AQUIS RESORT AT THE GREAT BARRIER REEF PTY LTD

ENVIRONMENTAL IMPACT STATEMENT

VOLUME 8

APPENDIX K

FLOODING

BMT WBM

AQUIS Resort at Great Barrier Reef Flooding Assessments Report to Support EIS

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April 2014

AQUIS Resort at Great Barrier Reef Flooding Assessments Report to Support EIS

Prepared for:	AQUIS Resort at Great Barrier Reef Pty Ltd
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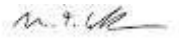
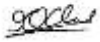
3	17/4/14	N. Collins		I. Clark	

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1 Introduction and Purpose of the Report

This report is one of a large number of technical reports prepared to support an Environmental Impact Statement (EIS) for the proposed AQUIS Resort at the Great Barrier Reef. The report addresses relevant aspects of the Terms of Reference (ToR) prepared by the Co-ordinator General for the Project on behalf of the Queensland Government in relation to flooding, including clauses 7.1 (a), 7.4, 7.24 (c), 7.25 (c) and (d), 7.27, 7.28, 7.33 and 7.34.

The investigation area comprised the site, and the Barron River delta, taking account of the full catchment of the Barron River and its tributaries, and the effect of water levels in the Coral Sea, including the effect of cyclonic storm tide.

Flooding is a major constraint to the development as the site is within the Barron River Delta and is flood affected, and existing site access roads are also flood affected.

The Barron River has a catchment area of 217,500 hectares, and drains extensive areas of the Atherton Tableland, dropping steeply through the Barron River gorge, to discharge to the sea via its delta, which contains several distributaries, including Thomatis / Richters, Redden and Barr Creeks. The delta has an area of around 4,000 hectares, which is largely used for sugar cane production.

The Captain Cook Highway traverses the delta, providing access via local roads to the delta townships of Machans Beach, Holloways Beach and Yorkeys Knob.

The Cairns International Airport is also within the delta in its southern extent.

This report describes the existing flooding environment, specific site flooding constraints, opportunities for development, and an assessment of development impacts on the environment. In addition, the report addresses site access requirements, and safety of people, including resort guests and staff, and the general public under all flooding events including extreme events. The report is the outcome of an intensive flooding investigation carried out since April 2013, which commenced with an initial constraints workshop, through initial conceptual design, project definition, initial advice statement and the EIS preparation process.

The EIS investigations have been undertaken in two stages, being:

- Stage 1 – Existing Situation; and
- Stage 2 – Impact Assessment and Mitigation.

This report details the outcomes of both Stage 1 and Stage 2.

2 Description of the Existing Environment and Values

2.1 General

The site is situated in the Barron River Delta at Yorkeys Knob in Cairns, and comprises several parcels of land on either side of Yorkeys Knob Road.

The Barron River has a catchment area of 2,175km^2, with major agriculture on the Atherton Tablelands, and across the delta itself. Figure 2-1 shows the extent and detail of the Barron River catchment.

The subject site itself is currently being cultivated for sugar cane and hence, is largely cleared of native vegetation. What native vegetation that remains is generally around the fringes of the parcel and along the section of Yorkeys Creek that flows through the site.

2.2 Climate

Yorkeys Knob is located within the wet-tropics climate zone. Table 2-1 provides a summary of climate statistics from the Bureau of Meteorology (BOM) station Cairns Aero (Station 031011). This rainfall station is located approximately 6.5km south of the site and has records from 1942 to the present. It has the most accumulated data and least amount of missing data and is therefore the most reliable gauge in the area. Further, given the proximity to the coast, similar topography and relatively close proximity of this rainfall station to the site, the climate data is expected to be representative of climate at the site. Figure 2-2 to Figure 2-4 provide graphical representations of this data.

As demonstrated from the presented data, the Cairns region experiences generally hot and humid summers and milder dryer winters. The summer months (January to March) is the period when the majority of rainfall occurs and as such there are defined wet and dry seasons for the area. Average annual rainfall is approximately 2000mm over approximately 154 days. The majority of flood events are therefore likely to occur between the months of January to March.

Data shows that relatively intense days of rainfall (>25mm) account for approximately half of Queensland's rainfall. Table 2-1 indicates that on average the Cairns region has 21 days of heavy rain per year. Studies have identified that for Queensland, extreme rainfall events have increased in their contribution to the annual rainfall total over the 20th century (Queensland rainfall – past, present and future, 2012).

Specifically for the Far North Queensland region, over the recent decade, there has been a 21% increase in average winter rainfall and a 10% increase in average summer rainfall (compared to the 1961-1990 average). This increase however is well within the bounds of natural variability. Local factors including topography, vegetation and broader scale weather patterns (e.g. El Nino events) strongly influence annual and seasonal rainfall which results in this natural variability (Climate change in the Far North Queensland Region, 2009).

The period between December and April is recognised as being Cyclone season however cyclones can form outside of this period (BOM, 2013).

Table 2-1 Summary of Climate Statistics from the Cairns AERO

Parameter	Month												Annual Average
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Mean maximum temperature (°C)	31	31	31	29	28	26	26	27	28	30	31	31	29
Mean minimum temperature (°C)	24	24	23	22	20	18	17	17	19	21	22	23	21
Mean rainfall (mm)	395	451	424	195	91	45	29	27	34	47	94	179	2007
Highest rainfall (mm)	1417	1287	1128	635	322	144	145	140	103	394	372	919	3149
Lowest rainfall (mm)	86	30	28	13	3	3	0	0	0	0	3	9	721
Highest daily rainfall (mm)	368	286	403	186	90	70	38	63	80	206	185	230	403
Mean no. of days of rain	18	19	19	18	14	10	9	8	8	8	10	14	155
Mean no. of days of rain >=1mm	16	16	16	15	10	7	6	5	5	6	8	11	120
Mean no. of days of rain >=10mm	8	10	8	5	3	1	1	1	1	1	3	4	45
Mean no. of days of rain >=25mm	5	5	5	2	1	0	0	0	0	0	1	2	21

(Source BOM 2013)

Figure 2-1 Extent and Detail of the Barron River Catchment

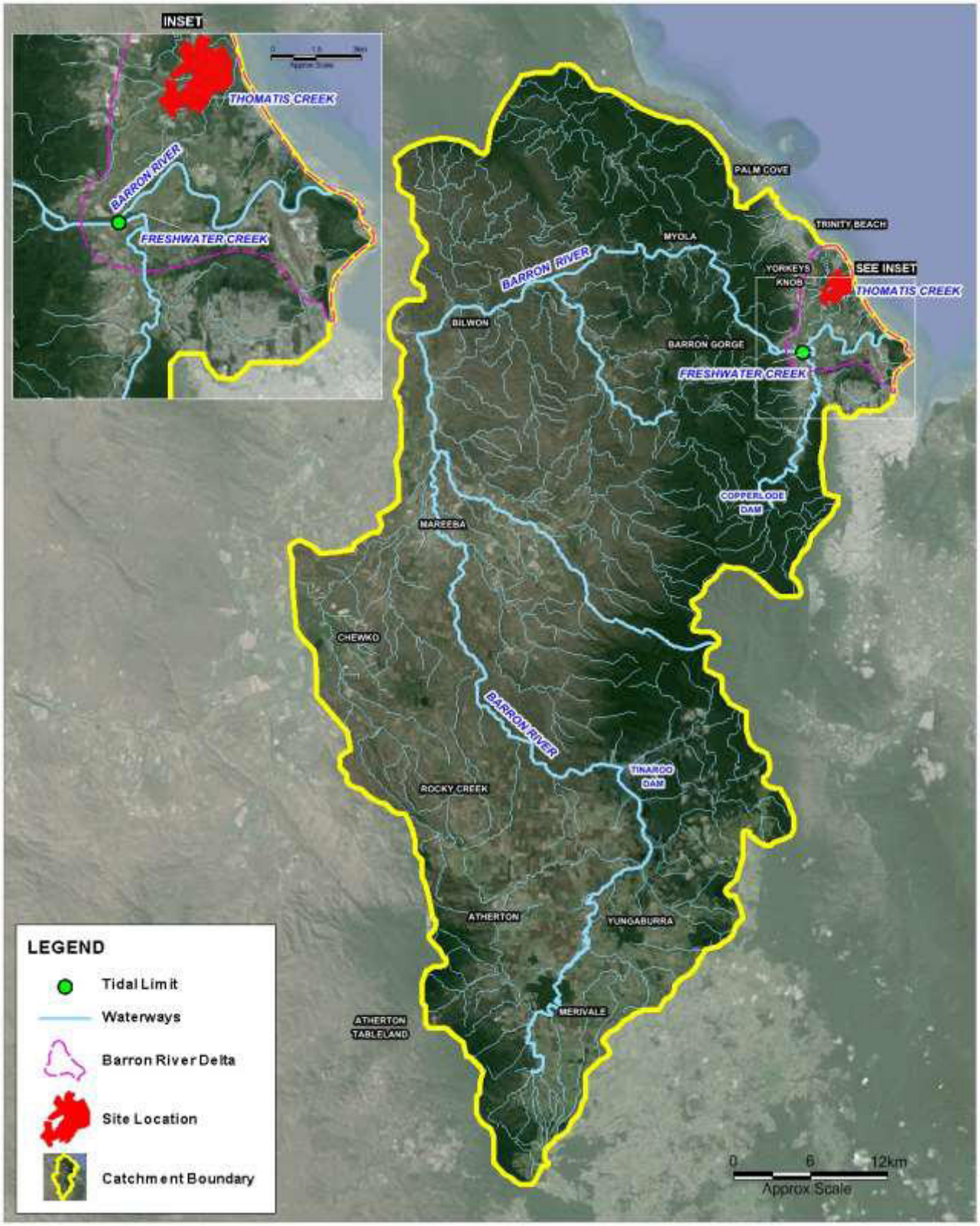


Figure 2-2 Monthly Rainfall

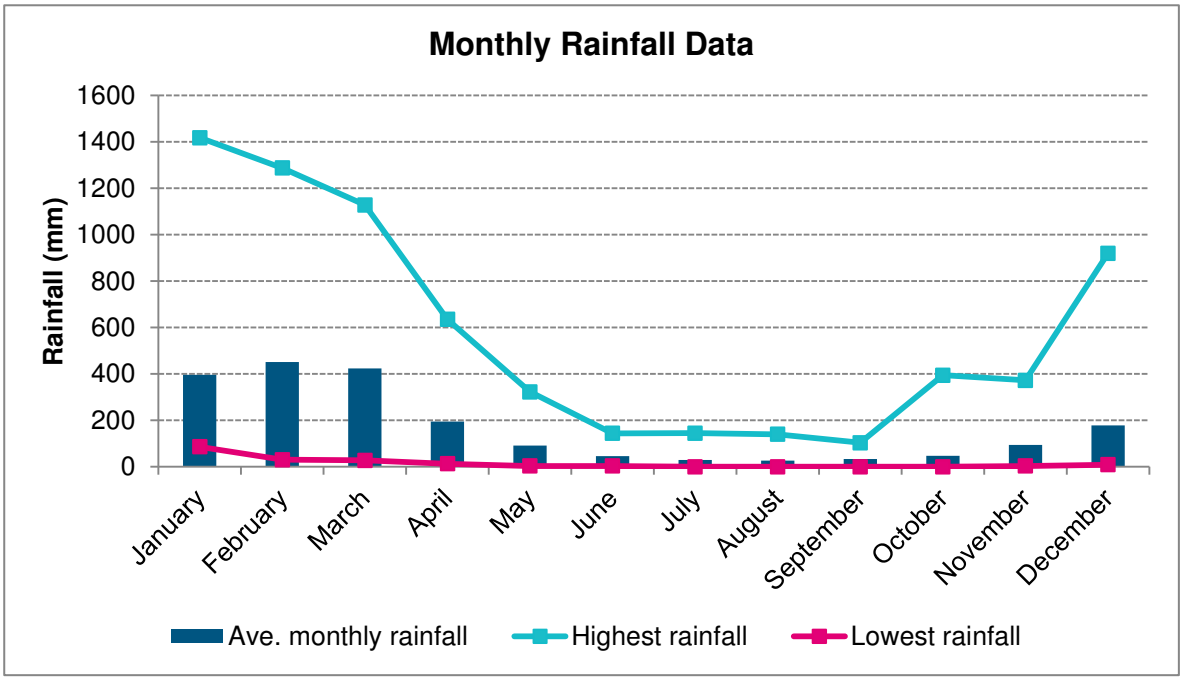


Figure 2-3 Highest Daily Rainfall

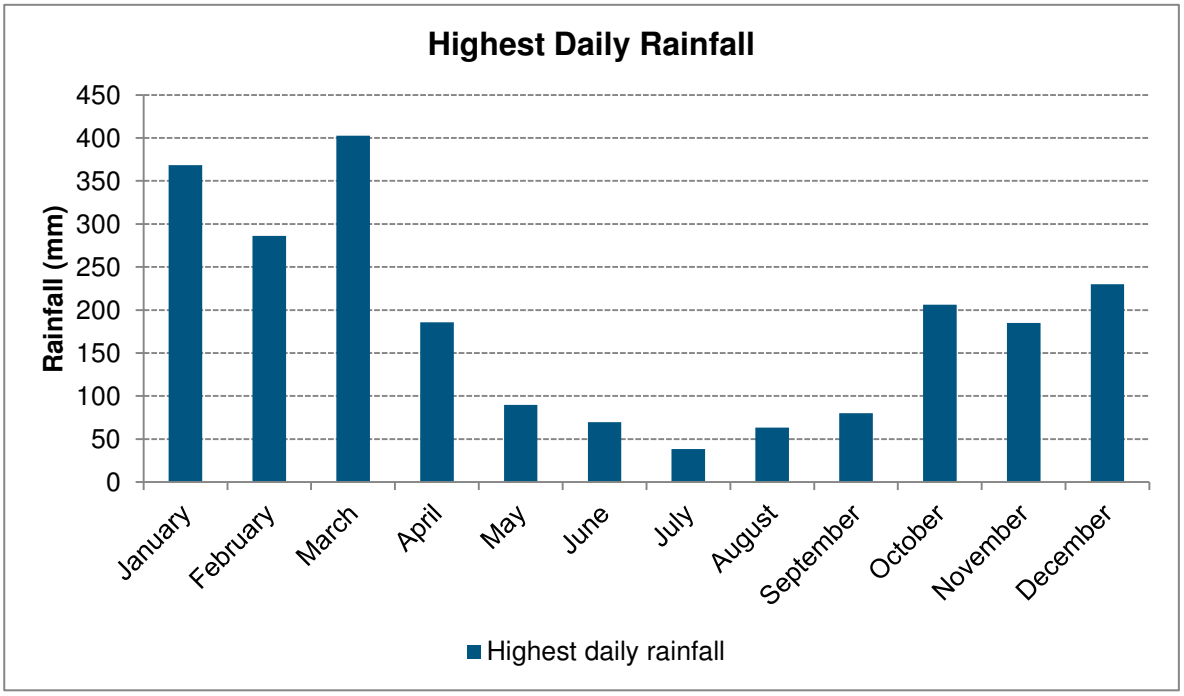
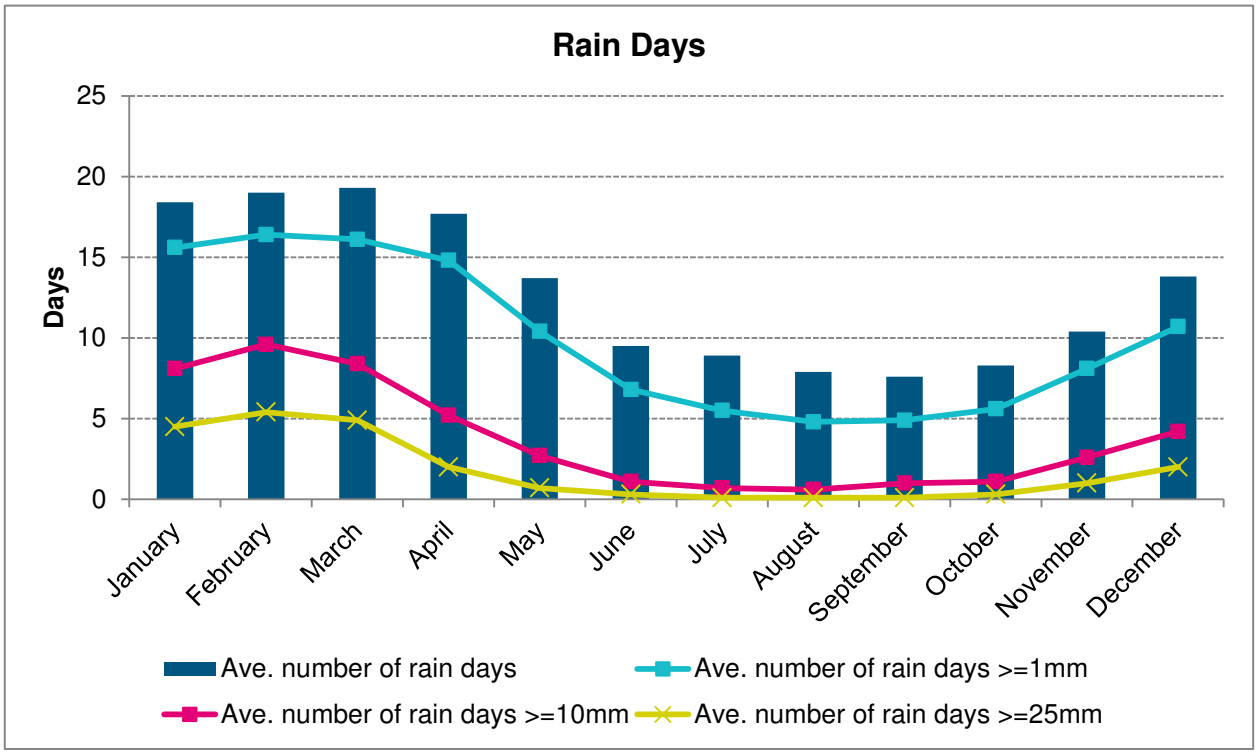


Figure 2-4 Number of Rain Days



2.3 The Barron Delta Flood Plain

Two large dams regulate flows down the river system, being Tinaroo Dam on the Barron River on the Atherton Tablelands, and Copperlode Falls Dam, on Freshwater Creek.

The Barron River drops from the Atherton Tablelands through the Barron Gorge before reaching the Barron Delta, which has several bifurcations to the sea, including Thomatis-Richters Creek which is immediately to the east of the subject site.

Based on long term stream gauge records at Myola, and the latest estimates for Freshwater Creek, design peak flood flow estimates are as shown in Table 2-2.

Table 2-2 Design Peak Flood Flows in the Barron River

ARI (Years)	*AEP %	Barron River Peak Flow (Myola) (m^3/s)	Freshwater Creek Entering the Delta (m^3/s)
100	1	6392	820
50	2	4896	726
20	5	3430	607
10	10	2600	504
5	20	1820	426
Probable Maximum Flood (PMF)		25255	2124

(Source: Connell Wagner – Review of Barron river Delta Flood Model ((August 2007))

**Annual Exceedance Probability*

Being a delta, it is a mobile system and over geological time, the main river channel has moved from Half Moon Creek, in the north, as far south as Saltwater Creek which runs through the airport. This is discussed further in our coastal processes report and in Chapter 5.4. In recent years, there has been considerable erosion along Thomatis-Richters Creek which carries as much as 30% of main channel flows during bank full floods.

Figure 2-5 shows the full extent of the delta, whilst Figure 2-6 shows the site and its proximity to Thomatis-Richters Creek in the east, and Half Moon Creek in the west.

Figure 2-5 The Barron River Delta Floodplain

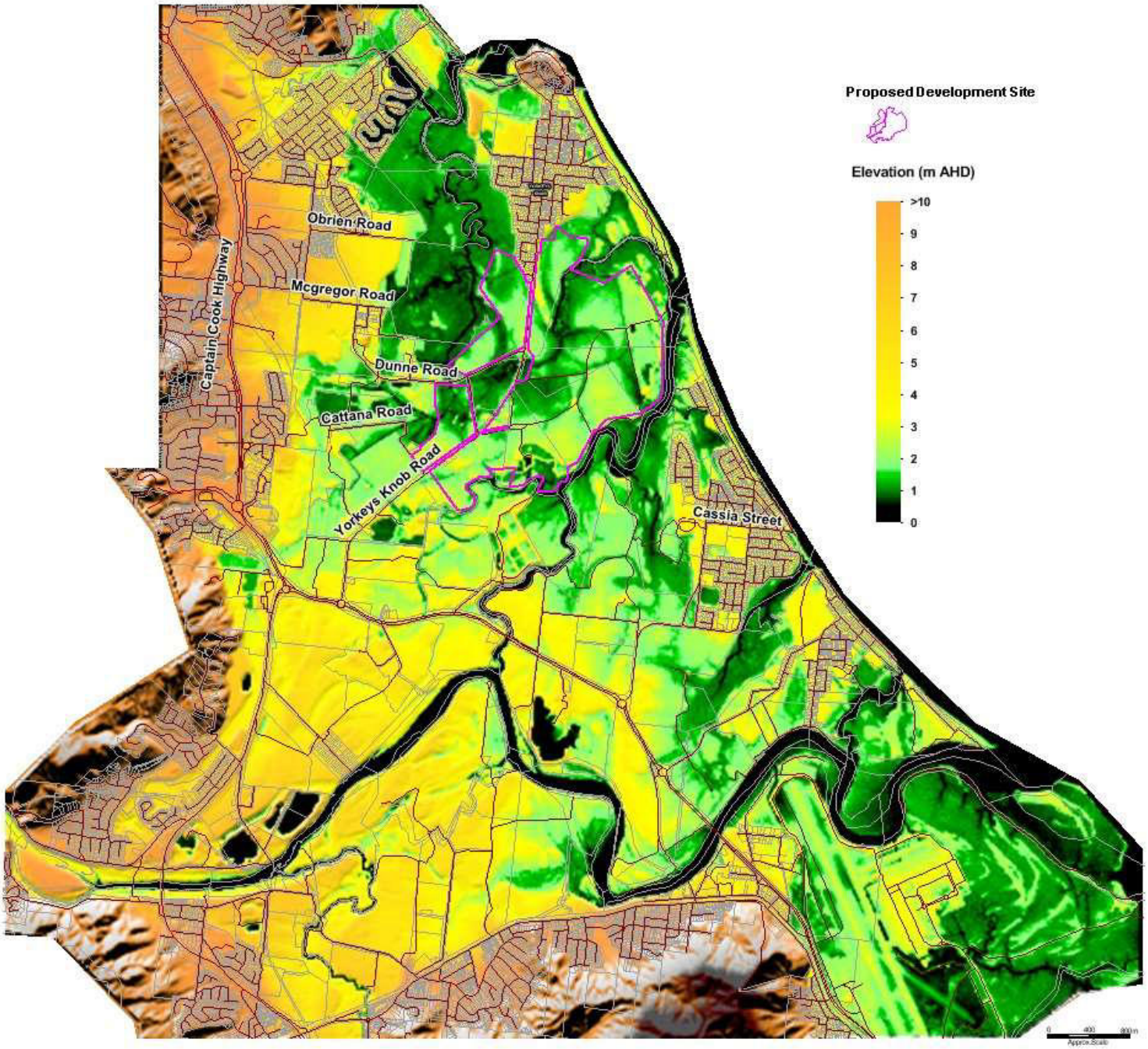
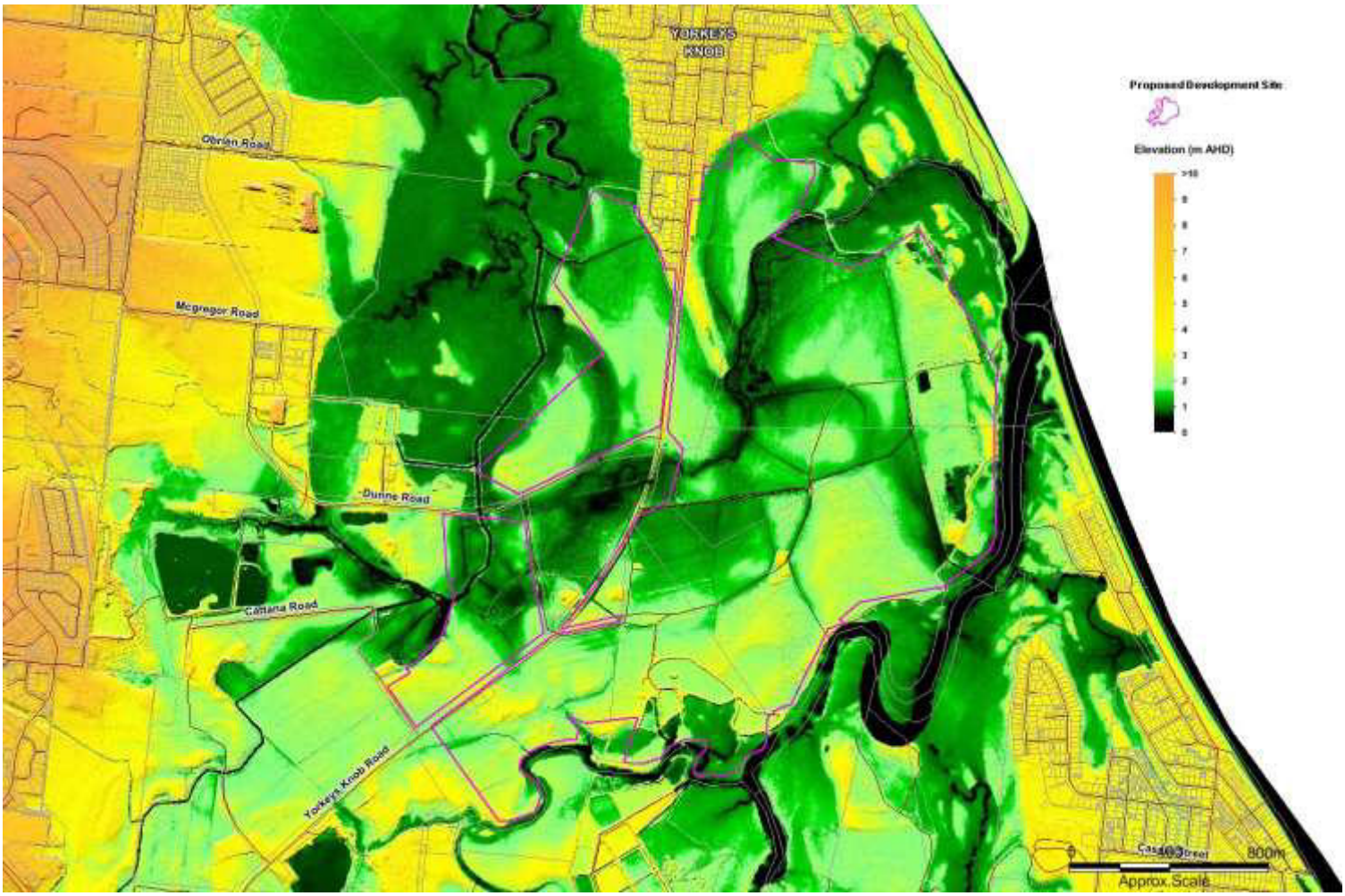


Figure 2-6 The Site



2.4 Historical Flooding

Regular flooding occurs in the Barron Delta and across the site. Gauging records are available since 1915, with at least a dozen major floods in that period that would have inundated the site. Major flooding also occurred in 1911 and 1913 from historic records, and these were very severe floods, around the 1% annual exceedance probability, or ARI 100 year level. Major floods also occurred in 1977 and 1979, and a large amount of data was gathered on these floods by the (then) Department of Harbours and Marine. This information is most helpful in understanding flooding in the delta.

a) March 1977

The March 1977 flood was one of the largest (estimated at approximately 1.4% AEP) on record since gauging began though was smaller than the 1911 and 1913 events.

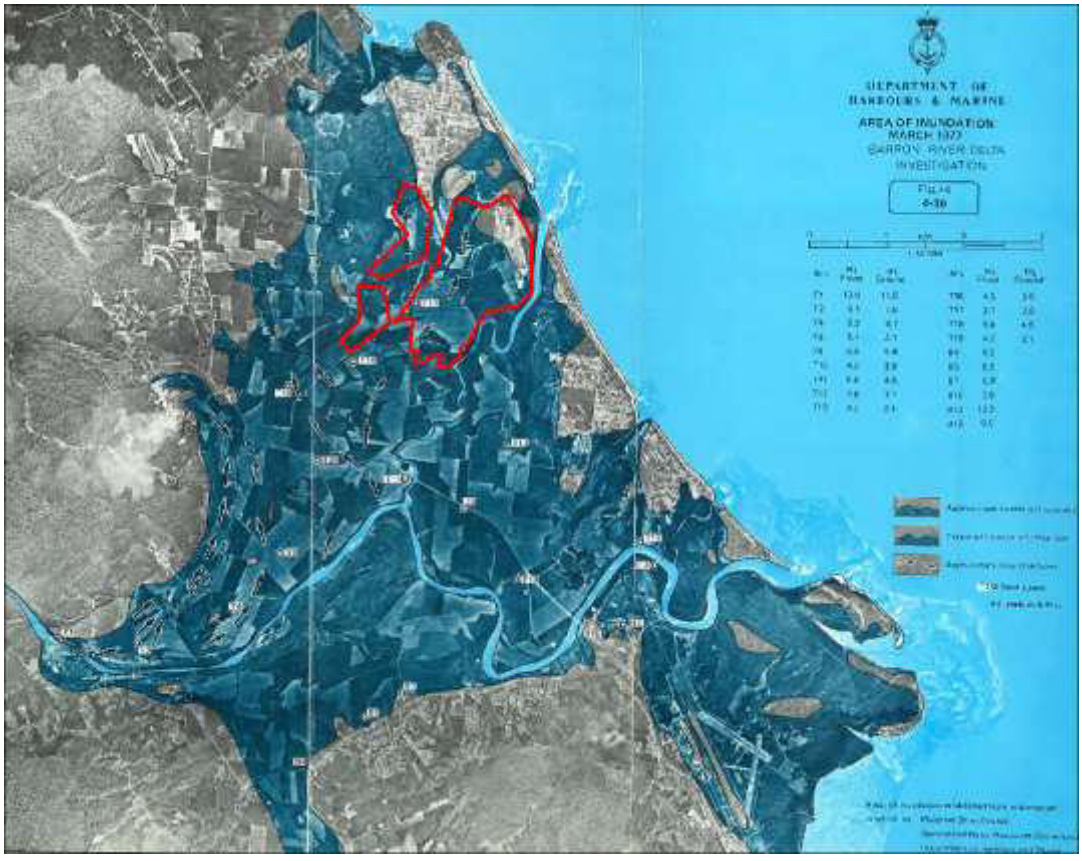
At the site, flood depths were generally 1 to 2 metres deep, with only the dunal system behind the foreshore being out of flood.

The Captain Cook Highway and Yorkeys Knob Road were cut during this event.

Figure 2-7 shows the extent of the March 1971 flood event.

Critical flooding occurred over a two day period, with flood waters receding after about four days.

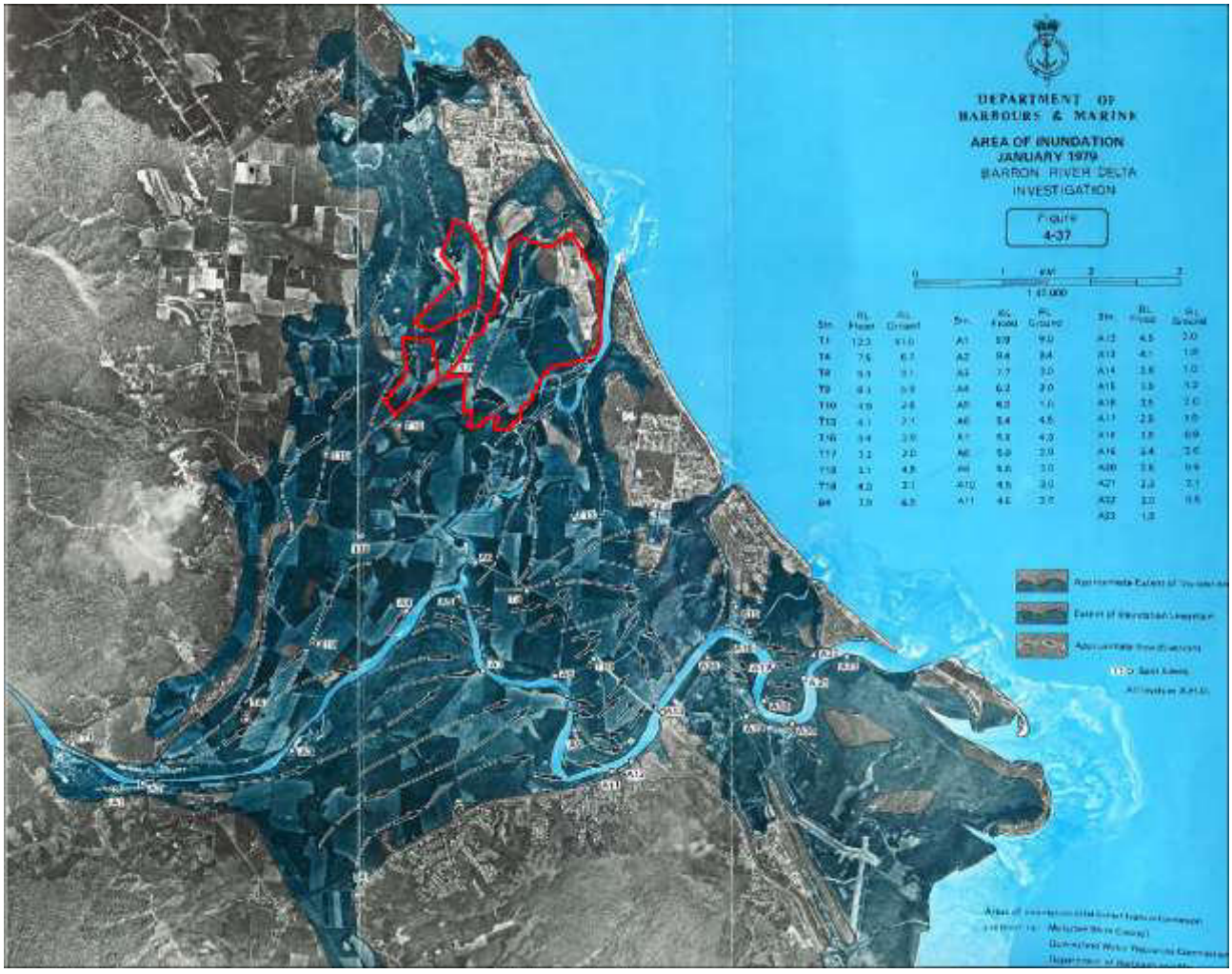
Figure 2-7 Inundation Extent in March 1977 Event



b) January 1979

The January 1979 flood was also a large (estimated at approximately 4% AEP) flood event, causing widespread flooding over a five day period. This caused similar inundation on the site to the March 1977 event, with the highway and Yorkeys Knob Road cut for the duration of this event.

