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Flooding and Coastal Advice for the Bayside Brunswick Development – Final Report

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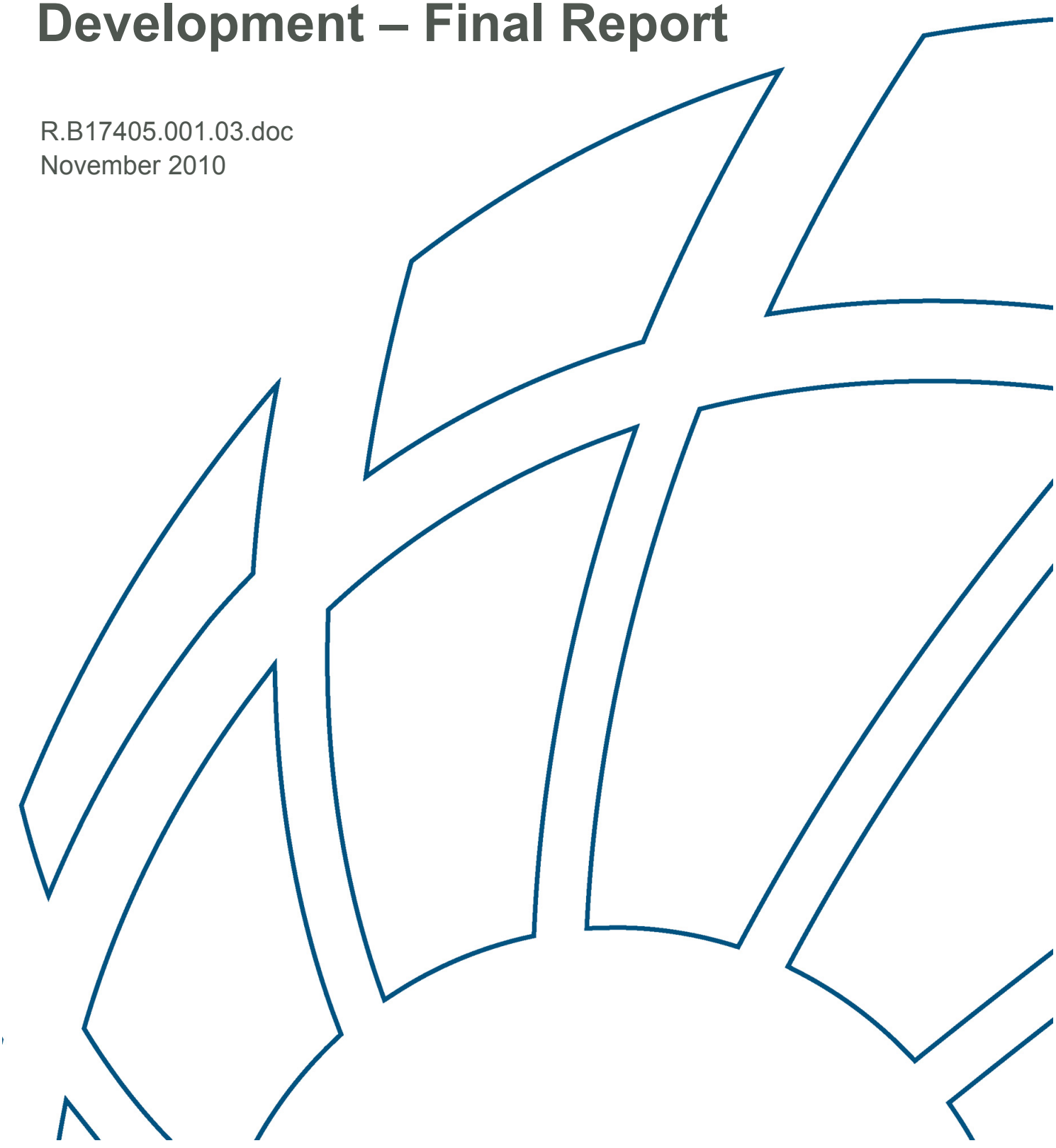
November 2010



Flooding and Coastal Advice for the Bayside Brunswick Development – Final Report

Prepared For:	Codlea Pty Ltd
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Document :	R.B17405.001.03.doc
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Client Reference	

Title :	Flooding and Coastal Advice for the Bayside Brunswick Development – Final Report
Author :	Ben Caddis and Chris Huxley
Synopsis :	This report documents the hydraulic flood impact and coastal hazard assessment undertaken for the Bayside Brunswick development assessment.

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE OF ISSUE	CHECKED BY		ISSUED BY	
0	21/08/09	JGJ		BMC	
1	17/11/10	AK		CDH	
2	25/11/10	AK		CDH	

DISTRIBUTION

DESTINATION	REVISION			
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1 INTRODUCTION

1.1 Purpose

Bayside Brunswick is a proposed urban residential development located to the south of Brunswick Heads, NSW. Construction of Stage 1 of the development was completed during the 1990's and is currently fully established.

Land Partners Pty Ltd have been engaged by Codlea Pty Ltd as lead consultants in the preparation of the Environmental Assessment for a Concept Plan for Stage 2 of the development, described as Lot 1 on DP871039. BMT WBM has subsequently been engaged by Codlea Pty Ltd to provide technical advice in relation to flooding and coastal processes.

In January 2007, the NSW Department of Planning issued its Director General's Environmental Assessment Requirements (DGRs) for the proposed development, which were subsequently revised in July 2008 (ref. 9041017) and October 2010 (ref. 05_0091). This assessment has been prepared to address items 5.1, 5.6 and 5.7 of the DGRs (October 2010) as described below.

Coastal Processes

5.1 Address coastal hazards and the provisions of the *Coastline Management Manual*. In particular consider impacts associated with wave and wind action, coastal erosion, sea level rise and more frequent and intense storms.

