Little Mindil Beach

25 Gilruth Avenue, The Gardens, Northern Territory

Hydraulic Assessment

KTT Investments Pty Ltd

17 June 2021

Document Verification

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1 INTRODUCTION

ADG Engineers Pty Ltd (Aust) was engaged by KTT Investments Pty Ltd to prepare a hydraulic assessment for a proposed mixed-use development located at 25 Gilruth Avenue, The Gardens, Northern Territory.

This report was compiled using information from the following sources:

- Site Investigations;
- Northern Territory Government Topographical Data;
- Architectural drawings by Hachem;
- Survey Plan prepared by Land Surveys.

1.1 PURPOSE OF REPORT

This report has been prepared to define the flooding extent caused by local catchment flows and ensure that the proposed development does not adversely impact peak levels external to the subject site. Additionally, it will describe how the proposed buildings will be protected from storm surge inundation.

1.2 PROPERTY DETAILS

The total site area is approximately 5.13ha and the existing land titles are provided in **Table 1** below.

Table 1 Property Detail

Title	Lot 7651, Town of Darwin
Street Address	25 Gilruth Avenue, The Gardens, Northern Territory
Site Area	5.13 ha

Figure 1. displays the locality of the subject site. The site is bound by Gilruth Avenue to the south-east, the Mindil Beach casino to the north-east, the Timor Sea to the north-west and Burnett Place to the south.

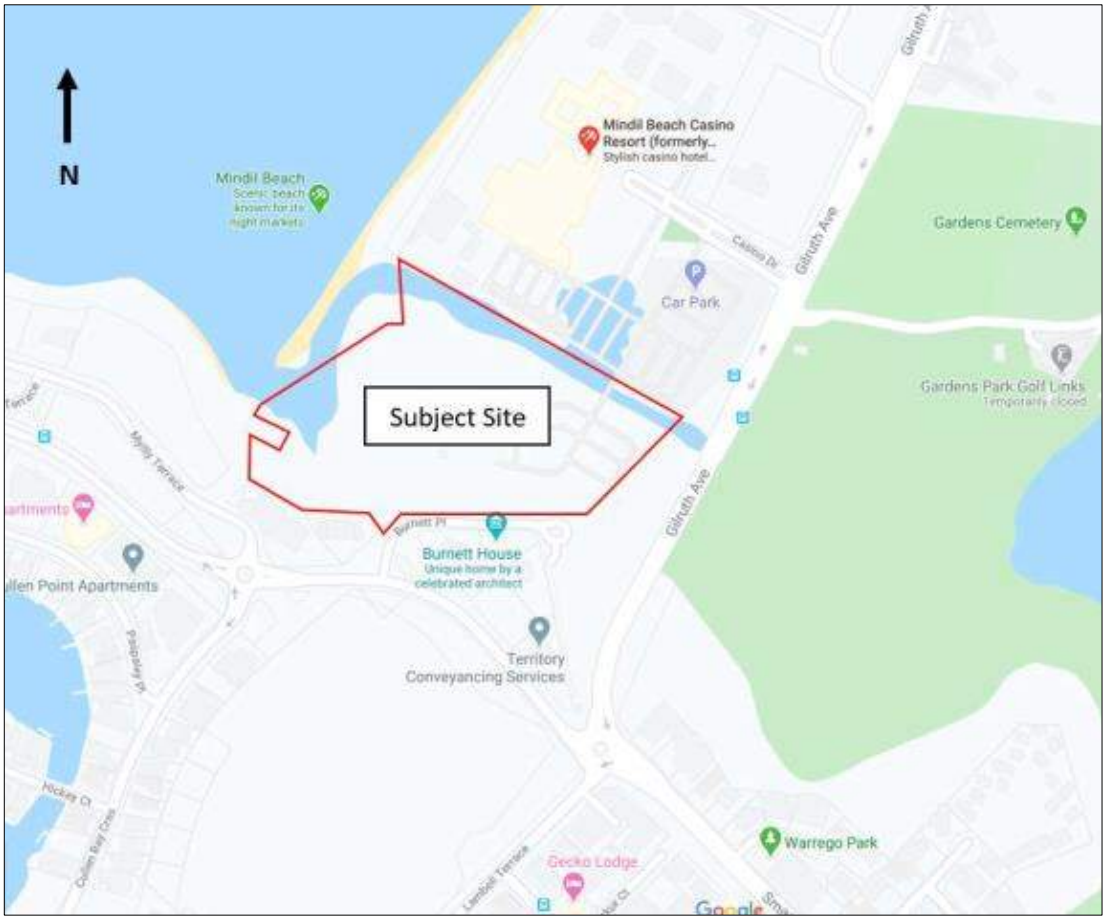

Figure 1 Locality Map (As accessed from Google maps 30.04.2020)

1.3 EXISTING SITE

The subject site generally falls from south to north at a grade of approximately 1%. The southern boundary of the site is comprised of a steep rock escarpment. The northern portion of the site contains a creek which drains a catchment to the west and discharges into the Timor Sea at Mindil Beach.