Figure 2-8 Inundation Extent in January 1979



2.5 Design Flood Events

Since 1981, there has been a number of flooding investigations in relation to the Barron Delta, with numerical modelling first applied in the mid-eighties. Currently there is a detailed full two-dimensional flood model that has been adopted by Cairns Regional Council that predicts the effects of design flood events across the delta (Connell Wagner, August 2007).

Selected extracts of results of this latest modelling are provided below. The ARI 5 year event is shown to represent relatively frequent flooding characteristics, whereas the ARI 100 year is a severe flood that occurs infrequently.

a) ARI 5 Year Flood Event

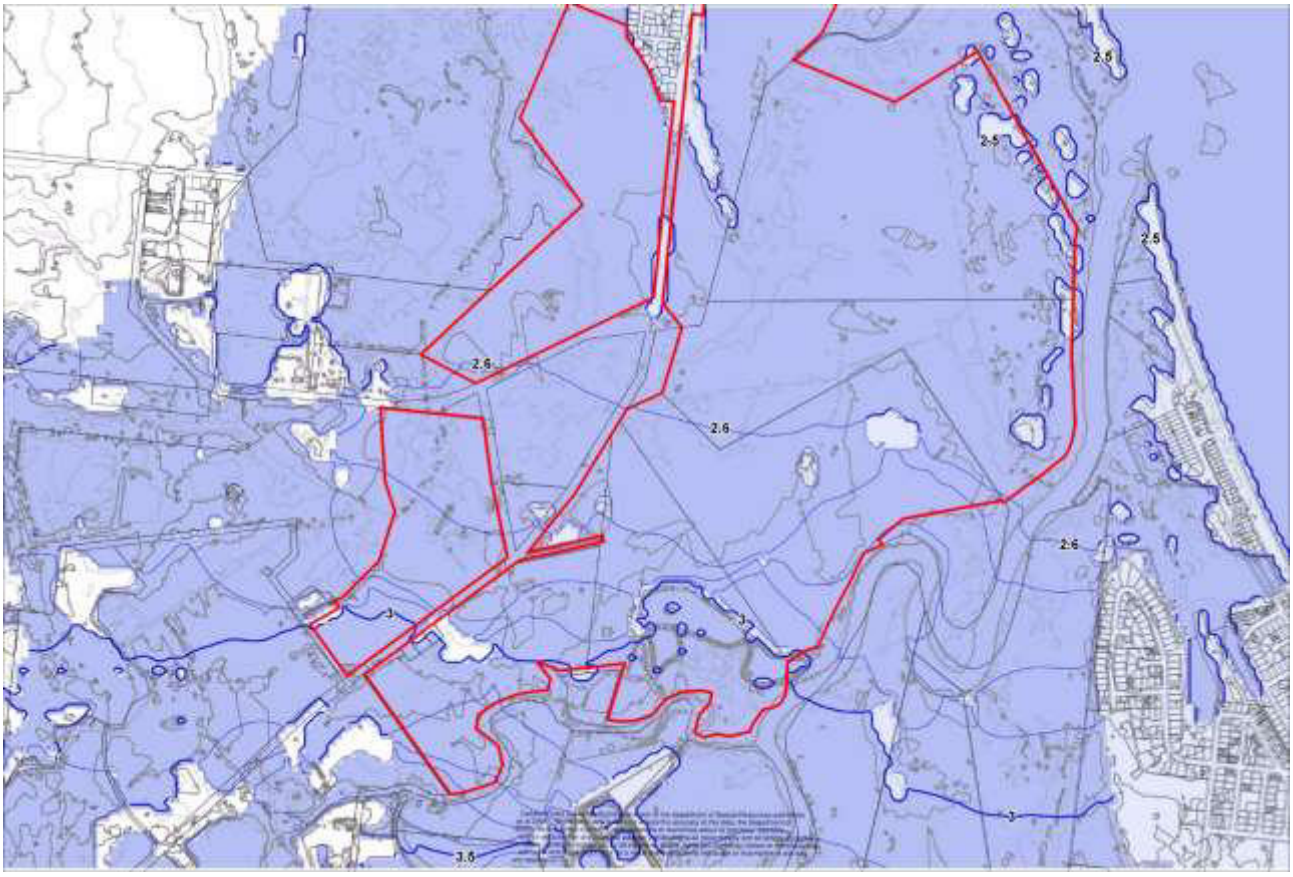
The table below provides approximate peak water levels and depths primarily associated with the main site to the east of Yorkeys Knob Road.

Figure 2-9 shows depths and flood contours across the site for the ARI 5 year flood event.

Table 2-3 Peak ARI 5 Year Flood Levels across the Site

Location	Approximate Peak Water Level (mAHD)	Approximate Depths (m)
Upper	3.0	0.6
Mid	2.5	0.5 to 1.5
Lower	2.5	0.5

Figure 2-9 ARI 5 Year Flood Levels and Depths



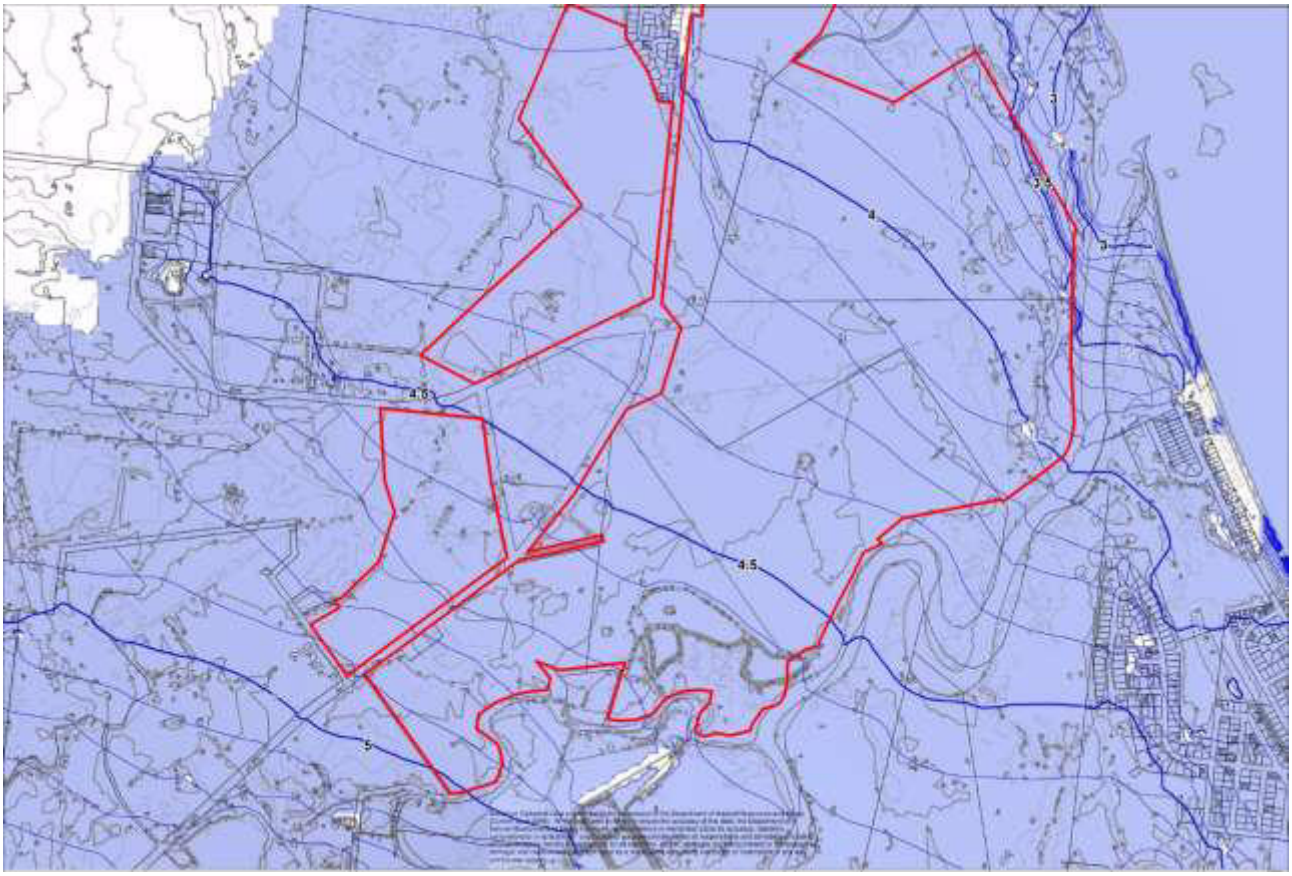
b) ARI 100 Year Flood Event

The table below provides approximate peak water levels and depths primarily associated with the main site to the east of Yorkeys Knob Road.

Table 2-4 Peak ARI 100 Year Flood Levels across the Site

Location	Approximate Peak Water Level (mAHD)	Approximate Depths (m)
Upper	4.5	2.5
Mid	4.3	1.0 to 3.5
Lower	3.5	2.0

Figure 2-10 ARI 100 Year Flood Levels and Depths



c) PMF Flood Event

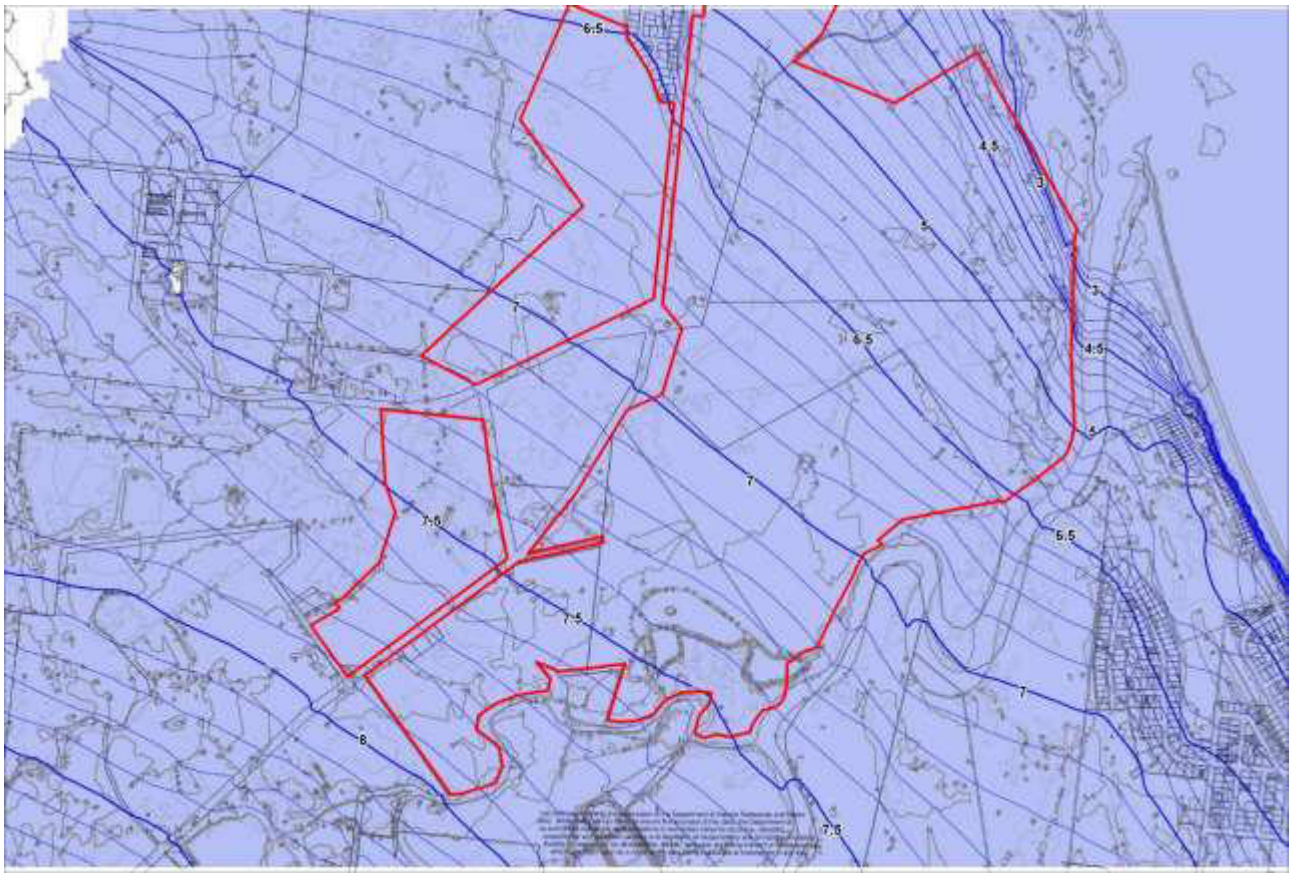
The Probable Maximum Flood (PMF) is used for emergency management planning and represents an extreme flood event.

The table below provides approximate peak water levels and depths primarily associated with the main site to the east of Yorkeys Knob Road.

Table 2-5 Peak PMF Flood Level across the Site

Location	Approximate Peak Water Level (mAHD)	Approximate Depths (m)
Upper	7.5	5.5
Mid	6.5	4.5 to 5.5
Lower	5.0	3.0 to 3.5

Figure 2-11 PMF Flood Levels and Depths



d) Frequent Flood Events

Based on our assessment of flooding, both historic and from flood modelling, minor flooding over the lower parts of the site above tide will occur every wet season, and that on average, most of the site is inundated to a shallow depth in an ARI 2 to 5 year flood event.

e) Climate Change Considerations

The Connell Wagner 2007 Flood Assessment Report has been used by Cairns Regional Council in the preparation of the Smithfield – Barron District Flood Inundation (ARI 100 year) Overlay Map. This Assessment Report adopts ocean tail water for coincident flood events of

RL 2.1m AHD, which is Highest Astronomical Tide plus an allowance of 300mm for sea level rise.

Sea level rise predictions by the Intergovernmental Panel on Climate Change (2007) indicate a medium case sea level rise of 0.8m by the year 2100.

At present, there is no State or Local Government requirement for consideration of increased or decreased rainfall and rainfall intensity due to climate change, with considerable uncertainty in the science underpinning such predictions.

Although no definitive State of Local government requirements are in place, the Queensland Government has published climate change predictions for Queensland and in particular for the Far North Queensland Region. The document 'ClimateQ: toward a greener Queensland' (2009) has published predictions for Annual and seasonal rainfall for 2070 (low and high emissions scenarios) and states:

Annual rainfall is projected to decrease by two per cent (-25mm) and three per cent (-38mm) under low and high emissions scenarios respectively. The largest seasonal decrease under a high emissions scenario of 16 per cent (-21mm) is projected for spring.

For Queensland in general it is predicted that there will be a stronger but shorter rainfall season during January and February thus resulting in dryer autumns. It is generally anticipated that the number of rainy days will decrease but the amount of rain falling on wet days may increase by up to 20 per cent. Extreme rainfall events are predicted to also become more frequent during the summer months (Queensland rainfall – past, present and future, 2012).

Sea level predictions to date have been based on the IPCC 2007 report, the Fifth Assessment Report is being published progressively over 2013 and 2014. The Working Group 1 report, Physical Science Basis, released September 2013, reinforces the global sea level rise predictions and projects a higher rate of sea level rise than previously predicted.

The revised ARI 100 year flood levels for the site, incorporating 0.8m predicted seas level rise) are provided in Table 2-6 below.

Table 2-6 Peak ARI 100 year flood levels across the site with climate change sea level rise of 0.8m by the year 2100

Location	Approximate Peak Water Level(m AHD)	Approximate Depths (m)
Upper	4.55	3.0
Mid	4.35	1.5 to 4.0
Lower	3.55	2.5

The reason that these levels are only marginally higher than those shown in Table 2-4 is that the frontal dune is the critical tail water control in both cases.

Any development levels for buildings and critical infrastructure need to be set using the year 2100 climate change levels.

Table 2-7 presents the design floor levels recommended for the development.

Table 2-7 Design Floor Levels

Type	ARI + Freeboard	Recommended Design Level (mAHD)		
		Upper	Mid	Lower
Lowest habitable floor	PMF or Higher	7.5	7.5	7.5
Evacuation floor	PMF or Higher	7.5	7.5	7.5

A minimum podium level of RL 7.5mAHD has been set for the development resort hotels and facilities on the central island.

3 The Proposed IAS Design

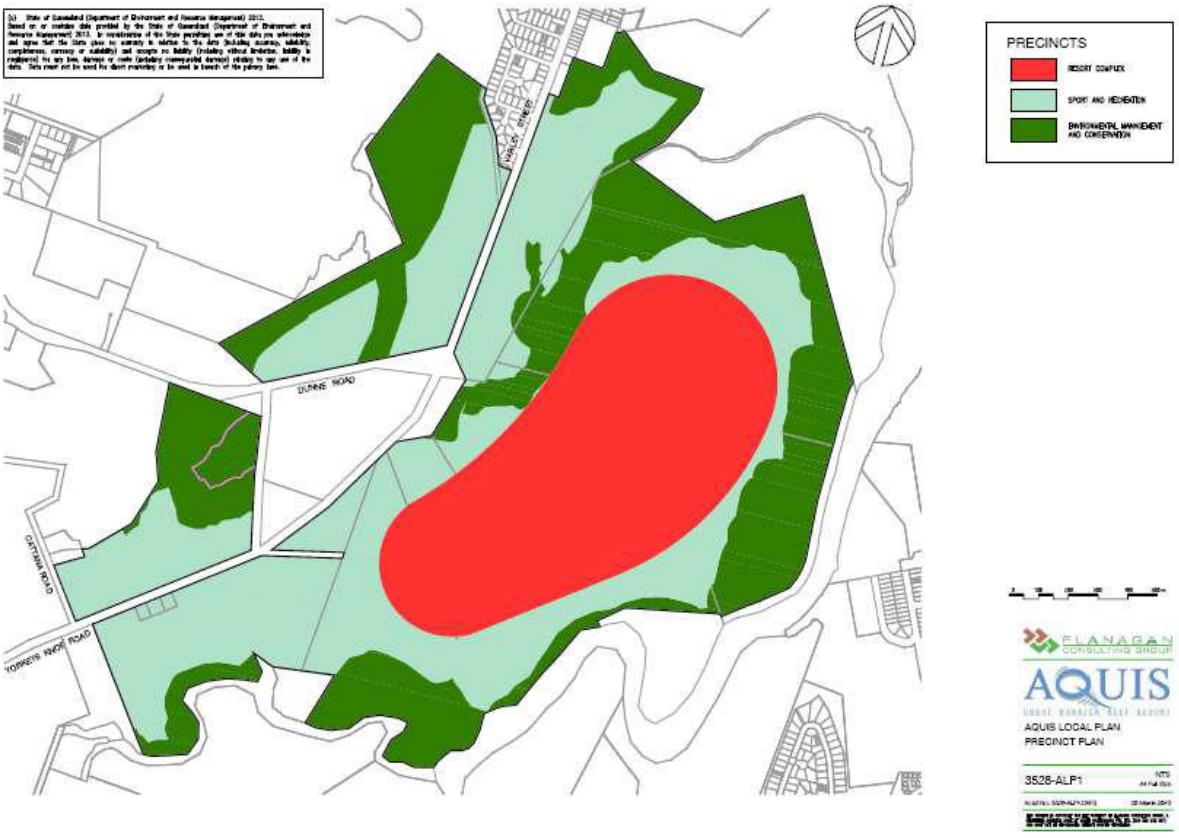
3.1 Precincts

The Aquis Resort includes the following key features, distributed over three precincts:

- Resort Complex precinct (73 ha including 33 ha lake).
- Sports and Recreation precinct (155 ha).
- Environment Conservation and Management precinct (113 ha).

The Precincts are shown on The Aquis Land Use Plan shown below on Figure 3-1.The Concept Features Plan (**Figure 3-2**) shows more details of likely features that may occupy the various precincts.

Figure 3-1 AQUIS Local Plan Precinct Plan ALP1



The distribution of land uses within the precincts is shown on the Aquis Local Plan Concept Master Plan ALP 2. **Figure 3-2**.

Figure 3-2 **AQUIS Local Plan Concept Master Plan ALP-2**

Aquis Resort involves an anticipated capital investment of **$8.15 billion AUD** from 2014 to 2024

ELEMENT	NO	GFA (M2)
Hotel rooms/suites configured in 8 towers	7500	625,000
Casinos	2	40,000
Convention and exposition	1	23,000
Theatres	2	5,000
Retail		10,000
Aquarium	1	2,250
Rainforest		2500
Circulation/shared space/back of house/services		350,000
Guest/staff parking	1400	80,000
Landscaping/lagoons/pools/entry water feature		110,000

The aquarium and rainforest are architectural features and not stand-alone uses. The proposal does not include any permanent residential elements.

The resort complex will be constructed over a basement level which will incorporate back-of-house support facilities including:

- kitchens
- staff facilities
- stores
- laundry
- refuse collection
- security
- maintenance facilities
- staff and guest parking facilities

In addition to the development components, the proposal also includes an upgrade of Yorkeys Knob Road and a section of the Captain Cook Highway to improve the trafficability from Yorkeys Knob and from the site out of the delta in a flood to ARI 50 year standard. This requires a major upgrade, with up to 1.5m raising of the roadways, with filling and very extensive additional culverting.

4 Potential Impacts and Opportunities and Constraints

In terms of opportunities the site is generally flat and is largely cleared of native vegetation, and it is generally well separated from flood sensitive urban development, with the exception of the very northern end of the site which is adjacent to the southern-most part of Yorkeys Knob Township.

Opportunities presented by the site of relevance to this report are:

- Large, generally flat site.
- Proximity to main road access across the delta.
- Proximity to Yorkeys Knob Township and the elevated headland.
- Proximity of site to coast on the eastern side (and therefore suitability for a lake solution to flooding).

Because of the very large area over all the parcels of land, significant buffering areas are available around the required site fill platforms to allow flood flows to divert around and through the development.

Key flooding constraints to the site development are:

- The flood prone nature of the site, with the entire site affected by Barron River flooding.
- The proximity to the shoreline and exposure to cyclonic storm tide, river and creek flooding, and cyclonic wave set-up and run-up / dune overtopping.
- Site road access has less than ARI 5 year immunity against flooding, and the evacuation route from the delta is about 4km.
- Besides the road access there is no alternative evacuation method and the site is isolated in flood events.
- Major delta flooding has historically caused major changes in the river and in Thomatis and Richters Creeks, and in the early eighties, it was thought that there was a risk that Thomatis / Richters Creek would become the main Barron River channel (Chapter 6, Barron River Delta Investigation, January 1981). This risk has since abated, with the creek entrance at the Barron River bifurcation stabilising and reducing in size over the last 30 years.

Potential impacts due to the necessary site earthworks are:

- Worsening of flooding of existing flood affected residential areas, and inundation of new areas.
- Worsening of the immunity of State and Council controlled roads.
- Exacerbation of stream erosion and stability.

In March 2012, the Queensland Floods Commission of Enquiry released its final report. The report had several findings which are relevant to the site of the proposed development and as such have been taken into consideration when assessing the site. Relevant recommendations from the report include:

7.16 The Queensland Government (or Councils) should consider including assessment criteria in their planning scheme which require that works in a floodplain:

- *Counteract any changes the works will cause to flood behaviour of all floods up to and including the acceptable defined flood event by measures taken within the subject site (for example, use of compensatory works, detention basins or other engineering mechanisms), and*
- *Do not change the flood characteristics outside the subject site in ways that result in:*
  - *Loss of flood plain storage*
  - *Loss of/changes to flow paths*
  - *Acceleration or retardation of flows, or*
  - *Any reduction in flood warning times elsewhere on the floodplain.*

7.24 The Queensland Government (or Councils should consider including assessment criteria in their planning schemes) should include assessment criteria in the model flood planning controls that address:

- *The prospect of isolation or hindered evacuation*
- *The impact of isolation or hindered evacuation*

Consideration of these recommendations form an integral part of the how the available land can be used, including the positioning of the development on the site, proximity to existing infrastructure, potential isolation and preservation of existing flooding characteristics (i.e. being as sympathetic to the existing flood characteristics of the site).

5 Management of Flooding

5.1 Flood Impact and Mitigation

In order to provide suitable levels of immunity from inundation, a combination of site filling and the use of elevated structures are proposed. Generally the ARI 100 year flood level is 2.5m to 3.5m above existing ground levels. The ARI 100 year event is generally set by local authorities as the minimum standard for setting floor levels and for providing protection to critical infrastructure from flooding. However, because of the value of the asset and the risk of flooding, AQUIS has committed elevating key components of the project above the Probable Maximum Flood level with a podium level set at RL 7.5mAHD for all central island buildings and features including:

- All hotels
- The casino
- The lagoons and swimming pools
- The exhibition and convention centre
- Commercial areas
- Theatres

A minimum of ARI 100 year immunity plus 500mm freeboard is required for:

- The main resort island including lagoon, aquarium and shopping complex.
- The serviced apartment islands.
- The core pool services and infrastructure area of the water park.
- All hotels and for the casino.
- The convention and exhibition centre.
- The stadium.
- The golf course clubhouse and amenities.

Table 2-7 in Section 2 provides the proposed design levels associated with the above areas.

To off-set potential adverse impacts, compensatory excavated waterways, in the form of a lake are proposed.

By careful sizing of the waterways, and control of -flow through the lake and across the site, no significant adverse flooding impacts are predicted.

To refine the IAS development Master Plan and to achieve acceptable flooding impacts, detailed flood modelling has been carried out, using a modified versions of Council's Barron River Delta Flood Model (August 2007). This is a full two dimensional dynamic flow model, and is the model approved by Cairns Regional Council for flood assessments. Modifications included conversion to the TUFLOW operating system for improved structure modelling and for speed of runs.

Besides the proposed resort development, flood modelling also included the proposed upgraded Yorkeys Knob Road to ARI 50 year trafficable standard.

Other resort facilities (situated outside of the main resort) such as the proposed golf course, sporting facilities and car parks have not been explicitly modelled for this EIS however they will be included in the detailed design phase. These facilities will be designed to achieve a no adverse impact on flooding.

Iteration and progressive refinement of the road culvert and upgrade arrangements, and of the resort cut and fill extents and configurations was required to achieve an acceptable outcome, in terms of flooding impacts. Hence, the IAS development has been modified to achieve an acceptable flooding outcome.

Overall predicted impacts for the ARI 100 year event for the modified development are as shown on Figure 5-1.

Upstream of the development, there are extensive areas of predicted flood level reduction. Downstream of the development, impacts are contained to non-urbanised areas. This demonstrates that the resort can feasibly be designed to achieve a no significant worsening impact beyond the site, in terms of actionable damage and nuisance.

Figure 5-2 shows predicted depths and velocities for the ARI 100 year event with the development and road upgrades in place. Figure 5-2 also shows that the site lots west of Yorkeys Knob Road are generally more susceptible to flooding than the eastern lots, and this was one of the factors considered in preparing the modified development proposal.

Predicted velocities across the site are generally less than 1m/s and therefore are non-scouring for grassed areas and are not highly hazardous to people

Flood modelling and impact assessment has also been carried out for a range of ARI flood events, with impact plots for the ARI 5, 10, 20 and 50 year events shown in Figure 5-3 to Figure 5-6.

These figures also demonstrate that acceptable flooding impacts can be achieved across the full range of ARI events.

In terms of the effect of climate change on predicted flooding impacts, the frontal dune downstream of the site acts as a control weir to delta floods once they have overtopped the channels, thus resulting in flatter flood slopes upstream of the dunes and a steeper gradient to the ocean level downstream of the dunes. With sea level rise, there will be a significant effect seaward of the dunal system, but only a small affect upstream of the dunes, as the dunes are only just overtopped. Therefore impacts with a higher sea level will be smaller to those presented above.

