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	Flood Advice Memo-Rev1e		
Classification:	Confidential		

North Byron Beach Resort Development - Flood Assessment – Initial Flood Modelling

Dear Sir,

Royal HaskoningDHV (RHDHV) has been commissioned to provide flood advice to support a planning proposal for “infill” of nine (9) E4 zoned lots along Bayshore Drive on the former golf course adjacent to Elements of Byron.

Our understanding is that the North Byron Beach Resort is proposing to Byron Shire Council to lodge a planning proposal to rezone 9 lots to the north of their existing development for the purposes of an E4 Environmental Living (Residential). It is our understanding that each of the lots would contain a single dwelling (possibly with detached garage).

The site is subject to flooding in a range of flood events from the Belongil Catchment, which is heavily influenced by tailwater levels in Belongil creek, including tidal and storm surge influence, and as such, the planning proposal will be supported by an submission by RHDHV as a qualified flood engineer.

This memo provides advice on:

- A review of previous flood studies relating to the study site and Belongil Creek.
- A review of the TUFLOW model made available by BSC that was developed as part of the SMEC (2009) Belongil Creek Flood Study and used in the subsequent Floodplain Risk Management Study and Plan (BMT WBM, 2015).
- Updates to the TUFLOW model including:
 - Improvements to the applied hydrology
 - Improvements to the ground elevation data (DEM)
- An initial assessment of the potential flood impact of raising 9 building pads above the required flood planning level.

1 Review of Previous Flood Studies

A range of literature containing information relevant to flooding at the study site (Belongil Creek) was reviewed. A list of key documents is presented below.

- Belongil Creek Flood Study - PWD (1986)
- North Beach Byron Flooding and Drainage – Maunsell (2005)
- Belongil Creek Flood Study – SMEC (2009)
- Belongil Creek TUFLOW Model Review - BMT WBM (2011)
- Belongil Creek Floodplain Risk Management Study - BMT WBM (2014)
- Belongil Creek Floodplain Risk Management Plan - BMT WBM (2014)
- Belongil Estuary Protection Works Investigations – Numerical Modelling of Entrance Behaviour- Royal HaskoningDHV (2015)

2 Review of Council Flood Study Model

A review of the TUFLOW model provided by BSC for use in the flood assessment found:

- The model extent was limited by the model domain (likely required due to computation limitation when the model was originally developed). This limited model domain is presented in **Figure 1**.
- Because of the limited model extent, the hydrological inflows were incorrectly applied in the subject site which significantly influence flood conditions in the study area. The method used to apply the hydrological inflows does not correctly consider important hydrological processes and significantly over-predicts the likely sub-catchment routing that would occur in the Byron hind-dune system, that flows southward toward the study area. It also meant that hydraulic controls such as the Black Rock Road were ignored. Flows from sub-catchments 1 (area north of Black Rock Road) and 2 (area between Black Rock Road and sub-catchment 3 divider (refer **Figure 1**)) were originally introduced in the small area defined at location 2 in **Figure 1**. This previous error resulted in three times the expected flow being introduced to the site in the 100 year ARI. This error has now been corrected.
- Model elevation data was based on limited photogrammetry and 2m contour data and was not based on LiDAR data (LiDAR was only flown in 2010 so not available when the model was originally developed). The DEM used in the SMEC (2009) Flood Study model is presented in **Figure 2**, while the DEM used in the current flood assessment is presented in **Figure 3**.
- The model used a combined 100yr ARI tidal and fluvial event to simulate the 100yr ARI flood event. The peak tidal water level in the 100yr ARI model was 2.413 m AHD, which is higher than the 2.29 m AHD which is presented in BMT WBM (2011) as the current 100yr ARI tidal water level.



Figure 1: SMEC (2009) Flood Study Model Setup and Catchments

- Notes:
- Red Line – Catchment Boundary
 - Green Lines – Sub-catchment inflow areas
 - Black Line – Model domain boundary / extent