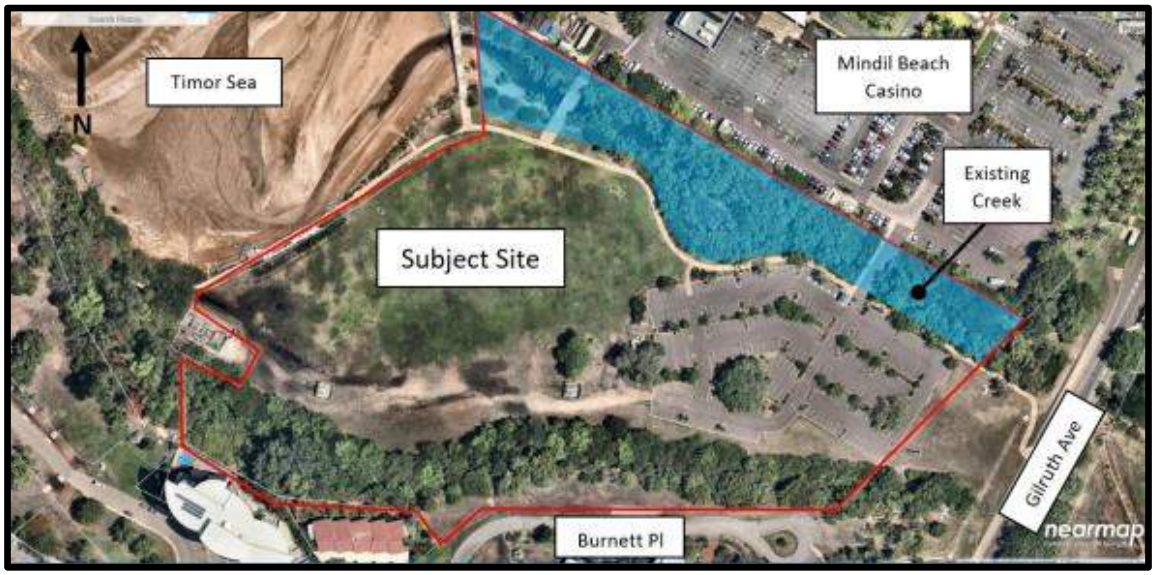

Figure 2 Existing Site Conditions (As accessed from Nearmap 30.04.2020)

2 PROPOSED DEVELOPMENT

The proposal will seek approval for development to create a multi-storey hotel, apartment and luxury villa precinct including commercial and function tenancies. The development does not propose any works within the exiting creek area, nor propose any additional crossings.

The site is identified as subject to storm surge as per the Northern Territory Storm Surge Mapping. Correspondence with NTG DENR Water Resources Division confirms that the Primary Storm Surge (PSS) level is 5.47 m AHD. The site is proposed to be filled to RL 5.80 m AHD to provide immunity from the PSS and an inclusion for freeboard. This filling is not expected to impact on peak storm surge levels.

This report will investigate flooding from local catchment flows only with a Medium High Water Springs (MHWS) tailwater applied.

3 DATA COLLECTION

A variety of data was collected and used as part of this analysis. The data and sources included:

- Design rainfall for the site based on Australian Rainfall and Runoff (AR & R) and Bureau of Meteorology (BOM) for the site;
- Existing topography for the site and surrounding areas based on data received from DIPL for the site and surrounding catchment; and
- Site Inspections to determine existing culvert sizes.

4 MODELLING PROCEDURE

Investigation of flood behaviour through the subject site required analysis and modelling of the upstream catchment and flow path behaviour. This involved:

- Hydrologic (Catchment) Analysis, to determine the catchment rainfall-runoff processes to produce peak flows. Hydrologic analysis was completed using data from AR&R and BOM.
- Hydraulic Modelling Analysis, which is used to simulate the flood behaviour of the catchment to produce flood levels, flow discharges and flow velocities. The model is also used to simulate conveyance to understand how water gets from one point to another. Hydraulic modelling was completed using TUFLOW software.

The steps used in each of these models for flood event simulation are described in the following sections below.

5 HYDROLOGIC MODELLING

To simulate rainfall events within the study area the rain-on-grid method has been utilised. This method applies rainfall directly to the 2D grid using rainfall depths sourced from the Bureau of Meteorology. The study area is suited to this hydrology input method as it contains several minor flowpaths converging to the creek outlet. The model calculates excess rainfall for each cell within the model based on the infiltration parameters of the specified surface type at that point. Impervious areas were assigned initial and continuing losses of 0 mm and 0 mm/hr respectively, while pervious areas were assigned initial and continuing losses extracted from the AR&R data hub, with pre-burst median rainfall subtracted from initial loss values to simulate wetting of the catchment prior to the design storm burst.

The 2D model has been run for storm durations from 10 minutes to 6 hours for each nominated AEP. An ensemble of 10 temporal patterns as determined from AR&R for each durations has been analysed. The following storm events were found to be critical for peak flow within the creek.

Table 2 Critical Storm Details

AEP	Critical Duration	Critical Temporal Pattern
63.2%	180 minutes	TP07
0.5EY	180 minutes	TP09
0.2EY	120 minutes	TP09
9.5%	90 minutes	TP05
4.9%	90 minutes	TP06
2%	120 minutes	TP07
1%	120 minutes	TP07

6 HYDRAULIC MODELLING

To assess flooding characteristics within the study area, a 1D/2D TUFLOW model was established. TUFLOW is capable of simulating flow for both small and large study areas using both 2-dimensional and 1-dimensional flow based on the topographic conditions of the study area.

6.1 Model Setup

The hydraulic model simulates the dynamic flooding behaviour along natural watercourses, constructed channels, and the floodplain. Setting up the hydraulic model involved:

- Create 2D surface using LiDAR data;
- Allocation of model boundaries;
- Input 1D elements such as pipes and culverts;
- Apply land uses based on infiltration characteristics; and
- Application of appropriate surface friction (Manning “n”)

Topography data of the site and surrounding area provided by DIPL was utilised to create the Digital Elevation Model (DEM) required for TUFLOW modelling of the existing scenario. A grid of 1m was used for modelling to best simulate the topographical condition of the site and increase the accuracy of the model results.

6.1.1 Manning's Coefficient

Based on recommendations from Australian Rainfall and Runoff (AR&R), orthographic photos and a site inspection, Manning's "n" was applied for the following areas shown in the table below.

