values of the different profiles would normally have been used as many of the beaches are accreting. However, the several anthropogenic influences (sand mining, dune stabilisation, etc.) would have distorted the average result. Therefore, the ALS data dated from 2006 has been used for the determination of the hazard lines. The ALS data was considered appropriate for use as a baseline for the mapping, and has the advantage of providing a greater density of data to allow more accurate placement of the hazard zones.

The immediate hazard limits due to the design beach erosion volume are shown in Figures D.14 to D.24 for the different beaches along Great Lakes coastline. They have been calculated in terms of chainage along each profile.

For the 2050 and 2100 planning periods, long term beach recession and sea level rise limits were added to the design storm recession for several locations along the beach, to determine the seaward limits of the *Zone of Reduced Foundation Capacity* and *Stable Foundation Zone*. Figures D.25 to D.35 illustrate the hazard limits for 2050 and D.36 to D.46 illustrate the hazard limits for 2100.

Similarly, coastal hazard maps for the 2060 planning period were also prepared to align with Council's adopted planning horizon and are illustrated in Figures D.47 to D.56.

It should be noted that the hazard mapping assumes that the dune is composed of erodible material and that the nearshore beach profile is in equilibrium with the wave climate. Where a superficial layer of sandy beach overlies bedrock or if there is presence of bedrock seaward of the beach, the erosion would be limited. Moreover, the bathymetric data are limited in numerous areas which could lead to inaccuracy in the sea level rise recession estimate.

Note: Erosion Hazard Line figures have not been produced for the beaches listed below, as there is no property of infrastructure at risk at these locations. However, Runup Hazard Line figures have been produced for Lighthouse Beach and Treachery Beach to inform inundation levels.

- Pebbly Beach
- Burgess Beach
- Shelly Beach
- Lighthouse Beach
- Treachery Beach

It should be recognised that no singular approach to defining coastline hazards for planning purposed will ever be definitive of unequivocal. Professional judgement and experience will always be required to assess and accommodate variability in the quality and coverage of available datasets, incomplete physical processes understanding, and the inherent limitation of analytical techniques, tools and numerical models to described or predict hazard components. By virtue, coastal hazard definition work for planning purposes should be viewed as a relatively coarse advisory tool only with the implicit limitations of the predictive capabilities of process reflected in the planning and management responses considered. In particular, uncertainty related to climate change

projections which will have profound influences on the form and alignment of coastal foreshores and frontal dune systems will remain dynamic and evolving areas of research. Given these uncertainties, it is recommended that hazard definition for planning purposes is considered from an appropriately conservative perspective and that associated long-term management strategies should be robust enough to accommodate changed or altered regimes of physical coastal processes, or their understanding, in the future.

This risk assessment assumes that the coast is only composed of sand and that the sand is not underlain by rock which may not be the case at Burgess Beach. Burgess Beach is underlain by bedrock along most of its length. Hence only the run-up at this beach has been mapped and no private property is at threat from coastal erosion. However, the entire sandy portion of the beach is under threat from erosion in a large storm event.

4 SUMMARY AND CONCLUSIONS

The assessment of coastal hazards has concluded that regarding immediate erosion risk and runup hazard along the Great Lakes coastline:

- For Nine Mile Beach, no dwellings or infrastructure is at immediate risk of storm damage since no dwelling is situated along the beachfront except the Tuncurry Golf Club which is located inland from the hazard lines.

- For Tuncurry Beach, there is no dwelling currently at immediate risk of storm damage, as development is well set back from the shoreline. However, there is a risk of damage to the northern breakwaters of Wallis Lake Entrance from scouring and exposure to wave impact of the training wall normally buries in the dune. The ability of the structure to withstand this effect is unable to be assessed.

- For Main Beach, no dwelling or infrastructure is at immediate risk of storm damage if the seawall is well maintained and has been engineered to provide adequate protection from the design storm event. It has been assumed that the seawall in front of the Surf Club and the southern half of Main Beach provides protection from beach storm erosion and long term recession. If the seawall fails, both the roadways of Beach Street and North Street will extend into *the Zone of Slope Adjustment*. A section of the car park located at the southern end of Main Beach and the ocean pool and adjacent foreshore may be at risk of inundation.

- For One Mile Beach, the Cape Hawke Surf Club building and part of the carpark at the southern end of the beach is at immediate risk of storm damage. Nearly half of the Cape Hawke Surf Club building and a large portion of the carpark lies within the immediate hazard line for the *Zone of Reduced Foundation Capacity*. The Cape Hawke Surf Club and part of Palmgrove Park will be at risk from coastal inundation. Along much of the beach, the dune crest is close to the maximum wave runup level and dune overtopping is possible in the design storm event.

- For Seven Mile Beach, there part of one dwelling at the southern end of the beach which lies within *the Zone of Reduced Foundation Capacity*. No properties along the beachfront are considered to be at risk from coastal inundation.

- For Elizabeth Beach, the Pacific Palms Surf Life Saving Club is not considered to be at immediate risk of storm damage. However, the creek outlet, beach access way and adjacent foreshore area located at the southern end of the beach may be at risk from inundation. Lakeside Crescent is located with *the Zone of Slope Adjustment* immediately adjacent to the creek crossing.

- For Sandbar, there are no dwellings or infrastructure located in the area.

- For Number One Beach, the existing Seal Rocks Road lies partly within *the Zone of Slope Adjustment*. Two lots on Seal Rocks Road at the western end of residential development lie within the immediate hazard line for the *Zone of Reduced Foundation Capacity*. There are no properties along Seal Rocks Road at risk from coastal inundation due to wave runup. However, the informal area for car parking at the eastern end of the beach may be at risk of wave inundation and is likely to be *the Zone of Slope Adjustment* (although outside the extent of calculations).

- For Boat Beach, the existing Kinka Road lies partly within the *Zone of Reduced Foundation Capacity* (small section in *the Zone of Slope Adjustment)*, including one private dwelling close to the central boat ramp. Most of the properties are underlain by bedrock which protects the existing development from reduced foundation capacity.

There is a risk that inundation could impact Kinka Road, and two properties close to the central boat ramp.

- For Bennetts Beach, there are no dwellings at immediate risk of storm damage. No properties along the beachfront are considered to be at risk from coastal inundation. However, the sand spit between Bennetts Beach and Yaccaba Head is at risk of coastal inundation, as the spit is low-lying and below the wave runup level.

For the 2050 planning period:

- For Tuncurry Beach and Nine Mile, there is no additional dwellings or infrastructure within the coastal hazard zones.

- For Main Beach, if the seawall is maintained in good condition until 2050, there are no additional dwellings or infrastructure extending into the hazard lines. However, if the seawall fails, part of five properties on North Street would lie within the 2050 hazard line for the *Zone of Slope Adjustment* and the Surf Club would lie within the *Zone of Reduced Foundation Capacity*. Erosion impacts may be exacerbated by the effects at western extremity of the seawall. The seawall would then be at risk of being out flanked.

- For One Mile Beach, the Cape Hawke Surf Club building lies within the 2050 hazard line for the *Zone of Slope Adjustment*. Some 21 low-lying lots along the southern half of the One Mile Beach lie partially within the *Zone of Reduced Foundation Capacity*. However, no building on these lots is currently located at risk. A large area of the car park at the southern end of the beach is also located within the *Zone of Reduced Foundation Capacity*.

- For Seven Mile Beach, coastal hazard lines get closer to Tiona while no additional dwelling extends into *the Zone of Reduced Foundation Capacity*. The park at the southern end of the beach has a larger area lying within *the Zone of Reduced Foundation Capacity*.

- For Elizabeth Beach, Lakeside Crescent at the southern end of the beach has a portion extending into the *Zone of Slope Adjustment* with a length up to 50 m. The carpark at the northern end of the beach and 63 m along the Lakeside Cres extends into the hazard lines for the *Zone of Reduced Foundation Capacity*.

- For Sandbar, there are no dwellings or infrastructure located in the area.

- For Number One Beach, a larger portion of Seal Rocks Road as well as one lot at the western end of development lies within the *Zone of Slope Adjustment*. Three additional lots lie partly within the *Zone of Reduced Foundation Capacity*.