Figure 5-1 Overall Predicted Impacts for the ARI 100 Year Event

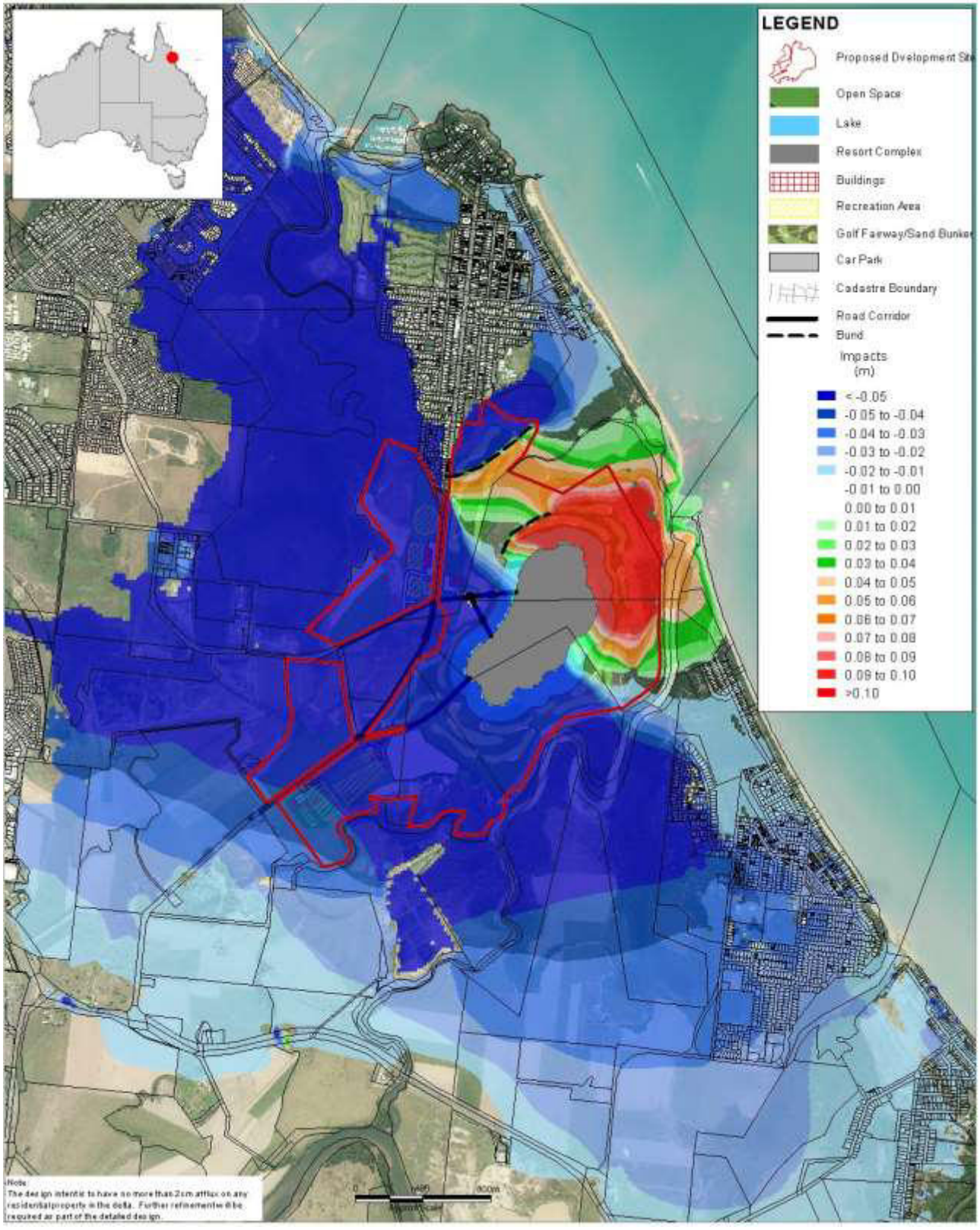


Figure 5-2 Predicted Depths and Velocities for the ARI 100 Year Event

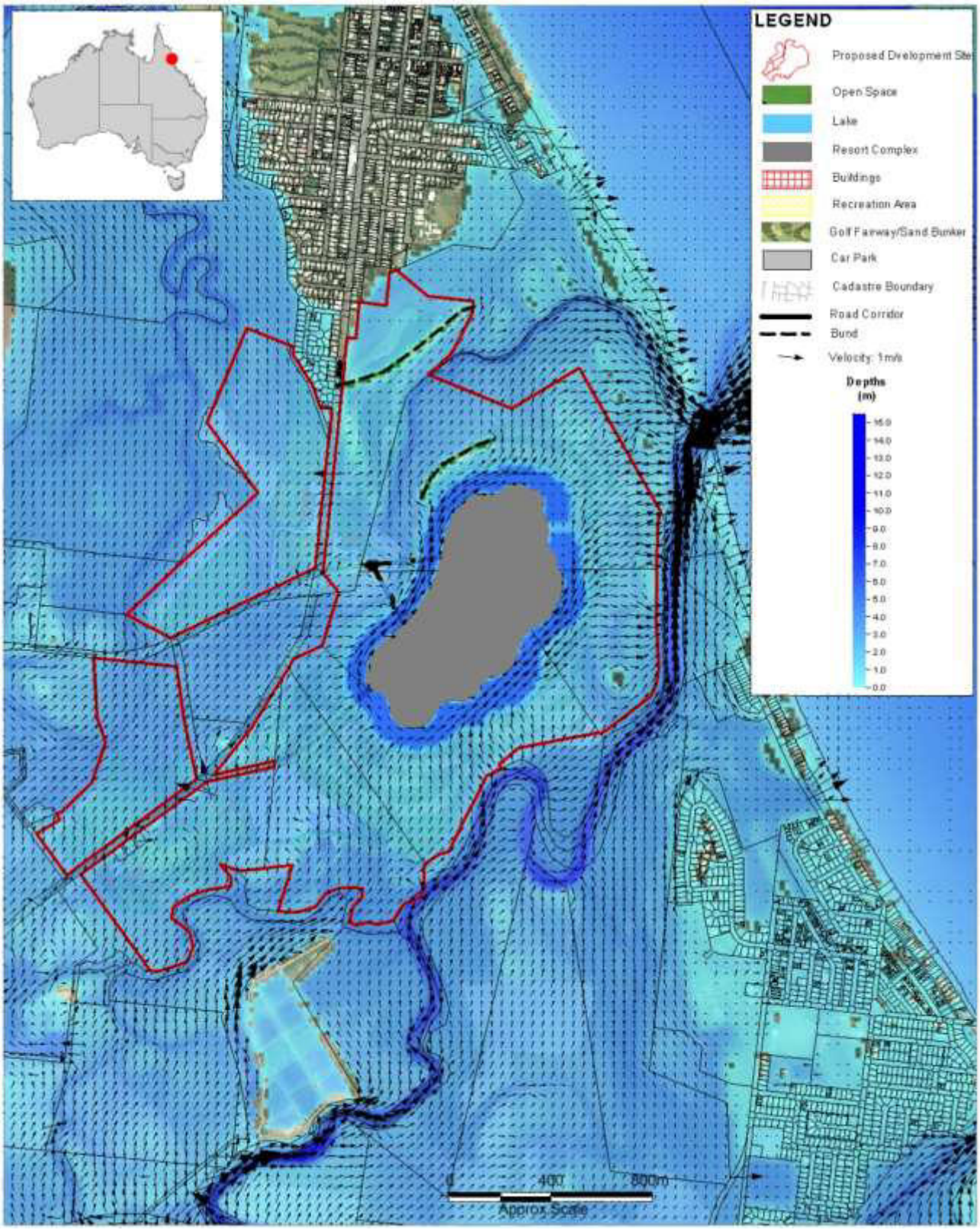


Figure 5-3 Overall Predicted Impacts for the ARI 5 Year Event

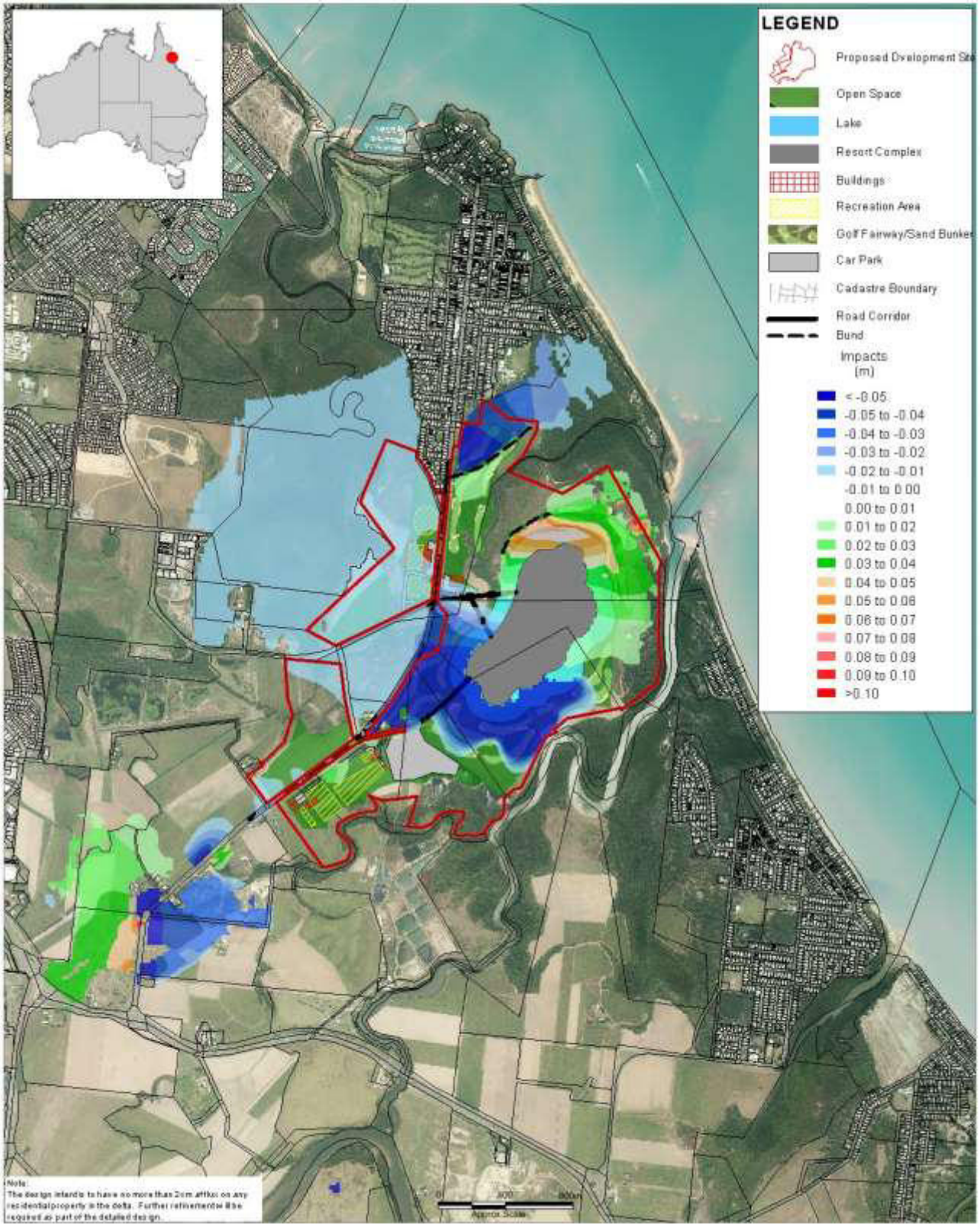


Figure 5-4 Overall Predicted Impacts for the ARI 10 Year Event

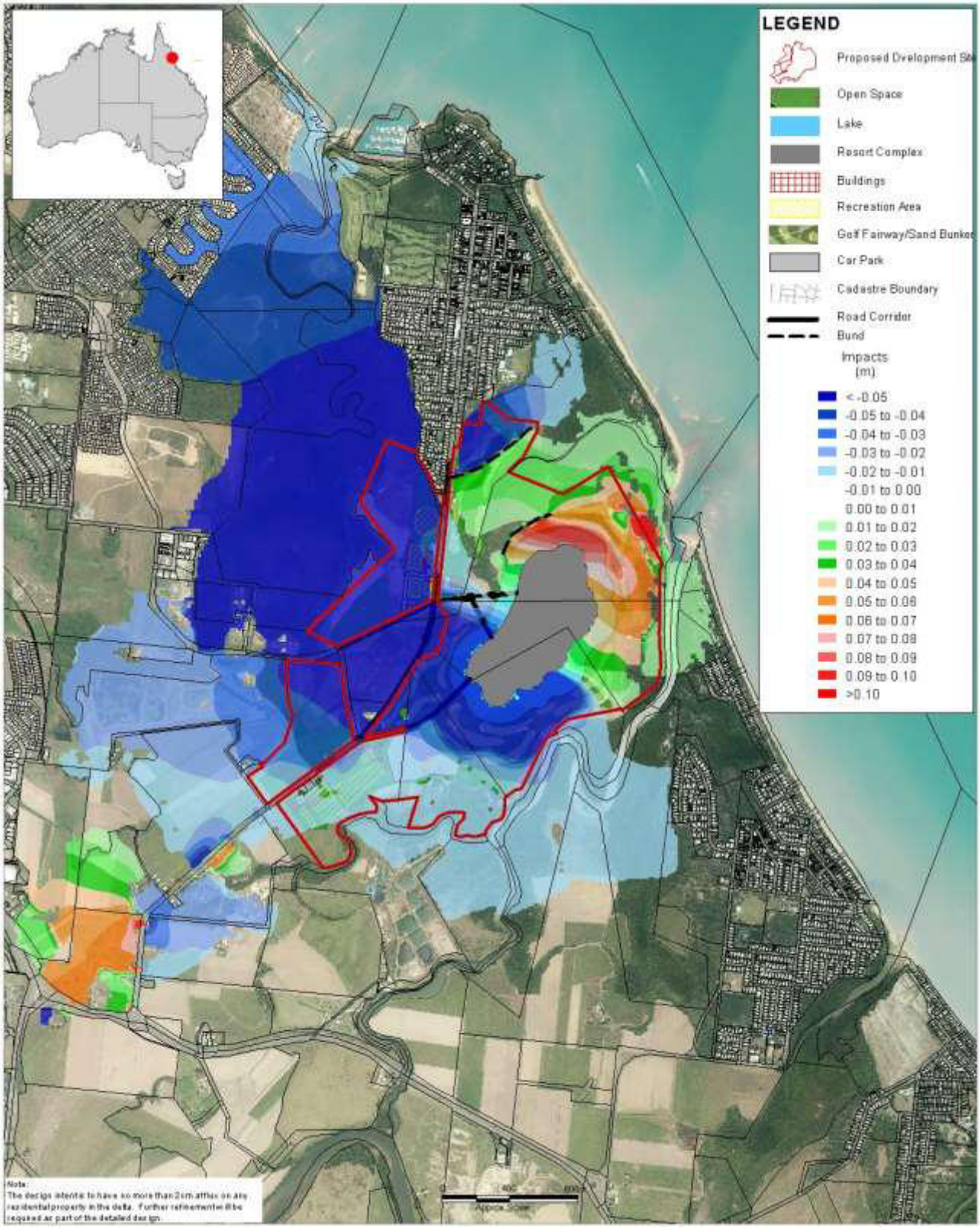


Figure 5-5 Overall Predicted Impacts for the ARI 20 Year Event

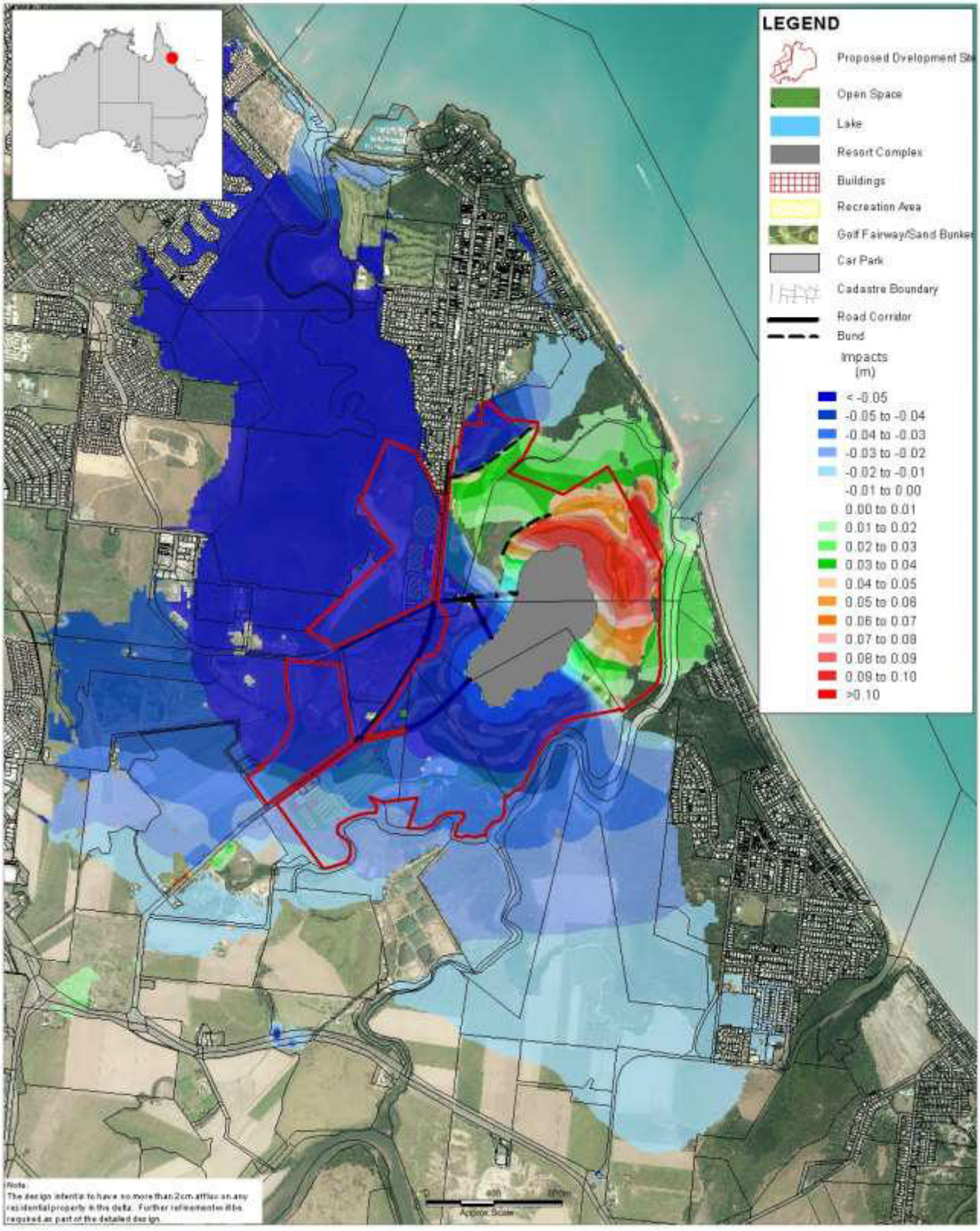
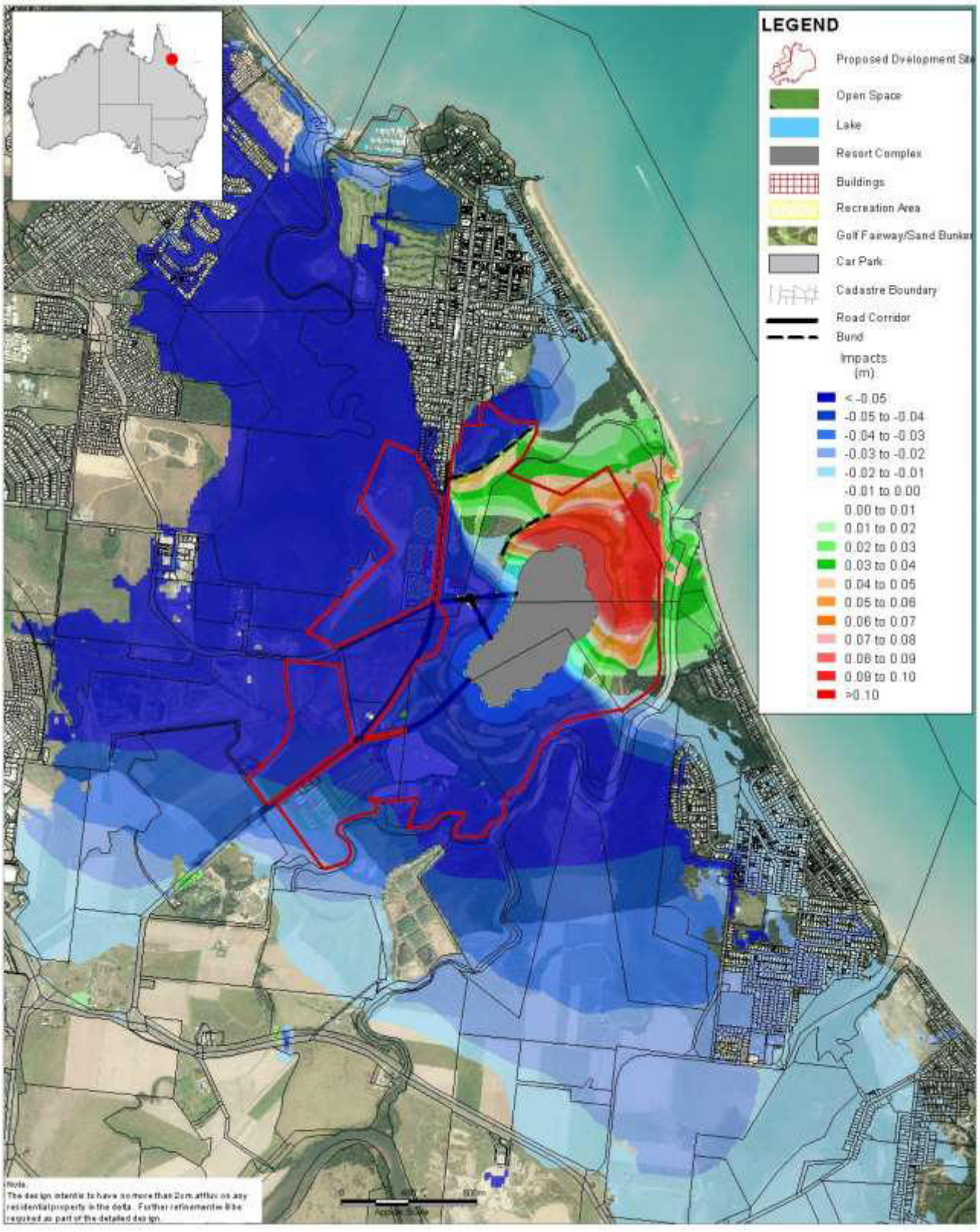


Figure 5-6 Overall Predicted Impacts for the ARI 50 Year Event



5.2 Site Access and Flooding

5.2.1 General

Access to the proposed development is from the Yorkeys Knob Road via the Captain Cook Highway. Yorkeys Knob Road currently has a 5 year or less ARI flood immunity and is well below recognised industry standards for critical access roads. Main Roads strive to achieve ARI 100 year standards on new highways, for example, though this is not always possible.

The Queensland Urban Drainage Manual (QUDM) recommends an ARI 50 year capacity for major road cross drainage associated with new developments. As part of the AQUIS development, approximately 3.7km of Yorkeys Knob Road from the Captain Cook Highway intersection to the Yorkeys Knob residential development (refer to Figure 5-8) will be improved to be trafficable in a 50 year ARI flood event. With regards to road infrastructure for flooding, the upgrade will consists of improved cross drainage to convey flood flows and an increase in vertical alignment by approximately 1.0m to 1.5m. Given the current low flood immunity, the upgrade to the 50 year ARI is a substantial improvement in trafficability between the highway and the Yorkeys Knob residential area during time of flooding from the Barron River, including local catchment flows.

Access within the site will also be to a minimum of ARI 50 year event trafficable.

5.2.2 Hydraulic Assessment

A hydraulic assessment using the TUFLOW model was undertaken to assess the cross drainage requirements for the proposed road upgrade to a trafficable 50 year ARI standard.

The results of the hydraulic assessment are provided in Figure 5-1 to Figure 5-6.

As depicted in these figures the assessment has limited the impacts to acceptable levels and will be further refined in detailed design to ensure no adverse impact to adjacent properties. Details of the existing and proposed road levels and cross drainage is provided in the Table 5-1 below and presented in Figure 5-7 and Figure 5-8.

Table 5-1 Proposed Road Levels and Cross Drainage Requirements

Location	Chainage (km)	Existing		Proposed	
		Road Level (m AHD)	*Culverts	Road Level (AHD)	*Culverts
Captain Cook Highway	0-0.5			4.9m to 4.7m	RCBC 14/2700x1800 RCBC 36/2700x1200 RCBC 20/2700x1200 RCBC 18/2700x1800 RCBC 14/2700x2100 RCBC 36/2700x1800 RCBC 14/2700x2100 RCBC 28/2700x1800
Yorkey's Knob Rd Roundabout	0-0.5	3.8m to 4.4m	RCBC 2/900x600 RCBC 5/1800x900		
Robinson Road South	0.5-1	3.0m to 4.3m	RCBC 1200x600 RCBC 1200x450	4.4m to 4.6m	RCBC 20/2700x900 RCBC 9/2700x1200 RCBC 15/2700x450
Robinson Road North	1-1.5	2.75m to 3.4m	RCBC 8/3600x1500 RCBC 14/1200x900 RCBC 10/1800x900	4.2m to 4.5m	RCBC 15/2700x450 RCBC 22/2700x600 RCBC 9/2700x2700 RCBC 20/2700x1200 RCBC 17/2700x600 RCBC 35/2700x1200
Cattana Road	1.5-2.0	2.32m to 3.3m	RCBC 3/1200x450 RCBC 2/1200x450 RCBC 10/1800x900	4.0m to 4.3m	RCBC 21/2700x1200 RCBC 12/2700x1200 RCBC 22/2700x600
Morabito Road	2.0-2.5	2.2m to 3.0m	RCBC 6/2400x900 RCBC 1200x600 RCBC 900x450	3.8m to 4.0m	RCBC 14/2700x1500 RCBC 11/2700x1200 RCBC 9/2700x1200 RCBC 20/2700x750
Yorkey's Creek	2.5-3.0	2.8m to 3.0m	RCBC 4/2700x1500 RCBC 9/1200x900 RCBC 1800x1200	3.7m to 3.8m	RCBC 21/2700x1800 RCBC 19/2700x1200 RCBC 29/2700x2100
Dunne Road	3.0-3.5	2.6m to 3.2m	N/A	3.6m to 3.8m	RCBC 20/2700x1200 RCBC 29/2700x750 RCBC 42/2700x750
Yorkey's Knob	3.5-4.0	2.5m and 4.4m	RCBC 2/900x450	3.5m and 4.4m	N/A

**An alternative bridge / viaduct may also be feasible providing the same waterway opening areas.*

Figure 5-7 Existing Road Levels & Culverts

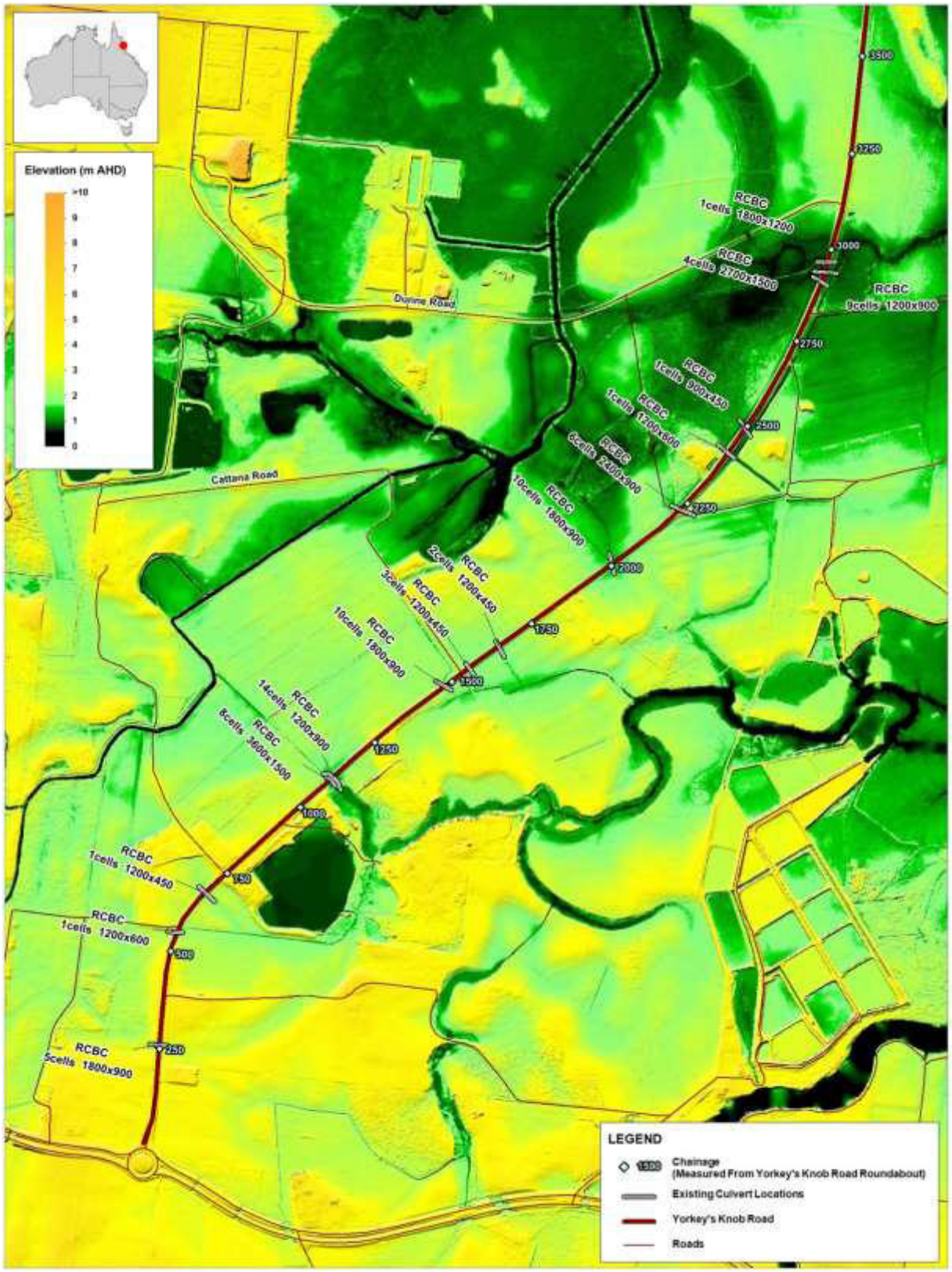
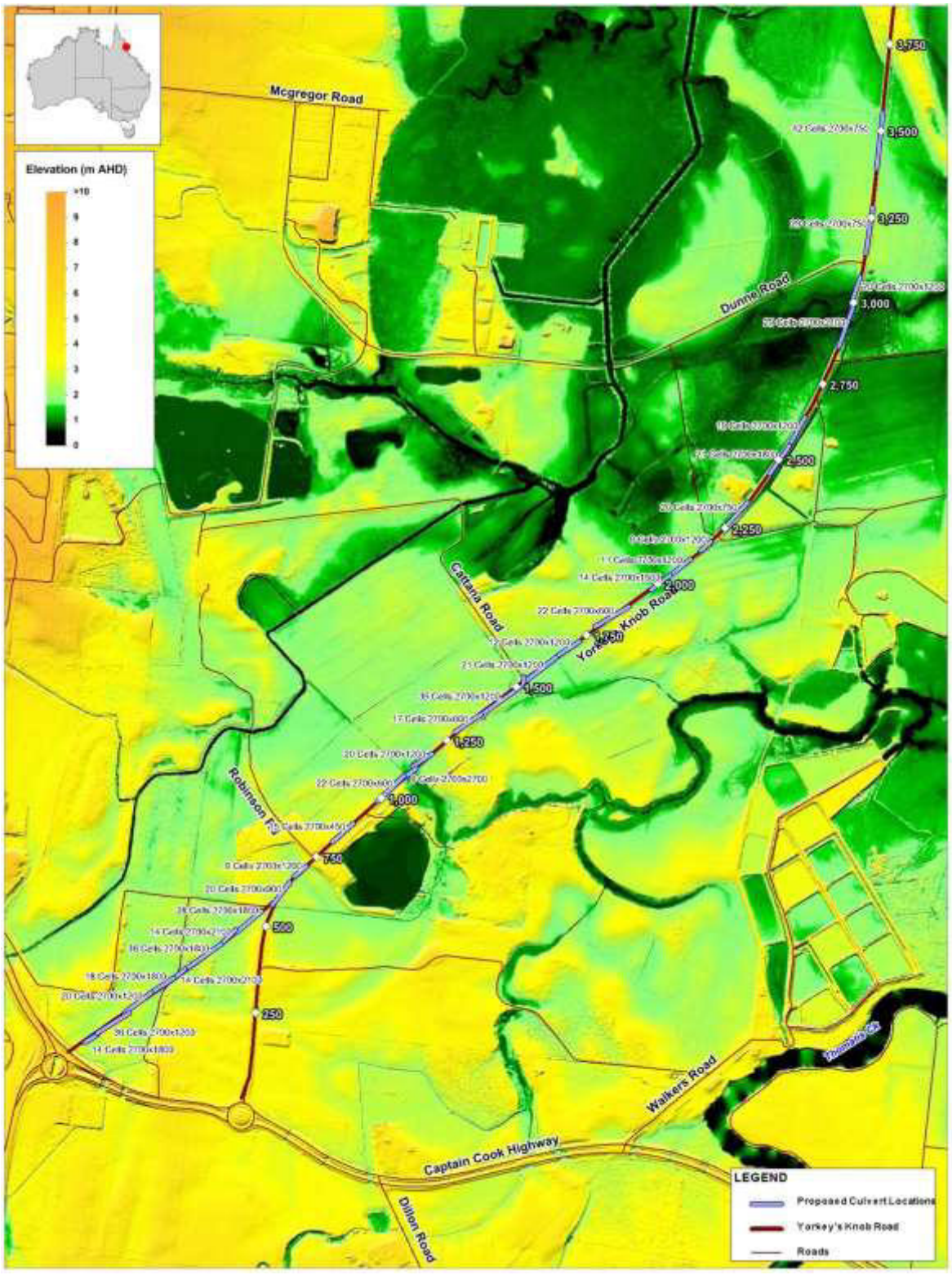


Figure 5-8 Proposed Road Levels & Culverts



5.3 Emergency Flood and Cyclonic Storm Tide Management to Ensure the Safety of People

Key elements of the proposed emergency flood management plan include:

- ARI 50 year flood and storm tide trafficable route from the site out of the delta to high ground.
- Cyclone warning monitoring.
- Sophisticated continuous river gauge monitoring system with automated warnings and action triggers.
- Early evacuation strategies for river flood and cyclone surge events managed by the resort management for special needs and medical emergency requirements.
- Stay put on-site safe refuge for guests and staff above the dominant PMF level, with suitable emergency water and food supplies, independent on-site power supply, suitable medical facilities and communication equipment. Independent fail-safe power supply is required for casino and hotel operation and will be designed to remain operational in a PMF event.
- A helipad above PMF level for emergency medical evacuations.
- Internal site access routes to resort refuge.

a) Cyclone Events

The strategy for major cyclone events will be one of "shelter in place" for guests and staff. Evacuation will only be considered for special needs people, and this evacuation would be early or for medical emergency cases.

The resort management will closely monitor Bureau of Meteorology cyclone tracking and track predictions and warnings

A dual fire / cyclone and flood alert, alarm and control system with appropriate evacuation warnings and orders will be required on all the resorts facilities. A similar system has recently been approved by Gold Coast City Council for the Florina Gardens Development at Merrimac.

EMQ and local emergency management agencies support a "shelter in place" approach, subject to the resort being able to provide safe refuge above the level of the design event. This requires that structures relied upon for this purpose is designed to withstand the loads imposed by the event.

b) Flood Events

The Barron River has in place an extensive ALERT flood warning system, run by the Bureau of Meteorology. The Bureau's stated aim is to provide between 3 and 9 hours warning of flood heights exceeding 5 metres at Kamerunga. This equates to less than 1,000 m^3/s (approximately an ARI 2 to 3 year event).

The Bureau operates 13 field stations of which six measure rainfall and river height, seven measure rainfall only and one monitors the water level at Lake Placid.

This information is continuously monitored by Cairns Regional Council and the Bureau, and the resort will install a third monitoring system at the resort, using sophisticated Greenspan equipment and software. A comprehensive emergency flood management plan is to be prepared in subsequent design stages, similar to that prepared for the Florina Gardens Gold Coast project.

With an ARI 50 year trafficable route proposed to be provided from the delta, we estimate that evacuation times for medical emergency or special needs cases will be available 12 to 24 hours after the Bureau's initial flood warning of greater than 5 metres depth at the Kamerunga gauge.

Safe refuge facilities within the resort hotels, above RL 7.5mAHD will be provided for staff and guests. This refuge could also provide additional safe refuge for residents in the surrounding Yorkeys Knob area.

The actual size of the refuge will be defined in detailed design, but with 8 hotel towers, there should be ample room available above the first floor level.