Table 3 Manning's Table

SURFACE	MANNINGS (n)
Medium Vegetation	0.08
Light Vegetation	0.06
Grass/Cleared Land	0.045
Roads/concrete	0.014

6.1.2 Inflow Locations

The rainfall inflow was modelled in TUFLOW using the rain-on-grid methodology. This method applies rainfall directly to the 2D grid using rainfall depths sourced from the Bureau of Meteorology.

6.1.3 Existing Culverts

The existing culverts in the model extent have been included as 1D elements. The culvert sizes are summarised in **Figure 3** below.

Figure 3 Existing Culverts

6.1.4 Downstream Boundary Condition

This flood assessment is focussed on local catchment flows rather than storm surge. Therefore a downstream boundary condition based on MHWS has been adopted. This level has been set at a fixed value of RL 2.9 m AHD.

6.1.5 Model Extent

The model extends over the entire catchment which contributes flow to the creek catchment. The creek further north of the site has also been included to capture any flow interaction to the east of Gilruth Avenue.

Figure 4 shows the TUFLOW model layout.

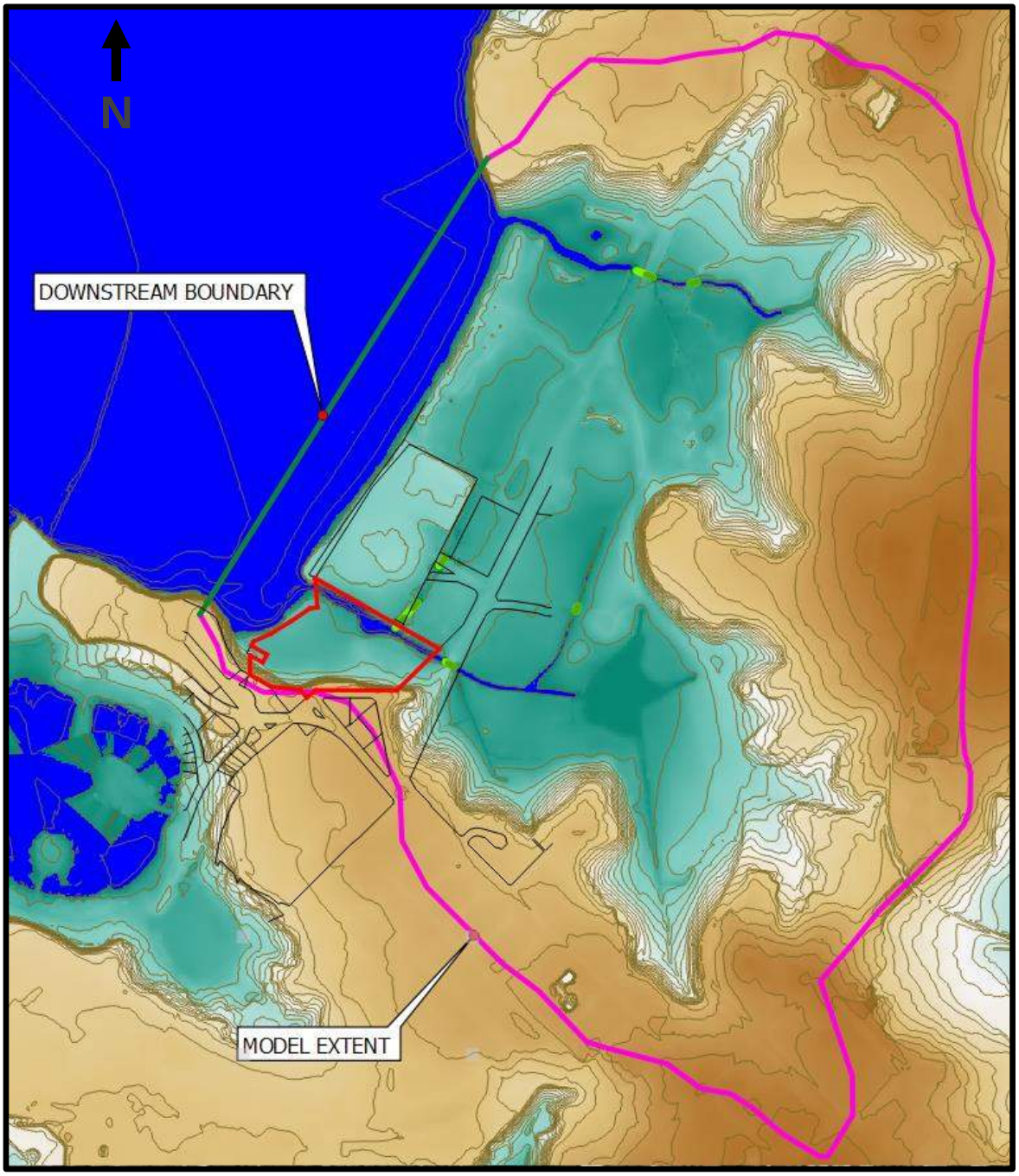

Figure 4 Model Layout

6.2 Existing Scenario

6.2.1 Existing Scenario Results

Hydraulic analysis of the study area in its existing condition was undertaken to establish and quantify existing flooding patterns and behaviour. Key model outputs characterising flood behaviour include flood extents, depths at critical locations, and peak flows. Pre-development modelling results are as follows:

- Runoff in the study area generally sheets across the impervious areas of the upper catchment and through defined flowpaths down the escarpment. The lower part of the catchment is generally flat and ponding occurs on both sides of Gilruth Avenue;

- The northern and southern creeks on Mindil Beach discharge flow to the ocean;
- The creek within the site conveys a peak flow of 11.7 m^3/s in a 1% AEP storm event;
- Depth of flow within the creek is up to 2.30 m in the 1% AEP storm event. **Figure 5** shows the 1% AEP pre-development flood depth plot across the catchment **and Figure 6** shows a close-up of the site; and
- Peak velocity within the creek is generally low due to the MHWS tailwater condition.