Flooding

5.6 Provide an assessment of any flood risk on site (for the full range of floods including events greater than the design flood, up to the probable maximum flood; and from coastal inundation; catchment based flooding or a combination of the two) and having consideration of any relevant provisions of the *NSW Floodplain Development Manual* (2005). The assessment should determine; the flood hazard in the area; address the impact of flooding on the proposal, address the impact of the proposal (including filling) on flood behaviour of the site and adjacent lands; and address adequate egress and safety in a flood event.

5.7 Assess the potential impacts of sea level rise and an increase in rainfall intensity on the flood regime of the site and adjacent lands with consideration of NSW Coastal Planning Guideline – Adapting to Sea Level Rise (NSW Government, 2010) and Practical consideration of Climate Change – Floodplain Risk Management guideline (DECC, October 2007)

1.2 Site Description

The subject site is located approximately 1.5km to the south of Brunswick Heads, between Simpsons Creek and the Pacific Highway. The site is bounded by Stage 1 of the Bayside development to the north, Simpsons Creek to the east, and forested rural land to the south and west. Refer to Figure 1-1 for locality of the site. A layout plan for the proposed development is presented in Appendix A.

Bayside Brunswick is located within the downstream reaches of the Simpsons Creek catchment. Simpsons Creek, along with Marshalls Creek, are the two largest tributaries of the Brunswick River, both joining the river near its mouth, to the north of Brunswick Heads.

From the Tyagarah airstrip, Simpsons Creek meanders northwards, parallel to the coastline and separated from the ocean by the coastal dunes. Along the western bank of the creek, a ridgeline separates the creek from the floodplain, connected by two small drainage gullies.

1.3 Previous Site Studies

In 2006, the following report was prepared for Stage 2 of the Bayside Brunswick development:

- Preliminary Assessment – Proposed Residential Subdivision at Brunswick Heads "Bayside Brunswick", 2006, Jim Glazebrook & Associates.

Described in that report are the key site constraints with respect to environmental issues.

1.4 Previous Studies

Over the past 23 years, various hydraulic studies of the Brunswick River system have been produced, for a variety of purposes. The key studies applicable to flooding within the Simpsons Creek catchment include:

- *Brunswick River Flood Study*, (Webb McKeown & Associates, 1986);
- Pacific Highway Upgrading at Brunswick Heads, Hydraulic Investigation, (WBM Oceanics, 1992); and
- Hydraulic Assessment for the Tandys Lane Pacific Highway Upgrade, (Kinhill Cameron McNamara, 1997).

The above reports were reviewed as part of this study. It is noted that the modelling techniques used for the previous studies have generally been superseded by more advanced techniques developed over recent years. However, these reports do contain important background information relevant to flood mechanisms within Simpsons Creek.

Within the Brunswick Heads region, the Byron Shire Coastline Hazard Definition Study (WBM, 2000) represents the most recent and applicable coastal processes/hazard study. As part of this study, the hazard line definition reported in the WBM study has been revised in line with current climate change guidelines.

1.5 Policies and Guidelines

The following policies and guidelines apply to this development with respect to flooding and coastal processes:

- NSW Coastal Policy 1997 – A Sustainable Future for the New South Wales Coast (NSW Government, 1997);
- Byron Shire Council's Development Control Plan 2002 – Part K – Flood Liable Land (BSC, 2002);

- Coastal Design Policy for NSW (NSW Government, 2003);
- *NSW Floodplain Development Manual* – the Management of Flood Liable Land (DIPNR, 2005);
- Practical Consideration of Climate Change – Floodplain Risk Management Guideline (DECC, 2007);
- Byron Shire Council's Draft 100 year Climate Change Flood Planning Scenarios (BSC, 2009);
- Draft Sea Level Rise Policy Statement (DECC, 2009); and
- NSW Coastal Planning Guideline – Adapting to Sea Level Rise (NSW Government, 2010).

1.6 Methodology

Review of available literature indicated that insufficient information to address the flooding related DGRs for the development. Therefore, a dynamically linked two-dimensional / one-dimensional (2D/1D) flood model of Simpsons Creek has been developed.

As agreed during a meeting with Byron Shire Council and the NSW Department of Environment, Climate Change and Water (DECCW) on 13 April 2009, the following approach has been followed:

- Develop a hydrological model of Simpsons Creek;
- Develop a 2D/1D TUFLOW hydraulic model of Simpsons Creek;
- Verify the flood model performance against one historical event;
- Sensitivity test key model assumptions;
- Simulate 20 and 100 year average recurrence interval (ARI) design events;
- Simulate the Probable Maximum Flood (PMF) event;
- Simulate climate change scenarios;
- Assess design flood conditions of the site; and
- Assess potential flood impacts due to the development.

These steps are described in further detail in Sections 2 to 6.

In addition, a coastal hazard assessment was undertaken. The outcomes of this desktop study are discussed in Section 7 of this report.

To ensure that all possible issues are addressed prior to the formalising of the final assessment report, a review of the draft assessment report has been completed in consultation with personnel from Byron Shire Council and the NSW Department of Environment, Climate Change and Water (DECCW). Following the review, Byron Shire Council provided a list of comments which have subsequently been addressed in this report. DECCW were satisfied with the assessment documented in the draft report, raising no additional queries.

Title:

Locality Plan

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2 DATA COLLECTION

2.1 Aerial Photography

Aerial photography, captured in 2003, has been provided by the NSW Department of Lands. High resolution aerial photography is required for land use mapping to define surface roughness.

2.2 Topographical Information

2.2.1 Bathymetric Survey

Bathymetric survey of the estuarine extents of the Brunswick River system was captured as part of the Department of Natural Resources' (DNR) Estuary Management Program. The survey was provided for this project by the NSW Department of Environment, Climate Change and Water (DECCW).

The bathymetric survey comprises spot levels captured, on average, every 5m along cross section lines perpendicular to Simpsons Creek. Cross sections are located at 25m and 50m centres, downstream and upstream of the Brunswick Heads footbridge respectively. Refer to Figure 2-2 for extents of bathymetric survey.