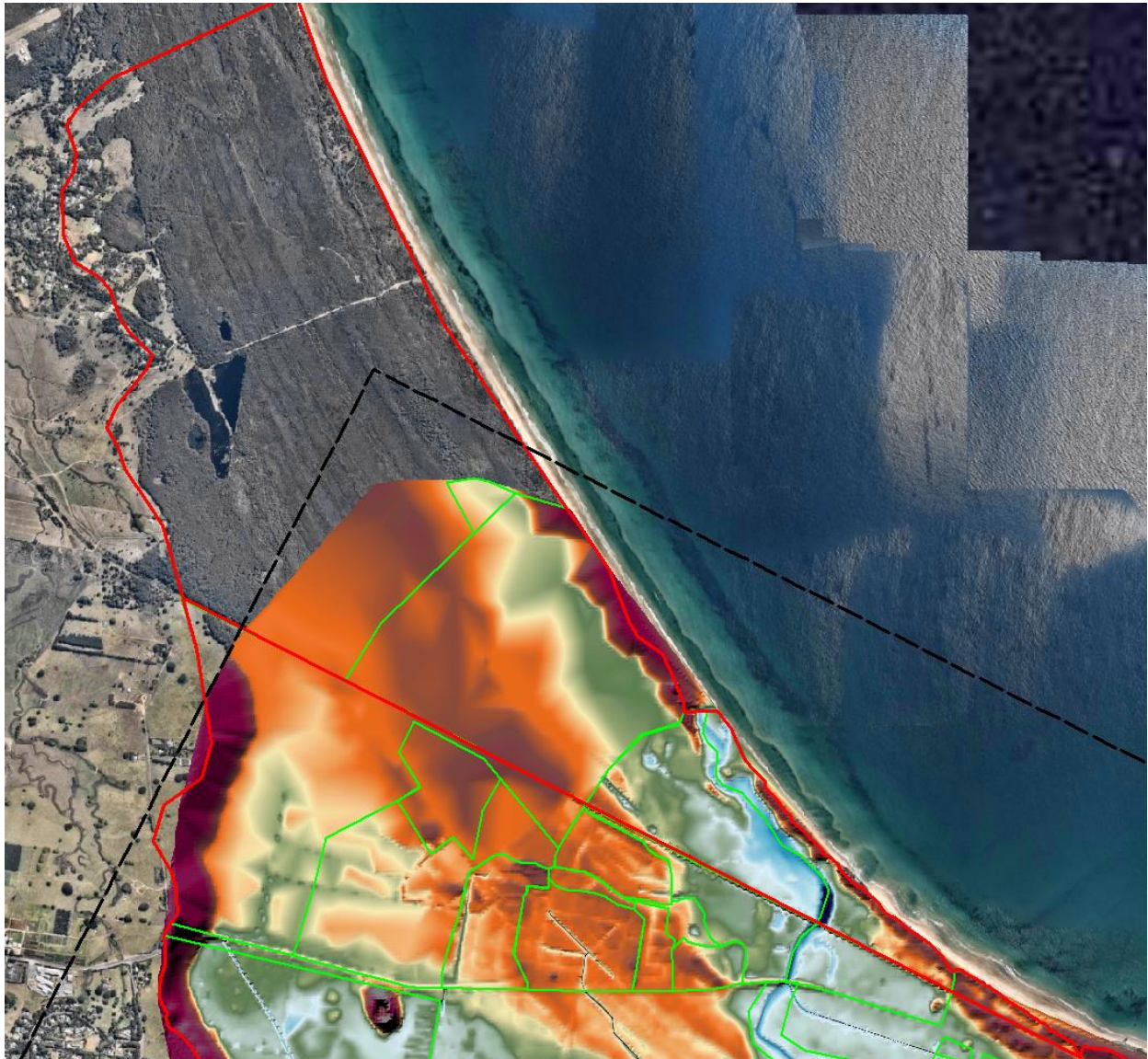


Figure 2: SMEC (2009) Flood Study Model Elevation data

3 Updates to Flood Model

Updates and improvements to the TUFLOW flood are outlined below.

3.1 Model Elevation Data

A number of sources of bathymetry/elevation data were used to create the final model including:

- Detailed ground model based on survey of the study site from Bennett & Bennett surveyors (September 2019);
- Floodplain and ground levels based on 2010 LPI LiDAR data;
- Nearshore and downstream channel bathymetry based on August 2015 survey (Bennett & Bennett);
- Belongil Creek channel and upstream bathymetry based on NSW Govt. (DPWS/OEH) survey from July 1994;

The resultant DEM used in the current flood assessment is presented in **Figure 3**.