- For Boat Beach, Kinka Road starts to be impacted by wave impact and slope adjustment, including two private dwellings extending into the *Zone of Slope Adjustment* also. Six dwellings close to the central boat ramp extends into the *Zone of Reduced Foundation Capacity*.

- For Bennetts Beach, half of the Tea Gardens Hawks Nest SLSC extends into the *Zone of Reduced Foundation Capacity* with the adjacent car park starting to be partly affected by reduced foundation capacity.

For the 2100 planning period:

- For Tuncurry Beach and Nine Mile Beach, no existing private dwelling is indicated to be at risk by 2100, though the vegetated dune seaward of the development may have

greatly receded within this timeframe. Coastal dune vegetation and fencing would need to be maintained to prevent loss of dune stability and prevent dune blowouts. Loss of dune vegetation would increase long term erosion and increase the coastal hazard risk to existing development.

- For Main Beach, the beach access way alongside the SLSC extends into the *Zone of Reduced Foundation Capacity* and may be adversely impacted by the edge effect of the seawall. The seawall would have been out flanked and it's integrity may be compromised as a result. The northern half of the Main Beach may have undergone significant recession and the northern tidal pool would no longer exist. For the southern half of the beach, the hazard lines stop in front of the seawall. This risk assessment assumes that the Main Beach seawall would provide adequate storm protection. In order to achieve this, the seawall should be maintained to an appropriate engineering standard. Should the seawall fail, many more dwellings at Main Beach as well as the SLSC would be subject to coastal hazards and reduced foundation capacity.
- For One Mile Beach, 21 lots within the immediate beach front along the southern half of the beach may be affected by wave impact and slope adjustment. Four additional lots and some 19 buildings would extend into the *Zone of Reduced Foundation Capacity*. The Surf Club at the southern end would lie completely within *the Zone of Slope Adjustment*, including the surrounding area of car parking.
- For Seven Mile Beach, three additional buildings located in Tiona would extend into *the Zone of Reduced Foundation Capacity*. The Lakes Way would be located at a distance of about 100 m away from the hazard line of *Reduced Foundation Capacity* so there would appear to be no risk of a breach of the dune here into Wallis Lake. Larger areas of the southern park along the beach would extend into *the Zone of Reduced Foundation Capacity* with the access way for the park to the beach at risk of wave impact and slope adjustment.
- For Elizabeth Beach, the SLSC and public toilet would extend partly into *the Zone of Reduced Foundation Capacity*, as well as a longer portion of the roadway of Lakeside Crescent (about 175 m length). The car park at the northern corner of the beach and a portion of Lakeside Crescent would lie partly within *the Zone of Slope Adjustment*, resulting in all the dwellings west of Lakeside Crescent at risk of losing direct access to Boomerang Beach and its surrounding development.
- For Sandbar, there are no dwellings or infrastructure located in the area.
- For Number One Beach, a larger portion of Seal Rocks Road and some four lots lie within the hazard line for the *Zone of Slope Adjustment*. One additional dwelling lies within the *Zone of Reduced Foundation Capacity*.
- For Boat Beach, the whole section of Kinka Road other than the cliff zone is affected by slope adjustment, including part of 11 private dwellings close to the central boat ramp. 14 dwellings extends into the *Zone of Reduced Foundation Capacity*.
- For Bennetts Beach, the Tea Gardens Hawks Nest SLSC would extend partly into *the Zone of Slope Adjustment and Wave Impact.* The car park adjacent to the SLSC and a portion of the beach access way behind the foredune along the southern Bennetts Beach would lie within *the Zone of Reduced Foundation Capacity*. No additional private property would be at risk of coastal hazard during the 2100 planning horizon since the town development is well set back from the shoreline.

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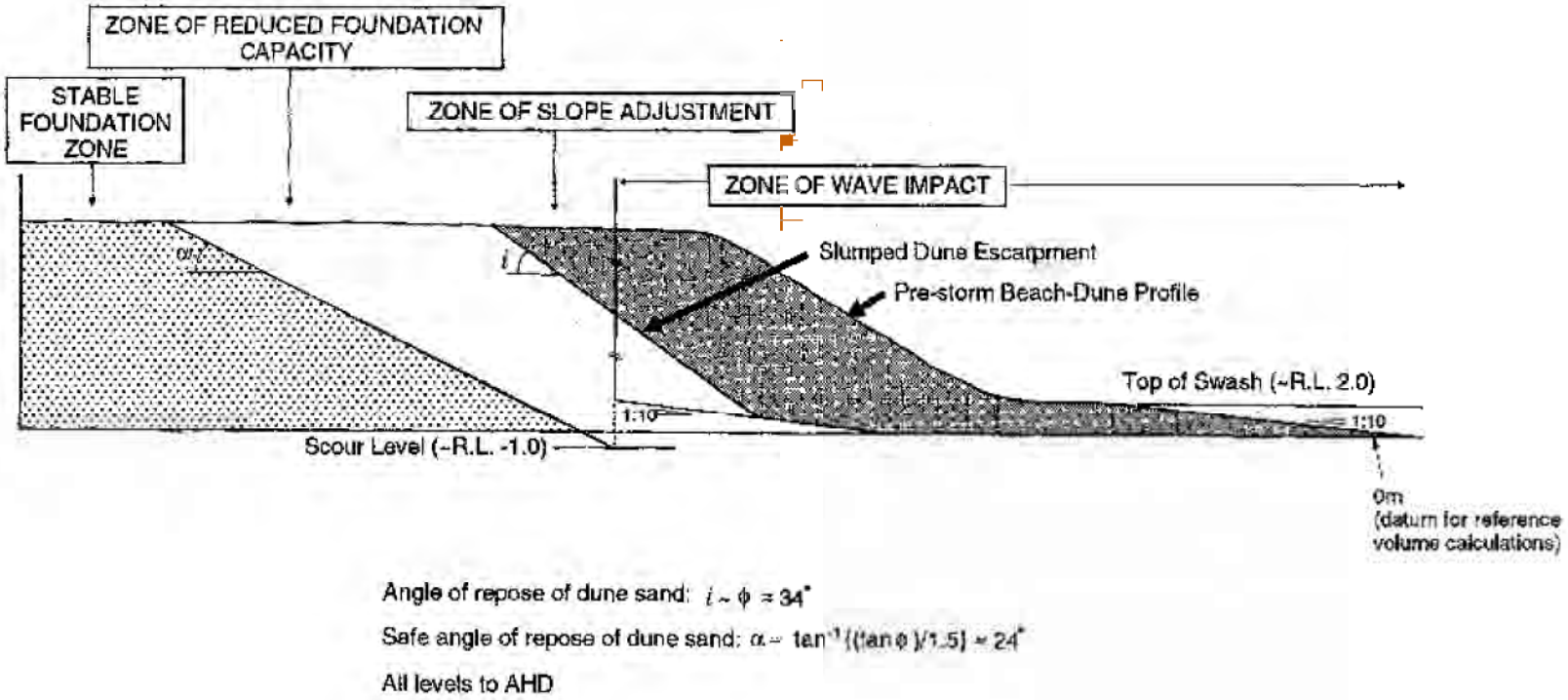


Figure D 1: Dune stability schema (after Nielsen et al., 1992)