Figure 5 Pre-Development Q100 Extent

Figure 6 Pre-Development Q100 Extent - Site

6.3 Post-Developed Scenario

The post-developed scenario involves the filling of the building footprint to achieve storm surge immunity. This has been represented conservatively in the post-development model scenario by a block of fill over the entire works extent.

6.3.1 Post-Developed Scenario Results

Post-development modelling results are as follows:

- The flooding behaviour of the catchment is not affected by the filling required over the site to provide storm surge immunity;
- The filling works are located outside of the creek flowpath;
- Peak flood levels, depths, and velocities are unchanged within the creek and across the catchment;
- The post-development 1% AEP depth plot is shown on **Figure 7**.

Figure 7 Post-Development Q100 Extent

6.4 Storm Surge Flood Inundation

As identified in the Northern Territory Storm Surge Mapping for the Darwin Area, the subject site is currently subject to Storm Surge flood inundation. As per correspondence with NTG DENR Water Resources Division (**Appendix B**), the Primary Storm Surge (PSS) has been confirmed as 5.47m AHD. As such the site will be filled to ensure the habitable floor level of the proposed development is at or above the PSS. To ensure the protection of the habitable spaces of the development, ADG propose applying a minimum 300mm freeboard to the PSS, meaning the minimum finished floor of all habitable building areas will be 5.80m AHD. Access and egress to the site will be maintained at all times with reference to the applicable Primary Storm Surge Level to ensure a flood free access point is maintained.

As part of our flood impact assessment, ADG have considered the water displacement effects of the proposed filling of the development site will deliver to the surrounding land parcels, in particular the adjacent Casino. The Northern Territory coastline can experience storm surge, which is an on-shore inundation resulting from strong onshore winds associated with a tropical cyclone. A Tropical Cyclone Storm Tide is the combined effects of a normal tide (low to high astronomical tide) plus storm surge plus wave setup. Storm surge inundation maps have been developed for areas in Greater Darwin and for communities in the Gulf and Top End regions. These maps are based on the projected mean sea level by year 2100 for hazard Return Periods (or Average Recurrence Intervals ARIs).

The storm surge is a macro effect which impacts significant portions of the Northern Territory Coastline. The proposed filling is a micro effect and in consideration of the relative proportionate volume of fill (approx. 35,000m^3) required to achieve the proposed finish floor level in comparison to the volume of the ocean affected by the storm surge, the proposed filling of the development site will deliver a negligible impact to the water level of the adjacent waterway and in turn will result in a negligible impact to the Storm Surge inundation level.

7 CONCLUSION

This study has reviewed the hydrology and hydraulics of the local catchment area for pre and post-development scenarios and investigated the impact of the proposed filling on the extent and depth of flooding.

Based on this study the following conclusions have been drawn;

- The site is to be filled to RL 5.80 m AHD to provide protection from storm surge;
- Local flooding is contained within the creek for storm events up to the 1% AEP;
- The extent of filling proposed to provide storm surge protection is located outside of the creek flowpath; and
- The filling works have no impact on peak levels and depths within the creek and through the wider catchment.

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Appendix A
Architectural Drawings

(Refer to Appendix 1B of the NT EPA Referral)

Appendix B
Correspondence with NTG DENR

Request from Harris Davidson about Storm Surge Level for the property Parcel – 7651, Town of Darwin, NT

The Surface Water group in DENR has carried out desktop study on storm surge level and flooding levels query for the property (**Parcel 7651, Town of Darwin, NT**) and have made the following comments based on available (published) relevant Mappings such as Storm Surge Flood Mappings and digital data as GIS layer:

SURFACE WATER COMMENTS:

- The lot of interest (**Parcel 7651** as shown in Figure 1 below**)** is affected by both Primary Storm Surge (PSS) and Secondary Storm Surge (SSS) inundation / flooding of 100 year and 1000 year ARI with approximate inundation levels as shown in Table 1 below *(Source: Darwin Area Storm Surge Inundation for 2100, November 2014 / prepared by GHD Pty Ltd for DLRM)*.


P1
P2
P3
P4
P5
S1
S2
S3
S4
S5
7651
6772


P1
P2
P3
P4
P5
S1
S2
S3
S4
S5
7651
6772

Figure 1 Location of Primary and Secondary Storm Surge Levels (P – Primary; S – Secondary)

Table 1 Primary and Secondary Storm Surge Levels

Locations	Primary Storm Surge Level (PSS) (mAHD)	Secondary Storm Surge Level (SSS) (mAHD)
P1	5.46	-
P2	5.46	-
P3	5.47	-
P4	5.47	-
P5	5.47	-
P6	5.46	-
S1	-	5.75
S2	-	5.86
S3	-	5.85
S4	-	5.79
S5	-	5.75
S6	-	5.76

Appendix C
Flood Depth Plots

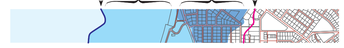
NORTHERN TERRITORY GOVERNMENT

GHD

SEA

NORTHERN TERRITORY STORM SURGE MAPPING

DARWIN AREA STORM SURGE INUNDATION for 2100



The technical information forming the basis of this storm surge inundation mapping is contained in the following reports prepared for the NT Government by Systems Engineering Australia Pty Ltd (SEA) or GHD:

1. Darwin Storm Tide Mapping Study - 2006
2. High Resolution Storm Tide and Climate Change Impacts Study - 2010
3. Rapid Creek Storm Surge Tide Mapping, Mapping update - 2018

Using the storm surge levels and estimates of Highest Astronomical Tide (HAT) from the above studies, the inundation and HAT extents for the projected mean sea level in 2100 were developed by GHD Pty Ltd in 2014 and 2016 based on the latest topographic information (2009, 2011 and 2015). This map is produced by the NT Government for the Darwin area based on the storm surge inundation and HAT extents.