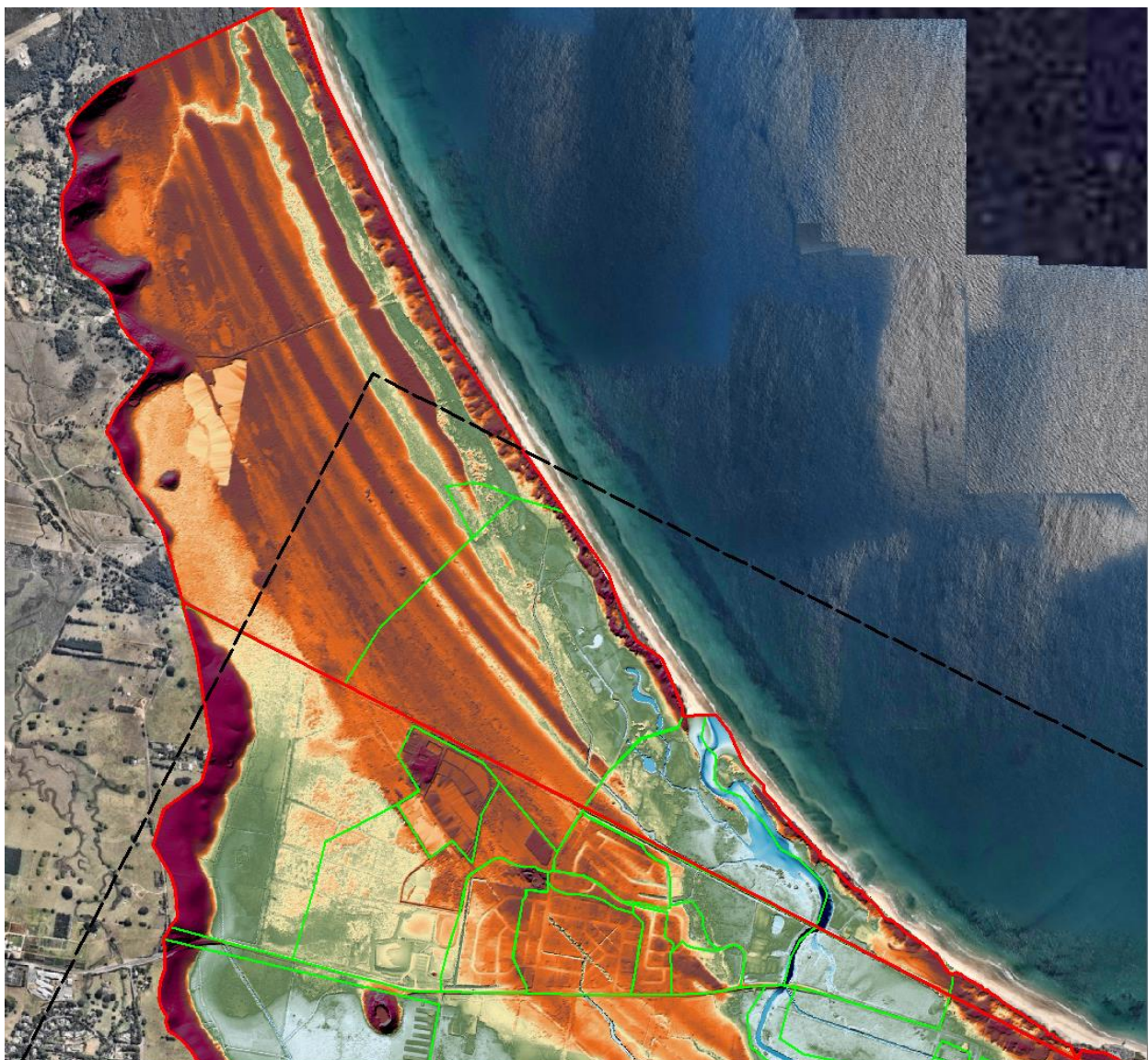


Figure 3: Updated Flood Assessment Model Elevation data

3.2 Model Structures

A number of drains and culverts specific to the study site were added to the model. Culvert inverts and sizes were based on information from BMT WBM (2013) as presented in **Figure 4** as well as data provided in the Bennett & Bennett survey files. The figure also shows the location of a number of drainage lines that were appropriately defined using z-shape model elements which ensure a continuous flow path and provide better resolution than the available LiDAR data.