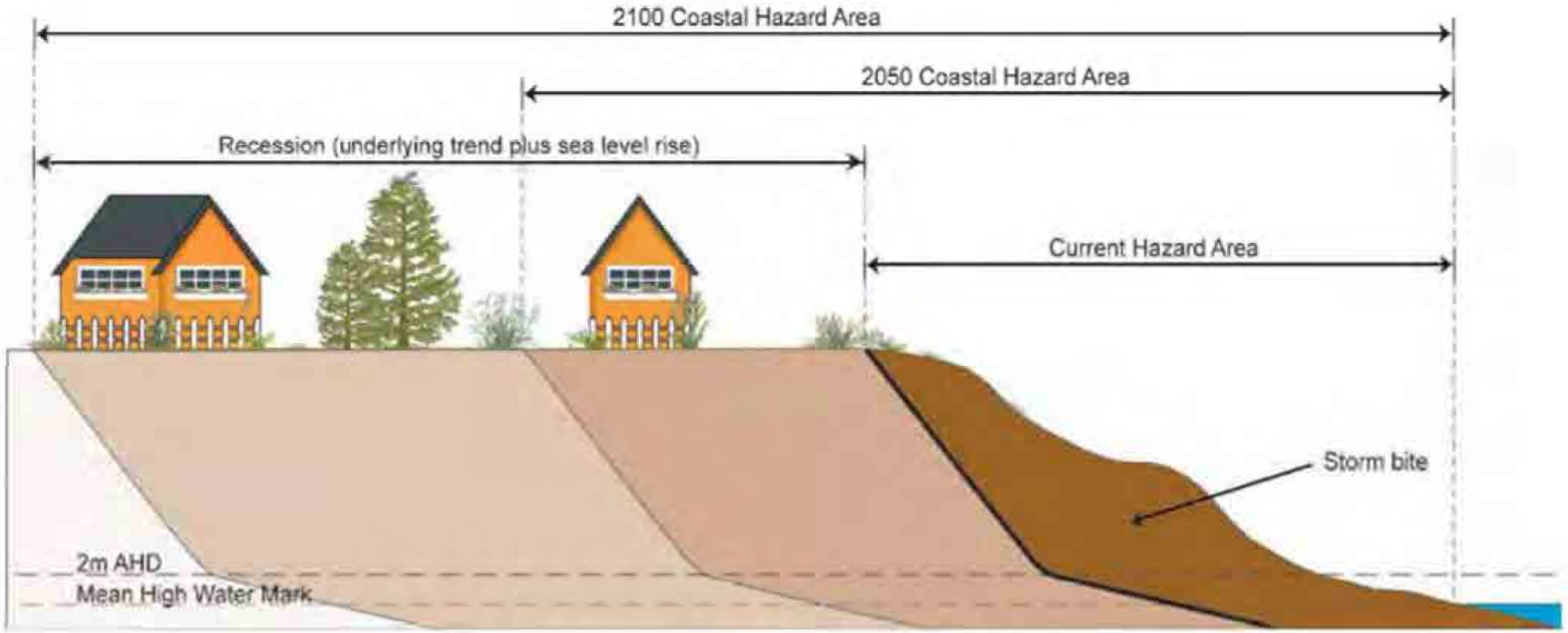
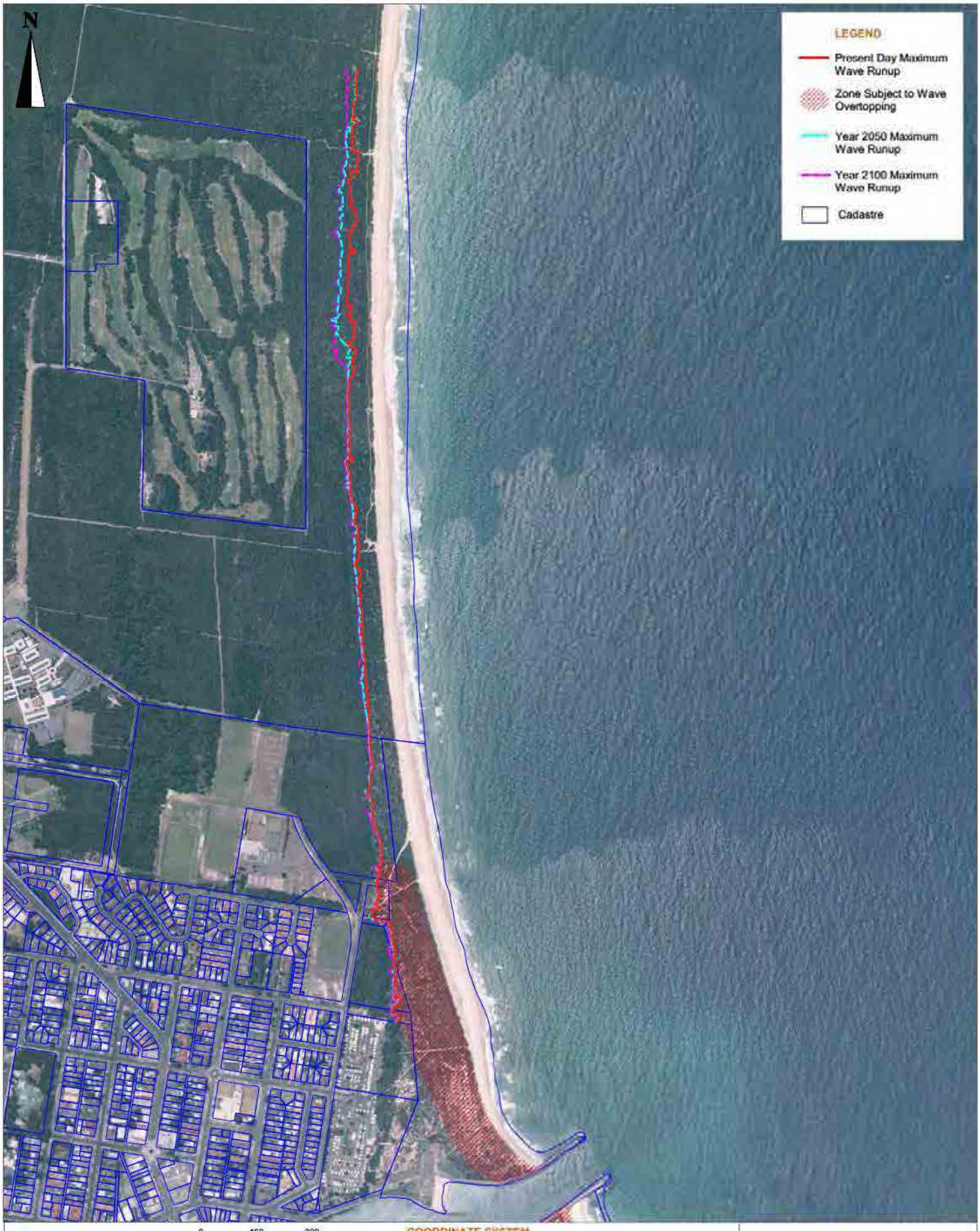


Figure D 2: Idealised schematic of a dune profile depicting the present day, 2050 and 2100 hazard areas (DECCW, 2010)



DATE 17/07/2012

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metres

COORDINATE SYSTEM
MGA 94 Zone 56

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D.3

FIGURE TITLE Runup Hazard Line - Nine Mile Beach

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DATE 17/07/2012 | 0 50 100 metres | COORDINATE SYSTEM MGA 94 Zone 56

FIG NO. D.4 | FIGURE TITLE Runup Hazard Line - Main Beach & Pebbly Beach

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COORDINATE SYSTEM
MGA 94 Zone 56