The map shows the total storm surge (technical terminology is storm tide) hazard risk due to tropical cyclones in terms of the ocean water level comprising the combined effects of astronomical tide plus storm surge plus wave setup for two statistical Average Recurrence Intervals (ARI). It also shows the estimated HAT extent. The "Primary Storm Surge Zone" shown on the map refers to the extent of inundation for a storm tide event of 100 year ARI (with approximately a 40% chance of exceedance within any 50 year period). The "Secondary Storm Surge Zone" shown on the map refers to the further extent of inundation for a storm tide event of 1000 year ARI (with approximately a 5% chance of exceedance within any 50 year period). The extents do not include the possible effects of very localised wave runup.

Average Recurrence Interval (ARI) is also called Return Period of the Risk and is defined as the "average" number of years between successive events of the same or greater magnitude. The ARI of a storm tide event gives no indication of when a storm tide of that magnitude may occur.

Highest Astronomical Tide (HAT) is the highest ocean level expected due to any combination of astronomical conditions alone and has an equivalent ARI of approximately 18.6 years. The HAT extent is used in this map as the reference for storm surge inundation. It is based on estimates of HAT levels derived from numerical hydrodynamic modelling that has not been verified by long term insitu measurements.

The Storm Surge information shown on the map is considered as indicative only.

For detailed interpretation of this map and further information contact:
Department of Environment, Parks and Water Security, Water Resources Division
4th Floor Goyder Centre, 25 Chung Wah Terrace,
Palmerston, Northern Territory.
T: (08) 8999 4455 **Email:** waterresources@nt.gov.au
PO Box 496, Palmerston, NT. 0831

Storm surge reports and maps are available on **https://nt.gov.au/floods**
This map has been updated in **September 2020** and supercedes all previous versions.

GENERAL FEATURES

- Local Government Area — LITCHFIELD
- Property / Road Boundaries (July 2020)
- Suburbs / Localities — STUART PARK
- Major Road
- Minor Road
- Park / Reserve
- Railway
- Gas pipeline
- Watercourse, Lake or Lagoon
- Mangroves

Data Source:
Cadastre, road centrelines and administrative information
Northern Territory Department of Infrastructure, Planning and Logistics.

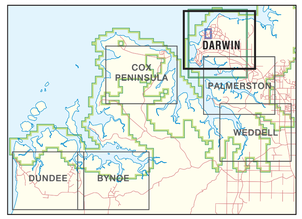
Map prepared by:
Department of Environment, Parks and Water Security,
Geospatial Services Branch
Drawing No. DENR2020066

metres 500 0 500 1000 1500 2000 metres 2500

Black numbered lines are 2500 metre intervals of the Map Grid of Australia (MGA) Zone 52
Transverse Mercator Projection Horizontal Datum: GDA 94

GDA This map was produced on the Geocentric Datum of Australia 1994 (GDA 94)