Minimum space required for the refuge should be 3.5 m^2/ person. Each floor of each hotel tower of the IAS proposal has an area exceeding 2,000m^2. With 8 towers, each with 10 stories or greater above PMF level, it would be possible to house the entire full occupancy of guests and all staff safely above the extreme flood levels, extreme cyclonic storm tide and wave level, and above severe tsunami level.

EMQ and local emergency management agencies support a “shelter in place” approach, subject to the resort being able to provide safe refuge above the level of the design event. This requires that structures relied upon for this purpose is designed to withstand the loads imposed by the event.

5.4 Stabilisation of Waterways & Waterbodies and Maintenance Requirements

Key elements to be addressed include:

- Historic long term movement and scour of Thomatis-Richters Creek.
- Previous Proposal for creek stabilisation.
- Recent Creek stabilisation.
- Local site bank erosion and river training requirements.
- Proposed mechanism for ensuring long term stabilisation.

Chapter 6.2.2 of the Coastal Processes Assessment Report discusses estuary dynamics.

A key recommendation for waterway stabilisation includes:

- Sinking fund contribution, a bond or bank guarantee for additional armour works to stabilise the bifurcation of Thomatis / Richters Creek from the Barron Delta, and to armour to protect from erosion existing river banks of Thomatis / Richters Creek.

Within the 100 year design life of the proposed development, the risk of such creek movement such that critical infrastructure would be threatened is considered to be very low.

5.5 Consideration of Siltation during Floods

During significant river flood events greater than ARI 2 year event, floodplain break-out of flow occurs (Review of Barron River Delta Flood Model, Connell Wagner 2007), with large suspended sediment loads carrying silts and fine sands across the delta, including across the site.

An important consideration, therefore, is how much siltation can occur on the site, including in the proposed site lake, from river flooding, and how this siltation is to be managed.

Based on the Barron River Delta Investigation, suspended sediment loads of up to 1200 mg/L were recorded (page 197). Assuming this load exists for the duration of the ARI 100 year flood (which is conservative), and using the numerical flood model of the delta to determine that over bank flooding at the site occurs for 48 hours, with an average of 500m^3/s, this would result in 103,680 tonnes of sediment entering the site in suspension. If we assume all of this material was to settle, this results in about 70,000m^3 of material deposited assuming a density of 1.5 t/m3.

The lake volume is 1.3 million m^3 and the site area is 340 hectares. This results in an average of 20 mm deposition across the site. Even if all of the suspended sediment in the ARI 100 year flood was deposited in the site lake,(area 33 hectares), this equates to an average siltation depth of 250 mm, in a 4m deep lake. These calculations are based on the conservative assumption that there is uniform and complete deposition across the proposed lake

In reality, only a small proportion of sediment will fall out of suspension, so actual average sedimentation will be much less. Sedimentation is also not limited to just the lake area.

An alternate method of estimating site siltation is by using annual sediment load for the Myola gauging station (Table 5.17 from the Barron River Delta Investigation) which estimates the highest annual load as being 281,000 tonnes for the period 1915 to 1929. Freshwater Creek will also contribute to the sediment load however Freshwater Creek is a regulated Creek, as a consequence of Copperlode Dam, and proportionally has a significantly smaller catchment compared to the Barron River. Therefore it as anticipated that Freshwater Creek will only have a minor load contribution compare to that of the Barron River.

The report estimates that 39% of the river flow goes down the Thomatis / Richters Creek system for minor floods (page 226), which results in 73,000 m^3(assuming the above density).

If we assume all this material were to fall out over the site, or just in the lake, this results in 20 mm and 220mm siltation respectively.

There will need to be clean-up after floods, and periodically, the lake may need to be de-silted, but based on the above, de-silting would be infrequent, and less than once every 10 years except for major events. On-site management of extracted material will be required and provision has been made in the Concept Land Use Plan for a major silt disposal facility on the western part of the site.

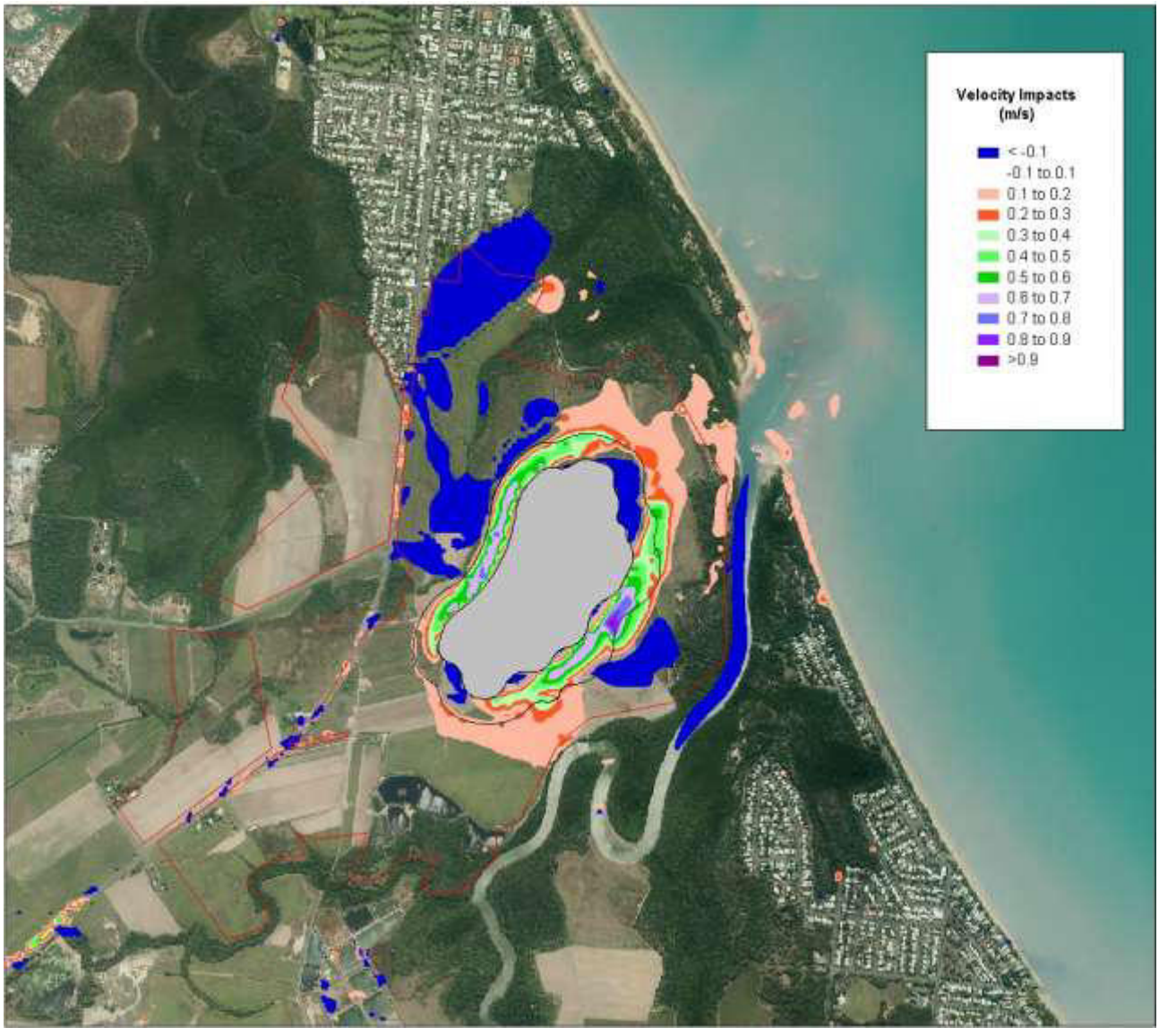
Annual lake bed surveys at selection cross sections will be required to monitor silt build-up over time.

Siltation/Erosion Potential of the Development

To assess the likelihood of sediment erosion/re-suspension within the site, the TUFLOW flood model was used to assess the potential change in velocity and bed shear stress due to the proposed AQUIS development.

Figure 5-9 provides a plot of the change in velocity from existing conditions to developed conditions with the proposed lake and building pads in place for the 100 year ARI storm event.

Figure 5-9 Velocity Impact plot of the 'lake' flood mitigation option



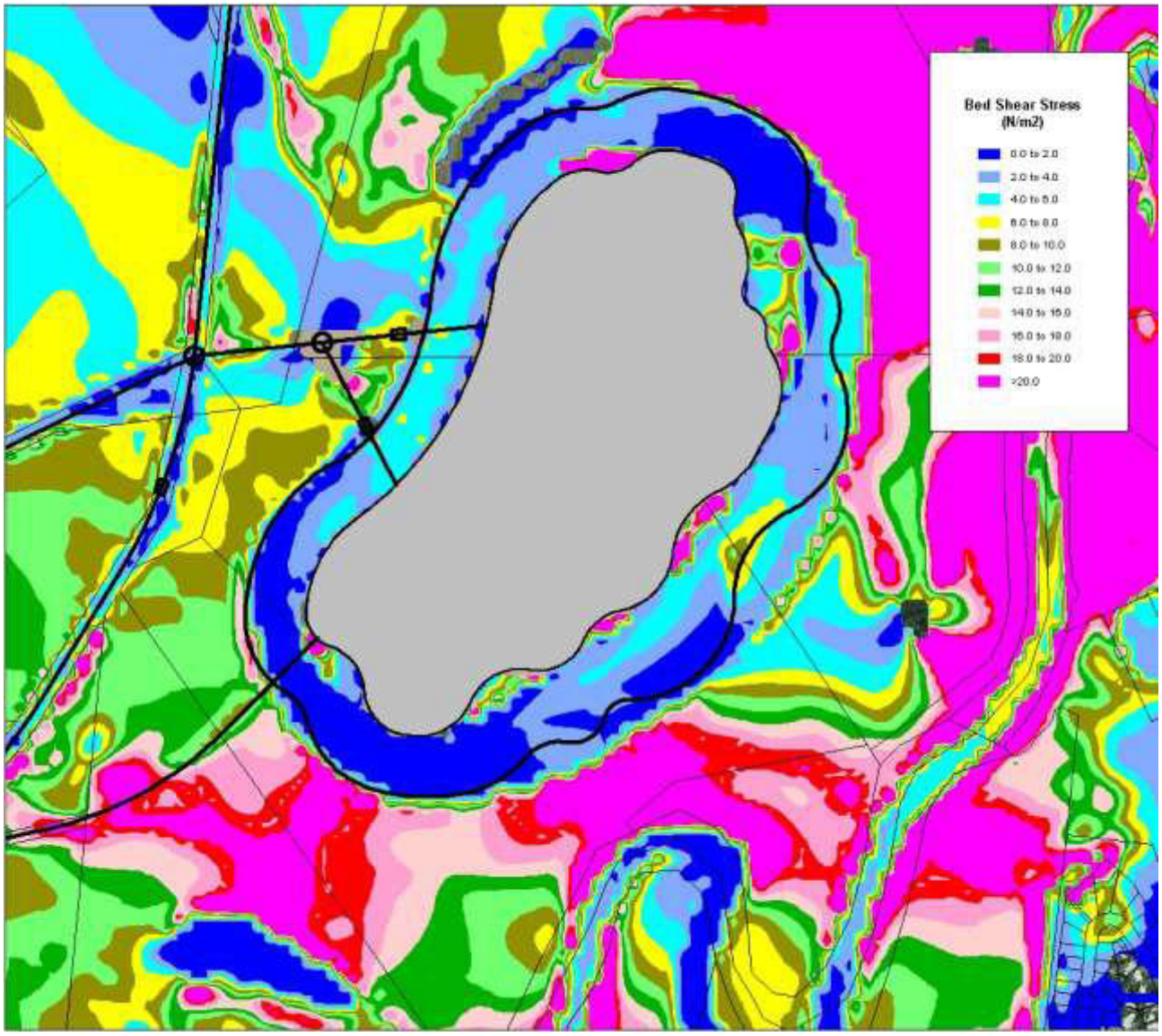
Results from the velocity plot (refer to Figure 5-9, above) indicate that development area to the west of the lake results in a decrease in peak velocity. As depicted in Figure B4 of Appendix B, the resulting peak velocity in this western portion of the development is less than 0.5m/s. Vegetation is proposed in this western area (i.e. rehabilitated and/or golf course) which will further limit the

potential for erosion. It should be noted that vegetation cover typically prevents erosion up to velocities of 1.5m/s to 2.0m/s.

An increase in peak velocity is predicted to occur on the north side and southern ends of the proposed development (refer to Figure 5-9, above). The increase is generally minor and in the order of 0.2m/s and largely within the development boundary. The velocities in these regions are generally less than 1m/s and similar to the western area will be either rehabilitated and/or covered with vegetation limiting the erosion potential.

Provided in Figure 5-10 below is the predicted bed shear stress for the proposed lake.

Figure 5-10 100 year ARI Bed Shear Stress



In terms of the proposed lake area, the results generally indicate a bed shear stress less than 6 N/m^2 for the ARI 100 year flood. It is important to note that the predicted bed shear stress plots are based on the average velocity vertically through the water column. In reality, the near bed velocity will be less than half the average velocity. i.e. the actual bed shear stress will be less than 3 N/m^2.

Based on data presented in Figure 7-11 of 'Open Channel Hydraulics', 1959 by Chow, the threshold of movement for sandy clays is around 10 N/m^2 (i.e. 0.21lb/ft^2) for material between loose and compact. As a result, there will be minimal re-suspension of sediments from the bed of the lake during both local and Barron River floods.

5.6 Overall Lake Siltation

In addition to potential siltation from river flood events, the proposed tidal exchange system for the proposed development lake from Richters Creek has the potential to ingest suspended sediments in the creek which may potentially settle in the site lake.

Based on available water quality monitoring results, typical average wet and dry season suspended solids levels in Richters Creek are 50 mg/L and 10 mg/L. The proposed lake tidal exchange system turns over 31,000 ML/annum (based on the tidal hydrodynamic modelling), so around 600 tonnes of suspended solids are ingested to the lake annually.

If we conservatively assume that all this suspended sediment is deposited in the lake, this equates to less than 2 mm/year average deposition across the lake.

6 Legislative Requirements and Planning Provisions

6.1 State Planning Policy SPP 1/03

In relation to flooding, a key State Government requirement is detailed in State Planning Policy SPP 1/03. Appendix 5 of the Policy Guideline requires that:

1. *Development maintains the safety of people on the development site from all floods up to and including the DFE (ARI 100 Year event (1% AEP)).*

Response: With development levels for buildings and critical infrastructure set above the ARI 100 year event, and with the incorporation of an appropriate emergency flood and cyclone management plan, this provision is met. In fact, a far higher standard is proposed with the main resort podium set above PMF level.

2. *Development does not result in adverse impacts on people's safety on the capacity to use land within the floodplain.*

Response: People at the resort will be safe as per the response above. By providing a major upgrade to Yorkeys Knob Road, with flood immunity greatly improved, the general public's safety is also improved. All resort hotels and facilities of the central island will be above PMF level.

Flood modelling has demonstrated that no significant adverse flooding impacts will result beyond the site.

3. *Development minimises the potential damage from flooding to property on the development site.*

Response: The development is proposed to be designed to ensure that critical infrastructure can withstand extreme flood and cyclone events, with all hotels, casino, swimming lagoon, and associated infrastructure set above the PMF level, with safe refuge areas all above the PMF.

4. *Public safety and the environment are not adversely affected by the detrimental impacts of floodwaters on hazardous materials manufactured or stored on site.*

Response: All chemicals and fuels, including pool and golf course chemical will be stored above the ARI 100 year flood level.

5. *Essential services infrastructure (e.g. on site electricity, gas, water supply, sewerage and telecommunications) maintains its functions during DFE.*

Response: The proposed development will comply with requirement and emergency power, water supply, sewerage and telecommunications to service on site emergency flood and cyclone refuges will be designed to remain functional in a PMF and extreme cyclone event.

6.2 Draft Single State Planning Policy of April 2013

Whilst still in draft form, we have assessed the development proposal against the mandatory requirements of the April 2013 draft State Planning Policy, as follows:

State Interest Check

The risks of adverse impacts from natural hazards are avoided or mitigated to protect people and property and enhance the community's resilience to natural hazards.

Response: With development levels for buildings and critical infrastructure set above the PMF level, and with the incorporation of an appropriate emergency flood and cyclone management plan, this provision is met.

People at the resort will be safe as per the response above. By providing a major upgrade to Yorkeys Knob Road, with flood immunity greatly improved, the general public's safety is also improved.

Flood modelling has demonstrated that no significant adverse flooding impacts will result beyond the site.

Policy 1: Reflecting the outcomes of a natural hazard investigation including natural hazard maps for the local government area.

Response: Cairns Plan relies on flooding mapping by Connell Wagener which is based on the current Council flood model. The mapping and the flood model has been utilised for flood assessments of the development.

Policy 2: Reflecting the outcomes of a natural hazard risk assessment.

Response: The natural hazard risk assessment for the Barron River delta comprises a number of investigations, including the Connell Wagner August 2007 Flood Study Report, and Cairns Regional Local Disaster Management Plan.

The flood management measures for the proposed development as described in this report reflect the outcomes of the natural risk assessment.

Policy 3: Reflecting the development potential of land by ensuring development in new and existing areas avoids or mitigates the risks of natural hazards to an acceptable or tolerable level.

Response: The proposed development and associated flood management strategy mitigates the risk of flooding to an acceptable level.

In relation to local government development assessment requirements (Chapter 4 of the Mandatory Requirements: flooding hazard document):

(1) The development will be designed using the flood management strategy described in this report to be compatible with the level of risk from flooding, with acceptable levels of risk to be achieved.

(2) The development siting, layout and access responds to the potential flood hazard and will minimise to an acceptable level the flood risk.

(3) The proposed development will be designed to withstand PMF flood and extreme cyclone event, providing resilience to flood hazard and suitable level of risk.

(4) The development will directly, indirectly or cumulatively avoid an unacceptable increase in flooding hazard, and will not significantly increase the potential for damage on the site or on other properties.

(5) The development will avoid the release of hazardous materials by storing all chemical and fuels above the ARI 100 year flood level.

(6) Natural processes in relations to flooding will be maintained by the proposed development.

6.3 Cairns Plan

a) Flood Management Code

An assessment of the proposed development against the relevant performance criteria and acceptable measures for this code is as follows:

Performance Criteria		Acceptable Measures		Comment on Compliance
P1	An acceptable level of flood immunity must be provided for new development	**A1.1**	Development satisfies the minimum levels set out in Table 1 below; and	All hotels, apartments, casino, swimming lagoon, and essential services will be provided above the PMF level, with safe refuge areas above the PMF, with suitable emergency services including independent power, water supply, sewerage and communications to support the safe refuge above the PMF.
P2	An acceptable level of flood immunity must be provided for the access to new development.	**A2.1**	Access to new development is in accordance with the Queensland Urban Drainage Manual.	With the proposed major upgrade to Yorkeys Knob Road, an ARI 50 year trafficable access to and from the site across and out of the delta will be achieved. The main access roads within the site will be to the same or higher standard.

Performance Criteria		Acceptable Measures		Comment on Compliance
P3	Development on premises does not result in a significant impact on other premises.	**A3.1**	Excavation or filling in premises results in a not worsening on other premises both upstream and downstream of up to20mm; and	Flood modelling has demonstrated that, subject to suitable detailed design, no significant adverse impact of flooding will result from the proposed development and that impacts can be limited to no more than 20mm. No development other than the lake intake / outlet is proposed within the riparian corridor, and this will consist of a buried pipeline aligned with existing cleared site tracks.
		A3.2	Development does not occur within the riparian corridor.	
P4	Drainage paths on premises are maintained free of obstruction to permit unimpeded flow of stormwater.	**A4.1**	Where premises contain a waterway a drainage reserve or easement with a minimum width of 10 metres from the high bank of the waterway is provided; and	All site areas will be free draining with the exception of the proposed site lake. No works are proposed within major waterways, except for the intake / outlet structure for the lake turn-over system which will be located within Richters Creek and Trinity Bay.
		A4.2	No excavation or filling of drainage paths are permitted.	
P5	New development does not create an adverse impact on existing properties within Barron Delta as mapped on the Smithfield – Barron District Flood Inundation (ARI 100 year) Overlay Map.	**A5.1**	No acceptable measures are specified. Note: The Planning Scheme Policy, Reports and Information Council May request, provides a guide to the information which should be provided to demonstrate that the Performance Criteria is achieved.	The proposed development has been demonstrated to show that, subject to suitable detailed design, there will be no significant adverse impact in relation to flooding on existing properties within the Barron Delta.

Table 1

Land Use	Fill Level	Floor Level
Residential Uses Tourist and Short Term Accommodation Uses Community Uses with a residential component	Immunity to 1 in 100 year ARI Flood	150mm above 1 in 100 year ARI immunity
Retail Uses Business and Commercial Uses Industry and Associated Uses Community Uses involving access by the public Permanent residential car parking	Immunity to 1 in 100 ARI Flood	Immunity to 1 in 100 year ARI Flood Event
Temporary car parking	Immunity to 1 in 20 year ARI Flood	
Parks and open space	Immunity to 1 in 5 year ARI Flood	

b) Excavation and Filling Code

An assessment of the proposed development against the relevant performance criteria and acceptable measures for this code is as follows:

Performance Criteria	Acceptable Measures	Comment on Compliance
P6 Excavation or filling must not adversely impact on other premises as a result of stormwater drainage flows or flooding	**A6.1** Stormwater drainage flows must be taken to a lawful point of discharge; and	The main resort precinct and all lands east of Yorkeys Knob Rd will drain directly to either the site lake or the Thomatis Richters Creek. Lake overflow will be to Yorkeys Creek within the site, and to Thomatis Richters Creek, the site properties west of Yorkeys Knob Rd are only proposed to be lightly developed, with no significant change in existing run-off characteristics, with existing farm drains off the site to be retained for site drainage. Hence, a lawful point of discharge can be achieved.
	A6.2 Excavation or filling must not result in: a) the ponding of water; or b) an erosive velocity of overland flow, on premises or adjacent premises; and	The site will be designed to be free draining, with the exception of the site lake. No significant adverse impacts on flood velocities are predicted beyond the site.
	A6.3 All berms must be: a) graded towards the upwards slope, and b) contain adequate drainage infrastructure to accommodate the changed drainage flows; and	Adequate drainage infrastructure is proposed as part of the development.

Performance Criteria	Acceptable Measures	Comment on Compliance
	A6.4 Excavation or filling must not result in an increase in the volume of water or concentration of water in: a) overland flow paths of the premises and other premises; and b) waterways; and	No increase in the volume of water or any significant concentration of water to other premises is proposed. Whilst the lake outlet is to Thomatis / Richters Creek, this does not result in adverse impact to other premises.
	A6.5 Excavation or filling must not occur: a) within a waterway; or b) within a riparian corridor; or c) below the 1 in 100 year flood line; and **A6.6** Excavation or filling complies with the Design Guidelines set out in the Planning Scheme Policy, Development Manual	No filling or excavation is proposed within a waterway. No filling or excavation is proposed within the riparian corridor except for the installation of a buried pipeline for the lake intake / out falls, with these being situated within existing cleared farm access tracks.

7 Subsequent Refinement of the Development in Terms of Flood Management

As part of the subsequent detailed design process, flood management for the proposed development will be refined. Key elements of the refinement include:

a) Detailed flood modelling to test and inform refinements to the layout and design to ensure no significant adverse flood impact occurs.

b) Refinements of the proposed upgrade to Yorkeys Knob Road to test and inform civil design of the road upgrade and required waterway crossings. This includes consideration of other criteria such as ecological needs for the crossing of Yorkeys Creek and other crossings for resort users.

c) Preparation of a detailed overall site emergency flood and cyclone event management plan that includes:

   i. Detailed hazard and risk assessment.

   ii. Detailing of flood and cyclone safety measures, including development levels, back-up power supply including fuelling arrangements, on-site water level monitoring, flood warning signage, helipad requirements, safe water supply, safe refuge areas and emergency supplies, flood detection and warning system, emergency evacuation measures, trigger levels, and guest and staff information / awareness.

   iii. Emergency flood / cyclone management group organisation and duties including chief and deputy wardens, communication office and block area wardens.

   iv. Flood / cyclone action plan and response procedures.

   v. Training and emergency response exercises.

8 Conclusions

Based on the investigation described in this report, we conclude the following:

a) Flooding is a major and significant constraint to the development of the site; however flooding is not such that it should preclude development.

b) Flooding must be carefully managed across the development, whilst ensuring that appropriate development levels for buildings, critical infrastructure and people are achieved.

c) Emergency flood and cyclone management planning with suitable safe, refuge areas above PMF and extreme cyclone level is a critical and integral part of the development proposal.

d) To provide adequate site access and emergency egress for medical emergency and special needs cases during floods, the development proposes a major upgrade of Yorkeys Knob Road to provide ARI 50 year trafficable conditions, compared to the existing less than ARI 2 Year situation. This provides additional and adequate time for emergency evacuation of medical and special needs cases by heavy vehicle in the event of a major flood. It also provides a significant community benefit for the township of Yorkeys Knob. Emergency evacuation can also be by helicopter. There is proposed to be a dedicated medical centre on site.

e) By carefully balancing site filling requirements to achieve suitable immunity development platforms, with compensatory lake excavation, it has been demonstrated that the development can be achieved with no significant adverse off-site flooding impacts.

f) By integrating a detailed emergency flood and cyclone management plan, with the design of the development, the risk to people and property within the development can be designed to achieve acceptable levels of risk.

g) The development will be designed to safely withstand extreme river flood and cyclone events under a future year 2100 climate change situation without failure of critical infrastructure, and will achieve a much higher standard than required under current State or Local Authority requirements.

h) The risk of waterway migration within the delta affecting the development will be mitigated by proposing a sinking fund contribution, bond or bank guarantee towards external river training works, such as further stabilisation of the Barron River / Thomatis Richters Creek bifurcation.

i) Subject to suitable detailed design, with the incorporation of the flood management measures outlined in this report, we conclude that there is a low risk of the development causing serious environmental harm in relation to flooding or in relation to causing environmental nuisance.

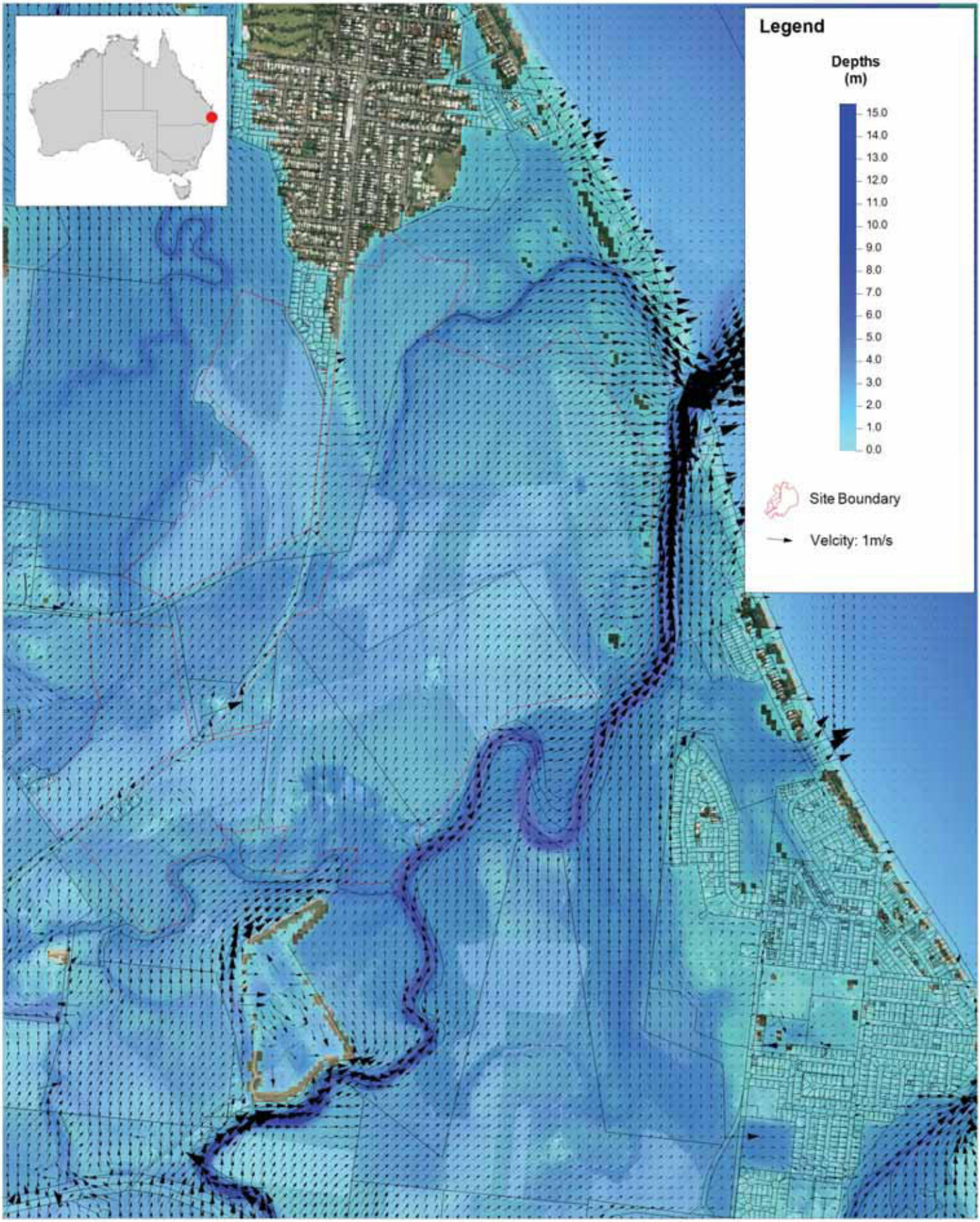
9 Qualifications

This report has been prepared using available information within the allocated time to demonstrate that the proposed development can be feasibly built and operated within a flood constrained site whilst ensuring that there is a low risk of environmental harm or environmental nuisance in relation to flooding.

Whilst limited flood modelling has been carried out to assist in the assessments, more detailed work will be required to allow refinement of the development in subsequent stages of investigation. Chapter 7 of this report describes additional elements of refinement required.

The accuracy of this report is therefore limited to the accuracy of the information used in the creation of the report. Future observed flooding conditions, particularly for extreme events, may vary, given the limitations of our knowledge of such events.