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FIG NO. D.5

FIGURE TITLE Runup Hazard Line - One Mile Beach & Burgess Beach

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FIG NO. D.6

FIGURE TITLE Runup Hazard Line - Seven Mile Beach

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FIG NO. D.7

FIGURE TITLE Runup Hazard Line - Elizabeth Beach

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FIG NO. D.8

FIGURE TITLE Runup Hazard Line - Sandbar Beach

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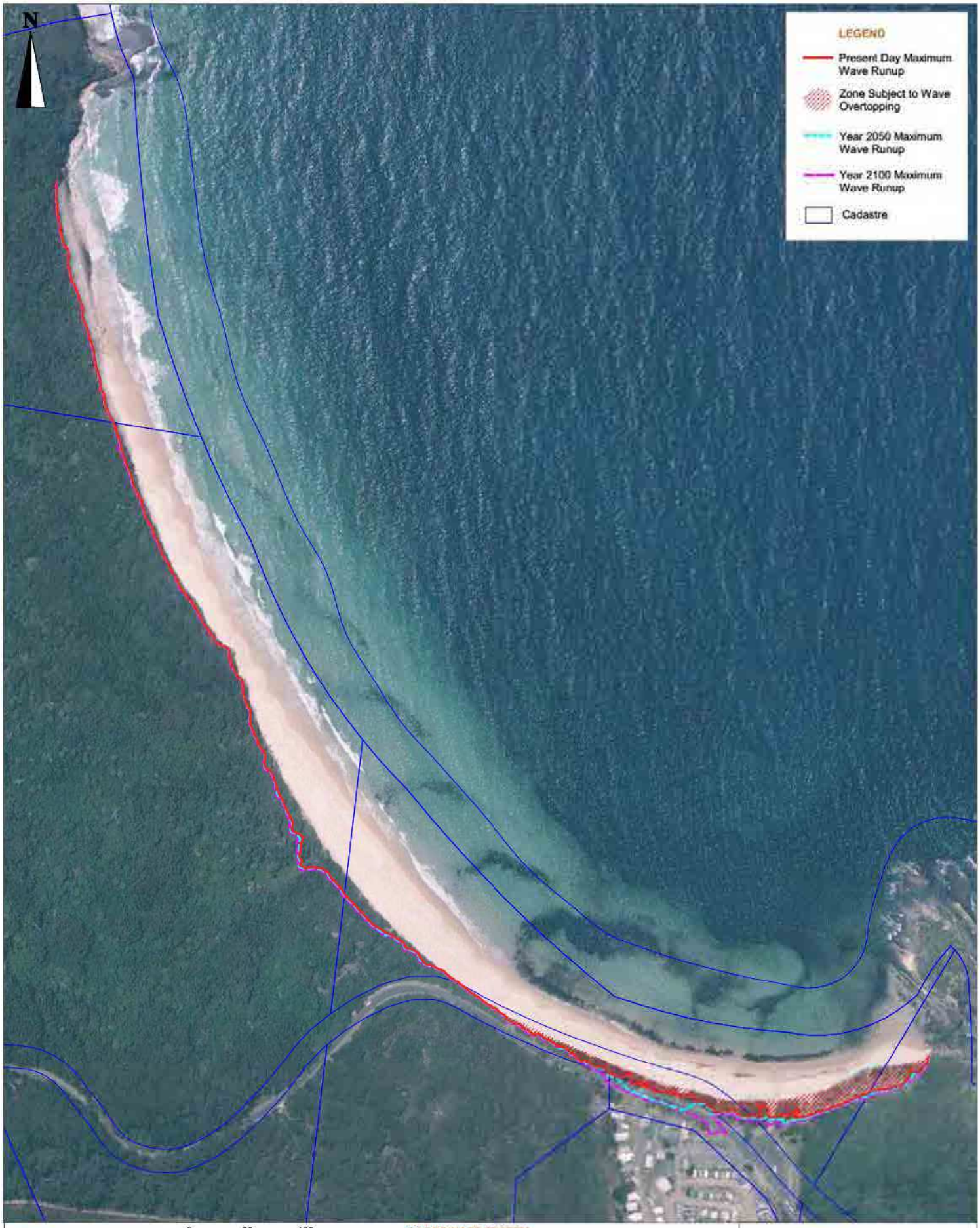

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FIG NO. D.9

FIGURE TITLE Runup Hazard Line - Number One Beach

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FIG NO. D.10

FIGURE TITLE Runup Hazard Line - Boat Beach

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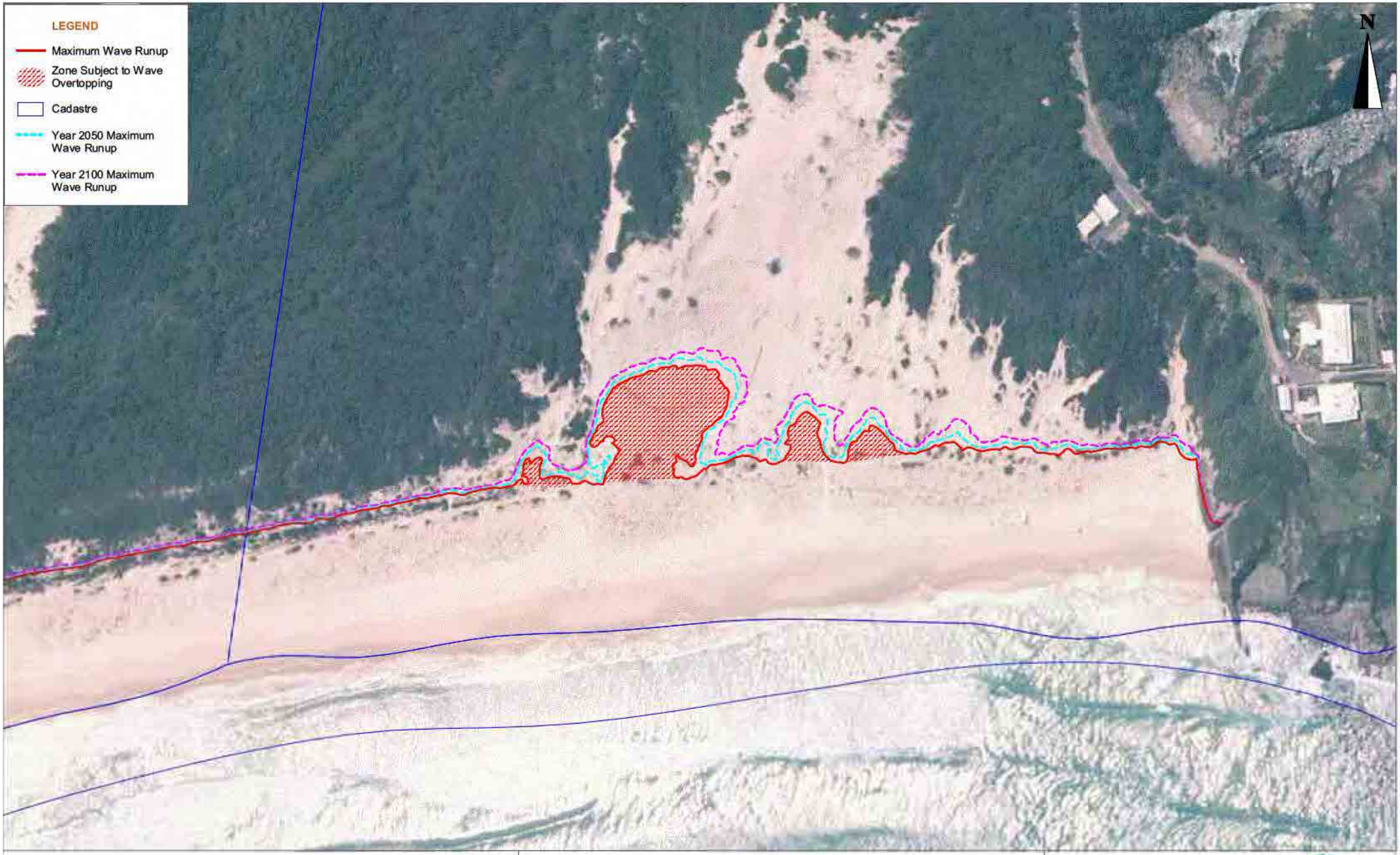

DATE 17/07/2012 | 0 30 60 metres | COORDINATE SYSTEM MGA 94 Zone 56 | FIG NO. D.11 | FIGURE TITLE Runup Hazard Line - Lighthouse Beach

PROJECT NO. 3001829 | PROJECT TITLE Great Lakes Coastal Hazard Study | CREATED BY M. GLATZ | LOCATION I:\projects\3001829 - Great Lakes Coastal Hazard Study\009DATA\GIS