2.2.2 ALS Survey

Airborne laser scanning (ALS) survey of the Brunswick River catchment was acquired by AAM Hatch between 31 August and 6 September 2008. The survey was captured for Byron Shire Council for use with the Brunswick River Flood Study Update, currently proposed for the 2009/2010 financial year.

Following endorsement by Council, AAM Hatch supplied a 12.8km^2 tile of the ALS survey to Codlea Pty Ltd for use with the Bayside Brunswick development.

Post-processing of the data by AAM Hatch included filtering out the non-ground strikes using an automated algorithm. Some manual checking was also performed. The reported accuracy of the data is:

- Vertical = +/- 0.15m (68% confidence level); and
- Horizontal = +/- 0.21m (68% confidence level).

Using this data, a digital elevation model (DEM) was generated as shown in Figure 2-3. The DEM covers the Simpsons Creek floodplain between the Tyagarah Airstrip and Brunswick Heads.

2.2.3 Ground Survey

A detailed topographic survey of the development site was provided by Land Partners. Additionally, four cross sections were surveyed by Land Partners along the Everitts Creek drainage channel. The cross sections identified top and bottom of banks, channel invert and overbank levels.

Clarification of certain site features and relevant hydraulic features was undertaken during site inspections.

2.3 Rainfall and Tidal Data

Pluviographic rainfall data for the May 2009 event, recorded every five minutes, were sourced from the Bureau of Meteorology (BOM) for the eight rainfall stations surrounding the Simpsons Creek catchment. Rainfall stations from the Brunswick River and Belongil Creek catchments, and the surrounding parts of the Richmond River catchment were used as discussed in Section 3.

Similarly, recorded water levels for the May 2009 event at the Brunswick River mouth were sourced from Manly Hydraulic Laboratory. Refer to Figure 2-1 for recorded tides from 17 May until 28 May 2009.