Appendix A Existing Case Detailed Flood Model Results



Title:

Aquis Great Barrier Reef Resort
ARI 100 Year Depths - Existing Site

Figure: A-1

Rev: A

N

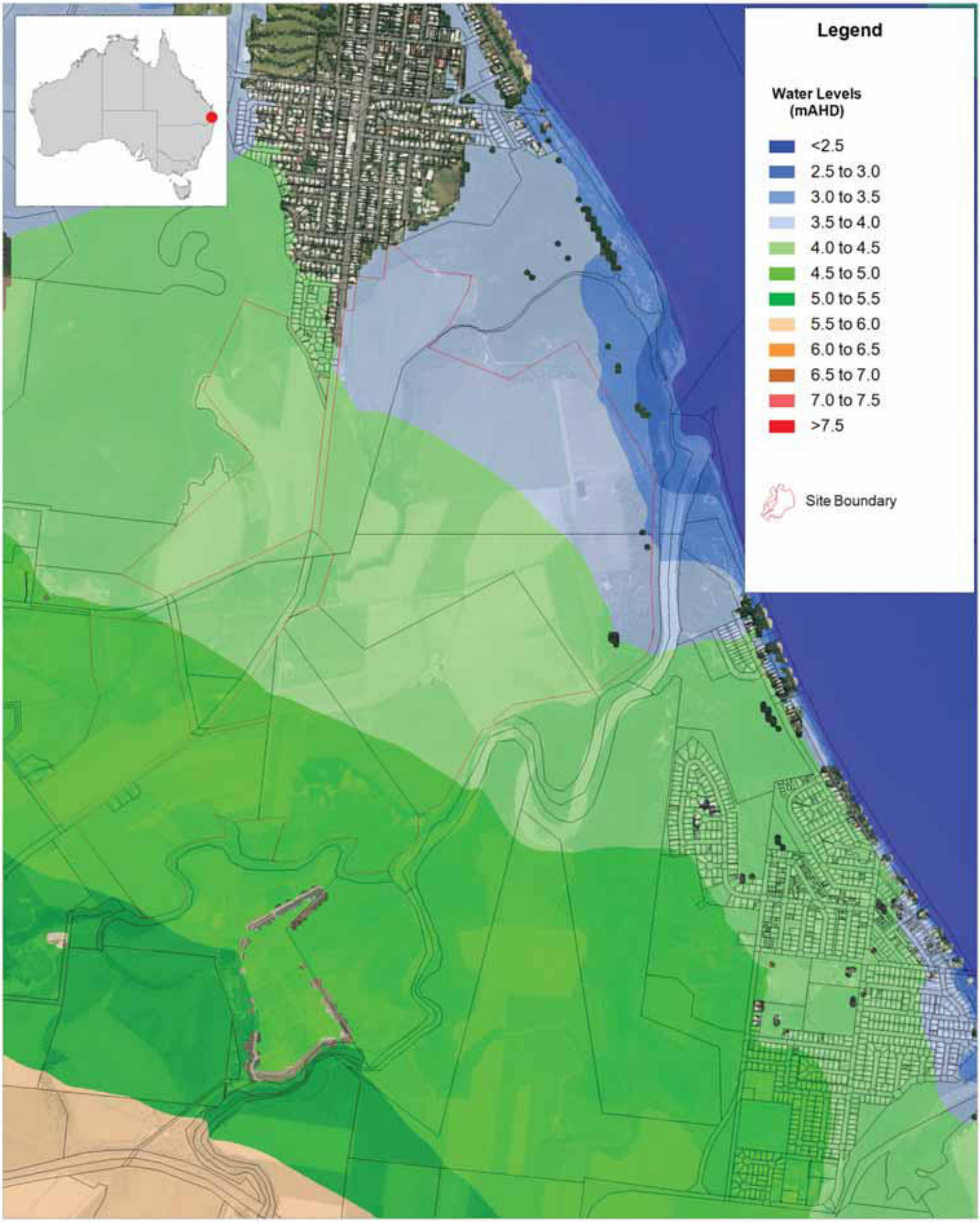
0 500 1,000

metres

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B20270.I.nc_Yorkeys Knob Development\DRG\FLD\ESG_004_130914_ex_100y_depths.wor



Title:

Aquis Great Barrier Reef Resort
ARI 100 Year Water Levels - Existing Site

Figure: A-2

Rev: A

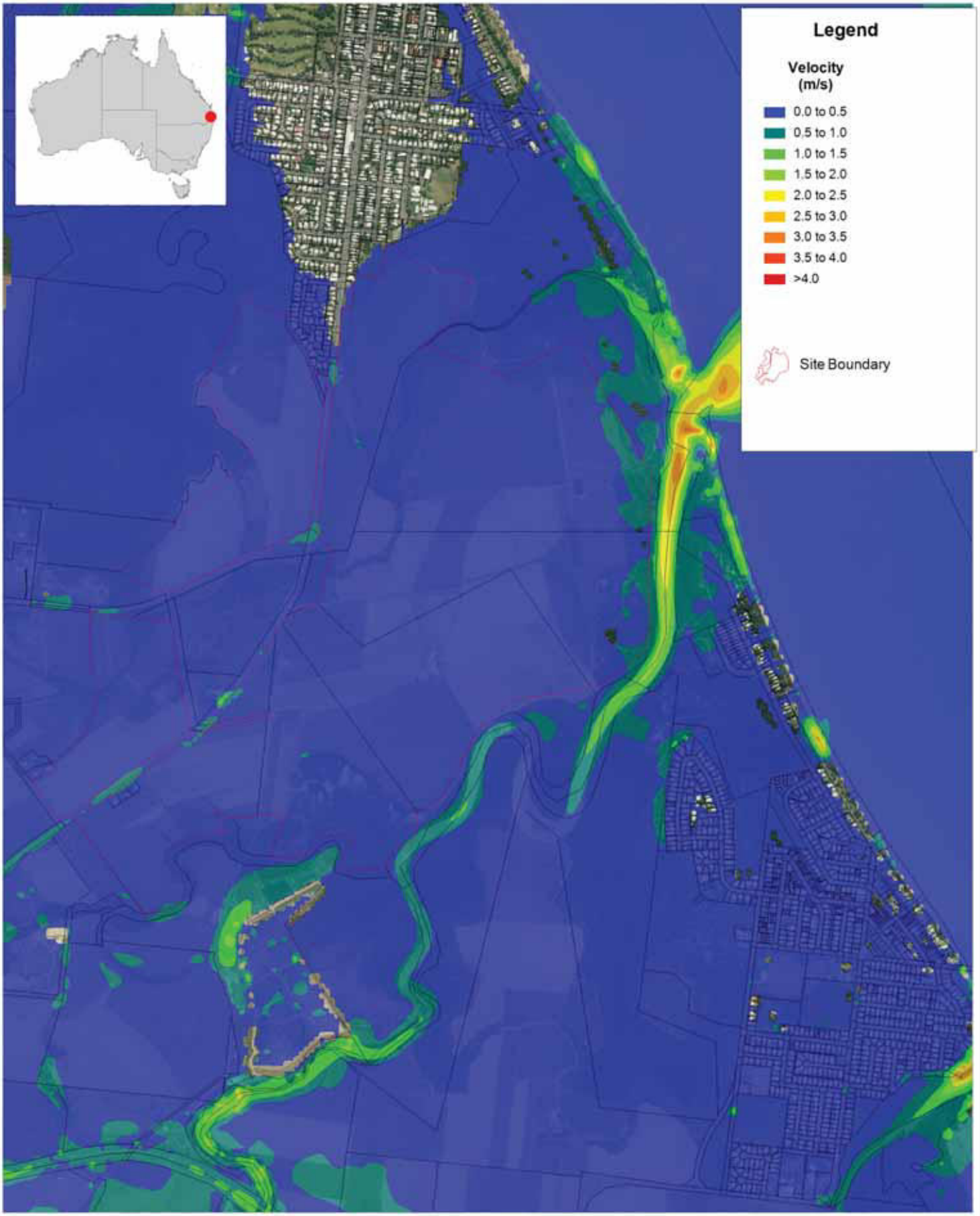
N

0 500 1,000

metres

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B20270.I.nc_Yorkeys Knob Development\DRG\FLD\ESG_005_130914_ex_Q100_WSL.wor



Title:

Aquis Great Barrier Reef Resort
ARI 100 Year Velocities - Existing Site

Figure: A-3

Rev: A

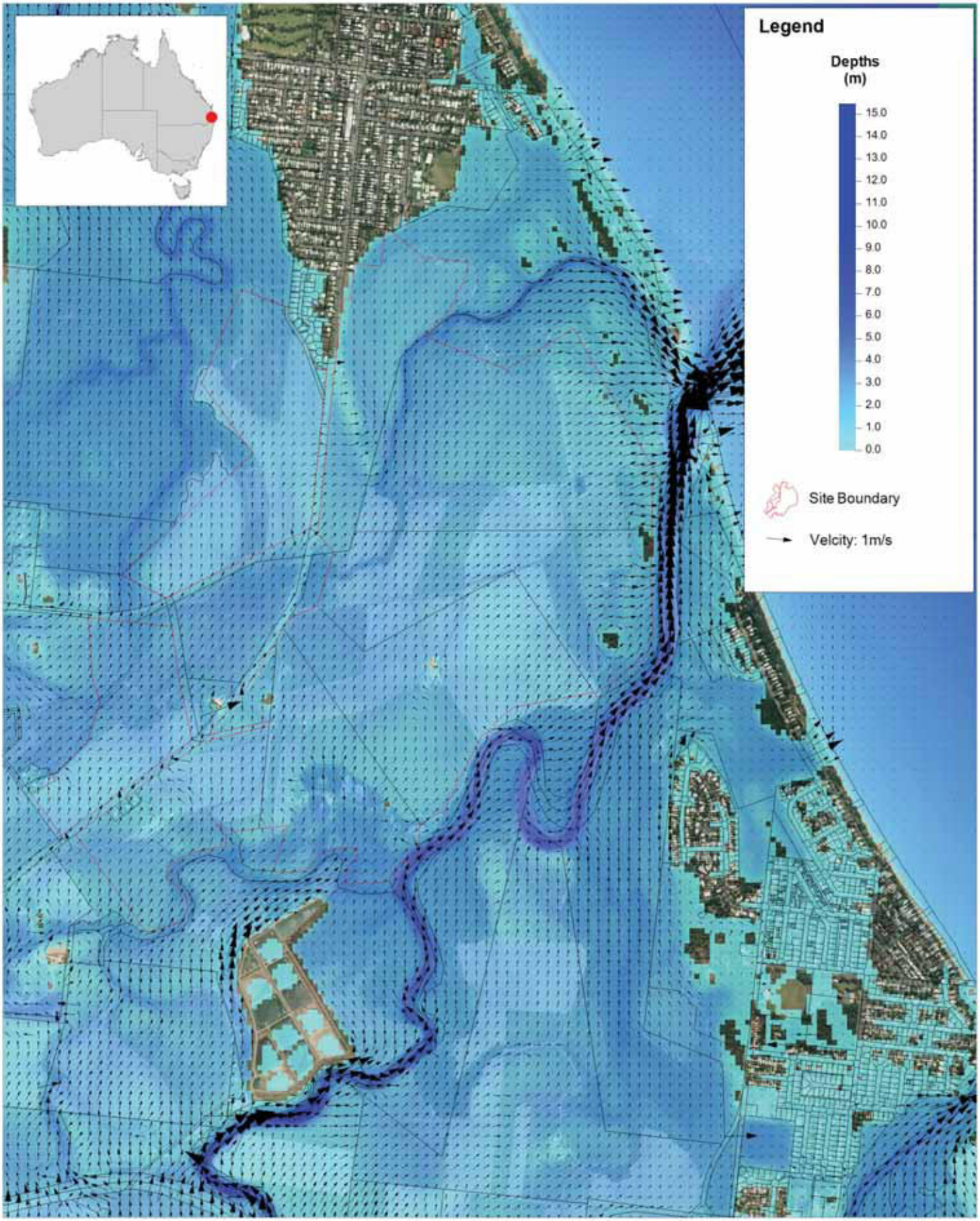
N

0 500 1,000

metres

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B20270.I.nc_Yorkeys Knob Development\DRG\FLD\ESG_006_130914_ex_Q100_vel.wor



Title:

Aquis Great Barrier Reef Resort
ARI 50 Year Depths - Existing Site

Figure: A-4

Rev: A

N

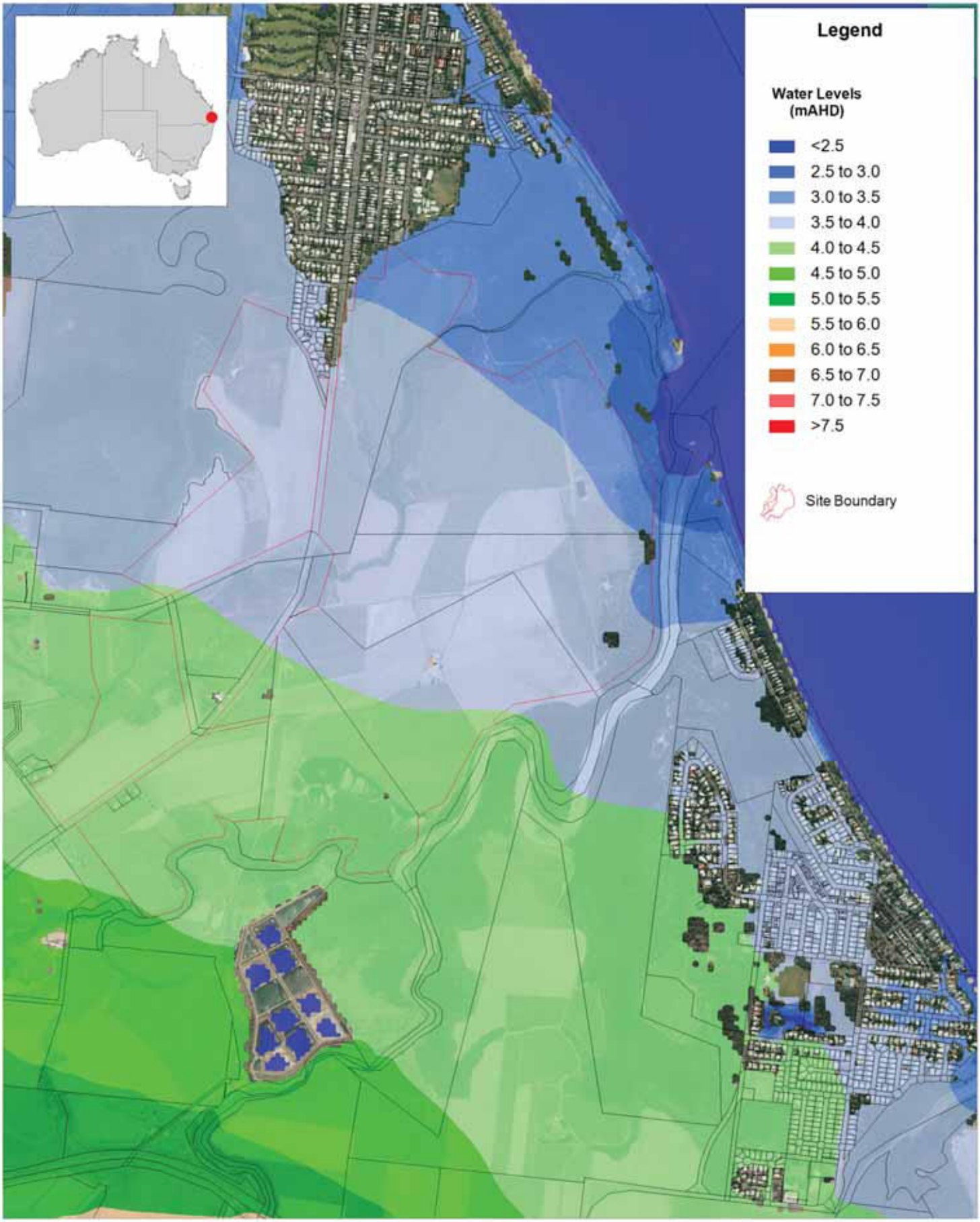
0 500 1,000

metres

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B20270.I.nc_Yorkeys Knob Development\DRG\FLD\ESG_004_130914_ex_50y_depths.wor



Title:

Aquis Great Barrier Reef Resort
ARI 50 Year Water Levels - Existing Site

Figure: A-5

Rev: A

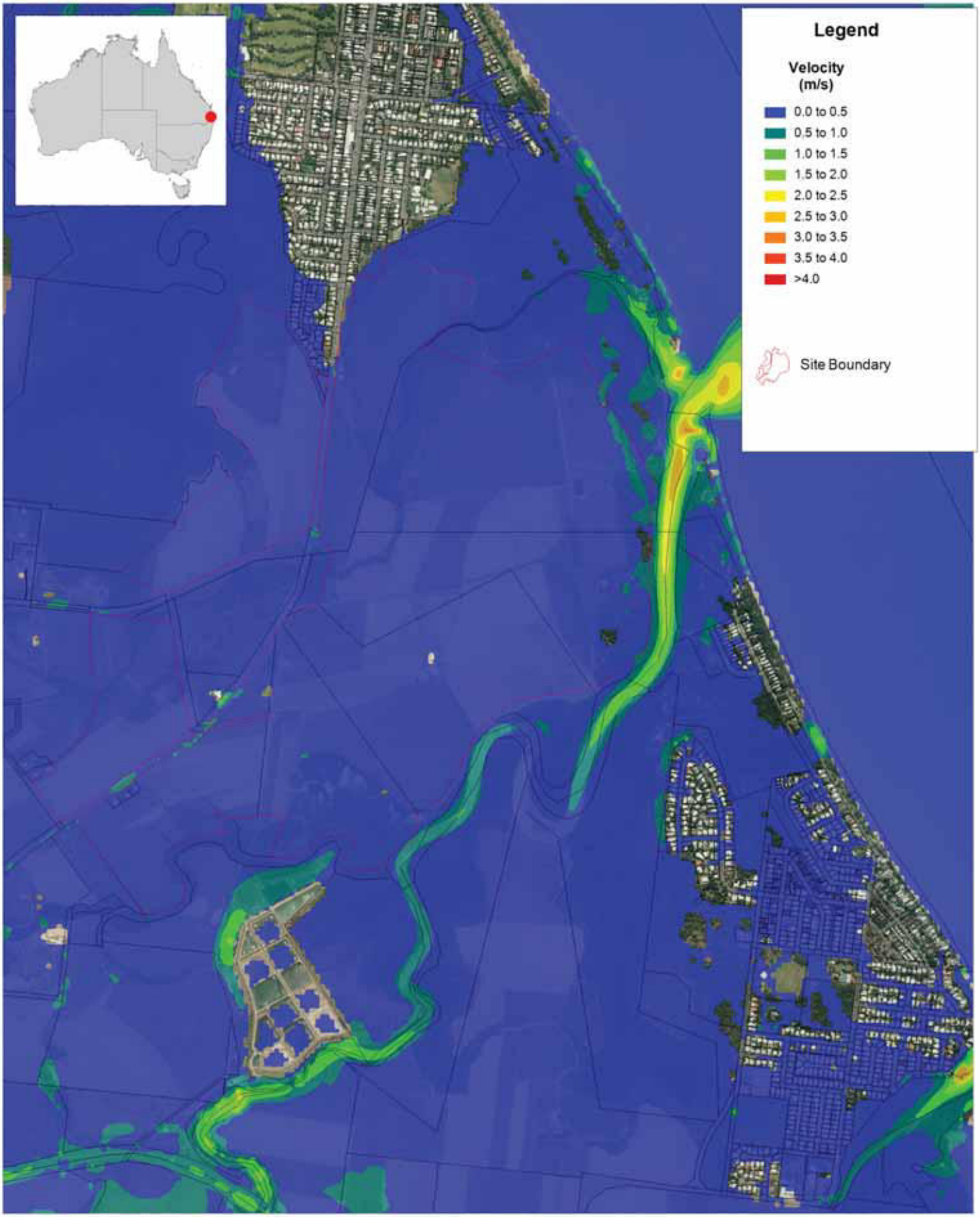
N

0 500 1,000

metres

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B20270.I.nc_Yorkeys Knob Development\DRG\FLD\ESG_005_130914_ex_50y_WSL.wor



Title:

Aquis Great Barrier Reef Resort
ARI 50 Year Velocities - Existing Site

Figure: A-6

Rev: A

N

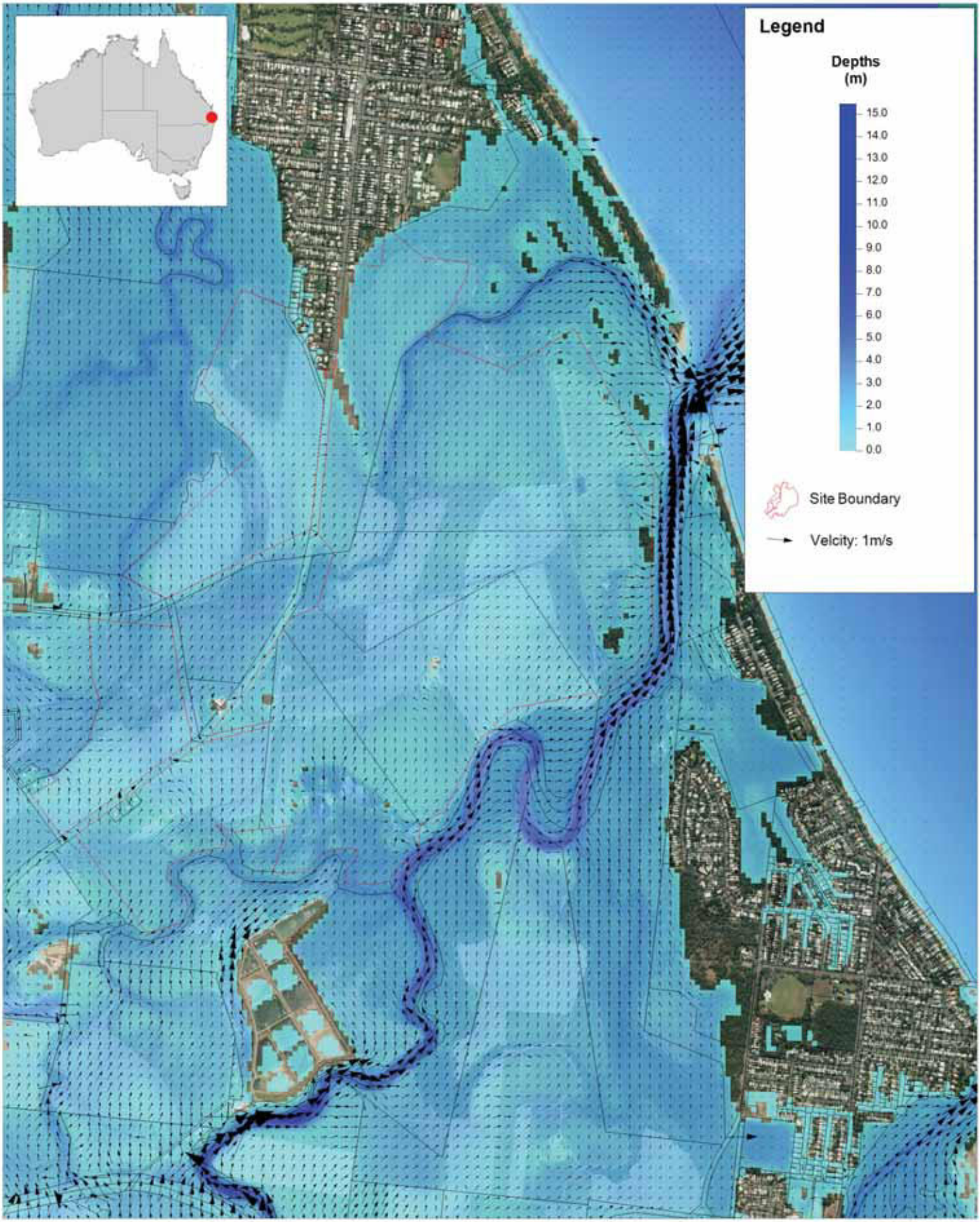
0 500 1,000

metres

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B20270.I.nc_Yorkeys Knob Development\DRG\FLD\ESG_006_130914_ex_50y_vel.wor



Title:

Aquis Great Barrier Reef Resort
ARI 20 Year Depths - Existing Site

Figure:	Rev:
A-7	A

N

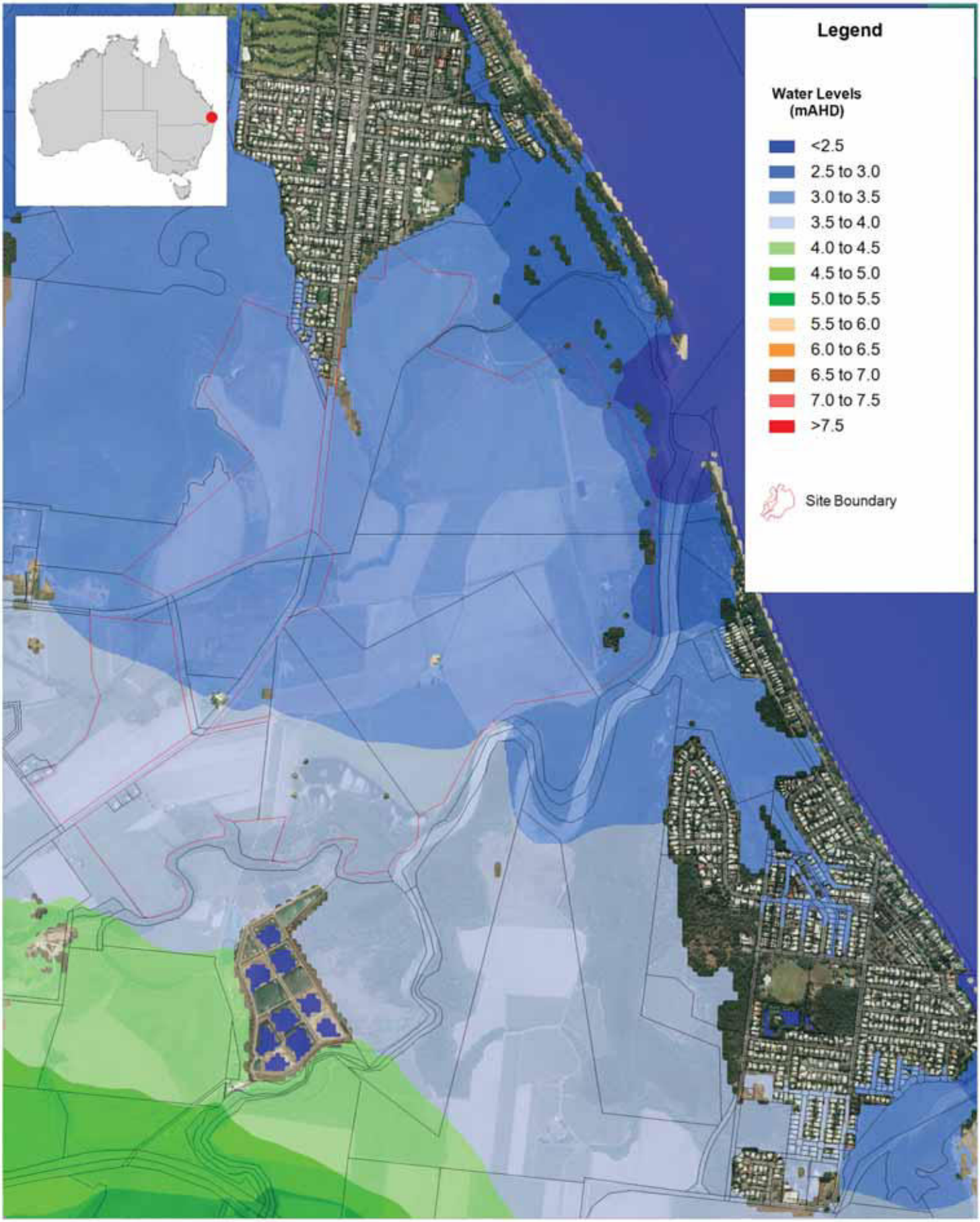
0 500 1,000

metres

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B20270.I.nc_Yorkeys Knob Development\DRG\FLD\ESG_004_130914_ex_20y_depths.wor



Title:

Aquis Great Barrier Reef Resort
ARI 20 Year Water Levels - Existing Site

Figure: A-8

Rev: A

N

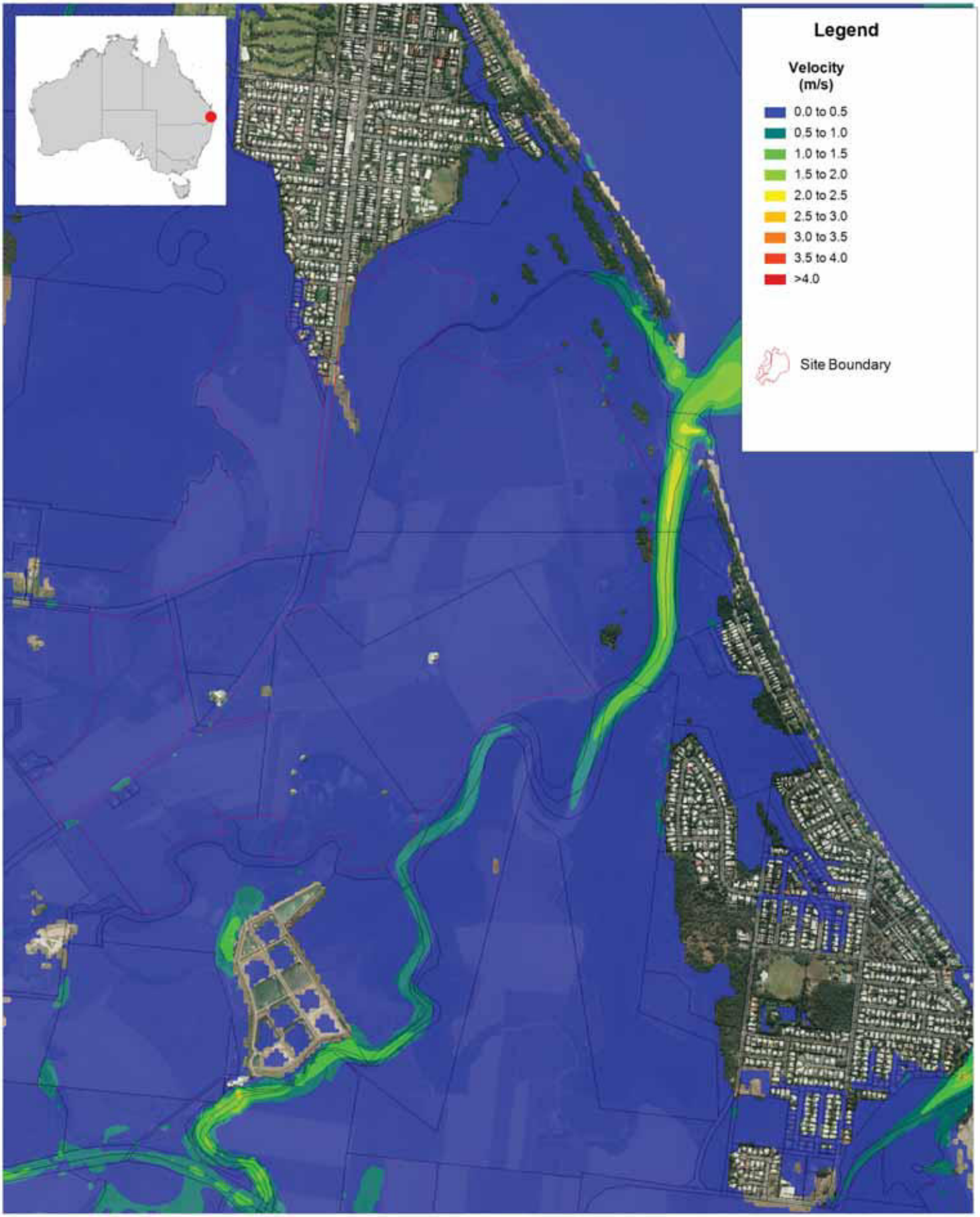
0 500 1,000

metres

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B20270.I.nc_Yorkeys Knob Development\DRG\FLD\ESG_005_130914_ex_20y_WSL.wor



Title:

Aquis Great Barrier Reef Resort
ARI 20 Year Velocities - Existing Site

Figure: A-9

Rev: A

N

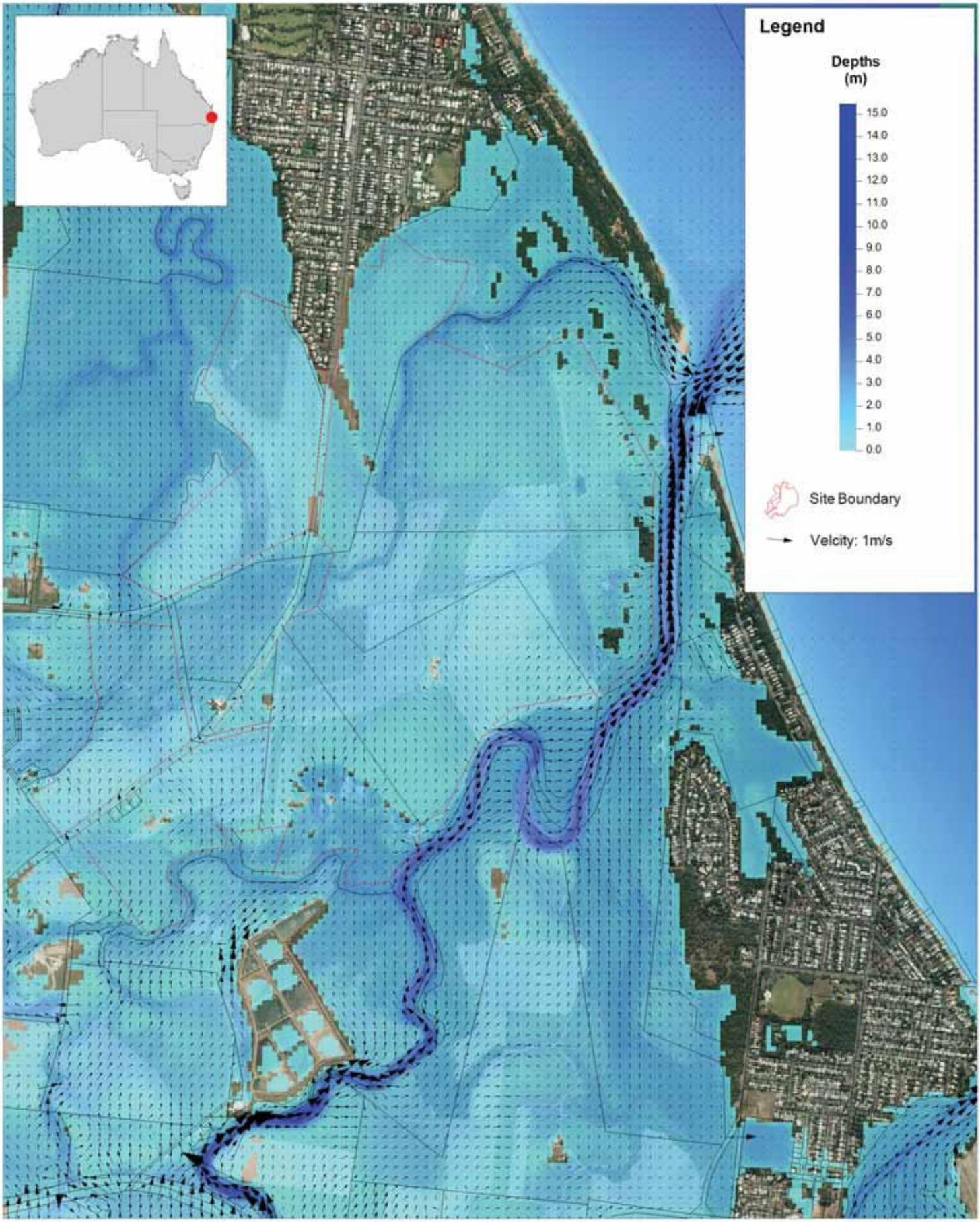
0 500 1,000

metres

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B20270.I.nc_Yorkeys Knob Development\DRG\FLD\ESG_006_130914_ex_20y_vel.wor



Title:

Aquis Great Barrier Reef Resort
ARI 10 Year Depths - Existing Site

Figure:	Rev:
A-10	A

N

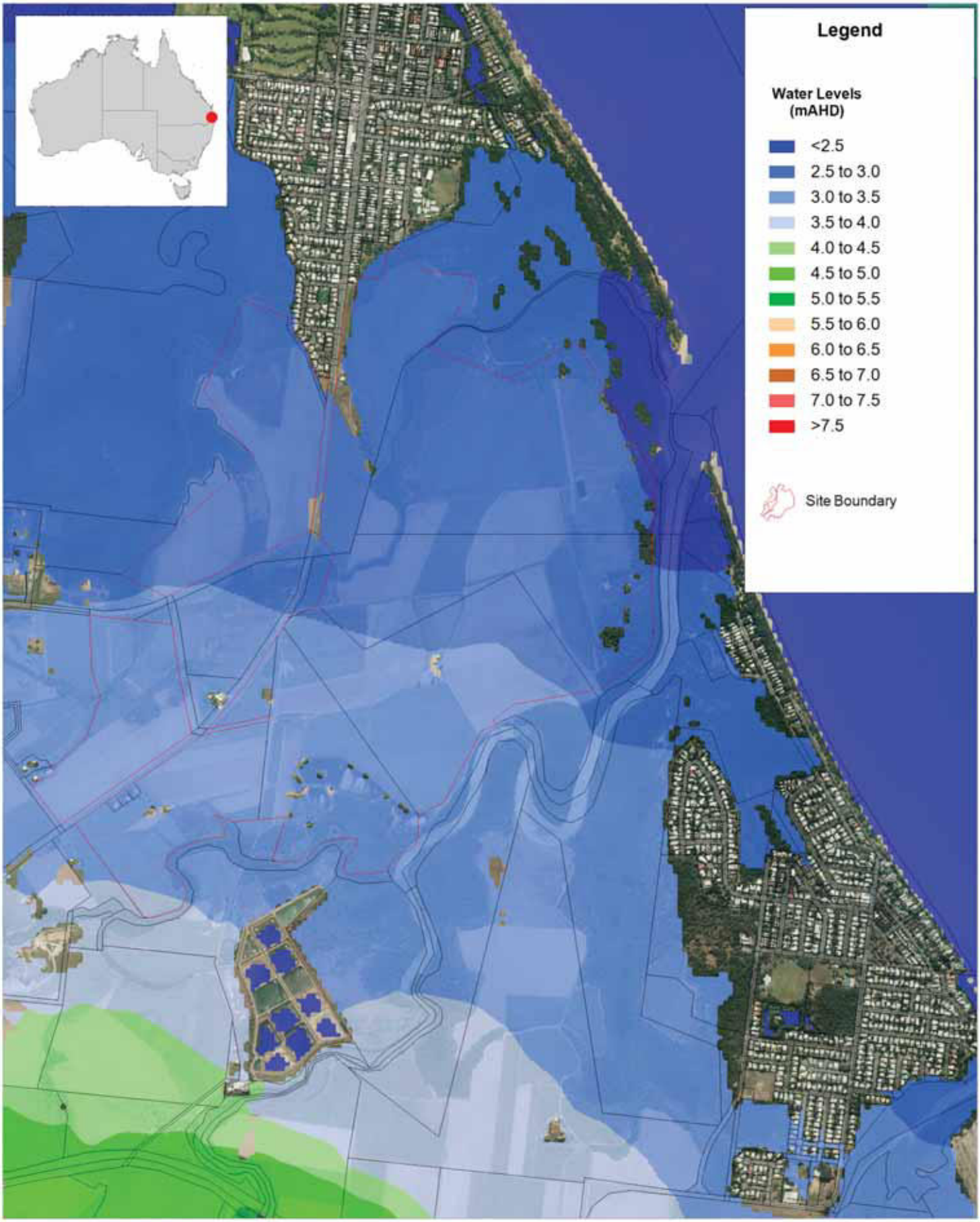
0 500 1,000

metres

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B20270.I.nc_Yorkeys Knob Development\DRG\FLD\ESG_004_130914_ex_10y_depths.wor



Title:

Aquis Great Barrier Reef Resort
ARI 10 Year Water Levels - Existing Site

Figure: A-11

Rev: A

N

0 500 1,000

metres

BMT WBM
www.bmtwbm.com.au

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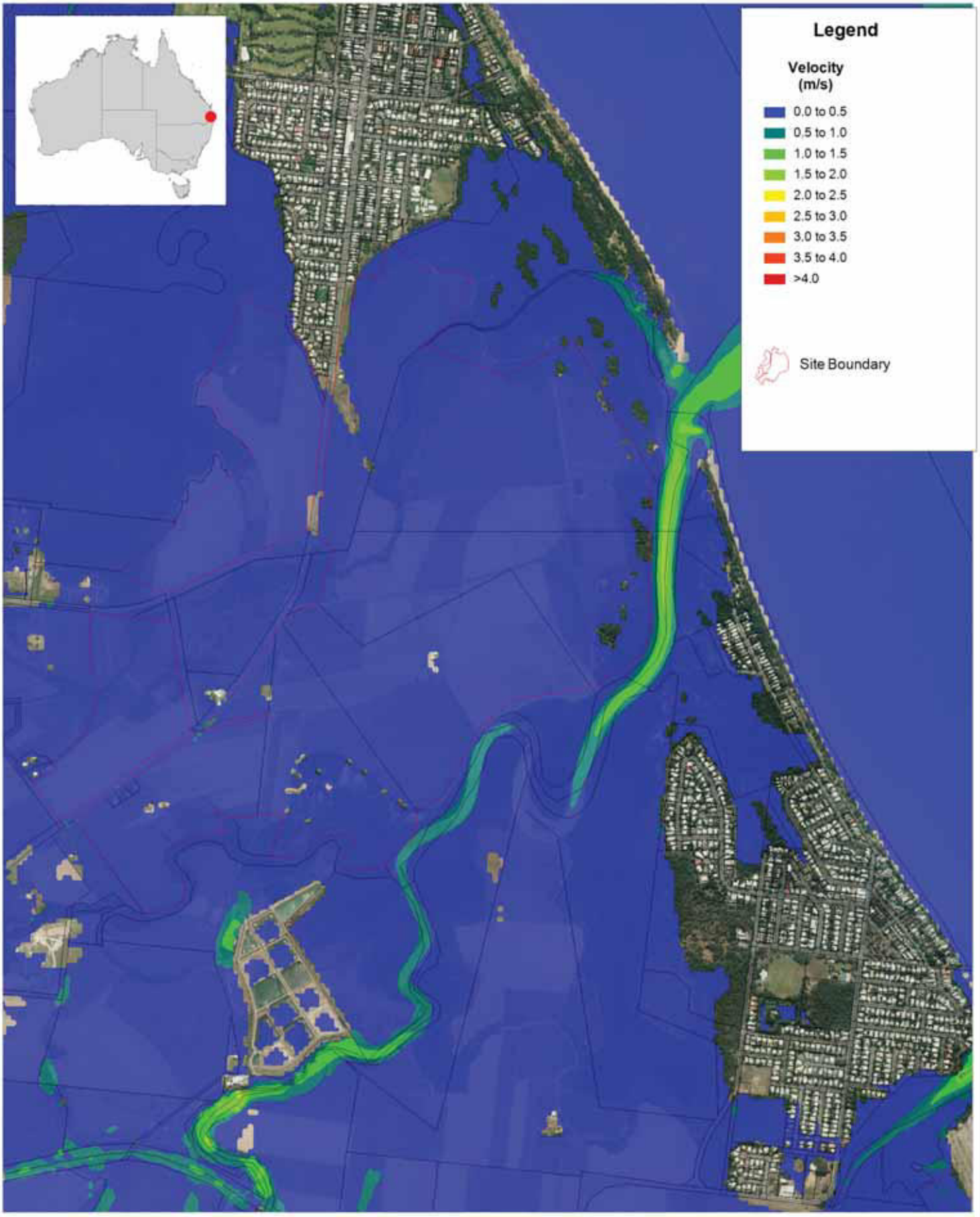

Title:

Aquis Great Barrier Reef Resort
ARI 10 Year Velocities - Existing Site

Figure: A-12

Rev: A

N

0 500 1,000

metres

BMT WBM

www.bmtwbm.com.au

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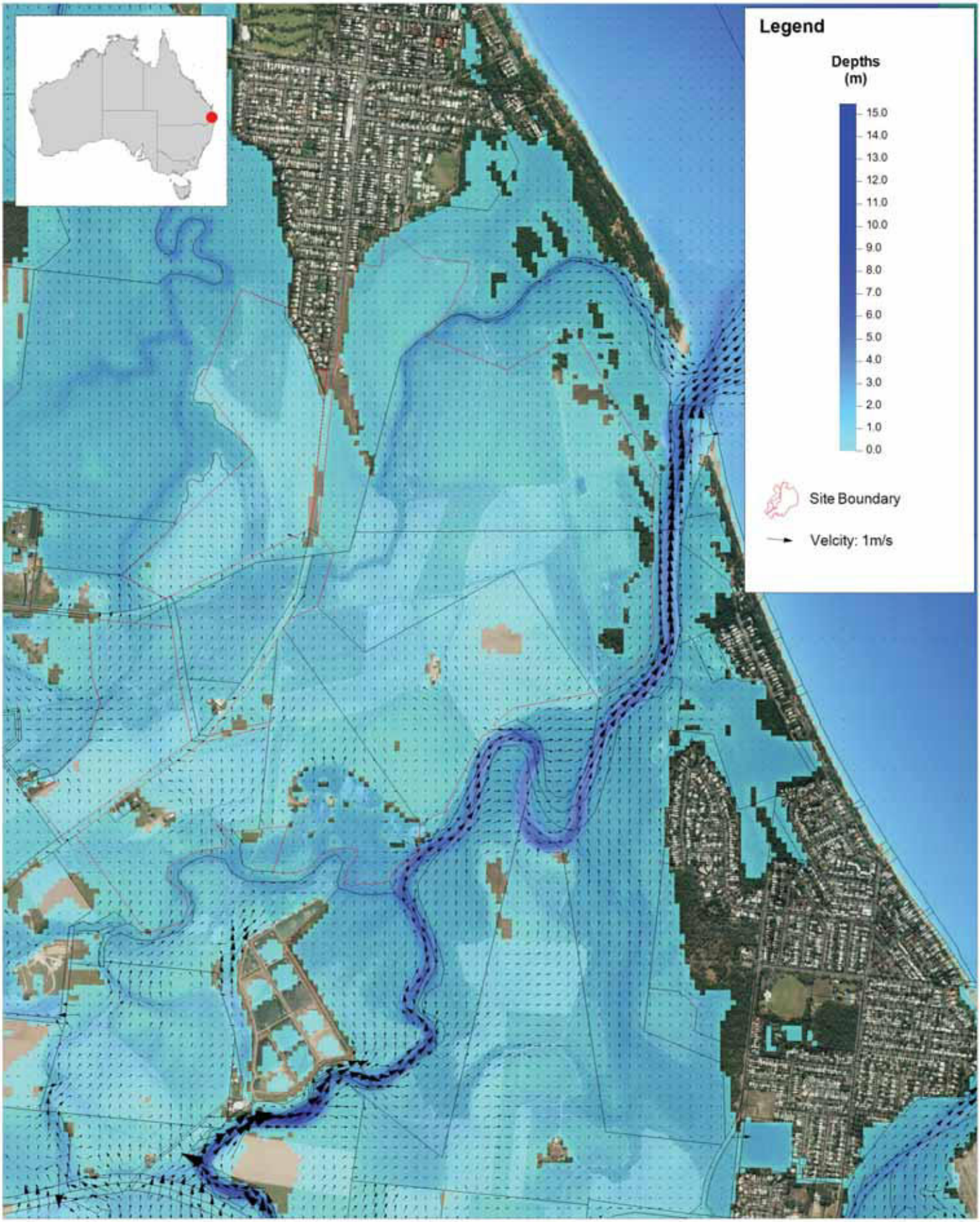


Title:

Aquis Great Barrier Reef Resort
ARI 5 Year Depths - Existing Site

Figure:	Rev:
A-13	A

N

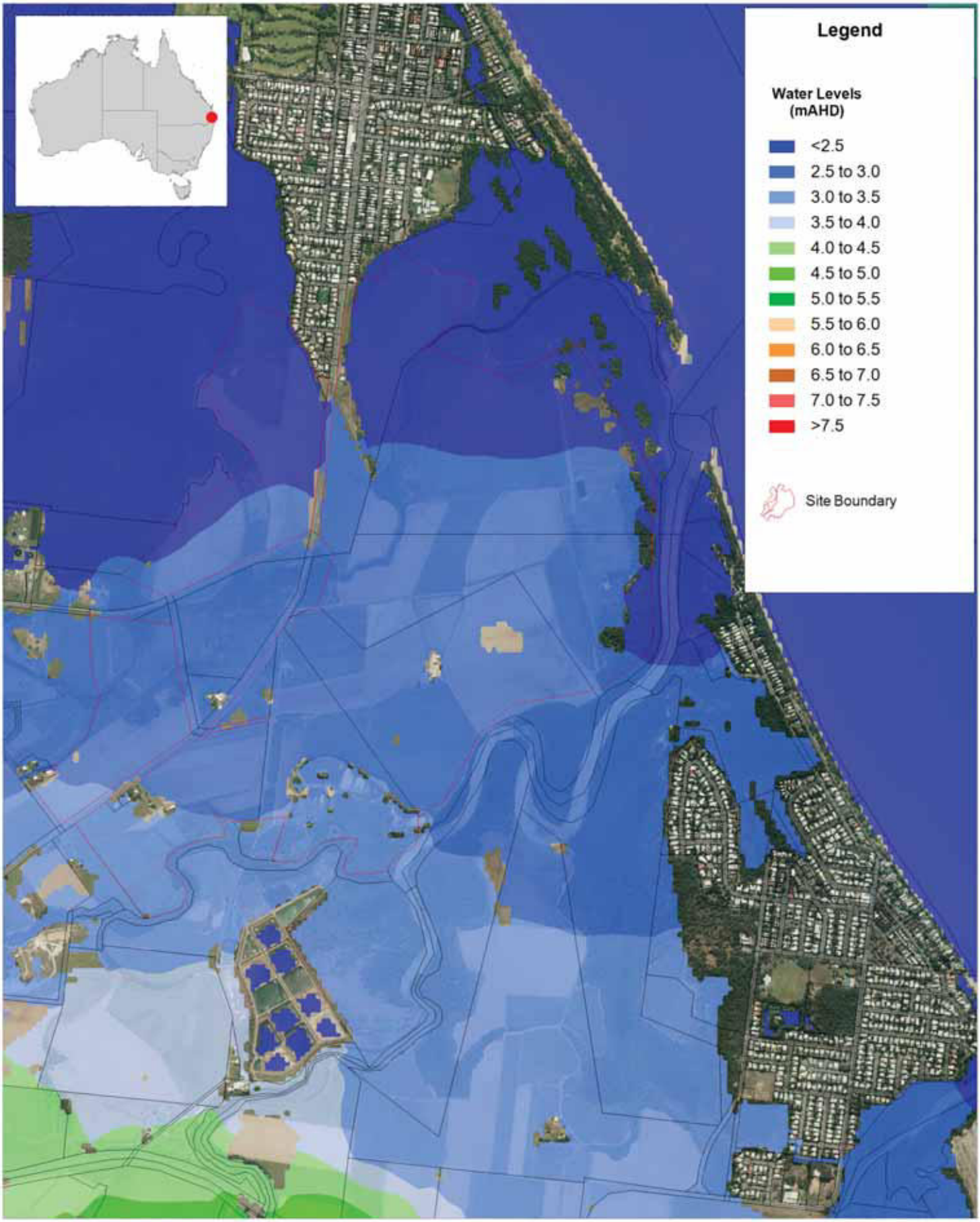
0 500 1,000

metres

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B20270.I.nc_Yorkeys Knob Development\DRG\FLD\ESG_004_130914_ex_5y_depths.wor



Title:

Aquis Great Barrier Reef Resort
ARI 5 Year Water Levels - Existing Site

Figure: A-14

Rev: A

N

0 500 1,000

metres

BMT WBM
www.bmtwbm.com.au

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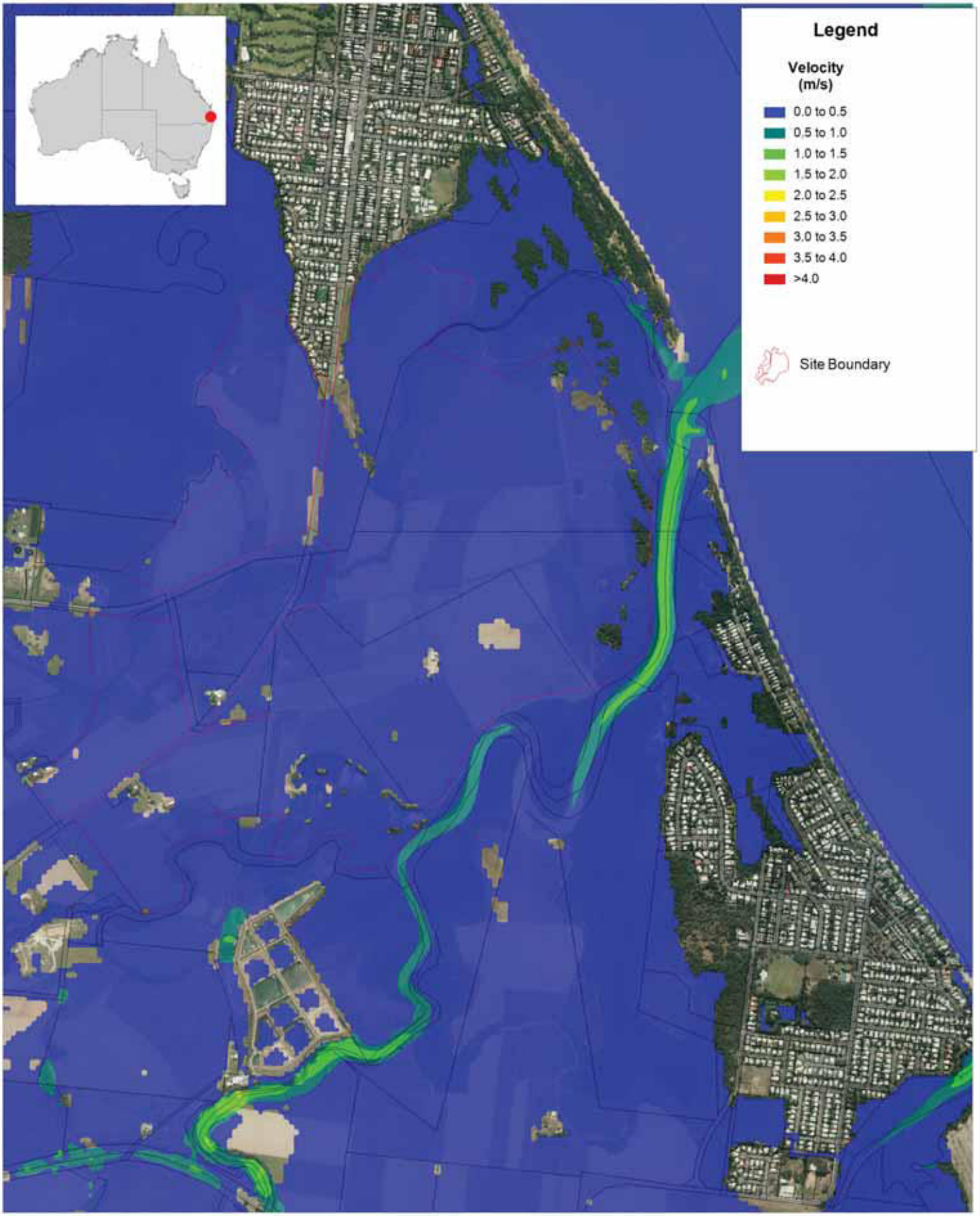


Title:

Aquis Great Barrier Reef Resort
ARI 5 Year Velocities - Existing Site

Figure: A-15

Rev: A

N

0 500 1,000

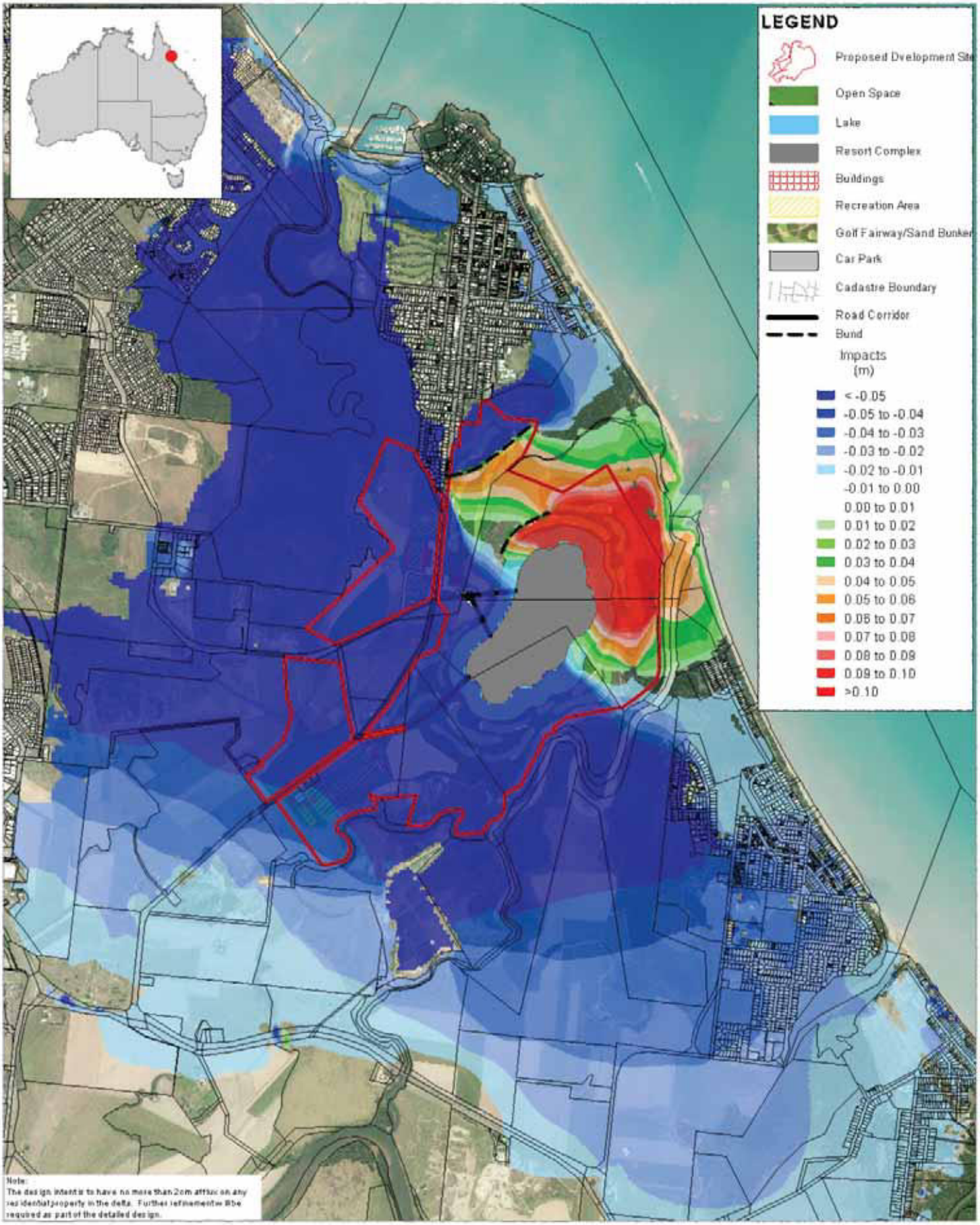
metres

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B20270.I.nc_Yorkeys Knob Development\DRG\FLD\ESG_006_130914_ex_5y_vel.wor

Appendix B Developed Case Detailed Flood Model Results



Title:

Aquis Great Barrier Reef Resort
ARI 100 Year Impacts - Developed Site

Figure: **B-1**

Rev: **A**

N

0 400 800m
Approx Scale

BMT WBM
www.bmtwbm.com.au

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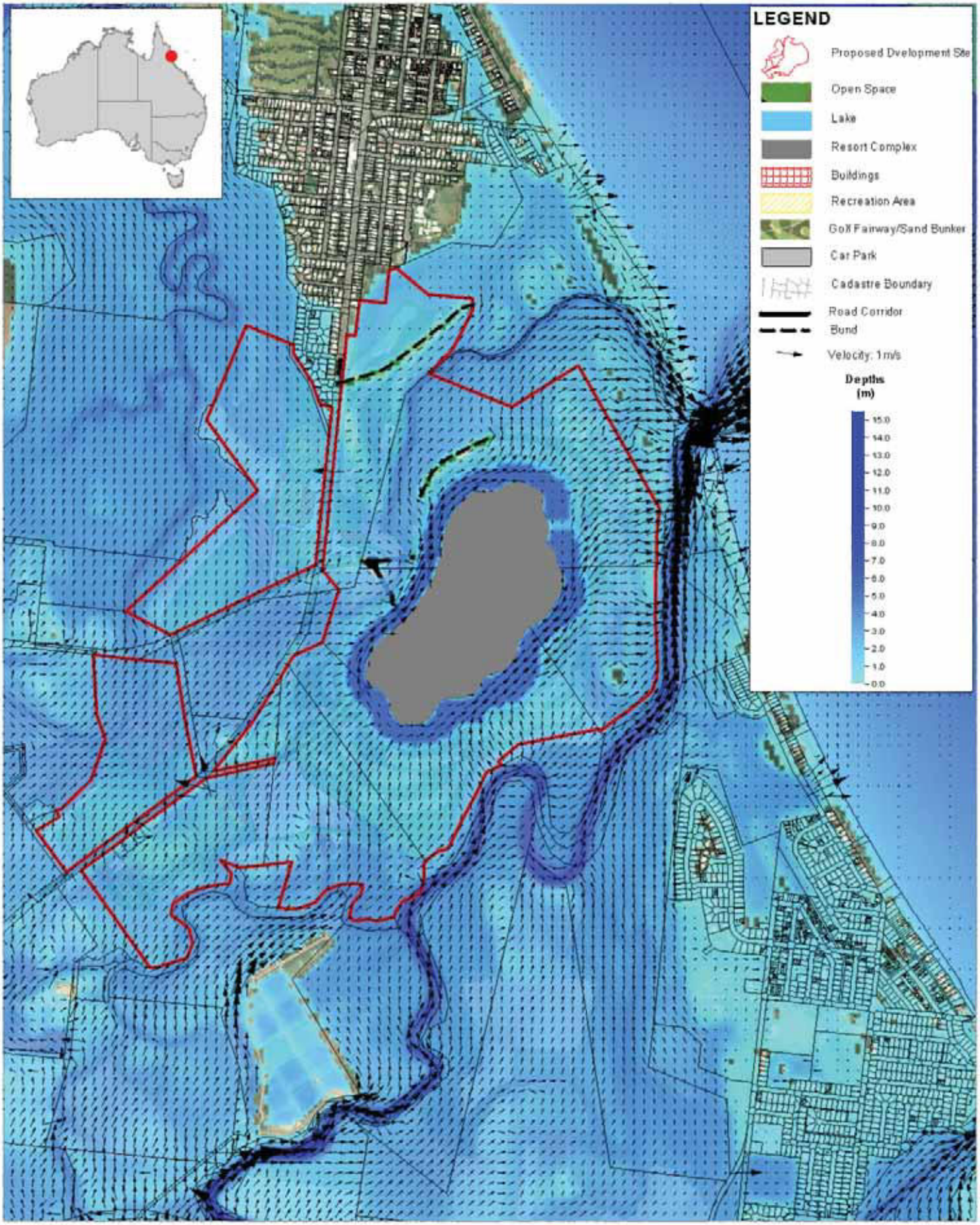

Title:

Aquis Great Barrier Reef Resort
ARI 100 Year Depths - Developed Site

Figure: **B-2**

Rev: **A**

N

0 400 800m

Approx.Scale

BMT WBM
www.bmtwbm.com.au

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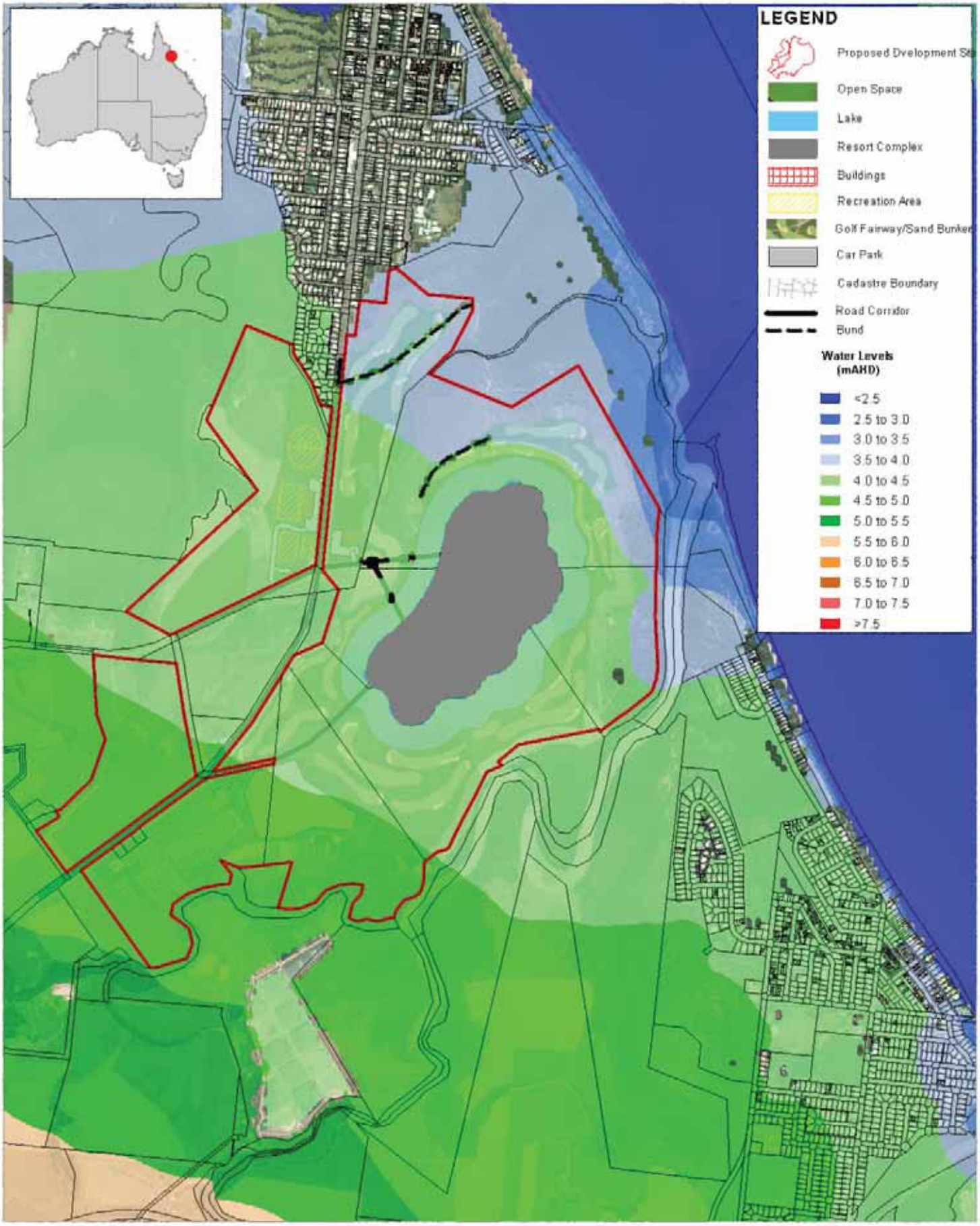

Title:

Aquis Great Barrier Reef Resort
ARI 100 Year Water Levels - Developed Site

Figure: **B-3**

Rev: **A**

N

0 400 800m

Approx.Scale

BMT WBM

www.bmtwbm.com.au

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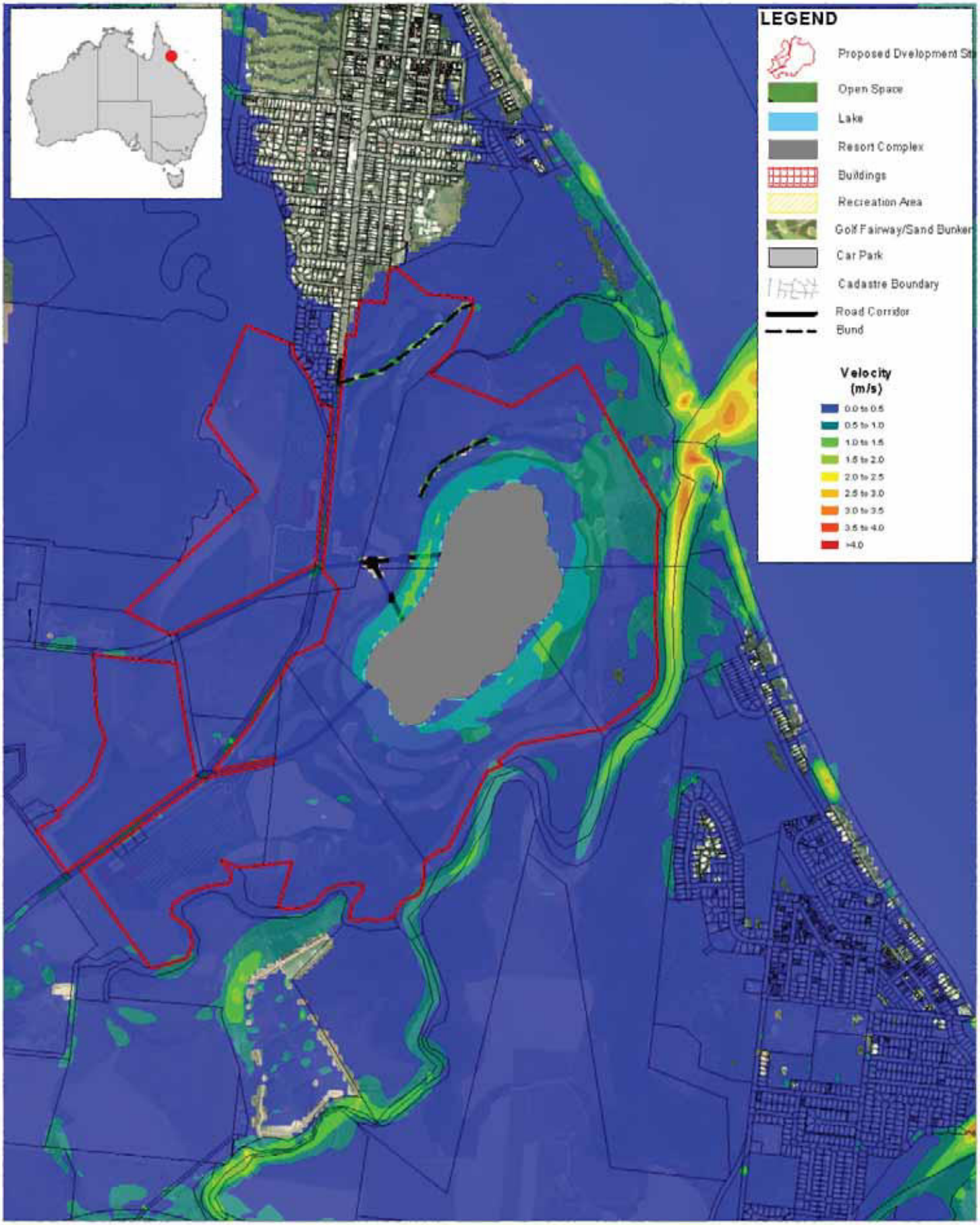

Title:

Aquis Great Barrier Reef Resort
ARI 100 Year Velocities - Developed Site

Figure: **B-4**

Rev: **A**

N

0 400 800m

Approx.Scale

BMT WBM

www.bmtwbm.com.au

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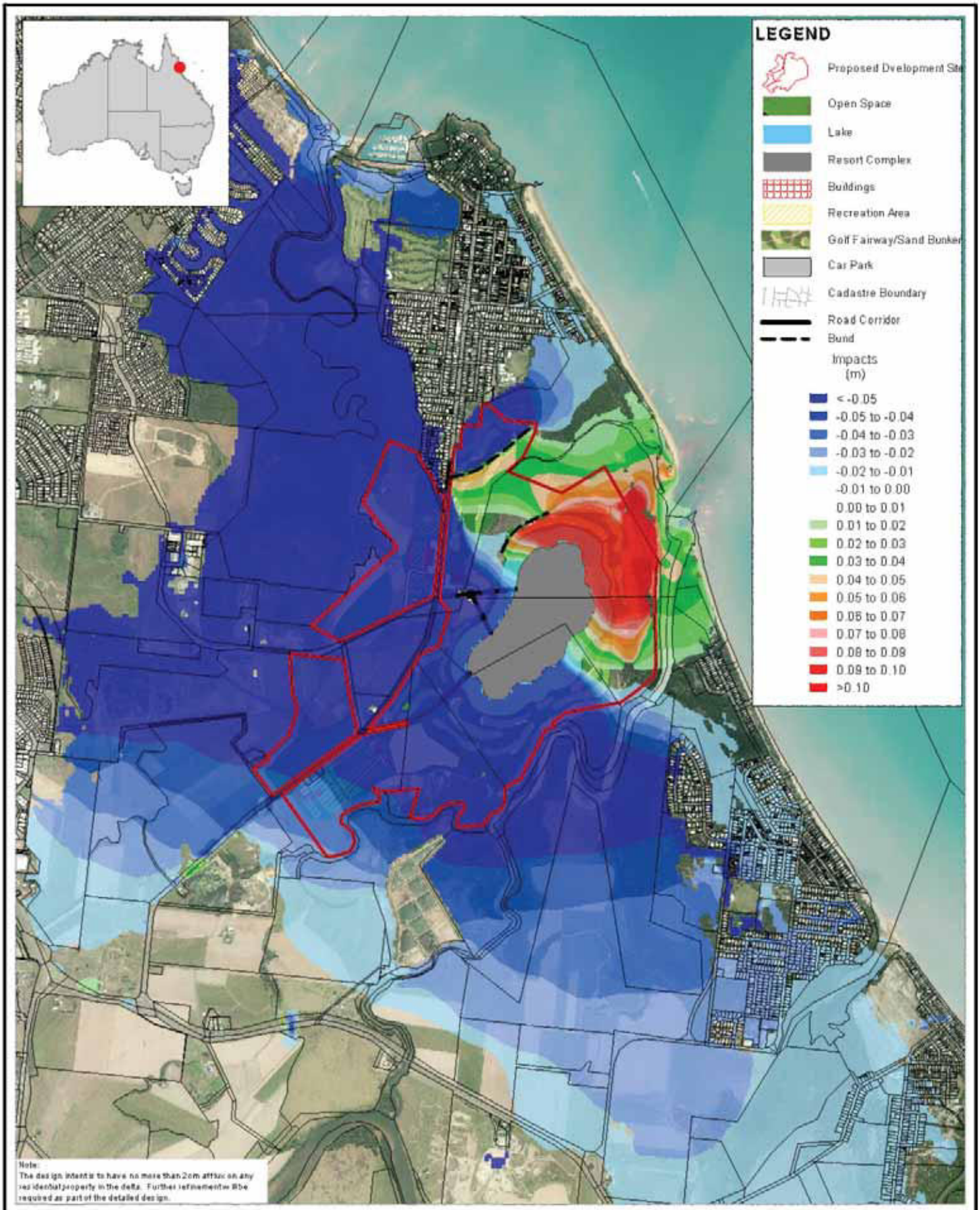


Title:

Aquis Great Barrier Reef Resort
ARI 50 Year Impacts - Developed Site

Figure: **B-5**

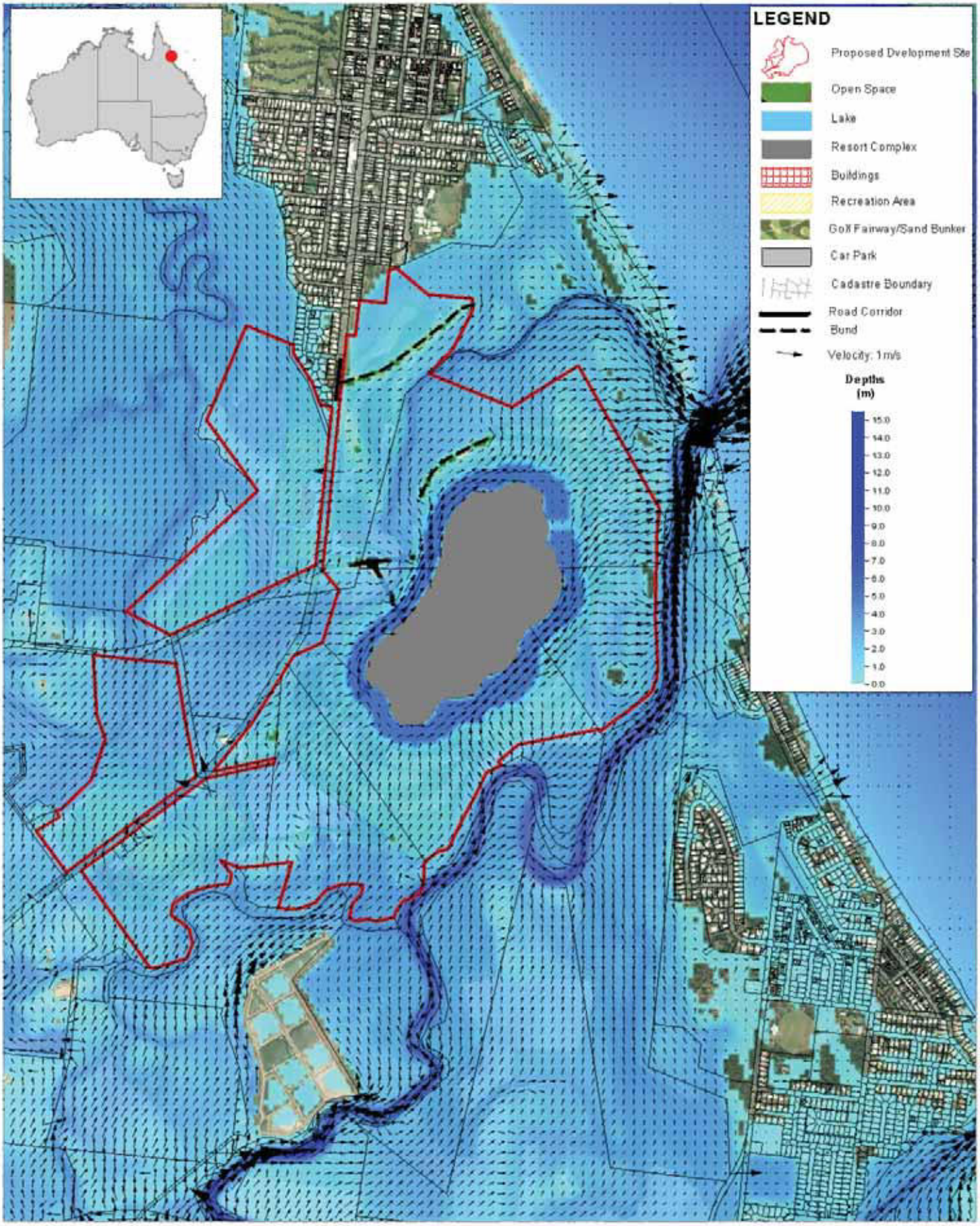
Rev: **A**

N

0 400 800m
Approx Scale

BMT WBM
www.bmtwbm.com.au

Filepath: I:\B20270.Inc_Yorkeys Knob Development\DRG\FLD\EIS_update\weir_002\ESG_001_140328_Weir_002_50y_impacts_R2.wor



Title:

Aquis Great Barrier Reef Resort
ARI 50 Year Depths - Developed Site

Figure: **B-6**

Rev: **A**

N

0 400 800m

Approx.Scale

BMT WBM

www.bmtwbm.com.au

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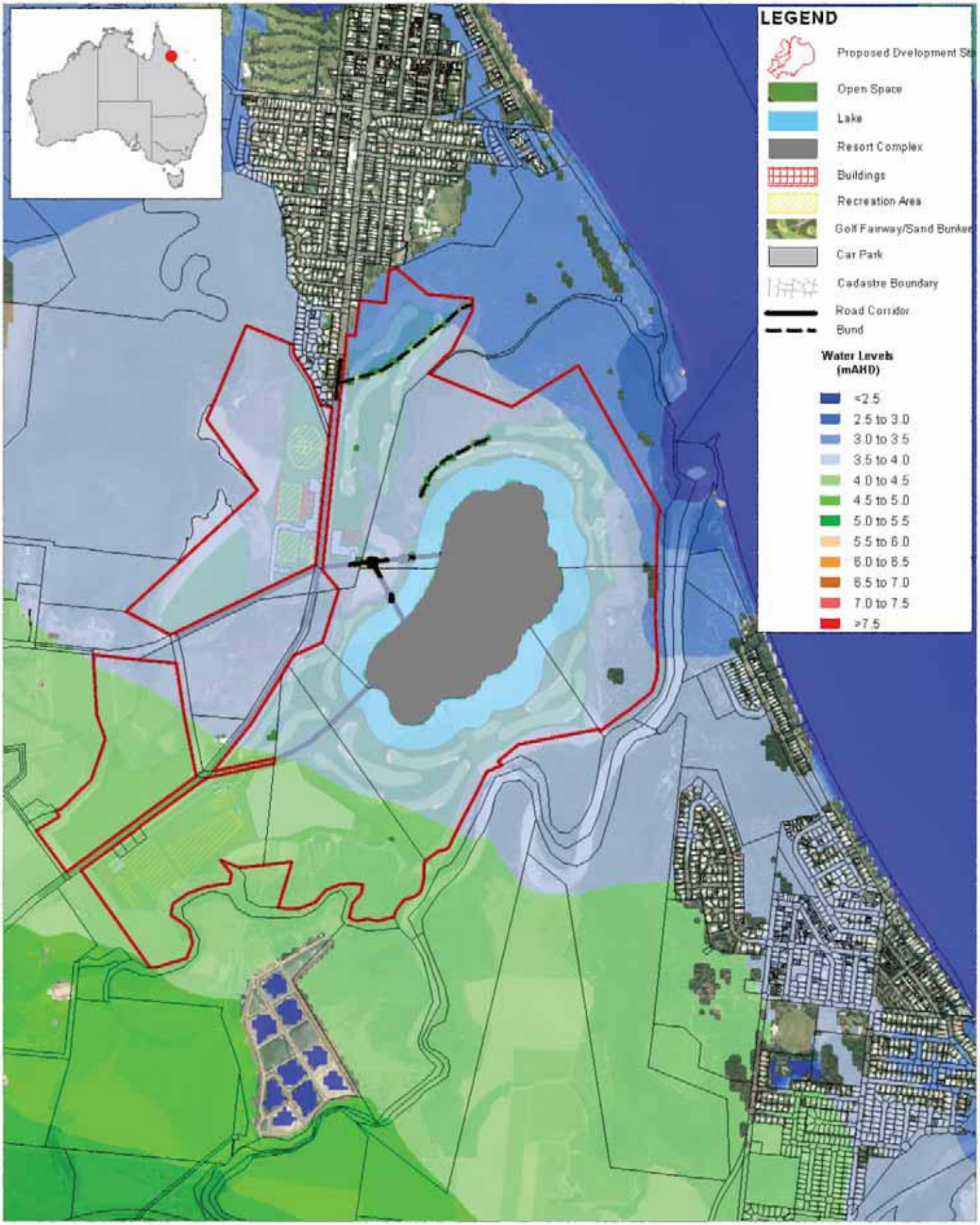

Title:

Aquis Great Barrier Reef Resort
ARI 50 Year Water Levels - Developed Site

Figure: **B-7**

Rev: **A**

N

0 400 800m

Approx.Scale

BMT WBM

www.bmtwbm.com.au

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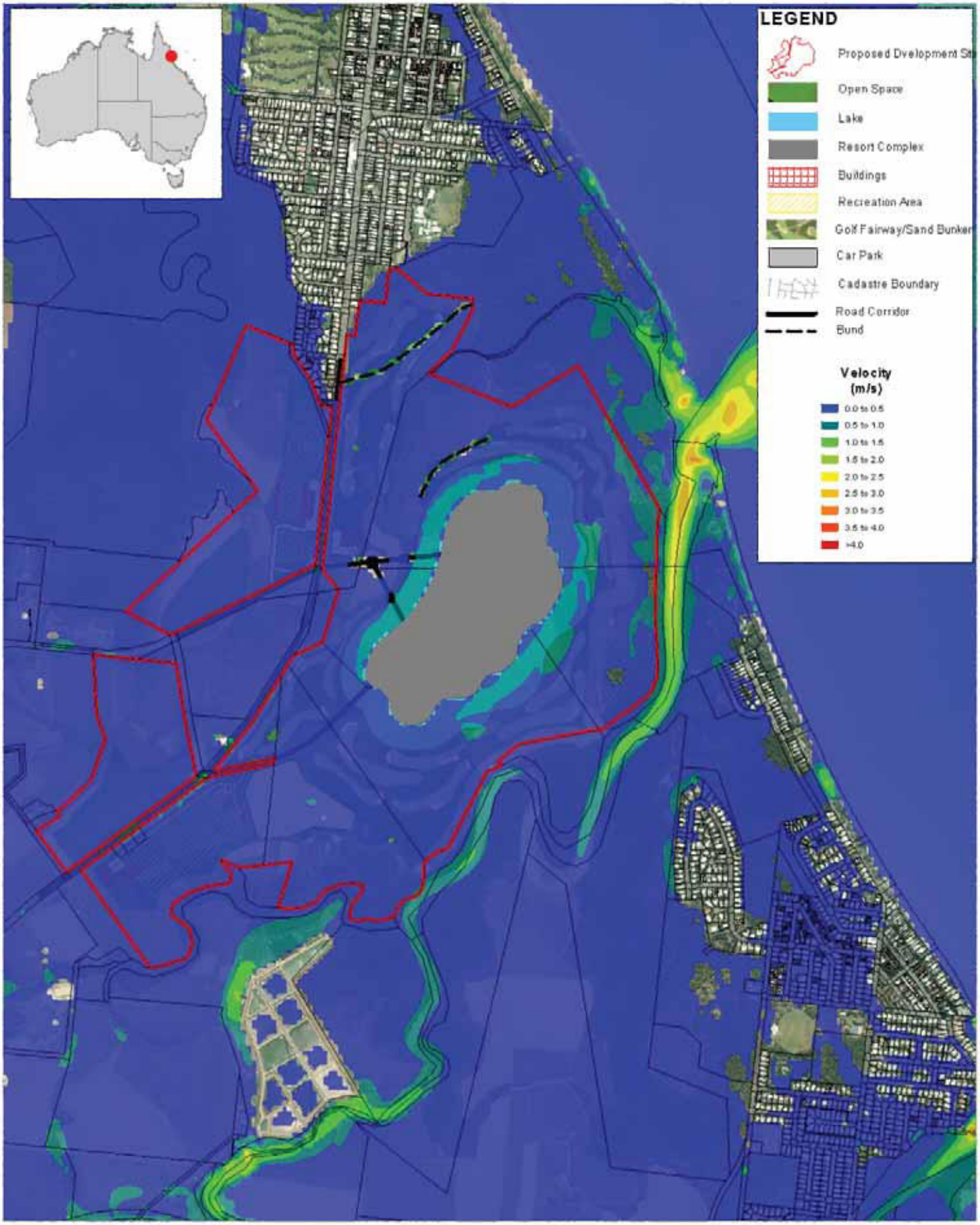

Title:

Aquis Great Barrier Reef Resort
ARI 50 Year Velocities - Developed Site

Figure: **B-8**

Rev: **A**

N

0 400 800m

Approx.Scale

BMT WBM

www.bmtwbm.com.au

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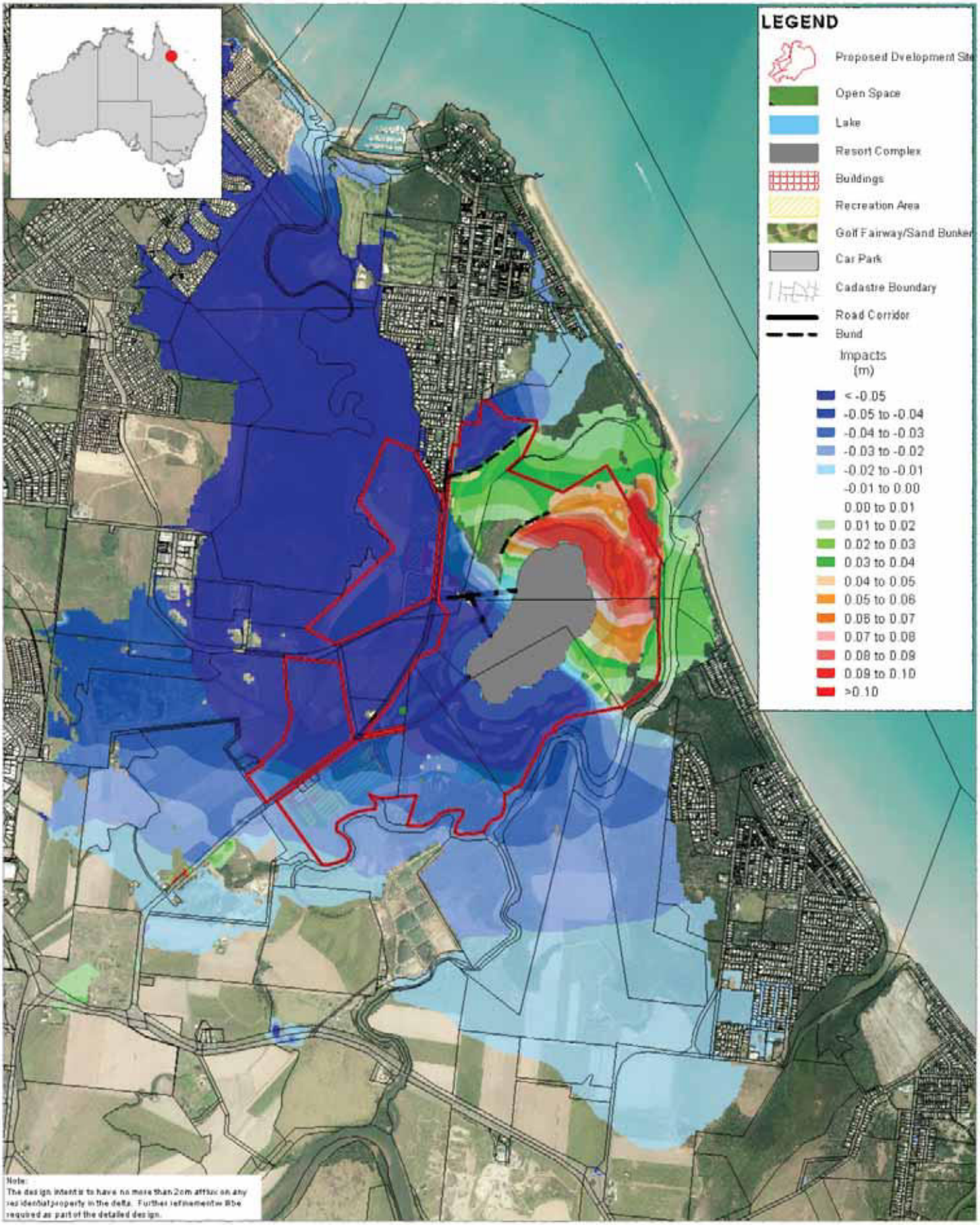


Title:

Aquis Great Barrier Reef Resort
ARI 20 Year Impacts - Developed Site

Figure: **B-9**

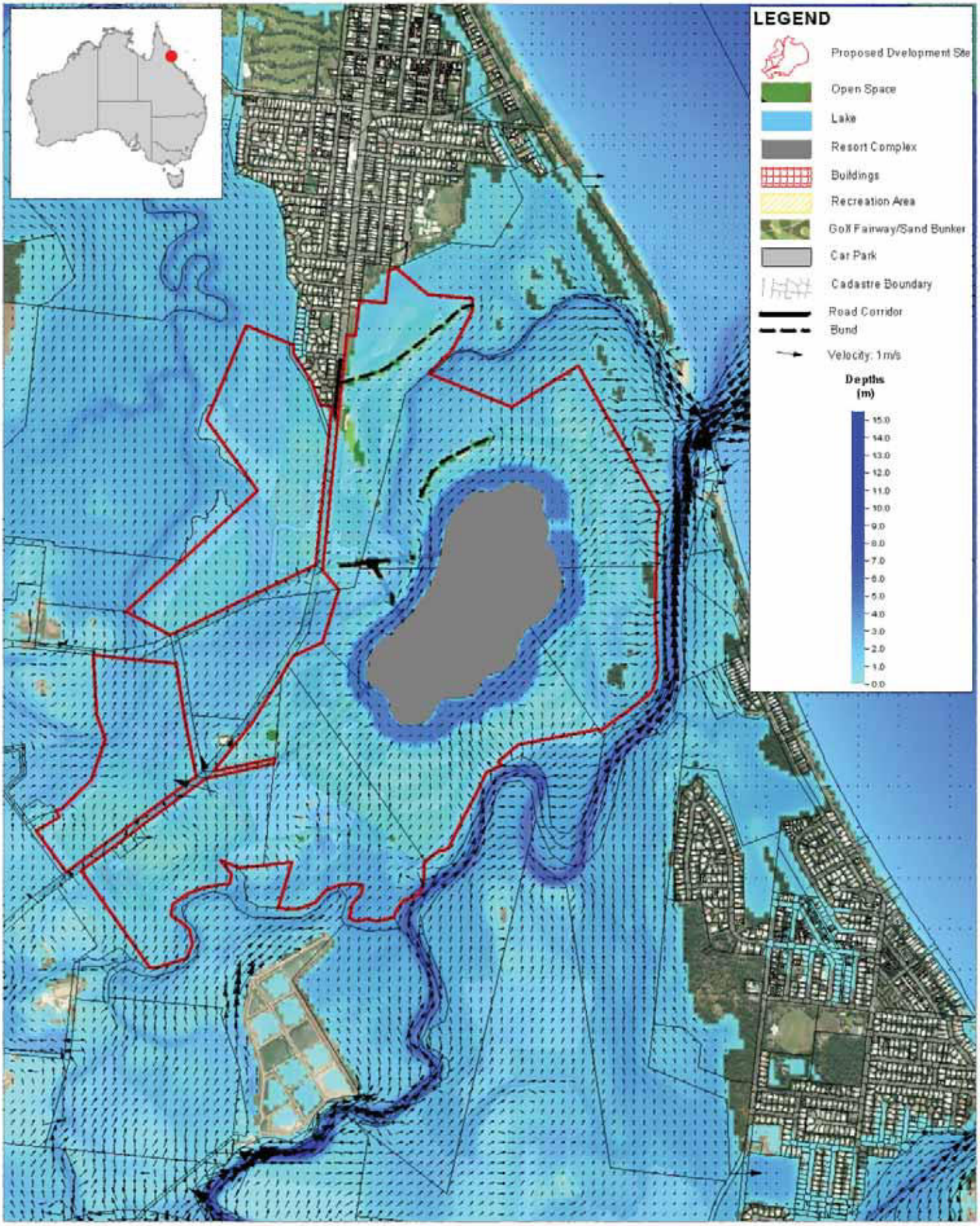
Rev: **A**

N

0 400 800m
Approx Scale

BMT WBM
www.bmtwbm.com.au

Filepath: I:\B20270.Inc_Yorkeys Knob Development\DRG\FLD\EIS_update\weir_002\ESG_001_140328_Weir_002_20y_impacts_R2.wor



Title:

Aquis Great Barrier Reef Resort
ARI 20 Year Depths - Developed Site

Figure: **B-10**

Rev: **A**

N

0 400 800m

Approx.Scale

BMT WBM
www.bmtwbm.com.au

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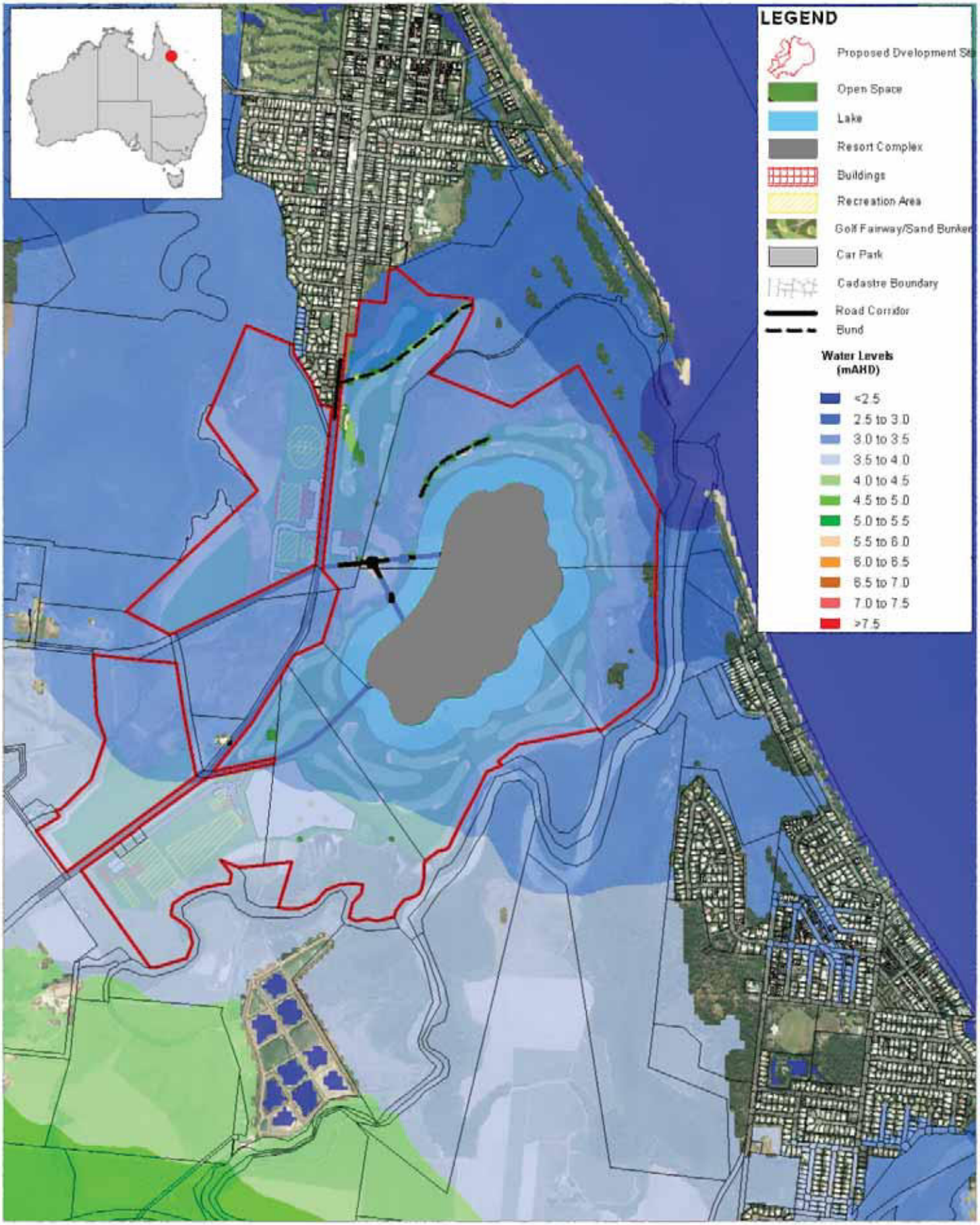

Title:

Aquis Great Barrier Reef Resort
ARI 20 Year Water Levels - Developed Site

Figure: **B-11**

Rev: **A**

N

0 400 800m

Approx.Scale

BMT WBM

www.bmtwbm.com.au

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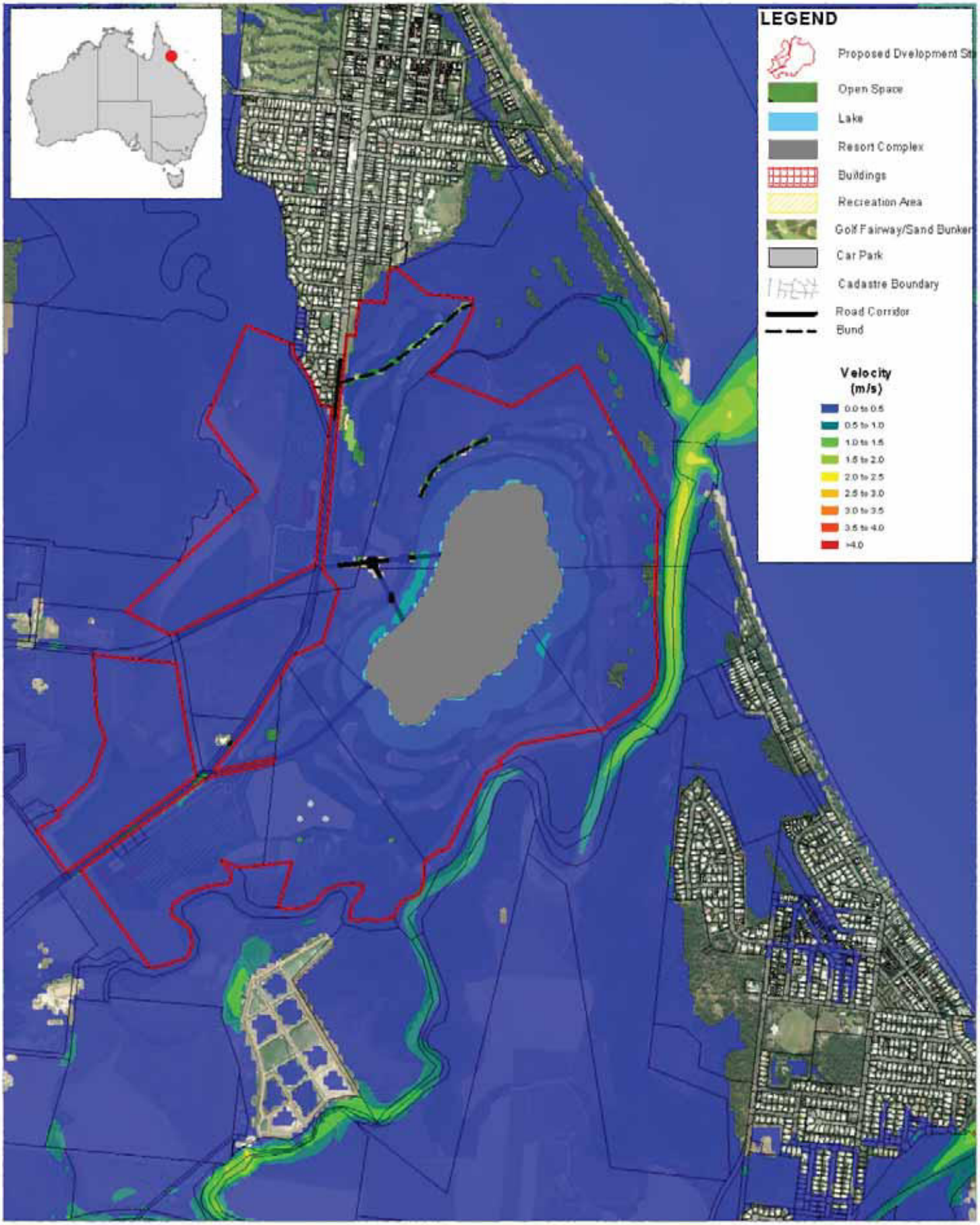