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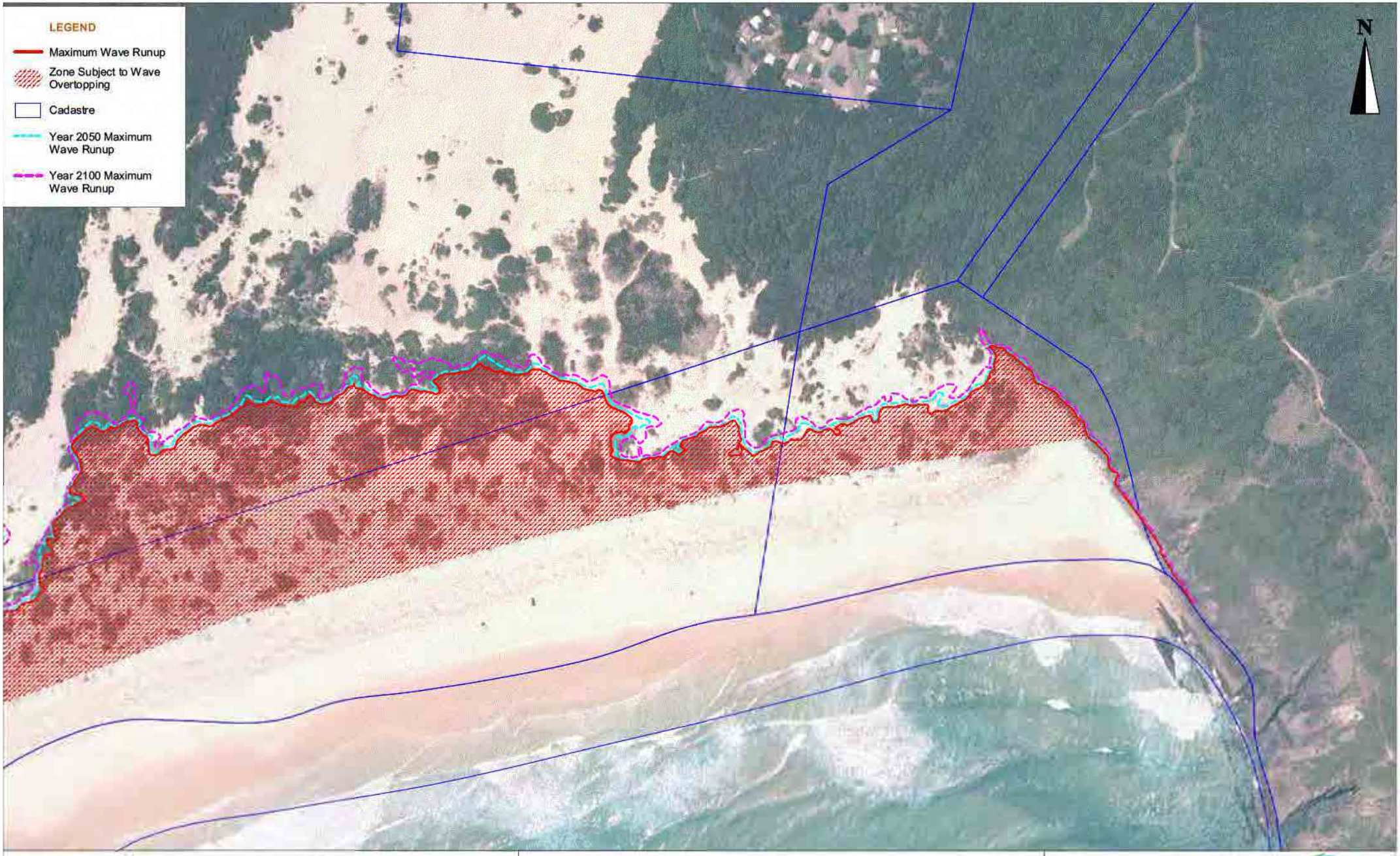

DATE 17/07/2012

0 50 100
metres

COORDINATE SYSTEM MGA 94 Zone 56

FIG NO. D.12

FIGURE TITLE Runup Hazard Line -Treachery Beach

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

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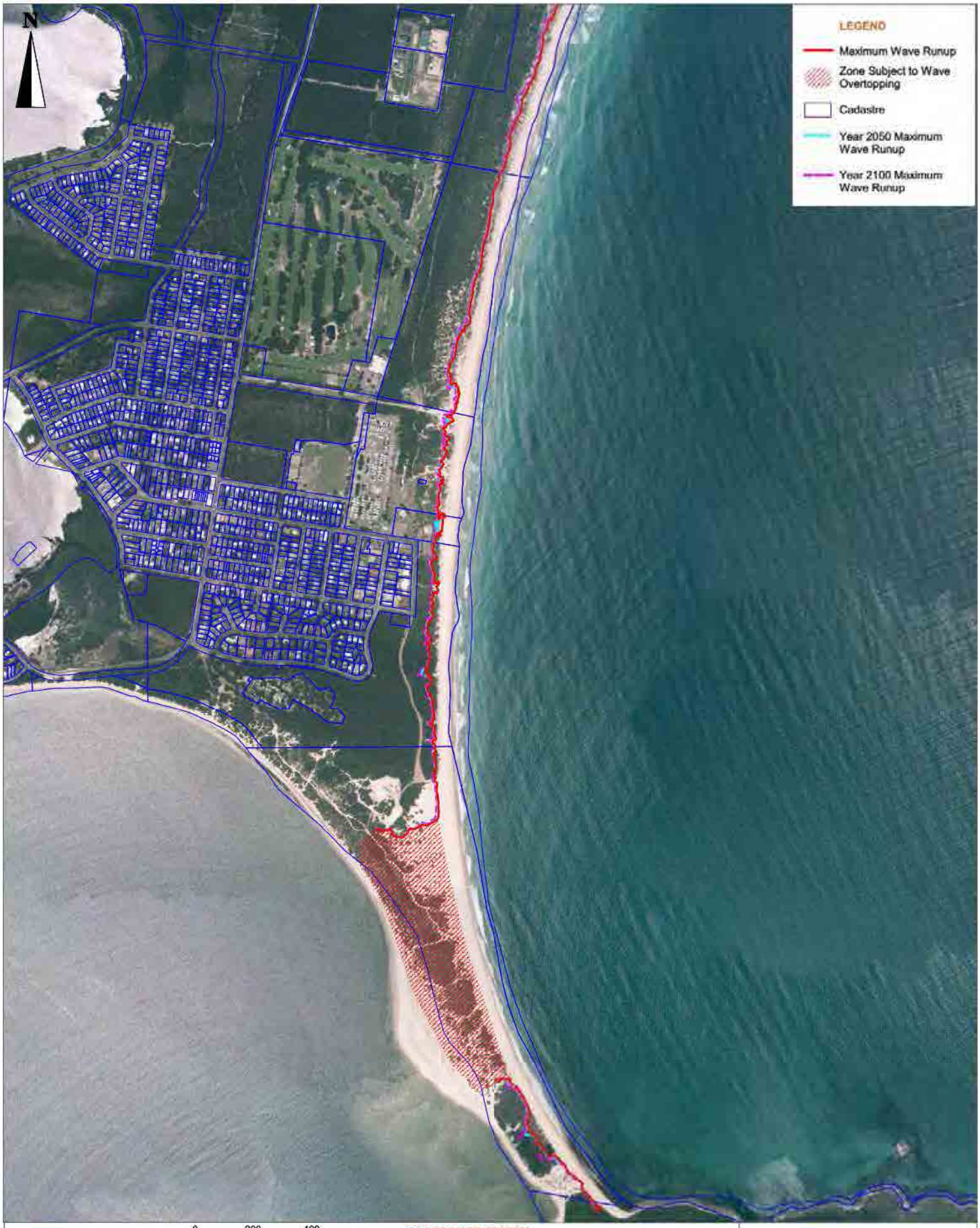