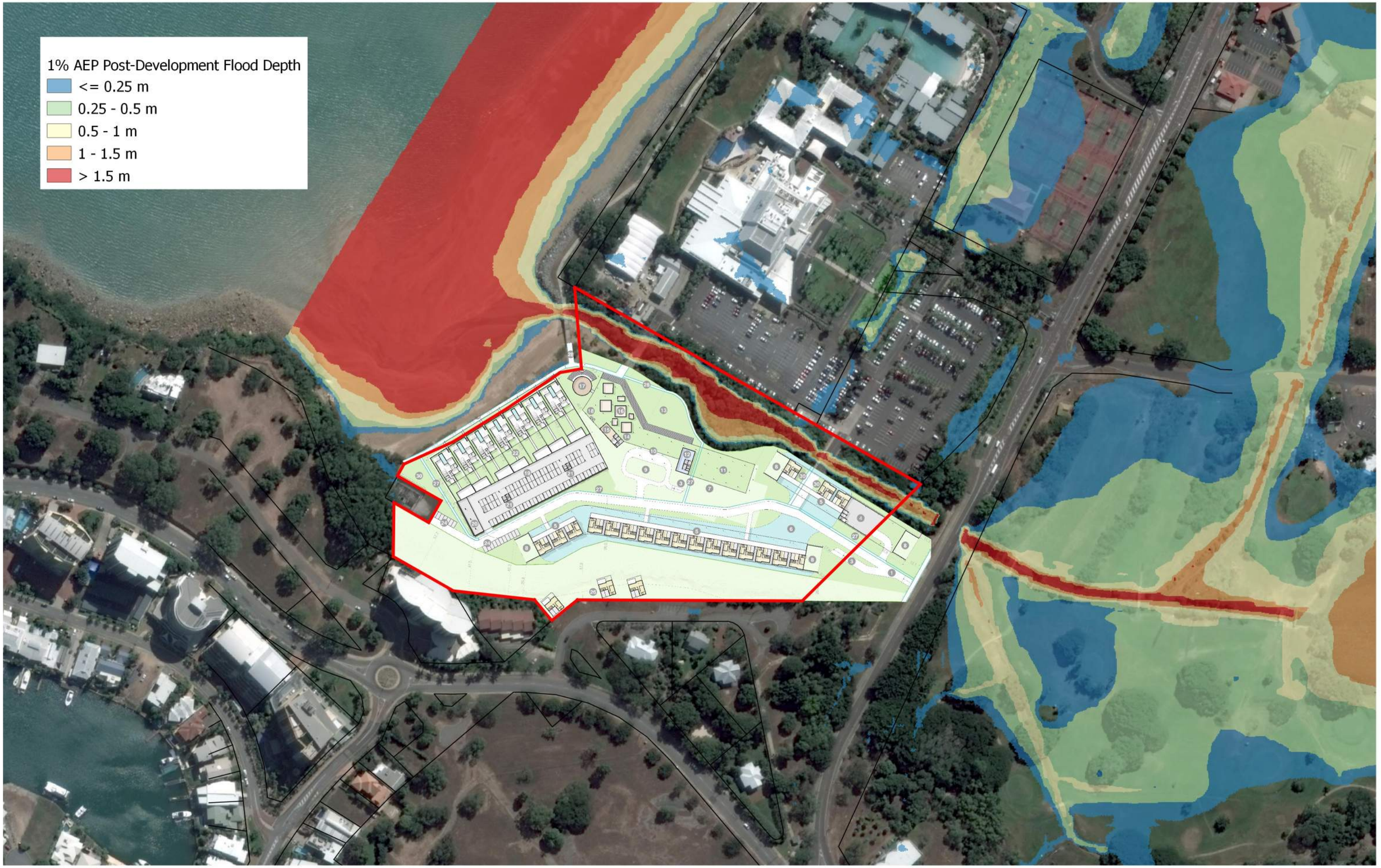
INDEX TO DARWIN REGION STORM SURGE MAPS



Extent of topographic information

2009 2011 2015

MAP LOCATION



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A	13.01.21	ORIGINAL ISSUE	JM	HD

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Project Name: LITTLE MINDIL BEACH THE GARDENS, NORTHERN TERRITORY	Designed By: HD	Checked By: HD	Approved By:
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Drawing No: HIA-02

Revision: A

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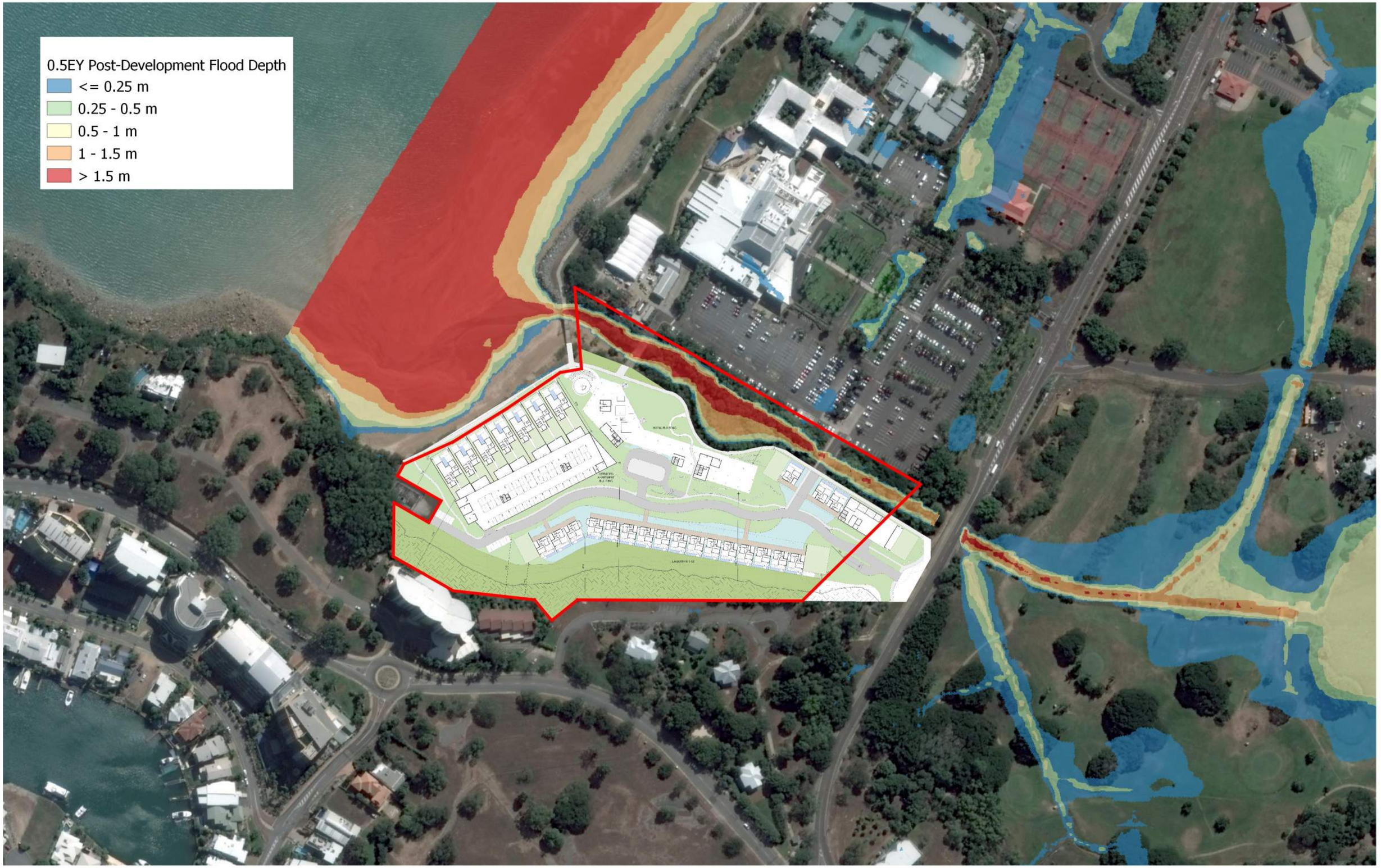
Title: POST-DEVELOPMENT FLOOD DEPTH - 1% AEP