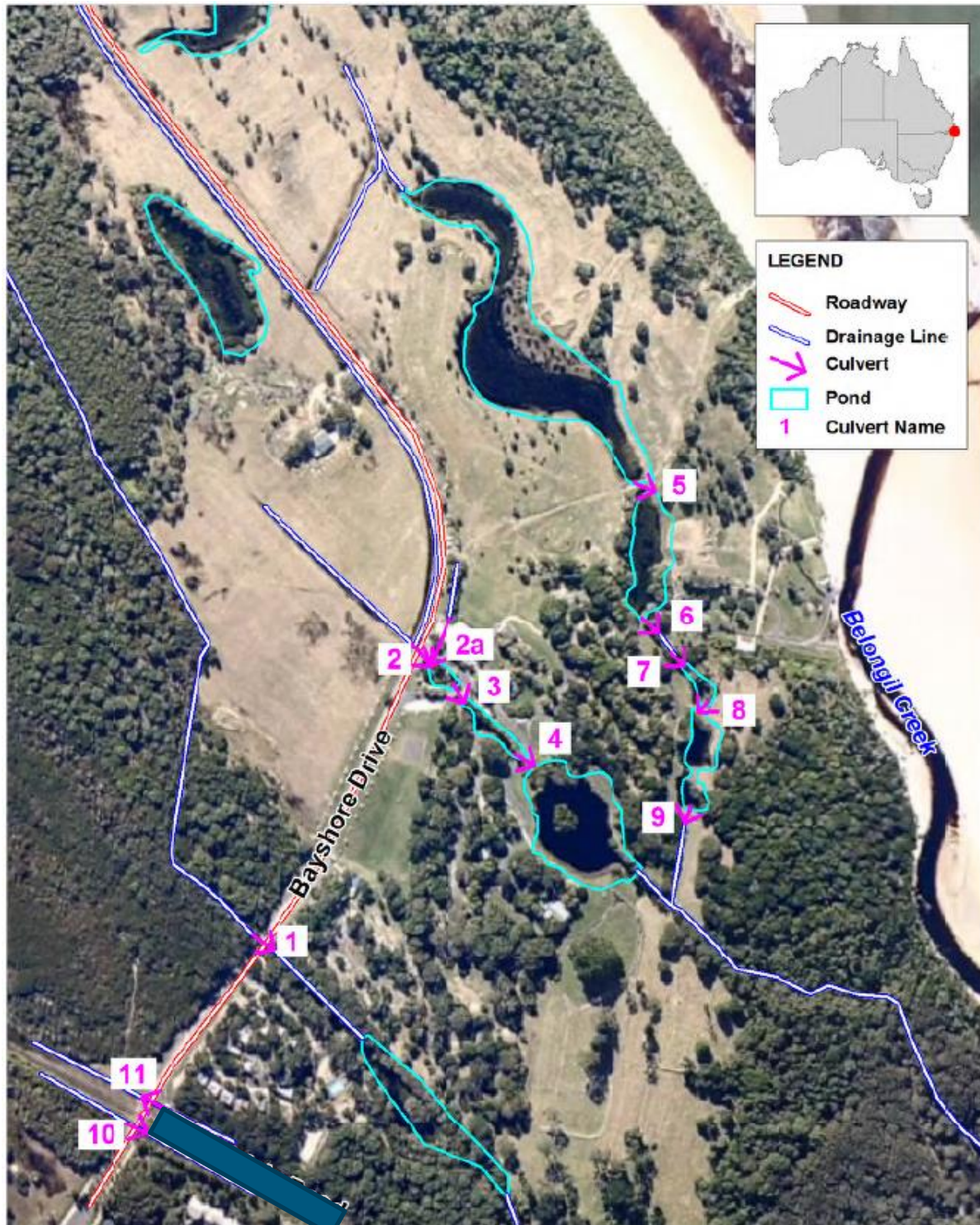


Figure 4: Location of Culverts (from BMT WBM (2013))

3.3 Model Extents and Application of Hydrologic Inflows

The model was extended to cover the full catchment extent (including the area north of Black Rock Road) as presented in **Figure 3**. While the hydrological model and provided inflows were unchanged, the method of applying the inflows was updated to provide a more realistic hydrologic input. For the two catchments north of the study site, the model was updated from the “standard SA inputs” (which inputs flow at the lowest point in the catchment), to an “SA all input” (which spreads inflow over the entire sub-catchment and is similar to a “direct rainfall” input). This is appropriate for the two sub-catchments which have a very complicated internal structure and should not be considered a single sub-catchment. The use of this hydrological input allows the hydraulic model (which includes an updated DEM) to define where the flow in these areas should go and allows the ground elevation definition to provide catchment storage.

4 Initial Flood Model Results

4.1 Peak Site Flood Levels

Peak flood levels at the site for a range of model configurations and design events are presented in **Table 1**.

Table 1: Predicted Peak Flood Levels

Model Run / Scenario / Design Event	Peak Flood Level (m AHD) *
Existing Flood Model - Base - 100yr Event (Q100 & T100)	2.62
Updated Flood Model - Base - 100yr Event (Q100 & T100)	2.35
Updated Flood Model - Base - 100yr Fluvial Only (Q100 & 0.5m Tide)	2.29
Updated Flood Model - Base - 100yr Tide Only (T100)	1.92
Updated Flood Model - 2050 - 100yr Tide Only (T100 + 0.4mSLR and 0.2m SS)	2.53
Updated Flood Model - 2100 - 100yr Tide Only (T100 + 0.9mSLR and 0.3m SS)	3.25
Updated Flood Model - Base - PMF Event (Q PMF & T100)	2.99

Notes: - Q100 is 100yr ARI fluvial deign event
 - T100 is 100yr ARI tidal deign event
 - SLR – sea level rise, SS – additional storm surge (wind & wave setup)
 * Please note that these results are preliminary in nature and may be subject to change following review.

4.2 Predicted Post Development Flood Impact

The model was updated to include 9 large (30x30m) building pads that were conservatively raised to 5 m AHD to allow preliminary assessment of flood impact. The assumed location of the included building pads and the predicted change in peak flood levels is presented in **Figure 5**. It should be noted that the actual location and size of the buildings will be determined at a later date, after consideration of coastal hazard and other design considerations. As the impact is caused by loss of flood storage, the actual location of the pads will have limited influence on the magnitude of the flood impact. The model predicts that the inclusion of the 9 large building pads would locally increase the peak flood levels a by maximum of 3-5 cm, and that the impact away from the proposed rezoning area the impact is less than 1 cm.