DATE 17/07/2012

0 200 400
metres

COORDINATE SYSTEM
MGA 94 Zone 56

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D.13

FIGURE TITLE Runup Harzard Line - Bennetts Beach

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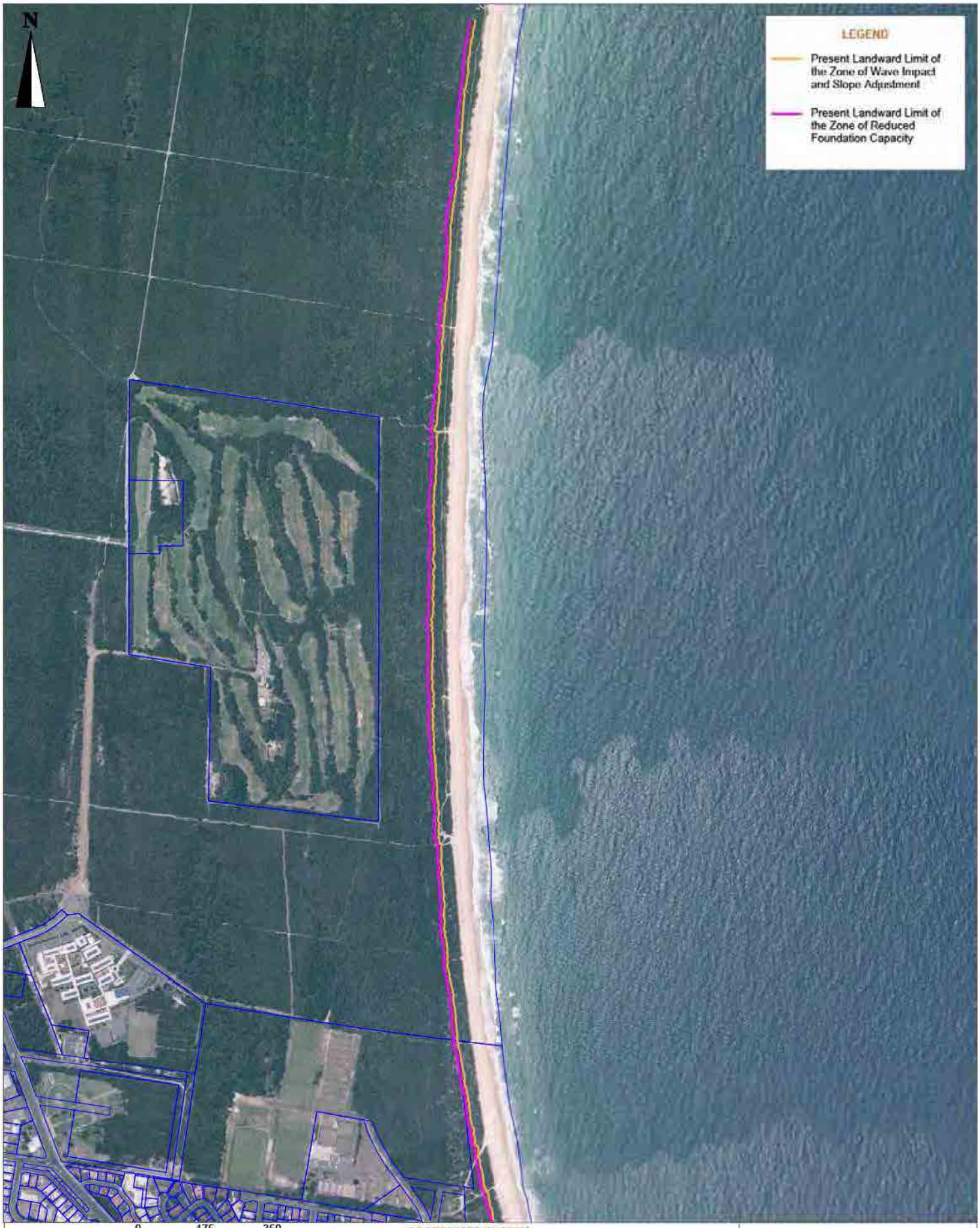

DATE 01/10/2010

COORDINATE SYSTEM MGA 94 Zone 56

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D. 14

FIGURE TITLE Present Hazard Zones at Nine Mile Beach

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DATE 01/10/2010

0 50 100
metres

COORDINATE SYSTEM
MGA 94 Zone 56

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D.15

FIGURE TITLE Present Hazard Zones at Tuncurry Beach

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DATE 25/08/2011 0 75 150 metres

COORDINATE SYSTEM MGA 94 Zone 56

FIG NO. D.16

FIGURE TITLE Present Hazard Zones at Main Beach

PROJECT NO. 3001629

PROJECT TITLE Great Lakes Coastal Hazard Study

CREATED BY A.XIAO

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DATE 10/03/2011

COORDINATE SYSTEM
MGA 94 Zone 56

PROJECT NO. 3001829 PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D.17 FIGURE TITLE Present Hazard Zones at One Mile Beach

CREATED BY M. GLATZ LOCATION I:\projects\3001829 - Great Lakes Coastal Hazard Study\005DATA\GIS

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DATE 01/02/2012

COORDINATE SYSTEM MGA 94 Zone 56

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D.18

FIGURE TITLE Present Day Hazard Zones at Seven Mile Beach / Booti Booti

CREATED BY A.XIAO

LOCATION I:\projects\3001829 - Great Lakes Coastal Hazard Study\009DATA\GIS\Workspaces

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DATE 24/03/2011

COORDINATE SYSTEM MGA 94 Zone 56

FIG NO. D.19

FIGURE TITLE Present Day Hazard Zone at Elizabeth Beach

PROJECT NO. 3001629

PROJECT TITLE Great Lakes Coastal Hazard Study

CREATED BY A. XIAO

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0 175 350
metres

DATE 18/11/2011

COORDINATE SYSTEM MGA 94 Zone 56

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D.20

FIGURE TITLE Present Day Hazard Zones at Sandbar Beach

CREATED BY A.XIAO

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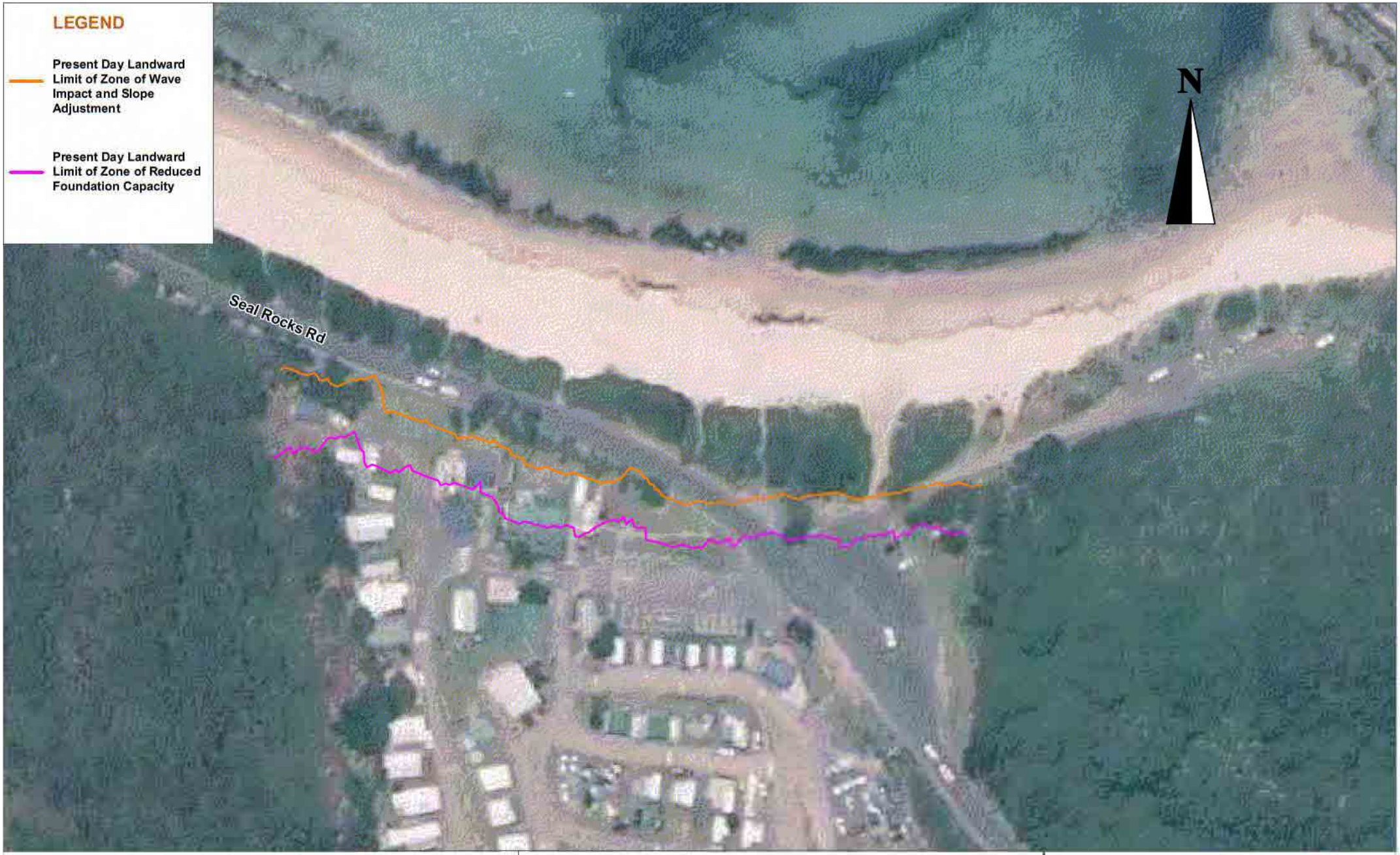