Title:

Aquis Great Barrier Reef Resort
ARI 20 Year Velocities - Developed Site

Figure: **B-12**

Rev: **A**

N

0 400 800m

Approx.Scale

BMT WBM

www.bmtwbm.com.au

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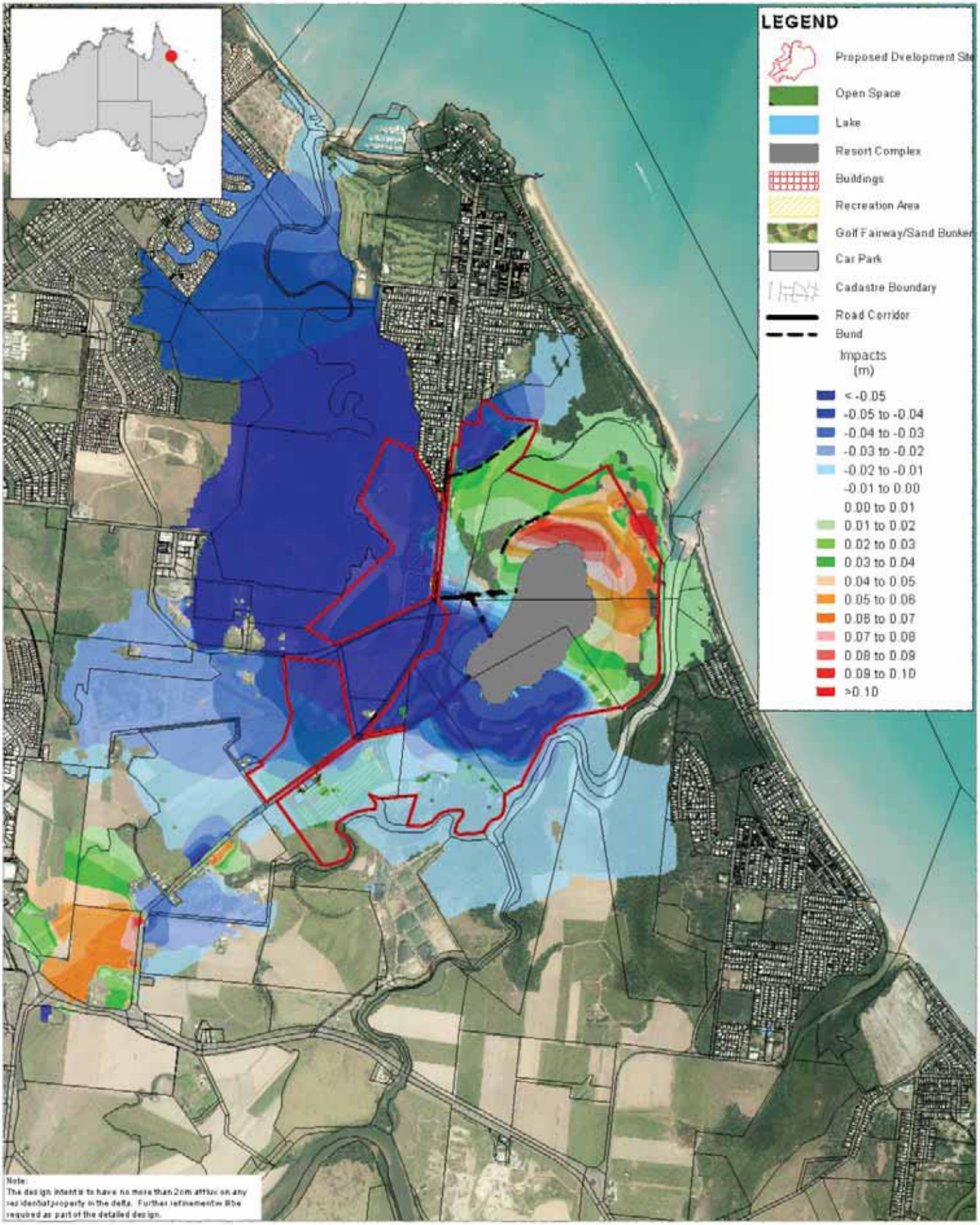


Title:

Aquis Great Barrier Reef Resort
ARI 10 Year Impacts - Developed Site

Figure: **B-13**

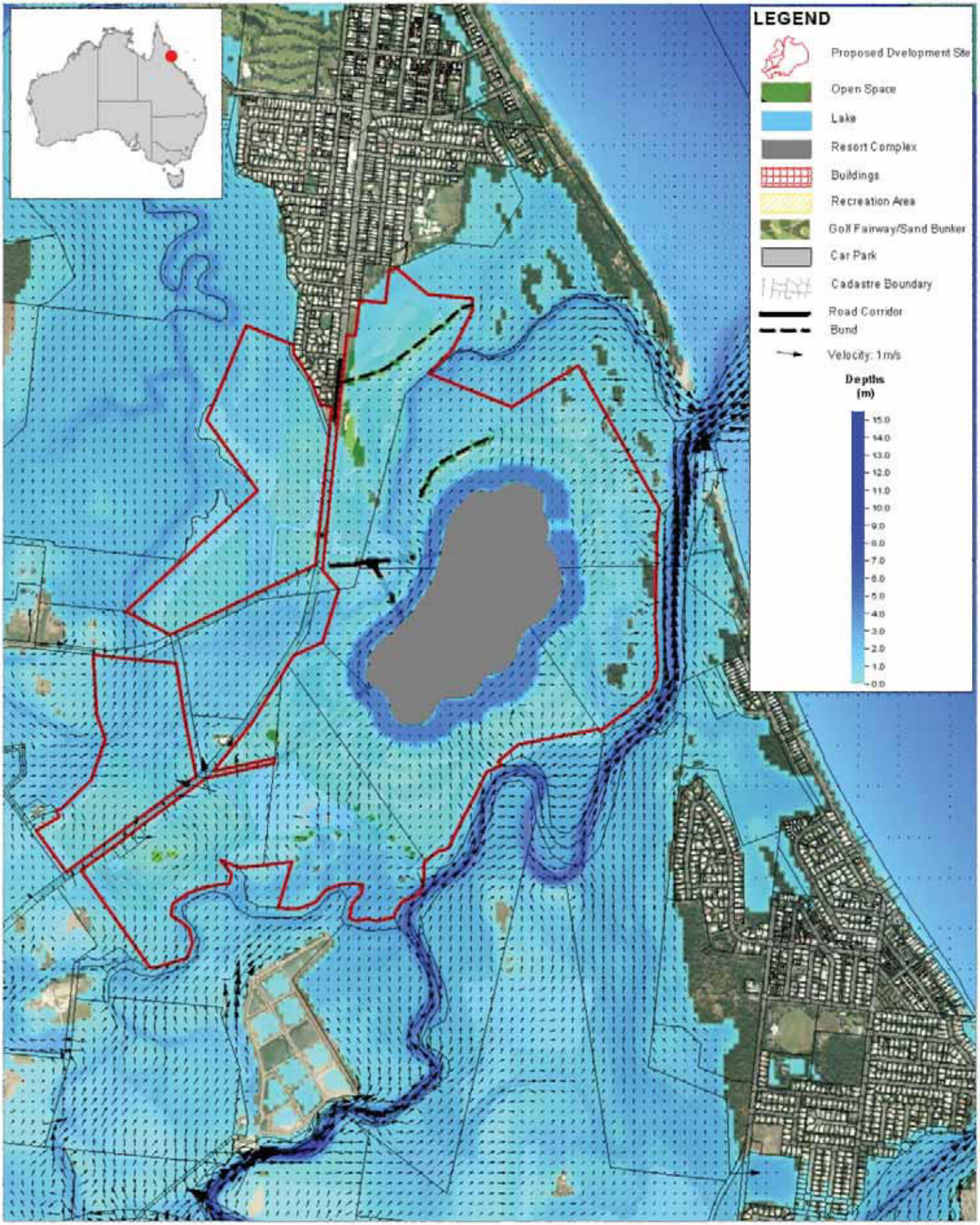
Rev: **A**

N

0 400 800m
Approx Scale

BMT WBM
www.bmtwbm.com.au

Filepath: I:\B20270.Inc_Yorkeys Knob Development\DRG\FLD\EIS_update\weir_002\ESG_001_140328_Weir_002_10y_impacts_R2.wor



Title:

Aquis Great Barrier Reef Resort
ARI 10 Year Depths - Developed Site

Figure: **B-14**

Rev: **A**

N

0 400 800m

Approx.Scale

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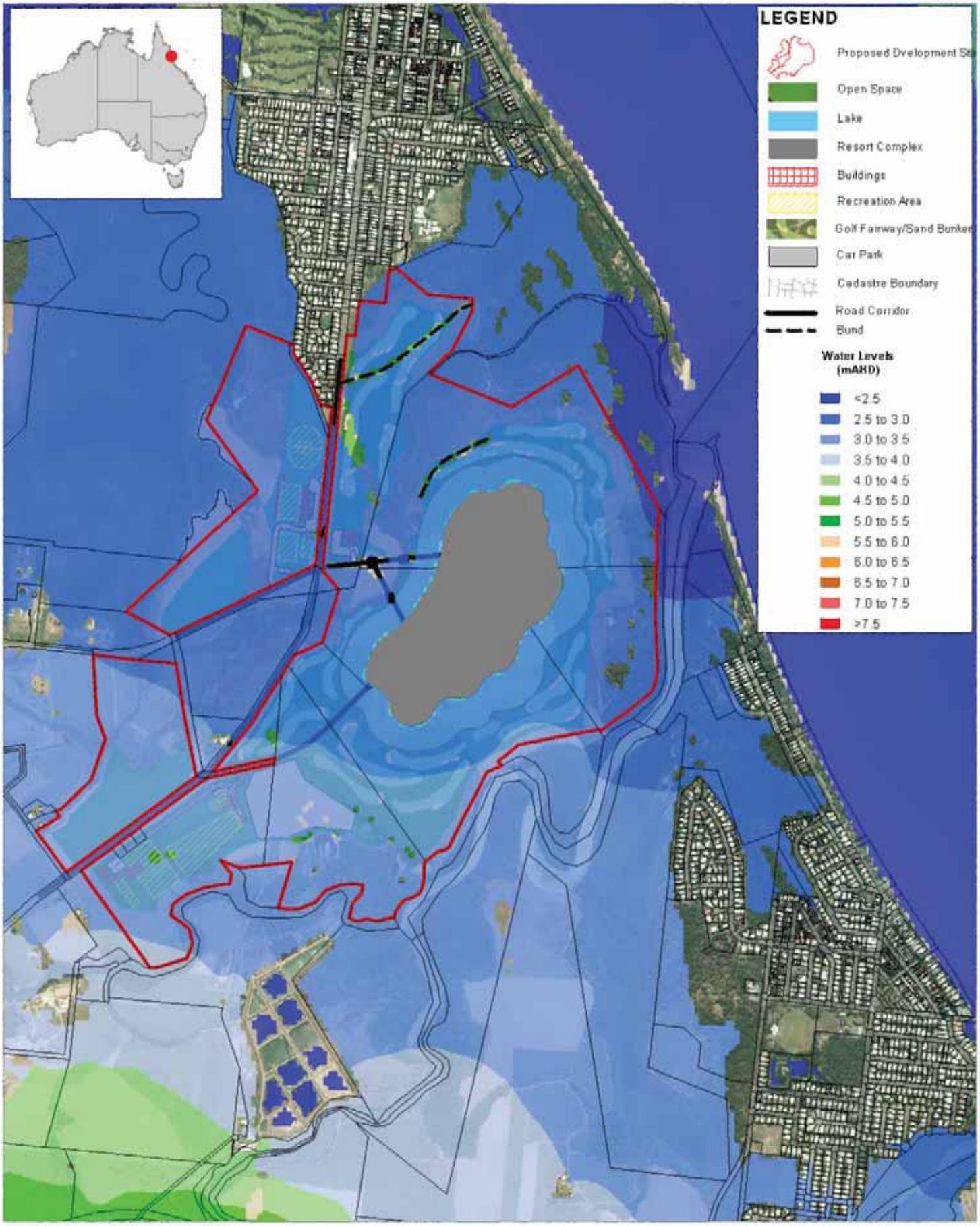

Title:

Aquis Great Barrier Reef Resort
ARI 10 Year Water Levels - Developed Site

Figure: **B-15**

Rev: **A**

N

0 400 800m

Approx.Scale

BMT WBM

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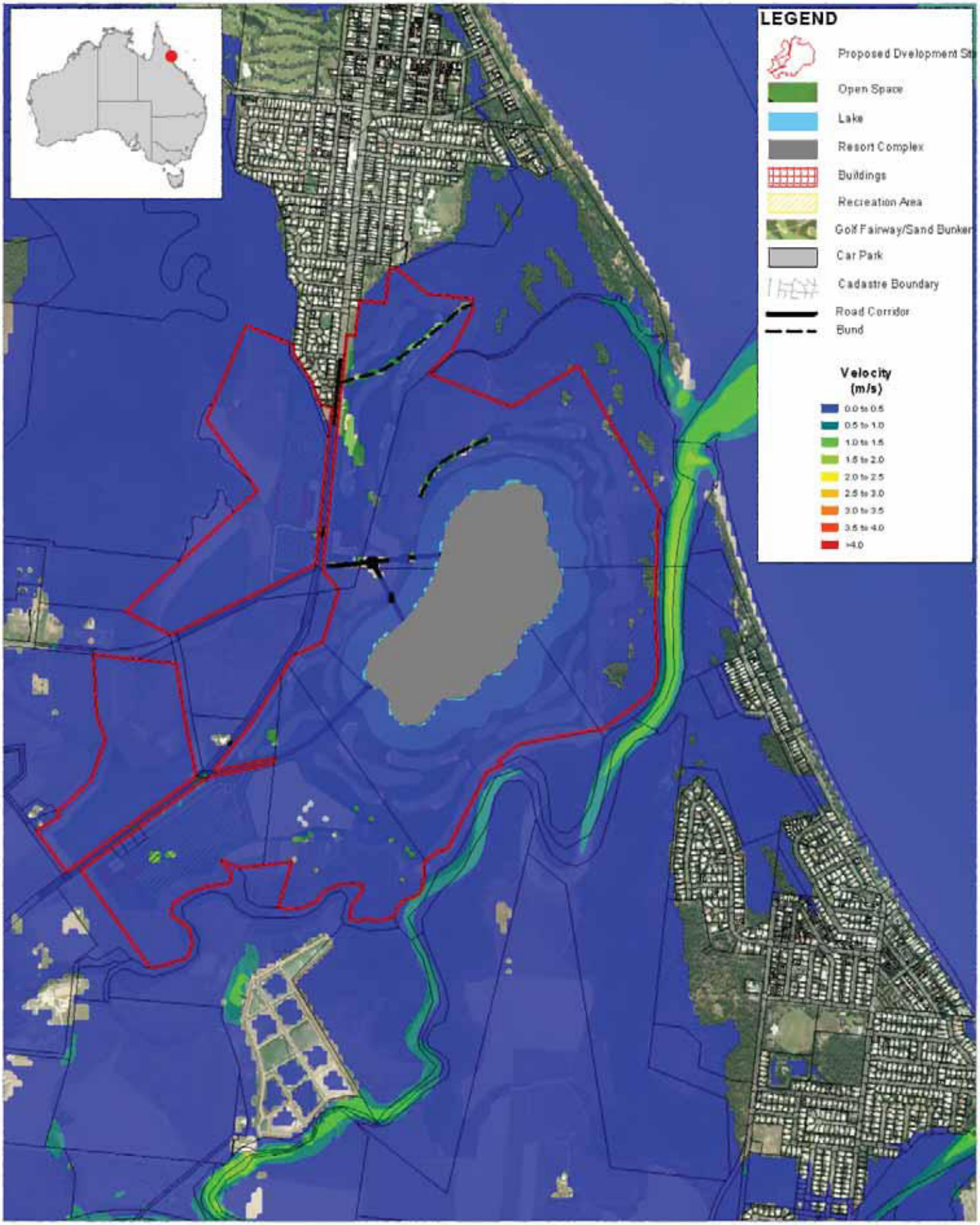
Filepath: I:\B20270.Inc_Yorkeys Knob Development\DRG\FLD\EIS_update\weir_002\ESG_001_140324_Weir_002_10y_WSL.wor



Title:

Aquis Great Barrier Reef Resort
ARI 10 Year Velocities - Developed Site

Figure: **B-16**

Rev: **A**

N

0 400 800m

Approx.Scale

BMT WBM
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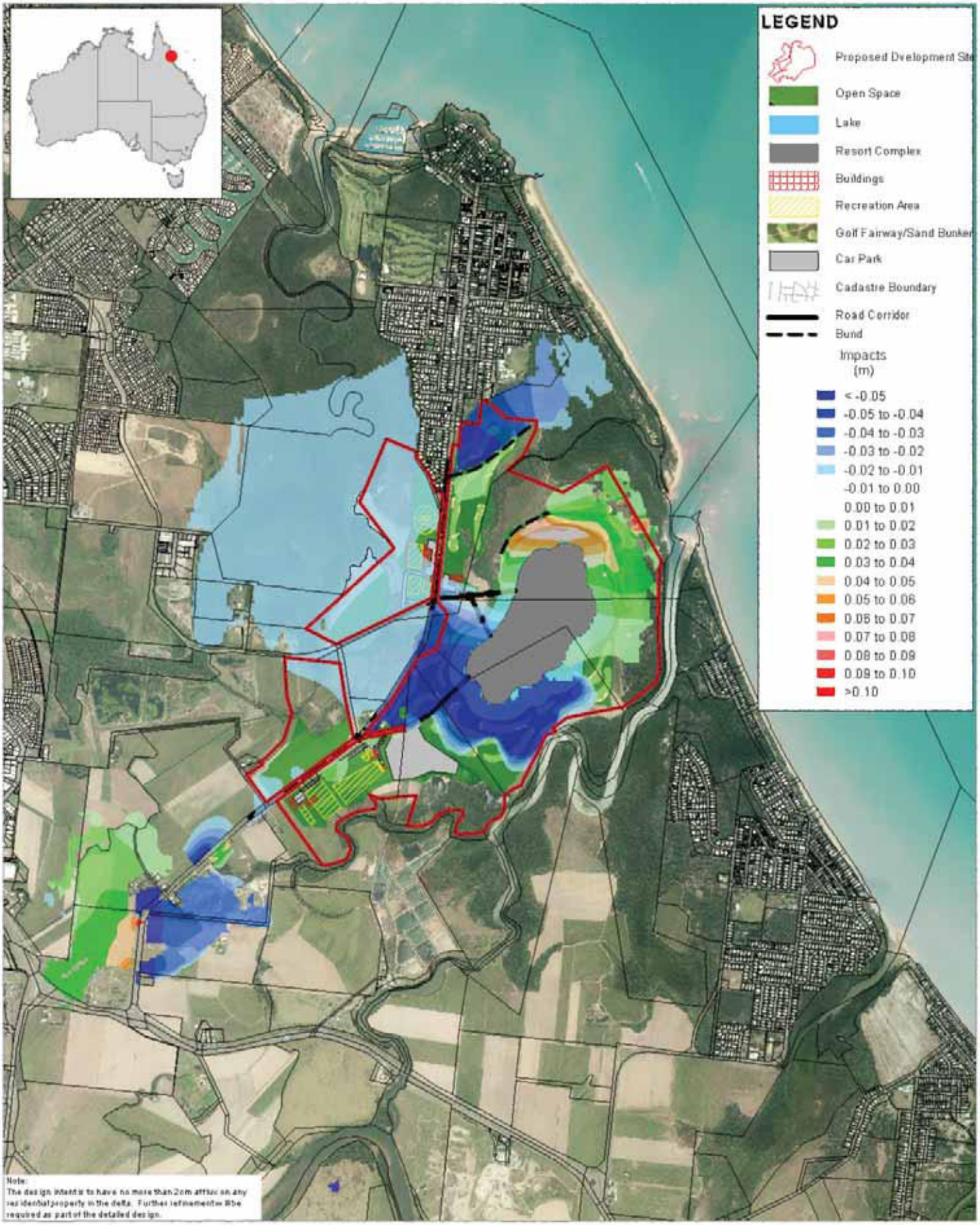

Title:

Aquis Great Barrier Reef Resort
ARI 5 Year Impacts - Developed Site

Figure: **B-17**

Rev: **A**

N

0 400 800m
Approx Scale

BMT WBM
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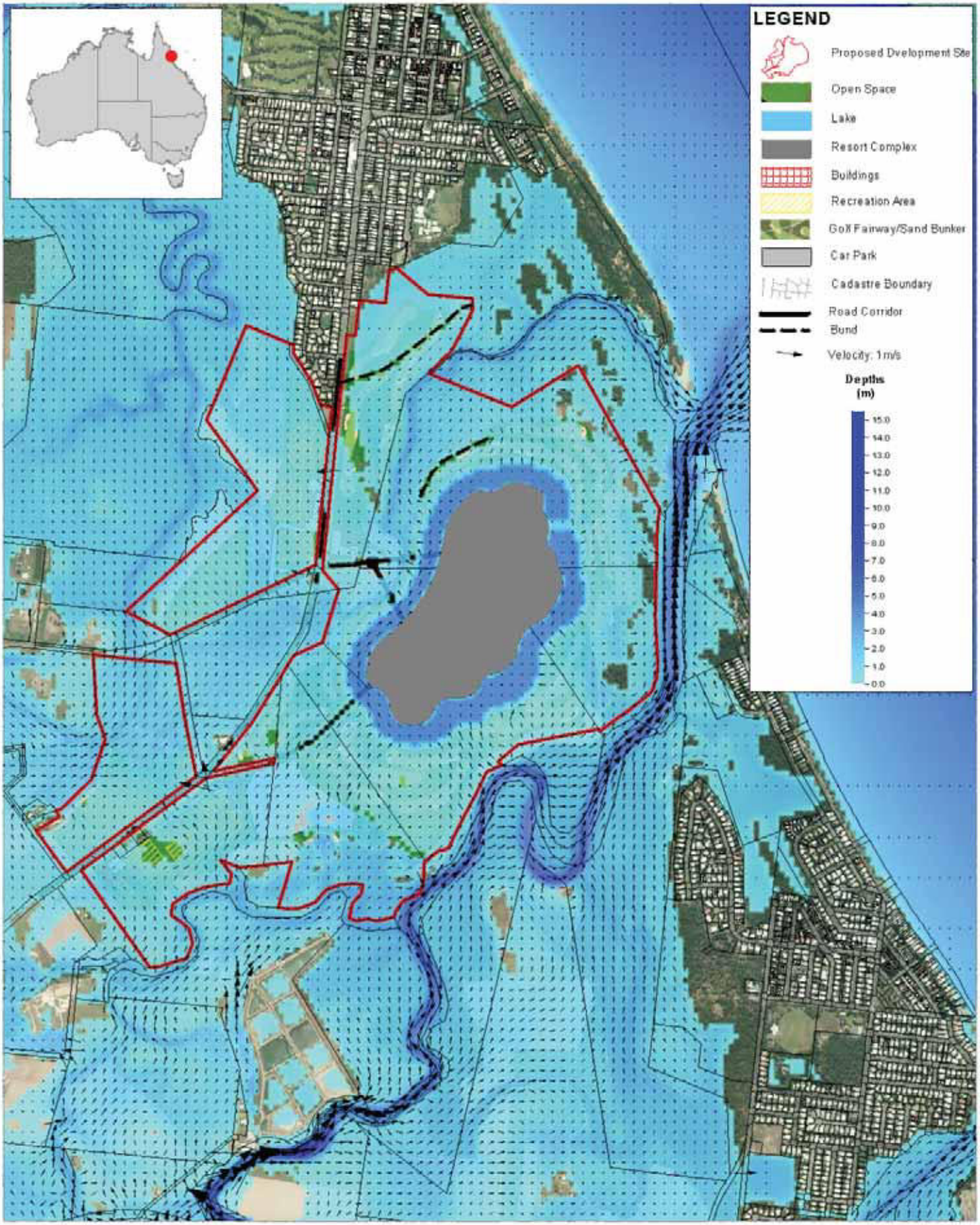
Filepath: I:\B20270.Inc_Yorkeys Knob Development\DRG\FLD\EIS_update\weir_002\ESG_001_140328_Weir_002_5y_impacts_R2.wor



Title:

Aquis Great Barrier Reef Resort
ARI 5 Year Depths - Developed Site

Figure: **B-18**

Rev: **A**

N

0 400 800m

Approx.Scale

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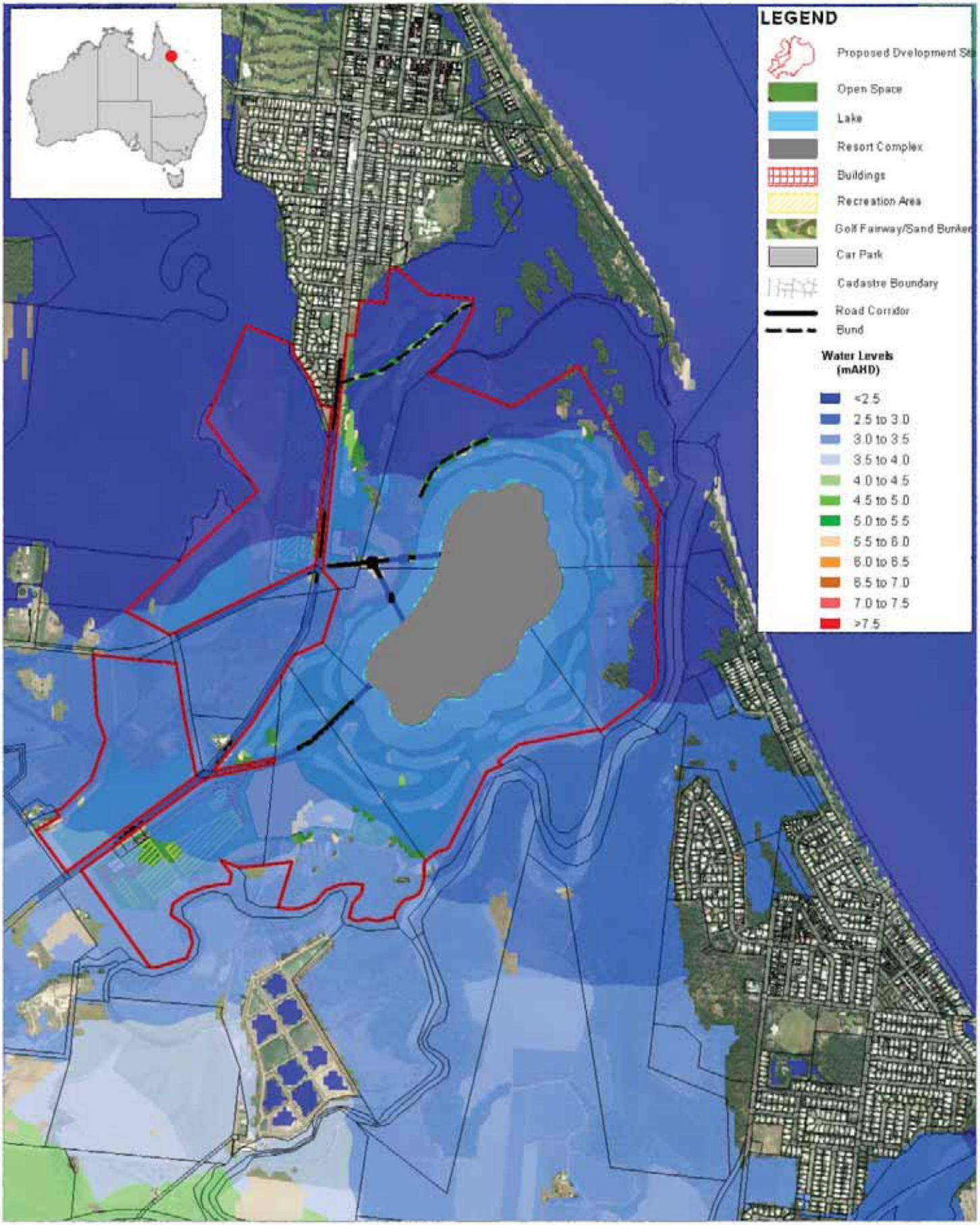
Filepath: I:\B20270.Inc_Yorkeys Knob Development\DRG\FLD\EIS_update\weir_002\ESG_002_140328_Weir_002_5y_Depths.wor



Title:

Aquis Great Barrier Reef Resort
ARI 5 Year Water Levels - Developed Site

Figure: **B-19**

Rev: **A**

N

0 400 800m

Approx.Scale

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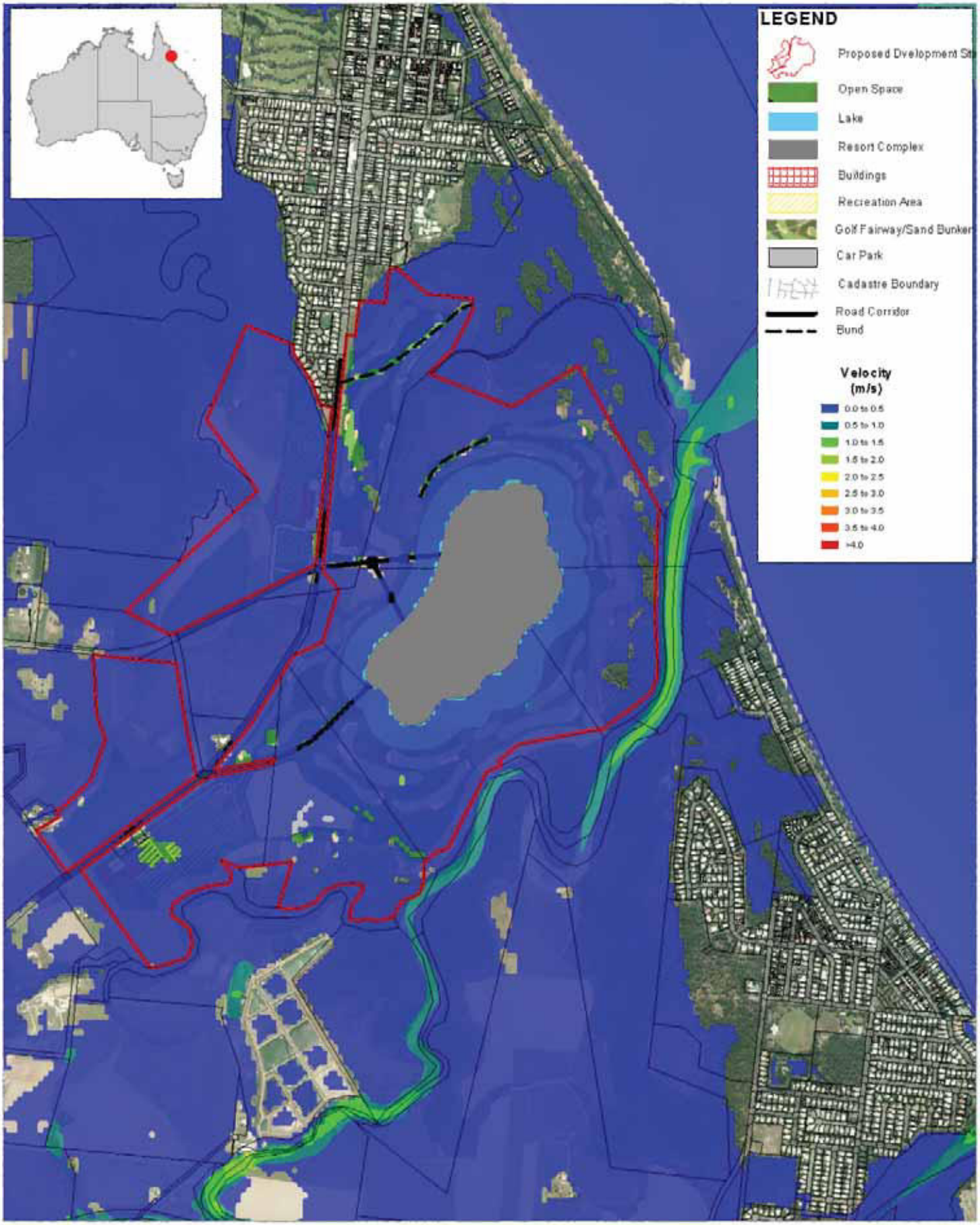
Filepath: I:\B20270.Inc_Yorkeys Knob Development\DRG\FLD\EIS_update\weir_002\ESG_001_140324_Weir_002_5y_WSL.wor



Title:

Aquis Great Barrier Reef Resort
ARI 5 Year Velocities - Developed Site

Figure: **B-20**

Rev: **A**

N

0 400 800m

Approx.Scale

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