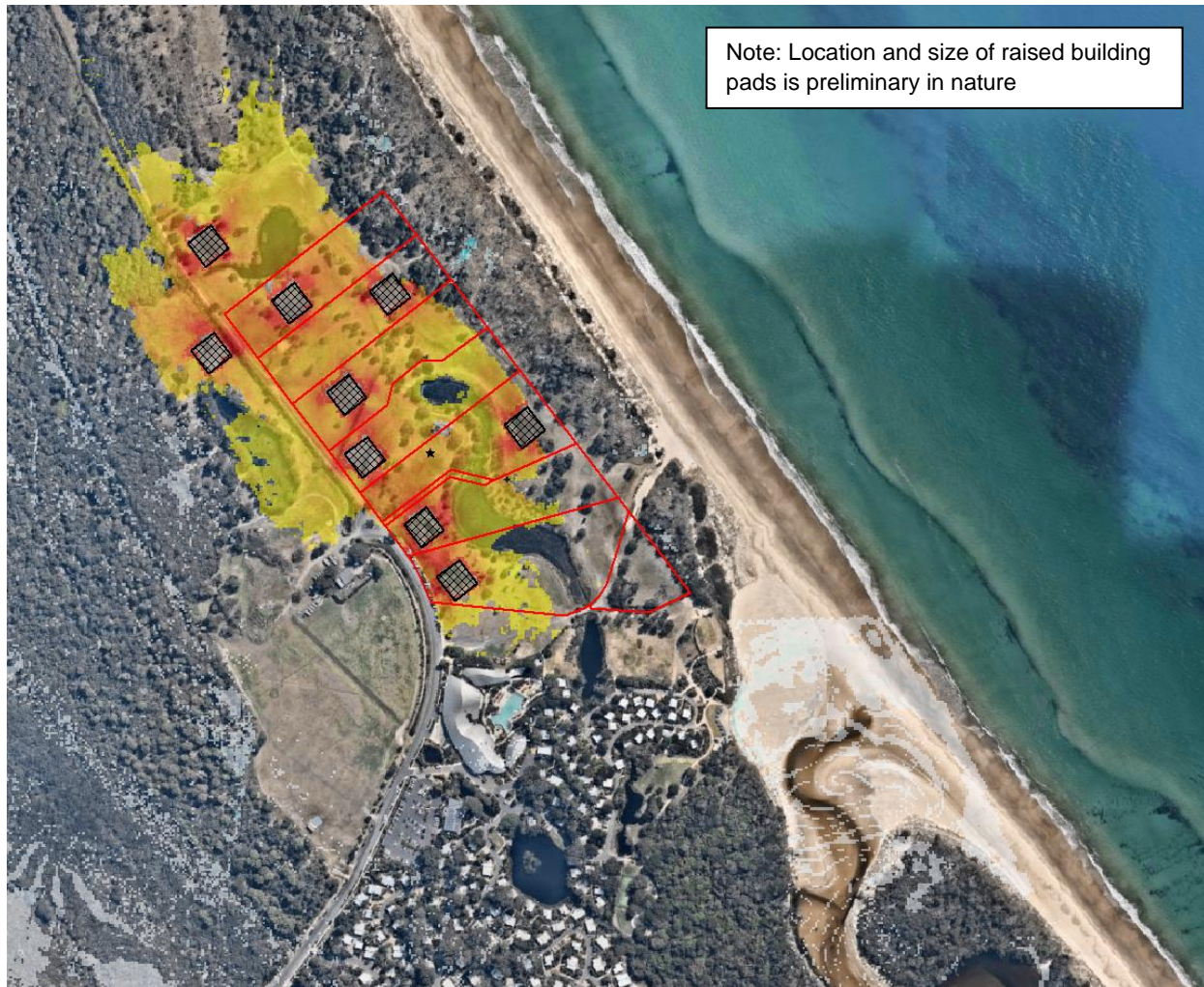


Figure 5: Location of Building Pads and Predicted Flood Impact (100yr ARI)

Notes:

- black hatched areas are nine, 30 x 30m raised pads (location of the pads is preliminary with the actual location and size of the buildings to be determined at a later date after consideration of coastal hazard and other design considerations).
- orange to red is increased flood levels between 1-5 cm

4.3 Existing & Predicted Post Development Flood Hazard

The existing and predicted post development flood hazard has been assessed using the flood hazard curves proposed by Smith et al. (2014) and recommended by the Australian Emergency Management Institute (AEMI). This approach provides a range of hazard classifications which increase in severity based on the safety threat posed to vehicles, people and buildings. These classifications and the corresponding flood hazard curves are shown in **Figure 6**.

The existing 100yr ARI flood hazard is presented in **Figure 7** and shows that the proposed development area is defined as an H3 hazard area. The predicted post development flood hazard is presented in **Figure 8** and shows that the proposed building pads would not result in a noticeable change to the hazard classification. The existing flood hazard for the PMF event is presented in **Figure 9** and shows that the proposed development area is now an H4 hazard area, however, given the PMF level is only 3.00 m AHD and the likely flood planning level is ~3.1 m AHD floor level will be above the PMF level which should reduce any potential issues associated with flood evacuation.