DATE 04/08/2011 0 20 40 metres COORDINATE SYSTEM MGA 94 Zone 56

FIG NO. D.21 FIGURE TITLE Present Day Hazard Zone at Number One Beach

PROJECT NO. 3001829 PROJECT TITLE Great Lakes Coastal Hazard Study

CREATED BY A.XIAO LOCATION \\projects\3001829 - Great Lakes Coastal Hazard Study\009DATA\GIS\Workspaces

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DATE 04/08/2011 | 0 50 100 metres | COORDINATE SYSTEM MGA 94 Zone 56 | FIG NO. D.22 | FIGURE TITLE Present Day Hazard Zone at Boot Beach

PROJECT NO. 3001829 | PROJECT TITLE Great Lakes Coastal Hazard Study | CREATED BY A.XIAO | LOCATION I:\projects\3001829 - Great Lakes Coastal Hazard Study\009DATA\GIS\Workspaces

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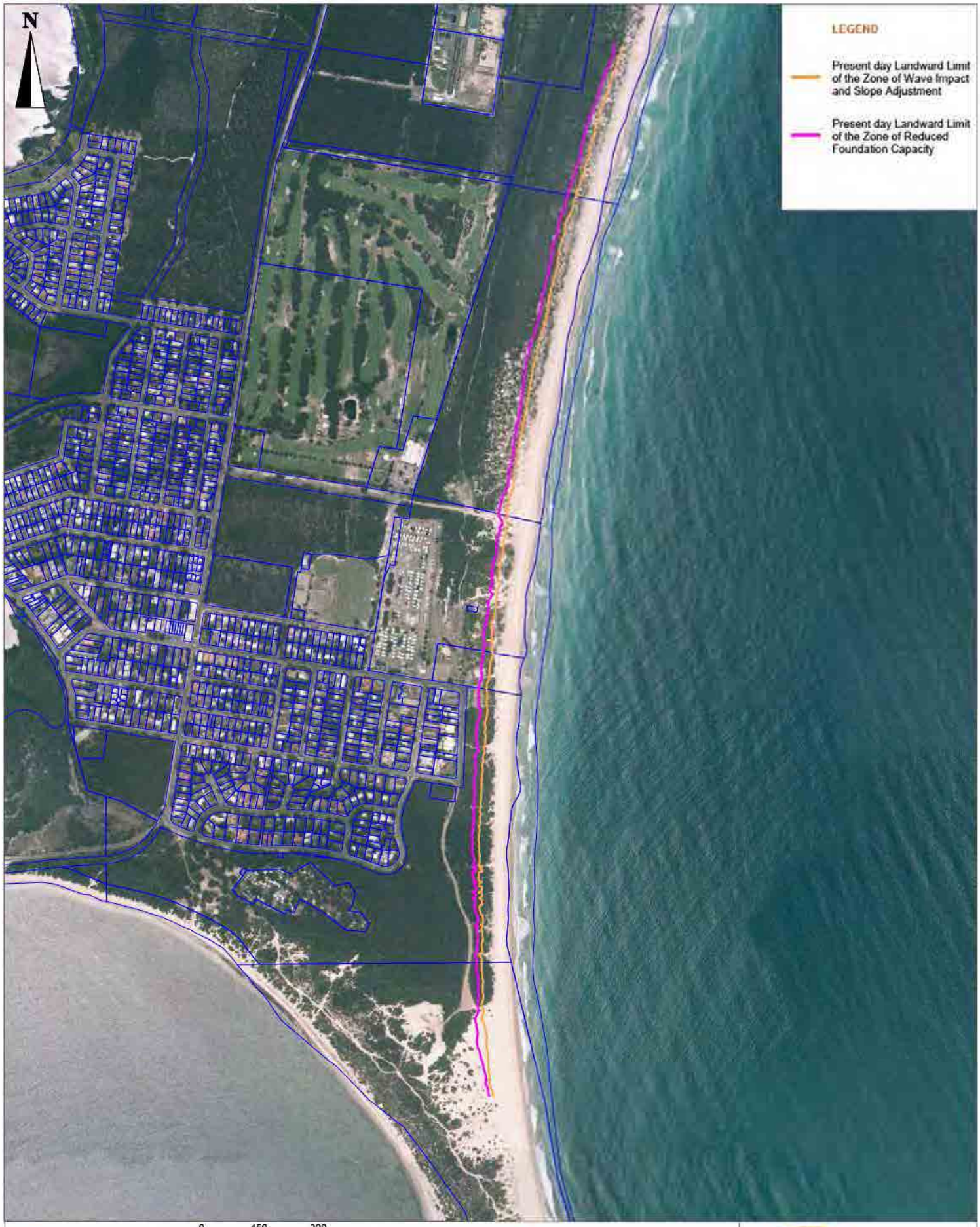

DATE 27/09/2011

0 150 300
metres

COORDINATE SYSTEM MGA 94 Zone 56

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D.23

FIGURE TITLE Present Day Hazard Zones at Bennetts Beach

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DATE 30/04/2013		COORDINATE SYSTEM MGA 94 Zone 56	
PROJECT NO. 30011283	PROJECT TITLE	Great Lakes Coastal Hazard Study	
FIG NO. D. 24	FIGURE TITLE	2060 Hazard Zones at Nine Mile Beach	
CREATED BY T.N	LOCATION	\\AUNCFP02\Group\Projects\30011283 - Great Lakes CZMP Newcastle\009DATA\...Tuncurry_updated_tn_20130423	

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Great Lakes COUNCIL

DATE	30/04/2013	COORDINATE SYSTEM	MGA 94 Zone 56
PROJECT NO.	30011283	PROJECT TITLE	Great Lakes Coastal Hazard Study
FIG NO.	D. 25	FIGURE TITLE	2060 Hazard Zones at Tuncurry Beach
CREATED BY	T.N	LOCATION	\\AUNCFP02\Group\Projects\30011283 - Great Lakes CZMP Newcastle\009DATA\... Tuncurry_updated_tn_20130423

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DATE 18/07/2012 0 75 150 metres

COORDINATE SYSTEM MGA 94 Zone 56

FIG NO. D. 26

FIGURE TITLE 2060 Hazard Zones at Main Beach

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

CREATED BY M. GLATZ

LOCATION I:\projects\3001829 - Great Lakes Coastal Hazard Study\009DATA\GIS

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DATE 18/07/2012

COORDINATE SYSTEM MGA 94 Zone 56

PROJECT NO. 3001829 PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D. 27 FIGURE TITLE 2060 Hazard Zones at One Mile Beach

CREATED BY M. GLATZ LOCATION I:\projects\3001829 - Great Lakes Coastal Hazard Study\009DATA\GIS