Drawing No.: HIA-04

Revision: A



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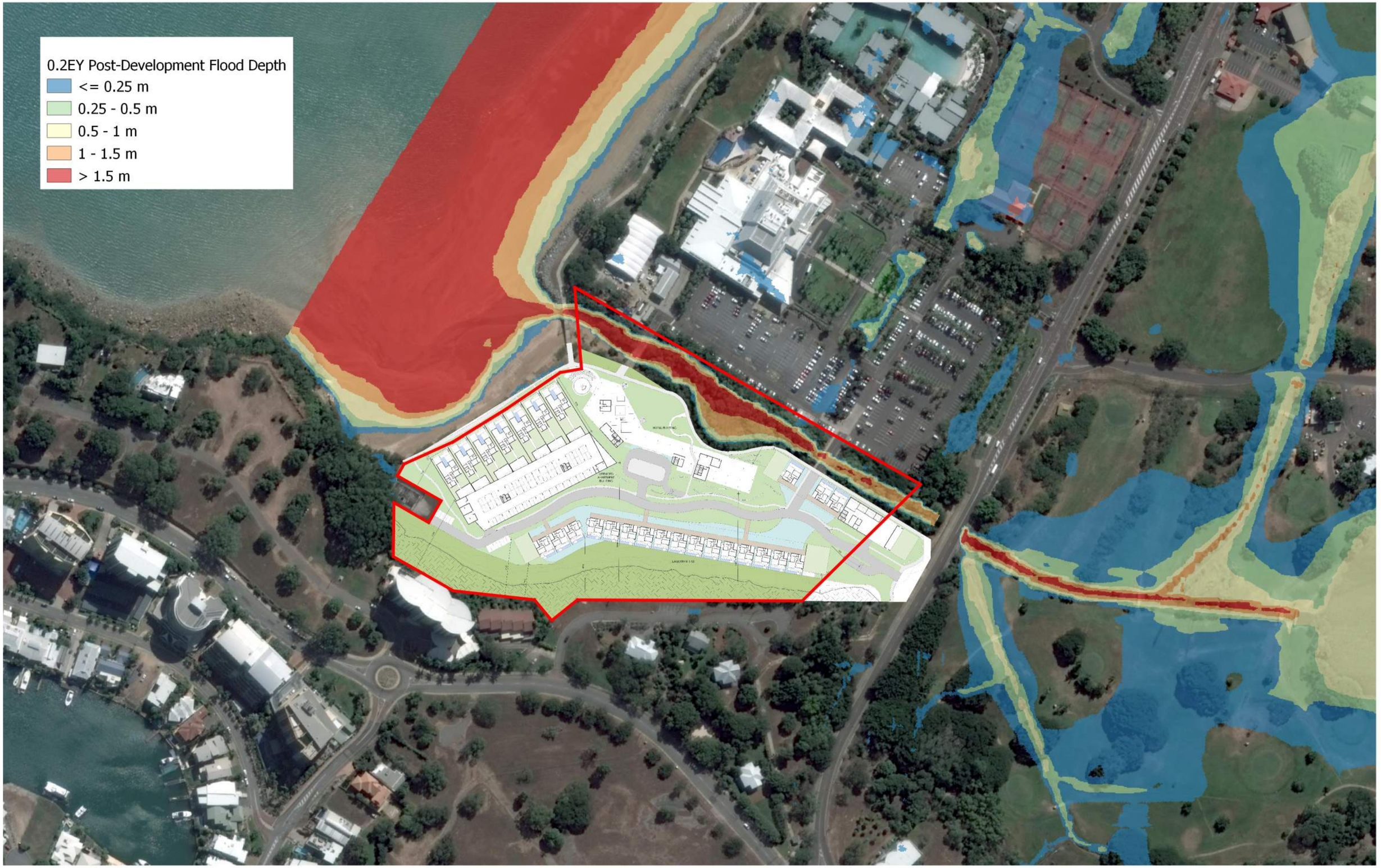
Drawing No: HIA-05	Revision: A



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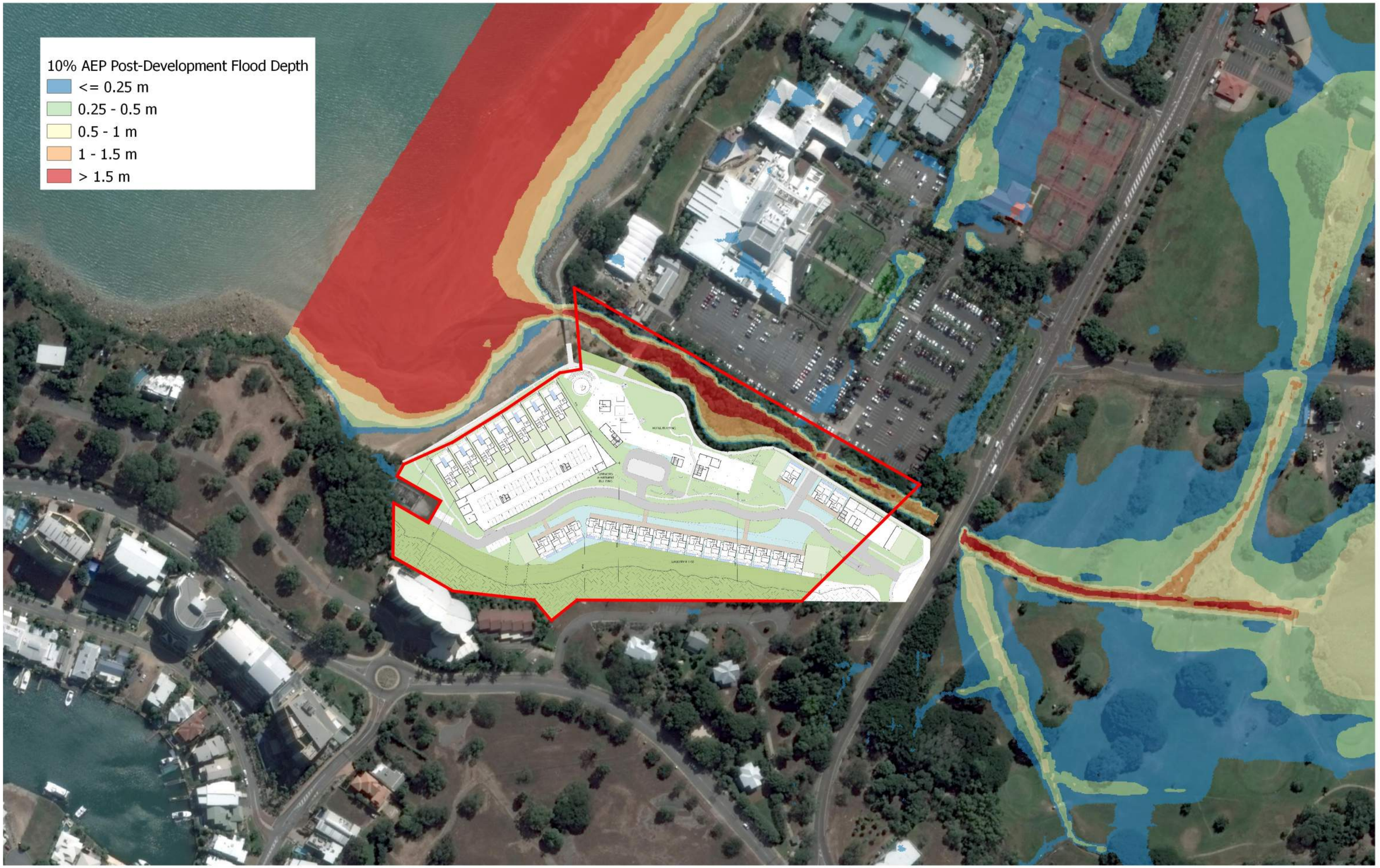