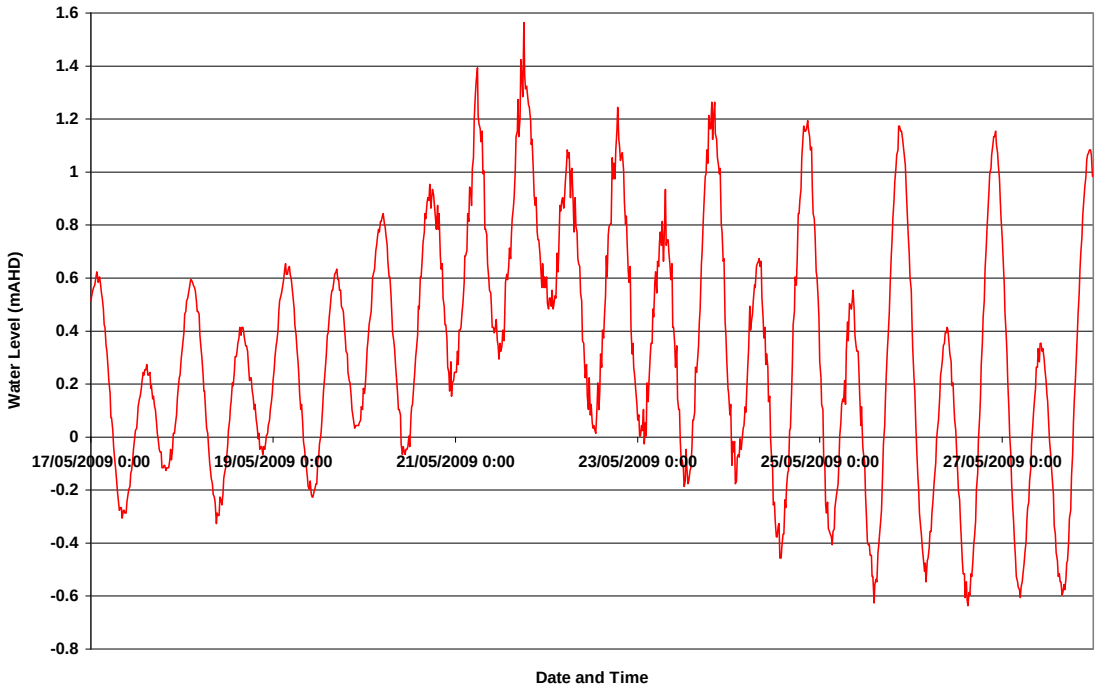


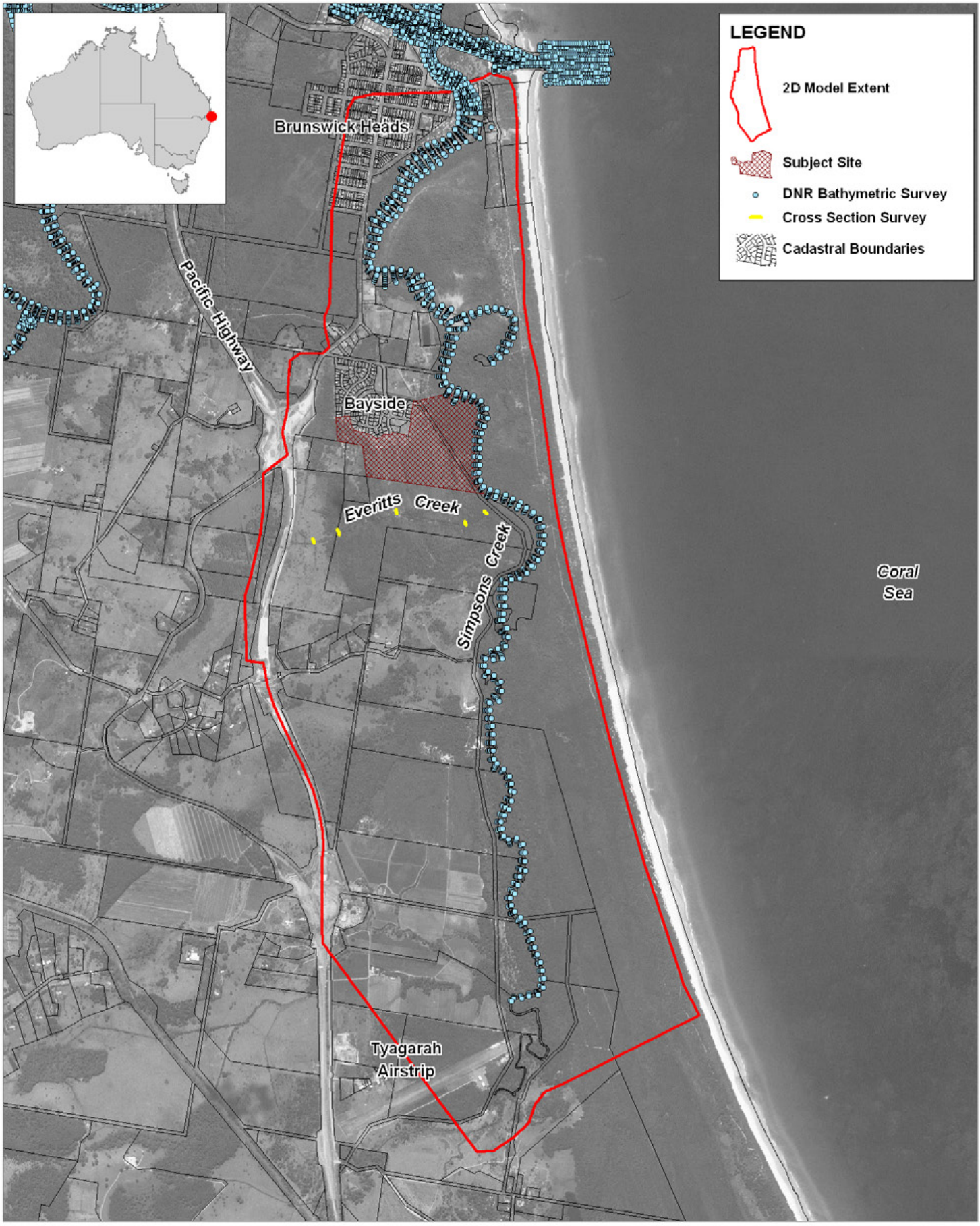
Figure 2-1 May 2009 Event Brunswick River Mouth Gauge Recordings

2.4 Historical Flood Level Information

The heavy rainfall and flooding across the Northern Rivers and Southeast Queensland area, which occurred during May 2009, provided a good opportunity for model verification. Although only minor flooding occurred within the Brunswick River system, 'out of bank' flow was evident along Simpsons Creek.

During the weeks following the event, BMT WBM engineers and Land Partners surveyors undertook a field data collection exercise. Subsequently, 12 flood debris marks and three visual recollections of flood behaviour by local residents were recorded and surveyed.

Refer to Figure 2-4 for flood mark survey locations.



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Bathymetric Survey Extents

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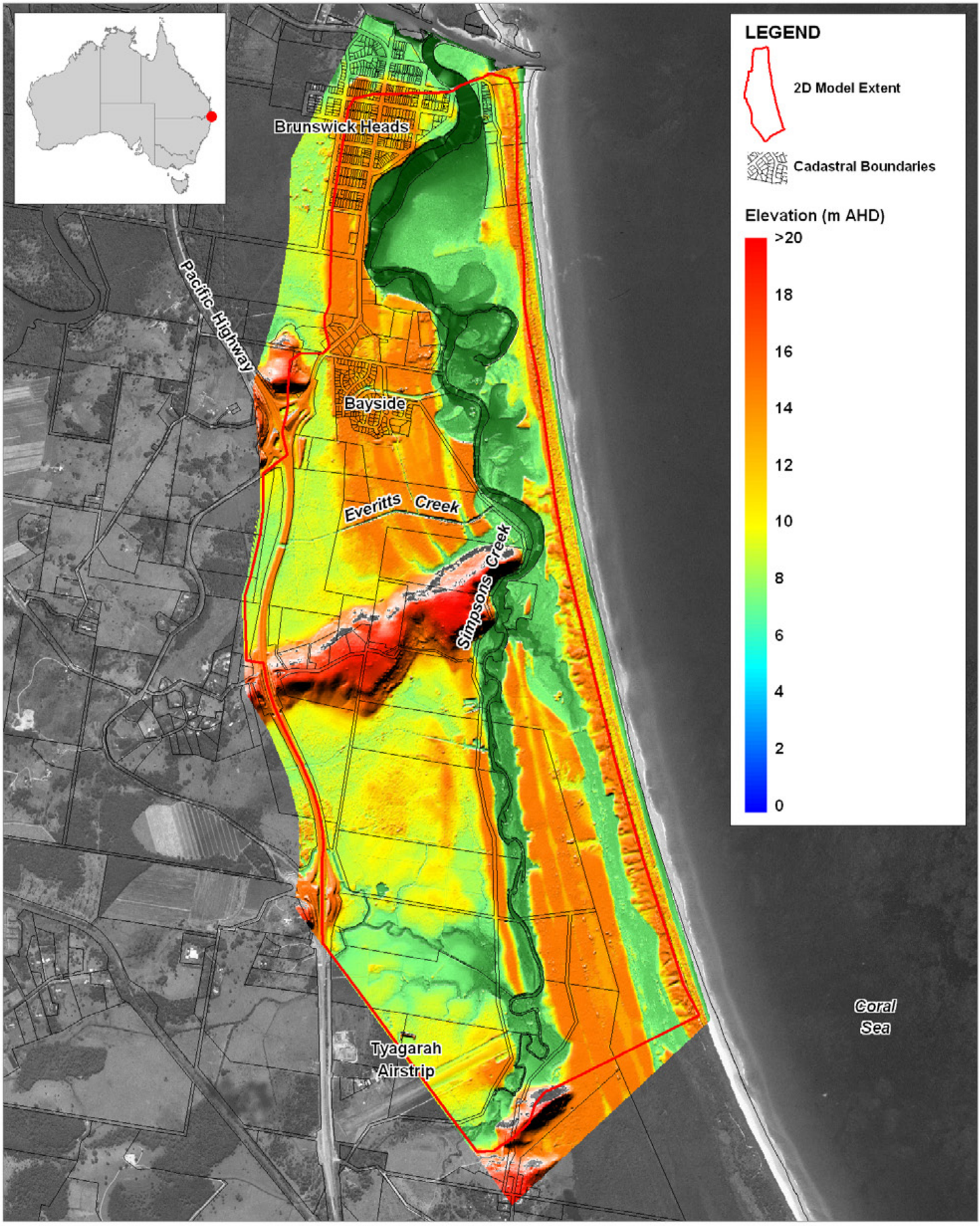