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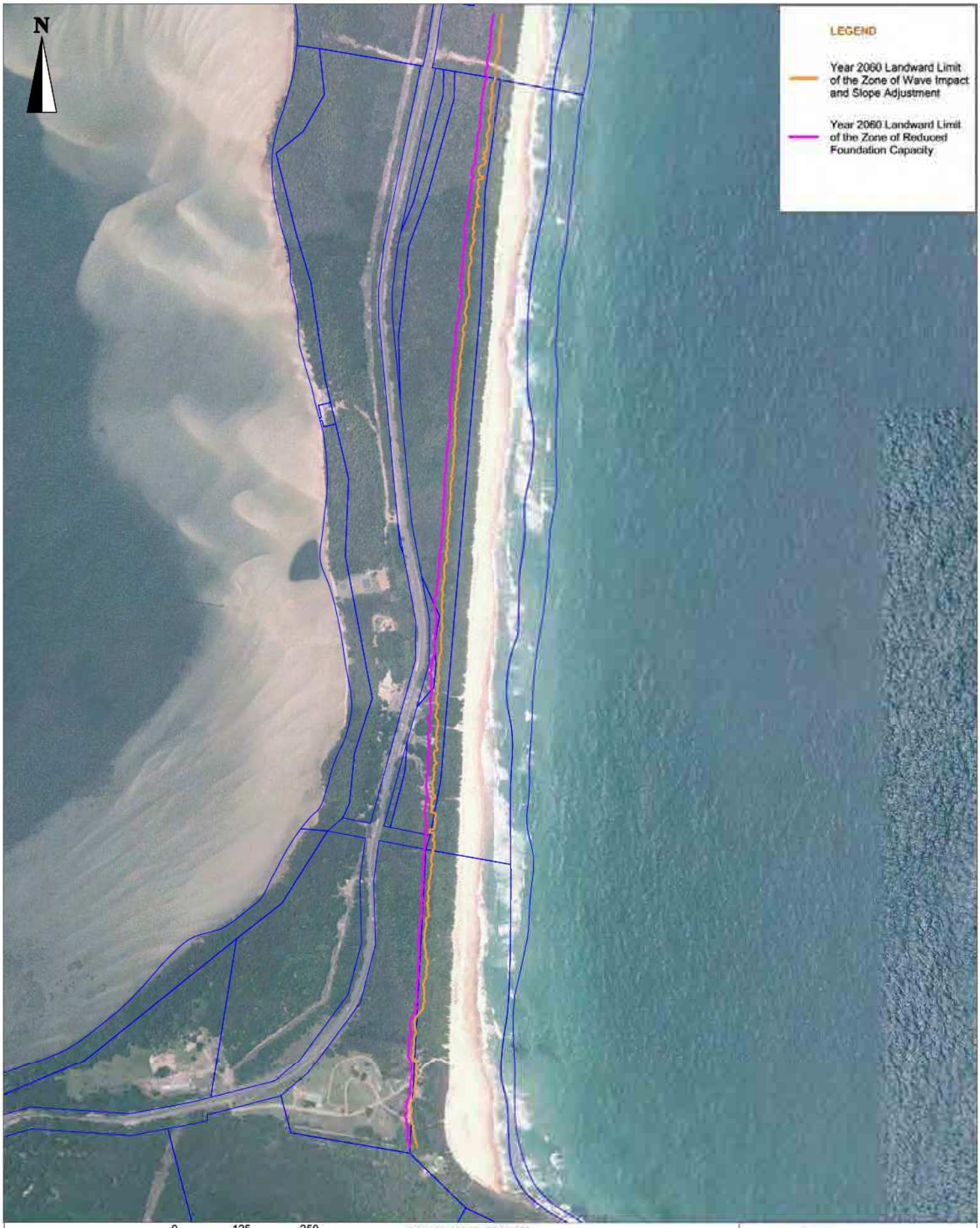

0 125 250
metres

DATE 18/07/2012

COORDINATE SYSTEM MGA 94 Zone 56

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D. 28

FIGURE TITLE Year 2060 Hazard Zones at Seven Mile Beach / Booti Booti

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FIG NO. D. 29

FIGURE TITLE 2060 Hazard Zone at Elizabeth Beach

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

CREATED BY M.GLATZ

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0 175 350
metres

DATE 18/07/2012 COORDINATE SYSTEM MGA 94 Zone 56

PROJECT NO. 3001829 PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D. 30 FIGURE TITLE Year 2060 Hazard Zones at Sandbar Beach

CREATED BY M.GLATZ LOCATION I:\projects\3001829 - Great Lakes Coastal Hazard Study\009DATA\GIS\Workspaces

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DATE 18/07/2012 0 20 40 metres COORDINATE SYSTEM MGA 94 Zone 56

FIG NO. D. 31 FIGURE TITLE Year 2060 Hazard Zone at Number One Beach

PROJECT NO. 3001829 PROJECT TITLE Great Lakes Coastal Hazard Study

CREATED BY M.GLATZ LOCATION \\projects\3001829 - Great Lakes Coastal Hazard Study\009DATA\GIS\Workspaces

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DATE 18/07/2012 | 0 50 100 metres | COORDINATE SYSTEM MGA 94 Zone 56

FIG NO. D. 32 | FIGURE TITLE Year 2060 Hazard Zone at Boat Beach

PROJECT NO. 3001829 | PROJECT TITLE Great Lakes Coastal Hazard Study

CREATED BY M.GLATZ | LOCATION I:\projects\3001829 - Great Lakes Coastal Hazard Study\009DATA\GIS\Workspaces

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DATE 18/07/2012

0 150 300
metres

COORDINATE SYSTEM
MGA 94 Zone 56

PROJECT NO. 3001829 PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D. 33 FIGURE TITLE Year 2060 Hazard Zones at Bennetts Beach

CREATED BY A.XIAO LOCATION I:\projects\3001829 - Great Lakes Coastal Hazard Study\009DATA\GIS\Workspaces

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DATE 30/04/2013		COORDINATE SYSTEM MGA 94 Zone 56	
PROJECT NO. 30011283	PROJECT TITLE	Great Lakes Coastal Hazard Study	
FIG NO. D 34	FIGURE TITLE	2100 Hazard Zones at Nine Mile Beach	
CREATED BY T.N	LOCATION	\\AUNCFP02\Group\Projects\30011283 - Great Lakes CZMP Newcastle\009DATA\...Tuncurry_updated_tn_20130423	

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DATE 30/04/2013		COORDINATE SYSTEM	MGA 94 Zone 56
PROJECT NO. 30011283	PROJECT TITLE	Great Lakes Coastal Hazard Study	
FIG NO. D.35	FIGURE TITLE	2100 Hazard Zones at Tuncurry Beach	
CREATED BY T.N	LOCATION	\\AUNCFP02\Group\Projects\30011283 - Great Lakes CZMP Newcastle\009DATA\... Tuncurry_updated_tn_20130423	

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DATE 18/07/2012 0 75 150 metres

COORDINATE SYSTEM MGA 94 Zone 56

FIG NO. D.36

FIGURE TITLE 2100 Hazard Zones at Main Beach

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

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DATE 18/07/2012

COORDINATE SYSTEM MGA 94 Zone 56

PROJECT NO. 3001829 PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D.37 FIGURE TITLE 2100 Hazard Zones at One Mile Beach

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0 125 250
metres

DATE 18/07/2012

COORDINATE SYSTEM MGA 94 Zone 56

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D.38

FIGURE TITLE Year 2100 Hazard Zones at Seven Mile Beach / Booti Booti

CREATED BY M.GLATZ

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DATE 18/07/2012

COORDINATE SYSTEM MGA 94 Zone 56

FIG NO. D.39

FIGURE TITLE 2100 Hazard Zone at Elizabeth Beach

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

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0 175 350
metres

DATE 18/07/2012

COORDINATE SYSTEM MGA 94 Zone 56

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D.40

FIGURE TITLE Year 2100 Hazard Zones at Sandbar Beach

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DATE 18/07/2012 0 20 40 metres COORDINATE SYSTEM MGA 94 Zone 56

FIG NO. D.41 FIGURE TITLE Year 2100 Hazard Zone at Number One Beach

PROJECT NO. 3001829 PROJECT TITLE Great Lakes Coastal Hazard Study

CREATED BY M.GLATZ LOCATION I:\projects\3001829 - Great Lakes Coastal Hazard Study\009DATA\GIS\Workspaces

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DATE 18/07/2012 | 0 50 100 metres | COORDINATE SYSTEM MGA 94 Zone 56

FIG NO. D.42 | FIGURE TITLE Year 2100 Hazard Zone at Boat Beach

PROJECT NO. 3001829 | PROJECT TITLE Great Lakes Coastal Hazard Study

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DATE 18/07/2012

0 150 300
metres

COORDINATE SYSTEM MGA 94 Zone 56

PROJECT NO. 3001829

PROJECT TITLE Great Lakes Coastal Hazard Study

FIG NO. D.43

FIGURE TITLE Year 2100 Hazard Zones at Bennetts Beach

CREATED BY A.XIAO

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