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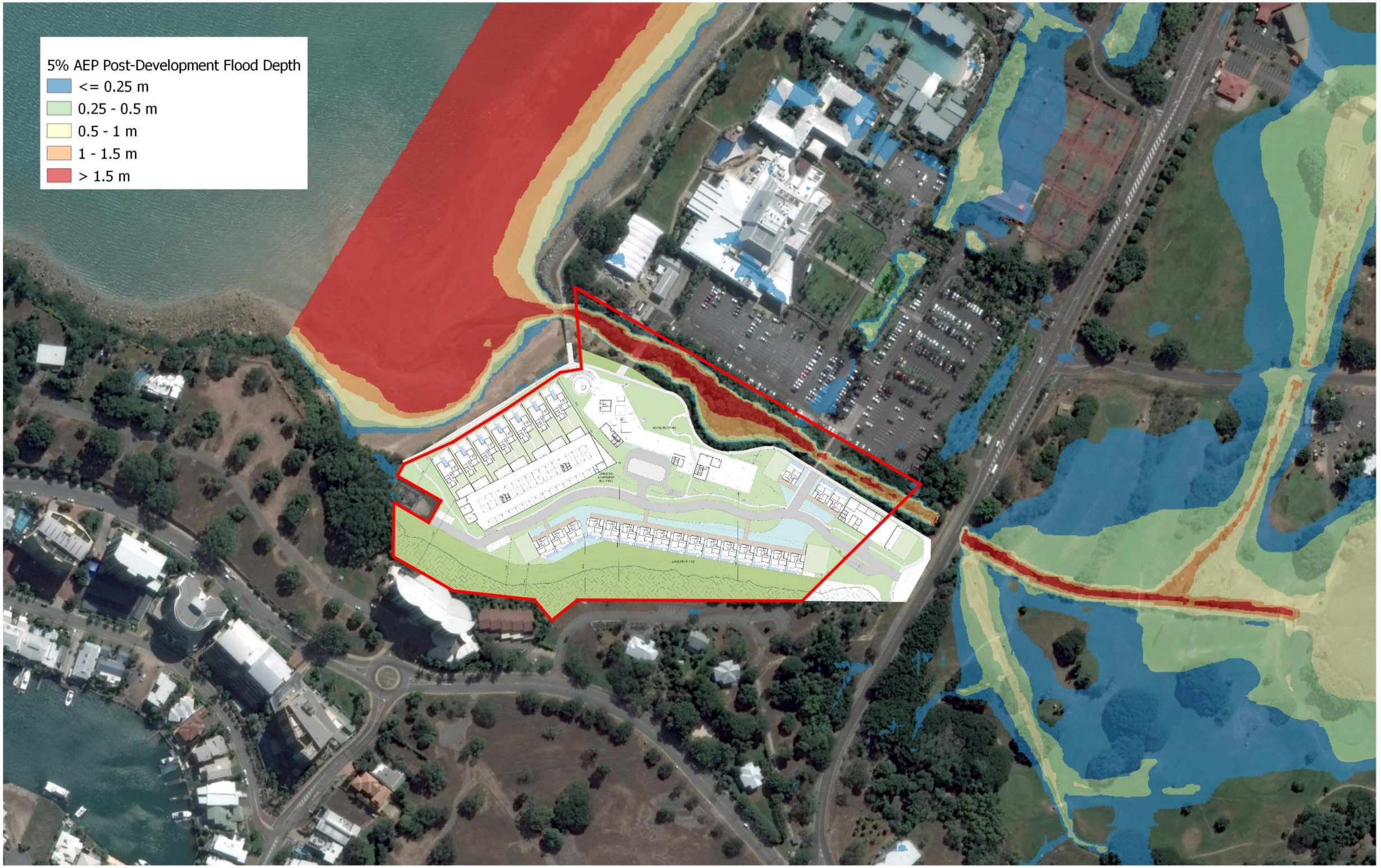

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Project Name: LITTLE MINDIL BEACH THE GARDENS, NORTHERN TERRITORY	Designed By: HD	Checked By: HD	Approved By:
	Project No: 23085	Drawn By: JM	Scale at A1: 1:2500

Title	
POST-DEVELOPMENT FLOOD DEPTH - 2% AEP	
Drawing No: HIA-09	Revision: A

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