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Digital Elevation Model

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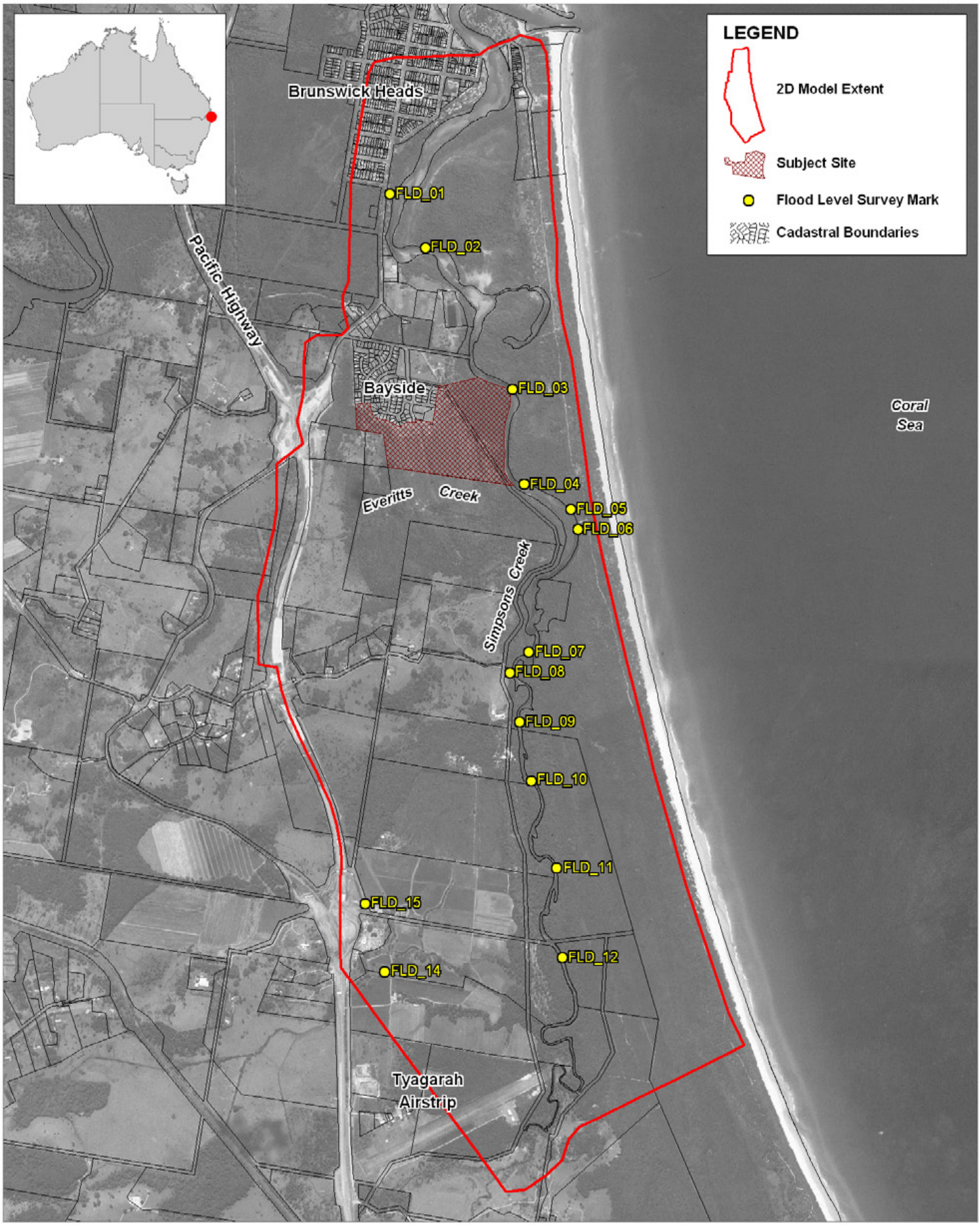

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May 2009 Event Flood Level Survey

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3 HYDROLOGIC MODEL DEVELOPMENT

3.1 Methodology

Hydrological modelling for the estimation of historical and design flood hydrographs has been undertaken using the Watershed Bounded Network Model (WBNM) software. WBNM uses a non-linear runoff-routing algorithm to convert rainfall excess into a flow hydrograph.

The key steps in the hydrological process undertaken are:

- Delineate the main study catchment boundary;
- Define sub-catchments by subdividing the parent catchment based on catchment characteristics such as topography and hydraulic controls;
- Estimate the impervious fraction of each sub-catchment;
- Assign appropriate values for initial and continuing losses;
- Assign May 2009 recorded rainfall time series for each sub-catchment, including a factor based on the derived rainfall isohyets for the event;
- Refine routing parameters in conjunction with hydraulic modelling to achieve best fit for hydraulic model verification; and
- Use the verified hydrologic model for design event simulation.