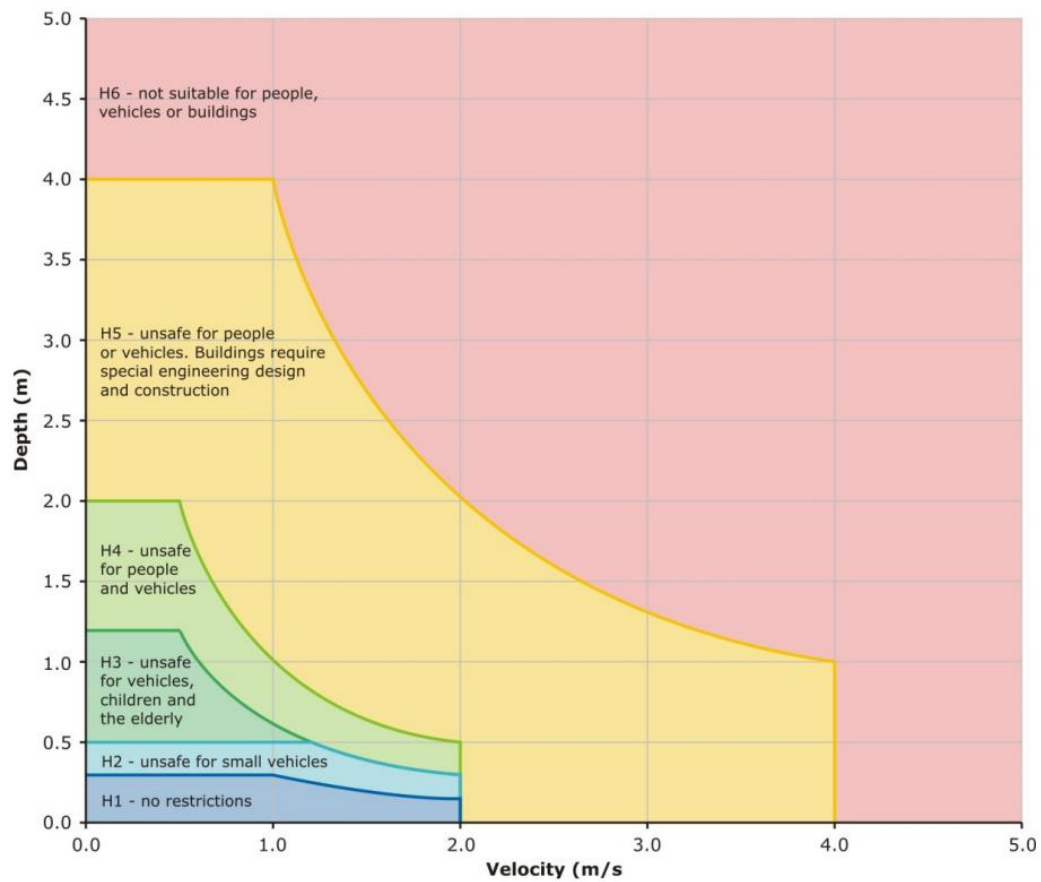


Figure 6: Combined Flood Hazard Curves

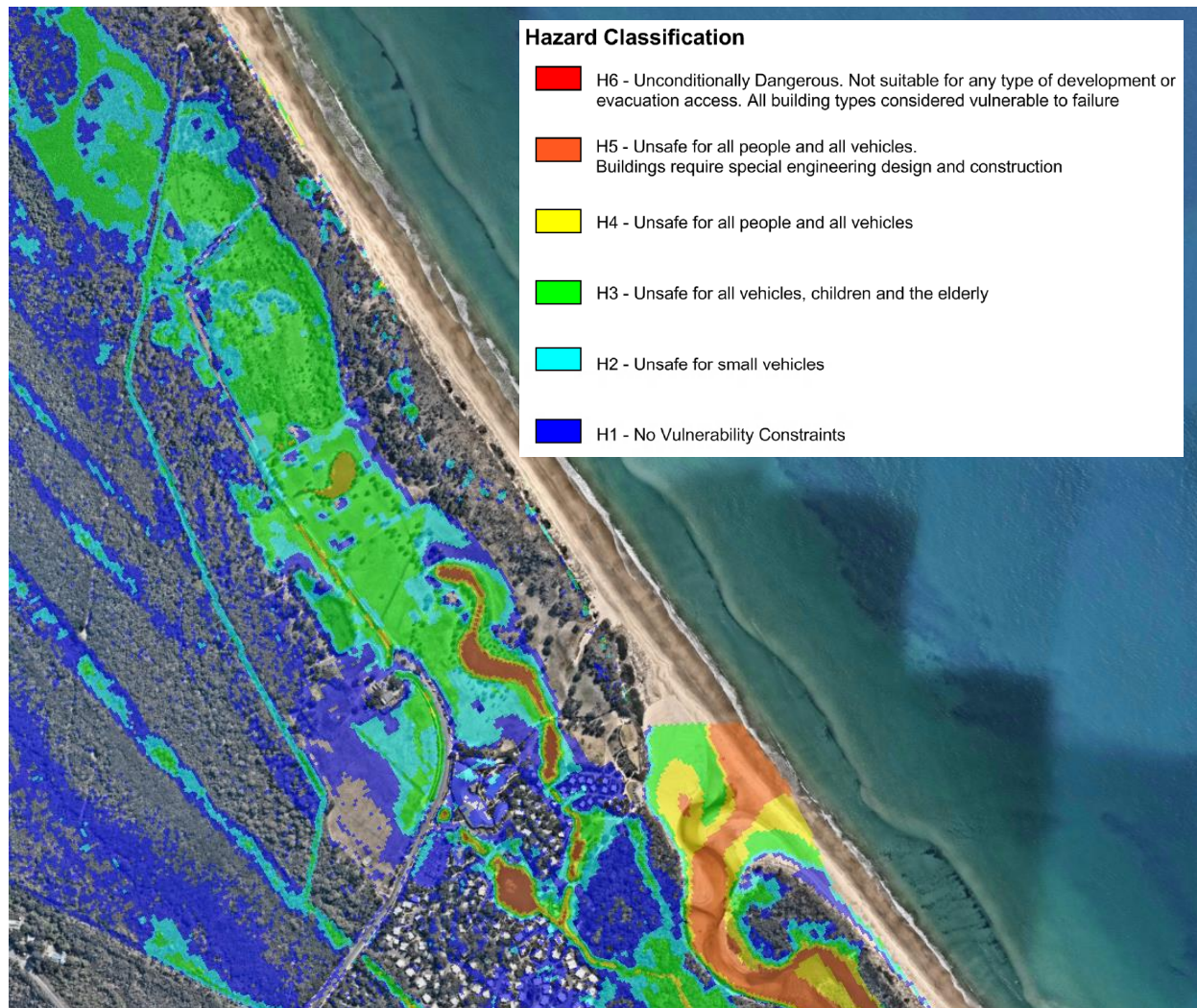


Figure 7: Existing 100yr ARI Flood Hazard

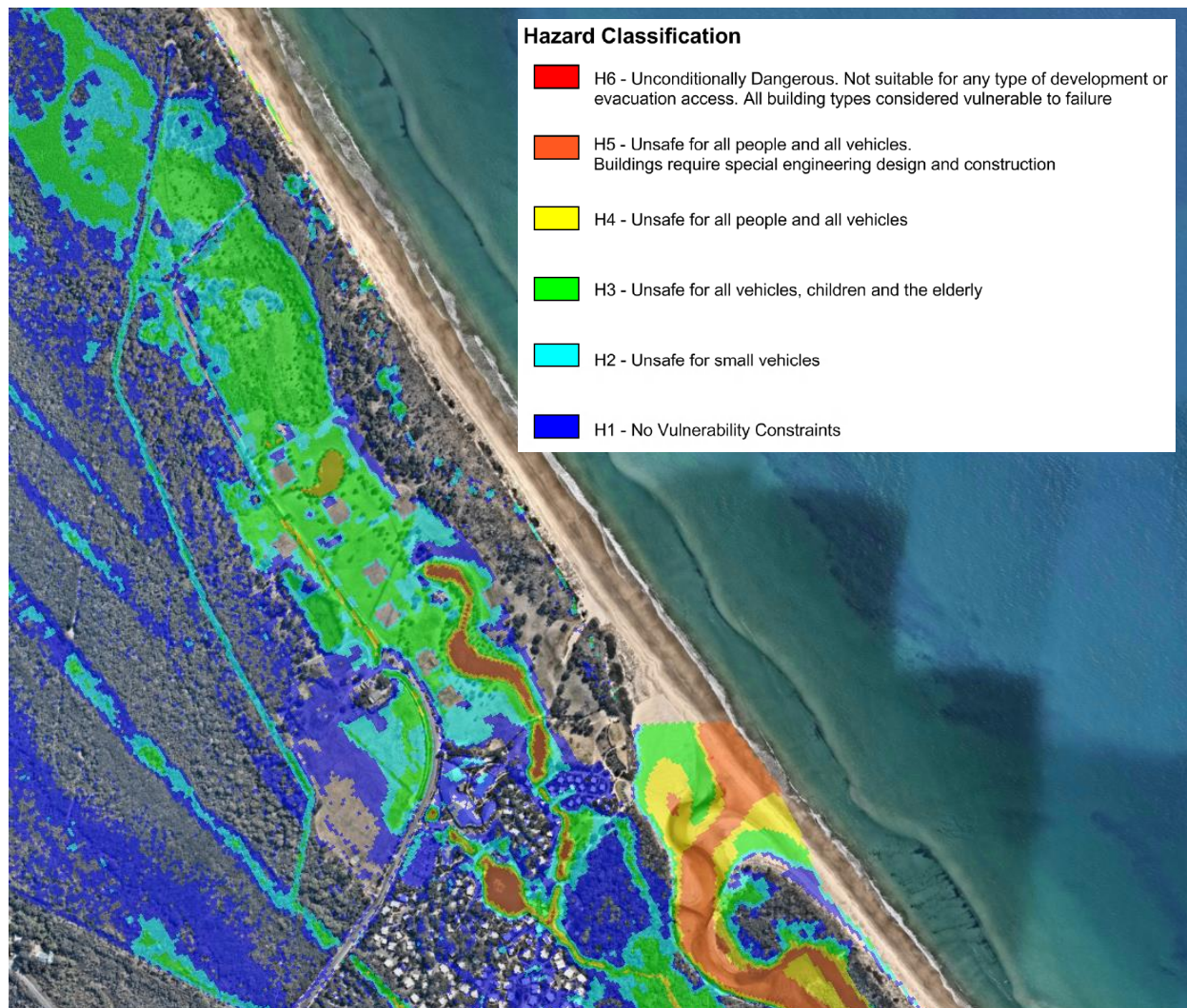


Figure 8: Predicted Post Development 100yr ARI Flood Hazard

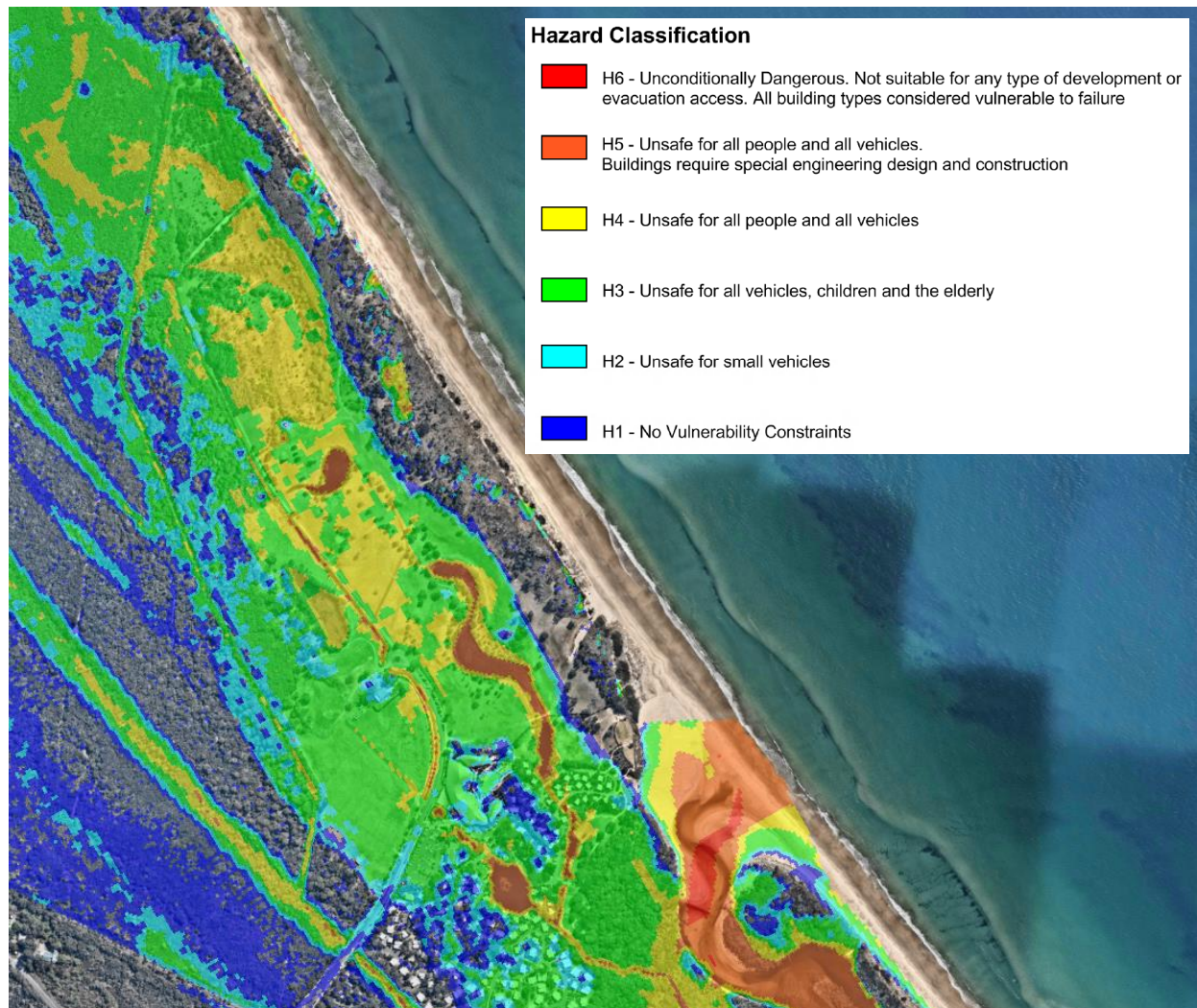


Figure 9: Existing PMF Flood Hazard

5 References

BMT WBM (2011) 'Belongil Creek Floodplain Risk Management Study and Plan, TUFLOW Model Review', October 2011.

BMT WBM (2013) 'North Beach Byron Flood Impact Assessment', Attachment 5 of Appendix G of DA for the establishment of resort Central Facilities at the North Byron Beach Resort, September 2013.

BMT WBM (2014a) 'Belongil Creek Floodplain Risk Management Study', Draft, August 2014.

BMT WBM (2014b) 'Belongil Creek Floodplain Risk Management Plan', Draft, August 2014.

BMT WBM (2015) 'Belongil Creek Floodplain Risk Management Study', Summary, March 2015.

DHI (2002) 'Design Ocean Levels Analysis – Belongil Creek, Byron Bay, Report of Maunsell Pty Ltd, December 2002.

Maunsell (2005) 'North Beach Byron Flooding and Drainage'

PWD (1986) 'Belongil Creek flood study', Report No. L.I.107

Royal HaskoningDHV (2015) 'Belongil Estuary Protection Works Investigations – Numerical Modelling' Report for North Byron Beach Resort, October 2015.

SMEC (2009) 'Belongil Creek Flood Study', Final Report, for Byron Shire Council, November 2009.

Should you have any queries regarding this technical memo, please do not hesitate to contact Rohan Hudson on 4926 9506 or Ben Patterson on 4926 9503.



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