3.2 Catchment Sub-Division

The Simpsons Creek catchment covers an area of approximately 65km^2 to the South Beach Road bridge at Brunswick Heads. The overall catchment includes the tributaries of Tyagarah Creek and Everitts Creek. For input into WBNM, the parent Simpsons Creek catchment has been sub-divided into 30 sub-catchments as shown on Figure 3-1.

An additional sub-catchment, S_14.01, represents the Pipeclay Creek catchment, which flows northwards between two hill ridges, to the west of the Casino-Murwillumbah railway at Myocum. Pipeclay Creek flows into Kings Creek, which itself flows into the Brunswick River to the west of Brunswick Heads.

Inspection of the digital elevation model (DEM) for that area suggests that sub-catchments S_14.01 and S_11.01 may be hydraulically linked.

During site inspection, flow was observed between sub-catchments S_11.01 and S_11.02, draining from west to east, through the bridge along the disused Casino-Murwillumbah railway between sub-catchments S_11.01 and S_11.02. However, the flow capacity of the bridge does not appear sufficient to convey all runoff from sub-catchment S_11.01 during significant events (sub-catchment area of 5.7 km^2). Refer to photos in Appendix B.

Testing of the flow transfer between sub-catchments S_11.01 and S_14.01 has been undertaken as part of the model verification. Additional sensitivity testing has been undertaken as part of the design event modelling presented later in this report.

3.3 Routing Parameters

The algorithms used for runoff routing within WBNM include two parameters:

- Catchment Lag Parameter (CLP) – describes the attenuation of the rainfall excess hyetograph as it is routed through the sub-catchment; and
- Stream Lag Parameter (SLP) – describes the attenuation of inflow hydrographs from upstream catchments as it is routed through the sub-catchment.

Both of these parameters have been shown to be relatively independent of catchment area, slope, and the magnitude of the flood event (Boyd & Bodhinayake, 2006). Numerous studies have been undertaken to determine appropriate values for the CLP, and values between 1.4 and 1.8 are typical to the East Coast. The lower the parameter, the greater the attenuation of the flood wave, and vice versa. A CLP of 1.6 was found to be most appropriate for this study as recommended in the WBNM User Manual (2007).

The SLP is directly related to the velocity of flow. Typically, a value of unity is applied to natural watercourses. During the Richmond River Flood Mapping Study (BMT WBM, Draft 2009), a joint hydraulic/hydrologic calibration exercise was undertaken for the entire Richmond River catchment. It was found that in downstream sub-catchments away from the escarpment, floodwaters would enter the floodplain, significantly reducing the velocity of flow. Floodwater would remain on the floodplains for many days, and even weeks in some areas. It was found that using conventional values for the SLP, WBNM was insufficiently attenuating the flood wave. This phenomenon was evident at many stream gauges where the peak flow actually occurred many days after the time estimated using WBNM. Hence, the SLP was adjusted based on the following criteria:

- An SLP of 1.0 was applied to all first order sub-catchments (all catchments not receiving flow from any upstream sub-catchment);
- An SLP of 2.0 was applied to all second order sub-catchments (all sub-catchments receiving flow from the first order sub-catchments);
- An SLP of 3.0 was applied to all third order sub-catchments (all sub-catchments receiving flow from the first and second order sub-catchments); and
- An SLP of 4.0 was applied to all sub-catchments greater than third order.

The SLP is inversely proportionate to the flow velocity, hence, an SLP of 2.0 equates to a halving of flow rates. This assumption is reasonable given the storage characteristics of the catchment. The approach adopted significantly improved the attenuation of the flood wave (flow rate and timing), resulting in an improved calibration.

The topography of the Simpsons Creek catchment has similar characteristics to the Richmond River catchment. The catchment is surrounded by a steep, responsive escarpment with expansive storage basins within the lower floodplain, which may take many days to drain.

During the model calibration/verification of the Richmond River flood model, use of these lag parameters was shown to result in the most appropriate catchment response and peak flow rates.

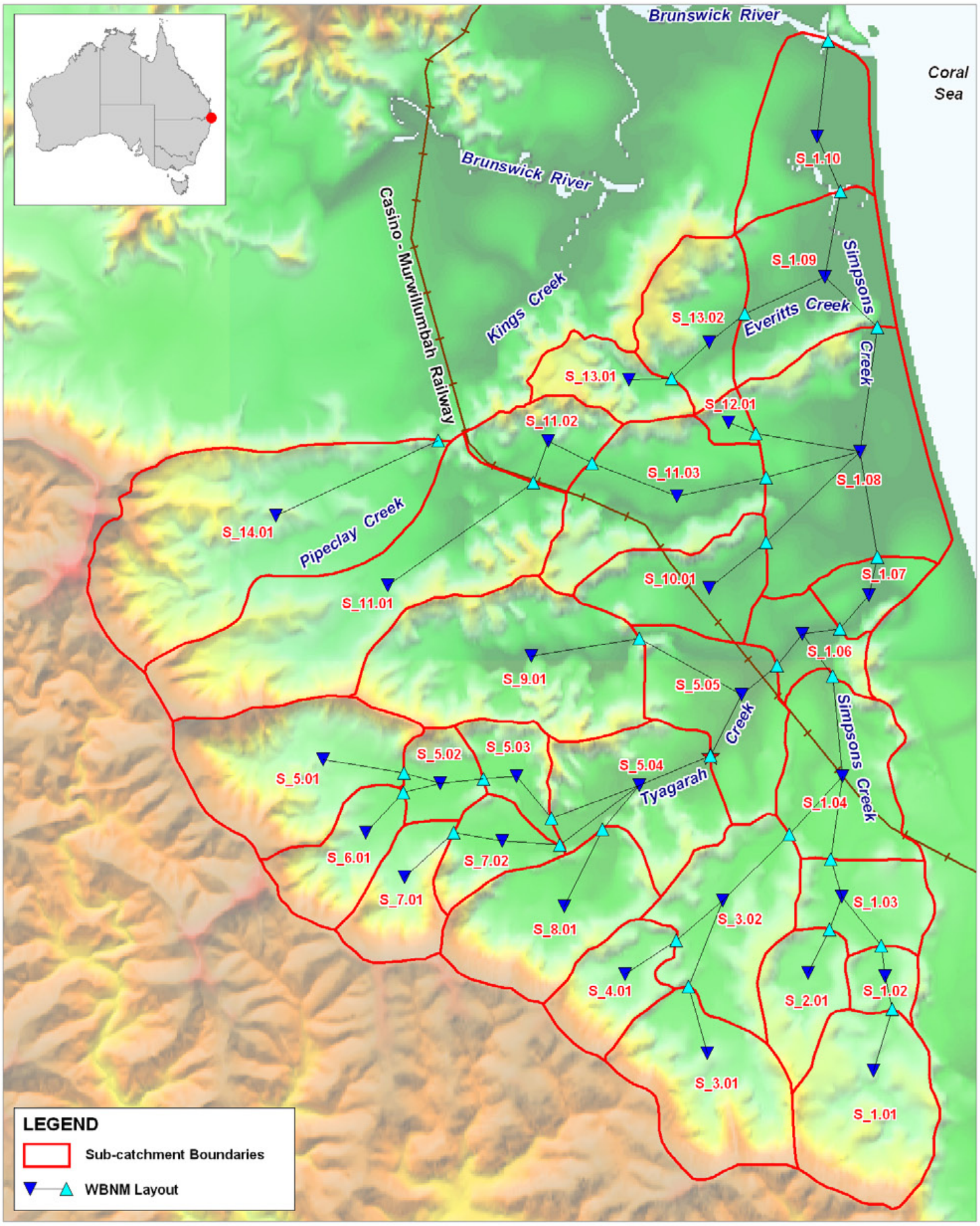
3.4 Rainfall Losses

The review of rainfall loss parameter values adopted by flood studies completed for neighbouring catchments shows a significant range in values. Table 3-1 lists the rainfall loss values used during the Belongil Creek Food Study (SMEC, 2009), Tweed Byron Coastal Creeks Flood Study (BMT WBM, 2010) and the current study.

Based on the significant range in neighbouring catchment loss parameters, values in accordance with Australian Rainfall and Runoff (IEAust., 1987) recommendations have been adopted for this study. The adopted values are 20mm initial and 2.5mm/hour continuing rainfall loss, as shown in Table 3-1. These loss values were tested during the model verification assessment and were subsequently considered appropriate for the design event modelling phase of the project.

Table 3-1 Rainfall Loss Parameter Comparison

Study	***Initial Loss (mm)***	***Continuing Loss (mm/hour)***	***Total Rainfall Loss Equivalent (mm) (30hr Duration Event)***	***Comment***
Belongil Creek Flood Study (SMEC, 2009)	10mm	Urban = 3.5mm/h Rural = 4mm/h Sandy = 10mm/h	Urban = 115mm Rural = 130mm Sandy Soils= 310mm	Values based on soil type analysis
Tweed Byron Coastal Creeks Flood Study (BMT WBM, 2010)	0mm	Urban = 0mm/h Other = 2mm/h	Urban = 0mm Other = 60mm	Conservative initial loss value reflecting catchment being saturated with rainfall prior to the design event
Bayside Brunswick	20mm	2.5mm/h	95mm	Based on Australian Rainfall and Runoff recommendations: Table 3.2 (IEAust., 1987)



Title:

Catchment Plan and Hydrologic Model Layout

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4 HYDRAULIC MODEL DEVELOPMENT

4.1 Methodology

Hydraulic modelling to define the flood behaviour along the watercourses and across the floodplain at the subject site has been undertaken using the TUFLOW hydrodynamic flood modelling software. TUFLOW enables the representation of the floodplain using a two dimensional (2D) grid with dynamically nested one dimensional (1D) elements, such as channels and structures.

The TUFLOW model covers a 10.45km^2 area between the Pacific Highway and the coast, from the Tyagarah Airstrip in the south to Brunswick Heads in the north. A 10m by 10m grid cell resolution was selected for the 2D domain as a compromise between model resolution and simulation run time. This resolution is considered suitable for this assessment. Each grid cell contains information relating to elevation, surface roughness and initial water level.

Adequate representation of channel geometry can often be compromised when modelling entirely in 2D. This is especially true when attempting to represent channels with complex geometry at a smaller scale than the size of the 2D elements, in this case 10m. Therefore, the following watercourses have been modelled by dynamically nesting 1D channels within the broader 2D domain:

- Simpsons Creek from the Tyagarah Airstrip to the downstream boundary;
- Everitts Creek between the floodplain and Simpsons Creek; and
- The drainage channel between the floodplain and Simpsons Creek, to the south of Andersons Ridge.

Refer to Figure 4-1 for hydraulic model layout.

4.2 Land Use

Surface roughness is represented in the model by land use polygons, which have been digitised from aerial photographs. Each land use type has been assigned an appropriate Manning's 'n' value, as adjusted during the model verification process.

4.3 Hydraulic Structures

The various culverts along the Pacific Highway and Gulgan Road were assessed for their requirement to be represented in the model. The following structures have been included in the hydraulic model:

- Gulgan Road – a single cell of 3.0m wide by 1.8m high provides a secondary flowpath for floodwaters within Everitts Creek. The culvert drains the floodplain to the west of Bayside directly into Kings Creek to the west of Brunswick Heads. This culvert influences flood levels to the west of Bayside, thus, has been included as a 1D element.

- Everitts Creek Pacific Highway crossing – a 20m plank bridge across Everitts Creek along the western edge of the 2D domain is an important hydraulic control for floodwaters entering from west of the Pacific Highway. This structure has been modelled as a 2D structure.

Along the Pacific Highway, between Tandys Lane and the Tyagarah Wreckers, the following transverse drainage culverts have been omitted from the model:

- 1 cell 2.4m wide by 1.2m high and 4 cells 2.4m wide by 1.5m high;
- 5 cells 2.4m wide by 1.2m high; and
- 2 cells 3.0m wide by 2.1m high.

Although these culverts may significantly control the flow entering the Simpsons Creek floodplain, sensitivity testing using the hydraulic model has shown that their inclusion did not influence flood behaviour at the subject site.

4.4 Boundary Conditions

Inflow hydrographs from upstream areas have been applied along line boundaries as shown on Figure 4-1. Rainfall within the bounds of the hydraulic model has been applied directly to the 2D domain. This rainfall utilises the same intensities and temporal patterns as the hydrologic model, with adjustment for relevant losses.

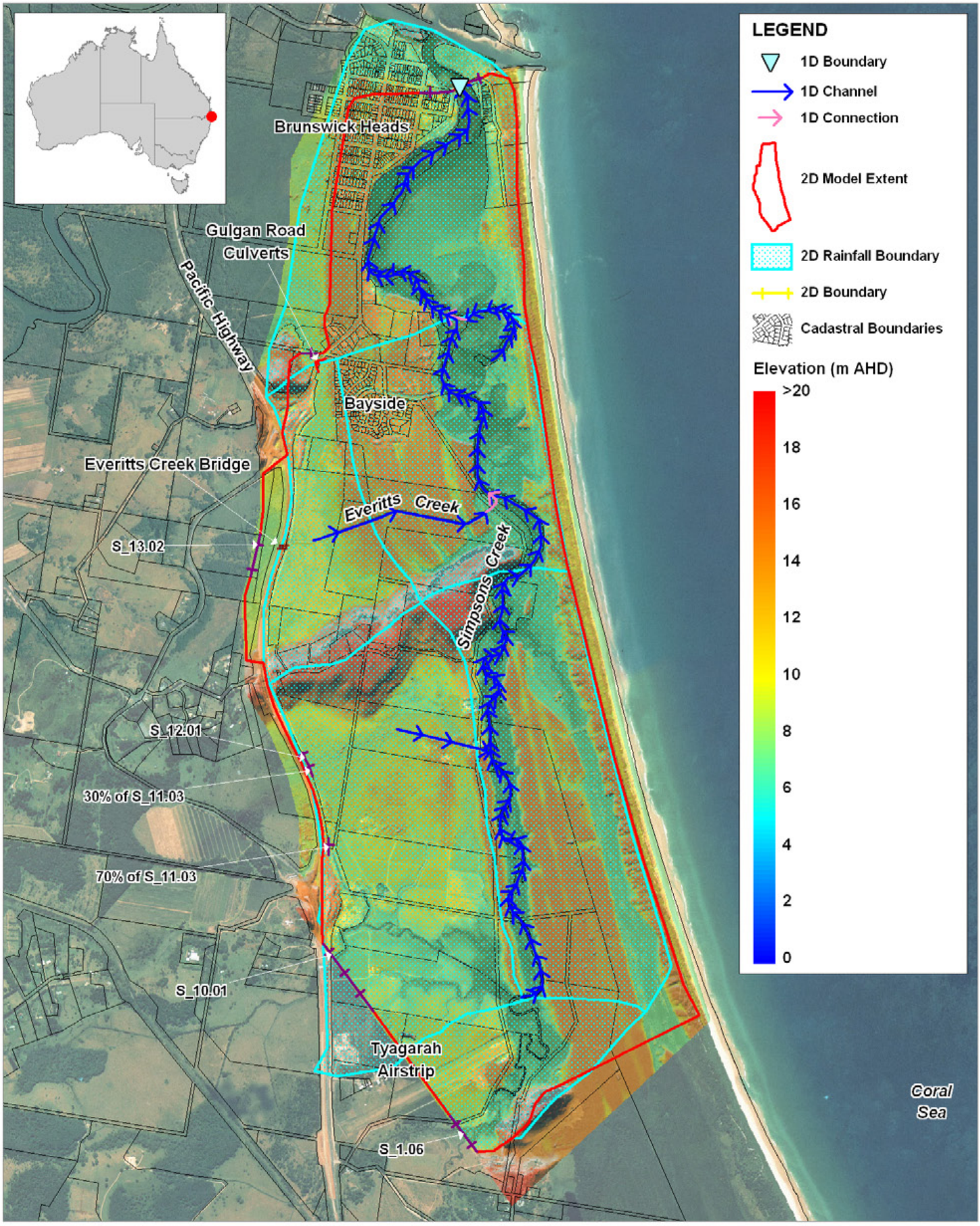
At the downstream end of the model, two boundaries have been applied as follows:

- Stage versus time boundary for the downstream end of Simpsons Creek. The boundary condition prescribed at this boundary is discussed further in Sections 5 and 6 of this report; and
- Flow versus time boundary at the downstream side of the Gulgan Road culverts. This boundary is automatically generated by TUFLOW, based on an assumed flood gradient of 0.5%.

4.5 Hydraulic Model Assumptions

The following assumptions have been applied to this model:

- **Belongil Creek** – during large flood events, flow transfer between Simpsons Creek and Belongil Creek to the south may be possible. Immediately to the south of Andersons Ridge, a flowpath behind the coastal dunes connects Simpsons Creek to the low lying ground beyond the southern extent of the hydraulic model. No inter-catchment flow has been assumed; and
- **Tidal boundary** –a boundary condition that represents ocean water levels at the South Beach Road bridge, Brunswick Heads, has been applied to the model. Application of the boundary at this location does not account for Brunswick River flooding, or attenuation of storm surge between the boundary and the ocean. However, these effects are expected to be minimal. Therefore, this assumption is considered suitable, as per previous studies.



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Hydraulic Model Layout

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